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Preface

This preface contains the following topics:

• Technology Rebrand
• Audience
• Documentation Accessibility
• Diversity and Inclusion
• Related Resources
• Conventions

Technology Rebrand

Oracle is rebranding the suite of products and components that support machine learning with Oracle Database and Big Data. This technology is now known as Oracle Machine Learning (OML).

The OML application programming interfaces (APIs) for SQL include PL/SQL packages, SQL functions, and data dictionary views. Using these APIs is described in publications, previously under the name Oracle Data Mining, that are now named Oracle Machine Learning for SQL (OML4SQL).

Audience

This guide is intended for application developers and database administrators who are familiar with SQL programming and Oracle Database administration and who have a basic understanding of machine learning concepts.

Documentation Accessibility

For information about Oracle’s commitment to accessibility, visit the Oracle Accessibility Program website at http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc.

Access to Oracle Support

Oracle customers that have purchased support have access to electronic support through My Oracle Support. For information, visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=info or visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=trs if you are hearing impaired.
Diversity and Inclusion

Oracle is fully committed to diversity and inclusion. Oracle respects and values having a diverse workforce that increases thought leadership and innovation. As part of our initiative to build a more inclusive culture that positively impacts our employees, customers, and partners, we are working to remove insensitive terms from our products and documentation. We are also mindful of the necessity to maintain compatibility with our customers’ existing technologies and the need to ensure continuity of service as Oracle’s offerings and industry standards evolve. Because of these technical constraints, our effort to remove insensitive terms is ongoing and will take time and external cooperation.

Related Resources

For more information, see these Oracle resources:

- Oracle Public Cloud
  http://cloud.oracle.com
- Oracle Machine Learning for SQL Concepts
- Oracle Machine Learning for SQL User’s Guide
- Oracle Database PL/SQL Packages and Types Reference
- Oracle Database Reference

Conventions

The following text conventions are used in this document:

<table>
<thead>
<tr>
<th>Convention</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>boldface</td>
<td>Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.</td>
</tr>
<tr>
<td>italic</td>
<td>Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.</td>
</tr>
<tr>
<td>monospace</td>
<td>Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.</td>
</tr>
</tbody>
</table>
Part I
Introductions

Part I presents an introduction to Oracle Machine Learning for SQL. The first chapter is a general, high-level overview for those who are new to machine learning technology.

Part I contains the following chapters:

• Introduction to Oracle Machine Learning for SQL
• Oracle Machine Learning Basics
1

Introduction to Oracle Machine Learning for SQL

Introduces Oracle Machine Learning for SQL to perform a variety of machine learning tasks.

• About Oracle Machine Learning for SQL
• Oracle Machine Learning for SQL in the Database Kernel
• Oracle Machine Learning for SQL with R Extensibility
• Oracle Machine Learning for SQL in Oracle Exadata
• About Partitioned Models
• Interfaces to Oracle Machine Learning for SQL
• Overview of Database Analytics

1.1 About Oracle Machine Learning for SQL

Understand the uses of Oracle Machine Learning for SQL and learn about different machine learning techniques.

OML4SQL provides a powerful, state-of-the-art machine learning capability within Oracle Database. You can use OML4SQL to build and deploy predictive and descriptive machine learning applications, to add intelligent capabilities to existing applications, and to generate predictive queries for data exploration.

OML4SQL offers a broad set of in-database algorithms for performing a variety of machine learning tasks, such as classification, regression, anomaly detection, feature extraction, clustering, and market basket analysis. The algorithms can work on standard case data, transactional data, star schemas, and unstructured text data. OML4SQL is uniquely suited to the analysis of very large data sets.

Oracle Machine Learning for SQL, along with Oracle Machine Learning for R and Oracle Machine Learning for Python, is a component of Oracle Machine Learning that provides three powerful APIs for in-database machine learning, among other features.

1.2 Oracle Machine Learning for SQL in the Database Kernel

Learn about the implementation of Oracle Machine Learning for SQL (OML4SQL) in Oracle Database kernel and its advantages.

OML4SQL is implemented in the Oracle Database kernel. OML4SQL models are first class database objects. Oracle Machine Learning for SQL processes use built-in features of Oracle Database to maximize scalability and make efficient use of system resources.

OML4SQL within Oracle Database offers many advantages:
• No Data Movement: Some machine learning products require that the data be exported from a corporate database and converted to a specialized format. With OML4SQL, no data movement or conversion is needed. This makes the entire process less complex, time-consuming, and error-prone, and it allows for the analysis of very large data sets.

• Security: Your data is protected by the extensive security mechanisms of Oracle Database. Moreover, specific database privileges are needed for different machine learning activities. Only users with the appropriate privileges can define, manipulate, or apply machine learning model objects.

• Data Preparation and Administration: Most data must be cleansed, filtered, normalized, sampled, and transformed in various ways before it can be mined. Up to 80% of the effort in a machine learning project is often devoted to data preparation. OML4SQL can automatically manage key steps in the data preparation process. Additionally, Oracle Database provides extensive administrative tools for preparing and managing data.

• Ease of Data Refresh: Machine learning processes within Oracle Database have ready access to refreshed data. OML4SQL can easily deliver machine learning results based on current data, thereby maximizing its timeliness and relevance.

• Oracle Database Analytics: Oracle Database offers many features for advanced analytics and business intelligence. You can easily integrate machine learning with other analytical features of the database, such as statistical analysis and OLAP.

• Oracle Technology Stack: You can take advantage of all aspects of Oracle's technology stack to integrate machine learning within a larger framework for business intelligence or scientific inquiry.

• Domain Environment: Machine learning models have to be built, tested, validated, managed, and deployed in their appropriate application domain environments. Machine learning results may need to be post-processed as part of domain specific computations (for example, calculating estimated risks and response probabilities) and then stored into permanent repositories or data warehouses. With OML4SQL, the pre- and post-machine learning activities can all be accomplished within the same environment.

• Application Programming Interfaces: The PL/SQL API and SQL language operators provide direct access to OML4SQL functionality in Oracle Database.

Related Topics
• Overview of Database Analytics
  An overview of native analytics supported by Oracle Database.

1.3 Oracle Machine Learning for SQL in Oracle Exadata

Understand how complex scoring and algorithmic processing is done using Oracle Exadata.

Scoring refers to the process of applying a OML4SQL model to data to generate predictions. The scoring process may require significant system resources. Vast amounts of data may be involved, and algorithmic processing may be very complex.

With OML4SQL, scoring can be off-loaded to intelligent Oracle Exadata Storage Servers where processing is extremely performant.

Oracle Exadata Storage Servers combine Oracle's smart storage software and Oracle's industry-standard hardware to deliver the industry's highest database storage
1.4 About Partitioned Models

Introduces partitioned models to organize and represent multiple models. When you build a model on your data set and apply it to new data, sometimes the prediction may be generic that performs badly when run on new and evolving data. To overcome this, the data set can be divided into different parts based on some characteristics. Oracle Machine Learning for SQL supports partitioned model. Partitioned models allow users to build a type of ensemble model for each data partition. The top-level model has sub models that are automatically produced. The sub models are based on the attribute options. For example, if your data set has an attribute called MARITAL with four values and you have defined it as the partitioned attribute. Then, four sub models are created for this attribute. The sub models are automatically managed and used as a single model. The partitioned model automates a typical machine learning task and can potentially achieve better accuracy through multiple targeted models.

The partitioned model and its sub models reside as first class, persistent database objects. Persistent means that the partitioned model has an on-disk representation.

To create a partitioned model, include the ODMS_PARTITION_COLUMNS setting. To define the number of partitions, include the ODMS_MAX_PARTITIONS setting. When you are making predictions, you must use the top-level model. The correct sub model is selected automatically based on the attribute, the attribute options, and the partition setting. You must include the partition columns as part of the USING clause when scoring. The GROUPING hint is an optional hint that applies to machine learning scoring functions when scoring partitioned models.

The partition names, key values, and the structure of the partitioned model are available in the ALL_MINING_MODEL_PARTITIONS view.

Related Topics

• Oracle Database Reference

See Also:


1.5 Interfaces to Oracle Machine Learning for SQL

Introduces supported interfaces for Oracle Machine Learning for SQL.
The programmatic interfaces to Oracle Machine Learning for SQL are PL/SQL for building and maintaining models and a family of SQL functions for scoring. OML4SQL also supports a graphical user interface, which is implemented as an extension to Oracle SQL Developer.

Oracle Predictive Analytics, a set of simplified OML4SQL routines, is built on top of OML4SQL and is implemented as a PL/SQL package.

### 1.5.1 PL/SQL API

Includes PL/SQL package for Oracle Machine Learning for SQL.

The OML4SQL PL/SQL API is implemented in the `DBMS_DATA_MINING` PL/SQL package, which contains routines for building, testing, and maintaining machine learning models. A batch apply operation is also included in this package.

The following example shows part of a simple PL/SQL script for creating an SVM classification model called `SVMC_SH_Clas_sample`. The model build uses weights, specified in a weights table, and settings, specified in a settings table. The weights influence the weighting of target classes. The settings override default behavior. The model uses Automatic Data Preparation (`prep_auto_on` setting). The model is trained on the data in `mining_data_build_v`.

#### Example 1-1   Creating a Classification Model

```sql
----------------------- CREATE AND POPULATE A CLASS WEIGHTS TABLE ------------------
CREATE TABLE svmc_sh_sample_class_wt (  
  target_value NUMBER,  
  class_weight NUMBER);
INSERT INTO svmc_sh_sample_class_wt VALUES (0,0.35);
INSERT INTO svmc_sh_sample_class_wt VALUES (1,0.65);
COMMIT;
----------------------- CREATE AND POPULATE A SETTINGS TABLE ------------------
CREATE TABLE svmc_sh_sample_settings (  
  setting_name  VARCHAR2(30),  
  setting_value VARCHAR2(4000));
BEGIN  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.algo_name, dbms_data_mining.algo_support_vector_machines);  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.svms_kernel_function, dbms_data_mining.svms_linear);  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.clas_weights_table_name, 'svmc_sh_sample_class_wt');  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.prep_auto, dbms_data_mining.prep_auto_on);
END;
/
------------------------ CREATE THE MODEL -------------------------------------
BEGIN  
  DBMS_DATA_MINING.CREATE_MODEL(  
    model_name          => 'SVMC_SH_Clas_sample',  
    mining_function     => dbms_data_mining.classification,  
    data_table_name     => 'mining_data_build_v',  
    case_id_column_name => 'cust_id',  
    target_column_name  => 'affinity_card',  
    settings_table_name => 'svmc_sh_sample_settings');
END;
/
```

---

Chapter 1

Interfaces to Oracle Machine Learning for SQL

---

Oracle Predictive Analytics, a set of simplified OML4SQL routines, is built on top of OML4SQL and is implemented as a PL/SQL package.

### 1.5.1 PL/SQL API

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  target_value NUMBER,  
  class_weight NUMBER);
INSERT INTO svmc_sh_sample_class_wt VALUES (0,0.35);
INSERT INTO svmc_sh_sample_class_wt VALUES (1,0.65);
COMMIT;
----------------------- CREATE AND POPULATE A SETTINGS TABLE ------------------
CREATE TABLE svmc_sh_sample_settings (  
  setting_name  VARCHAR2(30),  
  setting_value VARCHAR2(4000));
BEGIN  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.algo_name, dbms_data_mining.algo_support_vector_machines);  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.svms_kernel_function, dbms_data_mining.svms_linear);  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.clas_weights_table_name, 'svmc_sh_sample_class_wt');  
  INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
    (dbms_data_mining.prep_auto, dbms_data_mining.prep_auto_on);
END;
/
------------------------ CREATE THE MODEL -------------------------------------
BEGIN  
  DBMS_DATA_MINING.CREATE_MODEL(  
    model_name          => 'SVMC_SH_Clas_sample',  
    mining_function     => dbms_data_mining.classification,  
    data_table_name     => 'mining_data_build_v',  
    case_id_column_name => 'cust_id',  
    target_column_name  => 'affinity_card',  
    settings_table_name => 'svmc_sh_sample_settings');
END;
/
```
1.5.2 SQL Functions

Oracle Machine Learning for SQL supports SQL functions for performing prediction, clustering, and feature extraction.

The functions score data by applying an OML4SQL model object or by running an analytic clause that performs dynamic scoring.

The following example shows a query that applies the classification model svmc_sh_clas_sample to the data in the view mining_data_apply_v. The query returns the average age of customers who are likely to use an affinity card. The results are broken out by gender.

Example 1-2   The PREDICTION Function

```sql
SELECT cust_gender,
       COUNT(*) AS cnt,
       ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION(svmc_sh_clas_sample USING *) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th>C</th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>59</td>
<td>41</td>
</tr>
<tr>
<td>M</td>
<td>409</td>
<td>45</td>
</tr>
</tbody>
</table>

Related Topics

- In-Database Scoring
  Scoring is the application of a machine learning algorithm to new data. In Oracle Machine Learning for SQL scoring engine and the data both reside within the database.

1.5.3 Oracle Data Miner

Oracle Machine Learning for SQL supports a graphical interface called Oracle Data Miner.

Oracle Data Miner is a graphical interface to OML4SQL. Oracle Data Miner is an extension to Oracle SQL Developer, which is available for download free of charge on the Oracle Technology Network.

Oracle Data Miner uses a work flow paradigm to capture, document, and automate the process of building, evaluating, and applying OML4SQL models. Within a work flow, you can specify data transformations, build and evaluate multiple models, and score multiple data sets. You can then save work flows and share them with other users.
For information about Oracle Data Miner, including installation instructions, visit Oracle Technology Network.

**Related Topics**

- Oracle Data Miner

### 1.5.4 Predictive Analytics

Predictive analytics is a technology that captures Oracle Machine Learning for SQL processes in simple routines.

Sometimes called "one-click machine learning," predictive analytics simplifies and automates the machine learning process.

Predictive analytics uses OML4SQL technology, but knowledge of OML4SQL is not needed to use predictive analytics. You can use predictive analytics by specifying an operation to perform on your data. You do not need to create or use OML4SQL models or understand the OML4SQL functions and algorithms summarized in "Oracle Machine Learning for SQL Basics ".

Oracle Machine Learning for SQL predictive analytics operations are described in the following table:
Table 1-1  Oracle Predictive Analytics Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPLAIN</td>
<td>Explains how individual predictors (columns) affect the variation of values in a target column</td>
</tr>
<tr>
<td>PREDICT</td>
<td>For each case (row), predicts the values in a target column</td>
</tr>
<tr>
<td>PROFILE</td>
<td>Creates a set of rules for cases (rows) that imply the same target value</td>
</tr>
</tbody>
</table>

The Oracle predictive analytics operations are implemented in the DBMS_PREDICTIVE_ANALYTICS PL/SQL package. They are also available in Oracle Data Miner.

Related Topics

• Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

1.6 Overview of Database Analytics

An overview of native analytics supported by Oracle Database.

Oracle Database supports an array of native analytical features. Since all these features are part of a common server it is possible to combine them efficiently. The results of analytical processing can be integrated with Oracle Business Intelligence Suite Enterprise Edition and other BI tools and applications.

The possibilities for combining different analytics are virtually limitless. Example 1-3 shows Oracle Machine Learning for SQL and text processing within a single SQL query. The query selects all customers who have a high propensity to attrite (> 80% chance), are valuable customers (customer value rating > 90), and have had a recent conversation with customer services regarding a Checking Plus account. The propensity to attrite information is computed using a OML4SQL model called `tree_model`. The query uses the Oracle Text CONTAINS operator to search call center notes for references to Checking Plus accounts.

Some of the native analytics supported by Oracle Database are described in the following table:

Table 1-2  Oracle Database Native Analytics

<table>
<thead>
<tr>
<th>Analytical Feature</th>
<th>Description</th>
<th>Documented In...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex data transformations</td>
<td>Data transformation is a key aspect of analytical applications and ETL (extract, transform, and load). You can use SQL expressions to implement data transformations, or you can use the DBMS_DATA_MINING_TRANSFORM package. DBMS_DATA_MINING_TRANSFORM is a flexible data transformation package that includes a variety of missing value and outlier treatments, as well as binning and normalization capabilities.</td>
<td>Oracle Database PL/SQL Packages and Types Reference</td>
</tr>
<tr>
<td>Analytical Feature</td>
<td>Description</td>
<td>Documented In...</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Statistical functions</td>
<td>Oracle Database provides a long list of SQL statistical functions with support for: hypothesis testing (such as t-test, F-test), correlation computation (such as pearson correlation), cross-tab statistics, and descriptive statistics (such as median and mode). The DBMS_STAT_FUNCS package adds distribution fitting procedures and a summary procedure that returns descriptive statistics for a column.</td>
<td>Oracle Database SQL Language Reference and Oracle Database PL/SQL Packages and Types Reference</td>
</tr>
<tr>
<td>Window and analytic SQL functions</td>
<td>Oracle Database supports analytic and windowing functions for computing cumulative, moving, and centered aggregates. With windowing aggregate functions, you can calculate moving and cumulative versions of SUM, AVERAGE, COUNT, MAX, MIN, and many more functions.</td>
<td>Oracle Database Data Warehousing Guide</td>
</tr>
<tr>
<td>Linear algebra</td>
<td>The UTL_NLA package exposes a subset of the popular BLAS and LAPACK (Version 3.0) libraries for operations on vectors and matrices represented as VARRAYs. This package includes procedures to solve systems of linear equations, invert matrices, and compute eigenvalues and eigenvectors.</td>
<td>Oracle Database PL/SQL Packages and Types Reference</td>
</tr>
<tr>
<td>OLAP</td>
<td>Oracle OLAP supports multidimensional analysis and can be used to improve performance of multidimensional queries. Oracle OLAP provides functionality previously found only in specialized OLAP databases. Moving beyond drill-downs and roll-ups, Oracle OLAP also supports time-series analysis, modeling, and forecasting.</td>
<td>Oracle OLAP User's Guide</td>
</tr>
<tr>
<td>Spatial analytics</td>
<td>Oracle Spatial provides advanced spatial features to support high-end GIS and LBS solutions. Oracle Spatial's analysis and machine learning capabilities include functions for binning, detection of regional patterns, spatial correlation, colocation machine learning, and spatial clustering. Oracle Spatial also includes support for topology and network data models and analytics. The topology data model of Oracle Spatial allows one to work with data about nodes, edges, and faces in a topology. It includes network analysis functions for computing shortest path, minimum cost spanning tree, nearest-neighbors analysis, traveling salesman problem, among others.</td>
<td>Oracle Spatial Developer's Guide</td>
</tr>
<tr>
<td>Graph</td>
<td>The Property Graph delivers advanced graph query and analytics capabilities in Oracle Database. The in-memory graph server (PGX) provides a machine learning library, which supports graph-empowered machine learning algorithms. The machine learning library supports DeepWalk, supervised GraphWise, and Pg2vec algorithms.</td>
<td>Oracle Database Graph Developer's Guide for Property Graph</td>
</tr>
<tr>
<td>Text Analysis</td>
<td>Oracle Text uses standard SQL to index, search, and analyze text and documents stored in the Oracle database, in files, and on the web. Oracle Text also supports automatic classification and clustering of document collections. Many of the analytical features of Oracle Text are layered on top of Oracle Machine Learning functionality.</td>
<td>Oracle Text Application Developer's Guide</td>
</tr>
</tbody>
</table>
Example 1-3  SQL Query Combining Oracle Machine Learning for SQL and Oracle Text

SELECT A.cust_name, A.contact_info
FROM customers A
WHERE PREDICTION_PROBABILITY(tree_model, 'attrite' USING A.*) > 0.8
AND A.cust_value > 90
AND A.cust_id IN
(SELECT B.cust_id
    FROM call_center B
    WHERE B.call_date BETWEEN '01-Jan-2005' AND '30-Jun-2005'
    AND CONTAINS(B.notes, 'Checking Plus', 1) > 0);
2

Oracle Machine Learning Basics

Understand the basic concepts of Oracle Machine Learning.

• Machine Learning Techniques
• Algorithms
• Data Preparation
• In-Database Scoring

2.1 Machine Learning Techniques

Each machine learning technique specifies a class of problems that can be modeled and solved.

A basic understanding of machine learning techniques and algorithms is required for using Oracle Machine Learning.

Machine learning techniques fall generally into two categories: supervised and unsupervised. Notions of supervised and unsupervised learning are derived from the science of machine learning, which has been called a sub-area of artificial intelligence.

Artificial intelligence refers to the implementation and study of systems that exhibit autonomous intelligence or behavior of their own. Machine learning deals with techniques that enable devices to learn from their own performance and modify their own functioning.

The following illustration provides an idea of how to use Oracle machine learning techniques.
Figure 2-1    How to Use Machine Learning techniques

- **Classification**
- **Regression**
- **Attribute Importance**
- **Association**
- **Feature Extraction**
- **Clustering**
- **Anomaly Detection**
- **Forecast**
- **Time Series**
- **Row Importance**

### Related Topics
- **Algorithms**
  An algorithm is a mathematical procedure for solving a specific kind of problem. For some machine learning techniques, you can choose among several algorithms.

### 2.1.1 Supervised Machine Learning

Overview of supervised machine learning.

Supervised learning is also known as directed learning. The learning process is directed by a previously known dependent attribute or target. Directed Oracle Machine Learning attempts to explain the behavior of the target as a function of a set of independent attributes or predictors.

Supervised learning generally results in predictive models. This is in contrast to unsupervised learning where the goal is pattern detection.

### 2.1.1.1 Supervised Learning: Testing

The process of applying the model to test data helps to determine whether the model, built on one chosen sample, is generalizable to other data. In other words, test data is used for scoring.
In particular, it helps to avoid the phenomenon of overfitting, which can occur when the logic of the model fits the build data too well and therefore has little predictive power.

### 2.1.1.2 Supervised Learning: Scoring

Learn about scoring in supervised learning.

Apply data, also called scoring data, is the actual population to which a model is applied. For example, you might build a model that identifies the characteristics of customers who frequently buy a certain product. To obtain a list of customers who shop at a certain store and are likely to buy a related product, you might apply the model to the customer data for that store. In this case, the store customer data is the scoring data.

Most supervised learning can be applied to a population of interest. The principal supervised machine learning techniques, classification and regression, can both be used for scoring.

Oracle Machine Learning does not support the scoring operation for attribute importance, another supervised technique. Models of this type are built on a population of interest to obtain information about that population; they cannot be applied to separate data. An attribute importance model returns and ranks the attributes that are most important in predicting a target value.

Oracle Machine Learning supports the supervised machine learning techniques described in the following table:

#### Table 2-1 Oracle Machine Learning Supervised Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
<th>Sample Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute Importance</td>
<td>Identifies the attributes that are most important in predicting a target attribute</td>
<td>Given customer response to an affinity card program, find the most significant predictors</td>
</tr>
<tr>
<td>Classification</td>
<td>Assigns items to discrete classes and predicts the class to which an item belongs</td>
<td>Given demographic data about a set of customers, predict customer response to an affinity card program</td>
</tr>
<tr>
<td>Regression</td>
<td>Approximates and forecasts continuous values</td>
<td>Given demographic and purchasing data about a set of customers, predict customers' age</td>
</tr>
</tbody>
</table>

### 2.1.2 Unsupervised Machine Learning

Overview of unsupervised machine learning.

Unsupervised learning is non-directed. There is no distinction between dependent and independent attributes. There is no previously-known result to guide the algorithm in building the model.

Unsupervised learning can be used for descriptive purposes. It can also be used to make predictions.

#### 2.1.2.1 Unsupervised Learning: Scoring

Introduces unsupervised learning, supported scoring operations, and unsupervised machine learning techniques.

Although unsupervised machine learning does not specify a target, most unsupervised learning can be applied to a population of interest. For example, clustering models use
descriptive machine learning techniques, but they can be applied to classify cases according to their cluster assignments. **Anomaly Detection**, although unsupervised, is typically used to predict whether a data point is typical among a set of cases.

Oracle Machine Learning supports the scoring operation for **Clustering** and **Feature Extraction**, both unsupervised machine learning techniques. Oracle Machine Learning does not support the scoring operation for **Association Rules**, another unsupervised function. Association models are built on a population of interest to obtain information about that population; they cannot be applied to separate data. An association model returns rules that explain how items or events are associated with each other. The association rules are returned with statistics that can be used to rank them according to their probability.

OML supports the unsupervised techniques described in the following table:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Sample Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anomaly Detection</td>
<td>Identifies items (outliers) that do not satisfy the characteristics of “normal” data</td>
<td>Given demographic data about a set of customers, identify customer purchasing behavior that is significantly different from the norm</td>
</tr>
<tr>
<td>Association Rules</td>
<td>Finds items that tend to co-occur in the data and specifies the rules that govern their co-occurrence</td>
<td>Find the items that tend to be purchased together and specify their relationship</td>
</tr>
<tr>
<td>Clustering</td>
<td>Finds natural groupings in the data</td>
<td>Segment demographic data into clusters and rank the probability that an individual belongs to a given cluster</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>Creates new attributes (features) using linear combinations of the original attributes</td>
<td>Given demographic data about a set of customers, group the attributes into general characteristics of the customers</td>
</tr>
</tbody>
</table>

**Related Topics**

- **Machine Learning Techniques**
  Part II provides basic conceptual information about machine learning techniques that the Oracle Machine Learning for SQL supports.

- **In-Database Scoring**
  Scoring is the application of a machine learning algorithm to new data. In Oracle Machine Learning for SQL scoring engine and the data both reside within the database.

### 2.2 Algorithms

An algorithm is a mathematical procedure for solving a specific kind of problem. For some machine learning techniques, you can choose among several algorithms.

Each algorithm produces a specific type of model, with different characteristics. Some machine learning problems can best be solved by using more than one algorithm in combination. For example, you might first use a feature extraction model to create an optimized set of predictors, then a classification model to make a prediction on the results.
# 2.2.1 Oracle Machine Learning Supervised Algorithms

Oracle Machine Learning for SQL (OML4SQL) supports the supervised machine learning algorithms described in the following table.

## Table 2-3  Oracle Machine Learning Algorithms for Supervised techniques

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Tree</td>
<td>Classification</td>
<td>Decision trees extract predictive information in the form of human-understandable rules. The rules are if-then-else expressions; they explain the decisions that lead to the prediction.</td>
</tr>
<tr>
<td>Explicit Semantic Analysis</td>
<td>Classification</td>
<td>Explicit Semantic Analysis (ESA) is designed to make predictions for text data. This algorithm can address use cases with hundreds of thousands of classes. In Oracle Database 12c Release 2, ESA was introduced as Feature Extraction algorithm.</td>
</tr>
<tr>
<td>Exponential Smoothing</td>
<td>Time Series</td>
<td>Exponential Smoothing (ESM) provides forecasts for time series data. Forecasts are made for each time period within a user-specified forecast window. ESM provides a total of 14 different time series models, including all the most popular estimates of trend and seasonal effects. Choice of model is controlled by user settings. ESM provides confidence bounds on its forecasts.</td>
</tr>
<tr>
<td>Generalized Linear Model</td>
<td>Classification and Regression</td>
<td>Generalized Linear Model (GLM) implements logistic regression for classification of binary targets and linear regression for continuous targets. GLM classification supports confidence bounds for prediction probabilities. GLM regression supports confidence bounds for predictions.</td>
</tr>
<tr>
<td>Minimum Description Length</td>
<td>Attribute Importance</td>
<td>Minimum Description Length (MDL) is an information theoretic model selection principle. MDL assumes that the simplest, most compact representation of data is the best and most probable explanation of the data.</td>
</tr>
<tr>
<td>Naive Bayes</td>
<td>Classification</td>
<td>Naive Bayes makes predictions using Bayes' Theorem, which derives the probability of a prediction from the underlying evidence, as observed in the data.</td>
</tr>
<tr>
<td>Neural Network</td>
<td>Classification and Regression</td>
<td>Neural Network in machine learning is an artificial algorithm inspired from biological neural network and is used to estimate or approximate Techniques that depend on a large number of generally unknown inputs. Neural Network is designed for classification and regression.</td>
</tr>
<tr>
<td>Random Forest</td>
<td>Classification</td>
<td>Random Forest is a powerful machine learning algorithm. The Random Forest algorithm builds a number of Decision Tree models and predicts using the ensemble of trees.</td>
</tr>
<tr>
<td>Support Vector Machine</td>
<td>Classification and Regression</td>
<td>Distinct versions of the Support Vector Machine (SVM) algorithm use different kernel Techniques to handle different types of data sets. Linear and Gaussian (nonlinear) kernels are supported. SVM classification attempts to separate the target classes with the widest possible margin. SVM regression tries to find a continuous function such that the maximum number of data points lie within an epsilon-wide tube around it.</td>
</tr>
<tr>
<td>XGBoost</td>
<td>Classification and Regression</td>
<td>XGBoost is machine learning algorithm for regression and classification that makes available the XGBoost open source package. Oracle Machine Learning for SQL XGBoost prepares training data, invokes XGBoost, builds and persists a model, and applies the model for prediction.</td>
</tr>
</tbody>
</table>
2.2.2 Oracle Machine Learning Unsupervised Algorithms

Oracle Machine Learning for SQL (OML4SQL) supports the unsupervised machine learning algorithms described in the following table.

Table 2-4  Oracle Machine Learning Algorithms for Unsupervised Techniques

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apriori</td>
<td>Association</td>
<td>Apriori performs market basket analysis by identifying co-occurring items (frequent itemsets) within a set. Apriori finds rules with support greater than a specified minimum support and confidence greater than a specified minimum confidence.</td>
</tr>
<tr>
<td>CUR Matrix Decomposition</td>
<td>Attribute Importance</td>
<td>CUR Matrix Decomposition is an alternative to Support Vector Machine (SVM) and Principal Component Analysis (PCA) and an important tool for exploratory data analysis. This algorithm performs analytical processing and singles out important columns and rows.</td>
</tr>
<tr>
<td>Expectation Maximization</td>
<td>Clustering</td>
<td>Expectation Maximization (EM) is a density estimation algorithm that performs probabilistic clustering. In density estimation, the goal is to construct a density function that captures how a given population is distributed. The density estimate is based on observed data that represents a sample of the population. Oracle Machine Learning supports probabilistic clustering and data frequency estimates and other applications of Expectation Maximization.</td>
</tr>
<tr>
<td>Explicit Semantic Analysis</td>
<td>Feature Extraction</td>
<td>Explicit Semantic Analysis (ESA) uses existing knowledge base as features. An attribute vector represents each feature or a concept. ESA creates a reverse index that maps every attribute to the knowledge base concepts or the concept-attribute association vector value.</td>
</tr>
<tr>
<td>k-Means</td>
<td>Clustering</td>
<td>k-Means is a distance-based clustering algorithm that partitions the data into a predetermined number of clusters. Each cluster has a centroid (center of gravity). Cases (individuals within the population) that are in a cluster are close to the centroid. OML4SQL supports an enhanced version of k-Means. It goes beyond the classical implementation by defining a hierarchical parent-child relationship of clusters.</td>
</tr>
<tr>
<td>Multivariate State Estimation Technique - Sequential Probability Ratio Test</td>
<td>Anomaly Detection</td>
<td>The Multivariate State Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT) algorithm is a nonlinear, nonparametric anomaly detection machine learning technique designed for monitoring critical processes. It detects subtle anomalies while also producing minimal false alarms.</td>
</tr>
<tr>
<td>Non-Negative Matrix Factorization</td>
<td>Feature Extraction</td>
<td>Non-Negative Matrix Factorization (NMF) generates new attributes using linear combinations of the original attributes. The coefficients of the linear combinations are non-negative. During model apply, an NMF model maps the original data into the new set of attributes (features) discovered by the model.</td>
</tr>
<tr>
<td>One Class Support Vector Machine</td>
<td>Anomaly Detection</td>
<td>One-class SVM builds a profile of one class. When the model is applied, it identifies cases that are somehow different from that profile. This allows for the detection of rare cases that are not necessarily related to each other.</td>
</tr>
</tbody>
</table>
Table 2-4  (Cont.) Oracle Machine Learning Algorithms for Unsupervised Techniques

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthogonal Partitioning Clustering</td>
<td>Clustering</td>
<td>Orthogonal Partitioning Clustering (O-Cluster) creates a hierarchical, grid-based clustering model. The algorithm creates clusters that define dense areas in the attribute space. A sensitivity parameter defines the baseline density level.</td>
</tr>
<tr>
<td>Singular Value Decomposition and Principal Component Analysis</td>
<td>Feature Extraction</td>
<td>Singular Value Decomposition (SVD) and Principal Component Analysis (PCA) are orthogonal linear transformations that are optimal at capturing the underlying variance of the data. This property is extremely useful for reducing the dimensionality of high-dimensional data and for supporting meaningful data visualization. In addition to dimensionality reduction, SVD and PCA have a number of other important applications, such as data de-noising (smoothing), data compression, matrix inversion, and solving a system of linear equations.</td>
</tr>
</tbody>
</table>

Related Topics

- **Algorithms**
  Oracle Machine Learning for SQL supports the algorithms listed in Part III. Part III provides basic conceptual information about the algorithms. There is at least one algorithm for each of the machine learning techniques.

2.3 Data Preparation

Preparing the data is a valuable step in solving machine learning problems.

The quality of a model depends to a large extent on the quality of the data used to build (train) it. Much of the time spent in any given machine learning project is devoted to data preparation. The data must be carefully inspected, cleansed, and transformed, and algorithm-appropriate data preparation methods must be applied.

The process of data preparation is further complicated by the fact that any data to which a model is applied, whether for testing or for scoring, must undergo the same transformations as the data used to train the model.

2.3.1 Oracle Machine Learning for SQL Simplifies Data Preparation

Learn about various features of Oracle Machine Learning for SQL for data preparation.

OML4SQL offers several features that significantly simplify the process of data preparation:

- **Embedded data preparation**: The transformations used in training the model are embedded in the model and automatically run whenever the model is applied to new data. If you specify transformations for the model, you only have to specify them once.

- **Automatic Data Preparation (ADP)**: Oracle Machine Learning for SQL supports an automated data preparation mode. When ADP is active, Oracle Machine Learning for SQL automatically performs the data transformations required by the algorithm. The transformation instructions are embedded in the model along with any user-specified transformation instructions.
• Automatic management of missing values and sparse data: Oracle Machine Learning for SQL uses consistent methodology across machine learning algorithms to handle sparsity and missing values.

• Transparency: Oracle Machine Learning for SQL provides model details, which are a view of the attributes that are internal to the model. This insight into the inner details of the model is possible because of reverse transformations, which map the transformed attribute values to a form that can be interpreted by a user. Where possible, attribute values are reversed to the original column values. Reverse transformations are also applied to the target of a supervised model, thus the results of scoring are in the same units as the units of the original target.

• Tools for custom data preparation: Oracle Machine Learning for SQL provides many common transformation routines in the `DBMS_DATA_MINING_TRANSFORM` PL/SQL package. You can use these routines, or develop your own routines in SQL, or both. The SQL language is well suited for implementing transformations in the database. You can use custom transformation instructions along with ADP or instead of ADP.

2.3.2 Case Data

Learn the importance of case data in machine learning.

Most machine learning algorithms act on single-record case data, where the information for each case is stored in a separate row. The data attributes for the cases are stored in the columns.

When the data is organized in transactions, the data for one case (one transaction) is stored in many rows. An example of transactional data is market basket data. With the single exception of Association Rules, which can operate on native transactional data, Oracle Machine Learning for SQL algorithms require single-record case organization.

2.3.2.1 Nested Data

Learn how nested columns are treated in Oracle Machine Learning for SQL.

OML4SQL supports attributes in nested columns. A transactional table can be cast as a nested column and included in a table of single-record case data. Similarly, star schemas can be cast as nested columns. With nested data transformations, Oracle Machine Learning for SQL can effectively mine data originating from multiple sources and configurations.

2.3.3 Text Data

Prepare and transform unstructured text data for machine learning.

Oracle Machine Learning for SQL interprets `CLOB` columns and long `VARCHAR2` columns automatically as unstructured text. Additionally, you can specify columns of short `VARCHAR2`, `CHAR`, `BLOB`, and `BFILE` as unstructured text. Unstructured text includes data items such as web pages, document libraries, Power Point presentations, product specifications, emails, comment fields in reports, and call center notes.

OML4SQL uses Oracle Text utilities and term weighting strategies to transform unstructured text for analysis. In text transformation, text terms are extracted and given numeric values in a text index. The text transformation process is configurable.
for the model and for individual attributes. Once transformed, the text can by mined with a OML4SQL algorithm.

**Related Topics**
- Prepare the Data
- Machine Learning Operations on Unstructured Text

### 2.4 In-Database Scoring

Scoring is the application of a machine learning algorithm to new data. In Oracle Machine Learning for SQL scoring engine and the data both reside within the database.

In traditional machine learning, models are built using specialized software on a remote system and deployed to another system for scoring. This is a cumbersome, error-prone process open to security violations and difficulties in data synchronization.

With OML4SQL, scoring is simple and secure. The scoring engine and the data both reside within the database. Scoring is an extension to the SQL language, so the results of machine learning can easily be incorporated into applications and reporting systems.

#### 2.4.1 Parallel Execution and Ease of Administration

All Oracle Machine Learning for SQL scoring routines support parallel execution for scoring large data sets.

In-database scoring provides performance advantages. All Oracle Machine Learning for SQL scoring routines support parallel execution, which significantly reduces the time required for executing complex queries and scoring large data sets.

In-database machine learning minimizes the IT effort needed to support OML4SQL initiatives. Using standard database techniques, models can easily be refreshed (re-created) on more recent data and redeployed. The deployment is immediate since the scoring query remains the same; only the underlying model is replaced in the database.

**Related Topics**
- Oracle Database VLDB and Partitioning Guide

#### 2.4.2 SQL Functions for Model Apply and Dynamic Scoring

In Oracle Machine Learning for SQL, scoring is performed by SQL language functions. Understand the different ways of scoring using SQL functions.

The functions perform prediction, clustering, and feature extraction. The functions can be invoked in two different ways: By applying a machine learning model object (Example 2-1), or by executing an analytic clause that computes the machine learning analysis dynamically and applies it to the data (Example 2-2). Dynamic scoring, which eliminates the need for a model, can supplement, or even replace, the more traditional methodology described in "The Machine Learning Process".

In Example 2-1, the `PREDICTION_PROBABILITY` function applies the model `svmc_sh_clas_sample`, created in Example 1-1, to score the data in `mining_data_apply_v`. The function returns the ten customers in Italy who are most likely to use an affinity card.

In Example 2-2, the functions `PREDICTION` and `PREDICTION_PROBABILITY` use the analytic syntax (the `OVER ()` clause) to dynamically score the data in `mining_data_apply_v`. The query
returns the customers who currently do not have an affinity card with the probability that they are likely to use.

Example 2-1  Applying a Oracle Machine Learning for SQL Model to Score Data

```sql
SELECT cust_id FROM
(SELECT cust_id,
    rank() over (order by PREDICTION_PROBABILITY(svmc_sh_clas_sample, 1
    USING *) DESC, cust_id) rnk
FROM mining_data_apply_v
WHERE country_name = 'Italy')
WHERE rnk <= 10
ORDER BY rnk;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>101445</td>
</tr>
<tr>
<td>100179</td>
</tr>
<tr>
<td>100662</td>
</tr>
<tr>
<td>100733</td>
</tr>
<tr>
<td>100554</td>
</tr>
<tr>
<td>100081</td>
</tr>
<tr>
<td>100344</td>
</tr>
<tr>
<td>100324</td>
</tr>
<tr>
<td>100185</td>
</tr>
<tr>
<td>101345</td>
</tr>
</tbody>
</table>

Example 2-2  Executing an Analytic Function to Score Data

```sql
SELECT cust_id, pred_prob FROM
(SELECT cust_id, affinity_card,
    PREDICTION(FOR TO_CHAR(affinity_card) USING *) OVER () pred_card,
    PREDICTION_PROBABILITY(FOR TO_CHAR(affinity_card), 1 USING *) OVER ()
    pred_prob
FROM mining_data_build_v)
WHERE affinity_card = 0
AND pred_card = 1
ORDER BY pred_prob DESC;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PRED_PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>102434</td>
<td>.96</td>
</tr>
<tr>
<td>102365</td>
<td>.96</td>
</tr>
<tr>
<td>102330</td>
<td>.96</td>
</tr>
<tr>
<td>101733</td>
<td>.95</td>
</tr>
<tr>
<td>102615</td>
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</tr>
<tr>
<td>102686</td>
<td>.94</td>
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<tr>
<td>102749</td>
<td>.93</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>101656</td>
<td>.51</td>
</tr>
</tbody>
</table>

Related Topics

- *Oracle Database SQL Language Reference*
- *Oracle Machine Learning for SQL User’s Guide*
Part II

Machine Learning Techniques

Part II provides basic conceptual information about machine learning techniques that the Oracle Machine Learning for SQL supports.

Machine learning techniques represent a class of problems that can be solved using OML4SQL algorithms.

Part II contains these chapters:

• Regression
• Classification
• Anomaly Detection
• Ranking
• Clustering
• Association
• Feature Selection
• Feature Extraction
• Row Importance
• Time Series

Note:
The term machine learning technique has no relationship to a SQL language function.

Related Topics

• Algorithms
  Oracle Machine Learning for SQL supports the algorithms listed in Part III. Part III provides basic conceptual information about the algorithms. There is at least one algorithm for each of the machine learning techniques.
  
• Oracle Database SQL Language Reference
3

Regression

Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.

- About Regression
- Testing a Regression Model
- Regression Algorithms
  - Generalized Linear Model
  - Neural Network
  - Support Vector Machine
  - XGBoost

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

3.1 About Regression

Regression is an Oracle Machine Learning for SQL function that predicts numeric values along a continuum.

Profit, sales, mortgage rates, house values, square footage, temperature, or distance can be predicted using Regression techniques. For example, a regression model can be used to predict the value of a house based on location, number of rooms, lot size, and other factors.

A regression task begins with a data set in which the target values are known. For example, a regression model that predicts house values can be developed based on observed data for many houses over a period of time. In addition to the value, the data can track the age of the house, square footage, number of rooms, taxes, school district, proximity to shopping centers, and so on. House value can be the target, the other attributes are the predictors, and the data for each house constitutes a case.

In the model build (training) process, a regression algorithm estimates the value of the target as a function of the predictors for each case in the build data. These relationships between predictors and target are summarized in a model, which can then be applied to a different data set in which the target values are unknown.

Regression models are tested by computing various statistics that measure the difference between the predicted values and the expected values. The historical data for a regression project is typically divided into two data sets: one for building the model, the other for testing the model.

Regression modeling has many applications in trend analysis, business planning, marketing, financial forecasting, time series prediction, biomedical and drug response modeling, and environmental modeling.
3.1.1 How Does Regression Work?

Understand regression as a mathematical expression.

You do not need to understand the mathematics used in regression analysis to develop and use quality regression models for Oracle Machine Learning for SQL. However, it is helpful to understand a few basic concepts.

Regression analysis seeks to determine the values of parameters for a function that cause the function to best fit a set of data observations that you provide. The following equation expresses these relationships in symbols. It shows that regression is the process of estimating the value of a continuous target \( y \) as a function \( F \) of one or more predictors \( (x_1, x_2, ..., x_n) \), a set of parameters \( (\theta_1, \theta_2, ..., \theta_n) \), and a measure of error \( e \).

\[
y = F(x, \theta) + e
\]

The predictors can be understood as independent variables and the target as a dependent variable. The error, also called the residual, is the difference between the expected and predicted value of the dependent variable. The regression parameters are also known as regression coefficients.

The process of training a regression model involves finding the parameter values that minimize a measure of the error, for example, the sum of squared errors.

There are different families of regression functions and different ways of measuring the error.

3.1.1.1 Linear Regression

A linear regression technique can be used if the relationship between the predictors and the target can be approximated with a straight line.

Regression with a single predictor is the easiest to visualize. Simple linear regression with a single predictor is shown in the following figure:

**Figure 3-1  Linear Regression With a Single Predictor**
Linear regression with a single predictor can be expressed with the following equation.

\[ y = \theta_2 x + \theta_1 + e \]

The regression parameters in simple linear regression are:

- The **slope** of the line \( \theta_2 \) — the angle between a data point and the regression line
- The **y intercept** \( \theta_1 \) — the point where \( x \) crosses the \( y \) axis \( (x = 0) \)

### 3.1.1.2 Multivariate Linear Regression

The term **multivariate linear regression** refers to linear regression with two or more predictors \((x_1, x_2, ..., x_n)\). When multiple predictors are used, the regression line cannot be visualized in two-dimensional space. However, the line can be computed by expanding the equation for single-predictor linear regression to include the parameters for each of the predictors.

\[ y = \theta_1 + \theta_2 x_1 + \theta_3 x_2 + \ldots + \theta_n x_{n-1} + e \]

### 3.1.1.3 Regression Coefficients

In multivariate linear regression, the regression parameters are often referred to as coefficients. When you build a multivariate linear regression model, the algorithm computes a coefficient for each of the predictors used by the model. The coefficient is a measure of the impact of the predictor \( x \) on the target \( y \). Numerous statistics are available for analyzing the regression coefficients to evaluate how well the regression line fits the data.

### 3.1.1.4 Nonlinear Regression

Often the relationship between \( x \) and \( y \) cannot be approximated with a straight line. In this case, a nonlinear regression technique can be used. Alternatively, the data can be preprocessed to make the relationship linear.

Nonlinear regression models define \( y \) as a function of \( x \) using an equation that is more complicated than the linear regression equation. In the following figure, \( x \) and \( y \) have a nonlinear relationship.

**Figure 3-2  Nonlinear Regression With a Single Predictor**
3.1.1.5 Multivariate Nonlinear Regression

The term **multivariate nonlinear regression** refers to nonlinear regression with two or more predictors \((x_1, x_2, \ldots, x_n)\). When multiple predictors are used, the nonlinear relationship cannot be visualized in two-dimensional space.

3.1.1.6 Confidence Bounds

A regression model predicts a numeric target value for each case in the scoring data. In addition to the predictions, some regression algorithms can identify confidence bounds, which are the upper and lower boundaries of an interval in which the predicted value is likely to lie.

When a model is built to make predictions with a given confidence, the confidence interval is produced along with the predictions. For example, a model predicts the value of a house to be $500,000 with a 95% confidence that the value is between $475,000 and $525,000.

### 3.2 Testing a Regression Model

A regression model is tested by applying it to test data with known target values and comparing the predicted values with the known values.

The test data must be compatible with the data used to build the model and must be prepared in the same way that the build data was prepared. Typically the build data and test data come from the same historical data set. A percentage of the records is used to build the model; the remaining records are used to test the model.

Test metrics are used to assess how accurately the model predicts these known values. If the model performs well and meets the business requirements, it can then be applied to new data to predict the future.

### 3.2.1 Regression Statistics

The Root Mean Squared Error and the Mean Absolute Error are commonly used statistics for evaluating the overall quality of a regression model. Different statistics may also be available depending on the regression methods used by the algorithm.

#### 3.2.1.1 Root Mean Squared Error

The Root Mean Squared Error (RMSE) is the square root of the average squared distance of a data point from the fitted line.

This SQL expression calculates the RMSE.

\[
\text{RMSE} = \sqrt{\frac{1}{n} \sum_{j=1}^{n} (\text{predicted}_j - \text{actual}_j)^2}
\]

This formula shows the RMSE in mathematical symbols. The large sigma character represents summation; \(j\) represents the current predictor, and \(n\) represents the number of predictors.
3.2.1.2 Mean Absolute Error

The Mean Absolute Error (MAE) is the average of the absolute value of the residuals (error). The MAE is very similar to the RMSE but is less sensitive to large errors.

This SQL expression calculates the MAE.

\[
\text{MAE} = \frac{1}{n} \sum_{j=1}^{n} |y_j - \hat{y}_j|
\]

This formula shows the MAE in mathematical symbols. The large sigma character represents summation; \( j \) represents the current predictor, and \( n \) represents the number of predictors.

3.3 Regression Algorithms

Oracle Machine Learning for SQL supports these algorithms for regression: Generalized Linear Model (GLM), Neural Network (NN), Support Vector Machine (SVM), and XGBoost.

GLM and SVM algorithms are particularly suited for analysing data sets that have very high dimensionality (many attributes), including transactional and unstructured data.

- **Generalized Linear Model**

  GLM is a popular statistical technique for linear modeling. Oracle Machine Learning for SQL implements GLM for regression and for binary classification. GLM provides extensive coefficient statistics and model statistics, as well as row diagnostics. GLM also supports confidence bounds.

- **Neural Network**

  Neural Network is a powerful algorithm that can learn arbitrary nonlinear regression functions.

- **Support Vector Machine**

  SVM is a powerful, state-of-the-art algorithm for linear and nonlinear regression. OML4SQL implements SVM for regression, classification, and anomaly detection. SVM regression supports two kernels: the Gaussian kernel for nonlinear regression and the linear kernel for linear regression.
Note:
OML4SQL uses the linear kernel SVM as the default regression algorithm.

- **XGBoost**
  XGBoost is machine learning algorithm for regression and classification that makes available the XGBoost open source package. Oracle Machine Learning for SQL XGBoost prepares training data, invokes XGBoost, builds and persists a model, and applies the model for prediction.

**Related Topics**

- **Generalized Linear Model**
  Learn how to use Generalized Linear Model (GLM) statistical technique for linear modeling.

- **Neural Network**
  Learn about the Neural Network algorithms for regression and classification machine learning techniques.

- **Support Vector Machine**
  Learn how to use Support Vector Machine (SVM), a powerful algorithm based on statistical learning theory.

- **XGBoost**
  XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.
Learn how to predict a categorical target through classification - the supervised machine learning technique.

- About Classification
- Testing a Classification Model
- Biasing a Classification Model
- Classification Algorithms
  - Decision Tree
  - Explicit Semantic Analysis
  - Generalized Linear Model
  - Multivariate State Estimation Technique - Sequential Probability Ratio Test
  - Naive Bayes
  - Random Forest
  - Support Vector Machine
  - XGBoost

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

4.1 About Classification

Classification is a machine learning technique that assigns items in a collection to target categories or classes.

The goal of classification is to accurately predict the target class for each case in the data. For example, a classification model can be used to identify loan applicants as low, medium, or high credit risks.

A classification task begins with a data set in which the class assignments are known. For example, a classification model that predicts credit risk can be developed based on observed data for many loan applicants over a period of time. In addition to the historical credit rating, the data might track employment history, home ownership or rental, years of residence, number and type of investments, and so on. Credit rating is the target, the other attributes are the predictors, and the data for each customer constitutes a case.

Classification are discrete and do not imply order. Continuous, floating-point values indicate a numerical, rather than a categorical, target. A predictive model with a numerical target uses a regression algorithm, not a classification algorithm.
The simplest type of classification problem is binary classification. In binary classification, the target attribute has only two possible values: for example, high credit rating or low credit rating. Multiclass targets have more than two values: for example, low, medium, high, or unknown credit rating.

In the model build (training) process, a classification algorithm finds relationships between the values of the predictors and the values of the target. Different classification algorithms use different techniques for finding relationships. These relationships are summarized in a model, which can then be applied to a different data set in which the class assignments are unknown.

Classification models are tested by comparing the predicted values to known target values in a set of test data. The historical data for a classification project is typically divided into two data sets: one for building the model; the other for testing the model.

Applying a classification model results in class assignments and probabilities for each case. For example, a model that classifies customers as low, medium, or high value also predicts the probability of each classification for each customer.

Classification has many applications in customer segmentation, business modeling, marketing, credit analysis, and biomedical and drug response modeling.

4.2 Testing a Classification Model

A classification model is tested by applying it to test data with known target values and comparing the predicted values with the known values.

The test data must be compatible with the data used to build the model and must be prepared in the same way that the build data was prepared. Typically the build data and test data come from the same historical data set. A percentage of the records is used to build the model; the remaining records are used to test the model.

Test metrics are used to assess how accurately the model predicts the known values. If the model performs well and meets the business requirements, it can then be applied to new data to predict the future.

4.2.1 Confusion Matrix

A confusion matrix displays the number of correct and incorrect predictions made by the model compared with the actual classifications in the test data. The matrix is $n$-by-$n$, where $n$ is the number of classes.

The following figure shows a confusion matrix for a binary classification model. The rows present the number of actual classifications in the test data. The columns present the number of predicted classifications made by the model.
In this example, the model correctly predicted the positive class (also called true positive (TP)) for `affinity_card` 516 times and incorrectly predicted (also called false negative (FN)) it 25 times. The model correctly predicted the negative class (also called true negative (TN)) for `affinity_card` 725 times and incorrectly predicted (also called false positive (FP)) it 10 times. The following can be computed from this confusion matrix:

- The model made 1241 correct predictions, that is, TP + TN, (516 + 725).
- The model made 35 incorrect predictions, that is, FN + FP, (25 + 10).
- There are 1276 total scored cases, (516 + 25 + 10 + 725).
- The error rate is 35/1276 = 0.0274. (FN+FP/Total)
- The overall accuracy rate is 1241/1276 = 0.9725 (TP+TN)/Total).

**Precision and Recall**

Consider the same example, the accuracy rate shows 0.97. However, there are cases where the model has incorrectly predicted. **Precision** (positive predicted value) is the ability of a classification model to return only relevant cases. Precision can be calculated as TP/TP+FP. **Recall** (sensitivity or true positive rate) is the ability of a classification model to return relevant cases. Recall can be calculated as TP/TP+FN. The precision in this example is 516/526 = 0.98. The recall in this example is 516/541 = 0.95. Ideally, the model is good when both precision and recall are 1. This can happen when the numerator and the denominator are equal. That means, for precision, FP is zero and for recall, FN is zero.

### 4.2.2 Lift

Lift measures the degree to which the predictions of a classification model are better than randomly-generated predictions.

Lift applies to binary classification only, and it requires the designation of a positive class. If the model itself does not have a binary target, you can compute lift by designating one class as positive and combining all the other classes together as one negative class.

Numerous statistics can be calculated to support the notion of lift. Basically, lift can be understood as a ratio of two percentages: the percentage of correct positive classifications made by the model to the percentage of actual positive classifications in the test data. For
example, if 40% of the customers in a marketing survey have responded favorably (the positive classification) to a promotional campaign in the past and the model accurately predicts 75% of them, the lift is obtained by dividing .75 by .40. The resulting lift is 1.875.

Lift is computed against quantiles that each contain the same number of cases. The data is divided into quantiles after it is scored. It is ranked by probability of the positive class from highest to lowest, so that the highest concentration of positive predictions is in the top quantiles. A typical number of quantiles is 10.

Lift is commonly used to measure the performance of response models in marketing applications. The purpose of a response model is to identify segments of the population with potentially high concentrations of positive responders to a marketing campaign. Lift reveals how much of the population must be solicited to obtain the highest percentage of potential responders.

Related Topics

• Positive and Negative Classes
  Discusses the importance of positive and negative classes in a confusion matrix.

4.2.2.1 Lift Statistics

Learn the different Lift statistics that Oracle Machine Learning for SQL can compute.

Oracle Machine Learning for SQL computes the following lift statistics:

• **Probability threshold** for a quantile $n$ is the minimum probability for the positive target to be included in this quantile or any preceding quantiles (quantiles $n-1$, $n-2$, ..., 1). If a cost matrix is used, a cost threshold is reported instead. The cost threshold is the maximum cost for the positive target to be included in this quantile or any of the preceding quantiles.

• **Cumulative gain** is the ratio of the cumulative number of positive targets to the total number of positive targets.

• **Target density** of a quantile is the number of true positive instances in that quantile divided by the total number of instances in the quantile.

• **Cumulative target density** for quantile $n$ is the target density computed over the first $n$ quantiles.

• **Quantile lift** is the ratio of the target density for the quantile to the target density over all the test data.

• **Cumulative percentage of records** for a quantile is the percentage of all cases represented by the first $n$ quantiles, starting at the end that is most confidently positive, up to and including the given quantile.

• **Cumulative number of targets** for quantile $n$ is the number of true positive instances in the first $n$ quantiles.

• **Cumulative number of nontargets** is the number of actually negative instances in the first $n$ quantiles.

• **Cumulative lift** for a quantile is the ratio of the cumulative target density to the target density over all the test data.

Related Topics

• Costs
4.2.3 Receiver Operating Characteristic (ROC)

ROC is a metric for comparing predicted and actual target values in a classification model. ROC, like Lift, applies to binary classification and requires the designation of a positive class. You can use ROC to gain insight into the decision-making ability of the model. How likely is the model to accurately predict the negative or the positive class?

ROC measures the impact of changes in the probability threshold. The probability threshold is the decision point used by the model for classification. The default probability threshold for binary classification is 0.5. When the probability of a prediction is 50% or more, the model predicts that class. When the probability is less than 50%, the other class is predicted. (In multiclass classification, the predicted class is the one predicted with the highest probability.)

Related Topics
- Positive and Negative Classes
  Discusses the importance of positive and negative classes in a confusion matrix.

4.2.3.1 The ROC Curve

ROC can be plotted as a curve on an X-Y axis. The false positive rate is placed on the X axis. The true positive rate is placed on the Y axis.

The top left corner is the optimal location on an ROC graph, indicating a high true positive rate and a low false positive rate.

4.2.3.2 Area Under the Curve

The area under the ROC curve (AUC) measures the discriminating ability of a binary classification model. The larger the AUC, the higher the likelihood that an actual positive case is assigned, and a higher probability of being positive than an actual negative case. The AUC measure is especially useful for data sets with unbalanced target distribution (one target class dominates the other).

4.2.3.3 ROC and Model Bias

The ROC curve for a model represents all the possible combinations of values in its confusion matrix.

Changes in the probability threshold affect the predictions made by the model. For instance, if the threshold for predicting the positive class is changed from 0.5 to 0.6, then fewer positive predictions are made. This affects the distribution of values in the confusion matrix: the number of true and false positives and true and false negatives differ.

You can use ROC to find the probability thresholds that yield the highest overall accuracy or the highest per-class accuracy. For example, if it is important to you to accurately predict the positive class, but you don’t care about prediction errors for the negative class, then you can lower the threshold for the positive class. This can bias the model in favor of the positive class.

A cost matrix is a convenient mechanism for changing the probability thresholds for model scoring.
4.2.3.4 ROC Statistics

Oracle Machine Learning for SQL computes the following ROC statistics:

- **Probability threshold**: The minimum predicted positive class probability resulting in a positive class prediction. Different threshold values result in different hit rates and different false alarm rates.
- **True negatives**: Negative cases in the test data with predicted probabilities strictly less than the probability threshold (correctly predicted).
- **True positives**: Positive cases in the test data with predicted probabilities greater than or equal to the probability threshold (correctly predicted).
- **False negatives**: Positive cases in the test data with predicted probabilities strictly less than the probability threshold (incorrectly predicted).
- **False positives**: Negative cases in the test data with predicted probabilities greater than or equal to the probability threshold (incorrectly predicted).
- **True positive fraction**: Hit rate. \( \frac{\text{true positives}}{\text{true positives} + \text{false negatives}} \)
- **False positive fraction**: False alarm rate. \( \frac{\text{false positives}}{\text{false positives} + \text{true negatives}} \)

4.3 Biasing a Classification Model

Costs, prior probabilities, and class weights are methods for biasing classification models.

4.3.1 Costs

A cost matrix is a mechanism for influencing the decision making of a model. A cost matrix can cause the model to minimize costly misclassifications. It can also cause the model to maximize beneficial accurate classifications.

For example, if a model classifies a customer with poor credit as low risk, this error is costly. A cost matrix can bias the model to avoid this type of error. The cost matrix can also be used to bias the model in favor of the correct classification of customers who have the worst credit history.

ROC is a useful metric for evaluating how a model behaves with different probability thresholds. You can use ROC to help you find optimal costs for a given classifier given different usage scenarios. You can use this information to create cost matrices to influence the deployment of the model.

4.3.1.1 Costs Versus Accuracy

Compares Cost matrix and Confusion matrix for costs and accuracy to evaluate model quality.

Like a confusion matrix, a cost matrix is an \( n \)-by-\( n \) matrix, where \( n \) is the number of classes. Both confusion matrices and cost matrices include each possible combination of actual and predicted results based on a given set of test data.
A confusion matrix is used to measure accuracy, the ratio of correct predictions to the total number of predictions. A cost matrix is used to specify the relative importance of accuracy for different predictions. In most business applications, it is important to consider costs in addition to accuracy when evaluating model quality.

Related Topics
- Confusion Matrix

4.3.1.2 Positive and Negative Classes

Discusses the importance of positive and negative classes in a confusion matrix.

The positive class is the class that you care the most about. Designation of a positive class is required for computing Lift and ROC.

In the confusion matrix, in the following figure, the value 1 is designated as the positive class. This means that the creator of the model has determined that it is more important to accurately predict customers who increase spending with an affinity card (affinity_card = 1) than to accurately predict non-responders (affinity_card = 0). If you give affinity cards to some customers who are not likely to use them, there is little loss to the company since the cost of the cards is low. However, if you overlook the customers who are likely to respond, you miss the opportunity to increase your revenue.

**Figure 4-2  Positive and Negative Predictions**

<table>
<thead>
<tr>
<th>ACTUAL CLASS</th>
<th>PREDICTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>affinity_card = 1</td>
<td>affinity_card = 1</td>
</tr>
<tr>
<td></td>
<td>affinity_card = 0</td>
</tr>
</tbody>
</table>

The true and false positive rates in this confusion matrix are:
- False positive rate — 10/(10 + 725) = .01
- True positive rate — 516/(516 + 25) = .95

Related Topics
- **Lift**
  Lift measures the degree to which the predictions of a classification model are better than randomly-generated predictions.
- **Receiver Operating Characteristic (ROC)**
  ROC is a metric for comparing predicted and actual target values in a classification model.
4.3.1.3 Assigning Costs and Benefits

In a cost matrix, positive numbers (costs) can be used to influence negative outcomes. Since negative costs are interpreted as benefits, negative numbers (benefits) can be used to influence positive outcomes.

Suppose you have calculated that it costs your business $1500 when you do not give an affinity card to a customer who can increase spending. Using the model with the confusion matrix shown in Figure 4-2, each false negative (misclassification of a responder) costs $1500. Misclassifying a non-responder is less expensive to your business. You estimate that each false positive (misclassification of a non-responder) only costs $300.

You want to keep these costs in mind when you design a promotion campaign. You estimate that it costs $10 to include a customer in the promotion. For this reason, you associate a benefit of $10 with each true negative prediction, because you can eliminate those customers from your promotion. Each customer that you eliminate represents a savings of $10. In your cost matrix, you specify this benefit as -10, a negative cost.

The following figure shows how you would represent these costs and benefits in a cost matrix:

![Figure 4-3 Cost Matrix Representing Costs and Benefits](image)

With Oracle Machine Learning for SQL you can specify costs to influence the scoring of any classification model. Decision Tree models can also use a cost matrix to influence the model build.

4.3.2 Priors and Class Weights

Learn about Priors and Class Weights in a classification model to produce a useful result.

With Bayesian models, you can specify Prior probabilities to offset differences in distribution between the build data and the real population (scoring data). With other
forms of classification, you are able to specify **Class Weights**, which have the same biasing effect as priors.

In many problems, one target value dominates in frequency. For example, the positive responses for a telephone marketing campaign is 2% or less, and the occurrence of fraud in credit card transactions is less than 1%. A classification model built on historic data of this type cannot observe enough of the rare class to be able to distinguish the characteristics of the two classes; the result can be a model that when applied to new data predicts the frequent class for every case. While such a model can be highly accurate, it is not be very useful. This illustrates that it is not a good idea to rely solely on accuracy when judging the quality of a classification model.

To correct for unrealistic distributions in the training data, you can specify priors for the model build process. Other approaches to compensating for data distribution issues include stratified sampling and anomaly detection.

**Related Topics**
- **Anomaly Detection**
  Learn how to detect rare cases in the data through anomaly detection - an unsupervised function.

### 4.4 Classification Algorithms

Learn the different classification algorithms used in Oracle Machine Learning for SQL.

Oracle Machine Learning for SQL provides the following algorithms for classification:

- **Decision Tree**
  Decision trees automatically generate rules, which are conditional statements that reveal the logic used to build the tree.

- **Explicit Semantic Analysis**
  Explicit Semantic Analysis (ESA) is designed to make predictions for text data. This algorithm can address use cases with hundreds of thousands of classes.

- **Generalized Linear Model**
  Generalized Linear Model (GLM) is a popular statistical technique for linear modeling. OML4SQL implements GLM for binary classification and for regression. GLM provides extensive coefficient statistics and model statistics, as well as row diagnostics. GLM also supports confidence bounds.

- **Naive Bayes**
  Naive Bayes uses Bayes’ Theorem, a formula that calculates a probability by counting the frequency of values and combinations of values in the historical data.

- **Random Forest**
  Random Forest is a powerful and popular machine learning algorithm that brings significant performance and scalability benefits.

- **Support Vector Machine**
  Support Vector Machine (SVM) is a powerful, state-of-the-art algorithm based on linear and nonlinear regression. OML4SQL implements SVM for binary and multiclass classification.

- **XGBoost**
XGBoost is machine learning algorithm for regression and classification that makes available the XGBoost open source package. Oracle Machine Learning for SQL XGBoost prepares training data, invokes XGBoost, builds and persists a model, and applies the model for prediction.

**Note:**
OML4SQL uses Naive Bayes as the default classification algorithm.

**Related Topics**

- **Decision Tree**
  Oracle Machine Learning for SQL supports Decision Tree as one of the classification algorithms. This chapter provides an overview of the Decision Tree algorithm.

- **Explicit Semantic Analysis**
  Learn how to use Explicit Semantic Analysis (ESA) as an unsupervised algorithm for feature extraction function and as a supervised algorithm for classification.

- **Generalized Linear Model**
  Learn how to use Generalized Linear Model (GLM) statistical technique for linear modeling.

- **Multivariate State Estimation Technique - Sequential Probability Ratio Test**
  The Multivariate State Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT) algorithm monitors critical processes and detects subtle anomalies.

- **Naive Bayes**
  Learn how to use the Naive Bayes classification algorithm.

- **Random Forest**
  Learn how to use Random Forest as a classification algorithm.

- **Support Vector Machine**
  Learn how to use Support Vector Machine (SVM), a powerful algorithm based on statistical learning theory.

- **XGBoost**
  XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.
Clustering

Learn how to discover natural groupings in the data through clustering - the unsupervised machine learning technique.

- About Clustering
- Evaluating a Clustering Model
- Clustering Algorithms
  - Expectation Maximization
  - k-Means
  - O-Cluster

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

5.1 About Clustering

Clustering analysis finds clusters of data objects that are similar to one another.

The members of a cluster are more like each other than they are like members of other clusters. Different clusters can have members in common. The goal of clustering analysis is to find high-quality clusters such that the inter-cluster similarity is low and the intra-cluster similarity is high.

Clustering, like classification, is used to segment the data. Unlike classification, clustering models segment data into groups that were not previously defined. Classification models segment data by assigning it to previously-defined classes, which are specified in a target. Clustering models do not use a target.

Clustering is useful for exploring data. You can use clustering algorithms to find natural groupings when there are many cases and no obvious groupings.

Clustering can serve as a useful data-preprocessing step to identify homogeneous groups on which you can build supervised models.

You can also use clustering for anomaly detection. Once you segment the data into clusters, you find that some cases do not fit well into any clusters. These cases are anomalies or outliers.

5.1.1 How are Clusters Computed?

There are several different approaches to the computation of clusters. Oracle Machine Learning for SQL supports the methods listed here.
• **Density-based**: This type of clustering finds the underlying distribution of the data and estimates how areas of high density in the data correspond to peaks in the distribution. High-density areas are interpreted as clusters. Density-based cluster estimation is probabilistic.

• **Distance-based**: This type of clustering uses a distance metric to determine similarity between data objects. The distance metric measures the distance between actual cases in the cluster and the prototypical case for the cluster. The prototypical case is known as the **centroid**.

• **Grid-based**: This type of clustering divides the input space into hyper-rectangular cells and identifies adjacent high-density cells to form clusters.

### 5.1.2 Scoring New Data

Although clustering is an unsupervised machine learning technique, Oracle Machine Learning for SQL supports the scoring operation for clustering. New data is scored probabilistically.

### 5.1.3 Hierarchical Clustering

Oracle Machine Learning for SQL supports clustering algorithms that perform hierarchical clustering.

The leaf clusters are the final clusters generated by the algorithm. Clusters higher up in the hierarchy are intermediate clusters.

#### 5.1.3.1 Rules

**Rules** describe the data in each cluster.

A rule is a conditional statement that captures the logic used to split a parent cluster into child clusters. A rule describes the conditions for a case to be assigned with some probability to a cluster.

#### 5.1.3.2 Support and Confidence

**Support** and **confidence** are metrics that describe the relationships between clustering rules and cases.

Support is the percentage of cases for which the rule holds. Confidence is the probability that a case described by this rule is actually assigned to the cluster.

### 5.1.4 Clustering Algorithms

Learn different clustering algorithms used in Oracle Machine Learning for SQL.

Oracle Machine Learning for SQL supports these clustering algorithms:

- **Expectation Maximization**
  
  Expectation Maximization is a probabilistic, density-estimation clustering algorithm.

- **k-Means**
  
  $k$-Means is a distance-based clustering algorithm. OML4SQL supports an enhanced version of $k$-Means.
• Orthogonal Partitioning Clustering (O-Cluster)

O-Cluster is a proprietary, grid-based clustering algorithm.

See Also:
Campos, M.M., Milenova, B.L., “O-Cluster: Scalable Clustering of Large High Dimensional Data Sets”, Oracle Data Mining Technologies, 10 Van De Graaff Drive, Burlington, MA 01803.

The main characteristics of the two algorithms are compared in the following table.

### Table 5-1  Clustering Algorithms Compared

<table>
<thead>
<tr>
<th>Feature</th>
<th>k-Means</th>
<th>O-Cluster</th>
<th>Expectation Maximization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clustering methodology</td>
<td>Distance-based</td>
<td>Grid-based</td>
<td>Distribution-based</td>
</tr>
<tr>
<td>Number of cases</td>
<td>Handles data sets of any size</td>
<td>More appropriate for data sets that have more than 500 cases. Handles large tables through active sampling</td>
<td>Handles data sets of any size</td>
</tr>
<tr>
<td>Number of attributes</td>
<td>More appropriate for data sets with a low number of attributes</td>
<td>More appropriate for data sets with a high number of attributes</td>
<td>Appropriate for data sets with many or few attributes</td>
</tr>
<tr>
<td>Number of clusters</td>
<td>User-specified</td>
<td>Automatically determined</td>
<td>Automatically determined</td>
</tr>
<tr>
<td>Hierarchical clustering</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Probabilistic cluster assignment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note:
OML4SQL uses k-Means as the default clustering algorithm.

Related Topics
• Oracle Machine Learning for SQL
• Expectation Maximization
  Learn how to use expectation maximization clustering algorithm.
• k-Means
  Oracle Machine Learning for SQL supports enhanced k-Means clustering algorithm. Learn how to use the algorithm.
• O-Cluster
  Learn how to use orthogonal partitioning clustering (O-Cluster), an Oracle-proprietary clustering algorithm.
5.2 Evaluating a Clustering Model

Since known classes are not used in clustering, the interpretation of clusters can present difficulties. How do you know if the clusters can reliably be used for business decision making?

Oracle Machine Learning for SQL clustering models support a high degree of model transparency. You can evaluate the model by examining information generated by the clustering algorithm: for example, the centroid of a distance-based cluster. Moreover, because the clustering process is hierarchical, you can evaluate the rules and other information related to each cluster’s position in the hierarchy.
6

Anomaly Detection

Learn how to detect rare cases in the data through anomaly detection - an unsupervised function.

• About Anomaly Detection
• Anomaly Detection Algorithms
  – Multivariate State Estimation Technique - Sequential Probability Ratio Test
  – One-Class SVM

Related Topics
• Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

See Also:
• Campos, M.M., Milenova, B.L., Yarmus, J.S., "Creation and Deployment of Data Mining-Based Intrusion Detection Systems in Oracle Database 10g"

6.1 About Anomaly Detection

The goal of anomaly detection is to identify items, events, or observations that are unusual within data that is seemingly 'normal'. This data may consist of traditional enterprise data or Internet of Things (IoT) sensor data.

Anomaly detection is an important tool for detecting, for example, fraud, network intrusions, enterprise computing service interruptions, sensor time series prognostics, and other rare events that can have great significance but are hard to find. Anomaly detection can be used to solve problems like the following:

• A law enforcement agency compiles data about illegal activities, but nothing about legitimate activities. How can a suspicious activity be flagged?
  The law enforcement data is all of one class. There are no counter-examples.

• An insurance agency processes millions of insurance claims, knowing that a very small number are fraudulent. How can the fraudulent claims be identified?
  The claims data contains very few counter-examples. They are outliers.
• An IT department encounters compute resource performance anomalies. How can such anomalies be detected along with their source causes, such as resource-contention issues and complex memory leaks?

The data contains sensor output from thousands of sensors.

• An oil and gas enterprise or utility company requires proactive maintenance of business-critical assets, such as oil rigs or smart meters, to reduce operations and maintenance costs, improve up-time of revenue-generating assets, and improve safety margins for life-critical systems.

6.1.1 Anomaly Detection as a form of One-Class Classification

Learn about anomaly detection as one-class classification in training data.

When applied to traditional data, anomaly detection can be viewed as a form of one-class classification, because ideally only one class is represented in the training data. An anomaly detection model predicts whether a data point is typical for a given distribution or not. An atypical data point can be either an outlier or an example of a previously unseen class.

Normally, a classification model must be trained on data that includes both examples and counterexamples for each class so that the model can learn to distinguish between them. For example, a model that predicts the side effects of a medication must be trained on data that includes a wide range of responses to the medication.

A one-class classifier develops a profile that generally describes a typical case in the training data. Deviation from the profile is identified as an anomaly. One-class classifiers are sometimes referred to as positive security models, because they seek to identify "good" behaviors and assume that all other behaviors are bad.

In single-class data, all the cases have the same classification. Counterexamples, instances of another class, are hard to specify or expensive to collect. For instance, in text document classification, it is easy to classify a document under a given topic. However, the universe of documents outside of this topic can be very large and diverse. Thus, it is not feasible to specify other types of documents as counterexamples. Anomaly detection can be used to find unusual instances of a particular type of document.

Note:

Solving a one-class classification problem can be difficult. The accuracy of one-class classifiers cannot usually match the accuracy of standard classifiers built with meaningful counter examples.

The goal of this type of anomaly detection is to provide some useful information where no information was previously attainable. However, if there are enough of the "rare" cases so that stratified sampling produces a training set with enough counterexamples for a standard classification model, then the classification may be a better solution.
Related Topics

• **About Classification**
  Classification is a machine learning technique that assigns items in a collection to target categories or classes.

### 6.1.2 Anomaly Detection for Time Series Data

Learn about anomaly detection in IoT sensor data.

With the growing number of sensors in the internet of things, the ability to identify anomalous events among potentially thousands of sensors is essential. For example, in the early detection of anomalies in business-critical enterprise computing servers and software systems, storage systems, and networks.

Enterprises require high anomaly detection accuracy, which implies lower false-alarm probabilities, lower missed-alarm probabilities, and lower overhead compute cost. The ability to distinguish between a real problem and sensor malfunction can significantly reduce costs in problem solution.

Building a model involves supplying historical, error-free operating data from, for example, monitored equipment. The resulting model is used to score new sensor data, also referred to as the *monitoring phase*, to estimate the expected sensor values.

### 6.2 Anomaly Detection Algorithms

For anomaly detection, Oracle Machine Learning for SQL has the following algorithms.

• Multivariate state Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT)
• One-Class Support Vector Machine (SVM)

Anomaly detection is a form of classification. When you create a model using the MSET-SPRT and One-Class SVM algorithms, specify the classification machine learning technique. These algorithms do not use a target.

Related Topics

• **Multivariate State Estimation Technique - Sequential Probability Ratio Test**
  The Multivariate State Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT) algorithm monitors critical processes and detects subtle anomalies.

• **One-Class SVM**
  Support Vector Machine (SVM) as a one-class classifier is used for detecting anomalies.
7

Ranking

Ranking is a regression machine learning technique.

- About Ranking
- Ranking Methods
- Ranking Algorithms
  - XGBoost

7.1 About Ranking

Ranking is a machine learning technique to rank items.

Ranking is useful for many applications in information retrieval such as e-commerce, social networks, recommendation systems, and so on. For example, a user searches for an article or an item to buy online. To build a recommendation system, it becomes important that similar articles or items of relevance appear to the user such that the user clicks or purchases the item. A simple regression model can predict the probability of a user to click an article or buy an item. However, it is more practical to use ranking technique and be able to order or rank the articles or items to maximize the chances of getting a click or purchase. The prioritization of the articles or the items influence the decision of the users.

The ranking technique directly ranks items by training a model to predict the ranking of one item over another item. In the training model, it is possible to have items, ranking one over the other by having a “score” for each item. Higher ranked items have higher scores and lower ranked items have lower scores. Using these scores, a model is built to predict which item ranks higher than the other.

7.2 Ranking Methods

Oracle Machine Learning supports pairwise and listwise ranking methods through XGBoost.

For a training data set, in a number of sets, each set consists of objects and labels representing their ranking. A ranking function is constructed by minimizing a certain loss function on the training data. Using test data, the ranking function is applied to get a ranked list of objects. Ranking is enabled for XGBoost using the regression function. OML4SQL supports pairwise and listwise ranking methods through XGBoost.

Pairwise ranking: This approach regards a pair of objects as the learning instance. The pairs and lists are defined by supplying the same `case_id` value. Given a pair of objects, this approach gives an optimal ordering for that pair. Pairwise losses are defined by the order of the two objects. In OML4SQL, the algorithm uses LambdaMART to perform pairwise ranking with the goal of minimizing the average number of inversions in ranking.

Listwise ranking: This approach takes multiple lists of ranked objects as learning instance. The items in a list must have the same `case_id`. The algorithm uses LambdaMART to perform list-wise ranking.
See Also:

- “Ranking Measures and Loss Functions in Learning to Rank” a research paper presentation at https://www.researchgate.net/
- Oracle Database PL/SQL Packages and Types Reference for a listing and explanation of the available model settings for XGBoost.

Note:

The term hyperparameter is also interchangeably used for model setting.

Related Topics

- XGBoost
  XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.
- DBMS_DATA_MINING — Algorithm Settings: XGBoost

7.3 Ranking Algorithms

Ranking falls under the Regression function.

OML4SQL supports XGBoost algorithm for ranking.

Related Topics

- XGBoost
  XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.
Association

Learn how to discover association rules through association - an unsupervised machine learning technique.

- About Association
- Transactional Data
- Association Algorithm
  - Apriori

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

8.1 About Association

Association is a Oracle Machine Learning for SQL function that discovers the probability of the co-occurrence of items in a collection.

The relationships between co-occurring items are expressed as Association Rules.

8.1.1 Association Rules

Identifies the pattern of association within the data.

The results of an association model are the rules that identify patterns of association within the data. Oracle Machine Learning for SQL does not support the scoring operation for association modeling.

Association rules can be applied as follows:

**Support**: How often do these items occur together in the data?
**Confidence**: How frequently the consequent occurs in transactions that contain the antecedent.
**Value**: How much business value is connected to item associations

8.1.2 Market-Basket Analysis

Association rules are often used to analyze sales transactions. For example, it is noted that customers who buy cereal at the grocery store often buy milk at the same time. In fact, association analysis find that 85% of the checkout sessions that include cereal also include milk. This relationship can be formulated as the following rule:

Cereal implies milk with 85% confidence
This application of association modeling is called **market-basket analysis**. It is valuable for direct marketing, sales promotions, and for discovering business trends. Market-basket analysis can also be used effectively for store layout, catalog design, and cross-sell.

### 8.1.3 Association Rules and eCommerce

Learn about application of association rules in other domains.

Association modeling has important applications in other domains as well. For example, in e-commerce applications, association rules may be used for Web page personalization. An association model might find that a user who visits pages A and B is 70% likely to also visit page C in the same session. Based on this rule, a dynamic link can be created for users who are likely to be interested in page C. The association rule is expressed as follows:

\[
A \text{ and } B \text{ imply } C \text{ with } 70\% \text{ confidence}
\]

**Related Topics**

- **Confidence**
  
  The confidence of a rule indicates the probability of both the antecedent and the consequent appearing in the same transaction.

### 8.2 Transactional Data

Learn about transactional data, also known as market-basket data.

Unlike other machine learning functions, association is transaction-based. In transaction processing, a case includes a collection of items such as the contents of a market basket at the checkout counter. The collection of items in the transaction is an attribute of the transaction. Other attributes might be a timestamp or user ID associated with the transaction.

Transactional data, also known as **market-basket data**, is said to be in **multi-record case** format because a set of records (rows) constitute a case. For example, in the following figure, case 11 is made up of three rows while cases 12 and 13 are each made up of four rows.

**Figure 8-1 Transactional Data**

<table>
<thead>
<tr>
<th>case ID</th>
<th>attribute1</th>
<th>attribute2</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANS_ID</td>
<td>ITEM_ID</td>
<td>OPER_ID</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>11</td>
<td>B</td>
<td>m5203</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>m5203</td>
</tr>
<tr>
<td>11</td>
<td>E</td>
<td>m5203</td>
</tr>
<tr>
<td>12</td>
<td>A</td>
<td>m5203</td>
</tr>
<tr>
<td>12</td>
<td>B</td>
<td>m5203</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
<td>m5203</td>
</tr>
<tr>
<td>12</td>
<td>E</td>
<td>m5203</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
<td>q5597</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
<td>q5597</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
<td>q5597</td>
</tr>
<tr>
<td>13</td>
<td>E</td>
<td>q5597</td>
</tr>
</tbody>
</table>
Non transactional data is said to be in a **single-record case** format because a single record (row) constitutes a case. In Oracle Machine Learning for SQL, association models can be built using either transactional or non transactional or two-dimensional data formats. If the data is non transactional, it is possible to transform to a nested column to make it transactional before association machine learning activities can be performed. Transactional format is the usual format but, the association rules model does accept two-dimensional input format. For non transactional input format, each distinct combination of the content in all columns other than the case ID column is treated as a unique item.

**Related Topics**
- *Oracle Machine Learning for SQL User’s Guide*
- *Data Preparation for Apriori*

### 8.3 Association Algorithm

Oracle Machine Learning for SQL uses the Apriori algorithm to calculate association rules for items in frequent itemsets.

**Related Topics**
- *Apriori*
  
  Learn how to calculate association rules using the Apriori algorithm.
Feature Selection

Learn how to perform feature selection and attribute importance.

Oracle Machine Learning for SQL supports attribute importance as a supervised and unsupervised machine learning technique.

- Finding the Attributes
- About Feature Selection and Attribute Importance
- Algorithms for Attribute Importance
  - CUR Matrix Decomposition
  - Minimum Description Length

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

9.1 Finding the Attributes

Find the attributes by using preprocessing steps to reduce the effect of noise, correlation, and high-dimensionality.

Sometimes too much information can reduce the effectiveness of OML4SQL. Some of the columns of data attributes assembled for building and testing a model in a supervised learning do not contribute meaningful information to the model. Some actually detract from the quality and accuracy of the model.

For example, you want to collect a great deal of data about a given population because you want to predict the likelihood of a certain illness within this group. Some of this information, perhaps much of it, has little or no effect on susceptibility to the illness. It is possible that attributes such as the number of cars per household do not have effect whatsoever.

Irrelevant attributes add noise to the data and can affect model accuracy. Noise increases the size of the model and the time and system resources needed for model building and scoring.

Data sets with many attributes can contain groups of attributes that are correlated. These attributes actually measure the same underlying feature. Their presence together in the build data can skew the patterns found by algorithm and affect the accuracy of the model.

Wide data (many attributes) typically results in more processing by machine learning algorithms. Model attributes are the dimensions of the processing space used by the algorithm. The higher the dimensionality of the processing space, the higher the computation cost involved in algorithmic processing.

To minimize the effects of noise, correlation, and high dimensionality, some form of dimension reduction is often a desirable preprocessing step. Feature selection involves identifying those attributes that are most predictive and selecting among those to provide the algorithm for model building. By removing attributes that add little or no value to a model has these benefits - potentially increasing model accuracy while reducing compute time since fewer
attributes need to be processed. Informative and representative samples are best suited in feature selection. Sometimes you can represent the variables that are important than to represent the linear combination of variables. You can single-out and measure the “importance” of a column or a row in a data matrix in an unsupervised manner (a low-rank matrix decomposition).

Feature selection optimization is performed in the Decision Tree algorithm and within Naive Bayes as an algorithm behavior. The Generalized Linear Model (GLM) algorithm can be configured to perform feature selection through model setting.

9.2 About Feature Selection and Attribute Importance

Finding the most significant predictors is the goal of some machine learning projects. For example, a model might seek to find the principal characteristics of clients who pose a high credit risk.

Oracle Machine Learning for SQL supports the attribute importance machine learning technique, which ranks attributes according to their importance. Attribute importance does not actually select the features, but ranks them as to their relevance to predicting the result. It is up to the user to review the ranked features and create a data set to include the desired features.

Feature selection is useful as a preprocessing step to improve computational efficiency in predictive modeling.

9.2.1 Attribute Importance and Scoring

The results of attribute importance are the attributes of the build data ranked according to their influence.

The ranking and the measure of importance can be used in selecting training data for classification and regression models. Also, used for selecting data for unsupervised algorithm like CUR matrix decomposition. Oracle Machine Learning for SQL does not support the scoring operation for attribute importance.

9.3 Algorithms for Attribute Importance

Understand the algorithms used for attribute importance.

Oracle Machine Learning for SQL supports the following algorithms for attribute importance:

- Minimum Description Length
- CUR Matrix Decomposition

Related Topics

- CUR Matrix Decomposition
  Learn how to use CUR decomposition based algorithm for attribute importance.
- Minimum Description Length
  Learn how to use Minimum Description Length, the supervised technique for calculating attribute importance.
Learn how to perform attribute reduction using feature extraction as an unsupervised function.

Oracle Machine Learning for SQL supports feature extraction as an unsupervised machine learning function.

- About Feature Extraction
- Algorithms for Feature Extraction
  - Explicit Semantic Analysis
  - Non-Negative Matrix Factorization
  - Singular Value Decomposition

Related Topics
- Oracle Machine Learning Basics
  Understand the basic concepts of Oracle Machine Learning.

### 10.1 About Feature Extraction

Feature extraction is a dimensionality reduction technique. Unlike feature selection, which selects and retains the most significant attributes, feature extraction actually transforms the attributes. The transformed attributes, or **features**, are linear combinations of the original attributes.

The feature extraction technique results in a much smaller and richer set of attributes. The maximum number of features can be user-specified or determined by the algorithm. By default, the algorithm determines it.

Models built on extracted features can be of higher quality, because fewer and more meaningful attributes describe the data.

Feature extraction projects a data set with higher dimensionality onto a smaller number of dimensions. As such it is useful for data visualization, since a complex data set can be effectively visualized when it is reduced to two or three dimensions.

Some applications of feature extraction are latent semantic analysis, data compression, data decomposition and projection, and pattern recognition. Feature extraction can also be used to enhance the speed and effectiveness of machine learning algorithms.

Feature extraction can be used to extract the themes of a document collection, where documents are represented by a set of key words and their frequencies. Each theme (feature) is represented by a combination of keywords. The documents in the collection can then be expressed in terms of the discovered themes.
10.1.1 Feature Extraction and Scoring

Oracle Machine Learning for SQL supports the scoring operation for feature extraction. As an unsupervised machine learning technique, feature extraction does not involve a target. When applied, a feature extraction model transforms the input into a set of features.

10.2 Algorithms for Feature Extraction

Understand the algorithms used for feature extraction.

OML4SQL supports these feature extraction algorithms:

- **Explicit Semantic Analysis** (ESA).
- **Non-Negative Matrix Factorization** (NMF).
- **Singular Value Decomposition** (SVD) and **Principal Component Analysis** (PCA).

**Note:**

OML4SQL uses NMF as the default feature extraction algorithm.

Related Topics

- **Explicit Semantic Analysis**
  Learn how to use Explicit Semantic Analysis (ESA) as an unsupervised algorithm for feature extraction function and as a supervised algorithm for classification.

- **Non-Negative Matrix Factorization**
  Learn how to use Non-Negative Matrix Factorization (NMF), an unsupervised algorithm, that Oracle Machine Learning for SQL uses for feature extraction.

- **Singular Value Decomposition**
  Learn how to use Singular Value Decomposition, an unsupervised algorithm for feature extraction.

- **PCA scoring**
  Learn about configuring Singular Value Decomposition (SVD) to perform Principal Component Analysis (PCA) projections.
11
Row Importance

Row importance is an unsupervised machine learning technique that can be applied to data as a preprocessing step prior to model building using other mining functions and algorithms.

- About Row Importance
- Row Importance Algorithms
  - CUR Matrix Decomposition

11.1 About Row Importance

Row importance captures the influence of the rows or cases in a data set.

Row importance technique is used in dimensionality reduction of large data sets. Row importance identifies the most influential rows of the data matrix. The rows with high importance are ranked by their importance scores. The “importance” of a row is determined by high statistical leverage scores. In CUR matrix decomposition, row importance is often combined with column (attribute) importance. Row importance can serve as a data preprocessing step prior to model building using regression, classification, and clustering.

Related Topics
- CUR Matrix Decomposition
  Learn how to use CUR decomposition based algorithm for attribute importance.
- Statistical Leverage Score
  Leverage scores are statistics that determine which column (or rows) are most representative with respect to a rank subspace of a matrix. The statistical leverage scores represent the column (or attribute) and row importance.
- CUR Matrix Decomposition Algorithm Configuration
  Configure the CUR Matrix Decomposition algorithm setting to build your model.

11.2 Selecting Important Rows

The rows with high importance are ranked by their importance scores. The "importance" of a row is determined by high statistical leverage scores.

Row importance, that is, rows with high leverage scores are reported as names (as case_id), scores (as importance), and ranks (by importance).

11.3 Row Importance Algorithms

Oracle Machine Learning for SQL supports CUR matrix decomposition algorithm for row and column (attribute) importance.

Popular algorithms for dimensionality reduction are Principal Component Analysis (PCA), Singular Value Decomposition (SVD), and CUR Matrix Decomposition. All these algorithms apply low-rank matrix decomposition.
In CUR matrix decomposition, the attributes include 2-Dimensional numerical columns, levels of exploded 2D categorical columns, and attribute name or subname or value pairs for nested columns. To arrive at row importance or selection, the algorithm computes singular vectors, calculates leverage scores, and then selects rows. Row importance is performed when users specify CURS_ROW_IMP_ENABLE for the CURS_ROW_IMPORTANCE parameter in the settings table and the case_id column is present. Unless users explicitly specify, row importance is not performed.

Related Topics

- **Singular Value Decomposition**
  Learn how to use Singular Value Decomposition, an unsupervised algorithm for feature extraction.

- **CUR Matrix Decomposition**
  Learn how to use CUR decomposition based algorithm for attribute importance.
12

Time Series

Learn about time series as an Oracle Machine Learning for SQL regression function.

- **About Time Series**
- **Choosing a Time Series Model**
- **Time Series Statistics**
- **Time Series Algorithm**
  - Exponential Smoothing

12.1 About Time Series

Time series is a machine learning technique that forecasts target value based solely on a known history of target values. It is a specialized form of regression, known in the literature as auto-regressive modeling.

The input to time series analysis is a sequence of target values. A case id column specifies the order of the sequence. The case id can be of type `NUMBER` or a date type (date, datetime, timestamp with timezone, or timestamp with local timezone). Regardless of case id type, the user can request that the model include trend, seasonal effects or both in its forecast computation. When the case id is a date type, the user must specify a time interval (for example, month) over which the target values are to be aggregated, along with an aggregation procedure (for example, sum). Aggregation is performed by the algorithm prior to constructing the model.

The time series model provide estimates of the target value for each step of a time window that can include up to 30 steps beyond the historical data. Like other regression models, time series models compute various statistics that measure the goodness of fit to historical data.

Forecasting is a critical component of business and governmental decision making. It has applications at the strategic, tactical and operation level. The following are the applications of forecasting:

- Projecting return on investment, including growth and the strategic effect of innovations
- Addressing tactical issues such as projecting costs, inventory requirements and customer satisfaction
- Setting operational targets and predicting quality and conformance with standards

**Related Topics**

- **Regression**
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.

12.2 Choosing a Time Series Model

Learn how to select a time series model.
Time series data may contain patterns that can affect predictive accuracy. For example, during a period of economic growth, there may be an upward trend in sales. Sales may increase in specific seasons (bathing suits in summer). To accommodate such series, it can be useful to choose a model that incorporates trend, seasonal effects, or both.

**Trend** can be difficult to estimate, when you must represent trend by a single constant. For example, if there is a grow rate of 10%, then after 7 steps, the value doubles. Local growth rates, appropriate to a few time steps can easily approach such levels, but thereafter drop. **Damped trend** models can more accurately represent such data, by reducing cumulative trend effects. Damped trend models can better represent variability in trend effects over the historical data. Damped trend models are a good choice when the data have significant, but variable trend.

Since modeling attempts to reduce error, how error is measured can affect model predictions. For example, data that exhibit a wide range of values may be better represented by error as fraction of level. An error of a few hundred feet in the measurement of the height of a mountain may be equivalent to an error of an inch or two in the measurement of the height of a child. Errors that are measured relative to value are called **multiplicative errors**. Errors that are the same across values are called **additive errors**. If there are multiplicative effects in the model, then the error type is multiplicative. If there are no explicit multiplicative effects, error type is left to user specification. The type need not be the same across individual effects. For example, trend can be additive while seasonality is multiplicative. This particular mixed type effect combination defines the popular Holt-Winters model.

**Note:**

Multiplicative error is not an appropriate choice for data that contain zeros or negative values. Thus, when the data contains such values, it is best not to choose a model with multiplicative effects or to set error type to be multiplicative.

### 12.3 Time Series Statistics

Learn to evaluate model quality by applying commonly used statistics.

As with other regression functions, there are commonly used statistics for evaluating the overall model quality. An expert user can also specify one of these figures of merit as criterion to optimize by the model build process. Choosing an optimization criterion is not required because model-specific defaults are available.

#### 12.3.1 Conditional Log-Likelihood

Log-likelihood is a figure of merit often used as an optimization criterion for models that provide probability estimates for predictions which depend on the values of the model's parameters.

The model probability estimates for the actual values in the training data then yields an estimate of the likelihood of the parameter values. Parameter values that yield high probabilities for the observed target values have high likelihood, and therefore indicate a good model. The calculation of log-likelihood depends on the form of the model.
Conditional log-likelihood breaks the parameters into two groups. One group is assumed to be correct and the other is assumed the source of any errors. Conditional log-likelihood is the log-likelihood of the latter group conditioned on the former group. For example, Exponential Smoothing (ESM) models make an estimate of the initial model state. The conditional log-likelihood of an ESM model is conditional on that initial model state (assumed to be correct). The ESM conditional log-likelihood is as follows:

$$L^*(\theta, x_n) = n \ln \left( \sum_{t=1}^{n} \frac{e_t^2}{k^2(x_{t-1})} \right) + 2 \sum_{t=1}^{n} \ln[k(x_{t-1})]$$

where \( e_t \) is the error at time \( t \) and \( k(x(t-1)) \) is 1 for ESM models with additive errors and is the estimated level at the previous time step in models with multiplicative error.

12.3.2 Mean Square Error (MSE) and Other Error Measures

Another time series figure of merit, that can also be used as an optimization criterion, is Mean Square Error (MSE).

The mean square error is computed as:

$$MSE = \frac{1}{n} \sum_{t=1}^{n} e_t^2$$

where the error at time \( t \) is the difference between the actual and model one step ahead forecast value at time \( t \) for models with additive error and that difference divided by the one-step ahead forecast for models with multiplicative error.

**Note:**

These "forecasts" are for over periods already observed and part of the input time series.

Since time series models can forecast for each of multiple steps ahead, time series can measure the error associated with such forecasts. Average Mean Square Error (AMSE), another figure of merit, does exactly that. For each period in the input time series, it computes a multi-step forecast, computes the error of those forecasts and averages the errors. AMSE computes the individual errors exactly as MSE does taking cognizance of error type (additive or multiplicative). The number of steps, \( k \), is determined by the user (default 3). The formula is as follows:

$$AMSE = \frac{1}{n} \sum_{t=1}^{n} \left( \sum_{i=1}^{k-1} \frac{e_{t+i}^2}{k} \right)$$
Other figure of merit relatives of MSE include the Residual Standard Error (RMSE), which is the square root of MSE, and the Mean Absolute Error (MAE) which is the average of the absolute value of the errors.

12.3.3 Irregular Time Series

Irregular time series are time series data where the time intervals between observed values are not equally spaced.

One common practice is for the time intervals between adjacent steps to be equally spaced. However, it is not always convenient or realistic to force such spacing on time series. Irregular time series do not make the assumption that time series are equally spaced, but instead use the case id's date and time values to compute the intervals between observed values. Models are constructed directly on the observed values with their observed spacing. Oracle time series analysis handles irregular time series.

12.3.4 Build and Apply

A new time series model is built when new data arrives.

Many of the Oracle Machine Learning for SQL functions have separate build and apply operations, because you can construct and potentially apply a model to many different sets of input data. However, time series input consists of the target value history only. Thus, there is only one set of appropriate input data. When new data arrive, good practice dictates that a new model be built. Since the model is only intended to be used once, the model statistics and forecasts are produced during model build and are available through the model views.

12.4 Time Series Algorithm

Oracle Machine Learning for SQL uses the Exponential Smoothing algorithm to forecast from time series data.

Related Topics

- Exponential Smoothing
  Learn about the Exponential Smoothing algorithm.
Part III

Algorithms

Oracle Machine Learning for SQL supports the algorithms listed in Part III. Part III provides basic conceptual information about the algorithms. There is at least one algorithm for each of the machine learning techniques.

Part III contains these chapters:

• Apriori
• CUR Matrix Decomposition
• Decision Tree
• Expectation Maximization
• Explicit Semantic Analysis
• Exponential Smoothing
• Generalized Linear Model
• k-Means
• Minimum Description Length
• Multivariate State Estimation Technique - Sequential Probability Ratio Test
• Naive Bayes
• Neural Network
• Non-Negative Matrix Factorization
• O-Cluster
• R Extensibility
• Random Forest
• Singular Value Decomposition
• Support Vector Machine
• XGBoost

Related Topics

• Machine Learning Techniques
  Part II provides basic conceptual information about machine learning techniques that the Oracle Machine Learning for SQL supports.
13

Apriori

Learn how to calculate association rules using the Apriori algorithm.

- **About Apriori**
- **Association Rules and Frequent Itemsets**
- **Data Preparation for Apriori**
- **Calculating Association Rules**
- **Evaluating Association Rules**

**Related Topics**

- **Association**
  Learn how to discover association rules through association - an unsupervised machine learning technique.
- **DBMS_DATA_MINING - Model Settings**
- **Machine Learning Function Settings**
- **Automatic Data Preparation**
- **Model Detail Views for Association Rules**
- **OML4SQL Examples**
- **OML4R Association Rules Example**
- **OML4R Code Examples**

13.1 About Apriori

Learn how to find associations involving rare events in a large number of items using Apriori.

An association machine learning problem can be decomposed into the following subproblems:

- Find all combinations of items in a set of transactions that occur with a specified minimum frequency. These combinations are called **frequent itemsets**.
- Calculate rules that express the probable co-occurrence of items within frequent itemsets.

Apriori calculates the probability of an item being present in a frequent itemset, given that another item or items is present.

Association rule machine learning is not recommended for finding associations involving rare events in problem domains with a large number of items. Apriori discovers patterns with frequencies above the minimum support threshold. Therefore, to find associations involving rare events, the algorithm must run with very low minimum support values. However, doing so potentially explodes the number of enumerated itemsets, especially in cases with a large number of items. This increases the execution time significantly. Classification or anomaly
detection is more suitable for discovering rare events when the data has a high number of attributes.

The build process for Apriori supports parallel execution.

Related Topics

• Example: Calculating Rules from Frequent Itemsets
  Example to calculating rules from frequent itemsets.

• Oracle Database VLDB and Partitioning Guide

13.2 Association Rules and Frequent Itemsets

The Apriori algorithm calculates rules that express probabilistic relationships between items in frequent itemsets. For example, a rule derived from frequent itemsets containing A, B, and C might state that if A and B are included in a transaction, then C is likely to also be included.

An association rule states that an item or group of items implies the presence of another item with some probability. Unlike decision tree rules, which predict a target, association rules express correlation.

13.2.1 Antecedent and Consequent

Defines antecedent and consequent in an Apriori algorithm.

The IF component of an association rule is known as the antecedent. The THEN component is known as the consequent. The antecedent and the consequent are disjoint; they have no items in common.

Oracle Machine Learning for SQL supports association rules that have one or more items in the antecedent and a single item in the consequent.

13.2.2 Confidence

Rules have an associated confidence, which is the conditional probability that the consequent occurs given the occurrence of the antecedent. You can specify the minimum confidence for rules.

13.3 Data Preparation for Apriori

Association models are designed to use transactional data. In transactional data, there is a one-to-many relationship between the case identifier and the values for each case. Each case ID/value pair is specified in a separate record (row).

13.3.1 Native Transactional Data and Star Schemas

Learn about storage format of transactional data.

Transactional data may be stored in native transactional format, with a non-unique case ID column and a values column, or it may be stored in some other configuration, such as a star schema. If the data is not stored in native transactional format, it must be transformed to a nested column for processing by the Apriori algorithm.
13.3.2 Items and Collections

In transactional data, a collection of items is associated with each case. The collection theoretically includes all possible members of the collection. For example, all products can theoretically be purchased in a single market-basket transaction. However, in actuality, only a tiny subset of all possible items are present in a given transaction; the items in the market-basket represent only a small fraction of the items available for sale in the store.

13.3.3 Sparse Data

Understand how sparse data is used in the Apriori algorithm.

Missing items in a collection indicate sparsity. Missing items may be present with a null value, or they may be missing.

Nulls in transactional data are assumed to represent values that are known but not present in the transaction. For example, three items out of hundreds of possible items might be purchased in a single transaction. The items that were not purchased are known but not present in the transaction.

Oracle Machine Learning for SQL assumes sparsity in transactional data. The Apriori algorithm is optimized for processing sparse data.

Note:

Apriori is not affected by Automatic Data Preparation.

13.3.4 Improved Sampling

Association rules (AR) can use a good sample size with performance guarantee, based on the work of Riondato and Upfal.

The AR algorithm computes the sample size by the following inputs:

- $d$-index of the dataset
- Absolute error $\varepsilon$
- Confidence level $\gamma$

The $d$-index is defined as the maximum integer $d$ such that the dataset contains at least $d$ transactions of length $d$ at the minimum. It is the upper bound of Vapnik-Chervonenkis (VC) dimension. The AR algorithm computes $d$-index of the dataset by scanning the length of all transactions in the dataset.
Users specify absolute error $\varepsilon$ and confidence level $\gamma$ parameters. A large $d$-index, small AR support, small $\varepsilon$ or large $\gamma$ can cause a large sample size. The sample size theoretically guarantees that the absolute error of both the support and confidence of the approximated AR (from sampling) is less than $\varepsilon$ compared to the exact AR with probability (or confidence level) at least $\gamma$. In this document this sample size is called AR-specific sample size.

13.3.4.1 Sampling Implementation

The sample size is only computed when users turn on the sampling (ODMS_SAMPLING is set as ODMS_SAMPLING_ENABLE) and do not specify the sample size (ODMS_SAMPLE_SIZE is unspecified).

Usage Notes

1. If ODMS_SAMPLING is unspecified or set as ODMS_SAMPLING_DISABLE, the sampling is not performed for AR and the exact AR is obtained.

2. If ODMS_SAMPLING is set as ODMS_SAMPLING_ENABLE and if ODMS_SAMPLE_SIZE is specified as positive integer number then the user-specified sample size (ODMS_SAMPLE_SIZE) is utilized. The sampling is performed in the general data preparation stage before the AR algorithm. The AR-specific sample size is not computed. The approximated AR is obtained.

3. If ODMS_SAMPLING is set as ODMS_SAMPLING_ENABLE and ODMS_SAMPLE_SIZE is not specified, the AR-specified sample size is computed and then sampling is performed in the AR algorithm. The approximated AR is obtained.

Note:

If the computed AR-specific sample size is larger than or equal to the total transaction size in the dataset, the sampling is not performed and the exact AR is obtained.

If users do not have a good idea on the choice of sample size for AR, it is suggested to leave ODMS_SAMPLE_SIZE unspecified, only specify proper values for sampling parameters and let AR algorithm compute the suitable AR-specific sample size.

See Also:

DBMS_DATA_MINING — Machine Learning Function Settings for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.
### 13.4 Calculating Association Rules

The first step in association analysis is the enumeration of **itemsets**. An itemset is any combination of two or more items in a transaction.

#### 13.4.1 Itemsets

Learn about itemsets.

The maximum number of items in an itemset is user-specified. If the maximum is two, then all the item pairs are counted. If the maximum is greater than two, then all the item pairs, all the item triples, and all the item combinations up to the specified maximum are counted.

The following table shows the itemsets derived from the transactions shown in the following example, assuming that maximum number of items in an itemset is set to 3.

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Itemsets</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>(B,D) (B,E) (D,E) (B,D,E)</td>
</tr>
<tr>
<td>13</td>
<td>(B,C) (B,D) (B,E) (C,D) (C,E) (D,E) (B,C,D) (B,C,E) (B,D,E) (C,D,E)</td>
</tr>
</tbody>
</table>

**Example 13-1**  **Sample Transactional Data**

<table>
<thead>
<tr>
<th>TRANS_ID</th>
<th>ITEM_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
</tr>
<tr>
<td>11</td>
<td>E</td>
</tr>
<tr>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>12</td>
<td>E</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>E</td>
</tr>
</tbody>
</table>

#### 13.4.2 Frequent Itemsets

Learn about frequent itemsets and support.

Association rules are calculated from itemsets. If rules are generated from all possible itemsets, there can be a very high number of rules and the rules may not be very meaningful. Also, the model can take a long time to build. Typically it is desirable to only generate rules from itemsets that are well-represented in the data. **Frequent itemsets** are those that occur with a minimum frequency specified by the user.

The minimum frequent itemset **support** is a user-specified percentage that limits the number of itemsets used for association rules. An itemset must appear in at least this percentage of all the transactions if it is to be used as a basis for rules.
The following table shows the itemsets from Table 13-1 that are frequent itemsets with support > 66%.

**Table 13-2  Frequent Itemsets**

<table>
<thead>
<tr>
<th>Frequent Itemset</th>
<th>Transactions</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B,C)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
<tr>
<td>(B,D)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
<tr>
<td>(B,E)</td>
<td>3 of 3</td>
<td>100%</td>
</tr>
<tr>
<td>(C,E)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
<tr>
<td>(D,E)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
<tr>
<td>(B,C,E)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
<tr>
<td>(B,D,E)</td>
<td>2 of 3</td>
<td>67%</td>
</tr>
</tbody>
</table>

Related Topics

- **Apriori**
  Learn how to calculate association rules using the Apriori algorithm.

### 13.4.3 Example: Calculating Rules from Frequent Itemsets

Example to calculating rules from frequent itemsets.

The following tables show the itemsets and frequent itemsets that were calculated in "Association". The frequent itemsets are the itemsets that occur with a minimum support of 67%; at least 2 of the 3 transactions must include the itemset.

**Table 13-3  Itemsets**

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>(B,D) (B,E) (D,E) (B,D,E)</td>
</tr>
<tr>
<td>13</td>
<td>(B,C) (B,D) (B,E) (C,D) (C,E) (D,E) (B,C,D) (B,C,E) (B,D,E) (C,D,E)</td>
</tr>
</tbody>
</table>

**Table 13-4  Frequent Itemsets with Minimum Support 67%**

<table>
<thead>
<tr>
<th>Itemset</th>
<th>Transactions</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B,C)</td>
<td>12 and 13</td>
<td>67%</td>
</tr>
<tr>
<td>(B,D)</td>
<td>11 and 13</td>
<td>67%</td>
</tr>
<tr>
<td>(B,E)</td>
<td>11, 12, and 13</td>
<td>100%</td>
</tr>
<tr>
<td>(C,E)</td>
<td>12 and 13</td>
<td>67%</td>
</tr>
<tr>
<td>(D,E)</td>
<td>11 and 13</td>
<td>67%</td>
</tr>
<tr>
<td>(B,C,E)</td>
<td>12 and 13</td>
<td>67%</td>
</tr>
<tr>
<td>(B,D,E)</td>
<td>11 and 13</td>
<td>67%</td>
</tr>
</tbody>
</table>
A rule expresses a conditional probability. Confidence in a rule is calculated by dividing the probability of the items occurring together by the probability of the occurrence of the antecedent.

For example, if B (antecedent) is present, what is the chance that C (consequent) is also present? What is the confidence for the rule "IF B, THEN C"?

As shown in Table 13-3:

- All 3 transactions include B (3/3 or 100%)
- Only 2 transactions include both B and C (2/3 or 67%)
- Therefore, the confidence of the rule "IF B, THEN C" is 67/100 or 67%.

The following table the rules that can be derived from the frequent itemsets in Table 13-4.

### Table 13-5  Frequent Itemsets and Rules

<table>
<thead>
<tr>
<th>Frequent Itemset</th>
<th>Rules</th>
<th>prob(antecedent and consequent) / prob(antecedent)</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B,C)</td>
<td>(If B then C)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(If C then B)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td>(B,D)</td>
<td>(If B then D)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(If D then B)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td>(B,E)</td>
<td>(If B then E)</td>
<td>100/100</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>(If E then B)</td>
<td>100/100</td>
<td>100%</td>
</tr>
<tr>
<td>(C,E)</td>
<td>(If C then E)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>(If E then C)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td>(D,E)</td>
<td>(If D then E)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>(If E then D)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td>(B,C,E)</td>
<td>(If B and C then E)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>(If B and E then C)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(If C and E then B)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td>(B,D,E)</td>
<td>(If B and D then E)</td>
<td>67/67</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>(If B and E then D)</td>
<td>67/100</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(If D and E then B)</td>
<td>67/67</td>
<td>100%</td>
</tr>
</tbody>
</table>

If the minimum confidence is 70%, ten rules are generated for these frequent itemsets. If the minimum confidence is 60%, sixteen rules are generated.

**Tip:**

Increase the minimum confidence if you want to decrease the build time for the model and generate fewer rules.
13.4.4 Aggregates

Aggregates refer to the quantities associated with each item that the user opts for association rules model to aggregate.

There can be more than one aggregate. For example, the user can specify the model to aggregate both profit and quantity.

13.4.5 Example: Calculating Aggregates

This example shows how to calculate aggregates using the customer grocery purchase and profit data.

Calculating Aggregates for Grocery Store Data

Assume a grocery store has the following data:

Table 13-6  Grocery Store Data

<table>
<thead>
<tr>
<th>Customer</th>
<th>Item A</th>
<th>Item B</th>
<th>Item C</th>
<th>Item D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer 1</td>
<td>Buys (Profit $5.00)</td>
<td>Buys (Profit $3.20)</td>
<td>Buys (Profit $12.00)</td>
<td>NA</td>
</tr>
<tr>
<td>Customer 2</td>
<td>Buys (Profit $4.00)</td>
<td>NA</td>
<td>Buys (Profit $4.20)</td>
<td>NA</td>
</tr>
<tr>
<td>Customer 3</td>
<td>Buys (Profit $3.00)</td>
<td>Buys (Profit $10.00)</td>
<td>Buys (Profit $14.00)</td>
<td>Buys (Profit $8.00)</td>
</tr>
<tr>
<td>Customer 4</td>
<td>Buys (Profit $2.00)</td>
<td>NA</td>
<td>NA</td>
<td>Buys (Profit $1.00)</td>
</tr>
</tbody>
</table>

The basket of each customer can be viewed as a transaction. The manager of the store is interested in not only the existence of certain association rules, but also in the aggregated profit if such rules exist.

In this example, one of the association rules can be (A, B)=>C for customer 1 and customer 3. Together with this rule, the store manager may want to know the following:

- The total profit of item A appearing in this rule
- The total profit of item B appearing in this rule
- The total profit for consequent C appearing in this rule
- The total profit of all items appearing in the rule

For this rule, the profit for item A is $5.00 + $3.00 = $8.00, for item B the profit is $3.20 + $10.00 = $13.20, for consequent C, the profit is $12.00 + $14.00 = $26.00, for the antecedent itemset (A, B) is $8.00 + $13.20 = $21.20. For the whole rule, the profit is $21.20 + $26.00 = $47.40.

Related Topics

- Oracle Database PL/SQL Packages and Types Reference
13.4.6 Including and Excluding Rules

Explains including rules and excluding rules used in association.

Including rules enables a user to provide a list of items such that at least one item from the list must appear in the rules that are returned. Excluding rules enables a user to provide a list of items such that no item from the list can appear in the rules that are returned.

**Note:**

Since each association rule includes both antecedent and consequent, a set of including or excluding rules can be specified for antecedent while another set of including or excluding rules can be specified for consequent. Including or excluding rules can also be defined for the association rule.

**Related Topics**
- *Oracle Machine Learning for SQL User’s Guide*
- *Oracle Database PL/SQL Packages and Types Reference*

13.4.7 Performance Impact for Aggregates

Aggregate function requires more memory usage and longer execution time.

For each item, the user may supply several columns to aggregate. It requires more memory to buffer the extra data and more time to compute the aggregate values.

13.5 Evaluating Association Rules

Evaluate association rules by using support and confidence.

Minimum support and confidence are used to influence the build of an association model. Support and confidence are also the primary metrics for evaluating the quality of the rules generated by the model. Additionally, Oracle Machine Learning for SQL supports lift for association rules. These statistical measures can be used to rank the rules and hence the usefulness of the predictions.

13.5.1 Support

The support of a rule indicates how frequently the items in the rule occur together. For example, cereal and milk might appear together in 40% of the transactions. If so, the following rules each have a support of 40%:

- cereal implies milk
- milk implies cereal

Support is the ratio of transactions that include all the items in the antecedent and consequent to the number of total transactions.

Support can be expressed in probability notation as follows:

\[ \text{support}(A \implies B) = P(A, B) \]
13.5.2 Minimum Support Count

Minimum support count defines minimum threshold in transactions that each rule must satisfy.

When the number of transactions is unknown, the support percentage threshold parameter can be tricky to set appropriately. For this reason, support can also be expressed as a count of transactions, with the greater of the two thresholds being used to filter out infrequent itemsets. The default is 1 indicating that this criterion is not applied.

Related Topics
- Association Rules
  Identifies the pattern of association within the data.
- Oracle Machine Learning for SQL User’s Guide
- Frequent Itemsets
  Learn about frequent itemsets and support.

13.5.3 Confidence

The confidence of a rule indicates the probability of both the antecedent and the consequent appearing in the same transaction.

Confidence is the conditional probability of the consequent given the antecedent. For example, cereal appears in 50 transactions; 40 of the 50 might also include milk. The rule confidence is:

cereal implies milk with 80% confidence

Confidence is the ratio of the rule support to the number of transactions that include the antecedent.

Confidence can be expressed in probability notation as follows.

\[
\text{confidence (A implies B) = } P(B|A), \text{ which is equal to } \frac{P(A, B)}{P(A)}
\]

Related Topics
- Confidence
- Frequent Itemsets
  Learn about frequent itemsets and support.

13.5.4 Reverse Confidence

The reverse confidence of a rule is defined as the number of transactions in which the rule occurs divided by the number of transactions in which the consequent occurs.

Reverse confidence eliminates rules that occur because the consequent is frequent. The default is 0.

Related Topics
- Confidence
Both support and confidence must be used to determine if a rule is valid. However, there are times when both of these measures may be high, and yet still produce a rule that is not useful. For example:

Convenience store customers who buy orange juice also buy milk with a 75% confidence. The combination of milk and orange juice has a support of 30%.

This at first sounds like an excellent rule, and in most cases, it would be. It has high confidence and high support. However, what if convenience store customers in general buy milk 90% of the time? In that case, orange juice customers are actually less likely to buy milk than customers in general.

A third measure is needed to evaluate the quality of the rule. Lift indicates the strength of a rule over the random co-occurrence of the antecedent and the consequent, given their individual support. It provides information about the improvement, the increase in probability of the consequent given the antecedent. Lift is defined as follows.

\[
\text{Lift} = \frac{\text{Rule Support}}{\text{Support(Antecedent)} \times \text{Support(Consequent)}}
\]

This can also be defined as the confidence of the combination of items divided by the support of the consequent. So in our milk example, assuming that 40% of the customers buy orange juice, the improvement would be:

\[
\frac{30\%}{(40\% \times 90\%)}
\]

which is 0.83 – an improvement of less than 1.

Any rule with an improvement of less than 1 does not indicate a real cross-selling opportunity, no matter how high its support and confidence, because it actually offers less ability to predict a purchase than does random chance.

**Tip:**

Decrease the maximum rule length if you want to decrease the build time for the model and generate simpler rules.

**Tip:**

Increase the minimum support if you want to decrease the build time for the model and generate fewer rules.
14
CUR Matrix Decomposition

Learn how to use CUR decomposition based algorithm for attribute importance.

• About CUR Matrix Decomposition
• Singular Vectors
• Statistical Leverage Score
• Column (Attribute) Selection and Row Selection
• CUR Matrix Decomposition Algorithm Configuration

Related Topics
• Feature Selection
  Learn how to perform feature selection and attribute importance.
• DBMS_DATA_MINING - Model Settings
• DBMS_DATA_MINING — Algorithm Settings: CUR Matrix Decomposition
• Automatic Data Preparation
• Model Detail Views for CUR Matrix Decomposition
• OML4SQL Examples

14.1 About CUR Matrix Decomposition

CUR Matrix Decomposition is a low-rank matrix decomposition algorithm that is explicitly expressed in a small number of actual columns and/or actual rows of data matrix.

CUR Matrix Decomposition was developed as an alternative to Singular Value Decomposition (SVD) and Principal Component Analysis (PCA). CUR Matrix Decomposition selects columns and rows that exhibit high statistical leverage or large influence from the data matrix. By implementing the CUR Matrix Decomposition algorithm, a small number of most important attributes and/or rows can be identified from the original data matrix. Therefore, CUR Matrix Decomposition is an important tool for exploratory data analysis. CUR Matrix Decomposition can be applied to a variety of areas and facilitates regression, classification, and clustering.

Related Topics
• Data Preparation for SVD
  Oracle Machine Learning for SQL implements Singular Value Decomposition (SVD) for numerical data and categorical data.

14.2 Singular Vectors

Singular Value Decomposition (SVD) is the first step in CUR Matrix Decomposition.
SVD returns left and right singular vectors for calculating column and row leverage scores. Perform SVD on the following matrix:

\[ A \in \mathbb{R}^{m \times n} \]

The matrix is factorized as follows:

\[ A = U \Sigma V^T \]

where \( U = [u_1, u_2, \ldots, u_m] \) and \( V = [v_1, v_2, \ldots, v_n] \) are orthogonal matrices. \( \Sigma \) is a diagonal \( m \times n \) matrix with non-negative real numbers \( \sigma_1, \ldots, \sigma_{\rho} \) on the diagonal, where \( \rho = \min\{m, n\} \) and \( \sigma_\xi \) is the \( \xi^{th} \) singular value of \( A \).

Let \( u_\xi \) and \( v_\xi \) be the \( \xi^{th} \) left and right singular vector of \( A \), the \( j^{th} \) column of \( A \) can thus be approximated by the top \( k \) singular vectors and corresponding singular values as:

\[ A' = \sum_{\xi=1}^{k} (\sigma_\xi u_\xi)v_j^\xi \]

where \( v_j^\xi \) is the \( j^{th} \) coordinate of the \( \xi^{th} \) right singular vector.

### 14.3 Statistical Leverage Score

Leverage scores are statistics that determine which column (or rows) are most representative with respect to a rank subspace of a matrix. The statistical leverage scores represent the column (or attribute) and row importance.

The normalized statistical leverage scores for all columns are computed from the top \( k \) right singular vectors as follows:

\[ \pi_j = \frac{1}{k} \sum_{\xi=1}^{k} (v_j^\xi)^2 \]

where \( k \) is called rank parameter and \( j = 1, \ldots, n \). Given that \( \pi_j \geq 0 \) and

\[ \sum_{j=1}^{n} \pi_j = 1 \]

these scores form a probability distribution over the \( n \) columns.

Similarly, the normalized statistical leverage scores for all rows are computed from the top \( k \) left singular vectors as:
where \( i = 1, \ldots, m \).

### 14.4 Column (Attribute) Selection and Row Selection

The CUR matrix decomposition in OML4SQL is designed for attribute and/or row importance. It returns attributes and rows with high importance that are ranked by their leverage (importance) scores. Column (Attribute) selection and row selection is the final stage in CUR Matrix Decomposition.

**Attribute selection:** Selects attributes with high leverage scores and reports their names, scores (as importance) and ranks (by importance).

**Row selection:** Selects rows with high leverage scores and reports their names, scores (as importance) and ranks (by importance).

1. CUR Matrix Decomposition first selects the \( j \)th column (or attribute) of \( A \) with probability \( p_j = \min\{1, c\pi_j\} \) for all \( j \in \{1, \ldots, n\} \).
2. If users enable row selection, select \( i \)th row of \( A \) with probability \( p'_i = \min\{1, r\pi'_i\} \) for all \( i \in \{1, \ldots, m\} \).
3. Report the name (or ID) and leverage score (as importance) for all selected attributes (if row importance is disabled) or for all selected attributes and rows (if row importance is enabled).

\( c \) is the approximated (or expected) number of columns that users want to select, and \( r \) is the approximated (or expected) number of rows that users want to select.

To realize column and row selections, you need to calculate the probability to select each column and row.

Calculate the probability for each column as follows:

\[
p_j = \min\{1, c\pi_j\}
\]

Calculate the probability for each row as follows:

\[
p'_i = \min\{1, r\pi'_i\}.
\]

A column or row is selected if the probability is greater than some threshold.

### 14.5 CUR Matrix Decomposition Algorithm Configuration

Configure the CUR Matrix Decomposition algorithm setting to build your model.

Create a model with the algorithm specific settings. Define the algorithm name as `ALGO_CUR_DECOMPOSITION` and mining function as `ATTRIBUTE_IMPORTANCE`.
Row Selection

To use this feature, specify the row importance setting CURS_ROW_IMPORTANCE to CURS_ROW_IMP_ENABLE.

Note:
The row selection is performed only when users specify that row importance is enabled and the CASE_ID column is present.
15
Decision Tree

Oracle Machine Learning for SQL supports Decision Tree as one of the classification algorithms. This chapter provides an overview of the Decision Tree algorithm.

- About Decision Tree
- Growing a Decision Tree
- Tuning the Decision Tree Algorithm
- Data Preparation for Decision Tree

Related Topics
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Decision Tree
- Automatic Data Preparation
- Model Detail Views for Decision Tree
- OML4SQL Examples
- OML4R Decision Tree Example
- OML4R Code Examples

15.1 About Decision Tree

Decision tree is a supervised machine learning algorithm used for classifying data. Decision tree has a tree structure built top-down that has a root node, branches, and leaf nodes.

In some applications of Oracle Machine Learning for SQL, the reason for predicting one outcome or another may not be important in evaluating the overall quality of a model. In others, the ability to explain the reason for a decision can be crucial. You can use decision tree rules to validate models in such problems. The Decision Tree algorithm, like Naive Bayes, is based on conditional probabilities. Unlike Naive Bayes, decision trees generate rules. A rule is a conditional statement that can be understood by humans and used within a database to identify a set of records.

For example, a Marketing professional requires complete descriptions of customer segments to launch a successful marketing campaign. The Decision Tree algorithm is ideal for this type of application.

Use decision tree rules to validate models. If the rules make sense to a subject matter expert, then this validates the model.
15.1.1 Decision Tree Rules

Introduces decision tree rules.

Oracle Machine Learning for SQL supports several algorithms that provide rules. In addition to decision trees, clustering algorithms provide rules that describe the conditions shared by the members of a cluster, and association rules provide rules that describe associations between attributes.

Rules provide model transparency, a window on the inner workings of the model. Rules show the basis for the model's predictions. Oracle Machine Learning for SQL supports a high level of model transparency. While some algorithms provide rules, all algorithms provide model details. You can examine model details to determine how the algorithm handles the attributes internally, including transformations and reverse transformations. Transparency is discussed in the context of data preparation and in the context of model building in Oracle Machine Learning for SQL User's Guide.

The following figure shows a rule generated by a Decision Tree model. This rule comes from a decision tree that predicts the probability that customers increase spending if given a loyalty card. A target value of 0 means not likely to increase spending; 1 means likely to increase spending.

**Figure 15-1 Sample Decision Tree Rule**

<table>
<thead>
<tr>
<th>Predicted Target Value: 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support: 0.0693</td>
</tr>
<tr>
<td>Confidence: 0.7404</td>
</tr>
<tr>
<td>Cases: 104</td>
</tr>
<tr>
<td>Level: 3</td>
</tr>
</tbody>
</table>

Split Rules: Full Rule Surrogate

YRS_RESIDENCE > 3.5 AND
EDUCATION is in { Assoc-A Bach, Masters PhD ProfSc } AND
CUST_MARITAL_STATUS is in { Divorc, Mabsent Mar-AF NeverM Separ Widowed }

The rule shown in the figure represents the conditional statement:

IF (current residence > 3.5 and has college degree and is single)
THEN predicted target value = 0

This rule is a full rule. A surrogate rule is a related attribute that can be used at apply time if the attribute needed for the split is missing.

**Related Topics**

- Understanding Reverse Transformations
- Model Detail Views for Decision Tree
- Clustering

Learn how to discover natural groupings in the data through clustering - the unsupervised machine learning technique.
15.1.1 Confidence and Support

Confidence and support are properties of rules. These statistical measures can be used to rank the rules and hence the predictions.

**Support**: The number of records in the training data set that satisfy the rule.

**Confidence**: The likelihood of the predicted outcome, given that the rule has been satisfied.

For example, consider a list of 1000 customers (1000 cases). Out of all the customers, 100 satisfy a given rule. Of these 100, 75 are likely to increase spending, and 25 are not likely to increase spending. The support of the rule is 100/1000 (10%). The confidence of the prediction (likely to increase spending) for the cases that satisfy the rule is 75/100 (75%).

15.1.2 Advantages of Decision Trees

Learn about the advantages of the Decision Tree algorithm.

The Decision Tree algorithm produces accurate and interpretable models with relatively little user intervention. The algorithm can be used for both binary and multiclass classification problems.

The algorithm is fast, both at build time and apply time. The build process for Decision Tree supports parallel execution. (Scoring supports parallel execution irrespective of the algorithm.)

Decision Tree scoring is especially fast. The tree structure, created in the model build, is used for a series of simple tests, (typically 2-7). Each test is based on a single predictor. It is a membership test: either IN or NOT IN a list of values (categorical predictor); or LESS THAN or EQUAL TO some value (numeric predictor).

**Related Topics**

- Oracle Database VLDB and Partitioning Guide

15.1.3 XML for Decision Tree Models

Learn about generating XML representation of Decision Tree models.

You can generate XML representing a Decision Tree model; the generated XML satisfies the definition specified in the Predictive Model Markup Language (PMML) version 2.1 specification.

**Related Topics**

- http://www.dmg.org

15.2 Growing a Decision Tree

Predict a target value by a sequence of questions to form or grow a decision tree. A sample here shows how to grow a decision tree.
A decision tree predicts a target value by asking a sequence of questions. At a given stage in the sequence, the question that is asked depends upon the answers to the previous questions. The goal is to ask questions that, taken together, uniquely identify specific target values. Graphically, this process forms a tree structure.

**Figure 15-2  Sample Decision Tree**

The figure is a decision tree with nine nodes (and nine corresponding rules). The target attribute is binary: 1 if the customer increases spending, 0 if the customer does not increase spending. The first split in the tree is based on the CUST_MARITAL_STATUS attribute. The root of the tree (node 0) is split into nodes 1 and 3. Married customers are in node 1; single customers are in node 3.

The rule associated with node 1 is:

Node 1 recordCount=712,0 Count=382, 1 Count=330
CUST_MARITAL_STATUS isIN "Married", surrogate:HOUSEHOLD_SIZE isIn "3""4-5"

Node 1 has 712 records (cases). In all 712 cases, the CUST_MARITAL_STATUS attribute indicates that the customer is married. Of these, 382 have a target of 0 (not likely to increase spending), and 330 have a target of 1 (likely to increase spending).

15.2.1 Splitting

The Decision Tree algorithm offers metrics for splitting the cases (records).

During the training process, the Decision Tree algorithm must repeatedly find the most efficient way to split a set of cases (records) into two child nodes. Oracle Machine Learning for SQL offers two homogeneity metrics, gini and entropy, for calculating the splits. The default metric is gini.
Homogeneity metrics assess the quality of alternative split conditions and select the one that results in the most homogeneous child nodes. Homogeneity is also called purity; it refers to the degree to which the resulting child nodes are made up of cases with the same target value. The objective is to maximize the purity in the child nodes. For example, if the target can be either yes or no (does or does not increase spending), the objective is to produce nodes where most of the cases either increase spending or most of the cases do not increase spending.

15.2.2 Cost Matrix

Learn about a cost matrix for the Decision Tree algorithm.

All classification algorithms, including Decision Tree, support a cost-benefit matrix at apply time. You can use the same cost matrix for building and scoring a decision tree model, or you can specify a different cost/benefit matrix for scoring.

Related Topics

- Costs
- Priors and Class Weights

Learn about Priors and Class Weights in a classification model to produce a useful result.

15.2.3 Preventing Over-Fitting

Understand over-fitting in trees and what can you do to resolve over-fitting.

In principle, the Decision Tree algorithm can grow each branch of the tree deeply enough to perfectly classify the training examples. While this is sometimes a reasonable strategy, in fact it can lead to difficulties when there is noise in the data, or when the number of training examples is too small to produce a representative sample of the true target function. In either of these cases, this simple algorithm can produce trees that over-fit the training examples. Over-fit is a condition where a model is able to accurately predict the data used to create the model, but does poorly on new data presented to it.

To prevent over-fitting, Oracle Machine Learning for SQL supports automatic pruning and configurable limit conditions that control tree growth. Limit conditions prevent further splits once the conditions have been satisfied. Pruning removes branches that have insignificant predictive power.

15.3 Tuning the Decision Tree Algorithm

Fine tune the Decision Tree algorithm with various parameters.

The Decision Tree algorithm is implemented with reasonable defaults for splitting and termination criteria. However several build settings are available for fine tuning.

You can specify a homogeneity metric for finding the optimal split condition for a tree. The default metric is gini. The entropy metric is also available.

Settings for controlling the growth of the tree are also available. You can specify the maximum depth of the tree, the minimum number of cases required in a child node, the minimum number of cases required in a node in order for a further split to be possible, the minimum number of cases in a child node, and the minimum number of cases required in a node in order for a further split to be possible.
The training data attributes are binned as part of the algorithm’s data preparation. You can alter the number of bins used by the binning step. There is a trade-off between the number of bins used and the time required for the build.

**See Also:**
DBMS_DATA_MINING —Algorithm Settings: Decision Tree for a listing and description of the available model settings.

**Note:**
The term hyperparameter is also interchangeably used for model setting.

## 15.4 Data Preparation for Decision Tree

The Decision Tree algorithm manages its own data preparation internally. It does not require pretreatment of the data.

Decision Tree is not affected by Automatic Data Preparation (ADP).

**Related Topics**
- Prepare the Data
16 Expectation Maximization

Learn how to use expectation maximization clustering algorithm.

- About Expectation Maximization
- Algorithm Enhancements
- Configuring the Algorithm
- Data Preparation for Expectation Maximization

Related Topics
- Clustering Algorithms
  Learn different clustering algorithms used in Oracle Machine Learning for SQL.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Expectation Maximization
- Automatic Data Preparation
- Model Detail Views for Expectation Maximization
- OML4SQL Examples
- OML4R Expectation Maximization Example
- OML4R Code Examples

16.1 About Expectation Maximization

Expectation maximization (EM) estimation of mixture models is a popular probability density estimation technique that is used in a variety of applications.

Oracle Machine Learning for SQL uses EM to implement a distribution-based clustering algorithm (EM-clustering).

16.1.1 Expectation Step and Maximization Step

The two steps to compute the likelihood of the current model and to maximize the likelihood defines the algorithm.

Expectation maximization is an iterative method. It starts with an initial parameter guess. The parameter values are used to compute the likelihood of the current model. This is the Expectation step. The parameter values are then recomputed to maximize the likelihood. This is the Maximization step. The new parameter estimates are used to compute a new expectation and then they are optimized again to maximize the likelihood. This iterative process continues until model convergence.
16.1.2 Probability Density Estimation

Compute reliable cluster assignment using probability density.

In density estimation, the goal is to construct a density function that captures how a given population is distributed. In probability density estimation, the density estimate is based on observed data that represents a sample of the population. Areas of high data density in the model correspond to the peaks of the underlying distribution.

Density-based clustering is conceptually different from distance-based clustering (for example k-Means) where emphasis is placed on minimizing inter-cluster and maximizing the intra-cluster distances. Due to its probabilistic nature, density-based clustering can compute reliable probabilities in cluster assignment. It can also handle missing values automatically.

16.2 Algorithm Enhancements

Expectation Maximization (EM) is enhanced to resolve some challenges in its standard form.

Although EM is well established as a distribution-based clustering algorithm, it presents some challenges in its standard form. The Oracle Machine Learning for SQL implementation includes significant enhancements, such as scalable processing of large volumes of data and automatic parameter initialization. The strategies that OML4SQL uses to address the inherent limitations of EM clustering are described further.

Note: The EM abbreviation is used here to refer to EM-clustering.

Limitations of Standard Expectation Maximization:

- Scalability: EM has linear scalability with the number of records and attributes. The number of iterations to convergence tends to increase with growing data size (both rows and columns). EM convergence can be slow for complex problems and can place a significant load on computational resources.
- High dimensionality: EM has limited capacity for modeling high dimensional (wide) data. The presence of many attributes slows down model convergence, and the algorithm becomes less able to distinguish between meaningful attributes and noise. The algorithm is thus compromised in its ability to find correlations.
- Number of components: EM typically requires the user to specify the number of components. In most cases, this is not information that the user can know in advance.
- Parameter initialization: The choice of appropriate initial parameter values can have a significant effect on the quality of the model. Initialization strategies that have been used for EM have generally been computationally expensive.
- From components to clusters: EM model components are often treated as clusters. This approach can be misleading since cohesive clusters are often
modeled by multiple components. Clusters that have a complex shape need to be modeled by multiple components.

16.2.1 Scalability

Expectation Maximization (EM) in Oracle Machine Learning for SQL, uses database parallel processing to achieve excellent scalability.

The OML4SQL implementation of Expectation Maximization uses database parallel processing to achieve excellent scalability. EM computations naturally lend themselves to row parallel processing, and the partial results are easily aggregated. The parallel implementation efficiently distributes the computationally intensive work across slave processes and then combines the partial results to produce the final solution.

Related Topics

• Oracle Database VLDB and Partitioning Guide

16.2.2 High Dimensionality

Process high dimensional data through Expectation Maximization.

The Oracle Machine Learning for SQL implementation of Expectation Maximization (EM) can efficiently process high-dimensional data with thousands of attributes. This is achieved through a two-fold process:

• The data space of single-column (not nested) attributes is analyzed for pair-wise correlations. Only attributes that are significantly correlated with other attributes are included in the EM mixture model. The algorithm can also be configured to restrict the dimensionality to the $M$ most correlated attributes.

• High-dimensional (nested) numerical data that measures events of similar type is projected into a set of low-dimensional features that are modeled by EM. Some examples of high-dimensional, numerical data are: text, recommendations, gene expressions, and market basket data.

16.2.3 Number of Components

The number of EM components are automatically determined.

Typical implementations of Expectation Maximization (EM) require the user to specify the number of model components. This is problematic because users do not generally know the correct number of components. Choosing too many or too few components can lead to over-fitting or under-fitting, respectively.

When model search is enabled, the number of EM components is automatically determined. The algorithm uses a held-aside sample to determine the correct number of components, except in the cases of very small data sets when Bayesian Information Criterion (BIC) regularization is used.

16.2.4 Parameter Initialization

Choosing appropriate initial parameter values can have a significant effect on the quality of the solution.
Expectation maximization (EM) is not guaranteed to converge to the global maximum of the likelihood function but may instead converge to a local maximum. Therefore different initial parameter values can lead to different model parameters and different model quality.

In the process of model search, the EM model is grown independently. As new components are added, their parameters are initialized to areas with poor distribution fit.

### 16.2.5 From Components to Clusters

Expectation Maximization produces assignment of model components to high-level clusters.

Expectation Maximization (EM) model components are often treated as clusters. However, this approach can be misleading. Cohesive clusters are often modeled by multiple components. The shape of the probability density function used in EM effectively predetermines the shape of the identified clusters. For example, Gaussian density functions can identify single peak symmetric clusters. Clusters of more complex shape need to be modeled by multiple components.

Ideally, high density areas of arbitrary shape must be interpreted as single clusters. To accomplish this, the Oracle Machine Learning for SQL implementation of EM builds a component hierarchy that is based on the overlap of the individual components’ distributions. OML4SQL EM uses agglomerative hierarchical clustering. Component distribution overlap is measured using the Bhattacharyya distance function. Choosing an appropriate cutoff level in the hierarchy automatically determines the number of high-level clusters.

The OML4SQL implementation of EM produces an assignment of the model components to high-level clusters. Statistics like means, variances, modes, histograms, and rules additionally describe the high-level clusters. The algorithm can be configured to either produce clustering assignments at the component level or at the cluster level.

### 16.3 Configuring the Algorithm

Configure Expectation Maximization (EM).

In Oracle Machine Learning for SQL, EM can effectively model very large data sets (both rows and columns) without requiring the user to supply initialization parameters or specify the number of model components. While the algorithm offers reasonable defaults, it also offers flexibility.

The following list describes some of the configurable aspects of EM:

- Whether or not independent non-nested column attributes are included in the model. The choice is system-determined by default.
- Whether to use Bernoulli or Gaussian distribution for numerical attributes. By default, the algorithm chooses the most appropriate distribution, and individual attributes may use different distributions. When the distribution is user-specified, it is used for all numerical attributes.
- Whether the convergence criterion is based on a held-aside data set or on Bayesian Information Criterion (BIC). The convergence criterion is system-determined by default.
• The percentage improvement in the value of the log likelihood function that is required to add a new component to the model. The default percentage is 0.001.

• Whether to define clusters as individual components or groups of components. Clusters are associated to groups of components by default.

• The maximum number of components in the model. If model search is enabled, the algorithm determines the number of components based on improvements in the likelihood function or based on regularization (BIC), up to the specified maximum.

• Whether the linkage function for the agglomerative clustering step uses the nearest distance within the branch (single linkage), the average distance within the branch (average linkage), or the maximum distance within the branch (complete linkage). By default the algorithm uses single linkage.

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### See Also:

**DBMS_DATA_MINING** — Algorithm Settings: Expectation Maximization for a listing and explanation of the available model settings.

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### Note:

The term hyperparameter is also interchangeably used for model setting.

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### Related Topics

- **DBMS_DATA_MINING - Global Settings**

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### 16.4 Data Preparation for Expectation Maximization

Learn how to prepare data for Expectation Maximization (EM).

If you use Automatic Data Preparation (ADP), you do not need to specify additional data preparation for Expectation Maximization. ADP normalizes numerical attributes (in non-nested columns) when they are modeled with Gaussian distributions. ADP applies a topN binning transformation to categorical attributes.

Missing value treatment is not needed since Oracle Machine Learning for SQL algorithms handle missing values automatically. The EM algorithm replaces missing values with the mean in single-column numerical attributes that are modeled with Gaussian distributions. In other single-column attributes (categoricals and numericals modeled with Bernoulli distributions), NULLs are not replaced; they are treated as a distinct value with its own frequency count. In nested columns, missing values are treated as zeros.

### Related Topics

- **Oracle Machine Learning for SQL User’s Guide**
17

Explicit Semantic Analysis

Learn how to use Explicit Semantic Analysis (ESA) as an unsupervised algorithm for feature extraction function and as a supervised algorithm for classification.

• About Explicit Semantic Analysis
• Data Preparation for ESA
• Scoring with ESA
• Terminologies in Explicit Semantic Analysis

Related Topics
• Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
• Feature Extraction
  Learn how to perform attribute reduction using feature extraction as an unsupervised function.
• DBMS_DATA_MINING - Model Settings
• DBMS_DATA_MINING — Algorithm Settings: Explicit Semantic Analysis
• Automatic Data Preparation
• Model Detail Views for Explicit Semantic Analysis
• OML4SQL Examples
• OML4R Explicit Semantic Analysis Example
• OML4R Code Examples

17.1 About Explicit Semantic Analysis

In Oracle Database 12c Release 2, Explicit Semantic Analysis (ESA) was introduced as an unsupervised algorithm for feature extraction. Starting from Oracle Database 18c, ESA is enhanced as a supervised algorithm for classification.

As a feature extraction algorithm, ESA does not discover latent features but instead uses explicit features represented in an existing knowledge base. As a feature extraction algorithm, ESA is mainly used for calculating semantic similarity of text documents and for explicit topic modeling. As a classification algorithm, ESA is primarily used for categorizing text documents. Both the feature extraction and classification versions of ESA can be applied to numeric and categorical input data as well.

The input to ESA is a set of attributes vectors. Every attribute vector is associated with a concept. The concept is a feature in the case of feature extraction or a target class in the case of classification. For feature extraction, only one attribute vector may be associated with any feature. For classification, the training set may contain multiple attribute vectors associated with any given target class. These rows related to one target class are aggregated into one by the ESA algorithm.
The output of ESA is a sparse attribute-concept matrix that contains the most important attribute-concept associations. The strength of the association is captured by the weight value of each attribute-concept pair. The attribute-concept matrix is stored as a reverse index that lists the most important concepts for each attribute.

**Note:**

For feature extraction the ESA algorithm does not project the original feature space and does not reduce its dimensionality. ESA algorithm filters out features with limited or uninformative set of attributes.

The scope of classification tasks that ESA handles is different than the classification algorithms such as Naive Bayes and Support Vector Machine. ESA can perform large scale classification with the number of distinct classes up to hundreds of thousands. The large scale classification requires gigantic training data sets with some classes having significant number of training samples whereas others are sparsely represented in the training data set.

### 17.1.1 Scoring with ESA

A typical feature extraction application of Explicit Semantic Analysis (ESA) is to identify the most relevant features of a given input and score their relevance. Scoring an ESA model produces data projections in the concept feature space.

If an ESA model is built from an arbitrary collection of documents, then each one is treated as a feature. You can then identify the most relevant documents in the collection. The feature extraction functions are: `FEATURE_DETAILS`, `FEATURE_ID`, `FEATURE_SET`, `FEATURE_VALUE`, and `FEATURE_COMPARE`.

A typical classification application of ESA is to predict classes of a given document and estimate the probabilities of the predictions. As a classification algorithm, ESA implements the following scoring functions: `PREDICTION`, `PREDICTION_PROBABILITY`, `PREDICTION_SET`, `PREDICTION_DETAILS`, `PREDICTION_COST`.

**Related Topics**
- Oracle Machine Learning for SQL User's Guide
- Oracle Database SQL Language Reference

### 17.1.2 Scoring Large ESA Models

Building an Explicit Semantic Analysis (ESA) model on a large collection of text documents can result in a model with many features or titles.

The model information for scoring is loaded into System Global Area (SGA) as a shared (shared pool size) library cache object. Different SQL predictive queries can reference this object. When the model size is large, it is necessary to set the SGA parameter in the database to a sufficient size that accommodates large objects. If the SGA is too small, the model may need to be re-loaded every time it is referenced which is likely to lead to performance degradation.
17.2 ESA for Text Analysis

Learn how Explicit Semantic Analysis (ESA) can be used for machine learning operations on text.

Explicit knowledge often exists in text form. Multiple knowledge bases are available as collections of text documents. These knowledge bases can be generic, for example, Wikipedia, or domain-specific. Data preparation transforms the text into vectors that capture attribute-concept associations. ESA is able to quantify semantic relatedness of documents even if they do not have any words in common. The function FEATURE_COMPARE can be used to compute semantic relatedness.

Related Topics
• Oracle Database SQL Language Reference

17.3 Data Preparation for ESA

Automatic Data Preparation normalizes input vectors to a unit length for Explicit Semantic Analysis (ESA).

When there are missing values in columns with simple data types (not nested), ESA replaces missing categorical values with the mode and missing numerical values with the mean. When there are missing values in nested columns, ESA interprets them as sparse. The algorithm replaces sparse numeric data with zeros and sparse categorical data with zero vectors. The Oracle Machine Learning for SQL data preparation transforms the input text into a vector of real numbers. These numbers represent the importance of the respective words in the text.

See Also:
DBMS_DATA_MINING —Algorithm Settings: Explicit Semantic Analysis for a listing and explanation of the available model settings.

Note:
The term hyperparameter is also interchangeably used for model setting.

17.4 Terminologies in Explicit Semantic Analysis

Discusses the terms associated with Explicit Semantic Analysis (ESA).

Multi-target Classification

The training items in these large scale classifications belong to several classes. The goal of classification in such case is to detect possible multiple target classes for one item. This kind of classification is called multi-target classification. The target column for ESA-based classification is extended. Collections are allowed as target column values. The collection type for the target in ESA-based classification is ORA_MINING_VARCHAR2_NT.

Large-scale classification
Large-scale classification applies to ontologies that contain gigantic numbers of categories, usually ranging in tens or hundreds of thousands. This large-scale classification also requires gigantic training datasets which are usually unbalanced, that is, some classes may have significant number of training samples whereas others may be sparsely represented in the training dataset. Large-scale classification normally results in multiple target class assignments for a given test case.

**Topic modeling**

Topic modelling refers to derivation of the most important topics of a document. Topic modeling can be explicit or latent. Explicit topic modeling results in the selection of the most relevant topics from a pre-defined set, for a given document. Explicit topics have names and can be verbalized. Latent topic modeling identifies a set of latent topics characteristic for a collection of documents. A subset of these latent topics is associated with every document under examination. Latent topics do not have verbal descriptions or meaningful interpretation.

**Related Topics**

- *Oracle Database PL/SQL Packages and Types Reference*
18

Exponential Smoothing

Learn about the Exponential Smoothing algorithm.

• About Exponential Smoothing
• Data Preparation for Exponential Smoothing Models

Related Topics
• Time Series
  Learn about time series as an Oracle Machine Learning for SQL regression function.
• DBMS_DATA_MINING - Model Settings
• DBMS_DATA_MINING — Algorithm Settings: Exponential Smoothing
• Automatic Data Preparation
• Model Detail Views for Exponential Smoothing
• OML4SQL Examples
• OML4R Code Examples

18.1 About Exponential Smoothing

Exponential smoothing is a forecasting method for time-series data. It is a moving average method where exponentially decreasing weights are assigned to past observations.

Exponential smoothing methods have been widely used in forecasting for over half a century. It has applications at the strategic, tactical, and operation level. For example, at a strategic level, forecasting is used for projecting return on investment, growth and the effect of innovations. At a tactical level, forecasting is used for projecting costs, inventory requirements, and customer satisfaction. At an operational level, forecasting is used for setting targets and predicting quality and conformance with standards.

In its simplest form, exponential smoothing is a moving average method with a single parameter which models an exponentially decreasing effect of past levels on future values. With a variety of extensions, exponential smoothing covers a broader class of models than competitors, such as the Box-Jenkins auto-regressive integrated moving average (ARIMA) approach. Oracle Machine Learning for SQL implements exponential smoothing using a state of the art state space method that incorporates a single source of error (SSOE) assumption which provides theoretical and performance advantages.

Exponential smoothing is extended to the following:

• A matrix of models that mix and match error type (additive or multiplicative), trend (additive, multiplicative, or none), and seasonality (additive, multiplicative, or none)
• Models with damped trends.
• Models that directly handle irregular time series and time series with missing values.
18.1.1 Exponential Smoothing Models

Exponential Smoothing models are a broad class of forecasting models that are intuitive, flexible, and extensible.

Members of this class include simple, single parameter models that predict the future as a linear combination of a previous level and a current shock. Extensions can include parameters for linear or non-linear trend, trend damping, simple or complex seasonality, related series, various forms of non-linearity in the forecasting equations, and handling of irregular time series.

Exponential smoothing assumes that a series extends infinitely into the past, but that influence of past on future, decays smoothly and exponentially fast. The smooth rate of decay is expressed by one or more smoothing constants. The smoothing constants are parameters that the model estimates. The assumption is made practical for modeling real world data by using an equivalent recursive formulation that is only expressed in terms of an estimate of the current level based on prior history and a shock to that estimate dependent on current conditions only. The procedure requires an estimate for the time period just prior to the first observation, that encapsulates all prior history. This initial observation is an additional model parameter whose value is estimated by the modeling procedure.

Components of ESM such as trend and seasonality extensions, can have an additive or multiplicative form. The simpler additive models assume that shock, trend, and seasonality are linear effects within the recursive formulation.

18.1.2 Simple Exponential Smoothing

Simple exponential smoothing assumes the data fluctuates around a stationary mean, with no trend or seasonal pattern.

In a simple Exponential Smoothing model, each forecast (smoothed value) is computed as the weighted average of the previous observations, where the weights decrease exponentially depending on the value of smoothing constant $\alpha$. Values of the smoothing constant, $\alpha$, near one, put almost all weight on the most recent observations. Values of $\alpha$ near zero allows the distant past observations to have a large influence.

18.1.3 Models with Trend but No Seasonality

The preferred form of additive (linear) trend is sometimes called Holt's method or double exponential smoothing.

Models with trend add a smoothing parameter $\gamma$ and optionally a damping parameter $\phi$. The damping parameter smoothly dampens the influence of past linear trend on future estimates of level, often improving accuracy.
18.1.4 Models with Seasonality but No Trend

When the time series average does not change over time (stationary), but is subject to seasonal fluctuations, the appropriate model has seasonal parameters but no trend.

Seasonal fluctuations are assumed to balance out over periods of length $m$, where $m$ is the number of seasons. For example, $m=4$ might be used when the input data are aggregated quarterly. For models with additive errors, the seasonal parameters must sum to zero. For models with multiplicative errors, the product of seasonal parameters must be one.

18.1.5 Models with Trend and Seasonality

Holt and Winters introduced both trend and seasonality in an Exponential Smoothing model. The original model, also known as Holt-Winters or triple exponential smoothing, considered an additive trend and multiplicative seasonality. Extensions include models with various combinations of additive and multiplicative trend, seasonality and error, with and without trend damping.

18.1.6 Prediction Intervals

To compute prediction intervals, an Exponential Smoothing (ESM) model is divided into three classes.

The simplest class is the class of linear models, which include, among others, simple ESM, Holt’s method, and additive Holt-Winters. Class 2 models (multiplicative error, additive components) make an approximate correction for violations of the Normality assumption. Class 3 modes use a simple simulation approach to calculate prediction intervals.

18.2 Data Preparation for Exponential Smoothing Models

Learn about preparing the data for an Exponential Smoothing (ESM) model.

To build an ESM model, you must supply the following:

- Input data
- An aggregation level and method, if the case id is a date type
- Partitioning column, if the data are partitioned

In addition, for a greater control over the build process, the user may optionally specify model build parameters, all of which have defaults:

- Model
- Error type
- Optimization criterion
- Forecast Window
- Confidence level for forecast bounds
- Missing value handling
- Whether the input series is evenly spaced
18.2.1 Input Data

Time series analysis, requires ordered input data. Hence, each data row must consist of an [index, value] pair, where the index specifies the ordering.

When the `CREATE_MODEL` procedure is used to initiate an Exponential Smoothing (ESM) model build, the `CASE_ID_COLUMN_NAME` specifies the column used to compute the indices of the input and the `TARGET_COLUMN_NAME` specifies the column used to compute the observed time series values. The time column bears Oracle number, or Oracle date, timestamp, timestamp with time zone, or timestamp with local time zone. The input time series are sorted according to the values of `CASE_ID` (time label). The case id column cannot contain missing values. The value column can contain missing values indicated as `NULL`. ESM also supports partitioned models and in such cases, the input table contains an extra column specifying the partition. All [index, value] pairs with the same partition ID form one complete time series. The Exponential Smoothing algorithm constructs models for each partition independently, although all models use the same model settings.

Properties of the data can result in a warning message or settings are ignored. Settings are ignored when if the user specifies a model with either multiplicative trend, multiplicative seasonality or both and the data contains values \( Y_t \leq 0 \), then the model type is set to the default. If the series contain fewer values than the number of user-specified seasons, then the seasonality specifications are ignored with a warning.

18.2.2 Accumulation

For the Exponential Smoothing algorithm, the accumulation procedure is applied when the column is a date type (`date`, `datetime`, `timestamp`, `timestamp with time zone`, or `timestamp with local timezone`).

The case id can be a `NUMBER` column whose sort index represents the position of the value in the time series sequence of values. The case id column can also be a date type. A date type is accumulated in accordance with a user specified accumulation window. Regardless of type, the case id is used to transform the column into an equally spaced time series. No accumulation is applied for a case id of type `NUMBER`. As an example, consider a time series about promotion events. The time column contains the date of each event, and the dates can be unequally spaced. The user must specify
the spacing interval, which is the spacing of the accumulated or transformed equally spaced
time series. In the example, if the user specifies the interval to be month, then an equally
spaced time series with profit for each calendar month is generated from the original time
series. Setting \texttt{EXSM\_INTERVAL} is used to specify the spacing interval. The user must also
specify a value for \texttt{EXSM\_ACCUMULATE}, for example, \texttt{EXSM\_ACCU\_MAX}, in which case the equally
spaced monthly series would contain the maximum profit over all events that month as the
observed time series value.

18.2.3 Missing Value

Input time series can contain missing values. A \texttt{NULL} entry in the target column indicates a
missing value. When the time column is of the type datetime, the accumulation procedure
can also introduce missing values. The setting \texttt{EXSM\_SETMISSING} can be used to specify how
to handle missing values. The special value \texttt{EXSM\_MISS\_AUTO} indicates that, if the series
contains missing values it is to be treated as an irregular time series.

\begin{itemize}
  \item \textbf{Note:}
  \begin{itemize}
    \item Missing value handling setting must be compatible with model setting, otherwise an
          error is thrown.
  \end{itemize}
\end{itemize}

18.2.4 Prediction

An Exponential Smoothing (ESM) model can be applied to make predictions by specifying the
prediction window.

Setting \texttt{EXSM\_PREDICTION\_STEP} can be used to specify the prediction window. The prediction
window is expressed in terms of number of intervals (setting \texttt{EXSM\_INTERVAL}), when the time
column is of the type datetime. If the time column is a number then the prediction window is
the number of steps to forecast. Regardless of whether the time series is regular or irregular,
\texttt{EXSM\_PREDICTION\_STEP} specifies the prediction window.

\begin{itemize}
  \item \textbf{See Also:}
  \begin{itemize}
    \item \emph{Oracle Database PL/SQL Packages and Types Reference} for a listing and
          explanation of the available model settings.
  \end{itemize}
\end{itemize}

\begin{itemize}
  \item \textbf{Note:}
  \begin{itemize}
    \item The term hyperparameter is also interchangeably used for model setting.
  \end{itemize}
\end{itemize}

18.2.5 Parallellism by Partition

Oracle Machine Learning for SQL supports parallellism by partition.

For example, a user can choose \texttt{PRODUCT\_ID} as one partition column and can generate
forecasts for different products in a model build. Although a distinct smoothing model is built
for each partition, all partitions share the same model settings. For example, if setting EXSM_MODEL is set to EXSM_SIMPLE, all partition models will be simple Exponential Smoothing models. Time series from different partitions can be distributed to different processes and processed in parallel. The model for each time series is built serially.
Learn how to use Generalized Linear Model (GLM) statistical technique for linear modeling. Oracle Machine Learning for SQL supports GLM for regression and binary classification.

- About Generalized Linear Model
- GLM in Oracle Machine Learning for SQL
- Scalable Feature Selection
- Tuning and Diagnostics for GLM
- GLM Solvers
- Data Preparation for GLM
- Linear Regression
- Logistic Regression

Related Topics
- Regression
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- Feature Selection
  Learn how to perform feature selection and attribute importance.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Generalized Linear Models
- Automatic Data Preparation
- Model Detail Views for Generalized Linear Model
- OML4SQL Examples
- OML4R Generalized Linear Model Example
- OML4R Code Examples

19.1 About Generalized Linear Model

Learn about Generalized Linear Model (GLM) models include and extend the class of linear models which address and accommodate some restrictive assumptions of the linear models.

Linear models make a set of restrictive assumptions, most importantly, that the target (dependent variable $y$) is normally distributed conditioned on the value of predictors with a constant variance regardless of the predicted response value. The advantage of linear models and their restrictions include computational simplicity, an interpretable model form, and the ability to compute certain diagnostic information about the quality of the fit.
GLM relaxes these restrictions, which are often violated in practice. For example, binary (yes/no or 0/1) responses do not have same variance across classes. Furthermore, the sum of terms in a linear model typically can have very large ranges encompassing very negative and very positive values. For the binary response example, we would like the response to be a probability in the range [0,1].

GLM accommodates responses that violate the linear model assumptions through two mechanisms: a link function and a variance function. The link function transforms the target range to potentially -infinity to +infinity so that the simple form of linear models can be maintained. The variance function expresses the variance as a function of the predicted response, thereby accommodating responses with non-constant variances (such as the binary responses).

Oracle Machine Learning for SQL includes two of the most popular members of the GLM family of models with their most popular link and variance functions:

- **Linear regression** with the identity link and variance function equal to the constant 1 (constant variance over the range of response values).
- **Logistic regression** with the logit link and binomial variance functions.

19.2 GLM in Oracle Machine Learning for SQL

Learn how Oracle Machine Learning for SQL implements the Generalized Linear Model (GLM) algorithm.

GLM is a parametric modeling technique. Parametric models make assumptions about the distribution of the data. When the assumptions are met, parametric models can be more efficient than non-parametric models.

The challenge in developing models of this type involves assessing the extent to which the assumptions are met. For this reason, quality diagnostics are key to developing quality parametric models.

19.2.1 Interpretability and Transparency

You can interpret and understand key characteristics of Generalized Linear Model (GLM) model through model details and global details.

You can interpret Oracle Machine Learnings’ GLM with ease. Each model build generates many statistics and diagnostics. Transparency is also a key feature: model details describe key characteristics of the coefficients, and global details provide high-level statistics.

Related Topics
- **Tuning and Diagnostics for GLM**
19.2.2 Wide Data

Generalized Linear Model (GLM) in Oracle Machine Learning for SQL is uniquely suited for handling wide data. The algorithm can build and score quality models that use a virtually limitless number of predictors (attributes). The only constraints are those imposed by system resources.

19.2.3 Confidence Bounds

Predict confidence bounds through the Generalized Linear Model (GLM) algorithm.

GLM have the ability to predict confidence bounds. In addition to predicting a best estimate and a probability (classification only) for each row, GLM identifies an interval wherein the prediction (regression) or probability (classification) lies. The width of the interval depends upon the precision of the model and a user-specified confidence level.

The confidence level is a measure of how sure the model is that the true value lies within a confidence interval computed by the model. A popular choice for confidence level is 95%. For example, a model might predict that an employee’s income is $125K, and that you can be 95% sure that it lies between $90K and $160K. Oracle Machine Learning for SQL supports 95% confidence by default, but that value can be configured.

Note:

Confidence bounds are returned with the coefficient statistics. You can also use the \texttt{PREDICTION_BOUNDS} SQL function to obtain the confidence bounds of a model prediction.

Related Topics
• Oracle Database SQL Language Reference

19.2.4 Ridge Regression

Understand the use of ridge regression for singularity (exact multicollinearity) in data.

The best regression models are those in which the predictors correlate highly with the target, but there is very little correlation between the predictors themselves. \textit{Multicollinearity} is the term used to describe multivariate regression with correlated predictors.

\textbf{Ridge regression} is a technique that compensates for multicollinearity. Oracle Machine Learning for SQL supports ridge regression for both regression and classification machine learning techniques. The algorithm automatically uses ridge if it detects singularity (exact multicollinearity) in the data.

Information about singularity is returned in the global model details.

Related Topics
• Global Model Statistics for Linear Regression
• Global Model Statistics for Logistic Regression
19.2.4.1 Configuring Ridge Regression

Configure ridge regression through build settings.

You can choose to explicitly enable ridge regression by specifying a build setting for the model. If you explicitly enable ridge, you can use the system-generated ridge parameter or you can supply your own. If ridge is used automatically, the ridge parameter is also calculated automatically.

The configuration choices are summarized as follows:

- Whether or not to override the automatic choice made by the algorithm regarding ridge regression
- The value of the ridge parameter, used only if you specifically enable ridge regression.

See Also:
Oracle Database PL/SQL Packages and Types Reference for a listing and explanation of the available model settings.

Note:
The term hyperparameter is also interchangeably used for model setting.

19.2.4.2 Ridge and Confidence Bounds

Models built with ridge regression do not support confidence bounds.

Related Topics
- Confidence Bounds
  Predict confidence bounds through the Generalized Linear Model (GLM) algorithm.

19.2.4.3 Ridge and Data Preparation

Learn about preparing data for ridge regression.

When ridge regression is enabled, different data preparation is likely to produce different results in terms of model coefficients and diagnostics. Oracle recommends that you enable Automatic Data Preparation for Generalized Linear Model models, especially when ridge regression is used.

Related Topics
- Data Preparation for GLM
  Learn about preparing data for the Generalized Linear Model (GLM) algorithm.
19.3 Scalable Feature Selection

Oracle Machine Learning for SQL supports a highly scalable and automated version of feature selection and generation for the Generalized Linear Model algorithm.

This scalable and automated capability can enhance the performance of the algorithm and improve accuracy and interpretability. Feature selection and generation are available for both linear regression and binary logistic regression.

19.3.1 Feature Selection

Feature selection is the process of choosing the terms to be included in the model. The fewer terms in the model, the easier it is for human beings to interpret its meaning. In addition, some columns may not be relevant to the value that the model is trying to predict. Removing such columns can enhance model accuracy.

19.3.1.1 Configuring Feature Selection

Feature selection is a build setting for Generalized Linear Model models. It is not enabled by default. When configured for feature selection, the algorithm automatically determines appropriate default behavior, but the following configuration options are available:

- The feature selection criteria can be AIC, SBIC, RIC, or α-investing. When the feature selection criteria is α-investing, feature acceptance can be either strict or relaxed.
- The maximum number of features can be specified.
- Features can be pruned in the final model. Pruning is based on t-statistics for linear regression or wald statistics for logistic regression.

19.3.1.2 Feature Selection and Ridge Regression

Feature selection and ridge regression are mutually exclusive. When feature selection is enabled, the algorithm can not use ridge.

> **Note:**
>
> If you configure the model to use both feature selection and ridge regression, then you get an error.

19.3.2 Feature Generation

Feature generation is the process of adding transformations of terms into the model. Feature generation enhances the power of models to fit more complex relationships between target and predictors.

19.3.2.1 Configuring Feature Generation

Learn about configuring feature generation.
Feature generation is only possible when feature selection is enabled. Feature generation is a build setting. By default, feature generation is not enabled.

The feature generation method can be either quadratic or cubic. By default, the algorithm chooses the appropriate method. You can also explicitly specify the feature generation method.

The following options for feature selection also affect feature generation:

- Maximum number of features
- Model pruning

Related Topics

- Oracle Database PL/SQL Packages and Types Reference

19.4 Tuning and Diagnostics for GLM

The process of developing a Generalized Linear Model model typically involves a number of model builds. Each build generates many statistics that you can evaluate to determine the quality of your model. Depending on these diagnostics, you may want to try changing the model settings or making other modifications.

19.4.1 Build Settings

Specify the build settings for Generalized Linear Model (GLM).

You can use specify build settings.

Additional build settings are available to:

- Control the use of ridge regression.
- Specify the handling of missing values in the training data.
- Specify the target value to be used as a reference in a logistic regression model.

See Also:

DBMS_DATA_MINING — Algorithm Settings: Generalized Linear Models for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.

Related Topics

- Ridge Regression
  Understand the use of ridge regression for singularity (exact multicollinearity) in data.
- Data Preparation for GLM
  Learn about preparing data for the Generalized Linear Model (GLM) algorithm.
19.4.2 Diagnostics

A Generalized Linear Model model generates many metrics to help you evaluate the quality of the model.

19.4.2.1 Coefficient Statistics

Learn about coefficient statistics for linear and logistic regression.

The same set of statistics is returned for both linear and logistic regression, but statistics that do not apply to the machine learning technique are returned as NULL.

Coefficient statistics are returned by the model detail views for a Generalized Linear Model (GLM) model.

Related Topics

- Coefficient Statistics for Linear Regression
- Coefficient Statistics for Logistic Regression
- Oracle Machine Learning for SQL User’s Guide

19.4.2.2 Global Model Statistics

Learn about high-level statistics describing the model.

Separate high-level statistics describing the model as a whole, are returned for linear and logistic regression. When ridge regression is enabled, fewer global details are returned.

Global statistics are returned by the model detail views for a Generalized Linear Model model.

Related Topics

- Global Model Statistics for Linear Regression
- Global Model Statistics for Logistic Regression
- Ridge Regression
  Understand the use of ridge regression for singularity (exact multicollinearity) in data.
- Oracle Machine Learning for SQL User’s Guide

19.4.2.3 Row Diagnostics

Generate row-statistics by configuring the Generalized Linear Model (GLM) algorithm.

GLM generates per-row statistics if you specify the name of a diagnostics table in the build setting GLMS_DIAGNOSTICS_TABLE_NAME.

GLM requires a case ID to generate row diagnostics. If you provide the name of a diagnostic table but the data does not include a case ID column, an exception is raised.

Related Topics

- Row Diagnostics for Linear Regression
- Row Diagnostics for Logistic Regression
19.5 GLM Solvers

Generalized Linear Model (GLM) algorithm applies different solvers. These solvers employ different approaches for optimization.

The GLM algorithm supports four different solvers: Cholesky, QR, Stochastic Gradient Descent (SGD), and Alternating Direction Method of Multipliers (ADMM) (on top of L-BFGS). The Cholesky and QR solvers employ classical decomposition approaches. The Cholesky solver is faster compared to the QR solver but less stable numerically. The QR solver handles better rank deficient problems without the help of regularization.

The SGD and ADMM (on top of L-BFGS) solvers are best suited for large scale data. The SGD solver employs the stochastic gradient descent optimization algorithm while ADMM (on top of L-BFGS) uses the Broyden-Fletcher-Goldfarb-Shanno optimization algorithm within an Alternating Direction Method of Multipliers framework. The SGD solver is fast but is sensitive to parameters and requires suitable scaled data to achieve good convergence. The L-BFGS algorithm solves unconstrained optimization problems and is more stable and robust than SGD. Also, L-BFGS uses ADMM in conjunction, which, results in an efficient distributed optimization approach with low communication cost.

Related Topics

- DBMS_DATA_MINING - Algorithm Settings: Neural Network
- DBMS_DATA_MINING — Algorithm Settings: Generalized Linear Models
- DBMS_DATA_MINING — Algorithm Settings: ADMM
- DBMS_DATA_MINING — Algorithm Settings: LBFGS

19.6 Data Preparation for GLM

Learn about preparing data for the Generalized Linear Model (GLM) algorithm.

Automatic Data Preparation (ADP) implements suitable data transformations for both linear and logistic regression.

See Also:

DBMS_DATA_MINING —Algorithm Settings: Generalized Linear Models for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting. Oracle recommends that you use ADP with GLM.

Related Topics

- Oracle Machine Learning for SQL User’s Guide
19.6.1 Data Preparation for Linear Regression

Learn about Automatic Data Preparation (ADP) for the Generalized Linear Model (GLM) algorithm.

When ADP is enabled, the algorithm chooses a transformation based on input data properties and other settings. The transformation can include one or more of the following for numerical data: subtracting the mean, scaling by the standard deviation, or performing a correlation transformation (Neter, et. al, 1990). If the correlation transformation is applied to numeric data, it is also applied to categorical attributes.

Prior to standardization, categorical attributes are exploded into N-1 columns where N is the attribute cardinality. The most frequent value (mode) is omitted during the explosion transformation. In the case of highest frequency ties, the attribute values are sorted alpha-numerically in ascending order, and the first value on the list is omitted during the explosion. This explosion transformation occurs whether or not ADP is enabled.

In the case of high cardinality categorical attributes, the described transformations (explosion followed by standardization) can increase the build data size because the resulting data representation is dense. To reduce memory, disk space, and processing requirements, use an alternative approach. Under these circumstances, the VIF statistic must be used with caution.

Related Topics

- Ridge and Data Preparation
  Learn about preparing data for ridge regression.

See Also:


19.6.2 Data Preparation for Logistic Regression

Categorical attributes are exploded into N-1 columns where N is the attribute cardinality. The most frequent value (mode) is omitted during the explosion transformation. In the case of highest frequency ties, the attribute values are sorted alpha-numerically in ascending order and the first value on the list is omitted during the explosion. This explosion transformation occurs whether or not Automatic Data Preparation (ADP) is enabled.

When ADP is enabled, numerical attributes are scaled by the standard deviation. This measure of variability is computed as the standard deviation per attribute with respect to the origin (not the mean) (Marquardt, 1980).

See Also:

19.6.3 Missing Values

When building or applying a model, Oracle Machine Learning for SQL automatically replaces missing values of numerical attributes with the mean and missing values of categorical attributes with the mode.

You can configure the Generalized Linear Model algorithm to override the default treatment of missing values. With the `ODMS_MISSING_VALUE_TREATMENT` setting, you can cause the algorithm to delete rows in the training data that have missing values instead of replacing them with the mean or the mode. However, when the model is applied, OML4SQL performs the usual mean/mode missing value replacement. As a result, it is possible that the statistics generated from scoring does not match the statistics generated from building the model.

If you want to delete rows with missing values in the scoring the model, you must perform the transformation explicitly. To make build and apply statistics match, you must remove the rows with NULLs from the scoring data before performing the apply operation. You can do this by creating a view.

```
CREATE VIEW viewname AS SELECT * from tablename
    WHERE column_name1 is NOT NULL
    AND column_name2 is NOT NULL
    AND column_name3 is NOT NULL ......
```

**Note:**

In OML4SQL, missing values in nested data indicate sparsity, not values missing at random.

The value `ODMS_MISSING_VALUE_DELETE_ROW` is only valid for tables without nested columns. If this value is used with nested data, an exception is raised.

19.7 Linear Regression

Oracle Machine Learning for SQL supports linear regression as the Generalized Linear Model regression algorithm. The algorithm assumes no target transformation and constant variance over the range of target values.

19.7.1 Coefficient Statistics for Linear Regression

Generalized Linear Model regression models generate the following coefficient statistics:

- Linear coefficient estimate
- Standard error of the coefficient estimate
- t-value of the coefficient estimate
- Probability of the t-value
- Variance Inflation Factor (VIF)
- Standardized estimate of the coefficient
• Lower and upper confidence bounds of the coefficient

19.7.2 Global Model Statistics for Linear Regression

Generalized Linear Model regression models generate the following statistics that describe the model as a whole:

• Model degrees of freedom
• Model sum of squares
• Model mean square
• Model $F$ statistic
• Model $F$ value probability
• Error degrees of freedom
• Error sum of squares
• Error mean square
• Corrected total degrees of freedom
• Corrected total sum of squares
• Root mean square error
• Dependent mean
• Coefficient of variation
• R-Square
• Adjusted R-Square
• Akaike's information criterion
• Schwarz's Baysian information criterion
• Estimated mean square error of the prediction
• Hocking Sp statistic
• JP statistic (the final prediction error)
• Number of parameters (the number of coefficients, including the intercept)
• Number of rows
• Whether or not the model converged
• Whether or not a covariance matrix was computed

19.7.3 Row Diagnostics for Linear Regression

For linear regression, the diagnostics table has the columns described in the following table. All the columns are NUMBER, except the CASE_ID column, which preserves the type from the training data.

Table 19-1  Diagnostics Table for GLM Regression Models

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE_ID</td>
<td>Value of the case ID column</td>
</tr>
</tbody>
</table>
### Table 19-1 (Cont.) Diagnostics Table for GLM Regression Models

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARGET_VALUE</td>
<td>Value of the target column</td>
</tr>
<tr>
<td>PREDICTED_VALUE</td>
<td>Value predicted by the model for the target</td>
</tr>
<tr>
<td>HAT</td>
<td>Value of the diagonal element of the hat matrix</td>
</tr>
<tr>
<td>RESIDUAL</td>
<td>Measure of error</td>
</tr>
<tr>
<td>STD_ERR_RESIDUAL</td>
<td>Standard error of the residual</td>
</tr>
<tr>
<td>STUDENTIZED_RESIDUAL</td>
<td>Studentized residual</td>
</tr>
<tr>
<td>PRED_RES</td>
<td>Predicted residual</td>
</tr>
<tr>
<td>COOKS_D</td>
<td>Cook's D influence statistic</td>
</tr>
</tbody>
</table>

### 19.8 Logistic Regression

Oracle Machine Learning for SQL supports binary logistic regression as a Generalized Linear Model classification algorithm. The algorithm uses the logit link function and the binomial variance function.

#### 19.8.1 Reference Class

You can use the build setting `GLMS_REFERENCE_CLASS_NAME` to specify the target value to be used as a reference in a binary logistic regression model. Probabilities are produced for the other (non-reference) class. By default, the algorithm chooses the value with the highest prevalence. If there are ties, the attributes are sorted alphanumerically in an ascending order.

#### 19.8.2 Class Weights

You can use the build setting `CLAS_WEIGHTS_TABLE_NAME` to specify the name of a class weights table. Class weights influence the weighting of target classes during the model build.

#### 19.8.3 Coefficient Statistics for Logistic Regression

Generalized Linear Model classification models generate the following coefficient statistics:

- Name of the predictor
- Coefficient estimate
- Standard error of the coefficient estimate
- Wald chi-square value of the coefficient estimate
- Probability of the Wald chi-square value
- Standardized estimate of the coefficient
- Lower and upper confidence bounds of the coefficient
- Exponentiated coefficient
19.8.4 Global Model Statistics for Logistic Regression

Generalized Linear Model classification models generate the following statistics that describe the model as a whole:

- Exponentiated coefficient for the upper and lower confidence bounds of the coefficient
- Akaike's criterion for the fit of the intercept only model
- Akaike's criterion for the fit of the intercept and the covariates (predictors) model
- Schwarz's criterion for the fit of the intercept only model
- Schwarz's criterion for the fit of the intercept and the covariates (predictors) model
- -2 log likelihood of the intercept only model
- -2 log likelihood of the model
- Likelihood ratio degrees of freedom
- Likelihood ratio chi-square probability value
- Pseudo R-square Cox an Snell
- Pseudo R-square Nagelkerke
- Dependent mean
- Percent of correct predictions
- Percent of incorrect predictions
- Percent of ties (probability for two cases is the same)
- Number of parameters (the number of coefficients, including the intercept)
- Number of rows
- Whether or not the model converged
- Whether or not a covariance matrix was computed.

19.8.5 Row Diagnostics for Logistic Regression

For logistic regression, the diagnostics table has the columns described in the following table. All the columns are NUMBER, except the CASE_ID and TARGET_VALUE columns, which preserve the type from the training data.

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE_ID</td>
<td>Value of the case ID column</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Value of the target value</td>
</tr>
<tr>
<td>TARGET_VALUE_PROB</td>
<td>Probability associated with the target value</td>
</tr>
<tr>
<td>HAT</td>
<td>Value of the diagonal element of the hat matrix</td>
</tr>
<tr>
<td>WORKING_RESIDUAL</td>
<td>Residual with respect to the adjusted dependent variable</td>
</tr>
<tr>
<td>PEARSON_RESIDUAL</td>
<td>The raw residual scaled by the estimated standard deviation of the target</td>
</tr>
<tr>
<td>DEVIANCE_RESIDUAL</td>
<td>Contribution to the overall goodness of fit of the model</td>
</tr>
</tbody>
</table>
### Table 19-2  (Cont.) Row Diagnostics Table for Logistic Regression

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Confidence interval displacement diagnostic</td>
</tr>
<tr>
<td>CBAR</td>
<td>Confidence interval displacement diagnostic</td>
</tr>
<tr>
<td>DIFDEV</td>
<td>Change in the deviance due to deleting an individual observation</td>
</tr>
<tr>
<td>DIFCHISQ</td>
<td>Change in the Pearson chi-square</td>
</tr>
</tbody>
</table>
Oracle Machine Learning for SQL supports enhanced k-Means clustering algorithm. Learn how to use the algorithm.

- About k-Means
- k-Means Algorithm Configuration
- Data Preparation for k-Means

Related Topics
- Clustering Algorithms
  Learn different clustering algorithms used in Oracle Machine Learning for SQL.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: k-Means
- Automatic Data Preparation
- Model Detail Views for k-Means
- OML4SQL Examples
- OML4R k-Means Example
- OML4R Code Examples

20.1 About k-Means

The k-Means algorithm is a distance-based clustering algorithm that partitions the data into a specified number of clusters.

Distance-based algorithms rely on a distance function to measure the similarity between cases. Cases are assigned to the nearest cluster according to the distance function used.

20.1.1 Oracle Machine Learning for SQL Enhanced k-Means

Implementation of k-Means in Oracle Machine Learning for SQL.

OML4SQL implements an enhanced version of the k-Means algorithm with the following features:

- **Distance function**: The algorithm supports Euclidean and Cosine distance functions. The default is Euclidean.


- **Cluster properties**: For each cluster, the algorithm returns the centroid, a histogram for each attribute, and a rule describing the hyperbox that encloses the majority of the data.
assigned to the cluster. The centroid reports the mode for categorical attributes and the mean and variance for numerical attributes.

This approach to k-Means avoids the need for building multiple k-Means models and provides clustering results that are consistently superior to the traditional k-Means.

20.1.2 Centroid

Defines a centroid in a cluster.

The centroid represents the most typical case in a cluster. For example, in a data set of customer ages and incomes, the centroid of each cluster would be a customer of average age and average income in that cluster. The centroid is a prototype. It does not necessarily describe any given case assigned to the cluster.

The attribute values for the centroid are the mean of the numerical attributes and the mode of the categorical attributes.

20.2 k-Means Algorithm Configuration

Learn about configuring the k-Means algorithm.

The Oracle Machine Learning for SQL enhanced k-Means algorithm supports several build-time settings. All the settings have default values. There is no reason to override the defaults unless you want to influence the behavior of the algorithm in some specific way.

You can configure k-Means by specifying the following considerations:

• Number of clusters
• Distance Function. The default distance function is Euclidean.

See Also:

DBMS_DATA_MINING —Algorithm Settings: k-Means for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.

20.3 Data Preparation for k-Means

Learn about preparing data for k-Means algorithm.

Normalization is typically required by the k-Means algorithm. Automatic Data Preparation performs normalization for k-Means. If you do not use ADP, you must normalize numeric attributes before creating or applying the model.

When there are missing values in columns with simple data types (not nested), k-Means interprets them as missing at random. The algorithm replaces missing categorical values with the mode and missing numerical values with the mean.
When there are missing values in nested columns, $k$-Means interprets them as sparse. The algorithm replaces sparse numerical data with zeros and sparse categorical data with zero vectors.

**Related Topics**

- *Oracle Database PL/SQL Packages and Types Reference*
- Prepare the Data
21
Minimum Description Length

Learn how to use Minimum Description Length, the supervised technique for calculating attribute importance.

- About MDL
- Data Preparation for MDL

Related Topics
- Feature Selection
  Learn how to perform feature selection and attribute importance.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING — Automatic Data Preparation
- Model Detail Views for Minimum Description Length
- OML4SQL Examples
- OML4R Code Examples

21.1 About MDL

Minimum Description Length (MDL) is an information theoretic model selection principle.

Information theoretic model selection principle is an important concept in information theory (the study of the quantification of information) and in learning theory (the study of the capacity for generalization based on empirical data).

MDL assumes that the simplest, most compact representation of the data is the best and most probable explanation of the data. The MDL principle is used to build Oracle Machine Learning for SQL attribute importance models.

The build process for attribute importance supports parallel execution.

Related Topics
- Oracle Database VLDB and Partitioning Guide

21.1.1 Compression and Entropy

Data compression is the process of encoding information using fewer bits than what the original representation uses. The MDL Principle is based on the notion that the shortest description of the data is the most probable. In typical instantiations of this principle, a model is used to compress the data by reducing the uncertainty (entropy) as discussed below. The description of the data includes a description of the model and the data as described by the model.

Entropy is a measure of uncertainty. It quantifies the uncertainty in a random variable as the information required to specify its value. Information in this sense is defined as the number...
of yes/no questions known as **bits** (encoded as 0 or 1) that must be answered for a complete specification. Thus, the information depends upon the number of values that variable can assume.

For example, if the variable represents the sex of an individual, then the number of possible values is two: female and male. If the variable represents the salary of individuals expressed in whole dollar amounts, then the values can be in the range $0-$10B, or billions of unique values. Clearly it takes more information to specify an exact salary than to specify an individual's sex.

21.1.1.1 Values of a Random Variable: Statistical Distribution

Information (the number of bits) depends on the statistical distribution of the values of the variable as well as the number of values of the variable. If we are judicious in the choice of Yes/No questions, then the amount of information for salary specification cannot be as much as it first appears. Most people do not have billion dollar salaries. If most people have salaries in the range $32000-$64000, then most of the time, it requires only 15 questions to discover their salary, rather than the 30 required, if every salary from $0-$100000000 were equally likely. In the former example, if the persons were known to be pregnant, then their sex is known to be female. There is no uncertainty, no Yes/No questions need be asked. The entropy is 0.

21.1.1.2 Values of a Random Variable: Significant Predictors

Suppose that for some random variable there is a predictor that when its values are known reduces the uncertainty of the random variable. For example, knowing whether a person is pregnant or not, reduces the uncertainty of the random variable sex-of-individual. This predictor seems like a valuable feature to include in a model. How about name? Imagine that if you knew the name of the person, you would also know the person's sex. If so, the name predictor would seemingly reduce the uncertainty to zero. However, if names are unique, then what was gained? Is the person named Sally? Is the person named George?... We would have as many Yes/No predictors in the name model as there are people. Therefore, specifying the name model would require as many bits as specifying the sex of each person.

21.1.1.3 Total Entropy

For a random variable, X, the **total entropy** is defined as minus the Probability(X) multiplied by the log to the base 2 of the Probability(X). This can be shown to be the variable's most efficient encoding.

21.1.2 Model Size

A Minimum Description Length (MDL) model takes into consideration the size of the model as well as the reduction in uncertainty due to using the model. Both model size and entropy are measured in bits. For our purposes, both numeric and categorical predictors are binned. Thus the size of each single predictor model is the number of predictor bins. The uncertainty is reduced to the within-bin target distribution.

21.1.3 Model Selection

Minimum Description Length (MDL) considers each attribute as a simple predictive model of the target class. **Model selection** refers to the process of comparing and ranking the single-predictor models.
MDL uses a communication model for solving the model selection problem. In the communication model there is a sender, a receiver, and data to be transmitted.

These single predictor models are compared and ranked with respect to the MDL metric, which is the relative compression in bits. MDL penalizes model complexity to avoid over-fit. It is a principled approach that takes into account the complexity of the predictors (as models) to make the comparisons fair.

### 21.1.4 The MDL Metric

Attribute importance uses a two-part code as the metric for transmitting each unit of data. The first part (preamble) transmits the model. The parameters of the model are the target probabilities associated with each value of the prediction.

For a target with \( j \) values and a predictor with \( k \) values, \( n_i \) (\( i = 1, \ldots, k \)) rows per value, there are \( C_i \), the combination of \( j-1 \) things taken \( n_i-1 \) at a time possible conditional probabilities. The size of the preamble in bits can be shown to be \( \text{Sum}(\log_2(C_i)) \), where the sum is taken over \( k \).

Computation like this represent the penalties associated with each single prediction model. The second part of the code transmits the target values using the model.

It is well known that the most compact encoding of a sequence is the encoding that best matches the probability of the symbols (target class values). Thus, the model that assigns the highest probability to the sequence has the smallest target class value transmission cost. In bits, this is the \( \text{Sum}(\log_2(p_i)) \), where the \( p_i \) are the predicted probabilities for row \( i \) associated with the model.

The predictor rank is the position in the list of associated description lengths, smallest first.

### 21.2 Data Preparation for MDL

Learn about preparing data for Minimum Description Length (MDL).

Automatic Data Preparation performs supervised binning for MDL. Supervised binning uses decision trees to create the optimal bin boundaries. Both categorical and numerical attributes are binned.

MDL handles missing values naturally as missing at random. The algorithm replaces sparse numerical data with zeros and sparse categorical data with zero vectors. Missing values in nested columns are interpreted as sparse. Missing values in columns with simple data types are interpreted as missing at random.

If you choose to manage your own data preparation, keep in mind that MDL usually benefits from binning. However, the discriminating power of an attribute importance model can be significantly reduced when there are outliers in the data and external equal-width binning is used. This technique can cause most of the data to concentrate in a few bins (a single bin in extreme cases). In this case, quantile binning is a better solution.

See Also:

DBMS_DATA_MINING — Automatic Data Preparation for a listing and explanation of the available model settings.
Note:
The term hyperparameter is also interchangeably used for model setting.

Related Topics
• Prepare the Data
Multivariate State Estimation Technique - Sequential Probability Ratio Test

The Multivariate State Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT) algorithm monitors critical processes and detects subtle anomalies.

- About Multivariate State Estimation Technique - Sequential Probability Ratio Test
- Score an MSET-SPRT Model

Related Topics
- Anomaly Detection
  Learn how to detect rare cases in the data through anomaly detection - an unsupervised function.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Multivariate State Estimation Technique - Sequential Probability Ratio Test
- Automatic Data Preparation
- Model Detail View for Multivariate State Estimation Technique - Sequential Probability Ratio Test
- OML4SQL Examples
- OML4R Code Examples

22.1 About Multivariate State Estimation Technique - Sequential Probability Ratio Test

Multivariate state Estimation Technique - Sequential Probability Ratio Test (MSET-SPRT) is an algorithm for anomaly detection and statistical testing.

MSET is a nonlinear, nonparametric anomaly detection machine learning technique that calibrates the expected behavior of a system based on historical data from the normal operational sequence of monitored signals. It incorporates the learned behavior of a system into a persistent model that represents the normal estimated behavior. You can deploy the model to evaluate a subsequent stream of live signal vectors using OML4SQL scoring functions. To form a hypothesis as to the overall health of the system, these functions calculate the difference between the estimated and the actual signal values (residuals) and use SPRT calculations to determine whether any of the signals have become degraded.

To build a good model, MSET requires sufficient historical data that adequately captures all normal modes of behavior of the system. Incomplete data results in false alerts when the system enters a mode of operation that was poorly represented in the historical data. MSET assumes that the characteristics of the data being monitored do not change over time. Once deployed, MSET is a stationary model and does not evolve as it monitors a data stream.
Both MSET and SPRT operate on continuous time-ordered sensor data. If the raw data stream needs to be pre-processed or sampled, you must do that before you pass the data to the MSET-SPRT model.

The `ALGO_MSET_SPRT` algorithm is designated as a classification machine learning technique. It generates a model in which each data row is labeled as either normal or anomalous. For anomalous predictions, the prediction details provide a list of the sensors that show the anomaly and a weight.

When creating an MSET-SPRT model with the `DBMS_DATA_MINING.CREATE_MODEL` function, use the `case_id` argument to provide a unique row identifier for the time-ordered data that the algorithm requires. The build is then able to sort the training data and create windows for sampling and variance estimation. If you do not provide a `case_id`, then an exception occurs.

MSET-SPRT supports only numeric data. An exception occurs if other column types are in the build data.

When the number of sensors is very high, MSET-SPRT leverages random projections to improve the scalability and robustness of the algorithm. Random projections is a technique that reduces dimensionality while preserving pairwise distances. By randomly projecting the sensor data, the problem is solved in a distance-preserving, lower-dimension space. The MSET hypothesis testing approach is applied on the projected data where each random projection can be viewed as a Monte Carlo simulation of system health. The overall probability of an anomaly follows a binomial distribution with the number of projections as the number of trials and the number of alerting projections as the number of successes.

**Note:**

An MSET-SPRT model with random projections does not produce prediction details. When random projections are employed, the nature of the prediction output changes. The prediction captures the global health of the system and it is not possible to attribute the cause to individual attributes. Therefore, `PREDICTION_DETAILS` returns an empty list.

**See Also:**

`DBMS_DATA_MINING - Algorithm Settings: Multivariate State Estimation Technique - Sequential Probability Ratio Test` for a listing and explanation of the available model settings.

**Note:**

The term hyperparameter is also interchangeably used for model setting.

**Related Topics**

- `DBMS_DATA_MINING - Algorithm Settings: Multivariate State Estimation Technique - Sequential Probability Ratio Test`
22.2 Score an MSET-SPRT Model

Scoring data with MSET-SPRT models is similar to scoring with classification algorithms, except that the SPRT methodology relies on ordered data because it tracks gradual shifts over multiple MSET predictions.

This is different than the typical usage of Oracle Database SQL prediction functions, which do not keep state information between rows.

The following functions are supported: `PREDICTION`, `PREDICTION_COST`, `PREDICTION_DETAILS`, `PREDICTION_PROBABILITY`, and `PREDICTION_SET`. These functions have syntax new in Oracle Database 21c for scoring MSET-SPRT models. That syntax has an `ORDER BY` clause to order and window the historical data.

The prediction functions return the following information:

- `PREDICTION` indicates whether the record is flagged as anomalous. It uses the same automatically generated labels as one-class SVM models: 1 for normal and 0 for anomalous.
- `PREDICTION_COST` performs an auto-cost analysis or a user-specified cost. A user-specified cost typically assigns a higher cost to false positives than to false negatives.
- `PREDICTION_DETAILS` specify the signals that support the prediction along with a weight.
- `PREDICTION_PROBABILITY` conveys a measure of certainty based on the consolidation logic.
- `PREDICTION_SET` returns the set of predictions (0, 1) and the corresponding prediction probabilities for each observation.

Note:

If the values in one or more of the columns specified in the `ORDER BY` clause are not unique, or do not represent a true chronology of data sample values, the SPRT predictions are not guaranteed to be meaningful or consistent between query executions.

Unlike other classification models, an MSET-SPRT model has no obvious probability measure associated with the anomalous label for the record as a whole. However, the consolidation logic can produce a measure of uncertainty in place of probability. For example, if an alert is raised for 2 anomalies over a window of 5 observations, a certainty of 0.5 is reported when 2 anomalies are seen within the 5 observation window. The certainty increases if more than 3 anomalies are seen and decreases if no anomalies are seen.

The `PREDICTION_DETAILS` function accommodates output of varying forms and can convey the required information regarding the individual signals that triggered an alarm. When random projections are engaged, only the overall `PREDICTION` and `PREDICTION_PROBABILITY` are computed and `PREDICTION_DETAILS` are not reported.

You must score the historical data in order to tune the SPRT parameters, such as false alerts and miss rates or consolidation logic, before you deploy the MSET model. The SPRT parameters are embedded in the model object to facilitate deployment. While scoring in the database is needed for parameter tuning and forensic analysis on historical data, monitoring
a stream of sensor data is more easily done outside of the database in an IoT service or on the edge device itself.

You can build and score an MSET-SPRT model as a partitioned model if the same columns that you use to build the model are present in the input scoring data set. If those columns are not present, the query results in an error.

**Related Topics**

- SQL Scoring Functions
- SQL Scoring Functions
- MSET_SPRT example on GitHub
23

Naive Bayes

Learn how to use the Naive Bayes classification algorithm.

- About Naive Bayes
- Tuning a Naive Bayes Model
- Data Preparation for Naive Bayes

Related Topics
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Naive Bayes
- Automatic Data Preparation
- Model Detail Views for Naive Bayes
- OML4SQL Examples
- OML4R Naive Bayes Example
- OML4R Code Examples

23.1 About Naive Bayes

Naive Bayes algorithm is based on conditional probabilities. It uses Bayes' theorem, a formula that calculates a probability by counting the frequency of values and combinations of values in the historical data.

Bayes' theorem finds the probability of an event occurring given the probability of another event that has already occurred. If $B$ represents the dependent event and $A$ represents the prior event, Bayes' theorem can be stated as follows.

\[
\text{Note: } \quad \text{Prob}(B \text{ given } A) = \frac{\text{Prob}(A \text{ and } B)}{\text{Prob}(A)}
\]

To calculate the probability of $B$ given $A$, the algorithm counts the number of cases where $A$ and $B$ occur together and divides it by the number of cases where $A$ occurs alone.
Example 23-1  Use Bayes' Theorem to Predict an Increase in Spending

Suppose you want to determine the likelihood that a customer under 21 increases spending. In this case, the prior condition (A) is “under 21,” and the dependent condition (B) is “increase spending.”

If there are 100 customers in the training data and 25 of them are customers under 21 who have increased spending, then:

\[ \text{Prob}(A \text{ and } B) = 25\% \]

If 75 of the 100 customers are under 21, then:

\[ \text{Prob}(A) = 75\% \]

Bayes' theorem predicts that 33% of customers under 21 are likely to increase spending (25/75).

The cases where both conditions occur together are referred to as **pairwise**. In Example 23-1, 25% of all cases are pairwise.

The cases where only the prior event occurs are referred to as **singleton**. In Example 23-1, 75% of all cases are singleton.

A visual representation of the conditional relationships used in Bayes' theorem is shown in the following figure.

**Figure 23-1  Conditional Probabilities in Bayes' Theorem**

For purposes of illustration, Example 23-1 and Figure 23-1 show a dependent event based on a single independent event. In reality, the Naive Bayes algorithm must usually take many independent events into account. In Example 23-1, factors such as income, education, gender, and store location might be considered in addition to age.

Naive Bayes makes the assumption that each predictor is conditionally independent of the others. For a given target value, the distribution of each predictor is independent of the other predictors. In practice, this assumption of independence, even when violated, does not degrade the model's predictive accuracy significantly, and makes the difference between a fast, computationally feasible algorithm and an intractable one.

Sometimes the distribution of a given predictor is clearly not representative of the larger population. For example, there might be only a few customers under 21 in the
training data, but in fact there are many customers in this age group in the wider customer base. To compensate for this, you can specify prior probabilities when training the model.

**Related Topics**
- Priors and Class Weights
  Learn about Priors and Class Weights in a classification model to produce a useful result.

### 23.1.1 Advantages of Naive Bayes

Learn about the advantages of Naive Bayes.

The Naive Bayes algorithm affords fast, highly scalable model building and scoring. It scales linearly with the number of predictors and rows.

The build process for Naive Bayes supports parallel execution. (Scoring supports parallel execution irrespective of the algorithm.)

Naive Bayes can be used for both binary and multiclass classification problems.

**Related Topics**
- Oracle Database VLDB and Partitioning Guide

### 23.2 Tuning a Naive Bayes Model

Introduces about probability calculation of pairwise occurrences and percentage of singleton occurrences.

Naive Bayes calculates a probability by dividing the percentage of pairwise occurrences by the percentage of singleton occurrences. If these percentages are very small for a given predictor, they probably do not contribute to the effectiveness of the model. Occurrences below a certain threshold can usually be ignored.

The following build settings are available for adjusting the probability thresholds. You can specify:

- The minimum percentage of pairwise occurrences required for including a predictor in the model.
- The minimum percentage of singleton occurrences required for including a predictor in the model.

The default thresholds work well for most models, so you need not adjust these settings.

**See Also:**
- DBMS_DATA_MINING — Algorithm Settings: Naive Bayes for a listing and explanation of the available model settings.

**Note:**
- The term hyperparameter is also interchangeably used for model setting.
23.3 Data Preparation for Naive Bayes

Learn about preparing the data for Naive Bayes.

Automatic Data Preparation (ADP) performs supervised binning for Naive Bayes. Supervised binning uses decision trees to create the optimal bin boundaries. Both categorical and numeric attributes are binned.

Naive Bayes handles missing values naturally as missing at random. The algorithm replaces sparse numerical data with zeros and sparse categorical data with zero vectors. Missing values in nested columns are interpreted as sparse. Missing values in columns with simple data types are interpreted as missing at random.

If you choose to manage your own data preparation, keep in mind that Naive Bayes usually requires binning. Naive Bayes relies on counting techniques to calculate probabilities. Columns must be binned to reduce the cardinality as appropriate. Numerical data can be binned into ranges of values (for example, low, medium, and high), and categorical data can be binned into meta-classes (for example, regions instead of cities). Equi-width binning is not recommended, since outliers cause most of the data to concentrate in a few bins, sometimes a single bin. As a result, the discriminating power of the algorithms is significantly reduced.

**Related Topics**

- Prepare the Data
Neural Network

Learn about the Neural Network algorithms for regression and classification machine learning techniques.

- About Neural Network
- Data Preparation for Neural Network
- Neural Network Algorithm Configuration
- Scoring with Neural Network

Related Topics
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- Regression
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING — Algorithm Settings: Neural Network
- Automatic Data Preparation
- Model Detail Views for Neural Network
- OML4SQL Examples
- OML4R Neural Network Example
- OML4R Code Examples

24.1 About Neural Network

The Neural Network algorithm in Oracle Machine Learning for SQL is designed for machine learning techniques like classification and regression.

In machine learning, an artificial neural network is an algorithm inspired from biological neural network and is used to estimate or approximate functions that depend on a large number of generally unknown inputs. An artificial neural network is composed of a large number of interconnected neurons which exchange messages between each other to solve specific problems. They learn by examples and tune the weights of the connections among the neurons during the learning process. The Neural Network algorithm is capable of solving a wide variety of tasks such as computer vision, speech recognition, and various complex business problems.

Related Topics
- Regression
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.
• **Classification**
  Learn how to predict a categorical target through classification - the supervised machine learning technique.

### 24.1.1 Neurons and Activation Functions

Neurons are the building blocks of a neural network.

A neuron takes one or more inputs having different weights and has an output which depends on the inputs. The output is achieved by adding up inputs of each neuron with weights and feeding the sum into the activation function.

A Sigmoid function is usually the most common choice for activation function but other non-linear functions, piecewise linear functions or step functions are also used. The **Rectified Linear Units function** `NNET_ACTIVATIONS_RELU` is a commonly used activation function that addresses the vanishing gradient problem for larger neural networks.

The following are some examples of activation functions:

- Logistic Sigmoid function
- Linear function
- Tanh function
- Arctan function
- Bipolar sigmoid function
- Rectified Linear Units

### 24.1.2 Loss or Cost function

A loss function or cost function is a function that maps an event or values of one or more variables onto a real number intuitively representing some “cost” associated with the event.

An optimization problem seeks to minimize a loss function. The form of loss function is chosen based on the nature of the problem and mathematical needs.

The following are the different loss functions for different scenarios:

- Binary classification: cross entropy function.
- Multi-class classification: softmax function.
- Regression: squared error function.

### 24.1.3 Forward-Backward Propagation

Understand forward-backward propagation.

Forward propagation computes the loss function value by weighted summing the previous layer neuron values and applying activation functions. Backward propagation calculates the gradient of a loss function with respect to all the weights in the network. The weights are initialized with a set of random numbers uniformly distributed within a region specified by user (by setting weights boundaries), or region defined by the number of nodes in the adjacent layers (data driven). The gradients are fed to an optimization method which in turn uses them to update the weights, in an attempt to minimize the loss function.
24.1.4 Optimization Solvers

An optimization solver is a function that searches for the optimal solution of the loss function to find the extreme value (maximum or minimum) of the loss (cost) function.


**Limited-memory Broyden–Fletcher–Goldfarb–Shanno Solver**

L-BFGS is a Quasi-Newton method. This method uses rank-one updates specified by gradient evaluations to approximate a Hessian matrix. This method only needs a limited amount of memory. L-BFGS is used to find the descent direction and line search is used to find the appropriate step size. The number of historical copies kept in the L-BFGS solver is defined by the `LBFGS_HISTORY_DEPTH` solver setting. When the number of iterations is smaller than the history depth, the Hessian computed by L-BFGS is accurate. When the number of iterations is larger than the history depth, the Hessian computed by L-BFGS is an approximation. Therefore, the history depth should not be too small or too large to avoid making the computation too slow. Typically, the value is between 3 and 10.

**Adam Solver**

Adam is an extension to stochastic gradient descent that uses mini-batch optimization. The L-BFGS solver may be a more stable solver whereas the Adam solver can make progress faster by seeing less data. Adam is computationally efficient, with little memory requirements, and is well-suited for problems that are large in terms of data or parameters or both.

24.1.5 Regularization

Understand regularization.

Regularization refers to a process of introducing additional information to solve an ill-posed problem or to prevent over-fitting. Ill-posed or over-fitting can occur when a statistical model describes random errors or noise instead of the underlying relationship. Typical regularization techniques include L1-norm regularization, L2-norm regularization, and held-aside.

Held-aside is usually used for large training date sets whereas L1-norm regularization and L2-norm regularization are mostly used for small training date sets.

24.1.6 Convergence Check

This checks if the optimal solution has been reached and if the iterations of the optimization has come to an end.

In L-BFGS solver, the convergence criteria includes maximum number of iterations, infinity norm of gradient, and relative error tolerance. For held-aside regularization, the convergence criteria checks the loss function value of the test data set, as well as the best model learned so far. The training is terminated when the model becomes worse for a specific number of iterations (specified by `NNET_HELDASIDE_MAX_FAIL`), or the loss function is close to zero, or the relative error on test data is less than the tolerance.
24.1.7 LBFGS_SCALE_HESSIAN

Defines LBFGS_SCALE_HESSIAN. It specifies how to set the initial approximation of the inverse Hessian at the beginning of each iteration. If the value is set to be LBFGS_SCALE_HESSIAN_ENABLE, then we approximate the initial inverse Hessian with Oren-Luenberger scaling. If it is set to be LBFGS_SCALE_HESSIAN_DISABLE, then we use identity as the approximation of the inverse Hessian at the beginning of each iteration.

Related Topics
• Oracle Database PL/SQL Packages and Types Reference

24.1.8 NNET_HELDASIDE_MAX_FAIL

Defines NNET_HELDASIDE_MAX_FAIL. Validation data (held-aside) is used to stop training early if the network performance on the validation data fails to improve or remains the same for NNET_HELDASIDE_MAX_FAIL epochs in a row.

Related Topics
• Oracle Database PL/SQL Packages and Types Reference

24.2 Data Preparation for Neural Network

Learn about preparing data for the Neural Network algorithm. The algorithm automatically "explodes" categorical data into a set of binary attributes, one per category value. Oracle Machine Learning for SQL algorithms automatically handle missing values and therefore, missing value treatment is not necessary. The algorithm automatically replaces missing categorical values with the mode and missing numerical values with the mean. The algorithm requires the normalization of numeric input and it uses z-score normalization. The normalization occurs only for two-dimensional numeric columns (not nested). Normalization places the values of numeric attributes on the same scale and prevents attributes with a large original scale from biasing the solution. Neural Network scales the numeric values in nested columns by the maximum absolute value seen in the corresponding columns.

Related Topics
• Prepare the Data

24.3 Neural Network Algorithm Configuration

Configure the Neural Network algorithm.

Specify Nodes Per Layer

```
INSERT INTO SETTINGS_TABLE (setting_name, setting_value) VALUES
    ('NNET_NODES_PER_LAYER', '2,3');
```
Specify Activation Functions Per Layer

The `NNET_ACTIVATIONS` setting specifies the activation functions or hidden layers.

See Also:

- DBMS_DATA_MINING —Algorithm Settings: Neural Network for a listing and explanation of the available model settings.

Note:

- The term hyperparameter is also interchangeably used for model setting.

24.4 Scoring with Neural Network

Learn to score with a Neural Network algorithm.

Scoring with Neural Network is the same as any other classification or regression algorithm. The following functions are supported: `PREDICTION`, `PREDICTION_PROBABILITY`, `PREDICTION_COST`, `PREDICTION_SET`, and `PREDICTION_DETAILS`.

Related Topics

- *Oracle Database SQL Language Reference*
Non-Negative Matrix Factorization

Learn how to use Non-Negative Matrix Factorization (NMF), an unsupervised algorithm, that Oracle Machine Learning for SQL uses for feature extraction.

- About NMF
- Tuning the NMF Algorithm
- Data Preparation for NMF

Related Topics
- Feature Extraction
  Learn how to perform attribute reduction using feature extraction as an unsupervised function.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING — Algorithm Settings: Non-Negative Matrix Factorization
- Automatic Data Preparation
- Model Detail Views for Non-Negative Matrix Factorization
- OML4SQL Examples
- OML4R Non-Negative Matrix Factorization Example
- OML4R Code Examples

See Also:

Paper "Learning the Parts of Objects by Non-Negative Matrix Factorization" by D. D. Lee and H. S. Seung in Nature (401, pages 788-791, 1999)

25.1 About NMF

Non-Negative Matrix Factorization is useful when there are many attributes and the attributes are ambiguous or have weak predictability. By combining attributes, NMF can produce meaningful patterns, topics, or themes. NMF is a feature extraction algorithm.

Each feature created by NMF is a linear combination of the original attribute set. Each feature has a set of coefficients, which are a measure of the weight of each attribute on the feature. There is a separate coefficient for each numerical attribute and for each distinct value of each categorical attribute. The coefficients are all non-negative.
25.1.1 Matrix Factorization

Non-Negative Matrix Factorization uses techniques from multivariate analysis and linear algebra. It decomposes the data as a matrix $M$ into the product of two lower ranking matrices $W$ and $H$. The sub-matrix $W$ contains the NMF basis; the sub-matrix $H$ contains the associated coefficients (weights).

The algorithm iteratively modifies the values of $W$ and $H$ so that their product approaches $M$. The technique preserves much of the structure of the original data and guarantees that both basis and weights are non-negative. The algorithm terminates when the approximation error converges or a specified number of iterations is reached.

The NMF algorithm must be initialized with a seed to indicate the starting point for the iterations. Because of the high dimensionality of the processing space and the fact that there is no global minimization algorithm, the appropriate initialization can be critical in obtaining meaningful results. Oracle Machine Learning for SQL uses a random seed that initializes the values of $W$ and $H$ based on a uniform distribution. This approach works well in most cases.

25.1.2 Scoring with NMF

Non-Negative Matrix Factorization (NMF) can be used as a pre-processing step for dimensionality reduction in classification, regression, clustering, and other machine learning tasks. Scoring an NMF model produces data projections in the new feature space. The magnitude of a projection indicates how strongly a record maps to a feature.

The SQL scoring functions for feature extraction support NMF models. When the functions are invoked with the analytical syntax, the functions build and apply a transient NMF model. The feature extraction functions are: FEATUER_DETAILS, FEATURE_ID, FEATURE_SET, and FEATURE_VALUE.

Related Topics

- Oracle Machine Learning for SQL User’s Guide

25.1.3 Text Analysis with NMF

Learn about text analysis with Non-Negative Matrix Factorization (NMF).

NMF is especially well-suited for analyzing text. In a text document, the same word can occur in different places with different meanings. For example, "hike" can be applied to the outdoors or to interest rates. By combining attributes, NMF introduces context, which is essential for explanatory power:

- "hike" + "mountain" -> "outdoor sports"
- "hike" + "interest" -> "interest rates"

Related Topics

- Oracle Machine Learning for SQL User’s Guide
25.2 Tuning the NMF Algorithm

Learn about configuring parameters for Non-Negative Matrix Factorization (NMF).

Oracle Machine Learning for SQL supports five configurable parameters for NMF. All of them have default values which are appropriate for most applications of the algorithm. The NMF settings are:

- Number of features. By default, the number of features is determined by the algorithm.
- Convergence tolerance. The default is .05.
- Number of iterations. The default is 50.
- Random seed. The default is -1.
- Non-negative scoring. You can specify whether negative numbers must be allowed in scoring results. By default they are allowed.

See Also:

DBMS_DATA_MINING —Algorithm Settings: Non-Negative Matrix Factorization for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.

25.3 Data Preparation for NMF

You can use Automatic Data Preparation (ADP) or supply your transformation like binning or normalization to prepare the data for Non-Negative Matrix Factorization (NMF).

ADP normalizes numerical attributes for NMF.

When there are missing values in columns with simple data types (not nested), NMF interprets them as missing at random. The algorithm replaces missing categorical values with the mode and missing numerical values with the mean.

When there are missing values in nested columns, NMF interprets them as sparse. The algorithm replaces sparse numerical data with zeros and sparse categorical data with zero vectors.

If you choose to manage your own data preparation, keep in mind that outliers can significantly impact NMF. Use a clipping transformation before binning or normalizing. NMF typically benefits from normalization. However, outliers with min-max normalization cause poor matrix factorization. To improve the matrix factorization, you need to decrease the error tolerance. This in turn leads to longer build times.

Related Topics

- Prepare the Data
Learn how to use orthogonal partitioning clustering (O-Cluster), an Oracle-proprietary clustering algorithm.

- **About O-Cluster**
- **Tuning the O-Cluster Algorithm**
- **Data Preparation for O-Cluster**

**Related Topics**
- **Clustering Algorithms**
  Learn different clustering algorithms used in Oracle Machine Learning for SQL.
- **DBMS_DATA_MINING - Model Settings**
- **DBMS_DATA_MINING - Algorithm Settings: O-Cluster**
- **Automatic Data Preparation**
- **Model Detail Views for O-Cluster**
- **OML4SQL Examples**
- **OML4R O-Cluster Example**
- **OML4R Code Examples**

**See Also:**
Campos, M.M., Milenova, B.L., “Clustering Large Databases with Numeric and Nominal Values Using Orthogonal Projections”, Oracle Data Mining Technologies, Oracle Corporation.

### 26.1 About O-Cluster

O-Cluster is a fast, scalable grid-based clustering algorithm well-suited for analysing large, high-dimensional data sets. The algorithm can produce high quality clusters without relying on user-defined parameters.

The objective of O-Cluster is to identify areas of high density in the data and separate the dense areas into clusters. It uses axis-parallel uni-dimensional (orthogonal) data projections to identify the areas of density. The algorithm looks for splitting points that result in distinct clusters that do not overlap and are balanced in size.

O-Cluster operates recursively by creating a binary tree hierarchy. The number of leaf clusters is determined automatically. The algorithm can be configured to limit the maximum number of clusters.
26.1.1 Partitioning Strategy

Partitioning strategy refers to the process of discovering areas of density in the attribute histograms. The process differs for numerical and categorical data. When both are present in the data, the algorithm performs the searches separately and then compares the results.

In choosing a partition, the algorithm balances two objectives: finding well separated clusters, and creating clusters that are balanced in size. The following paragraphs detail how partitions for numerical and categorical attributes are identified.

26.1.1.1 Partitioning Numerical Attributes

To find the best valid cutting plane, O-Cluster searches the attribute histograms for bins of low density (valleys) between bins of high density (peaks).

O-Cluster attempts to find a pair of peaks with a valley between them where the difference between the peak and valley histogram counts is statistically significant.

A sensitivity level parameter specifies the lowest density that may be considered a peak. Sensitivity is an optional parameter for numeric data. It may be used to filter the splitting point candidates.

26.1.1.2 Partitioning Categorical Attributes

Categorical values do not have an intrinsic order associated with them. Therefore it is impossible to apply the notion of histogram peaks and valleys that is used to partition numerical values. Instead the counts of individual values form a histogram.

Bins with large counts are interpreted as regions with high density. The clustering objective is to separate these high-density areas and effectively decrease the entropy (randomness) of the data.

O-Cluster identifies the histogram with highest entropy along the individual projections. Entropy is measured as the number of bins above sensitivity level. O-Cluster places the two largest bins into separate partitions, thereby creating a splitting predicate. The remainder of the bins are assigned randomly to the two resulting partitions.

26.1.2 Active Sampling

The O-Cluster algorithm operates on a data buffer of a limited size. It uses an active sampling mechanism to handle data sets that do not fit into memory.

After processing an initial random sample, O-Cluster identifies cases that are of no further interest. Such cases belong to frozen partitions where further splitting is highly unlikely. These cases are replaced with examples from ambiguous regions where further information (additional cases) is needed to find good splitting planes and continue partitioning. A partition is considered ambiguous if a valid split can only be found at a lower confidence level.

Cases associated with frozen partitions are marked for deletion from the buffer. They are replaced with cases belonging to ambiguous partitions. The histograms of the ambiguous partitions are updated and splitting points are reevaluated.
26.1.3 Process Flow

At a high level, O-Cluster algorithm evaluates, splits the data into new partition, and searches for cutting planes inside the new partitions.

The O-Cluster algorithm evaluates possible splitting points for all projections in a partition, selects the best one, and splits the data into two new partitions. The algorithm proceeds by searching for good cutting planes inside the newly created partitions. Thus, O-Cluster creates a binary tree structure that divides the input space into rectangular regions with no overlaps or gaps.

The main processing stages are:

1. Load the buffer. Assign all cases from the initial buffer to a single active root partition.
2. Compute histograms along the orthogonal uni-dimensional projections for each active partition.
3. Find the best splitting points for active partitions.
4. Flag ambiguous and frozen partitions.
5. When a valid separator exists, split the active partition into two new active partitions and start over at step 2.
6.Reload the buffer after all recursive partitioning on the current buffer is completed. Continue loading the buffer until either the buffer is filled again, or the end of the data set is reached, or until the number of cases is equal to the data buffer size.

Note:

O-Cluster requires at most one pass through the data

26.1.4 Scoring

The clusters discovered by O-Cluster are used to generate a Bayesian probability model that can be used to score new data.

The generated probability model is a mixture model where the mixture components are represented by a product of independent normal distributions for numerical attributes and multinomial distributions for categorical attributes.

26.2 Tuning the O-Cluster Algorithm

You can configure build-time settings for O-Cluster.

The O-Cluster algorithm supports two build-time settings. Both settings have default values. There is no reason to override the defaults unless you want to influence the behavior of the algorithm in some specific way.

You can configure O-Cluster by specifying any of the following:

- **Buffer size** — Size of the processing buffer.
- **Sensitivity factor** — A fraction that specifies the peak density required for separating a new cluster.
See Also:

DBMS_DATA_MINING — Algorithm Settings: O-Cluster for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.

Related Topics

- Active Sampling
  The O-Cluster algorithm operates on a data buffer of a limited size. It uses an active sampling mechanism to handle data sets that do not fit into memory.
- Partitioning Strategy

26.3 Data Preparation for O-Cluster

Use Automatic Data Preparation (ADP) to prepare the data for O-Cluster.

ADP bins numerical attributes for O-Cluster. It uses a specialized form of equi-width binning that computes the number of bins per attribute automatically. Numerical columns with all nulls or a single value are removed. O-Cluster handles missing values naturally as missing at random.

Note:

O-Cluster does not support nested columns, sparse data, or unstructured text.

Related Topics

- Prepare the Data

26.3.1 User-Specified Data Preparation for O-Cluster

You can prepare the data for O-Cluster by considering the points listed here.

Keep the following in mind if you choose to prepare the data for O-Cluster:

- O-Cluster does not necessarily use all the input data when it builds a model. It reads the data in batches (the default batch size is 50000). It only reads another batch if it believes, based on statistical tests, that uncovered clusters can still exist.
- Binary attributes must be declared as categorical.
- Automatic equi-width binning is highly recommended. The bin identifiers are expected to be positive consecutive integers starting at 1.
- The presence of outliers can significantly impact clustering algorithms. Use a clipping transformation before binning or normalizing. Outliers with equi-width
binning can prevent O-Cluster from detecting clusters. As a result, the whole population appears to fall within a single cluster.

Related Topics

- *Oracle Database PL/SQL Packages and Types Reference*
R Extensibility

This topic applies only to Oracle on-premises.

Learn how to build an analytics model and score in R. The R extensible algorithms are enhanced to support and register additional algorithms for users who use SQL and graphical user interface.

• Oracle Machine Learning for SQL with R Extensibility
• Scoring with R
• About Algorithm Metadata Registration

Related Topics
• DBMS_DATA_MINING - Model Settings
• DBMS_DATA_MINING — Algorithm Settings: ALGO_EXTENSIBLE_LANG
• OML4SQL Examples
• OML4R Extensible R Example
• OML4R Code Examples

27.1 Oracle Machine Learning for SQL with R Extensibility

Learn how you can use Oracle Machine Learning for SQL to build, score, and view machine learning models as well as R models.

The OML4SQL framework is enhanced extending the OML4SQL algorithm set with algorithms from the open source R ecosystem. Oracle Machine Learning for SQL is implemented in the Oracle Database kernel. The OML4SQL models are Database schema objects. With the extensibility enhancement, the OML4SQL framework can build, score, and view both OML4SQL models and R models.

Registration of R scripts

The R engine on the database server runs the R scripts to build, score, and view R models. These R scripts must be registered with the database beforehand by a privileged user with rqAdmin role. You must first install Oracle Machine Learning for R to register the R scripts.

Functions of Oracle Machine Learning for SQL with R Model

The following functions are supported for an R model:

• OML4SQL DBMS_DATA_MINING package is enhanced to support R model. For example, CREATE_MODEL and DROP_MODEL.
• MODEL VIEW to get the R model details about a single model and a partitioned model.
• OML4SQL SQL functions are enhanced to operate with the R model functions. For example, PREDICTION and CLUSTER_ID.
R model extensibility supports the following OML4SQL functions:

- Association
- Attribute Importance
- Regression
- Classification
- Clustering
- Feature Extraction

27.2 Scoring with R

Learn how to build and score with an Oracle Machine Learning for R model.

For more information, see Oracle Machine Learning for SQL User’s Guide

27.3 About Algorithm Metadata Registration

Algorithm metadata registration allows for a uniform and consistent approach of registering new algorithm functions and their settings.

Users have the ability to add new R-based algorithms through the registration process. The new algorithms appear as available within Oracle Machine Learning for R and within the appropriate machine learning techniques. Based on the registration metadata, the settings page is dynamically rendered. The advantages are as follows:

- Manage R-based algorithms more easily
- Specify R-based algorithm for model build
- Clean individual properties in JSON structure
- Share R-based algorithm across user

Algorithm metadata registration extends the machine learning model capability of Oracle Machine Learning for SQL.

See Also:

DBMS_DATA_MINING — Algorithm Settings: ALGO_EXTENSIBLE_LANG for a listing and explanation of the available model settings.

Note:

The term hyperparameter is also interchangeably used for model setting.

Related Topics

- Create Model Using Registration Information
- FETCH_JSON_SCHEMA Procedure
- REGISTER_ALGORITHM Procedure
• JSON Schema for R Extensible Algorithm

27.3.1 Algorithm Metadata Registration

Algorithm metadata registration allows for a uniform and consistent approach of registering new algorithm functions and their settings.

User have the ability to add new algorithms through the `REGISTER_ALGORITHM` procedure registration process. The new algorithms can appear as available within Oracle Machine Learning for SQL for their appropriate machine learning functions. Based on the registration metadata, the settings page is dynamically rendered. Algorithm metadata registration extends the machine learning model capability of OML4SQL.

**Related Topics**

- *Oracle Database PL/SQL Packages and Types Reference*
- `FETCH_JSON_SCHEMA` Procedure
- `REGISTER_ALGORITHM` Procedure
- JSON Schema for R Extensible Algorithm
Random Forest

Learn how to use Random Forest as a classification algorithm.

- About Random Forest
- Building a Random Forest
- Scoring with Random Forest

Related Topics
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Settings: Random Forest
- Automatic Data Preparation
- Model Detail Views for Random Forest
- OML4SQL Examples
- OML4R Random Forest Example
- OML4R Code Examples

28.1 About Random Forest

Random Forest is a classification algorithm that builds an \textit{ensemble} (also called \textit{forest}) of trees.

The algorithm builds a number of Decision Tree models and predicts using the ensemble. An individual decision tree is built by choosing a random sample from the training data set as the input. At each node of the tree, only a random sample of predictors is chosen for computing the split point. This introduces variation in the data used by the different trees in the forest. The parameters RFOR_SAMPLING_RATIO and RFOR_MTRY are used to specify the sample size and number of predictors chosen at each node. Users can use ODMS_RANDOM_SEED to set the random seed value before running the algorithm.

Related Topics
- Decision Tree
  Oracle Machine Learning for SQL supports Decision Tree as one of the classification algorithms. This chapter provides an overview of the Decision Tree algorithm.
- Splitting
  The Decision Tree algorithm offers metrics for splitting the cases (records).
- Data Preparation for Decision Tree
  The Decision Tree algorithm manages its own data preparation internally. It does not require pretreatment of the data.
28.2 Building a Random Forest

The Random Forest is built upon existing infrastructure and Application Programming Interfaces (APIs) of Oracle Machine Learning for SQL.

Random forest models provide attribute importance ranking of predictors. The model is built by specifying parameters in the existing APIs. The scoring is performed using the same SQL queries and APIs as the existing classification algorithms. OML4SQL implements a variant of classical Random Forest algorithm. This implementation supports big data sets. The implementation of the algorithm differs in the following ways:

- OML4SQL does not support bagging and instead provides sampling without replacement
- Users have the ability to specify the depth of the tree. Trees are not built to maximum depth.

Note: The term hyperparameter is also interchangeably used for model setting.

Related Topics
- DBMS_DATA_MINING — Algorithm Settings: Random Forest

28.3 Scoring with Random Forest

Learn to score with the Random Forest algorithm.

Scoring with Random Forest is the same as any other classification algorithm. The following functions are supported: PREDICTION, PREDICTION_PROBABILITY, PREDICTION_COST, PREDICTION_SET, and PREDICTION_DETAILS.

Related Topics
- Oracle Database SQL Language Reference
Singular Value Decomposition

Learn how to use Singular Value Decomposition, an unsupervised algorithm for feature extraction.

- About Singular Value Decomposition
- Configuring the Algorithm
- Data Preparation for SVD

Related Topics
- Feature Extraction
  Learn how to perform attribute reduction using feature extraction as an unsupervised function.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING - Algorithm Constants and Settings: Singular Value Decomposition
- Automatic Data Preparation
- Model Detail Views for Singular Value Decomposition
- OML4SQL Examples
- OML4R Singular Value Decomposition Example
- OML4R Code Examples

29.1 About Singular Value Decomposition

SVD and the closely-related PCA are well established feature extraction methods that have a wide range of applications. Oracle Machine Learning for SQL implements Singular Value Decomposition (SVD) as a feature extraction algorithm and Principal Component Analysis (PCA) as a special scoring method for SVD models.

SVD and PCA are orthogonal linear transformations that are optimal at capturing the underlying variance of the data. This property is very useful for reducing the dimensionality of high-dimensional data and for supporting meaningful data visualization.

SVD and PCA have a number of important applications in addition to dimensionality reduction. These include matrix inversion, data compression, and the imputation of unknown data values.

29.1.1 Matrix Manipulation

Singular Value Decomposition (SVD) is a factorization method that decomposes a rectangular matrix $X$ into the product of three matrices: $U$, $S$, and $V$. 
The matrix consists of a set of 'left' orthonormal bases. The values in S are called singular values. They are non-negative, and their magnitudes indicate the importance of the corresponding bases (components). The singular values reflect the amount of data variance captured by the bases. The first basis (the one with largest singular value) lies in the direction of the greatest data variance. The second basis captures the orthogonal direction with the second greatest variance, and so on.

SVD essentially performs a coordinate rotation that aligns the transformed axes with the directions of maximum variance in the data. This is a useful procedure under the assumption that the observed data has a high signal-to-noise ratio and that a large variance corresponds to interesting data content while a lower variance corresponds to noise.

SVD makes the assumption that the underlying data is Gaussian distributed and can be well described in terms of means and covariances.

### 29.1.2 Low Rank Decomposition

Singular Value Decomposition (SVD) keeps lower-order bases (the ones with the largest singular values) and ignores higher-order bases (the ones with the smallest singular values) to capture the most important aspects of the data.

To reduce dimensionality, SVD keeps lower-order bases and ignores higher-order bases. The rationale behind this strategy is that the low-order bases retain the characteristics of the data that contribute most to its variance and are likely to capture the most important aspects of the data.

Given a data set $X$ $(n \times m)$, where $n$ is the number of rows and $m$ is the number of attributes, a low-rank SVD uses only $k$ components ($k \leq \min(m, n)$). In typical implementations of SVD, the value of $k$ requires a visual inspection of the ranked singular values associated with the individual components. In OML4SQL, SVD automatically estimates the cutoff point, which corresponds to a significant drop in the explained variance.

SVD produces two sets of orthonormal bases ($U$ and $V$). Either of these bases can be used as a new coordinate system. In OML4SQL, SVD, $V$ is the new coordinate system, and $U$ represents the projection of $X$ in this coordinate system. The algorithm computes the projection of new data as follows:

$$\tilde{X} = XV_kS_k^{-1}$$
where \( X (nxk) \) is the projected data in the reduced data space, defined by the first \( k \) components, and \( V_k \) and \( S_k \) define the reduced component set.

### 29.1.3 Scalability

In Oracle Machine Learning for SQL, Singular Value Decomposition (SVD) can process data sets with millions of rows and thousands of attributes. Oracle Machine Learning for SQL automatically recommends an appropriate number of features, based on the data, for dimensionality reduction.

SVD has linear scalability with the number of rows and cubic scalability with the number of attributes when a full decomposition is computed. A low-rank decomposition is typically linear with the number of rows and linear with the number of columns. The scalability with the reduced rank depends on how the rank compares to the number of rows and columns. It can be linear when the rank is significantly smaller or cubic when it is on the same scale.

### 29.2 Configuring the Algorithm

Several options are available for configuring the Singular Value Decomposition (SVD) algorithm.

Among several options are: settings to control model size and performance, and whether to score with SVD projections or Principal Component Analysis (PCA) projections.

#### See Also:

DBMS_DATA_MINING — Algorithm Constants and Settings: Singular Value Decomposition for a listing and explanation of the available model settings.

#### Note:

The term hyperparameter is also interchangeably used for model setting.

### 29.2.1 Model Size

Learn how a model size is decided based on the rows in the build data and algorithm-specific setting.

The \( U \) matrix in Singular Value Decomposition has as many rows as the number of rows in the build data. To avoid creating a large model, the \( U \) matrix persists only when an algorithm-specific setting is enabled. By default the \( U \) matrix does not persist.

### 29.2.2 Performance

Singular Value Decomposition can use approximate computations to improve performance.

Approximation may be appropriate for data sets with many columns. An approximate low-rank decomposition provides good solutions at a reasonable computational cost. The quality of the approximation is dependent on the characteristics of the data.
29.2.3 PCA scoring

Learn about configuring Singular Value Decomposition (SVD) to perform Principal Component Analysis (PCA) projections.

SVD models can be configured to perform PCA projections. PCA is closely related to SVD. PCA computes a set of orthonormal bases (principal components) that are ranked by their corresponding explained variance. The main difference between SVD and PCA is that the PCA projection is not scaled by the singular values. The PCA projection to the new coordinate system is given by:

$$\tilde{X} = X V_k$$

where

$$X$$

is the projected data in the reduced data space, defined by the first $$k$$ components, and $$V_k$$ defines the reduced component set.

Related Topics
- Oracle Database PL/SQL Packages and Types Reference

29.3 Data Preparation for SVD

Oracle Machine Learning for SQL implements Singular Value Decomposition (SVD) for numerical data and categorical data.

When the build data is scored with SVD, Automatic Data Preparation does nothing. When the build data is scored with Principal Component Analysis (PCA), Automatic Data Preparation shifts the numerical data by mean.

Missing value treatment is not needed, because OML4SQL algorithms handle missing values automatically. SVD replaces numerical missing values with the mean and categorical missing values with the mode. For sparse data (missing values in nested columns), SVD replaces missing values with zeros.

Related Topics
- Prepare the Data
Support Vector Machine

Learn how to use Support Vector Machine (SVM), a powerful algorithm based on statistical learning theory.

Oracle Machine Learning for SQL implements SVM for classification, regression, and anomaly detection.

- About Support Vector Machine
- Tuning an SVM Model
- Data Preparation for SVM
- SVM Classification
- One-Class SVM
- SVM Regression

Related Topics
- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- Regression
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.
- Anomaly Detection
  Learn how to detect rare cases in the data through anomaly detection - an unsupervised function.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING — Algorithm Settings: Support Vector Machine
- Automatic Data Preparation
- Model Detail View for Support Vector Machine
- OML4SQL Examples
- OML4R Support Vector Machine Example
- OML4R Code Examples
- Oracle Machine Learning for SQL

See Also:

30.1 About Support Vector Machine

Support Vector Machine (SVM) is a powerful, state-of-the-art algorithm with strong theoretical foundations based on the Vapnik-Chervonenkis theory.

SVM has strong **regularization** properties. Regularization refers to the generalization of the model to new data.

30.1.1 Advantages of SVM

Support Vector Machine (SVM) implements solvers for scalability and handling large volumes of data.

Oracle Machine Learning for SQL SVM implementation includes two types of solvers, an Interior Point Method (IPM) solver and a Sub-Gradient Descent (SGD) solver. The IPM solver provides stable and accurate solutions, however, it may not be able to handle data of high dimensionality. For high-dimensional and/or large data, for example, text, ratings, and so on, the SGD solver is a better choice. Both solvers have highly scalable parallel implementations and can handle large volumes of data.

30.1.2 Advantages of SVM in Oracle Machine Learning for SQL

Describes advantages of using the Support Vector Machine (SVM) algorithm.

Oracle Machine Learning for SQL has its own proprietary implementation of SVM, which exploits the many benefits of the algorithm while compensating for some of the limitations inherent in the SVM framework. OML4SQL SVM provides the scalability and usability that are needed in a production quality OML4SQL system.

30.1.2.1 Usability

Explains usability for Support Vector Machine (SVM) in Oracle Machine Learning for SQL.

Usability is a major enhancement, because SVM has often been viewed as a tool for experts. The algorithm typically requires data preparation, tuning, and optimization. Oracle Machine Learning minimizes these requirements. You do not need to be an expert to build a quality SVM model in OML4SQL. For example:

- Data preparation is not required in most cases.
- Default tuning parameters are generally adequate.

**Related Topics**

- **Data Preparation for SVM**
  Support Vector Machine (SVM) uses normalization and missing value treatment for data preparation.

- **Tuning an SVM Model**
  The Support Vector Machine (SVM) algorithm has built-in mechanisms that automatically choose appropriate settings based on the data.
30.1.2.2 Scalability

Learn how to scale the data for Support Vector Machine (SVM).

When dealing with very large data sets, sampling is often required. However, sampling is not required with Oracle Machine Learning for SQL SVM, because the algorithm itself uses stratified sampling to reduce the size of the training data as needed.

OML4SQL SVM is highly optimized. It builds a model incrementally by optimizing small working sets toward a global solution. The model is trained until convergence on the current working set, then the model adapts to the new data. The process continues iteratively until the convergence conditions are met. The Gaussian kernel uses caching techniques to manage the working sets.

Related Topics

- **Kernel-Based Learning**
  Learn about kernel-based functions to transform the input data for Support Vector Machine (SVM).

30.1.3 Kernel-Based Learning

Learn about kernel-based functions to transform the input data for Support Vector Machine (SVM).

SVM is a kernel-based algorithm. A **kernel** is a function that transforms the input data to a high-dimensional space where the problem is solved. Kernel functions can be linear or nonlinear.

Oracle Machine Learning for SQL supports linear and Gaussian (nonlinear) kernels.

In OML4SQL, the **linear kernel** function reduces to a linear equation on the original attributes in the training data. A linear kernel works well when there are many attributes in the training data.

The **Gaussian kernel** transforms each case in the training data to a point in an $n$-dimensional space, where $n$ is the number of cases. The algorithm attempts to separate the points into subsets with homogeneous target values. The Gaussian kernel uses nonlinear separators, but within the kernel space it constructs a linear equation.

**Note:**

Active Learning is not relevant in Oracle Database 12c Release 2 and later. A setting similar to Active Learning is `ODMS_SAMPLING`.

Related Topics

- **Oracle Database PL/SQL Packages and Types Reference**

30.2 Tuning an SVM Model

The Support Vector Machine (SVM) algorithm has built-in mechanisms that automatically choose appropriate settings based on the data.
You may need to override the system-determined settings for some domains.
Settings pertain to regression, classification, and anomaly detection unless otherwise specified.

See Also:
 DBMS_DATA_MINING —Algorithm Settings: Support Vector Machine for a
listing and explanation of the available model settings.

Note:
The term hyperparameter is also interchangeably used for model setting.

30.3 Data Preparation for SVM

Support Vector Machine (SVM) uses normalization and missing value treatment for
data preparation.

The SVM algorithm operates natively on numeric attributes. SVM uses z-score
normalization on numeric attributes. The normalization occurs only for two-dimensional
numeric columns (not nested). The algorithm automatically "explodes" categorical data
into a set of binary attributes, typically one per category value. For example, a
character column for marital status with values married or single is transformed to
two numeric attributes: married and single. The new attributes can have the value 1
(true) or 0 (false).

When there are missing values in columns with simple data types (not nested), SVM
interprets them as missing at random. The algorithm automatically replaces missing
categorical values with the mode and missing numerical values with the mean.

When there are missing values in the nested columns, SVM interprets them as sparse.
The algorithm automatically replaces sparse numerical data with zeros and sparse
categorical data with zero vectors.

30.3.1 Normalization

Transform data through normalization for Support Vector Machine (SVM).

SVM require the normalization of numeric input. Normalization places the values of
numeric attributes on the same scale and prevents attributes with a large original scale
from biasing the solution. Normalization also minimizes the likelihood of overflows and
underflows.

30.3.2 SVM and Automatic Data Preparation

You can prepare data by treating and transforming data manually or through Automatic
Data Preparation (ADP) for Support Vector Machine (SVM).
The SVM algorithm automatically handles missing value treatment and the transformation of
categorical data, but normalization and outlier detection must be handled by ADP or prepared
manually. ADP performs min-max normalization for SVM.

**Note:**
Oracle recommends that you use ADP with SVM. The transformations performed
by ADP are appropriate for most models.

**Related Topics**
- Oracle Machine Learning for SQL User's Guide

### 30.4 SVM Classification

Support Vector Machine (SVM) classification is based on the concept of decision planes that
define decision boundaries.

A decision plane is one that separates between a set of objects having different class
memberships. SVM finds the vectors ("support vectors") that define the separators giving the
widest separation of classes.

SVM classification supports both binary, multiclass, and multitarget classification. Multitarget
allows multiple class labels to be associated with a single row. The target type is a collection
of type ORA_MININGVARCHAR2_NT.

**Related Topics**
- Oracle Database PL/SQL Packages and Types Reference

#### 30.4.1 Class Weights

Learn when to implement class weights to a data in Support Vector Machine (SVM).

In SVM classification, weights are a biasing mechanism for specifying the relative importance
of target values (classes).

SVM models are automatically initialized to achieve the best average prediction across all
classes. However, if the training data does not represent a realistic distribution, you can bias
the model to compensate for class values that are under-represented. If you increase the
weight for a class, then the percent of correct predictions for that class must increase.

**Related Topics**
- Priors and Class Weights
  Learn about Priors and Class Weights in a classification model to produce a useful result.

### 30.5 One-Class SVM

Support Vector Machine (SVM) as a one-class classifier is used for detecting anomalies.

Oracle Machine Learning for SQL uses SVM as the one-class classifier for anomaly
detection. When SVM is used for anomaly detection, it has the classification machine
learning technique but no target.
One-class SVM models, when applied, produce a prediction and a probability for each case in the scoring data. If the prediction is 1, the case is considered typical. If the prediction is 0, the case is considered anomalous. This behavior reflects the fact that the model is trained with normal data.

You can specify the percentage of the data that you expect to be anomalous with the \texttt{SVMS\_OUTLIER\_RATE} build setting. If you have some knowledge that the number of "suspicious" cases is a certain percentage of your population, then you can set the outlier rate to that percentage. The model approximately identifies that many "rare" cases when applied to the general population.

\textbf{Related Topics}

- \textbf{Classification}
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- \textbf{DBMS\_DATA\_MINING - Model Settings}
- \textbf{DBMS\_DATA\_MINING - Algorithm Settings: Support Vector Machine}
- Automatic Data Preparation
- Model Detail View for Support Vector Machine
- OML4SQL Examples
- OML4R SVM Example
- OML4R Code Examples

\section*{30.6 SVM Regression}

Learn how to use epsilon-insensitivity loss function to solve regression problems in Support Vector Machine (SVM).

SVM uses an epsilon-insensitive loss function to solve regression problems.

SVM regression tries to find a continuous function such that the maximum number of data points lie within the epsilon-wide insensitivity tube. Predictions falling within epsilon distance of the true target value are not interpreted as errors.

The epsilon factor is a regularization setting for SVM regression. It balances the margin of error with model robustness to achieve the best generalization to new data.

\textbf{Related Topics}

- SVM Model Settings
XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.

- About XGBoost
- Scoring with XGBoost

Related Topics

- Classification
  Learn how to predict a categorical target through classification - the supervised machine learning technique.
- Regression
  Learn how to predict a continuous numerical target through regression - the supervised machine learning technique.
- Ranking
  Ranking is a regression machine learning technique.
- DBMS_DATA_MINING - Model Settings
- DBMS_DATA_MINING — Algorithm Settings: XGBoost
- Automatic Data Preparation
- Model Detail Views for XGBoost
- OML4SQL Examples

31.1 About XGBoost

Oracle Machine Learning for SQL XGBoost prepares training data, invokes XGBoost, builds and persists a model, and applies the model for prediction.

OML4SQL XGBoost is a scalable gradient tree boosting system that supports both classification and regression. It makes available the open source gradient boosting framework.

You can use XGBoost as a stand-alone predictor or incorporate it into real-world production pipelines for a wide range of problems such as ad click-through rate prediction, hazard risk prediction, web text classification, and so on.

The OML4SQL XGBoost algorithm takes three types of parameters: general parameters, booster parameters, and task parameters. You set the parameters through the model settings table. The algorithm supports most of the settings of the open source project.

Through XGBoost, OML4SQL supports a number of different classification and regression specifications, ranking models, and survival models. Binary and multiclass models are supported under the classification machine learning technique while regression, ranking, count, and survival are supported under the regression machine learning technique.

XGBoost also supports partitioned models and internalizes the data preparation. Currently, XGBoost is available only on Oracle Database Linux platform.
31.2 Ranking Methods

Oracle Machine Learning supports pairwise and listwise ranking methods through XGBoost.

For a training data set, in a number of sets, each set consists of objects and labels representing their ranking. A ranking function is constructed by minimizing a certain loss function on the training data. Using test data, the ranking function is applied to get a ranked list of objects. Ranking is enabled for XGBoost using the regression function. OML4SQL supports pairwise and listwise ranking methods through XGBoost.

Pairwise ranking: This approach regards a pair of objects as the learning instance. The pairs and lists are defined by supplying the same `case_id` value. Given a pair of objects, this approach gives an optimal ordering for that pair. Pairwise losses are defined by the order of the two objects. In OML4SQL, the algorithm uses LambdaMART to perform pairwise ranking with the goal of minimizing the average number of inversions in ranking.

Listwise ranking: This approach takes multiple lists of ranked objects as learning instance. The items in a list must have the same `case_id`. The algorithm uses LambdaMART to perform list-wise ranking.

**See Also:**

- “Ranking Measures and Loss Functions in Learning to Rank” a research paper presentation at https://www.researchgate.net/
- Oracle Database PL/SQL Packages and Types Reference for a listing and explanation of the available model settings for XGBoost.

**Note:**

The term hyperparameter is also interchangeably used for model setting.

**Related Topics**

- **XGBoost**
  XGBoost is highly-efficient, scalable machine learning algorithm for regression and classification that makes available the XGBoost Gradient Boosting open source package.
- **DBMS_DATA_MINING — Algorithm Settings: XGBoost**
31.3 Scoring with XGBoost

Learn how to score with XGBoost.

The SQL scoring functions supported for a classification XGBoost model are PREDICTION, PREDICTION_COST, PREDICTION_DETAILS, PREDICTION_PROBABILITY, and PREDICTION_SET.

The scoring functions supported for a regression XGBoost model are PREDICTION and PREDICTION_DETAILS.

The prediction functions return the following information:

- **PREDICTION** returns the predicted value.
- **PREDICTION_COST** returns a measure of cost for a given prediction as an Oracle NUMBER. (classification only)
- **PREDICTION_DETAILS** returns the SHAP (SHapley Additive exPlanation) contributions.
- **PREDICTION_PROBABILITY** returns the probability for a given prediction. (classification only)
- **PREDICTION_SET** returns the prediction and the corresponding prediction probability for each observation. (classification only)

**Related Topics**

- SQL Scoring Functions
Part IV

Using the Oracle Machine Learning for SQL API

Learn how to use Oracle Machine Learning for SQL application programming interface.

- Oracle Machine Learning With SQL
- About the Oracle Machine Learning for SQL API
- Prepare the Data
- Create a Model
- Scoring and Deployment
- Machine Learning Operations on Unstructured Text
- Administrative Tasks for Oracle Machine Learning for SQL
- Oracle Machine Learning for SQL Examples
Oracle Machine Learning With SQL

Learn how to solve business problems using the Oracle Machine Learning for SQL application programming interface (API).

• Highlights of the Oracle Machine Learning for SQL API
• Example: Targeting Likely Candidates for a Sales Promotion
• Example: Analyzing Preferred Customers
• Example: Segmenting Customer Data
• Example: Comparison of Texts Using an ESA Model

32.1 Highlights of the Oracle Machine Learning for SQL API

Learn about the advantages of OML4SQL application programming interface (API).

Machine learning is a valuable technology in many application domains. It has become increasingly indispensable in the private sector as a tool for optimizing operations and maintaining a competitive edge. Machine learning also has critical applications in the public sector and in scientific research. However, the complexities of machine learning application development and the complexities inherent in managing and securing large stores of data can limit the adoption of machine learning technology.

OML4SQL is uniquely suited to addressing these challenges. The machine learning engine is implemented in the database kernel, and the robust administrative features of Oracle Database are available for managing and securing the data. While supporting a full range of machine learning algorithms and procedures, the API also has features that simplify the development of machine learning applications.

The OML4SQL API consists of extensions to Oracle SQL, the native language of the database. The API offers the following advantages:

• Scoring in the context of SQL queries. Scoring can be performed dynamically or by applying machine learning models.
• Automatic Data Preparation (ADP) and embedded transformations.
• Model transparency. Algorithm-specific queries return details about the attributes that were used to create the model.
• Scoring transparency. Details about the prediction, clustering, or feature extraction operation can be returned with the score.
• Simple routines for predictive analytics.
• A workflow-based graphical user interface (GUI) within Oracle SQL Developer. You can download SQL Developer free of charge from the following site:

Oracle Data Miner
32.2 Example: Predicting Likely Candidates for a Sales Promotion

This example shows the `PREDICTION` query to target customers in Brazil for a special promotion that offers coupons and an affinity card.

The query uses data on marital status, education, and income to predict the customers who are most likely to take advantage of the incentives. The query applies a Decision Tree model called `dt_sh_clas_sample` to score the customer data. The model is created by the `oml4sql-classification-decision-tree.sql` example.

**Example 32-1   Predict Best Candidates for an Affinity Card**

```sql
SELECT cust_id
FROM mining_data_apply_v
WHERE
    PREDICTION(dt_sh_clas_sample
                USING cust_marital_status, education, cust_income_level ) = 1
    AND country_name IN 'Brazil';

CUST_ID
---------
100404
100607
101113
```

The same query, but with a bias to favor false positives over false negatives, is shown here.

```sql
SELECT cust_id
FROM mining_data_apply_v
WHERE
    PREDICTION(dt_sh_clas_sample COST MODEL
                USING cust_marital_status, education, cust_income_level ) = 1
    AND country_name IN 'Brazil';

CUST_ID
---------
100139
100163
100275
100404
100607
101113
101170
101463
```
The **COST MODEL** keywords cause the cost matrix associated with the model to be used in making the prediction. The cost matrix, stored in a table called `dt_sh_sample_costs`, specifies that a false negative is eight times more costly than a false positive. Overlooking a likely candidate for the promotion is far more costly than including an unlikely candidate.

```sql
SELECT * FROM dt_sh_sample_cost;
```

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### 32.3 Example: Analyzing Preferred Customers

The examples in this section reveal information about customers who use affinity cards or are likely to use affinity cards.

**Example 32-2  Find Demographic Information About Preferred Customers**

This query returns the gender, age, and length of residence of typical affinity card holders. The anomaly detection model, `SVMO_SH_Clas_sample`, returns 1 for typical cases and 0 for anomalies. The demographics are predicted for typical customers only; outliers are not included in the sample. The model is created by the `oml4sql-singular-value-decomposition.sql` example.

```sql
SELECT cust_gender, round(avg(age)) age,
       round(avg(yrs_residence)) yrs_residence,
       count(*) cnt
FROM mining_data_one_class_v
WHERE PREDICTION(SVMO_SH_Clas_sample using *) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th>CUST_GENDER</th>
<th>AGE</th>
<th>YRS_RESIDENCE</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>40</td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>M</td>
<td>45</td>
<td>5</td>
<td>304</td>
</tr>
</tbody>
</table>

**Example 32-3  Dynamically Identify Customers Who Resemble Preferred Customers**

This query identifies customers who do not currently have an affinity card, but who share many of the characteristics of affinity card holders. The `PREDICTION` and `PREDICTION_PROBABILITY` functions use an `OVER` clause instead of a predefined model to classify the customers. The predictions and probabilities are computed dynamically.

```sql
SELECT cust_id, pred_prob
FROM
  (SELECT cust_id, affinity_card,
       PREDICTION(FOR TO_CHAR(affinity_card) USING *) OVER () pred_card,
       PREDICTION_PROBABILITY(FOR TO_CHAR(affinity_card),1 USING *) OVER () pred_prob
  FROM mining_data_build_v)
WHERE affinity_card = 0
  AND pred_card = 1
ORDER BY pred_prob DESC;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PRED_PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Example 32-4  Predict the Likelihood that a New Customer Becomes a Preferred Customer

This query computes the probability of a first-time customer becoming a preferred customer (an affinity card holder). This query can be run in real time at the point of sale.

The new customer is a 44-year-old American executive who has a bachelors degree and earns more than $300,000/year. He is married, lives in a household of 3, and has lived in the same residence for the past 6 years. The probability of this customer becoming a typical affinity card holder is only 5.8%.

```
SELECT PREDICTION_PROBABILITY(SVMO_SH_Clas_sample, 1 USING
  44 AS age,
  6 AS yrs_residence,
  'Bach.' AS education,
  'Married' AS cust_marital_status,
  'Exec.' AS occupation,
  'United States of America' AS country_name,
  'M' AS cust_gender,
  'L: 300,000 and above' AS cust_income_level,
  '3' AS houshold_size
) prob_typical
FROM DUAL;
```

```
PROB_TYPICAL
------------
5.8
```

Example 32-5  Use Predictive Analytics to Find Top Predictors

The DBMS_PREDICTIVE_ANALYTICS PL/SQL package contains routines that perform simple machine learning operations without a predefined model. In this example, the EXPLAIN routine computes the top predictors for affinity card ownership. The procedure does not create a model that can be stored in the database for further exploration. Automatic Data Preparation is also performed behind the scenes. The results show that household size, marital status, and age are the top three predictors.

```
BEGIN
  DBMS_PREDICTIVE_ANALYTICS.EXPLAIN(
    data_table_name => 'mining_data_test_v',
    explain_column_name => 'affinity_card',
  )
END;
```
Another way to arrive at top predictors for affinity ownership is by using attribute importance mining function. Create a model with the Minimum Description Length algorithm. Define 
mining_function as ATTRIBUTE_IMPORTANCE. You can then query the DM$VA model detail view to get the top three predictors.

BEGIN DBMS_DATA_MINING DROP_MODEL('AI_EXPLAIN_OUTPUT');
EXCEPTION WHEN OTHERS THEN NULL; END;
/
DECLARE
    v_setlst DBMS_DATA_MINING.SETTING_LIST;
BEGIN
    v_setlst('ALGO_NAME') := 'ALGO_AI_MDL';
    v_setlst('PREP_AUTO') := 'ON';
    DBMS_DATA_MINING.CREATE_MODEL2(
        MODEL_NAME => 'AI_EXPLAIN_OUTPUT',
        MINING_FUNCTION => 'ATTRIBUTE_IMPORTANCE',
        DATA_QUERY => 'select * from mining_data_test_v',
        SET_LIST => v_setlst,
        CASE_ID_COLUMN_NAME => 'CUST_ID',
        TARGET_COLUMN_NAME => 'AFFINITY_CARD');
END;

Find the top 3 predictors from the DM$VA model detail view:
SELECT ATTRIBUTE_NAME, ATTRIBUTE_IMPORTANCE_VALUE, ATTRIBUTE_RANK FROM DM$VAI_EXPLAIN_OUTPUT;

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>ATTRIBUTE_IMPORTANCE_VALUE</th>
<th>ATTRIBUTE_RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOUSEHOLD_SIZE</td>
<td>0.16154338717879052</td>
<td>1</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>0.1561477632217005</td>
<td>2</td>
</tr>
<tr>
<td>AGE</td>
<td>0.08440594628406521</td>
<td>3</td>
</tr>
</tbody>
</table>

32.4 Example: Segmenting Customer Data

The examples in this section use an Expectation Maximization clustering model to segment the customer data based on common characteristics.
Example 32-6  Compute Customer Segments

This query computes natural groupings of customers and returns the number of customers in each group. The em_sh_clus_sample model is created by the oml4sql-singular-value-decomposition.sql example.

```sql
SELECT CLUSTER_ID(em_sh_clus_sample USING *) AS clus, COUNT(*) AS cnt
FROM mining_data_apply_v
GROUP BY CLUSTER_ID(em_sh_clus_sample USING *)
ORDER BY cnt DESC;
```

<table>
<thead>
<tr>
<th>CLUS</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>311</td>
</tr>
<tr>
<td>3</td>
<td>294</td>
</tr>
<tr>
<td>7</td>
<td>215</td>
</tr>
<tr>
<td>12</td>
<td>201</td>
</tr>
<tr>
<td>17</td>
<td>123</td>
</tr>
<tr>
<td>16</td>
<td>114</td>
</tr>
<tr>
<td>14</td>
<td>86</td>
</tr>
<tr>
<td>19</td>
<td>64</td>
</tr>
<tr>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

Example 32-7  Find the Customers Who Are Most Likely To Be in the Largest Segment

The query in Example 32-6 shows that segment 9 has the most members. The following query lists the five customers who are most likely to be in segment 9.

```sql
SELECT cust_id
FROM (SELECT cust_id, RANK() over (ORDER BY prob DESC, cust_id) rnk_clus2
     FROM (SELECT cust_id,
           ROUND(CLUSTER_PROBABILITY(em_sh_clus_sample, 9 USING *),3) prob
           FROM mining_data_apply_v))
WHERE rnk_clus2 <= 5
ORDER BY rnk_clus2;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100002</td>
</tr>
<tr>
<td>100012</td>
</tr>
<tr>
<td>100016</td>
</tr>
<tr>
<td>100019</td>
</tr>
<tr>
<td>100021</td>
</tr>
</tbody>
</table>

Example 32-8  Find Key Characteristics of the Most Representative Customer in the Largest Cluster

The query in Example 32-7 lists customer 100002 first in the list of likely customers for segment 9. The following query returns the five characteristics that are most significant in determining the assignment of customer 100002 to segments with probability > 20% (only segment 9 for this customer).

```sql
SELECT S.cluster_id, probability prob,
       CLUSTER_DETAILS(em_sh_clus_sample, S.cluster_id, 5 using T.*) det
FROM
  (SELECT v.*, CLUSTER_SET(em_sh_clus_sample, NULL, 0.2 USING *) pset
   FROM mining_data_apply_v v
   WHERE cust_id = 100002) T,
TABLE(T.pset) S
```
ORDER BY 2 desc;

<table>
<thead>
<tr>
<th>CLUSTER_ID</th>
<th>PROB DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

<Details algorithm="Expectation Maximization" cluster="9">
  <Attribute name="YRS_RESIDENCE" actualValue="4" weight="1" rank="1"/>
  <Attribute name="EDUCATION" actualValue="Bach." weight="0" rank="2"/>
  <Attribute name="AFFINITY_CARD" actualValue="0" weight="0" rank="3"/>
  <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight="0" rank="4"/>
  <Attribute name="Y_BOX_GAMES" actualValue="0" weight="0" rank="5"/>
</Details>

32.5 Example : Comparison of Texts Using an ESA Model

The examples show the FEATURE_COMPARE function comparing texts for semantic relatedness (similarity) using the Explicit Semantic Analysis (ESA) prebuilt Wikipedia-based model, which extracts topics and compares text.

The examples shows an ESA model built against a prebuilt Wiki data set rendering over 200,000 features. The documents are analyzed as text and the document titles are given as the feature IDs. In the first example, the pair of sentence scores higher because Nick Price is a golfer born in South Africa.

Similar Texts

SELECT 1-FEATURE_COMPARE(esa_wiki_mod USING 'There are several PGA tour golfers from South Africa' text AND USING 'Nick Price won the 2002 Mastercard Colonial Open' text) similarity FROM DUAL;

SIMILARITY
----------
.110

The output metric shows distance calculation. Therefore, smaller number represent more similar texts. So, 1 minus the distance in the queries result in similarity.

Dissimilar Texts

SELECT 1-FEATURE_COMPARE(esa_wiki_mod USING 'There are several PGA tour golfers from South Africa' text AND USING 'John Elway played quarterback for the Denver Broncos' text) similarity FROM DUAL;

SIMILARITY
----------
.004
About the Oracle Machine Learning for SQL API

Overview of the OML4SQL application programming interface (API) components.

- About Oracle Machine Learning Models
- Oracle Machine Learning Data Dictionary Views
- Oracle Machine Learning Modeling, Transformations, and Convenience Functions
- Oracle Machine Learning for SQL Scoring Functions
- Oracle Machine Learning for SQL Statistical Functions

33.1 About Oracle Machine Learning Models

Machine learning models are database schema objects that perform machine learning techniques.

As with all schema objects, access to machine learning models is controlled by database privileges. Models can be exported and imported. They support comments and they can be tracked in the Oracle Database auditing system.

Machine learning models are created by the `CREATE_MODEL2` or the `CREATE_MODEL` procedures in the `DBMS_DATA_MINING` PL/SQL package. Models are created for a specific machine learning technique, and they use a specific algorithm to perform that function. **Machine learning function** is a term that refers to a class of machine learning problems to be solved. Examples of machine learning techniques are: regression, classification, attribute importance, clustering, anomaly detection, and feature selection. OML4SQL supports one or more algorithms for each machine learning technique.

Along with the machine learning technique, in the `CREATE_MODEL2` procedure, you can specify an algorithm and other characteristics of a model. In `CREATE_MODEL` procedure you can specify a settings table to specify an algorithm and other characteristics of a model. Some settings are general, some are specific to a machine learning technique, and some are specific to an algorithm.

**Note:**

Most types of machine learning models can be used to score data. However, it is possible to score data without applying a model. Dynamic scoring and predictive analytics return scoring results without a user-supplied model. They create and apply transient models that are not visible to you.
Related Topics

- **Dynamic Scoring**
  You can perform dynamic scoring if, for some reason, you do not want to apply a predefined model.

- **DBMS_PREDICTIVE_ANALYTICS**
  Understand the routines of `DBMS_PREDICTIVE_ANALYTICS` package.

- **Create a Model**
  Explains how to create Oracle Machine Learning for SQL models and to query model details.

- **Administrative Tasks for Oracle Machine Learning for SQL**
  Explains how to perform administrative tasks related to Oracle Machine Learning for SQL.

### 33.2 Oracle Machine Learning Data Dictionary Views

Lists Oracle Machine Learning data dictionary views.

The data dictionary views for Oracle Machine Learning are listed in the following table. A database administrator (DBA) and USER versions of the views are also available.

<table>
<thead>
<tr>
<th>View Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL_MINING_MODELS</td>
<td>Provides information about all accessible machine learning models</td>
</tr>
<tr>
<td>ALL_MINING_MODEL_ATTRIBUTES</td>
<td>Provides information about the attributes of all accessible machine learning models</td>
</tr>
<tr>
<td>ALL_MINING_MODEL_PARTITION</td>
<td>Provides information about the partitions of all accessible partitioned machine learning models</td>
</tr>
<tr>
<td>ALL_MINING_MODEL_SETTINGS</td>
<td>Provides information about the configuration settings for all accessible machine learning models</td>
</tr>
<tr>
<td>ALL_MINING_MODEL_VIEWS</td>
<td>Provides information about the model views for all accessible machine learning models</td>
</tr>
<tr>
<td>ALL_MINING_MODEL_XFORMS</td>
<td>Provides the user-specified transformations embedded in all accessible machine learning models</td>
</tr>
</tbody>
</table>

#### 33.2.1 ALL_MINING_MODELS

Describes an example of `ALL_MINING_MODELS` and shows a sample query.

The following example describes `ALL_MINING_MODELS` and shows a sample query.

**Example 33-1   ALL_MINING_MODELS**

```
describe ALL_MINING_MODELS
Name                                      Null?    Type
----------------------------------------- --------
```

---
The following query returns the models accessible to you that use the Support Vector Machine algorithm.

```sql
SELECT mining_function, model_name
FROM all_mining_models
WHERE algorithm = 'SUPPORT VECTOR MACHINES'
ORDER BY mining_function, model_name;
```

<table>
<thead>
<tr>
<th>MINING_FUNCTION</th>
<th>MODEL_NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASSIFICATION</td>
<td>PART2_CLAS_SAMPLE</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
<td>PART_CLAS_SAMPLE</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
<td>SVMC_SH_CLAS_SAMPLE</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
<td>SVMO_SH_CLAS_SAMPLE</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
<td>T_SVM_CLAS_SAMPLE</td>
</tr>
<tr>
<td>REGRESSION</td>
<td>SVMR_SH_REGR_SAMPLE</td>
</tr>
</tbody>
</table>

The models are created by the following examples:

- **PART2_CLAS_SAMPLE** by `oml4sql-partitioned-models-svm.sql`
- **PART_CLAS_SAMPLE** by `oml4sql-partitioned-models-svm.sql`
- **SVMC_SH_CLAS_SAMPLE** by `oml4sql-classification-svm.sql`
- **SVMO_SH_CLAS_SAMPLE** by `oml4sql-anomaly-detection-lcsvm.sql`
- **T_SVM_CLAS_SAMPLE** by `oml4sql-classification-text-analysis-svm.sql`
- **SVMR_SH_REGR_SAMPLE** by `oml4sql-regression-svm.sql`

### 33.2.2 ALL_MINING_MODEL_ATTRIBUTES

Describes an example of **ALL_MINING_MODEL_ATTRIBUTES** and shows a sample query.

The following example describes **ALL_MINING_MODEL_ATTRIBUTES** and shows a sample query. Attributes are the predictors or conditions that are used to create models and score data.

**Example 33-2**  **ALL_MINING_MODEL_ATTRIBUTES**

```sql
describe ALL_MINING_MODEL_ATTRIBUTES
```

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>MINING_FUNCTION</td>
<td></td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>ALGORITHM</td>
<td></td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>CREATION_DATE</td>
<td>NOT NULL</td>
<td>DATE</td>
</tr>
<tr>
<td>BUILD_DURATION</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>MODEL_SIZE</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>PARTITIONED</td>
<td></td>
<td>VARCHAR2(3)</td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>
The following query returns the attributes of an SVM classification model named T_SVM_CLAS_SAMPLE. The model has both categorical and numerical attributes and includes one attribute that is unstructured text. The model is created by the oml4sql-classification-text-analysis-svm.sql example

```
SELECT attribute_name, attribute_type, target
FROM all_mining_model_attributes
WHERE model_name = 'T_SVM_CLAS_SAMPLE'
ORDER BY attribute_name;
```

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>ATTRIBUTE_TYPE</th>
<th>TAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFINITY_CARD</td>
<td>CATEGORICAL</td>
<td>YES</td>
</tr>
<tr>
<td>AGE</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>BOOKKEEPING_APPLICATION</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>BULK_PACK_DISKETTES</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>TEXT</td>
<td>NO</td>
</tr>
<tr>
<td>COUNTRY_NAME</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>CUST_GENDER</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>CUST_INCOME_LEVEL</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>FLAT_PANEL_MONITOR</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>HOME_THEATER_PACKAGE</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>HOUSEHOLD_SIZE</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>OCCUPATION</td>
<td>CATEGORICAL</td>
<td>NO</td>
</tr>
<tr>
<td>OS_DOC_SET_KANJI</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>PRINTER_SUPPLIES</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>YRS_RESIDENCE</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
<tr>
<td>Y_BOX_GAMES</td>
<td>NUMERICAL</td>
<td>NO</td>
</tr>
</tbody>
</table>

### 33.2.3 ALL_MINING_MODEL_PARTITIONS

Describes an example of ALL_MINING_MODEL_PARTITIONS and shows a sample query.

The following example describes ALL_MINING_MODEL_PARTITIONS and shows a sample query.

**Example 33-3**  ALL_MINING_MODEL_PARTITIONS

describe ALL_MINING_MODEL_PARTITIONS

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>PARTITION_NAME</td>
<td></td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>POSITION</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>COLUMN_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>COLUMN_VALUE</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

The following query returns the partition names and partition key values for two partitioned models. Model PART2_CLAS_SAMPLE has a two column partition key
with system-generated partition names. The models are created by the oml4sql-partitioned-models-svm.sql example.

SELECT model_name, partition_name, position, column_name, column_value
    FROM all_mining_model_partitions
    ORDER BY model_name, partition_name, position;

<table>
<thead>
<tr>
<th>MODEL_NAME</th>
<th>PARTITION_</th>
<th>POSITION</th>
<th>COLUMN_NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P0</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P0</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P1</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P1</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P2</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P2</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P3</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P3</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P4</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P4</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P5</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART2_CLAS_SAMPLE</td>
<td>DM$$_P5</td>
<td>2</td>
<td>CUST_INCOME_LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART_CLAS_SAMPLE</td>
<td>F</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART_CLAS_SAMPLE</td>
<td>M</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART_CLAS_SAMPLE</td>
<td>U</td>
<td>1</td>
<td>CUST_GENDER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

33.2.4 ALL_MINING_MODEL_SETTINGS

Describes an example of ALL_MINING_MODEL_SETTINGS and shows a sample query.

The following example describes ALL_MINING_MODEL_SETTINGS and shows a sample query. Settings influence model behavior. Settings may be specific to an algorithm or to a machine learning technique, or they may be general.

Example 33-4  ALL_MINING_MODEL_SETTINGS

```
describe ALL_MINING_MODEL_SETTINGS
Name           Null?  Type
------------------------  -------- ----------------------------
OWNER            NOT NULL VARCHAR2(128)
The following query returns the settings for a model named SVD_SH_SAMPLE. The model uses the Singular Value Decomposition algorithm for feature extraction. The model is created by the omlsql-singular-value-decomposition.sql example.

```
SELECT setting_name, setting_value, setting_type
FROM all_mining_model_settings
WHERE model_name = 'SVD_SH_SAMPLE'
ORDER BY setting_name;
```

<table>
<thead>
<tr>
<th>SETTING_NAME</th>
<th>SETTING_VALUE</th>
<th>SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGO_NAME</td>
<td>ALGO_SINGULAR_VALUE_DECOMP</td>
<td>INPUT</td>
</tr>
<tr>
<td>ODMS_MISSING_VALUE_TREATMENT</td>
<td>ODMS_MISSING_VALUE_AUTO</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>ODMS_SAMPLING</td>
<td>ODMS_SAMPLING_DISABLE</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>PREP_AUTO</td>
<td>OFF</td>
<td>INPUT</td>
</tr>
<tr>
<td>SVDS_SCORING_MODE</td>
<td>SVDS_SCORING_SVD</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVDS_U_MATRIX_OUTPUT</td>
<td>SVDS_U_MATRIX_ENABLE</td>
<td>INPUT</td>
</tr>
</tbody>
</table>

33.2.5 ALL_MINING_MODEL_VIEWS

Describes an example of ALL_MINING_MODEL_VIEWS and shows a sample query.

The following example describes ALL_MINING_MODEL_VIEWS and shows a sample query. Model views provide details on the models.

**Example 33-5**    ALL_MINING_MODEL_VIEWS

describe ALL_MINING_MODEL_VIEWS

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>VIEW_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>VIEW_TYPE</td>
<td>VARCHAR2(128)</td>
<td></td>
</tr>
</tbody>
</table>

The following query returns the model views for the SVD_SH_SAMPLE model. The model uses the Singular Value Decomposition algorithm for feature extraction. The model is created by the omlsql-singular-value-decomposition.sql example.

```
SELECT view_name, view_type
FROM all_mining_model_views
WHERE model_name = 'SVD_SH_SAMPLE'
ORDER BY view_name;
```

<table>
<thead>
<tr>
<th>VIEW_NAME</th>
<th>VIEW_TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM$VESVD_SH_SAMPLE</td>
<td>Singular Value Decomposition S Matrix</td>
</tr>
<tr>
<td>DM$VGSVD_SH_SAMPLE</td>
<td>Global Name-Value</td>
</tr>
</tbody>
</table>

Oracle Machine Learning Data Dictionary Views
33.2.6 ALL_MINING_MODEL_XFORMS

Describes an example of ALL_MINING_MODEL_XFORMS and provides a sample query.

The following example describes ALL_MINING_MODEL_XFORMS and provides a sample query.

**Example 33-6  ALL_MINING_MODEL_XFORMS**

describe ALL_MINING_MODEL_XFORMS

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>NOT NULL</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td></td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_SPEC</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>EXPRESSION</td>
<td></td>
<td>CLOB</td>
</tr>
<tr>
<td>REVERSE</td>
<td></td>
<td>VARCHAR2(3)</td>
</tr>
</tbody>
</table>

The following query returns the embedded transformations for a model PART2_CLAS_SAMPLE. The model is created by the oml4sql-partitioned-models-svm.sql example.

```sql
SELECT attribute_name, expression
FROM all_mining_model_xforms
WHERE model_name = 'PART2_CLAS_SAMPLE'
ORDER BY attribute_name;
```

ATTRIBUTE_NAME

-------------------------

EXPRESSION

-----------------------------------------------------------------------------------------------------------------

---

CUST_INCOME_LEVEL

CASE CUST_INCOME_LEVEL WHEN 'A: Below 30,000' THEN
'LOW'
  WHEN 'L: 300,000 and above' THEN
'HIGH'
  ELSE 'MEDIUM' END
33.3 Oracle Machine Learning Modeling, Transformations, and Convenience Functions

You can access PL/SQL interface to perform data modeling, transformations, and predictive analytics.

The following table displays the PL/SQL packages for Oracle Machine Learning. In Oracle Database releases prior to Release 21c, Oracle Machine Learning was named Oracle Data Mining.

### Table 33-2  Oracle Machine Learning PL/SQL Packages

<table>
<thead>
<tr>
<th>Package Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBMS_DATA_MINING</td>
<td>Routines for creating and managing machine learning models</td>
</tr>
<tr>
<td>DBMS_DATA_MINING_TRANSFORM</td>
<td>Routines for transforming the data for machine learning</td>
</tr>
<tr>
<td>DBMS_PREDICTIVE_ANALYTICS</td>
<td>Routines that perform predictive analytics</td>
</tr>
</tbody>
</table>

**Related Topics**

- DBMS_DATA_MINING
- DBMS_DATA_MINING_TRANSFORM
- DBMS_PREDICTIVE_ANALYTICS

### 33.3.1 DBMS_DATA_MINING

Understand the routines of **DBMS_DATA_MINING** package.

The **DBMS_DATA_MINING** package contains routines for creating machine learning models, for performing operations on the models, and for querying them. The package includes routines for:

- Creating, dropping, and performing other DDL operations on machine learning models
- Obtaining detailed information about model attributes, rules, and other information internal to the model (model details)
- Computing test metrics for classification models
- Specifying costs for classification models
- Exporting and importing models
- Building models using Oracle Machine Learning native algorithms as well as algorithms written in R

**Related Topics**

- Oracle Database PL/SQL Packages and Types Reference
33.3.2 DBMS_DATA_MINING_TRANSFORM

Understand the routines of DBMS_DATA_MINING_TRANSFORM package.

The DBMS_DATA_MINING_TRANSFORM package contains routines that perform data transformations such as binning, normalization, and outlier treatment. The package includes routines for:

- Specifying transformations in a format that can be embedded in a machine learning model.
- Specifying transformations as relational views (external to machine learning model objects).
- Specifying distinct properties for columns in the build data. For example, you can specify that the column must be interpreted as unstructured text, or that the column must be excluded from Automatic Data Preparation.

Related Topics
- Oracle Database PL/SQL Packages and Types Reference

33.3.2.1 Transformation Methods in DBMS_DATA_MINING_TRANSFORM

Summarizes the methods for transforming data in DBMS_DATA_MINING_TRANSFORM package.

Table 33-3  DBMS_DATA_MINING_TRANSFORM Transformation Methods

<table>
<thead>
<tr>
<th>Transformation Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XFORM interface</td>
<td>CREATE, INSERT, and XFORM routines specify transformations in external views</td>
</tr>
<tr>
<td>STACK interface</td>
<td>CREATE, INSERT, and XFORM routines specify transformations for embedding in a model</td>
</tr>
<tr>
<td>SET_TRANSFORM</td>
<td>Specifies transformations for embedding in a model</td>
</tr>
</tbody>
</table>

The statements in the following example create a Support Vector Machine (SVM) classification model called T_SVM_CLAS_SAMPLE with an embedded transformation that causes the comments attribute to be treated as unstructured text data. The T_SVM_CLAS_SAMPLE model is created by oml4sql-classification-text-analysis-svm.sql example.

Example 33-7  Sample Embedded Transformation

DECLARE
  xformlist dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.SET_TRANSFORM(
    xformlist, 'comments', null, 'comments', null, 'TEXT');
  dbms_data_mining.classification(
    model_name        => 'T_SVM_CLAS_SAMPLE',
    mining_function   => dbms_data_mining.classification,
    data_table_name   => 'mining_build_text',
    case_id_column_name => 'cust_id',
    target_column_name => 'affinity_card',
    settings_table_name => 't_svmc_sample_settings',
    xform_list => xformlist);
33.3.3 DBMS_PREDICTIVE_ANALYTICS

Understand the routines of DBMS_PREDICTIVE_ANALYTICS package.

The DBMS_PREDICTIVE_ANALYTICS package contains routines that perform an automated form of machine learning known as predictive analytics. With predictive analytics, you do not need to be aware of model building or scoring. All machine learning activities are handled internally by the procedure. The DBMS_PREDICTIVE_ANALYTICS package includes these routines:

- **EXPLAIN** ranks attributes in order of influence in explaining a target column.
- **PREDICT** predicts the value of a target column based on values in the input data.
- **PROFILE** generates rules that describe the cases from the input data.

The EXPLAIN statement in the following example lists attributes in the view `mining_data_build_v` in order of their importance in predicting `affinity_card`.

**Example 33-8 Sample EXPLAIN Statement**

```
BEGIN
    DBMS_PREDICTIVE_ANALYTICS.EXPLAIN(
        data_table_name              => 'mining_data_build_v',
        explain_column_name          => 'affinity_card',
        result_table_name            => 'explain_results');
END;
/
```

Related Topics

- Oracle Database PL/SQL Packages and Types Reference

33.4 Oracle Machine Learning for SQL Scoring Functions

Understand the different OML4SQL scoring functions.

Use these OML4SQL functions to score data. The functions can apply a machine learning model schema object to the data, or they can dynamically mine the data by executing an analytic clause. SQL functions are available for all OML4SQL algorithms that support the scoring operation. All OML4SQL functions, as listed in the following table can operate on an R machine learning model with the corresponding OML4SQL function. However, the functions are not limited to the ones listed here.

**Table 33-4 OML4SQL Functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLUSTER_ID</td>
<td>Returns the ID of the predicted cluster</td>
</tr>
<tr>
<td>CLUSTERDETAILS</td>
<td>Returns detailed information about the predicted cluster</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CLUSTER_DISTANCE</td>
<td>Returns the distance from the centroid of the predicted cluster</td>
</tr>
<tr>
<td>CLUSTER_PROBABILITY</td>
<td>Returns the probability of a case belonging to a given cluster</td>
</tr>
<tr>
<td>CLUSTER_SET</td>
<td>Returns a list of all possible clusters to which a given case belongs along with the associated probability of inclusion</td>
</tr>
<tr>
<td>FEATURE_COMPARE</td>
<td>Compares two similar and dissimilar set of texts from two different documents or keyword phrases or a combination of both</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>Returns the ID of the feature with the highest coefficient value</td>
</tr>
<tr>
<td>FEATURE_DETAILS</td>
<td>Returns detailed information about the predicted feature</td>
</tr>
<tr>
<td>FEATURE_SET</td>
<td>Returns a list of objects containing all possible features along with the associated coefficients</td>
</tr>
<tr>
<td>FEATURE_VALUE</td>
<td>Returns the value of the predicted feature</td>
</tr>
<tr>
<td>ORA_DM_PARTITION_NAME</td>
<td>Returns the partition names for a partitioned model</td>
</tr>
<tr>
<td>PREDICTION</td>
<td>Returns the best prediction for the target</td>
</tr>
<tr>
<td>PREDICTION_BOUNDS</td>
<td>(GLM only) Returns the upper and lower bounds of the interval wherein the predicted values (linear regression) or probabilities (logistic regression) lie.</td>
</tr>
<tr>
<td>PREDICTION_COST</td>
<td>Returns a measure of the cost of incorrect predictions</td>
</tr>
<tr>
<td>PREDICTION_DETAILS</td>
<td>Returns detailed information about the prediction</td>
</tr>
<tr>
<td>PREDICTION_PROBABILITY</td>
<td>Returns the probability of the prediction</td>
</tr>
<tr>
<td>PREDICTION_SET</td>
<td>Returns the results of a classification model, including the predictions and associated probabilities for each case</td>
</tr>
</tbody>
</table>
The following example shows a query that returns the results of the `CLUSTER_ID` function. The query applies the model `em_sh_clus_sample`, which finds groups of customers that share certain characteristics. The query returns the identifiers of the clusters and the number of customers in each cluster. The `em_sh_clus_sample` model is created by the `oml4sql-singular-value-decomposition.sql` example.

**Example 33-9  CLUSTER_ID Function**

```sql
-- List the clusters into which the customers in this data set have been grouped.
SELECT CLUSTER_ID(em_sh_clus_sample USING *) AS clus, COUNT(*) AS cnt
FROM mining_data_apply_v
GROUP BY CLUSTER_ID(em_sh_clus_sample USING *)
ORDER BY cnt DESC;
```

```
SQL> -- List the clusters into which the customers in this data set have been grouped.
SQL> SELECT CLUSTER_ID(em_sh_clus_sample USING *) AS clus, COUNT(*) AS cnt
2    FROM mining_data_apply_v
3  GROUP BY CLUSTER_ID(em_sh_clus_sample USING *)
4  ORDER BY cnt DESC;
```

<table>
<thead>
<tr>
<th>CLUS</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>311</td>
</tr>
<tr>
<td>3</td>
<td>294</td>
</tr>
<tr>
<td>7</td>
<td>215</td>
</tr>
<tr>
<td>12</td>
<td>201</td>
</tr>
<tr>
<td>17</td>
<td>123</td>
</tr>
<tr>
<td>16</td>
<td>114</td>
</tr>
<tr>
<td>14</td>
<td>86</td>
</tr>
<tr>
<td>19</td>
<td>64</td>
</tr>
<tr>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

**Related Topics**

- **Scoring and Deployment**
  Explains the scoring and deployment features of Oracle Machine Learning for SQL.

- **OML4SQL Scoring Functions**

**33.5 Oracle Machine Learning for SQL Statistical Functions**

Various SQL statistical functions are available in Oracle Database to explore and analyze data.

A variety of scalable statistical functions are accessible through SQL in Oracle Database. These statistical functions are implemented as SQL functions. The SQL statistical functions can be used to compute standard univariate statistics such as `MEAN`, `MAX`, `MIN`, `MEDIAN`, `MODE`, and standard deviation on the data. Users can also perform various other statistical functions such as t-test, f-test, aggregate functions, analytic functions, or ANOVA. The functions listed in the following table are available from SQL.
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPROX_COUNT</td>
<td>Returns approximate count of an expression</td>
</tr>
<tr>
<td>APPROX_SUM</td>
<td>Returns approximate sum of an expression</td>
</tr>
<tr>
<td>APPROX_RANK</td>
<td>Returns approximate value in a group of values</td>
</tr>
<tr>
<td>CORR</td>
<td>Returns the coefficient of correlation of a set of number pairs</td>
</tr>
<tr>
<td>CORR_S</td>
<td>Calculates the Spearman’s rho correlation coefficient</td>
</tr>
<tr>
<td>CORR_K</td>
<td>Calculates the Kendall’s tau-b correlation coefficient</td>
</tr>
<tr>
<td>COVAR_POP</td>
<td>Returns the population covariance of a set of number pairs</td>
</tr>
<tr>
<td>COVAR_SAMP</td>
<td>Returns the sample covariance of a set of number pairs</td>
</tr>
<tr>
<td>LAG</td>
<td>LAG is an analytic function. It provides access to more than one row of a table at the same time without a self join.</td>
</tr>
<tr>
<td>LEAD</td>
<td>LEAD is an analytic function. It provides access to more than one row of a table at the same time without a self join.</td>
</tr>
<tr>
<td>STATS_BINOMIAL_TEST</td>
<td>STATS_BINOMIAL_TEST is an exact probability test used for dichotomous variables, where only two possible values exist.</td>
</tr>
<tr>
<td>STATS_CROSSTAB</td>
<td>STATS_CROSSTAB is a method used to analyze two nominal variables.</td>
</tr>
<tr>
<td>STATS_F_TEST</td>
<td>STATS_F_TEST tests whether two variances are significantly different.</td>
</tr>
<tr>
<td>STATS_KS_TEST</td>
<td>STATS_KS_TEST is a Kolmogorov-Smirnov function that compares two samples to test whether they are from the same population or from populations that have the same distribution.</td>
</tr>
<tr>
<td>STATS_MODE</td>
<td>Takes as its argument a set of values and returns the value that occurs with the greatest frequency</td>
</tr>
<tr>
<td>STATS_MW_TEST</td>
<td>A Mann Whitney test compares two independent samples to test the null hypothesis that two populations have the same distribution function against the alternative hypothesis that the two distribution functions are different.</td>
</tr>
<tr>
<td>STATS_ONE_WAY_ANOVA</td>
<td>Tests differences in means (for groups or variables) for statistical significance by comparing two different estimates of variance</td>
</tr>
<tr>
<td>STATS_T_TEST_*</td>
<td>The t-test measures the significance of a difference of means</td>
</tr>
<tr>
<td>STATS_T_TEST_ONE</td>
<td>A one-sample t-test</td>
</tr>
<tr>
<td>STATS_T_TEST_PAIRED</td>
<td>A two-sample, paired t-test (also known as a crossed t-test)</td>
</tr>
<tr>
<td>STATS_T_TEST_INDEPU</td>
<td>A t-test of two independent groups with the same variance (pooled variances)</td>
</tr>
<tr>
<td></td>
<td>A t-test of two independent groups with unequal variance (unpooled variances)</td>
</tr>
</tbody>
</table>
### Table 33-5 (Cont.) SQL Statistical Functions Supported by OML4SQL

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STDDEV</td>
<td>returns the sample standard deviation of a set of numbers</td>
</tr>
<tr>
<td>STDDEV_POP</td>
<td>Computes the population standard deviation and returns the square root of the population variance</td>
</tr>
<tr>
<td>STDDEV_SAMP</td>
<td>Computes the cumulative sample standard deviation and returns the square root of the sample variance</td>
</tr>
<tr>
<td>SUM</td>
<td>Returns the sum of values</td>
</tr>
</tbody>
</table>

DBMS_STAT_FUNCS PL/SQL package is also available for users.

**Related Topics**

- **Scoring and Deployment**
  Explains the scoring and deployment features of Oracle Machine Learning for SQL.

- **Oracle Machine Learning for R User’s Guide**
Prepare the Data

Learn how to access and treat the data that can be used to build a model.

- Data Requirements
- About Attributes
- Use Nested Data
- Use Market Basket Data
- Use Retail Data for Analysis
- Handle Missing Values

34.1 Data Requirements

Understand how data is stored and viewed for Oracle Machine Learning.

Machine learning activities require data that is defined within a single table or view. The information for each record must be stored in a separate row. The data records are commonly called cases. Each case can optionally be identified by a unique case ID. The table or view itself can be referred to as a case table.

The CUSTOMERS table in the SH schema is an example of a table that could be used for machine learning. All the information for each customer is contained in a single row. The case ID is the CUST_ID column. The rows listed in the following example are selected from SH.CUSTOMERS.

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CUST_GENDER</th>
<th>CUST_YEAR_OF_BIRTH</th>
<th>CUST_MAIN_PHONE_NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>1946</td>
<td>127-379-8954</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>1957</td>
<td>680-327-1419</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>1939</td>
<td>115-509-3391</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>1934</td>
<td>577-104-2792</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>1969</td>
<td>563-667-7731</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>1925</td>
<td>682-732-7260</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>1964</td>
<td>234-693-8728</td>
</tr>
</tbody>
</table>

Note:

Oracle Machine Learning requires single-record case data for all types of models except association models, which can be built on native transactional data.
34.1.1 Column Data Types

Understand the different types of column data in a case table.

The columns of the case table hold the attributes that describe each case. In Example 34-1, the attributes are: CUST_GENDER, CUST_YEAR_OF_BIRTH, and CUST_MAIN_PHONE_NUMBER. The attributes are the predictors in a supervised model or the descriptors in an unsupervised model. The case ID, CUST_ID, can be viewed as a special attribute; it is not a predictor or a descriptor.

OML4SQL supports standard Oracle data types as well as the following collection types:

- DM_NESTED_CATEGORICALS
- DM_NESTED_NUMERICALS
- DM_NESTED_BINARY_DOUBLES
- DM_NESTED_BINARY_FLOATS

34.1.2 Data Sets for Classification and Regression

Understand how data sets are used for training and testing the model.

You need two case tables to build and validate classification and regression models. One set of rows is used for training the model, another set of rows is used for testing the model. It is often convenient to derive the build data and test data from the same data set. For example, you could randomly select 60% of the rows for training the model; the remaining 40% could be used for testing the model.

Models that implement other machine learning functions, such as attribute importance, clustering, association, or feature extraction, do not use separate test data.

34.1.3 Scoring Requirements

Learn how scoring is done in Oracle Machine Learning for SQL.

Most machine learning models can be applied to separate data in a process known as scoring. Oracle Machine Learning for SQL supports the scoring operation for classification, regression, anomaly detection, clustering, and feature extraction.
The scoring process matches column names in the scoring data with the names of the columns that were used to build the model. The scoring process does not require all the columns to be present in the scoring data. If the data types do not match, OML4SQL attempts to perform type coercion. For example, if a column called `PRODUCT_RATING` is `VARCHAR2` in the training data but `NUMBER` in the scoring data, OML4SQL effectively applies a `TO_CHAR()` function to convert it.

The column in the test or scoring data must undergo the same transformations as the corresponding column in the build data. For example, if the `AGE` column in the build data was transformed from numbers to the values `CHILD`, `ADULT`, and `SENIOR`, then the `AGE` column in the scoring data must undergo the same transformation so that the model can properly evaluate it.

**Note:**

OML4SQL can embed user-specified transformation instructions in the model and reapply them whenever the model is applied. When the transformation instructions are embedded in the model, you do not need to specify them for the test or scoring data sets.

OML4SQL also supports Automatic Data Preparation (ADP). When ADP is enabled, the transformations required by the algorithm are performed automatically and embedded in the model along with any user-specified transformations.

**See Also:**

Automatic Data Preparation and Embed Transformations in a Model for more information on automatic and embedded data transformations.

### 34.2 About Attributes

Attributes are the items of data that are used in machine learning. Attributes are also referred as variables, fields, or predictors.

In predictive models, attributes are the predictors that affect a given outcome. In descriptive models, attributes are the items of information being analyzed for natural groupings or associations. For example, a table of employee data that contains attributes such as job title, date of hire, salary, age, gender, and so on.

#### 34.2.1 Data Attributes and Model Attributes

**Data attributes** are columns in the data set used to build, test, or score a model. **Model attributes** are the data representations used internally by the model.

Data attributes and model attributes can be the same. For example, a column called `SIZE`, with values `S`, `M`, and `L`, are attributes used by an algorithm to build a model. Internally, the model attribute `SIZE` is most likely be the same as the data attribute from which it was derived.
On the other hand, a nested column `SALES_PROD`, containing the sales figures for a group of products, does not correspond to a model attribute. The data attribute can be `SALES_PROD`, but each product with its corresponding sales figure (each row in the nested column) is a model attribute.

Transformations also cause a discrepancy between data attributes and model attributes. For example, a transformation can apply a calculation to two data attributes and store the result in a new attribute. The new attribute is a model attribute that has no corresponding data attribute. Other transformations such as binning, normalization, and outlier treatment, cause the model's representation of an attribute to be different from the data attribute in the case table.

**Related Topics**

- **Use Nested Data**
  A join between the tables for one-to-many relationship is represented through nested columns.

- **Embed Transformations in a Model**
  You can specify your own transformations and embed them in a model by creating a transformation list and passing it to `DBMS_DATA_MINING.CREATE_MODEL2` or `DBMS_DATA_MINING.CREATE_MODEL`.

---

### 34.2.2 Target Attribute

Understand what a **target** means in machine learning and understand the different target data types.

The **target** of a supervised model is a special kind of attribute. The target column in the training data contains the historical values used to train the model. The target column in the test data contains the historical values to which the predictions are compared. The act of scoring produces a prediction for the target.

Clustering, feature extraction, association, and anomaly detection models do not use a target.

Nested columns and columns of unstructured data (such as `BFILE`, `CLOB`, or `BLOB`) cannot be used as targets.

**Table 34-1 Target Data Types**

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Target Data Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td><code>VARCHAR2, CHAR</code></td>
</tr>
<tr>
<td></td>
<td><code>NUMBER, FLOAT</code></td>
</tr>
<tr>
<td></td>
<td><code>BINARY_DOUBLE, BINARY_FLOAT, ORA_MININGVARCHAR2_NT</code></td>
</tr>
<tr>
<td>Regression</td>
<td><code>NUMBER, FLOAT</code></td>
</tr>
<tr>
<td></td>
<td><code>BINARY_DOUBLE, BINARY_FLOAT</code></td>
</tr>
</tbody>
</table>
You can query the * _MINING_MODEL_ATTRIBUTES_ view to find the target for a given model.

Related Topics

- **ALL_MINING_MODEL_ATTRIBUTES**
  Describes an example of ALL_MINING_MODEL_ATTRIBUTES and shows a sample query.
- **Oracle Database PL/SQL Packages and Types Reference**

### 34.2.3 Numericals, Categoricals, and Unstructured Text

Explain numeric, categorical, and unstructured text attributes.

Model attributes are numerical, categorical, or unstructured (text). Data attributes, which are columns in a case table, have Oracle data types, as described in “Column Data Types”.

Numerical attributes can theoretically have an infinite number of values. The values have an implicit order, and the differences between them are also ordered. Oracle Machine Learning for SQL interprets NUMBER, FLOAT, BINARY_DOUBLE, BINARY_FLOAT, DM_NESTED_NUMERICALS, DM_NESTED_BINARY_DOUBLES, and DM_NESTED_BINARY_FLOATS as numerical.

Categorical attributes have values that identify a finite number of discrete categories or classes. There is no implicit order associated with the values. Some categoricals are binary: they have only two possible values, such as yes or no, or male or female. Other categoricals are multi-class: they have more than two values, such as small, medium, and large.

OML4SQL interprets CHAR and VARCHAR2 as categorical by default, however these columns may also be identified as columns of unstructured data (text). OML4SQL interprets columns of DM_NESTED_CATEGORICALS as categorical. Columns of CLOB, BLOB, and BFILE always contain unstructured data.

The target of a classification model is categorical. (If the target of a classification model is numeric, it is interpreted as categorical.) The target of a regression model is numerical. The target of an attribute importance model is either categorical or numerical.

Related Topics

- **Column Data Types**
  Understand the different types of column data in a case table.
- **Machine Learning Operations on Unstructured Text**
  Explains how to use Oracle Machine Learning for SQL to operate on unstructured text.

### 34.2.4 Model Signature

Learn about model signature and the data types that are considered in the build data.

The model signature is the set of data attributes that are used to build a model. Some or all of the attributes in the signature must be present for scoring. The model accounts for any missing columns on a best-effort basis. If columns with the same names but different data types are present, the model attempts to convert the data type. If extra, unused columns are present, they are disregarded.

The model signature does not necessarily include all the columns in the build data. Algorithm-specific criteria can cause the model to ignore certain columns. Other columns can be eliminated by transformations. Only the data attributes actually used to build the model are included in the signature.

The target and case ID columns are not included in the signature.
34.2.5 Scoping of Model Attribute Name

Learn about model attribute name.

The model attribute name consists of two parts: a column name, and a subcolumn name.

\texttt{column\_name\[.subcolumn\_name\]}

The \texttt{column\_name} component is the name of the data attribute. It is present in all model attribute names. Nested attributes and text attributes also have a \texttt{subcolumn\_name} component as shown in the following example.

**Example 34-2  Model Attributes Derived from a Nested Column**

The nested column \texttt{SALESPROD} has three rows.

\texttt{SALESPROD\(\text{ATTRIBUTE\_NAME, VALUE}\)}

\begin{verbatim}
((PROD1, 300),
 (PROD2, 245),
 (PROD3, 679))
\end{verbatim}

The name of the data attribute is \texttt{SALESPROD}. Its associated model attributes are:

\texttt{SALESPROD.PROD1}
\texttt{SALESPROD.PROD2}
\texttt{SALESPROD.PROD3}

34.2.6 Model Details

Model details reveal information about model attributes and their treatment by the algorithm. Oracle recommends that users leverage the model detail views for the respective algorithm.

Transformation and reverse transformation expressions are associated with model attributes. Transformations are applied to the data attributes before the algorithmic processing that creates the model. Reverse transformations are applied to the model attributes after the model has been built, so that the model details are expressed in the form of the original data attributes, or as close to it as possible.

Reverse transformations support model transparency. They provide a view of the data that the algorithm is working with internally but in a format that is meaningful to a user.

**Deprecated \texttt{GET\_MODEL\_DETAILS}**

There is a separate \texttt{GET\_MODEL\_DETAILS} routine for each algorithm. Starting from Oracle Database 12c Release 2, the \texttt{GET\_MODEL\_DETAILS} are deprecated. Oracle recommends to use Model Detail Views for the respective algorithms.

**Related Topics**

- \texttt{Model Detail Views}
  Model detail views provide information about models.
34.3 Use Nested Data

A join between the tables for one-to-many relationship is represented through nested columns.

Oracle Machine Learning for SQL requires a case table in single-record case format, with each record in a separate row. What if some or all of your data is in multi-record case format, with each record in several rows? What if you want one attribute to represent a series or collection of values, such as a student's test scores or the products purchased by a customer?

This kind of one-to-many relationship is usually implemented as a join between tables. For example, you can join your customer table to a sales table and thus associate a list of products purchased with each customer.

OML4SQL supports dimensioned data through nested columns. To include dimensioned data in your case table, create a view and cast the joined data to one of the machine learning nested table types. Each row in the nested column consists of an attribute name/value pair. OML4SQL internally processes each nested row as a separate attribute.

Note:
O-Cluster is the only algorithm that does not support nested data.

Related Topics
- Example: Creating a Nested Column for Market Basket Analysis
  The example shows how to define a nested column for market basket analysis.

34.3.1 Nested Object Types

Nested tables are object data types that can be used in place of other data types.

Oracle Database supports user-defined data types that make it possible to model real-world entities as objects in the database. Collection types are object data types for modeling multi-valued attributes. Nested tables are collection types. Nested tables can be used anywhere that other data types can be used.

OML4SQL supports the following nested object types:

- DM_NESTED_BINARY_DOUBLES
- DM_NESTED_BINARY_FLOATS
- DM_NESTED_NUMERICALS
- DM_NESTED_CATEGORICALS

Descriptions of the nested types are provided in this example.

Example 34-3  OML4SQL Nested Data Types

describe dm_nested_binary_double
Name Null? Type
----------------------------------------- -------- ----------------------------
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE  BINARY_DOUBLE

describe dm_nested_binary_doubles
DM_NESTED_BINARY_DOUBLES TABLE OF SYS.DM_NESTED_BINARY_DOUBLE
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE BINARY_DOUBLE

describe dm_nested_binary_float
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE BINARY_FLOAT

describe dm_nested_binary_floats
DM_NESTED_BINARY_FLOATS TABLE OF SYS.DM_NESTED_BINARY_FLOAT
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE BINARY_FLOAT

describe dm_nested_numerical
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE NUMBER

describe dm_nested_numericals
DM_NESTED_NUMERICALS TABLE OF SYS.DM_NESTED_NUMERICAL
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE NUMBER

describe dm_nested_categorical
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE VARCHAR2(4000)

describe dm_nested_categoricals
DM_NESTED_CATEGORICALS TABLE OF SYS.DM_NESTED_CATEGORICAL
Name Null? Type
ATTRIBUTE_NAME VARCHAR2(4000)
VALUE VARCHAR2(4000)

Related Topics

- Oracle Database Object-Relational Developer's Guide
34.3.2 Example: Transforming Transactional Data for Machine Learning

In this example, a comparison is shown for sale of products in four regions with data before transformation and then after transformation.

**Example 34-4** shows data from a view of a sales table. It includes sales for three of the many products sold in four regions. This data is not suitable for machine learning at the product level because sales for each case (product), is stored in several rows.

**Example 34-5** shows how this data can be transformed for machine learning. The case ID column is `PRODUCT`. `SALES_PER_REGION`, a nested column of type `DM_NESTED_NUMERICALS`, is a data attribute. This table is suitable for machine learning at the product case level, because the information for each case is stored in a single row.

Oracle Machine Learning for SQL treats each nested row as a separate model attribute, as shown in **Example 34-6**.

**Note:**
The presentation in this example is conceptual only. The data is not actually pivoted before being processed.

**Example 34-4**  Product Sales per Region in Multi-Record Case Format

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>REGION</th>
<th>SALES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod1</td>
<td>NE</td>
<td>556432</td>
</tr>
<tr>
<td>Prod2</td>
<td>NE</td>
<td>670155</td>
</tr>
<tr>
<td>Prod3</td>
<td>NE</td>
<td>3111</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prod1</td>
<td>NW</td>
<td>90887</td>
</tr>
<tr>
<td>Prod2</td>
<td>NW</td>
<td>100999</td>
</tr>
<tr>
<td>Prod3</td>
<td>NW</td>
<td>750437</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prod1</td>
<td>SE</td>
<td>82153</td>
</tr>
<tr>
<td>Prod2</td>
<td>SE</td>
<td>57322</td>
</tr>
<tr>
<td>Prod3</td>
<td>SE</td>
<td>28938</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prod1</td>
<td>SW</td>
<td>3297551</td>
</tr>
<tr>
<td>Prod2</td>
<td>SW</td>
<td>4972019</td>
</tr>
<tr>
<td>Prod3</td>
<td>SW</td>
<td>884923</td>
</tr>
</tbody>
</table>

**Example 34-5**  Product Sales per Region in Single-Record Case Format

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>SALES_PER_REGION</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------</td>
<td>------------------</td>
</tr>
<tr>
<td>Prod1</td>
<td>('NE', 556432)</td>
</tr>
<tr>
<td></td>
<td>('NW', 90887)</td>
</tr>
<tr>
<td></td>
<td>('SE', 82153)</td>
</tr>
<tr>
<td></td>
<td>('SW', 3297551)</td>
</tr>
</tbody>
</table>
Example 34-6  Model Attributes Derived From SALES_PER_REGION

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>SALES_PER_REGION.NE</th>
<th>SALES_PER_REGION.NW</th>
<th>SALES_PER_REGION.SE</th>
<th>SALES_PER_REGION.SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod1</td>
<td>556432</td>
<td>90887</td>
<td>82153</td>
<td>3297551</td>
</tr>
<tr>
<td>Prod2</td>
<td>670155</td>
<td>100999</td>
<td>57322</td>
<td>4972019</td>
</tr>
<tr>
<td>Prod3</td>
<td>3111</td>
<td>750437</td>
<td>28938</td>
<td>884923</td>
</tr>
</tbody>
</table>

34.4 Use Market Basket Data

Understand the use of association and Apriori for market basket analysis.

Market basket data identifies the items sold in a set of baskets or transactions. Oracle Machine Learning for SQL provides the association machine learning function for market basket analysis.

Association models use the Apriori algorithm to generate association rules that describe how items tend to be purchased in groups. For example, an association rule can assert that people who buy peanut butter are 80% likely to also buy jelly.

Market basket data is usually transactional. In transactional data, a case is a transaction and the data for a transaction is stored in multiple rows. OML4SQL association models can be built on transactional data or on single-record case data. The ODMS_ITEM_ID_COLUMN_NAME and ODMS_ITEM_VALUE_COLUMN_NAME settings specify whether the data for association rules is in transactional format.

**Note:**

Association models are the only type of model that can be built on native transactional data. For all other types of models, OML4SQL requires that the data be presented in single-record case format.

The Apriori algorithm assumes that the data is transactional and that it has many missing values. Apriori interprets all missing values as sparse data, and it has its own native mechanisms for handling sparse data.
34.4.1 Example: Creating a Nested Column for Market Basket Analysis

The example shows how to define a nested column for market basket analysis.

Association models can be built on native transactional data or on nested data. The following example shows how to define a nested column for market basket analysis.

The following SQL statement transforms this data to a column of type DM_NESTED_NUMERICALS in a view called SALES_TRANS_CUST_NESTED. This view can be used as a case table for machine learning.

```
CREATE VIEW sales_trans_cust_nested AS
    SELECT trans_id,
           CAST(COLLECT(DM_NESTED_NUMERICAL(
                prod_name, 1))
           AS DM_NESTED_NUMERICALS) custprods
    FROM sales_trans_cust
    GROUP BY trans_id;
```

This query returns two rows from the transformed data.

```
SELECT * FROM sales_trans_cust_nested
WHERE trans_id < 101000
AND trans_id > 100997;
```

```
TRANS_ID  CUSTPRODS(ATTRIBUTE_NAME, VALUE)
-------  ------------------------------------------------
100998   DM_NESTED_NUMERICALS
           (DM_NESTED_NUMERICAL('O/S Documentation Set - English', 1))
100999   DM_NESTED_NUMERICALS
           (DM_NESTED_NUMERICAL('CD-RW, High Speed Pack of 5', 1),
            DM_NESTED_NUMERICAL('External 8X CD-ROM', 1),
            DM_NESTED_NUMERICAL('SIMM- 16MB PCMCIAII card', 1))
```

Example 34-7  Convert to a Nested Column

The view SALES_TRANS_CUST provides a list of transaction IDs to identify each market basket and a list of the products in each basket.

describe sales_trans_cust
Name                  Null?    Type
---------------------- -------- ----------------
TRANS_ID              NOT NULL NUMBER
PROD_NAME             NOT NULL VARCHAR2 (50)
QUANTITY              NOT NULL NUMBER

Related Topics
• Handle Missing Values
  Understand sparse data and missing values.
34.5 Use Retail Data for Analysis

Retail analysis often makes use of association rules and association models. The association rules are enhanced to calculate aggregates along with rules or itemsets.

Related Topics
- Oracle Machine Learning for SQL Concepts

34.5.1 Example: Calculating Aggregates

This example shows how to calculate aggregates using the customer grocery purchase and profit data.

Calculating Aggregates for Grocery Store Data

Assume a grocery store has the following data:

Table 34-2  Grocery Store Data

<table>
<thead>
<tr>
<th>Customer</th>
<th>Item A</th>
<th>Item B</th>
<th>Item C</th>
<th>Item D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buys (Profit $5.00)</td>
<td>Buys (Profit $3.20)</td>
<td>Buys (Profit $12.00)</td>
<td>NA</td>
</tr>
<tr>
<td>Customer 1</td>
<td>Buys (Profit $4.00)</td>
<td>NA</td>
<td>Buys (Profit $4.20)</td>
<td>NA</td>
</tr>
<tr>
<td>Customer 2</td>
<td>Buys (Profit $3.00)</td>
<td>Buys (Profit $10.00)</td>
<td>Buys (Profit $14.00)</td>
<td>Buys (Profit $8.00)</td>
</tr>
<tr>
<td>Customer 3</td>
<td>Buys (Profit $2.00)</td>
<td>NA</td>
<td>NA</td>
<td>Buys (Profit $1.00)</td>
</tr>
</tbody>
</table>

The basket of each customer can be viewed as a transaction. The manager of the store is interested in not only the existence of certain association rules, but also in the aggregated profit if such rules exist.

In this example, one of the association rules can be (A, B) => C for customer 1 and customer 3. Together with this rule, the store manager may want to know the following:

- The total profit of item A appearing in this rule
- The total profit of item B appearing in this rule
- The total profit for consequent C appearing in this rule
- The total profit of all items appearing in the rule

For this rule, the profit for item A is $5.00 + $3.00 = $8.00, for item B the profit is $3.20 + $10.00 = $13.20, for consequent C, the profit is $12.00 + $14.00 = $26.00, for the antecedent itemset (A, B) is $8.00 + $13.20 = $21.20. For the whole rule, the profit is $21.20 + $26.00 = $47.40.

Related Topics
- Oracle Database PL/SQL Packages and Types Reference
34.6 Handle Missing Values

Understand sparse data and missing values.

Oracle Machine Learning for SQL distinguishes between sparse data and data that contains random missing values. The latter means that some attribute values are unknown. Sparse data, on the other hand, contains values that are assumed to be known, although they are not represented in the data.

A typical example of sparse data is market basket data. Out of hundreds or thousands of available items, only a few are present in an individual case (the basket or transaction). All the item values are known, but they are not all included in the basket. Present values have a quantity, while the items that are not represented are sparse (with a known quantity of zero).

OML4SQL interprets missing data as follows:

- Missing at random: Missing values in columns with a simple data type (not nested) are assumed to be missing at random.
- Sparse: Missing values in nested columns indicate sparsity.

34.6.1 Examples: Missing Values or Sparse Data?

Example to show sparse and missing data.

The examples in this section illustrate how Oracle Machine Learning for SQL identifies data as either sparse or missing at random.

34.6.1.1 Sparsity in a Sales Table

Understand how Oracle Machine Learning for SQL interprets missing data in nested column.

A sales table contains point-of-sale data for a group of products that are sold in several stores to different customers over a period of time. A particular customer buys only a few of the products. The products that the customer does not buy do not appear as rows in the sales table.

If you were to figure out the amount of money a customer has spent for each product, the unpurchased products have an inferred amount of zero. The value is not random or unknown; it is zero, even though no row appears in the table.

Note that the sales data is dimensioned (by product, stores, customers, and time) and are often represented as nested data for machine learning.

Since missing values in a nested column always indicate sparsity, you must ensure that this interpretation is appropriate for the data that you want to mine. For example, when trying to mine a multi-record case data set containing movie ratings from users of a large movie database, the missing ratings are unknown (missing at random), but Oracle Machine Learning for SQL treats the data as sparse and infer a rating of zero for the missing value.

34.6.1.2 Missing Values in a Table of Customer Data

When the data is not available for some attributes, those missing values are considered to be missing at random.
A table of customer data contains demographic data about customers. The case ID column is the customer ID. The attributes are age, education, profession, gender, household size, and so on. Not all the data is available for each customer. Any missing values are considered to be missing at random. For example, if the age of customer 1 and the profession of customer 2 are not present in the data, that information is unknown. It does not indicate sparsity.

Note that the customer data is not dimensioned. There is a one-to-one mapping between the case and each of its attributes. None of the attributes are nested.

34.6.2 Missing Value Treatment in Oracle Machine Learning for SQL

Summarizes the treatment of missing values in OML4SQL.

Missing value treatment depends on the algorithm and on the nature of the data (categorical or numerical, sparse or missing at random). Missing value treatment is summarized in the following table.

Note:
OML4SQL performs the same missing value treatment whether or not you are using Automatic Data Preparation (ADP).

<table>
<thead>
<tr>
<th>Table 34-3 Missing Value Treatment by Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing Data</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>NUMERICAL missing at random</td>
</tr>
<tr>
<td>CATEGORICAL missing at random</td>
</tr>
</tbody>
</table>
Table 34-3 (Cont.) Missing Value Treatment by Algorithm

<table>
<thead>
<tr>
<th>Missing Data</th>
<th>EM, GLM, NMF, k-Means, SVD, SVM</th>
<th>DT, MDL, NB, OC</th>
<th>Apriori</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMERICAL sparse</td>
<td>The algorithm replaces sparse numerical data with zeros.</td>
<td>O-Cluster does not support nested data and therefore does not support sparse data. Decision Tree (DT), Minimum Description Length (MDL), and Naive Bayes (NB) replace sparse numerical data with zeros.</td>
<td>The algorithm handles sparse data.</td>
</tr>
<tr>
<td>CATEGORICAL sparse</td>
<td>All algorithms except SVD replace sparse categorical data with zero vectors. SVD does not support categorical data.</td>
<td>O-Cluster does not support nested data and therefore does not support sparse data. DT, MDL, and NB replace sparse categorical data with the special value DM$\text{SPARSE}$.</td>
<td>The algorithm handles sparse data.</td>
</tr>
</tbody>
</table>

34.6.3 Changing the Missing Value Treatment

Transform the missing data as sparse or missing at random.

If you want Oracle Machine Learning for SQL to treat missing data as sparse instead of missing at random or missing at random instead of sparse, transform it before building the model.

If you want missing values to be treated as sparse, but OML4SQL interprets them as missing at random, you can use a SQL function like `NVL` to replace the nulls with a value such as "NA". OML4SQL does not perform missing value treatment when there is a specified value.

If you want missing nested attributes to be treated as missing at random, you can transform the nested rows into physical attributes in separate columns — as long as the case table stays within the 1000 column limitation imposed by the Database. Fill in all of the possible attribute names, and specify them as null. Alternatively, insert rows in the nested column for all the items that are not present and assign a value such as the mean or mode to each one.

Related Topics

- Oracle Database SQL Language Reference

34.7 About Transformations

Understand how you can transform data by using Automatic Data Preparation (ADP) and embedded data transformation.

A transformation is a SQL expression that modifies the data in one or more columns. Data must typically undergo certain transformations before it can be used to build a model. Many Oracle Machine Learning algorithms have specific transformation requirements. Before data
can be scored, it must be transformed in the same way that the training data was transformed.

Oracle Machine Learning for SQL supports ADP, which automatically implements the transformations required by the algorithm. The transformations are embedded in the model and automatically run whenever the model is applied.

If additional transformations are required, you can specify them as SQL expressions and supply them as input when you create the model. These transformations are embedded in the model as they are with ADP.

With automatic and embedded data transformation, most of the work of data preparation is handled for you. You can create a model and score multiple data sets in a few steps:

1. Identify the columns to include in the case table.
2. Create nested columns if you want to include transactional data.
3. Write SQL expressions for any transformations not handled by ADP.
4. Create the model, supplying the SQL expressions (if specified) and identifying any columns that contain text data.
5. Ensure that some or all of the columns in the scoring data have the same name and type as the columns used to train the model.

Related Topics
• Scoring Requirements
  Learn how scoring is done in Oracle Machine Learning for SQL.

See Also:
OML provides algorithm-specific automatic data preparation and other model building-related features

34.8 Prepare the Case Table

The first step in preparing data for machine learning is the creation of a case table.

If all the data resides in a single table and all the information for each case (record) is included in a single row (single-record case), this process is already taken care of. If the data resides in several tables, creating the data source involves the creation of a view. For the sake of simplicity, the term "case table" is used here to refer to either a table or a view.

Related Topics
• Prepare the Data
  Learn how to access and treat the data that can be used to build a model.
34.8.1 Convert Column Data Types

In OML, string columns are treated as categorical and number columns as numerical. If you have a numeric column that you want to be treated as a categorical, you must convert it to a string. For example, the day number of the week.

For example, zip codes identify different postal zones; they do not imply order. If the zip codes are stored in a numeric column, they are interpreted as a numeric attribute. You must convert the data type so that the column data can be used as a categorical attribute by the model. You can do this using the `TO_CHAR` function to convert the digits 1-9 and the `LPAD` function to retain the leading 0, if there is one.

```
LPAD(TO_CHAR(ZIPCODE),5,'0')
```

34.8.2 Extract Datetime Column Values

You can extract values from a datetime or interval value using the `EXTRACT` function.

The `EXTRACT` function extracts and returns the value of a specified datetime field from a datetime or interval value expression. The values that can be extracted are `YEAR`, `MONTH`, `DAY`, `HOUR`, `MINUTE`, `SECOND`, `TIMEZONE_HOUR`, `TIMEZONE_MINUTE`, `TIMEZONE_REGION`, and `TIMEZONE_ABBR`.

```
select cust_id, time_stamp,
       extract(year from time_stamp) year,
       extract(month from time_stamp) month,
       extract(day from time_stamp) day_of_month,
       to_char(time_stamp,'ww') week_of_year,
       to_char(time_stamp,'D') day_of_week,
       extract(hour from time_stamp) hour,
       extract(minute from time_stamp) minute,
       extract(second from time_stamp) second
from sales_ts
```

34.8.3 Text Transformation

Learn text processing using Oracle Machine Learning for SQL.

You can use OML4SQL to process text. Columns of text in the case table can be processed once they have undergone the proper transformation.

The text column must be in a table, not a view. The transformation process uses several features of Oracle Text; it treats the text in each row of the table as a separate document. Each document is transformed to a set of text tokens known as `terms`, which have a numeric value and a text label. The text column is transformed to a nested column of `DM_NESTED_NUMERICALS`.

34.8.4 About Business and Domain-Sensitive Transformations

Understand why you need to transform data according to business problems.
Some transformations are dictated by the definition of the business problem. For example, you want to build a model to predict high-revenue customers. Since your revenue data for current customers is in dollars you need to define what “high-revenue” means. Using some formula that you have developed from past experience, you can recode the revenue attribute into ranges Low, Medium, and High before building the model.

Another common business transformation is the conversion of date information into elapsed time. For example, date of birth can be converted to age.

Domain knowledge can be very important in deciding how to prepare the data. For example, some algorithms produce unreliable results if the data contains values that fall far outside of the normal range. In some cases, these values represent errors or abnormalities. In others, they provide meaningful information.

**Related Topics**

- **Outlier Treatment**
  Understand what you must do to treat outliers.

### 34.8.5 Create Nested Columns

In transactional data, the information for each case is contained in multiple rows. When the data source includes transactional data (multi-record case), the transactions must be aggregated to the case level in nested columns.

An example is sales data in a star schema when machine learning at the product level. Sales is stored in many rows for a single product (the case) because the product is sold in many stores to many customers over a period of time.

**See Also:**

- **Using Nested Data** for information about converting transactional data to nested columns
Create a Model

Explains how to create Oracle Machine Learning for SQL models and to query model details.

- Before Creating a Model
- Choose the Machine Learning Technique
- Choose the Algorithm
- Automatic Data Preparation
- Embed Transformations in a Model
- The CREATE_MODEL2 Procedure
- The CREATE_MODEL Procedure
- Specify Model Settings
- Model Settings in the Data Dictionary
- Model Detail Views

35.1 Before Creating a Model

Explains the preparation steps before creating a model.

Models are database schema objects that perform machine learning. The `DBMS_DATA_MINING` PL/SQL package is the API for creating, configuring, evaluating, and querying machine learning models (model details).

Before you create a model, you must decide what you want the model to do. You must identify the training data and determine if transformations are required. You can specify model settings to influence the behavior of the model behavior. The preparation steps are summarized in the following table.

<table>
<thead>
<tr>
<th>Preparation Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose the machine learning function</td>
<td>See Choose the Machine Learning Technique</td>
</tr>
<tr>
<td>Choose the algorithm</td>
<td>See Choose the Algorithm</td>
</tr>
<tr>
<td>Identify the build (training) data</td>
<td>See Prepare the Data</td>
</tr>
<tr>
<td>For classification and regression models, identify the test data</td>
<td>See Data Sets for Classification and Regression</td>
</tr>
<tr>
<td>Determine your data transformation strategy and create and populate a settings tables (if needed)</td>
<td>See Specify Model Settings</td>
</tr>
</tbody>
</table>


Related Topics

- **About Oracle Machine Learning Models**
  Machine learning models are database schema objects that perform machine learning techniques.

- **DBMS_DATA_MINING**
  Understand the routines of DBMS_DATA_MINING package.

35.2 Automatic Data Preparation

Most algorithms require some form of data transformation. During the model build process, Oracle Machine Learning for SQL can automatically perform the transformations required by the algorithm.

You can choose to supplement the automatic transformations with additional transformations of your own, or you can choose to manage all the transformations yourself.

In calculating automatic transformations, OML4SQL uses heuristics that address the common requirements of a given algorithm. This process results in reasonable model quality in most cases.

Binning and normalization are transformations that are commonly needed by machine learning algorithms.

**Related Topics**

- Oracle Database PL/SQL Packages and Types Reference

35.2.1 Binning

Binning, also called discretization, is a technique for reducing the cardinality of continuous and discrete data. Binning groups related values together in bins to reduce the number of distinct values.

Binning can improve resource utilization and model build response time dramatically without significant loss in model quality. Binning can improve model quality by strengthening the relationship between attributes.

Supervised binning is a form of intelligent binning in which important characteristics of the data are used to determine the bin boundaries. In supervised binning, the bin boundaries are identified by a single-predictor decision tree that takes into account the joint distribution with the target. Supervised binning can be used for both numerical and categorical attributes.

35.2.2 Normalization

Learn about normalization.

Normalization is the most common technique for reducing the range of numerical data. Most normalization methods map the range of a single variable to another range (often 0,1).

35.2.3 How ADP Transforms the Data

The following table shows how ADP prepares the data for each algorithm.
### Table 35-2  Oracle Machine Learning Algorithms With ADP

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Machine Learning Function</th>
<th>Treatment by ADP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apriori</td>
<td>Association rules</td>
<td>ADP has no effect on association rules.</td>
</tr>
<tr>
<td>CUR Matrix</td>
<td>Feature selection</td>
<td>ADP has no effect on CUR Matrix Decomposition</td>
</tr>
<tr>
<td>Decomposition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision Tree</td>
<td>Classification</td>
<td>ADP has no effect on Decision Tree. Data preparation is handled by the algorithm.</td>
</tr>
<tr>
<td>Expectation</td>
<td>Clustering</td>
<td>Single-column (not nested) numerical columns that are modeled with Gaussian</td>
</tr>
<tr>
<td>Maximization</td>
<td></td>
<td>distributions are normalized. ADP has no effect on the other types of columns.</td>
</tr>
<tr>
<td>GLM</td>
<td>Classification and regression</td>
<td>Numerical attributes are normalized.</td>
</tr>
<tr>
<td>k-Means</td>
<td>Clustering</td>
<td>Numerical attributes are normalized.</td>
</tr>
<tr>
<td>MDL</td>
<td>Attribute importance</td>
<td>All attributes are binned with supervised binning.</td>
</tr>
<tr>
<td>MSET-SPRT</td>
<td>Classification (for anomaly detection)</td>
<td>Z-score normalization is performed.</td>
</tr>
<tr>
<td>Naive Bayes</td>
<td>Classification</td>
<td>All attributes are binned with supervised binning.</td>
</tr>
<tr>
<td>Neural Network</td>
<td>Classification and regression</td>
<td>Numerical attributes are normalized.</td>
</tr>
<tr>
<td>NMF</td>
<td>Feature extraction</td>
<td>Numerical attributes are normalized.</td>
</tr>
<tr>
<td>O-Cluster</td>
<td>Clustering</td>
<td>Numerical attributes are binned with a specialized form of equi-width binning,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>which computes the number of bins per attribute automatically. Numerical columns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with all nulls or a single value are removed.</td>
</tr>
<tr>
<td>Random Forest</td>
<td>Classification</td>
<td>ADP has no effect on Random Forest. Data preparation is handled by the algorithm.</td>
</tr>
<tr>
<td>SVD</td>
<td>Feature extraction</td>
<td>Numeric attributes are centered if PCA is selected.</td>
</tr>
<tr>
<td>SVM</td>
<td>Classification, anomaly detection, and regression</td>
<td>Numerical attributes are normalized.</td>
</tr>
<tr>
<td>XG Boost</td>
<td>Classification and regression</td>
<td>ADP has no effect on XG Boost.</td>
</tr>
</tbody>
</table>

⚠️ **See Also:**

- *Oracle Database PL/SQL Packages and Types Reference*
- Part III, Algorithms, in *Oracle Machine Learning for SQL Concepts* for more information about algorithm-specific data preparation
35.3 Embed Transformations in a Model

You can specify your own transformations and embed them in a model by creating a transformation list and passing it to `DBMS_DATA_MINING.CREATE_MODEL2` or `DBMS_DATA_MINING.CREATE_MODEL`.

The transformation instructions are embedded in the model and reapplied whenever the model is applied to new data.

An example of how you can use `xform_list` to embed your transformations is shown here with `CREATE_MODEL2` and `CREATE_MODEL` procedures.

```sql
DBMS_DATA_MINING.CREATE_MODEL2 (  
  model_name          IN VARCHAR2,  
  mining_function     IN VARCHAR2,  
  data_query          IN CLOB,  
  set_list            IN SETTING_LIST,  
  case_id_column_name IN VARCHAR2 DEFAULT NULL,  
  target_column_name  IN VARCHAR2 DEFAULT NULL,  
  xform_list          IN TRANSFORM_LIST DEFAULT NULL);  

DBMS_DATA_MINING.CREATE_MODEL(  
  model_name           IN VARCHAR2,  
  mining_function      IN VARCHAR2,  
  data_table_name      IN VARCHAR2,  
  case_id_column_name  IN VARCHAR2 DEFAULT NULL,  
  target_column_name   IN VARCHAR2 DEFAULT NULL,  
  settings_table_name  IN VARCHAR2 DEFAULT NULL,  
  data_schema_name     IN VARCHAR2 DEFAULT NULL,  
  settings_schema_name IN VARCHAR2 DEFAULT NULL,  
  xform_list           IN TRANSFORM_LIST DEFAULT NULL);  
```

35.3.1 Specify Transformation Instructions for an Attribute

You can pass transformation instructions for an attribute by defining a transformation list.

A transformation list is defined as a table of transformation records. Each record (`transform_rec`) specifies the transformation instructions for an attribute.

```sql
TYPE transform_rec IS RECORD (  
  attribute_name      VARCHAR2(30),  
  attribute_subname   VARCHAR2(4000),  
  expression          EXPRESSION_REC,  
  reverse_expression  EXPRESSION_REC,  
  attribute_spec      VARCHAR2(4000));
```

The fields in a transformation record are described in this table.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>attribute_name</td>
<td>These fields identify the attribute, as described in “Scoping of Model Attribute Name”</td>
</tr>
<tr>
<td>attribute_subname</td>
<td></td>
</tr>
</tbody>
</table>
Table 35-3  (Cont.) Fields in a Transformation Record for an Attribute

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
</table>
| expression        | A SQL expression for transforming the attribute. For example, this expression transforms the age attribute into two categories: child and adult:[0,19) for 'child' and [19,) for adult  
CASE WHEN age < 19 THEN 'child' ELSE 'adult'
Expression and reverse expressions are stored in expression_rec objects. See "Expression Records" for details.  |
| reverse_expression| A SQL expression for reversing the transformation. For example, this expression reverses the transformation of the age attribute: DECODE(age,'child','(-Inf,19)','[19,Inf)') |
| attribute_spec    | Specifies special treatment for the attribute. The attribute_spec field can be null or it can have one or more of these values:  
  • FORCE_IN — For GLM, forces the inclusion of the attribute in the model build when the ftr_selection_enable setting is enabled. (ftr_selection_enable is disabled by default.) If the model is not using GLM, this value has no effect. FORCE_IN cannot be specified for nested attributes or text.  
  • NOPREP — When ADP is on, prevents automatic transformation of the attribute. If ADP is not on, this value has no effect. You can specify NOPREP for a nested attribute, but not for an individual subname (row) in the nested attribute.  
  • TEXT — Indicates that the attribute contains unstructured text. ADP has no effect on this setting. TEXT may optionally include subsettings POLICY_NAME, TOKEN_TYPE, and MAX_FEATURES.  
See Example 35-1 and Example 35-2. |

Related Topics

• Scoping of Model Attribute Name
  Learn about model attribute name.

• Expression Records
  Example of a transformation record.

35.3.1.1 Expression Records

Example of a transformation record.

The transformation expressions in a transformation record are expression_rec objects.

```sql
TYPE expression_rec IS RECORD (  
  stmt DBMS_SQL.VARCHAR2A,  
  lb BINARY_INTEGER DEFAULT 1,  
  ub BINARY_INTEGER DEFAULT 0);  

TYPE varchar2a IS TABLE OF VARCHAR2(32767) INDEX BY BINARY_INTEGER;  
```

ORACLE
The `stmt` field stores a `VARCHAR2A`, which allows transformation expressions to be very long, as they can be broken up across multiple rows of `VARCHAR2`. Use the `DBMS_DATA_MINING_TRANSFORM.SET_EXPRESSION` procedure to create an `expression_rec`.

### 35.3.1.2 Attribute Specifications

Learn how to define the characteristics specific to an attribute through attribute specification.

The attribute specification in a transformation record defines characteristics that are specific to this attribute. If not null, the attribute specification can include values `FORCE_IN`, `NOPREP`, or `TEXT`, as described in Table 35-3.

**Example 35-1  An Attribute Specification with Multiple Keywords**

If more than one attribute specification keyword is applicable, you can provide them in a comma-delimited list. The following expression is the specification for an attribute in a GLM model. Assuming that the `ftr_selection_enable` setting is enabled, this expression forces the attribute to be included in the model. If ADP is on, automatic transformation of the attribute is not performed.

"FORCE_IN,NOPREP"

**Example 35-2  A Text Attribute Specification**

For text attributes, you can optionally specify subsettings `POLICY_NAME`, `TOKEN_TYPE`, and `MAX_FEATURES`. The subsettings provide configuration information that is specific to text transformation. In this example, the transformation instructions for the text content are defined in a text policy named `my_policy` with token type is `THEME`. The maximum number of extracted features is 3000.

"TEXT(POLICY_NAME:my_policy)(TOKEN_TYPE:THEME)(MAX_FEATURES:3000)"

### Related Topics

- [Configure a Text Attribute](#)
  Provide transformation instructions for text attribute or unstructured text by explicitly identifying the column datatypes.

### 35.3.2 Build a Transformation List

You can build transformation list by `SET_TRANSFORM`, `STACK`, and `GET_*` methods. These methods are listed here.

A transformation list is a collection of transformation records. When a new transformation record is added, it is appended to the top of the transformation list. You can use any of the following methods to build a transformation list:

- The `SET_TRANSFORM` procedure in `DBMS_DATA_MINING_TRANSFORM`
- The `STACK` interface in `DBMS_DATA_MINING_TRANSFORM`
- The `GET_MODEL_TRANSFORMATIONS` and `GET_TRANSFORM_LIST` functions in `DBMS_DATA_MINING`
35.3.2.1 SET_TRANSFORM

The SET_TRANSFORM procedure applies a specified SQL expression to a specified attribute. The SET_TRANSFORM procedure adds a single transformation record to a transformation list.

```sql
DBMS_DATA_MINING_TRANSFORM.SET_TRANSFORM (    xform_list               IN OUT NOCOPY TRANSFORM_LIST,    attribute_name           VARCHAR2,    attribute_subname        VARCHAR2,    expression               VARCHAR2,    reverse_expression       VARCHAR2,    attribute_spec           VARCHAR2 DEFAULT NULL);
```

SQL expressions that you specify with SET_TRANSFORM must fit within a VARCHAR2. To specify a longer expression, you can use the SET_EXPRESSION procedure, which builds an expression by appending rows to a VARCHAR2 array. For example, the following statement appends a transformation instruction for `country_id` to a list of transformations called `my_xforms`. The transformation instruction divides `country_id` by 10 before algorithmic processing begins. The reverse transformation multiplies `country_id` by 10.

```sql
dbms_data_mining_transform.SET_TRANSFORM (my_xforms,    'country_id', NULL, 'country_id/10', 'country_id*10');
```

The reverse transformation is applied in the model details. If `country_id` is the target of a supervised model, the reverse transformation is also applied to the scored target.

35.3.2.2 The STACK Interface

The STACK interface creates transformation records from a table of transformation instructions and adds them to a transformation list.

The STACK interface offers a set of pre-defined transformations that you can apply to an attribute or to a group of attributes. For example, you can specify supervised binning for all categorical attributes.

The STACK interface specifies that all or some of the attributes of a given type must be transformed in the same way. For example, STACK_BIN_CAT appends binning instructions for categorical attributes to a transformation list. The STACK interface consists of three steps:

1. A CREATE procedure creates a transformation definition table. For example, CREATE_BIN_CAT creates a table to hold categorical binning instructions. The table has columns for storing the name of the attribute, the value of the attribute, and the bin assignment for the value.

2. An INSERT procedure computes the bin boundaries for one or more attributes and populates the definition table. For example, INSERT_BIN_CAT_FREQ performs frequency-based binning on some or all of the categorical attributes in the data source and populates a table created by CREATE_BIN_CAT.

3. A STACK procedure creates transformation records from the information in the definition table and appends the transformation records to a transformation list. For example, STACK_BIN_CAT creates transformation records for the information stored in a categorical binning definition table and appends the transformation records to a transformation list.
35.3.2.3 GET_MODEL_TRANSFORMATIONS and GET_TRANSFORM_LIST

Use the functions to create a new transformation list.

These two functions can be used to create a new transformation list from the transformations embedded in an existing model.

The GET_MODEL_TRANSFORMATIONS function returns a list of embedded transformations.

```sql
DBMS_DATA_MINING.GET_MODEL_TRANSFORMATIONS (model_name IN VARCHAR2)
RETURN DMTRANSFORMS PIPELINED;
```

GET_MODEL_TRANSFORMATIONS returns a table of dm_transform objects. Each dm_transform has these fields:

- attribute_name VARCHAR2(4000)
- attribute_subname VARCHAR2(4000)
- expression CLOB
- reverse_expression CLOB

The components of a transformation list are transform_rec, not dm_transform. The fields of a transform_rec are described in Table 35-3. You can call GET_MODEL_TRANSFORMATIONS to convert a list of dm_transform objects to transform_rec objects and append each transform_rec to a transformation list.

```sql
DBMS_DATA_MINING.GET_TRANSFORM_LIST (xform_list OUT NOCOPY TRANSFORM_LIST,
model_xforms IN DMTRANSFORMS);
```

See Also:

"DBMS_DATA_MINING_TRANSFORM Operational Notes", "SET_TRANSFORM Procedure", "CREATE_MODEL Procedure", and "GET_MODEL_TRANSFORMATIONS Function" in Oracle Database PL/SQL Packages and Types Reference

35.3.3 Transformation Lists and Automatic Data Preparation

You can use Automatic Data Preparation (ADP) and transformation lists to customize the data transformation.

If you enable ADP and you specify a transformation list, the transformation list is embedded with the automatic, system-generated transformations. The transformation list is processed before the automatic transformations.

If you enable ADP and do not specify a transformation list, only the automatic transformations are embedded in the model.

If ADP is disabled (the default) and you specify a transformation list, your custom transformations are embedded in the model. No automatic transformations are performed.
If ADP is disabled (the default) and you do not specify a transformation list, no transformations is embedded in the model. You have to transform the training, test, and scoring data sets yourself if necessary. You must take care to apply the same transformations to each data set.

35.3.4 Oracle Machine Learning for SQL Transformation Routines

Learn about transformation routines.

OML4SQL provides routines that implement various transformation techniques in the DBMS_DATA_MINING_TRANSFORM package.

Related Topics

- Oracle Database SQL Language Reference

35.3.4.1 Binning Routines

Explains binning techniques in OML4SQL.

A number of factors go into deciding a binning strategy. Having fewer values typically leads to a more compact model and one that builds faster, but it can also lead to some loss in accuracy.

Model quality can improve significantly with well-chosen bin boundaries. For example, an appropriate way to bin ages is to separate them into groups of interest, such as children 0-13, teenagers 13-19, youth 19-24, working adults 24-35, and so on.

The following table lists the binning techniques provided by OML4SQL:

Table 35-4  Binning Methods in DBMS_DATA_MINING_TRANSFORM

<table>
<thead>
<tr>
<th>Binning Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-N Most Frequent Items</td>
<td>You can use this technique to bin categorical attributes. You specify the number of bins. The value that occurs most frequently is labeled as the first bin, the value that appears with the next frequency is labeled as the second bin, and so on. All remaining values are in an additional bin.</td>
</tr>
<tr>
<td>Supervised Binning</td>
<td>Supervised binning is a form of intelligent binning, where bin boundaries are derived from important characteristics of the data. Supervised binning builds a single-predictor decision tree to find the interesting bin boundaries with respect to a target. It can be used for numerical or categorical attributes.</td>
</tr>
<tr>
<td>Equi-Width Binning</td>
<td>You can use equi-width binning for numerical attributes. The range of values is computed by subtracting the minimum value from the maximum value, then the range of values is divided into equal intervals. You can specify the number of bins or it can be calculated automatically. Equi-width binning must usually be used with outlier treatment.</td>
</tr>
<tr>
<td>Quantile Binning</td>
<td>Quantile binning is a numerical binning technique. Quantiles are computed using the SQL analytic function NTILE. The bin boundaries are based on the minimum values for each quantile. Bins with equal left and right boundaries are collapsed, possibly resulting in fewer bins than requested.</td>
</tr>
</tbody>
</table>
Related Topics

- **Routines for Outlier Treatment**
  Understand the transformations used for outlier treatment.

### 35.3.4.2 Normalization Routines

Learn about normalization routines in Oracle Machine Learning for SQL.

Most normalization methods map the range of a single attribute to another range, typically 0 to 1 or -1 to +1.

Normalization is very sensitive to outliers. Without outlier treatment, most values are mapped to a tiny range, resulting in a significant loss of information.

<table>
<thead>
<tr>
<th>Table 35-5</th>
<th>Normalization Methods in DBMS_DATA_MINING_TRANSFORM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transformation</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Min-Max Normalization</td>
<td>This technique computes the normalization of an attribute using the minimum and maximum values. The shift is the minimum value, and the scale is the difference between the maximum and minimum values.</td>
</tr>
<tr>
<td>Scale Normalization</td>
<td>This normalization technique also uses the minimum and maximum values. For scale normalization, shift = 0, and scale = max(abs(max), abs(min)).</td>
</tr>
<tr>
<td>Z-Score Normalization</td>
<td>This technique computes the normalization of an attribute using the mean and the standard deviation. Shift is the mean, and scale is the standard deviation.</td>
</tr>
</tbody>
</table>

Related Topics

- **Routines for Outlier Treatment**
  Understand the transformations used for outlier treatment.

### 35.3.4.3 Outlier Treatment

Understand what you must do to treat outliers.

A value is considered an outlier if it deviates significantly from most other values in the column. The presence of outliers can have a skewing effect on the data and can interfere with the effectiveness of transformations such as normalization or binning.

Outlier treatment methods such as trimming or clipping can be implemented to minimize the effect of outliers.

Outliers represent problematic data, for example, a bad reading due to the abnormal condition of an instrument. However, in some cases, especially in the business arena, outliers are perfectly valid. For example, in census data, the earnings for some of the richest individuals can vary significantly from the general population. Do not treat this information as an outlier, since it is an important part of the data. You need domain knowledge to determine outlier handling.
35.3.4.4 Routines for Outlier Treatment

Understand the transformations used for outlier treatment.

**Outliers** are extreme values, typically several standard deviations from the mean. To minimize the effect of outliers, you can Winsorize or trim the data.

**Winsorizing** involves setting the tail values of an attribute to some specified value. For example, for a 90% Winsorization, the bottom 5% of values are set equal to the minimum value in the 5th percentile, while the upper 5% of values are set equal to the maximum value in the 95th percentile.

**Trimming** sets the tail values to NULL. The algorithm treats them as missing values.

Outliers affect the different algorithms in different ways. In general, outliers cause distortion with equi-width binning and min-max normalization.

<table>
<thead>
<tr>
<th>Transformation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trimming</td>
<td>This technique trims the outliers in numeric columns by sorting the non-null values, computing the tail values based on some fraction, and replacing the tail values with nulls.</td>
</tr>
<tr>
<td>Windsorizing</td>
<td>This technique trims the outliers in numeric columns by sorting the non-null values, computing the tail values based on some fraction, and replacing the tail values with some specified value.</td>
</tr>
</tbody>
</table>

35.4 Understand Reverse Transformations

Reverse transformations ensure that information returned by the model is expressed in a format that is similar to or the same as the format of the data that was used to train the model. Internal transformations are reversed in the model details and in the results of scoring.

Some of the attributes used by the model correspond to columns in the build data. However, because of logic specific to the algorithm, nested data, and transformations, some attributes do not correspond to columns.

For example, a nested column in the training data is not interpreted as an attribute by the model. During the model build, OML4SQL explodes nested columns, and each row (an attribute name/value pair) becomes an attribute.

Some algorithms, for example Support Vector Machine (SVM) and Generalized Linear Model (GLM), only operate on numeric attributes. Any non-numeric column in the build data is exploded into binary attributes, one for each distinct value in the column (SVM). GLM does not generate a new attribute for the most frequent value in the original column. These binary attributes are set to one only if the column value for the case is equal to the value associated with the binary attribute.

Algorithms that generate coefficients present challenges in interpreting the results. Examples are SVM and Non-Negative Matrix Factorization (NMF). These algorithms produce coefficients that are used in combination with the transformed attributes. The coefficients are relevant to the data on the transformed scale, not the original data scale.

For all these reasons, the attributes listed in the model details do not resemble the columns of data used to train the model. However, attributes that undergo embedded transformations,
whether initiated by Automatic Data Preparation (ADP) or by a user-specified transformation list, appear in the model details in their pre-transformed state, as close as possible to the original column values. Although the attributes are transformed when they are used by the model, they are visible in the model details in a form that can be interpreted by a user.

Related Topics
• ALTER_REVERSE_EXPRESSION Procedure
• GET_MODEL_TRANSFORMATIONS Function
• Model Detail Views
  Model detail views provide information about models.

35.5 The CREATE_MODEL Procedure

Shows the settings in the CREATE_MODEL procedure.

The CREATE_MODEL procedure in the DBMS_DATA_MINING package uses the specified data to create a machine learning model with the specified name and machine learning function. The model can be created with configuration settings and user-specified transformations.

PROCEDURE CREATE_MODEL(
    model_name            IN VARCHAR2,
    mining_function       IN VARCHAR2,
    data_table_name       IN VARCHAR2,
    case_id_column_name   IN VARCHAR2,
    target_column_name    IN VARCHAR2 DEFAULT NULL,
    settings_table_name   IN VARCHAR2 DEFAULT NULL,
    data_schema_name      IN VARCHAR2 DEFAULT NULL,
    settings_schema_name  IN VARCHAR2 DEFAULT NULL,
    xform_list            IN TRANSFORM_LIST DEFAULT NULL);

The following example builds a classification model using the Support Vector Machine algorithm.

Create the settings table
CREATE TABLE svm_model_settings (  setting_name VARCHAR2(30),  setting_value VARCHAR2(30));  
  -- Populate the settings table
  -- Specify SVM. By default, Naive Bayes is used for classification.
  -- Specify ADP. By default, ADP is not used.
  BEGIN
    INSERT INTO svm_model_settings (setting_name, setting_value) VALUES
      (dbms_data_mining.algo_name, dbms_data_mining.algo_support_vector_machines);
    INSERT INTO svm_model_settings (setting_name, setting_value) VALUES
      (dbms_data_mining.prep_auto,dbms_data_mining.prep_auto_on);
    COMMIT;
  END;
/
  -- Create the model using the specified settings
  BEGIN
    DBMS_DATA_MINING.CREATE_MODEL(  model_name => 'svm_model',  mining_function => dbms_data_mining.classification,  data_table_name => 'mining_data_build_v',  case_id_column_name => 'case_id',  settings_table_name => 'svm_model_settings');
case_id_column_name => 'cust_id',
target_column_name => 'affinity_card',
settings_table_name => 'svm_model_settings');
END;
/

Related Topics
• Oracle Database PL/SQL Packages and Types Reference

35.5.1 Choose the Machine Learning Technique

Describes providing an Oracle Machine Learning for SQL machine learning function for the CREATE_MODEL and CREATE_MODEL2 procedure.

An OML4SQL machine learning technique specifies a class of problems that can be modeled and solved. You specify a machine learning with the mining_function argument of the CREATE_MODEL and CREATE_MODEL2 procedure.

OML4SQL machine learning functions implement either supervised or unsupervised learning. Supervised learning uses a set of independent attributes to predict the value of a dependent attribute or target. Unsupervised learning does not distinguish between dependent and independent attributes. Supervised functions are predictive. Unsupervised functions are descriptive.

>Note:

In OML4SQL terminology, a function is a general type of problem to be solved by a given approach to machine learning. In SQL language terminology, a function is an operation that returns a result.

In OML4SQL documentation, the term function, or machine learning function refers to an OML4SQL machine learning function; the term SQL function or SQL machine learning function refers to a SQL function for scoring (applying machine learning models).

You can specify any of the values in the following table for the mining_function parameter to the CREATE_MODEL and CREATE_MODEL2 procedure.

Table 35-7  Oracle Machine Learning mining_function Values

<table>
<thead>
<tr>
<th>mining_function Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATION</td>
<td>Association is a descriptive machine learning function. An association model identifies relationships and the probability of their occurrence within a data set (association rules). Association models use the Apriori algorithm.</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>Attribute importance is a predictive machine learning function. An attribute importance model identifies the relative importance of attributes in predicting a given outcome. Attribute importance models use the Minimum Description Length algorithm and CUR Matrix Decomposition.</td>
</tr>
</tbody>
</table>
Table 35-7 (Cont.) Oracle Machine Learning mining_function Values

<table>
<thead>
<tr>
<th>mining_function Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASSIFICATION</td>
<td>Classification is a predictive machine learning function. A classification model uses historical data to predict a categorical target. Classification models can use Naive Bayes, Neural Network, Decision Tree, logistic regression, Random Forest, Support Vector Machine, Explicit Semantic Analysis, or XGBoost. The default is Naive Bayes. You can also specify the classification machine learning function for anomaly detection for a One-Class SVM model and a Multivariate State Estimation Technique - Sequential Probability Ratio Test model.</td>
</tr>
<tr>
<td>CLUSTERING</td>
<td>Clustering is a descriptive machine learning function. A clustering model identifies natural groupings within a data set. Clustering models can use ( k )-Means, O-Cluster, or Expectation Maximization. The default is ( k )-Means.</td>
</tr>
<tr>
<td>FEATURE_EXTRACTION</td>
<td>Feature extraction is a descriptive machine learning function. A feature extraction model creates a set of optimized attributes. Feature extraction models can use Non-Negative Matrix Factorization, Singular Value Decomposition (which can also be used for Principal Component Analysis) or Explicit Semantic Analysis. The default is Non-Negative Matrix Factorization.</td>
</tr>
<tr>
<td>REGRESSION</td>
<td>Regression is a predictive machine learning function. A regression model uses historical data to predict a numerical target. Regression models can use Support Vector Machine, GLM regression, or XGBoost. The default is Support Vector Machine.</td>
</tr>
<tr>
<td>TIME_SERIES</td>
<td>Time series is a predictive machine learning function. A time series model forecasts the future values of a time-ordered series of historical numeric data over a user-specified time window. Time series models use the Exponential Smoothing algorithm. The default is Exponential Smoothing.</td>
</tr>
</tbody>
</table>

Related Topics
- Oracle Machine Learning for SQL Concepts

35.5.2 Choose the Algorithm

Learn about providing the algorithm settings for a model.

The ALGO_NAME setting specifies the algorithm for a model. If you use the default algorithm for the machine learning technique, or if there is only one algorithm available for the machine learning technique, then you do not need to specify the ALGO_NAME setting.

Table 35-8 Oracle Machine Learning Algorithms

<table>
<thead>
<tr>
<th>ALGO_NAME Value</th>
<th>Algorithm</th>
<th>Default?</th>
<th>Machine Learning Model Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGO_AI_MDL</td>
<td>Minimum Description Length</td>
<td>—</td>
<td>Attribute importance</td>
</tr>
</tbody>
</table>
Table 35-8 (Cont.) Oracle Machine Learning Algorithms

<table>
<thead>
<tr>
<th>ALGO_NAME Value</th>
<th>Algorithm</th>
<th>Default?</th>
<th>Machine Learning Model Function</th>
<th>Machine Learning Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGO_APRIORI_ASSOCIATION_RULES</td>
<td>Apriori</td>
<td>—</td>
<td>Association</td>
<td></td>
</tr>
<tr>
<td>ALGO_CUR_DECOMPOSITION</td>
<td>CUR Matrix Decomposition</td>
<td>—</td>
<td>Attribute importance</td>
<td></td>
</tr>
<tr>
<td>ALGO_DECISION_TREE</td>
<td>Decision Tree</td>
<td>—</td>
<td>Classification</td>
<td></td>
</tr>
<tr>
<td>ALGO_EXPECTATION_MAXIMIZATION</td>
<td>Expectation Maximization</td>
<td>—</td>
<td>Clustering</td>
<td></td>
</tr>
<tr>
<td>ALGO_EXPLICIT_SEMANTIC_ANALYSIS</td>
<td>Explicit Semantic Analysis</td>
<td>—</td>
<td>Feature extraction and classification</td>
<td></td>
</tr>
<tr>
<td>ALGO_EXPONENTIAL_SMOOTHING</td>
<td>Exponential Smoothing</td>
<td>—</td>
<td>Time series</td>
<td></td>
</tr>
<tr>
<td>ALGO_EXTENSIBLE_LANG</td>
<td>Language used for an extensible algorithm</td>
<td>—</td>
<td>All machine learning functions are supported</td>
<td></td>
</tr>
<tr>
<td>ALGO_GENERALIZED_LINEAR_MODEL</td>
<td>Generalized Linear Model</td>
<td>—</td>
<td>Classification and regression</td>
<td></td>
</tr>
<tr>
<td>ALGO_KMEANS</td>
<td>k-Means</td>
<td>yes</td>
<td>Clustering</td>
<td></td>
</tr>
<tr>
<td>ALGO_MSET_SPRT</td>
<td>Multivariate State Estimation Technique</td>
<td>—</td>
<td>Anomaly detection (classification with no target)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Sequential Probability Ratio Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALGO_NAIVE_BAYES</td>
<td>Naive Bayes</td>
<td>yes</td>
<td>Classification</td>
<td></td>
</tr>
<tr>
<td>ALGO_NEURAL_NETWORK</td>
<td>Neural Network</td>
<td>—</td>
<td>Classification</td>
<td></td>
</tr>
<tr>
<td>ALGO_NONNEGATIVE_MATRIX_FACTOR</td>
<td>Non-Negative Matrix Factorization</td>
<td>yes</td>
<td>Feature extraction</td>
<td></td>
</tr>
<tr>
<td>ALGO_O_CLUSTER</td>
<td>O-Cluster</td>
<td>—</td>
<td>Clustering</td>
<td></td>
</tr>
<tr>
<td>ALGO_RANDOM_FOREST</td>
<td>Random Forest</td>
<td>—</td>
<td>Classification</td>
<td></td>
</tr>
<tr>
<td>ALGO_SINGULAR_VALUE_DECOMP</td>
<td>Singular Value Decomposition (can also be used for Principal Component Analysis)</td>
<td>—</td>
<td>Feature extraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
<td>Support Vector Machine</td>
<td>yes</td>
<td>Default regression algorithm; regression, classification, and anomaly detection (classification with no target)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALGO_XGBOOST</td>
<td>XGBoost</td>
<td>—</td>
<td>Classification and regression</td>
<td></td>
</tr>
</tbody>
</table>

Related Topics

- Specify Model Settings
  Understand how to configure machine learning models at build time.
- Oracle Machine Learning for SQL Concepts
35.5.3 Supply Transformations

Use xform_list to specify transformations in the model creation procedures.

You can optionally specify transformations for the build data in the xform_list parameter to CREATE_MODEL2 and CREATE_MODEL procedures. The transformation instructions are embedded in the model and reapplied whenever the model is applied to new data.

35.5.3.1 Create a Transformation List

You can create a transformation list using the DBMS_DATA_MINING_TRANSFORM package.

The following are the ways to create a transformation list:

- The STACK interface in DBMS_DATA_MINING_TRANSFORM.
  The STACK interface offers a set of pre-defined transformations that you can apply to an attribute or to a group of attributes. For example, you can specify supervised binning for all categorical attributes.

- The SET_TRANSFORM procedure in DBMS_DATA_MINING_TRANSFORM.
  The SET_TRANSFORM procedure applies a specified SQL expression to a specified attribute. For example, the following statement appends a transformation instruction for country_id to a list of transformations called my_xforms. The transformation instruction divides country_id by 10 before algorithmic processing begins. The reverse transformation multiplies country_id by 10.

  ```
  dbms_data_mining_transform.SET_TRANSFORM (my_xforms, 'country_id', NULL, 'country_id/10', 'country_id*10');
  ```

  The reverse transformation is applied in the model details. If country_id is the target of a supervised model, the reverse transformation is also applied to the scored target.

35.5.3.2 Transformation List and Automatic Data Preparation

You can provide transformation list and Automatic Data Preparation (ADP) to customize the data transformation.

The transformation list argument to CREATE_MODEL2 and CREATE_MODEL interacts with the PREP_AUTO setting, which controls ADP:

- When ADP is on and you specify a transformation list, your transformations are applied with the automatic transformations and embedded in the model. The transformations that you specify are processed before the automatic transformations.

- When ADP is off and you specify a transformation list, your transformations are applied and embedded in the model, but no system-generated transformations are performed.

- When ADP is on and you do not specify a transformation list, the system-generated transformations are applied and embedded in the model.
• When ADP is off and you do not specify a transformation list, no transformations are embedded in the model; you must separately prepare the data sets you use for building, testing, and scoring the model.

Related Topics
• Embed Transformations in a Model
  You can specify your own transformations and embed them in a model by creating a transformation list and passing it to \texttt{DBMS\_DATA\_MINING\_CREATE\_MODEL2} or \texttt{DBMS\_DATA\_MINING\_CREATE\_MODEL}.
• \texttt{Oracle Database PL/SQL Packages and Types Reference}

35.5.4 About Partitioned Models

Introduces partitioned models to organize and represent multiple models.

When you build a model on your data set and apply it to new data, sometimes the prediction may be generic that performs badly when run on new and evolving data. To overcome this, the data set can be divided into different parts based on some characteristics. Oracle Machine Learning for SQL supports partitioned model. Partitioned models allow users to build a type of ensemble model for each data partition. The top-level model has sub models that are automatically produced. The sub models are based on the attribute options. For example, if your data set has an attribute called MARITAL with four values and you have defined it as the partitioned attribute. Then, four sub models are created for this attribute. The sub models are automatically managed and used as a single model. The partitioned model automates a typical machine learning task and can potentially achieve better accuracy through multiple targeted models.

The partitioned model and its sub models reside as first class, persistent database objects. Persistent means that the partitioned model has an on-disk representation.

To create a partitioned model, include the \texttt{ODMS\_PARTITION\_COLUMNS} setting. To define the number of partitions, include the \texttt{ODMS\_MAX\_PARTITIONS} setting. When you are making predictions, you must use the top-level model. The correct sub model is selected automatically based on the attribute, the attribute options, and the partition setting. You must include the partition columns as part of the \texttt{USING} clause when scoring. The \texttt{GROUPING} hint is an optional hint that applies to machine learning scoring functions when scoring partitioned models.

The partition names, key values, and the structure of the partitioned model are available in the \texttt{ALL\_MINING\_MODEL\_PARTITIONS} view.

Related Topics
• \texttt{Oracle Database Reference}

\textbf{See Also:}

\textit{Oracle Database SQL Language Reference} on how to use \texttt{GROUPING} hint.
\textit{Oracle Machine Learning for SQL User’s Guide} to understand more about partitioned models.
35.5.4.1 Partitioned Model Build Process

To build a partitioned model, Oracle Machine Learning for SQL requires a partitioning key specified in a settings table.

The partitioning key is a comma-separated list of one or more columns (up to 16) from the input data set. The partitioning key horizontally slices the input data based on discrete values of the partitioning key. That is, partitioning is performed as list values as opposed to range partitioning against a continuous value. The partitioning key supports only columns of the data type NUMBER and VARCHAR2.

During the build process the input data set is partitioned based on the distinct values of the specified key. Each data slice (unique key value) results in its own model partition. The resultant model partition is not separate and is not visible to you as a standalone model. The default value of the maximum number of partitions for partitioned models is 1000 partitions. You can also set a different maximum partitions value. If the number of partitions in the input data set exceeds the defined maximum, OML4SQL throws an exception.

The partitioned model organizes features common to all partitions and the partition specific features. The common features consist of the following metadata:

- The model name
- The machine learning function
- The machine learning algorithm
- A super set of all machine learning model attributes referenced by all partitions (signature)
- A common set of user-defined column transformations
- Any user-specified or default build settings that are interpreted as global; for example, the Auto Data Preparation (ADP) setting

35.5.4.2 DDL in Partitioned model

Learn about maintenance of partitioned models thorough DDL operations.

Partitioned models are maintained through the following DDL operations:

- Drop model or drop partition
- Add partition

35.5.4.2.1 Drop Model or Drop Partition

Oracle Machine Learning for SQL supports dropping a single model partition for a given partition name.

If only a single partition remains, you cannot explicitly drop that partition. Instead, you must either add additional partitions prior to dropping the partition or you may choose to drop the model itself. When dropping a partitioned model, all partitions are dropped in a single atomic operation. From a performance perspective, Oracle recommends DROP_PARTITION followed by an ADD_PARTITION instead of leveraging the REPLACE option due to the efficient behavior of the DROP_PARTITION option.
35.5.4.2.2 Add Partition

Oracle Machine Learning for SQL supports adding a single partition or multiple partitions to an existing partitioned model.

The addition occurs based on the input data set and the name of the existing partitioned model. The operation takes the input data set and the existing partitioned model as parameters. The partition keys are extracted from the input data set and the model partitions are built against the input data set. These partitions are added to the partitioned model. In the case where partition keys for new partitions conflict with the existing partitions in the model, you can select from the following three approaches to resolve the conflicts:

- **ERROR**: Terminates the ADD operation without adding any partitions.
- **REPLACE**: Replaces the existing partition for which the conflicting keys are found.
- **IGNORE**: Eliminates the rows having the conflicting keys.

If the input data set contains multiple keys, then the operation creates multiple partitions. If the total number of partitions in the model increases to more than the user-defined maximum specified when the model was created, then you get an error. The default threshold value for the number of partitions is 1000.

35.5.4.3 Partitioned Model Scoring

The scoring of the partitioned model is the same as that of the non-partitioned model.

The syntax of the machine learning function remains the same but is extended to provide an optional hint. The optional hint can impact the performance of a query which involves scoring a partitioned model.

For scoring a partitioned model, the signature columns used during the build for the partitioning key must be present in the scoring data set. These columns are combined to form a unique partition key. The unique key is then mapped to a specific underlying model partition, and the identified model partition is used to score that row.

The partitioned objects that are necessary for scoring are loaded on demand during the query execution and are aged out depending on the System Global Area (SGA) memory.

In this example an SVM model is used to predict the number of years a customer resides at their residence but partitioned on customer gender. The model is then used to predict the target. This example highlights the model settings that you can define when you create a partitioned model. The following example is using a view created from the SH schema tables. The CREATE MODEL2 procedure is used for creating the model. The partition attribute is CUST_GENDER. This attribute has two options M and F.

```sql
%script
BEGIN DBMS_DATA_MINING.DROP_MODEL('SVM_MOD_PARTITIONED');
EXCEPTION WHEN OTHERS THEN NULL; END;
/
DECLARE
  v_setlst DBMS_DATA_MINING.SETTING_LIST;
BEGIN
  v_setlst('ALGO_NAME'):= 'ALGO_SUPPORT_VECTOR_MACHINES';
  v_setlst('SVMS_KERNEL_FUNCTION')  :='SVMS_LINEAR';
  v_setlst('ODMS_PARTITION_COLUMS'):= 'CUST_GENDER';
```
DBMS_DATA_MINING.CREATE_MODEL2(
    MODEL_NAME          => 'SVM_MOD_PARTITIONED',
    MINING_FUNCTION     => 'REGRESSION',
    DATA_QUERY          => 'SELECT * FROM CUSTOMERS_DEMO',
    SET_LIST            => v_setlst,
    CASE_ID_COLUMN_NAME => 'CUST_ID',
    TARGET_COLUMN_NAME  => 'YRS_RESIDENCE');
END;

PL/SQL procedure successfully completed.

---------------------------
PL/SQL procedure successfully completed.

The following code sample shows the prediction.

%script

SELECT cust_id, YRS_RESIDENCE,
       ROUND(PREDICTION(SVM_MOD_PARTITIONED USING *),2)
FROM CUSTOMERS_DEMO;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>YRS_RESIDENCE</th>
<th>PRED_YRS_RESIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100100</td>
<td>4</td>
<td>4.71</td>
</tr>
<tr>
<td>100200</td>
<td>2</td>
<td>1.62</td>
</tr>
<tr>
<td>100300</td>
<td>4</td>
<td>4.66</td>
</tr>
<tr>
<td>100400</td>
<td>6</td>
<td>5.9</td>
</tr>
<tr>
<td>100500</td>
<td>2</td>
<td>2.07</td>
</tr>
<tr>
<td>100600</td>
<td>3</td>
<td>2.74</td>
</tr>
<tr>
<td>100700</td>
<td>6</td>
<td>5.78</td>
</tr>
<tr>
<td>100800</td>
<td>5</td>
<td>7.22</td>
</tr>
<tr>
<td>100900</td>
<td>4</td>
<td>4.88</td>
</tr>
<tr>
<td>101000</td>
<td>7</td>
<td>6.49</td>
</tr>
<tr>
<td>101100</td>
<td>4</td>
<td>3.54</td>
</tr>
<tr>
<td>101200</td>
<td>1</td>
<td>1.46</td>
</tr>
<tr>
<td>101300</td>
<td>4</td>
<td>4.34</td>
</tr>
<tr>
<td>101400</td>
<td>4</td>
<td>4.34</td>
</tr>
</tbody>
</table>

Related Topics
- Oracle Database SQL Language Reference

35.6 The CREATE_MODEL2 Procedure

Shows the settings in the CREATE_MODEL2 procedure.

The CREATE_MODEL2 procedure in the DBMS_DATA_MINING package is a procedure to define model settings and build a model. In the CREATE_MODEL procedure, the input is a table or a view and if such an object is not already present, the user must create it. By
using the CREATE_MODEL2 procedure, the user does not need to create such transient database objects. The model can use configuration settings and user-specified transformations.

```sql
DBMS_DATA_MINING.CREATE_MODEL2 (  
model_name            IN VARCHAR2,
mining_function       IN VARCHAR2,
data_query            IN CLOB,
set_list              IN SETTING_LIST,
case_id_column_name   IN VARCHAR2 DEFAULT NULL,
target_column_name    IN VARCHAR2 DEFAULT NULL,
xform_list            IN TRANSFORM_LIST DEFAULT NULL);
```

The `data_query` parameter species a query which provides training data for building the model. The `set_list` parameter specifies the `SETTING_LIST`. `SETTING_LIST` is a table of CLOB index by VARCHAR2(30); Where the index is the setting name and the CLOB is the setting value for that name. The rest of the parameters are covered in the CREATE.MODEL procedure.

The following CREATE_MODEL2 procedure builds a regression model using GLM algorithm.

```sql
DECLARE
    v_setlst DBMS_DATA_MINING.SETTING_LIST;
BEGIN
    v_setlst('PREP_AUTO') := 'ON';
    v_setlst('ALGO_NAME') := 'ALGO_GENERALIZED_LINEAR_MODEL';
    v_setlst('GLMS_DIAGNOSTICS_TABLE_NAME') := 'GLMR_DIAG';
    v_setlst('GLMS_FTR_SELECTION') := 'GLMS_FTR_SELECTION_ENABLE';
    v_setlst('GLMS_FTR_GENERATION') := 'GLMS_FTR_GENERATION_ENABLE';

    DBMS_DATA_MINING.CREATE_MODEL2(  
        MODEL_NAME          =>'GLMR_REGR',
        MINING_FUNCTION     =>'REGRESSION',
        DATA_QUERY          =>'SELECT * FROM TRAINING_DATA',
        SET_LIST            =>v_setlst,
        CASE_ID_COLUMN_NAME =>'HID',
        TARGET_COLUMN_NAME  =>'MEDV');
END;
```

Related Topics

• Oracle Database PL/SQL Packages and Types Reference

35.7 Specify Model Settings

Understand how to configure machine learning models at build time.

Numerous configuration settings are available for configuring machine learning models at build time. To specify settings, create a settings table with the columns shown in the following table and pass the table to CREATE_MODEL.

You can use CREATE_MODEL2 procedure where you can directly pass the model settings to a variable that can be used in the procedure. The variable can be declared with DBMS_DATA_MINING.SETTING_LIST procedure.
Table 35-9  Settings Table Required Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>setting_name</td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>setting_value</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

Example 35-3 creates a settings table for a Support Vector Machine (SVM) classification model. Since SVM is not the default classifier, the ALGO_NAME setting is used to specify the algorithm. Setting the SVMS_KERNEL_FUNCTION to SVMS_LINEAR causes the model to be built with a linear kernel. If you do not specify the kernel function, the algorithm chooses the kernel based on the number of attributes in the data.

Example 35-4 creates a model with the model settings that are stored in a variable from SETTING_LIST.

Some settings apply generally to the model, others are specific to an algorithm. Model settings are referenced in Table 35-10 and Table 35-11.

Table 35-10  General Model Settings

<table>
<thead>
<tr>
<th>Settings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine learning function settings</td>
<td>Machine Learning Technique Settings</td>
</tr>
<tr>
<td>Algorithm names</td>
<td>Algorithm Names</td>
</tr>
<tr>
<td>Global model characteristics</td>
<td>Global Settings</td>
</tr>
<tr>
<td>Automatic Data Preparation</td>
<td>Automatic Data Preparation</td>
</tr>
</tbody>
</table>

Table 35-11  Algorithm-Specific Model Settings

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUR Matrix Decomposition</td>
<td>DBMS_DATA_MINING — Algorithm Settings: CUR Matrix Decomposition</td>
</tr>
<tr>
<td>Decision Tree</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Decision Tree</td>
</tr>
<tr>
<td>Expectation Maximization</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Expectation Maximization</td>
</tr>
<tr>
<td>Explicit Semantic Analysis</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Explicit Semantic Analysis</td>
</tr>
<tr>
<td>Exponential Smoothing</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Exponential Smoothing Models</td>
</tr>
<tr>
<td>Generalized Linear Model</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Generalized Linear Models</td>
</tr>
<tr>
<td>k-Means</td>
<td>DBMS_DATA_MINING — Algorithm Settings: k-Means</td>
</tr>
<tr>
<td>Multivariate State Estimation Technique -</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Multivariate State Estimation</td>
</tr>
<tr>
<td>Sequential Probability Ratio Test</td>
<td>Technique - Sequential Probability Ratio Test</td>
</tr>
<tr>
<td>Naive Bayes</td>
<td>Algorithm Settings: Naive Bayes</td>
</tr>
<tr>
<td>Neural Network</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Neural Network</td>
</tr>
<tr>
<td>Non-Negative Matrix Factorization</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Non-Negative Matrix Factorization</td>
</tr>
<tr>
<td>O-Cluster</td>
<td>Algorithm Settings: O-Cluster</td>
</tr>
</tbody>
</table>
Table 35-11  (Cont.) Algorithm-Specific Model Settings

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Forest</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Random Forest</td>
</tr>
<tr>
<td>Singular Value Decomposition</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Singular Value Decomposition</td>
</tr>
<tr>
<td>Support Vector Machine</td>
<td>DBMS_DATA_MINING — Algorithm Settings: Support Vector Machine</td>
</tr>
<tr>
<td>XGBoost</td>
<td>DBMS_DATA_MINING — Algorithm Settings: XGBoost</td>
</tr>
</tbody>
</table>

**Note:**

Some XGBoost objectives apply only to classification function models and other objectives apply only to regression function models. If you specify an incompatible objective value, an error is raised. In the `DBMS_DATA_MINING.CREATE_MODEL` procedure, if you specify `DBMS_DATA_MINING.CLASSIFICATION` as the function, then the only objective values that you can use are the binary and multi values. The one exception is `binary: logitraw`, which produces a continuous value and applies only to a regression model. If you specify `DBMS_DATA_MINING.REGRESSION` as the function, then you can specify `binary: logitraw` or any of the count, rank, reg, and survival values as the objective.

The values for the XGBoost objective setting are listed in the Settings for Learning Tasks table in DBMS_DATA_MINING — Algorithm Settings: XGBoost.

Example 35-3  Creating a Settings Table and Creating an SVM Classification Model Using CREATE.MODEL procedure

```sql
CREATE TABLE svmc_sh_sample_settings (  
    setting_name VARCHAR2(30),  
    setting_value VARCHAR2(4000));
BEGIN  
    INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
        (dbms_data_mining.algo_name, dbms_data_mining.algo_support_vector_machines);  
    INSERT INTO svmc_sh_sample_settings (setting_name, setting_value) VALUES  
        (dbms_data_mining.svms_kernel_function, dbms_data_mining.svms_linear);  
    COMMIT;
END;
/
-- Create the model using the specified settings
BEGIN
    DBMS_DATA_MINING.CREATE_MODEL(  
        model_name => 'svm_model',  
        mining_function => dbms_data_mining.classification,  
        data_table_name => 'mining_data_build_v',  
        case_id_column_name => 'cust_id',  
        target_column_name => 'affinity_card',  
        settings_table_name => 'svmc_sh_sample_settings');
END;
```
Example 35-4  Specify Model Settings for a GLM Regression Model Using CREATE_MODEL2 procedure

DECLARE
  v_setlist DBMS_DATA_MINING.SETTING_LIST;
BEGIN
  v_setlist('PREP_AUTO') := 'ON';
  v_setlist('ALGO_NAME') := 'ALGO_GENERALIZED_LINEAR_MODEL';
  v_setlist('GLMS_DIAGNOSTICS_TABLE_NAME') := 'GLMR_DIAG';
  v_setlist('GLMS_FTR_SELECTION') := 'GLMS_FTR_SELECTION_ENABLE';
  v_setlist('GLMS_FTR_GENERATION') := 'GLMS_FTR_GENERATION_ENABLE';

  DBMS_DATA_MINING.CREATE_MODEL2(
    MODEL_NAME          => 'GLM_REGR',
    MINING_FUNCTION     => 'REGRESSION',
    DATA_QUERY          => 'select * from TRAINING_DATA',
    SET_LIST            => v_setlist,
    CASE_ID_COLUMN_NAME => 'HID',
    TARGET_COLUMN_NAME  => 'MEDV');
END;

Related Topics
•  Oracle Database PL/SQL Packages and Types Reference

35.7.1 Specify Costs

Specify a cost matrix table to build a Decision Tree model.

The CLAS_COST_TABLE_NAME setting specifies the name of a cost matrix table to be used in building a Decision Tree model. A cost matrix biases a classification model to minimize costly misclassifications. The cost matrix table must have the columns shown in the following table:

Table 35-12  Cost Matrix Table Required Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>valid target data type</td>
</tr>
<tr>
<td>predicted_target_value</td>
<td>valid target data type</td>
</tr>
<tr>
<td>cost</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Decision Tree is the only algorithm that supports a cost matrix at build time. However, you can create a cost matrix and associate it with any classification model for scoring.

If you want to use costs for scoring, create a table with the columns shown in Table 35-12, and use the DBMS_DATA_MINING.ADD_COST_MATRIX procedure to add the cost matrix table to the model. You can also specify a cost matrix inline when invoking a PREDICTION function. Table 34-1 has details for valid target data types.

Related Topics
•  Oracle Machine Learning for SQL Concepts
35.7.2 Specify Prior Probabilities

Prior probabilities can be used to offset differences in distribution between the build data and the actual population.

The `CLAS_PRIORS_TABLE_NAME` setting specifies the name of a table of prior probabilities to be used in building a Naive Bayes model. The priors table must have the columns shown in the following table.

Table 35-13 Priors Table Required Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>target_value</td>
<td>valid target data type</td>
</tr>
<tr>
<td>prior_probability</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Related Topics

- **Target Attribute**
  Understand what a **target** means in machine learning and understand the different target data types.
- **Oracle Machine Learning for SQL Concepts**

35.7.3 Specify Class Weights

Specify class weights table settings in logistic regression or Support Vector Machine (SVM) classification to favor higher weighted classes.

The `CLAS_WEIGHTS_TABLE_NAME` setting specifies the name of a table of class weights to be used to bias a logistic regression (Generalized Linear Model classification) or SVM classification model to favor higher weighted classes. The weights table must have the columns shown in the following table.

Table 35-14 Class Weights Table Required Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>target_value</td>
<td>Valid target data type</td>
</tr>
<tr>
<td>class_weight</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Related Topics

- **Target Attribute**
  Understand what a **target** means in machine learning and understand the different target data types.
- **Oracle Machine Learning for SQL Concepts**
35.7.4 Model Settings in the Data Dictionary

Explain about `ALL/USER/DBA_MINING_MODEL_SETTINGS` in data dictionary view.

Information about Oracle Machine Learning model settings can be obtained from the data dictionary view `ALL/USER/DBA_MINING_MODEL_SETTINGS`. When used with the `ALL` prefix, this view returns information about the settings for the models accessible to the current user. When used with the `USER` prefix, it returns information about the settings for the models in the user's schema. The `DBA` prefix is only available for DBAs.

The columns of `ALL_MINING_MODEL_SETTINGS` are described as follows and explained in the following table.

```sql
SQL> describe all_mining_model_settings
Name                      Null?    Type
------------------------- -------- ----------------------------
OWNER                        NOT NULL VARCHAR2(30)
MODEL_NAME                  NOT NULL VARCHAR2(30)
SETTING_NAME                NOT NULL VARCHAR2(30)
SETTING_VALUE                   VARCHAR2(4000)
SETTING_TYPE                    VARCHAR2(7)
```

Table 35-15 ALL_MINING_MODEL_SETTINGS

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>owner</td>
<td>Owner of the machine learning model.</td>
</tr>
<tr>
<td>model_name</td>
<td>Name of the machine learning model.</td>
</tr>
<tr>
<td>setting_name</td>
<td>Name of the setting.</td>
</tr>
<tr>
<td>setting_value</td>
<td>Value of the setting.</td>
</tr>
<tr>
<td>setting_type</td>
<td>INPUT if the value is specified by a user. DEFAULT if the value is system-generated.</td>
</tr>
</tbody>
</table>

The following query lists the settings for the Support Vector Machine (SVM) classification model `SVMC_SH_CLAS_SAMPLE`. The `ALGO_NAME`, `CLAS_WEIGHTS_TABLE_NAME`, and `SVMS_KERNEL_FUNCTION` settings are user-specified. These settings have been specified in a settings table for the model. The `SVMC_SH_CLAS_SAMPLE` model is created by the `oml4sql-classification-svm.sql` example.

Example 35-5 ALL_MINING_MODEL_SETTINGS

```sql
SQL> COLUMN setting_value FORMAT A35
SQL> SELECT setting_name, setting_value, setting_type
FROM all_mining_model_settings
WHERE model_name in 'SVMC_SH_CLAS_SAMPLE';
```

<table>
<thead>
<tr>
<th>SETTING_NAME</th>
<th>SETTING_VALUE</th>
<th>SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVMS_ACTIVE_LEARNING</td>
<td>SVMS_AL_ENABLE</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>PREP_AUTO</td>
<td>OFF</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVMS_COMPLEXITY_FACTOR</td>
<td>0.244212</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVMS_KERNEL_FUNCTION</td>
<td>SVMS_LINEAR</td>
<td>INPUT</td>
</tr>
<tr>
<td>CLAS_WEIGHTS_TABLE_NAME</td>
<td>svmc_sh_sample_class_wt</td>
<td>INPUT</td>
</tr>
</tbody>
</table>
35.7.5 Specify Oracle Machine Learning Model Settings for an R Model

This topic applies only to Oracle on-premises.

The machine learning model settings for an R language model determine the characteristics of the model and are specified in the model settings table.

You can build a machine learning model in the R language by specifying R as the value of the ALGO_EXTENSIBLE_LANG setting in the model settings table. You can create a model by combining in the settings table generic settings that do not require an algorithm, such as ODMS_PARTITION_COLUMNS and ODMS_SAMPLING. You can also specify the following settings, which are exclusive to an R machine learning model.

- ALGO_EXTENSIBLE_LANG
- RALG_BUILD_FUNCTION
- RALG_BUILD_PARAMETER
- RALG_DETAILS_FORMAT
- RALG_DETAILS_FUNCTION
- RALG_SCORE_FUNCTION
- RALG_WEIGHT_FUNCTION

Related Topics

- Registered R Scripts

The RALG_*_FUNCTION settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.

35.7.5.1 ALGO_EXTENSIBLE_LANG

Use the ALGO_EXTENSIBLE_LANG setting to specify the language for the Oracle Machine Learning for SQL extensible algorithm framework.

Currently, R is the only valid value for the ALGO_EXTENSIBLE_LANG setting. When you set the value for ALGO_EXTENSIBLE_LANG to R, the machine learning models are built using the R language. You can use the following settings in the settings table to specify the characteristics of the R model.

- RALG_BUILD_FUNCTION
- RALG_BUILD_PARAMETER
- RALG_DETAILS_FUNCTION
- RALG_DETAILS_FORMAT
- RALG_SCORE_FUNCTION
- RALG_WEIGHT_FUNCTION
Related Topics

- **Registered R Scripts**
  The RALG_*_FUNCTION settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.

### 35.7.5.2 RALG_BUILD_FUNCTION

Use the RALG_BUILD_FUNCTION setting to specify the name of an existing registered R script for building an Oracle Machine Learning for SQL model using the R language.

You must specify both the RALG_BUILD_FUNCTION and ALGO_EXTENSIBLE_LANG settings in the model settings table. The R script defines an R function that has as the first input argument an R data.frame object for training data. The function returns an Oracle Machine Learning model object. The first data argument is mandatory. The RALG_BUILD_FUNCTION can accept additional model build parameters.

**Note:**
The valid inputs for input parameters are numeric and string scalar data types.

### Example 35-6  Example of RALG_BUILD_FUNCTION

This example shows how to specify the name of the R script MY_LM_BUILD_SCRIPT that is used to build the model.

Begin
```
insert into model_setting_table values
(dbms_data_mining.ralg_build_function,'MY_LM_BUILD_SCRIPT');
End;
/
```

The R script MY_LM_BUILD_SCRIPT defines an R function that builds the LM model. You must register the script MY_LM_BUILD_SCRIPT in the Oracle Machine Learning for R script repository which uses the existing OML4R security restrictions. You can use the OML4R sys.rqScriptCreate procedure to register the script. OML4R requires the RQADMIN role to register R scripts.

For example:

Begin
```
sys.rqScriptCreate('MY_LM_BUILD_SCRIPT', 'function(data, formula, model.frame) {lm(formula = formula, data=data, model = as.logical(model.frame))}');
End;
/
```

For Clustering and Feature Extraction machine learning function model builds, the R attributes dm$nclus and dm$nfeat must be set on the return R model to indicate the number of clusters and features respectively.
The R script `MY_KM_BUILD_SCRIPT` defines an R function that builds the \( k \)-Means model for clustering. The R attribute `dm$nclus` is set with the number of clusters for the returned clustering model.

```
'function(dat) {
  dat.scaled <- scale(dat)
  set.seed(6543); mod <- list()
  fit <- kmeans(dat.scaled, centers = 3L)
  mod[[1L]] <- fit
  mod[[2L]] <- attr(dat.scaled, "scaled:center")
  mod[[3L]] <- attr(dat.scaled, "scaled:scale")
  attr(mod, "dm$nclus") <- nrow(fit$centers)
  mod}
```

The R script `MY_PCA_BUILD_SCRIPT` defines an R function that builds the PCA model. The R attribute `dm$nfeat` is set with the number of features for the returned feature extraction model.

```
'function(dat) {
  mod <- prcomp(dat, retx = FALSE)
  attr(mod, "dm$nfeat") <- ncol(mod$rotation)
  mod}
```

Related Topics

- **RALG_BUILD_PARAMETER**
  The `RALG_BUILD_FUNCTION` input parameter specifies a list of numeric and string scalar values in SQL SELECT query statement format.

- **Registered R Scripts**
  The `RALG_*_FUNCTION` settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.

35.7.5.2.1 RALG_BUILD_PARAMETER

The `RALG_BUILD_FUNCTION` input parameter specifies a list of numeric and string scalar values in SQL SELECT query statement format.

Example 35-7  Example of RALG_BUILD_PARAMETER

The `RALG_BUILD_FUNCTION` input parameters must be a list of numeric and string scalar values. The input parameters are optional.

The syntax of the parameter is:

```
'SELECT value parameter name ...FROM dual'
```

This example shows how to specify a formula for the input argument 'formula' and a numeric value of zero for input argument 'model.frame' using the `RALG_BUILD_PARAMETER`. These input arguments must match with the function signature of the R script used in the `RALG_BUILD_FUNCTION` parameter.

Begin
insert into model_setting_table values
(dbms_data_mining.ralg_build_parameter, 'select ''AGE ~ .'' as "formula", 0
as "model.frame" from dual');
End;
/

Related Topics

• **RALG_BUILD_FUNCTION**
  Use the RALG_BUILD_FUNCTION setting to specify the name of an existing registered R script for building an Oracle Machine Learning for SQL model using the R language.

### 35.7.5.3 RALG_DETAILS_FUNCTION

The **RALG_DETAILS_FUNCTION** specifies the R model metadata that is returned in the R data.frame.

Use the **RALG_DETAILS_FUNCTION** to specify an existing registered R script that generates model information. The script defines an R function that contains the first input argument for the R model object. The output of the R function must be a data.frame. **The columns of the data.frame are defined by the RALG_DETAILS_FORMAT setting, and may contain only numeric or string scalar types.**

**Example 35-8   Example of RALG_DETAILS_FUNCTION**

This example shows how to specify the name of the R script `MY_LM_DETAILS_SCRIPT` in the model settings table. This script defines the R function that is used to provide the model information.

Begin
insert into model_setting_table values
(dbms_data_mining.ralg_details_function, 'MY_LM_DETAILS_SCRIPT');
End;
/

In the Oracle Machine Learning for R script repository, the script `MY_LM_DETAILS_SCRIPT` is registered as:

'function(mod) data.frame(name=names(mod$coefficients),
 coef=mod$coefficients)'

Related Topics

• **Registered R Scripts**
  The **RALG_*_FUNCTION** settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.

• **RALG_DETAILS_FORMAT**
  Use the **RALG_DETAILS_FORMAT** setting to specify the names and column types in the model view.
35.7.5.3.1 RALG_DETAILS_FORMAT

Use the RALG_DETAILS_FORMAT setting to specify the names and column types in the model view.

The value of the setting is a string that contains a SELECT statement to specify a list of numeric and string scalar data types for the name and type of the model view columns.

When the RALG_DETAILS_FORMAT and RALG_DETAILS_FUNCTION settings are both specified, a model view by the name DM$VD <model_name> is created along with an R model in the current schema. The first column of the model view is PARTITION_NAME. It has the value NULL for non-partitioned models. The other columns of the model view are defined by RALG_DETAILS_FORMAT setting.

Example 35-9  Example of RALG_DETAILS_FORMAT

This example shows how to specify the name and type of the columns for the generated model view. The model view contains the varchar2 column attr_name and the number column coef_value after the first column partition_name.

Begin
insert into model_setting_table values
(dbms_data_mining.ralg_details_format, 'select cast(''a'' as varchar2(20))
as attr_name, 0 as coef_value from dual');
End;
/

Related Topics

- RALG_DETAILS_FUNCTION
  The RALG_DETAILS_FUNCTION specifies the R model metadata that is returned in the R data.frame.

35.7.5.4 RALG_SCORE_FUNCTION

Use the RALG_SCORE_FUNCTION setting to specify an existing registered R script for R algorithm machine learning model to use for scoring data.

The specified R script defines an R function. The first input argument defines the model object. The second input argument defines the R data.frame that is used for scoring data.

Example 35-10  Example of RALG_SCORE_FUNCTION

This example shows how the R function takes the Linear Model model and scores the data in the data.frame. The function argument object is the LM model. The argument newdata is a data.frame containing the data to score.

function(object, newdata) {res <- predict.lm(object, newdata = newdata, se.fit = TRUE); data.frame(fit=res$fit, se=res$se.fit, df=summary(object)$df[1L])}

The output of the R function must be a data.frame. Each row represents the prediction for the corresponding scoring data from the input data.frame. The columns of the data.frame are specific to machine learning functions, such as:
**Regression:** A single numeric column for the predicted target value, with two optional columns containing the standard error of the model fit, and the degrees of freedom number. The optional columns are needed for the SQL function `PREDICTION_BOUNDS` to work.

**Example 35-11  Example of RALG_SCORE_FUNCTION for Regression**

This example shows how to specify the name of the R script `MY_LM_PREDICT_SCRIPT` that is used to score the model in the model settings table `model_setting_table`.

```sql
Begin
  insert into model_setting_table values
  (dbms_data_mining.ralg_score_function, 'MY_LM_PREDICT_SCRIPT');
End;
/
```

In the Oracle Machine Learning for R script repository, the script `MY_LM_PREDICT_SCRIPT` is registered as:

```r
function(object, newdata) {
data.frame(pre = predict(object, newdata = newdata))
}
```

**Classification:** Each column represents the predicted probability of one target class. The column name is the target class name.

**Example 35-12  Example of RALG_SCORE_FUNCTION for Classification**

This example shows how to specify the name of the R script `MY_LOGITGLM_PREDICT_SCRIPT` that is used to score the logit Classification model in the model settings table `model_setting_table`.

```sql
Begin
  insert into model_setting_table values
  (dbms_data_mining.ralg_score_function, 'MY_LOGITGLM_PREDICT_SCRIPT');
End;
/
```

In the OML4R script repository, `MY_LOGITGLM_PREDICT_SCRIPT` is registered as follows. It is a logit Classification with two target classes, "0" and "1".

```r
'function(object, newdata) {
pred <- predict(object, newdata = newdata, type="response");
  res <- data.frame(1-pred, pred);
  names(res) <- c("0", "1");
  res}'
```

**Clustering:** Each column represents the predicted probability of one cluster. The columns are arranged in order of cluster ID. Each cluster is assigned a cluster ID, and they are consecutive values starting from 1. To support `CLUSTER_DISTANCE` in the R model, the output of R score function returns an extra column containing the value of the distance to each cluster in order of cluster ID after the columns for the predicted probability.
Example 35-13  Example of RALG_SCORE_FUNCTION for Clustering

This example shows how to specify the name of the R script `MY_CLUSTER_PREDICT_SCRIPT` that is used to score the model in the model settings table `model_setting_table`.

```
Begin
insert into model_setting_table values
  (dbms_data_mining.ralg_score_function, 'MY_CLUSTER_PREDICT_SCRIPT');
End;
/
```

In the OML4R script repository, the script `MY_CLUSTER_PREDICT_SCRIPT` is registered as:

```
'function(object, dat) {
  mod <- object[[1L]]; ce <- object[[2L]]; sc <- object[[3L]];
  newdata = scale(dat, center = ce, scale = sc);
  centers <- mod$centers;
  ss <- sapply(as.data.frame(t(centers)),
              function(v) rowSums(scale(newdata, center=v, scale=FALSE)^2));
  if (!is.matrix(ss)) ss <- matrix(ss, ncol=length(ss));
  disp <- -1 / (2* mod$tot.withinss/length(mod$cluster));
  distr <- exp(disp*ss);
  prob <- distr / rowSums(distr);
  as.data.frame(cbind(prob, sqrt(ss)))}'
```

**Feature Extraction:** Each column represents the coefficient value of one feature. The columns are arranged in order of feature ID. Each feature is assigned a feature ID, which are consecutive values starting from 1.

Example 35-14  Example of RALG_SCORE_FUNCTION for Feature Extraction

This example shows how to specify the name of the R script `MY_FEATURE_EXTRACTION_SCRIPT` that is used to score the model in the model settings table `model_setting_table`.

```
Begin
insert into model_setting_table values
  (dbms_data_mining.ralg_score_function, 'MY_FEATURE_EXTRACTION_SCRIPT');
End;
/
```

In the OML4R script repository, the script `MY_FEATURE_EXTRACTION_SCRIPT` is registered as:

```
'function(object, dat) { as.data.frame(predict(object, dat)) }'
```

The function fetches the centers of the features from the R model, and computes the feature coefficient based on the distance of the score data to the corresponding feature center.

**Related Topics**

- **Registered R Scripts**
  The `RALG_*_FUNCTION` settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.
35.7.5.5 RALG_WEIGHT_FUNCTION

Use the RALG_WEIGHT_FUNCTION setting to specify the name of an existing registered R script that computes the weight or contribution for each attribute in scoring. The specified R script is used in the SQL function PREDICTION_DETAILS to evaluate attribute contribution.

The specified R script defines an R function containing the first input argument for a model object, and the second input argument of an R data.frame for scoring data. When the machine learning function is Classification, Clustering, or Feature Extraction, the target class name, cluster ID, or feature ID is passed by the third input argument to compute the weight for that particular class, cluster, or feature. The script returns a data.frame containing the contributing weight for each attribute in a row. Each row corresponds to that input scoring data.frame.

Example 35-15 Example of RALG_WEIGHT_FUNCTION

This example specifies the name of the R script MY_PREDICT_WEIGHT_SCRIPT that computes the weight or contribution of R model attributes in the model_setting_table.

Begin
insert into model_setting_table values
    (dbms_data_mining.ralg_weight_function, 'MY_PREDICT_WEIGHT_SCRIPT');
End;
/

In the Oracle Machine Learning for R script repository, the script MY_PREDICT_WEIGHT_SCRIPT for Regression is registered as:

'function(mod, data) { coef(mod)[-1]*data }'

In the OML4R script repository, the script MY_PREDICT_WEIGHT_SCRIPT for logit Classification is registered as:

'function(mod, dat, clas) {
    v <- predict(mod, newdata=dat, type = "response");
    v0 <- data.frame(v, 1-v); names(v0) <- c("0", "1");
    res <- data.frame(lapply(seq_along(dat),
        function(x, dat) {
            if(is.numeric(dat[[x]])) dat[,x] <- as.numeric(0)
            else dat[,x] <- as.factor(NA);
            vv <- predict(mod, newdata = dat, type = "response");
            vv <- data.frame(vv, 1-vv); names(vv) <- c("0", "1");
            v0[[clas]] / vv[[clas]], dat = dat));
        names(res) <- names(dat);
        res}'

Related Topics
• Registered R Scripts

The RALG_*_FUNCTION settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.
35.7.5.6 Registered R Scripts

The RALG_*_FUNCTION settings must specify R scripts that exist in the Oracle Machine Learning for R script repository.

You can register the R scripts using the OML4R SQL procedure sys.rqScriptCreate. To register a script, you must have the RQADMIN role.

The RALG_*_FUNCTION settings include the following functions:

- RALG_BUILD_FUNCTION
- RALG_DETAILS_FUNCTION
- RALG_SCORE_FUNCTION
- RALG_WEIGHT_FUNCTION

**Note:**

The R scripts must exist in the OML4R script repository for an R model to function.

After an R model is built, the name of the specified R script become a model setting. These R scripts must exist in the OML4R script repository for an R model to remain functional.

You can manage the R memory that is used to build, score, and view the R models through OML4R as well.

35.7.5.7 R Model Demonstration Scripts

You can access R model demonstration scripts under rdbms/demo:

dmraidemo.sql  dmrglmdemo.sql  dmrpcademo.sql
dmrardemo.sql  dmrkmdemo.sql  dmrrfdemo.sql
dmrtddemo.sql   dmrnndemo.sql

35.8 Model Detail Views

Model detail views provide information about models.

The following are the model views, grouped by model function:

**Association:**
- Model Detail Views for Association Rules
- Model Detail View for Frequent Itemsets
- Model Detail Views for Transactional Itemsets
- Model Detail View for Transactional Rule

**Classification, Regression, and Anomaly Detection:**
- Model Detail Views for Classification Algorithms
35.8.1 Model Detail Views for Association Rules

The model detail view `DM$VRmodel_name` contains the generated rules for association models.

Depending on the settings of the model, this rule view has different sets of columns. Settings `ODMS_ITEM_ID_COLUMN_NAME` and `ODMS_ITEM_VALUE_COLUMN_NAME` determine how each item is defined. If `ODMS_ITEM_ID_COLUMN_NAME` is set, the input format is called transactional input, otherwise, the input format is called 2-Dimensional input. With transactional input, if setting `ODMS_ITEM_VALUE_COLUMN_NAME` is not set, each item is defined by `ITEM_NAME`, otherwise, each item is defined by `ITEM_NAME` and `ITEM_VALUE`. With 2-Dimensional input, each item is defined by `ITEM_NAME`,
Setting **ASSO_AGGREGATES** specifies the columns to aggregate, which is displayed in the view.

**Note:**
Setting **ASSO_AGGREGATES** is not allowed for 2-dimensional input.

The following shows the views with different settings.

**Transactional Input Without ASSO_AGGREGATES Setting**

When you set **ITEM_NAME** (**ODMS_ITEM_ID_COLUMN_NAME**) and do not set **ITEM_VALUE** (**ODMS_ITEM_VALUE_COLUMN_NAME**), the view contains the following. The consequent item is defined with only the name field. If you also set **ITEM_VALUE**, the view has the additional column **CONSEQUENT_VALUE** that specifies the value field.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANTECEDENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_NAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ANTECEDENT</td>
<td>SYS.XMLTYPE</td>
</tr>
</tbody>
</table>

**Table 35-16  Rule View Columns for Transactional Inputs**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model to retrieve details.</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>The identifier of the rule.</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>The number of transactions that satisfy the rule.</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>The likelihood of a transaction satisfying the rule.</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>The degree of improvement in the prediction over random chance when the rule is satisfied.</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>The number of transactions in which the rule occurs divided by the number of transactions in which the consequent occurs.</td>
</tr>
<tr>
<td>ANTECEDENT_SUPPORT</td>
<td>The ratio of the number of transactions that satisfy the antecedent to the total number of transactions.</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>The total number of attributes referenced in the antecedent and consequent of the rule.</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>The ratio of the number of transactions that satisfy the consequent to the total number of transactions.</td>
</tr>
<tr>
<td>CONSEQUENT_NAME</td>
<td>The name of the consequent.</td>
</tr>
</tbody>
</table>
Table 35-16  (Cont.) Rule View Columns for Transactional Inputs

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSEQUENT_VALUE</td>
<td>The value of the consequent. This column is present when Item_value (ODMS_ITEM_VALUE_COLUMN_NAME) is set with TYPE as numerical or categorical.</td>
</tr>
</tbody>
</table>
| ANTECEDENT        | The antecedent is described as an itemset. At the itemset level, it specifies the number of aggregates, and if not zero, the names of the columns to be aggregated (as well as the mapping to ASSO_AGG). The itemset contains >= 1 items.  
  - When ODMS_ITEM_VALUE_COLUMN_NAME is not set, each item is defined by item_name. As an example, if the antecedent contains one item B, then it is represented as follows:  
    `<itemset NUMAGGR="0"><item><item_name>B</item_name></item></itemset>`
  
  As another example, if the antecedent contains two items, A and C, then it is represented as follows:
  
    `<itemset NUMAGGR="0"><item><item_name>A</item_name></item><item><item_name>C</item_name></item></itemset>`
  
  - When setting ODMS_ITEM_VALUE_COLUMN_NAME is set, each item is defined by item_name and item_value. As an example, if the antecedent contains two items, (name A, value 1) and (name C, value 1), then it is represented as follows:

    `<itemset NUMAGGR="0"><item><item_name>A</item_name><item_value>1</item_value></item><item><item_name>C</item_name><item_value>1</item_value></item></itemset>`

Transactional Input With ASSO_AGGREGATES Setting

Similar to the view without an aggregates setting, there are three cases:

- **Rule view when ODMS_ITEM_ID_COLUMN_NAME is set and Item_value (ODMS_ITEM_VALUE_COLUMN_NAME) is not set.**
- **Rule view when ODMS_ITEM_ID_COLUMN_NAME is set and Item_value (ODMS_ITEM_VALUE_COLUMN_NAME) is set with TYPE as numerical, the view has a CONSEQUENT_VALUE column.**
- **Rule view when ODMS_ITEM_ID_COLUMN_NAME is set and Item_value (ODMS_ITEM_VALUE_COLUMN_NAME) is set with TYPE as categorical, the view has a CONSEQUENT_VALUE column.**

For the example that produces the following rules, see “Example: Calculating Aggregates” in *Oracle Machine Learning for SQL Concepts*.

The view reports two sets of aggregates results:
1. **ANT_RULE_PROFIT** refers to the total profit for the antecedent itemset with respect to the rule, the profit for each individual item of the antecedent itemset is shown in the **ANTECEDENT** column, **CON_RULE_PROFIT** refers to the total profit for the consequent item with respect to the rule.

In the example, for rule (A, B) => C, the rule itemset (A, B, C) occurs in the transactions of customer 1 and customer 3. The **ANT_RULE_PROFIT** is $21.20, The **ANTECEDENT** is shown as follow, which tells that item A has profit 5.00 + 3.00 = $8.00 and item B has profit 3.20 + 10.00 = $13.20, which sum up to **ANT_RULE_PROFIT**.

   <itemset NUMAGGR="1" ASSO_AGG0="profit"><item><item_name>A</item_name><ASSO_AGG0>8.0E+000</ASSO_AGG0></item><item><item_name>B</item_name><ASSO_AGG0>1.32E+001</ASSO_AGG0></item></itemset>

The **CON_RULE_PROFIT** is 12.00 + 14.00 = $26.00

2. **ANT_PROFIT** refers to the total profit for the antecedent itemset, while **CON_PROFIT** refers to the total profit for the consequent item. The difference between **CON_PROFIT** and **CON_RULE_PROFIT** (the same applies to **ANT_PROFIT** and **ANT_RULE_PROFIT**) is that **CON_PROFIT** counts all profit for the consequent item across all transactions where the consequent occurs, while **CON_RULE_PROFIT** only counts across transactions where the rule itemset occurs.

For example, item C occurs in transactions for customer 1, 2 and 3, **CON_PROFIT** is 12.00 + 4.20 + 14.00 = $30.20, while **CON_RULE_PROFIT** only counts transactions for customer 1 and 3 where the rule itemset (A, B, C) occurs.

Similarly, **ANT_PROFIT** counts all transactions where itemset (A, B) occurs, while **ANT_RULE_PROFIT** counts only transactions where the rule itemset (A, B, C) occurs. In this example, by coincidence, both count transactions for customer 1 and 3, and have the same value.

**Example 35-16**  **Examples**

The following example shows the view when setting **ASSO_AGGREGATES** specifies column profit and column sales to be aggregated. In this example, **ITEM_VALUE** column is not specified.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANTECEDENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_NAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ANTECEDENT</td>
<td>SYS.XMLTYPE</td>
</tr>
<tr>
<td>ANT_RULE_PROFIT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CON_RULE_PROFIT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ANT_PROFIT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CON_PROFIT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ANT_RULE_SALES</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CON_RULE_SALES</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
The rule view has a `CONSEQUENT_VALUE` column when `ODMS_ITEM_ID_COLUMN_NAME` is set and `Item_value(ODMS_ITEM_VALUE_COLUMN_NAME)` is set with `TYPE` as numerical or categorical.

### 2-Dimensional Inputs

In Oracle Machine Learning for SQL, association models can be built using either transactional or two-dimensional data formats. For two-dimensional input, each item is defined by three fields: `NAME`, `VALUE` and `SUBNAME`. The `NAME` field is the name of the column. The `VALUE` field is the content of the column. The `SUBNAME` field is used when the input data table contains a nested table. In that case, `SUBNAME` is the name of the nested table’s column. See, Example: Creating a Nested Column for Market Basket Analysis. In this example, there is a nested column. The `CONSEQUENT_SUBNAME` is the `ATTRIBUTE_NAME` part of the nested column. That is, 'O/S Documentation Set - English' and `CONSEQUENT_VALUE` is the value part of the nested column, which is, 1.

The view uses three columns for the consequent. The rule view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANTECEDENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_NAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>CONSEQUENT_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>CONSEQUENT_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ANTECEDENT</td>
<td>SYS.XMLTYPE</td>
</tr>
</tbody>
</table>

**Note:**

All of the types for three columns for the consequent are `VARCHAR2`. `ASSO_AGGREGATES` is not applicable for 2-Dimensional input format.

The following table displays rule view columns for 2-Dimensional input with the descriptions of only the fields that are specific to 2-D inputs.

**Table 35-17  Rule View for 2-Dimensional Input**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSEQUENT_SUBNAME</td>
<td>For two-dimensional inputs, <code>CONSEQUENT_SUBNAME</code> is used for nested column in the input data table.</td>
</tr>
</tbody>
</table>
Table 35-17  (Cont.) Rule View for 2-Dimensional Input

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSEQUENT_VALUE</td>
<td>The value of the consequent when setting Item_value is set with TYPE as numerical or categorical.</td>
</tr>
</tbody>
</table>
| ANTECEDENT             | The antecedent is described as an itemset. The itemset contains $\geq 1$ items. Each item is defined using ITEM_NAME, ITEM_SUBNAME, and ITEM_VALUE. As an example, assuming that this is not a nested table input, and the antecedent contains one item: (name ADDR, value MA). The antecedent (XMLtype) is as follows:  
```xml
<itemset NUMAGGR="0"><item><item_name>ADDR</item_name><item_subname></item_subname><item_value>MA</item_value></item></itemset>
```

For 2-Dimensional input with nested table, the subname field is filled.

Global Detail for Association Rules

A single global detail is produced by an association model. The following table describes a global detail returned for association model.

Table 35-18  Global Detail for an Association Model

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEMSET_COUNT</td>
<td>The number of itemsets generated.</td>
</tr>
<tr>
<td>MAX_SUPPORT</td>
<td>The maximum support.</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build.</td>
</tr>
<tr>
<td>RULE_COUNT</td>
<td>The number of association rules in the model generated.</td>
</tr>
<tr>
<td>TRANSACTION_COUNT</td>
<td>The number of the transactions in the input data.</td>
</tr>
</tbody>
</table>

35.8.2 Model Detail View for Frequent Itemsets

The model detail view contains information about frequent itemsets.

The frequent itemsets view `DMSVI model_name` has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ITEMSET_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ITEMSET</td>
<td>SYS.XMLTYPE</td>
</tr>
</tbody>
</table>
Table 35-19  Frequent Itemsets View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>ITEMSET_ID</td>
<td>Itemset identifier</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>Support of the itemset</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>Number of items in the itemset</td>
</tr>
<tr>
<td>ITEMSET</td>
<td>Frequent itemset</td>
</tr>
</tbody>
</table>

The structure of the `SYS.XMLTYPE` column `itemset` is the same as the corresponding Antecedent column of the rule view.

35.8.3 Model Detail Views for Transactional Itemsets

The model detail view contains information about the transactional itemsets.

For the very common case of transactional data without aggregates, `DM$VT model_name` view provides the itemsets information in transactional format. This view can help improve performance for some queries as compared to the view with the XML column. The transactional itemsets view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ITEMSET_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ITEM_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ITEM_NAME</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

Table 35-20  Transactional Itemsets View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>ITEMSET_ID</td>
<td>Itemset identifier</td>
</tr>
<tr>
<td>ITEM_ID</td>
<td>Item identifier</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>Support of the itemset</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>Number of items in the itemset</td>
</tr>
<tr>
<td>ITEM_NAME</td>
<td>The name of the item</td>
</tr>
</tbody>
</table>

35.8.4 Model Detail View for Transactional Rule

The model detail view for transactional rules contains information about transactional rules and transactional itemsets.

Transactional data without aggregates also has a transactional rule view `DM$VA model_name`. This view can improve performance for some queries as
compared to the view with the XML column. The transactional rule view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANTECEDEnt_PREDICATE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>CONSEQUENT_PREDICATE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_ITEMSET_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANTECEDEnt_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-21  Transactional Rule View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>RULE_ID</td>
<td>Rule identifier</td>
</tr>
<tr>
<td>ANTECEDEnt_PREDICATE</td>
<td>Name of the Antecedent item.</td>
</tr>
<tr>
<td>CONSEQUENT_PREDICATE</td>
<td>Name of the Consequent item.</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>Support of the rule</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>The likelihood a transaction satisfies the rule when it contains the Antecedent.</td>
</tr>
<tr>
<td>RULE_LIFT</td>
<td>The degree of improvement in the prediction over random chance when the rule is satisfied</td>
</tr>
<tr>
<td>RULE_REVCONFIDENCE</td>
<td>The number of transactions in which the rule occurs divided by the number of transactions in which the consequent occurs</td>
</tr>
<tr>
<td>RULE_ITEMSET_ID</td>
<td>Itemset identifier</td>
</tr>
<tr>
<td>ANTECEDEnt_SUPPORT</td>
<td>The ratio of the number of transactions that satisfy the antecedent to the total number of transactions</td>
</tr>
<tr>
<td>CONSEQUENT_SUPPORT</td>
<td>The ratio of the number of transactions that satisfy the consequent to the total number of transactions</td>
</tr>
<tr>
<td>NUMBER_OF_ITEMS</td>
<td>Number of items in the rule</td>
</tr>
</tbody>
</table>

35.8.5 Model Detail Views for Classification Algorithms

Model detail views for classification algorithms are the target map view and scoring cost view, which are applicable to all classification algorithms.

The target map view DM$VT$model name describes the target distribution for classification models. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The scoring cost view \texttt{DM\$VC\_model\_name} describes the scoring cost matrix for classification models. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ACTUAL_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>COST</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-23  Scoring Cost View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ACTUAL_TARGET_VALUE</td>
<td>A valid target value</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>Predicted target value</td>
</tr>
<tr>
<td>COST</td>
<td>Associated cost for the actual and predicted target value pair</td>
</tr>
</tbody>
</table>

35.8.6 Model Detail Views for Decision Tree

The model detail views for Decision Tree are the split information view, node statistics view, node description view, and the cost matrix view.

The split information view \texttt{DM\$VP\_model\_name} describes the decision tree hierarchy and the split information for each level in the decision tree. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>PARENT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>SPLIT_TYPE</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>NODE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
</tbody>
</table>
Table 35-24  Split Information View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>PARENT</td>
<td>Node ID of the parent</td>
</tr>
<tr>
<td>SPLIT_TYPE</td>
<td>The main or surrogate split</td>
</tr>
<tr>
<td>NODE</td>
<td>The node ID</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>The attribute used as the splitting criterion at the parent node to produce this node.</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Split attribute subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>Split operator</td>
</tr>
<tr>
<td>VALUE</td>
<td>Value used as the splitting criterion. This is an XML element described using the &lt;Element&gt; tag. For example, &lt;Element&gt;Windy&lt;/Element&gt;&lt;Element&gt;Hot&lt;/Element&gt;.</td>
</tr>
</tbody>
</table>

The node statistics view DM$VImodel_name describes the statistics associated with individual tree nodes. The statistics include a target histogram for the data in the node. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>NODE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NODE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>TARGET_SUPPORT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-25  Node Statistics View

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>NODE</td>
<td>The node ID</td>
</tr>
<tr>
<td>NODE_SUPPORT</td>
<td>Number of records in the training set that belong to the node</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>Predicted Target value</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>A target value seen in the training data</td>
</tr>
<tr>
<td>TARGET_SUPPORT</td>
<td>The number of records that belong to the node and have the value specified in the TARGET_VALUE column</td>
</tr>
</tbody>
</table>
Higher level node descriptions are in the `DM$VO model_name` view. The `DM$VO model_name` view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>NODE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>NODE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>PARENT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>VALUE</td>
<td>SYS.XMLTYPE</td>
</tr>
</tbody>
</table>

Table 35-26  Node Description View

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>NODE</td>
<td>The node ID</td>
</tr>
<tr>
<td>NODE_SUPPORT</td>
<td>Number of records in the training set that belong to the node</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>Predicted Target value</td>
</tr>
<tr>
<td>PARENT</td>
<td>The ID of the parent</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Specifies the attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Specifies the attribute subname</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>Attribute predicate operator - a conditional operator taking the following values: <code>IN, =, &lt;&gt;, &lt;, &gt;, &lt;=, and &gt;=</code></td>
</tr>
</tbody>
</table>
| VALUE                 | Value used as the description criterion. This is an XML element described using the `<Element>` tag. For example, `<Element>Windy</Element>`.<Element>Hot</Element>`.

The `DM$VM model_name` view describes the cost matrix used by the Decision Tree build. The `DM$VM model_name` view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ACTUAL_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>COST</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>
### Table 35-27  Cost Matrix View

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ACTUAL_TARGET_VALUE</td>
<td>Valid target value</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>Predicted Target value</td>
</tr>
<tr>
<td>COST</td>
<td>Associated cost for the actual and predicted target value pair</td>
</tr>
</tbody>
</table>

The following table describes the global view for a Decision Tree model.

### Table 35-28  Decision Tree Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>

### 35.8.7 Model Detail Views for Generalized Linear Model

Model detail views for Generalized Linear Model (GLM) contain details and row diagnostics for linear and logistic regression models.

The model details view `DM$VD$model_name` describes the final model information for both linear regression models and logistic regression models.

For linear regression, the view `DM$VD$model_name` has the following columns:

#### Name                               Type
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>FEATURE_EXPRESSION</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>STD_ERROR</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>TEST_STATISTIC</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>P_VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>VIF</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>STD_COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>LOWER_COEFF_LIMIT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>UPPER_COEFF_LIMIT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

For logistic regression, the view `DM$VD$model_name` has the following columns:

#### Name                               Type
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
</tbody>
</table>
### Table 35-29  Model View for Linear and Logistic Regression Models

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Valid target value</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>The attribute name when there is no subname, or first part of the attribute name when there is a subname. ATTRIBUTE_NAME is the name of a column in the source table or view. If the column is a non-nested, numeric column, then ATTRIBUTE_NAME is the name of the machine learning attribute. For the intercept, ATTRIBUTE_NAME is null. Intercepts are equivalent to the bias term in SVM models.</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns. When the nested column is numeric, the machine learning attribute is identified by the combination ATTRIBUTE_NAME - ATTRIBUTE_SUBNAME. If the column is not nested, ATTRIBUTE_SUBNAME is null. If the attribute is an intercept, both the ATTRIBUTE_NAME and the ATTRIBUTE_SUBNAME are null.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>A unique value that can be assumed by a categorical column or nested categorical column. For categorical columns, a machine learning attribute is identified by a unique ATTRIBUTE_NAME.ATTRIBUTE_VALUE pair. For nested categorical columns, a machine learning attribute is identified by the combination: ATTRIBUTE_NAME.ATTRIBUTE_SUBNAME.ATTRIBUTE_VALUE. For numerical attributes, ATTRIBUTE_VALUE is null.</td>
</tr>
</tbody>
</table>
Table 35-29  (Cont.) Model View for Linear and Logistic Regression Models

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEATURE_EXPRESSION</td>
<td>The feature name constructed by the algorithm when feature selection is enabled. If feature selection is not enabled, the feature name is the fully-qualified attribute name ( (&lt;\text{attribute}_\text{name}.\text{attribute}_\text{subname}&gt; \text{if the attribute is in a nested column}) ). For categorical attributes, the algorithm constructs a feature name that has the following form: ( \text{fully-qualified}_\text{attribute}_\text{name}.\text{attribute}_\text{value} ). When feature generation is enabled, a term in the model can be a single machine learning attribute or the product of up to 3 machine learning attributes. Component machine learning attributes can be repeated within a single term. If feature generation is not enabled or, if feature generation is enabled, but no multiple component terms are discovered by the CREATE model process, then FEATURE_EXPRESSION is null.</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>The estimated coefficient.</td>
</tr>
<tr>
<td>STD_ERROR</td>
<td>Standard error of the coefficient estimate.</td>
</tr>
<tr>
<td>TEST_STATISTIC</td>
<td>For linear regression, the t-value of the coefficient estimate. For logistic regression, the Wald chi-square value of the coefficient estimate.</td>
</tr>
<tr>
<td>P_VALUE</td>
<td>Probability of the TEST_STATISTIC under the (NULL) hypothesis that the term in the model is not statistically significant. A low probability indicates that the term is significant, while a high probability indicates that the term can be better discarded. Used to analyze the significance of specific attributes in the model.</td>
</tr>
<tr>
<td>VIF</td>
<td>Variance Inflation Factor. The value is zero for the intercept. For logistic regression, VIF is null.</td>
</tr>
<tr>
<td>STD_COEFFICIENT</td>
<td>Standardized estimate of the coefficient.</td>
</tr>
<tr>
<td>LOWER_COEFF_LIMIT</td>
<td>Lower confidence bound of the coefficient.</td>
</tr>
<tr>
<td>UPPER_COEFF_LIMIT</td>
<td>Upper confidence bound of the coefficient.</td>
</tr>
<tr>
<td>EXP_COEFFICIENT</td>
<td>Exponentiated coefficient for logistic regression. For linear regression, EXP_COEFFICIENT is null.</td>
</tr>
<tr>
<td>EXP_LOWER_COEFF_LIMIT</td>
<td>Exponentiated coefficient for lower confidence bound of the coefficient for logistic regression. For linear regression, EXP_LOWER_COEFF_LIMIT is null.</td>
</tr>
<tr>
<td>EXP_UPPER_COEFF_LIMIT</td>
<td>Exponentiated coefficient for upper confidence bound of the coefficient for logistic regression. For linear regression, EXP_UPPER_COEFF_LIMIT is null.</td>
</tr>
</tbody>
</table>
The row diagnostic view `DM$VA model_name` describes row level information for both linear regression models and logistic regression models. For linear regression, the view `DM$VA model_name` has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>NUMBER/VARCHAR2, DATE, TIMESTAMP, TIMESTAMP WITH TIME ZONE, TIMESTAMP WITH LOCAL TIME ZONE</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>Hat</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>STD_ERR_RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>STUDENTIZED_RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>PRED_RES</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>COOKS_D</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-30  Row Diagnostic View for Linear Regression

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>Name of the case identifier</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>The actual target value as taken from the input row</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>The model predicted target value for the row</td>
</tr>
<tr>
<td>HAT</td>
<td>The diagonal element of the n*n (n=number of rows) that the Hat matrix identifies with a specific input row. The model predictions for the input data are the product of the Hat matrix and vector of input target values. The diagonal elements (Hat values) represent the influence of the (i^{th}) row on the (i^{th}) fitted value. Large Hat values are indicators that the (i^{th}) row is a point of high leverage, a potential outlier.</td>
</tr>
<tr>
<td>RESIDUAL</td>
<td>The difference between the predicted and actual target value for a specific input row.</td>
</tr>
<tr>
<td>STD_ERR_RESIDUAL</td>
<td>The standard error residual, sometimes called the Studentized residual, re-scales the residual to have constant variance across all input rows in an effort to make the input row residuals comparable. The process multiplies the residual by square root of the row weight divided by the product of the model mean square error and 1 minus the Hat value.</td>
</tr>
<tr>
<td>STUDENTIZED_RESIDUAL</td>
<td>Studentized deletion residual adjusts the standard error residual for the influence of the current row.</td>
</tr>
<tr>
<td>PRED_RES</td>
<td>The predictive residual is the weighted square of the deletion residuals, computed as the row weight multiplied by the square of the residual divided by 1 minus the Hat value.</td>
</tr>
<tr>
<td>COOKS_D</td>
<td>Cook's distance is a measure of the combined impact of the (i^{th}) case on all of the estimated regression coefficients.</td>
</tr>
</tbody>
</table>
For logistic regression, the view `DM$Vamodel_name` has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>NUMBER/VARCHAR2, DATE, TIMESTAMP,</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMP WITH TIME ZONE,</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMP WITH LOCAL TIME ZONE</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>TARGET_VALUE_PROB</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>Hat</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>WORKING_RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>PEARSON_RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>DEVIANCE_RESIDUAL</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>C</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CBAR</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>DIFDEV</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>DIFCHISQ</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

### Table 35-31  Row Diagnostic View for Logistic Regression

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>Name of the case identifier</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>The actual target value as taken from the input row</td>
</tr>
<tr>
<td>TARGET_VALUE_PROB</td>
<td>Model estimate of the probability of the predicted target value.</td>
</tr>
<tr>
<td>Hat</td>
<td>The Hat value concept from linear regression is extended to logistic</td>
</tr>
<tr>
<td></td>
<td>regression by multiplying the linear regression Hat value by the variance</td>
</tr>
<tr>
<td></td>
<td>function for logistic regression, the predicted probability multiplied by 1</td>
</tr>
<tr>
<td></td>
<td>minus the predicted probability.</td>
</tr>
<tr>
<td>WORKING_RESIDUAL</td>
<td>The working residual is the residual of the working response. The</td>
</tr>
<tr>
<td></td>
<td>working response is the response on the linearized scale. For logistic</td>
</tr>
<tr>
<td></td>
<td>regression it has the form: the i&lt;sup&gt;th&lt;/sup&gt; row residual divided by</td>
</tr>
<tr>
<td></td>
<td>the variance of the i&lt;sup&gt;th&lt;/sup&gt; row prediction. The variance of the</td>
</tr>
<tr>
<td></td>
<td>prediction is the predicted probability multiplied by 1 minus the predicted</td>
</tr>
<tr>
<td></td>
<td>probability. WORKING_RESIDUAL is the difference between the working</td>
</tr>
<tr>
<td></td>
<td>response and the linear predictor at convergence.</td>
</tr>
<tr>
<td>PEARSON_RESIDUAL</td>
<td>The Pearson residual is a re-scaled version of the working residual,</td>
</tr>
<tr>
<td></td>
<td>accounting for the weight. For logistic regression, the Pearson residual</td>
</tr>
<tr>
<td></td>
<td>multiplies the residual by a factor that is computed as square root of the</td>
</tr>
<tr>
<td></td>
<td>weight divided by the variance of the predicted probability for the i&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>row. RESIDUAL is 1 minus the predicted probability of the actual target</td>
</tr>
<tr>
<td></td>
<td>value for the row.</td>
</tr>
<tr>
<td>DEVIANCE_RESIDUAL</td>
<td>The DEVIANCE_RESIDUAL is the contribution to the model deviance of the</td>
</tr>
<tr>
<td></td>
<td>i&lt;sup&gt;th&lt;/sup&gt; observation. For logistic regression it has the form the</td>
</tr>
<tr>
<td></td>
<td>square root of 2 times the log(1 + e&lt;sup&gt;-eta&lt;/sup&gt;) - eta for the</td>
</tr>
<tr>
<td></td>
<td>non-reference class and square root of 2 times the log (1 + eta) for the</td>
</tr>
<tr>
<td></td>
<td>reference class, where eta is the linear prediction (the prediction</td>
</tr>
<tr>
<td></td>
<td>as if the model were a linear regression).</td>
</tr>
</tbody>
</table>
Table 35-31  (Cont.) Row Diagnostic View for Logistic Regression

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Measures the overall change in the fitted logits due to the deletion of the $i^{th}$ observation for all points including the one deleted (the $i^{th}$ point). It is computed as the square of the Pearson residual multiplied by the Hat value divided by the square of 1 minus the Hat value. Confidence interval displacement diagnostics that provides scalar measure of the influence of individual observations.</td>
</tr>
<tr>
<td>CBAR</td>
<td>$C$ and $CBAR$ are extensions of Cooks’ distance for logistic regression. $CBAR$ measures the overall change in the fitted logits due to the deletion of the $i^{th}$ observation for all points excluding the one deleted (the $i^{th}$ point). It is computed as the square of the Pearson residual multiplied by the Hat value divided by (1 minus the Hat value) Confidence interval displacement diagnostic which measures the influence of deleting an individual observation.</td>
</tr>
<tr>
<td>DIFDEV</td>
<td>A statistic that measures the change in deviance that occurs when an observation is deleted from the input. It is computed as the square of the deviance residual plus $CBAR$.</td>
</tr>
<tr>
<td>DIFCHISQ</td>
<td>A statistic that measures the change in the Pearson chi-square statistic that occurs when an observation is deleted from the input. It is computed as $CBAR$ divided by the Hat value.</td>
</tr>
</tbody>
</table>

Global Details for GLM: Linear Regression

The following table describes global details for a linear regression model.

Table 35-32  Global Details for Linear Regression

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADJUSTED_R_SQUARE</td>
<td>Adjusted R-Square</td>
</tr>
<tr>
<td>AIC</td>
<td>Akaike’s information criterion</td>
</tr>
<tr>
<td>COEFF_VAR</td>
<td>Coefficient of variation</td>
</tr>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The following are the possible values: • YES • NO</td>
</tr>
<tr>
<td>CORRECTED_TOTAL_DF</td>
<td>Corrected total degrees of freedom</td>
</tr>
<tr>
<td>CORRECTED_TOT_SS</td>
<td>Corrected total sum of squares</td>
</tr>
<tr>
<td>DEPENDENT_MEAN</td>
<td>Dependent mean</td>
</tr>
<tr>
<td>ERROR_DF</td>
<td>Error degrees of freedom</td>
</tr>
<tr>
<td>ERROR_MEAN_SQUARE</td>
<td>Error mean square</td>
</tr>
<tr>
<td>ERROR_SUM_SQUARES</td>
<td>Error sum of squares</td>
</tr>
<tr>
<td>F_VALUE</td>
<td>Model $F$ value statistic</td>
</tr>
<tr>
<td>GMSEP</td>
<td>Estimated mean square error of the prediction, assuming multivariate normality</td>
</tr>
<tr>
<td>HOCKING_SP</td>
<td>Hocking Sp statistic</td>
</tr>
</tbody>
</table>
### Table 35-32  (Cont.) Global Details for Linear Regression

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITERATIONS</td>
<td>Tracks the number of SGD iterations. Applicable only when the solver is SGD.</td>
</tr>
<tr>
<td>J_P</td>
<td>JP statistic (the final prediction error)</td>
</tr>
<tr>
<td>MODEL_DF</td>
<td>Model degrees of freedom</td>
</tr>
<tr>
<td>MODEL_F_P_VALUE</td>
<td>Model F value probability</td>
</tr>
<tr>
<td>MODEL_MEAN_SQUARE</td>
<td>Model mean square error</td>
</tr>
<tr>
<td>MODEL_SUM_SQUARES</td>
<td>Model sum of square errors</td>
</tr>
<tr>
<td>NUM_PARAMS</td>
<td>Number of parameters (the number of coefficients, including the intercept)</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows</td>
</tr>
<tr>
<td>R_SQ</td>
<td>R-Square</td>
</tr>
<tr>
<td>RANK_DEFICIENCY</td>
<td>The number of predictors excluded from the model due to multi-collinearity</td>
</tr>
<tr>
<td>ROOT_MEAN_SQ</td>
<td>Root mean square error</td>
</tr>
<tr>
<td>SBIC</td>
<td>Schwarz’s Bayesian information criterion</td>
</tr>
</tbody>
</table>

### Global Details for GLM: Logistic Regression

The following table returns global details for a logistic regression model.

### Table 35-33  Global Details for Logistic Regression

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC_INTERCEPT</td>
<td>Akaike’s criterion for the fit of the baseline, intercept-only, model</td>
</tr>
<tr>
<td>AIC_MODEL</td>
<td>Akaike’s criterion for the fit of the intercept and the covariates (predictors) mode</td>
</tr>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The following are the possible values:</td>
</tr>
<tr>
<td></td>
<td>• YES</td>
</tr>
<tr>
<td></td>
<td>• NO</td>
</tr>
<tr>
<td>DEPENDENT_MEAN</td>
<td>Dependent mean</td>
</tr>
<tr>
<td>ITERATIONS</td>
<td>Tracks the number of SGD iterations (number of IRLS iterations). Applicable only when the solver is SGD.</td>
</tr>
<tr>
<td>LR_DF</td>
<td>Likelihood ratio degrees of freedom</td>
</tr>
<tr>
<td>LR_CHI_SQ</td>
<td>Likelihood ratio chi-square value</td>
</tr>
<tr>
<td>LR_CHI_SQ_P_VALUE</td>
<td>Likelihood ratio chi-square probability value</td>
</tr>
<tr>
<td>NEG2_LL_INTERCEPT</td>
<td>-2 log likelihood of the baseline, intercept-only, model</td>
</tr>
<tr>
<td>NEG2_LL_MODEL</td>
<td>-2 log likelihood of the model</td>
</tr>
<tr>
<td>NUM_PARAMS</td>
<td>Number of parameters (the number of coefficients, including the intercept)</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows</td>
</tr>
</tbody>
</table>
Table 35-33   (Cont.) Global Details for Logistic Regression

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCT_CORRECT</td>
<td>Percent of correct predictions</td>
</tr>
<tr>
<td>PCT_INCORRECT</td>
<td>Percent of incorrectly predicted rows</td>
</tr>
<tr>
<td>PCT_TIED</td>
<td>Percent of cases where the estimated probabilities are equal for both target classes</td>
</tr>
<tr>
<td>PSEUDO_R_SQ_CS</td>
<td>Pseudo R-square Cox and Snell</td>
</tr>
<tr>
<td>PSEUDO_R_SQ_N</td>
<td>Pseudo R-square Nagelkerke</td>
</tr>
<tr>
<td>RANK_DEFICIENCY</td>
<td>The number of predictors excluded from the model due to multicollinearity</td>
</tr>
<tr>
<td>SC_INTERCEPT</td>
<td>Schwarz's Criterion for the fit of the baseline, intercept-only, model</td>
</tr>
<tr>
<td>SC_MODEL</td>
<td>Schwarz's Criterion for the fit of the intercept and the covariates (predictors) model</td>
</tr>
</tbody>
</table>

**Note:**
- When ridge regression is enabled, fewer global details are returned. For information about ridge, see *Oracle Machine Learning for SQL Concepts*.
- When the value is `NULL` for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

**Related Topics**
- *Oracle Database PL/SQL Packages and Types Reference*
- *Model Detail Views for Global Information*

Model detail views for global information contain information about global statistics, alerts, and computed settings.

35.8.8 Model Detail View for Multivariate State Estimation Technique - Sequential Probability Ratio Test

The model detail view for Multivariate State Estimation Technique - Sequential Probability Ratio Test contains information about an MSET-SPRT model.

The following table lists the name-value pair for an MSET-SPRT model that appears in the `DM$VGmodel_name` view of global statistics. This statistic is included when due to memory constraints MSET-SPRT cannot use the `MSET_MEMORY_VECTORS` value set by the user.
Table 35-34  MSET-SPRT Information in the Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_MVEC</td>
<td>The number of memory vectors used by the model.</td>
</tr>
</tbody>
</table>

35.8.9 Model Detail Views for Naive Bayes

The model detail views for Naive Bayes are the prior view and result view.

The prior view `DM$VP model_name` describes the priors of the targets for a Naive Bayes model. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TARGET_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>PRIOR_PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>COUNT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-35  Prior View for Naive Bayes

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>TARGET_NAME</td>
<td>Name of the target column</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Target value, numerical or categorical</td>
</tr>
<tr>
<td>PRIOR_PROBABILITY</td>
<td>Prior probability for a given TARGET_VALUE</td>
</tr>
<tr>
<td>COUNT</td>
<td>Number of rows for a given TARGET_VALUE</td>
</tr>
</tbody>
</table>

The Naive Bayes result view `DM$VV model_view` describes the conditional probabilities of the Naive Bayes model. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TARGET_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>CONDITIONAL_PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>COUNT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-36  Result View for Naive Bayes

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>The name of a feature in the model</td>
</tr>
</tbody>
</table>
Table 35-36  (Cont.) Result View for Naive Bayes

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARGET_NAME</td>
<td>Name of the target column</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Target value, numerical or categorical</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Machine learning attribute value for the column</td>
</tr>
<tr>
<td>CONDITIONAL_PROBABILITY</td>
<td>Conditional probability of a machine learning attribute for a</td>
</tr>
<tr>
<td>COUNT</td>
<td>Number of rows for a given machine learning attribute and a</td>
</tr>
</tbody>
</table>

The following table describes the global view for a Naive Bayes model.

Table 35-37  Naive Bayes Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>

35.8.10 Model Detail Views for Neural Network

Model detail views for Neural Network contain information about the weights of the neurons: input layer and hidden layers.

A Neural Network model has the following views:

Weights: DM$VAmodel_name

The view DM$VAmodel_name has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>LAYER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>IDX_FROM</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>IDX_TO</td>
<td>NUMBER</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
### Table 35-38  Weights View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>LAYER</td>
<td>Layer ID, 0 as an input layer</td>
</tr>
<tr>
<td>IDX_FROM</td>
<td>Node index that the weight connects from (attribute id for input layer)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Attribute name (only for the input layer)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Attribute subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>IDX_TO</td>
<td>Node index that the weights connects to</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Target value. The value is null for regression.</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>Value of the weight</td>
</tr>
</tbody>
</table>

The view `DM$VGmodel_name` is a pre-existing view. The following name-value pairs are added to the view.

### Table 35-39  Neural Networks Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The following are the possible values:</td>
</tr>
<tr>
<td></td>
<td>• YES</td>
</tr>
<tr>
<td></td>
<td>• NO</td>
</tr>
<tr>
<td>ITERATIONS</td>
<td>Number of iterations</td>
</tr>
<tr>
<td>LOSS_VALUE</td>
<td>Loss function value (if it is with NNET_REGULARIZER_HELDASIDE regularization, it is the loss function value on test data)</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows in the model (or partitioned model)</td>
</tr>
</tbody>
</table>

### 35.8.11 Model Detail Views for Random Forest

Model detail views for Random Forest contain variable importance measures and statistics.

A Random Forest model has the following statistics views:

- Variable importance statistics `DM$VAmodel_name`
- Random Forest statistics in the model global view `DM$VGmodel_name`

One of the important outputs from a Random Forest model build is a ranking of attributes based on their relative importance. This is measured using Mean Decrease Gini. The view `DM$VAmodel_name` has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
</tbody>
</table>
Table 35-40  Variable Importance Model View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name. The value is null for models which are not partitioned.</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>Measure of importance for an attribute in the forest (mean Decrease Gini value)</td>
</tr>
</tbody>
</table>

The view DM$VG$model_name is a pre-existing view. The following name-value pairs are added to the view.

Table 35-41  Random Forest Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVG_DEPTH</td>
<td>Average depth of the trees in the forest</td>
</tr>
<tr>
<td>AVG_NODECOUNT</td>
<td>Average number of nodes per tree</td>
</tr>
<tr>
<td>MAX_DEPTH</td>
<td>Maximum depth of the trees in the forest</td>
</tr>
<tr>
<td>MAX_NODECOUNT</td>
<td>Maximum number of nodes per tree</td>
</tr>
<tr>
<td>MIN_DEPTH</td>
<td>Minimum depth of the trees in the forest</td>
</tr>
<tr>
<td>MIN_NODECOUNT</td>
<td>Minimum number of nodes per tree</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>

35.8.12 Model Detail View for Support Vector Machine

Model detail views for Support Vector Machine (SVM) contain linear coefficients and support vector statistics.

The linear coefficient view DM$VL$model_name describes the coefficients of a linear SVM algorithm. The target_value field in the view is present only for classification and has the type of the target. Regression models do not have a target_value field.

The reversed_coefficient field shows the value of the coefficient after reversing the automatic data preparation transformations. If data preparation is disabled, then coefficient and reversed_coefficient have the same value. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
</tbody>
</table>
Table 35-42  Linear Coefficient View for Support Vector Machine

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>Target value, numerical or categorical</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Value of a categorical attribute</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>Projection coefficient value</td>
</tr>
<tr>
<td>REVERSED_COEFFICIENT</td>
<td>Coefficient transformed on the original scale</td>
</tr>
</tbody>
</table>

The following table describes the SVM statistics global view.

Table 35-43  Support Vector Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance:</td>
</tr>
<tr>
<td></td>
<td>• YES</td>
</tr>
<tr>
<td></td>
<td>• NO</td>
</tr>
<tr>
<td>ITERATIONS</td>
<td>Number of iterations performed during build</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows used for the build</td>
</tr>
<tr>
<td>REMOVED_ROWS_ZERO_NORM</td>
<td>Number of rows removed due to 0 norm. This applies to one-class linear models only.</td>
</tr>
</tbody>
</table>

35.8.13 Model Detail Views for XGBoost

The model detail views for XGBoost contain information about an XGBoost model.

The DM$VImodel_name view reports the feature importance values for each attribute of each partition of the model.

The view has the following columns for tree models (gbtree and dart boosters).

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>GAIN</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
Table 35-44  Feature Importance View for a Tree Model

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNAME</td>
<td>The name of a partition in a partitioned model.</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>The column name.</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>The nested column subname; the value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>The value of a categorical attribute.</td>
</tr>
<tr>
<td>GAIN</td>
<td>The fractional contribution of each feature to the model based on the total gain of a feature's splits; a higher percentage means a more important predictive feature.</td>
</tr>
<tr>
<td>COVER</td>
<td>The number of observations related to the feature.</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>A percentage representing the relative number of times a feature has been used in trees.</td>
</tr>
</tbody>
</table>

For a linear model (gblinear) booster, the feature importance is the absolute magnitude of linear coefficients.

The view has the following columns for linear models.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CLASS</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-45  Feature Importance View for a Linear Model

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNAME</td>
<td>The name of a partition in a partitioned model.</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>The column name.</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>The nested column subname; the value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>The value of a categorical attribute.</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>The linear coefficient of the feature.</td>
</tr>
<tr>
<td>CLASS</td>
<td>The class label for a multiclass model.</td>
</tr>
</tbody>
</table>

The DM$VGmodel_name view reports global statistics for an XGBoost model. The statistics include an evaluation of the training data set done by the evaluation metric you specified with the learning task eval_metric setting, or by the default eval_metric if you didn't specify one. The view contains only the result of the last training iteration. When you specify more than one eval_metric, the view contains multiple rows, one for each eval_metric.
35.8.14 Model Detail Views for Clustering Algorithms

Oracle Machine Learning for SQL supports these clustering algorithms: Expectation Maximization (EM), k-Means (KM), and orthogonal partitioning clustering (O-Cluster, OC).

All clustering algorithms share the following views:

- **Cluster description** $\text{DM}\$VD$model_name$
- **Attribute statistics** $\text{DM}\$VA$model_name$
- **Histogram statistics** $\text{DM}\$VH$model_name$
- **Rule statistics** $\text{DM}\$VR$model_name$

The cluster description view $\text{DM}\$VD$model_name$ describes cluster level information about a clustering model. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>RECORD_COUNT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PARENT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>TREE_LEVEL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>LEFT_CHILD_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RIGHT_CHILD_ID</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

**Table 35-46  Cluster Description View for Clustering Algorithm**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>Specifies the label of the cluster</td>
</tr>
<tr>
<td>RECORD_COUNT</td>
<td>Specifies the number of records</td>
</tr>
<tr>
<td>PARENT</td>
<td>The ID of the parent</td>
</tr>
<tr>
<td>TREE_LEVEL</td>
<td>Specifies the number of splits from the root</td>
</tr>
<tr>
<td>LEFT_CHILD_ID</td>
<td>The ID of the child cluster on the left side of the split</td>
</tr>
<tr>
<td>RIGHT_CHILD_ID</td>
<td>The ID of the child cluster on the right side of the split</td>
</tr>
</tbody>
</table>

The attribute view $\text{DM}\$VA$model_name$ describes attribute level information about a clustering model. The values of the mean, variance, and mode for a particular cluster can be obtained from this view. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
</tbody>
</table>
ATTRIBUTE_SUBNAME                      VARCHAR2(4000)
MEAN                                      BINARY_DOUBLE
VARIANCE                                   BINARY_DOUBLE
MODE_VALUE                                  VARCHAR2(4000)

Table 35-47  Attribute View for Clustering Algorithms

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>Specifies the label of the cluster</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Specifies the attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Specifies the attribute subname</td>
</tr>
<tr>
<td>MEAN</td>
<td>The field returns the average value of a numeric attribute</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>The variance of a numeric attribute</td>
</tr>
<tr>
<td>MODE_VALUE</td>
<td>The mode is the most frequent value of a categorical attribute</td>
</tr>
</tbody>
</table>

The histogram view DMS$VH$model_name describes histogram level information about a clustering model. The bin information as well as bin counts can be obtained from this view. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>LOWER_BIN_BOUNDARY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>UPPER_BIN_BOUNDARY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>COUNT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-48  Histogram View for Clustering Algorithms

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>Specifies the label of the cluster</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Specifies the attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Specifies the attribute subname</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>Bin ID</td>
</tr>
<tr>
<td>LOWER_BIN_BOUNDARY</td>
<td>Numeric lower bin boundary</td>
</tr>
<tr>
<td>UPPER_BIN_BOUNDARY</td>
<td>Numeric upper bin boundary</td>
</tr>
</tbody>
</table>
Table 35-48  (Cont.) Histogram View for Clustering Algorithms

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>COUNT</td>
<td>Histogram count</td>
</tr>
</tbody>
</table>

The rule view DMSVR\texttt{model_name} describes the rule level information about a clustering model. The information is provided at attribute predicate level. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>VARCHAR2 (2)</td>
</tr>
<tr>
<td>NUMERIC_VALUE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CONFIDENCE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-49  Rule View for Clustering Algorithms

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>Specifies the label of the cluster</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Specifies the attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Specifies the attribute subname</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>Attribute predicate operator - a conditional operator taking the following values: \texttt{IN}, =, &lt;&gt;, &lt;, &gt;, &lt;=, and &gt;=</td>
</tr>
<tr>
<td>NUMERIC_VALUE</td>
<td>Numeric lower bin boundary</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>SUPPORT</td>
<td>Attribute predicate support</td>
</tr>
<tr>
<td>CONFIDENCE</td>
<td>Attribute predicate confidence</td>
</tr>
<tr>
<td>RULE_SUPPORT</td>
<td>Rule level support</td>
</tr>
<tr>
<td>RULE_CONFIDENCE</td>
<td>Rule level confidence</td>
</tr>
</tbody>
</table>
35.8.15 Model Detail Views for Expectation Maximization

Model detail views for Expectation Maximization (EM) contain additional information about an EM model.

The following views contain information that is not in the clustering views for an EM model. For the clustering views, refer to "Model Detail Views for Clustering Algorithms".

The component view $DM.VO$model_name describes the EM components. The component view contains information about their prior probabilities and what cluster they map to. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>COMPONENT_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PRIOR_PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-50  Component View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>COMPONENT_ID</td>
<td>Unique identifier of a component</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>PRIOR_PROBABILITY</td>
<td>Component prior probability</td>
</tr>
</tbody>
</table>

The mean and variance component view $DM.VM$model_name provides information about the mean and variance parameters for the attributes by Gaussian distribution models. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>COMPONENT_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>MEAN</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

The frequency component view $DM.VF$model_name provides information about the parameters of the multi-valued Bernoulli distributions used by the EM model. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>COMPONENT_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
</tbody>
</table>
Table 35-51  Frequency Component View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>COMPONENT_ID</td>
<td>Unique identifier of a component</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>The frequency of the multivalued Bernoulli distribution for the attribute/value combination specified by ATTRIBUTE_NAME and ATTRIBUTE_VALUE.</td>
</tr>
</tbody>
</table>

For 2-Dimensional columns, EM provides an attribute ranking similar to that of attribute importance. This ranking is based on a rank-weighted average over Kullback–Leibler divergence computed for pairs of columns. This unsupervised attribute importance is shown in the DM$VI_model_name view and has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_1</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_2</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>DEPENDENCY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-52  2-Dimensional Attribute Ranking for Expectation Maximization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE_VALUE</td>
<td>Importance value</td>
</tr>
<tr>
<td>ATTRIBUTE_RANK</td>
<td>An attribute rank based on the importance value</td>
</tr>
</tbody>
</table>

The pairwise Kullback–Leibler divergence is reported in the DM$VE_model_name view. This metric evaluates how much the observed joint distribution of two attributes diverges from the expected distribution under the assumption of independence. That is, the higher the value, the more dependent the two attributes are. The dependency value is scaled based on the size of the grid used for each pairwise computation. That ensures that all values fall within the [0; 1] range and are comparable. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_1</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_2</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>DEPENDENCY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
Table 35-53  Kullback-Leibler Divergence for Expectation Maximization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_1</td>
<td>Name of an attribute 1</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME_2</td>
<td>Name of an attribute 2</td>
</tr>
<tr>
<td>DEPENDENCY</td>
<td>Scaled pairwise Kullback-Leibler divergence</td>
</tr>
</tbody>
</table>

The projection table DMSVP$E_{model_name}$ shows the coefficients used by random projections to map nested columns to a lower dimensional space. The view has rows only when nested or text data is present in the build data. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-54  Projection table for Expectation Maximization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>Name of feature</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>Projection coefficient. The representation is sparse; only the non-zero coefficients are returned.</td>
</tr>
</tbody>
</table>

Global Details for Expectation Maximization

The following table describes global details for EM.

Table 35-55  Global Details for Expectation Maximization

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The possible values are:</td>
</tr>
<tr>
<td></td>
<td>• YES</td>
</tr>
<tr>
<td></td>
<td>• NO</td>
</tr>
<tr>
<td>LOGLIKELIHOOD</td>
<td>Loglikelihood on the build data</td>
</tr>
</tbody>
</table>
Table 35-55  (Cont.) Global Details for Expectation Maximization

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_COMPONENTS</td>
<td>Number of components produced by the model</td>
</tr>
<tr>
<td>NUM_CLUSTERS</td>
<td>Number of clusters produced by the model</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows used in the build</td>
</tr>
<tr>
<td>RANDOM_SEED</td>
<td>The random seed value used for the model build</td>
</tr>
<tr>
<td>REMOVED_COMPONENTS</td>
<td>The number of empty components excluded from the model</td>
</tr>
</tbody>
</table>

Related Topics

- Model Detail Views for Clustering Algorithms
  Oracle Machine Learning for SQL supports these clustering algorithms: Expectation Maximization (EM), \( k \)-Means (KM), and orthogonal partitioning clustering (O-Cluster, OC).

35.8.16 Model Detail Views for \( k \)-Means

Model detail views for \( k \)-Means (KM) contain clustering and scoring information.

The following views contain information that is not in the clustering views for a \( k \)-Means model. For the clustering views, refer to "Model Detail Views for Clustering Algorithms". For \( k \)-Means, the cluster description view `DM$VD$model_name` has an additional column:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPERSION</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-56  Cluster Description for \( k \)-Means

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPERSION</td>
<td>A measure used to quantify whether a set of observed occurrences are dispersed compared to a standard statistical model.</td>
</tr>
</tbody>
</table>

The scoring view `DM$VC$model_name` describes the centroid of each leaf clusters:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
Table 35-57  Scoring View for k-Means

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>CLUSTER_NAME</td>
<td>Specifies the label of the cluster</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>VALUE</td>
<td>Specifies the centroid value</td>
</tr>
</tbody>
</table>

The following table describes global view for k-Means.

Table 35-58  k-Means Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The following are the possible values:</td>
</tr>
<tr>
<td></td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows used in the build</td>
</tr>
<tr>
<td>REMOVED_ROWS_ZERO_NORM</td>
<td>Number of rows removed due to 0 norm. This applies only to models using cosine distance.</td>
</tr>
</tbody>
</table>

Related Topics

- Model Detail Views for Clustering Algorithms
  Oracle Machine Learning for SQL supports these clustering algorithms: Expectation Maximization (EM), k-Means (KM), and orthogonal partitioning clustering (O-Cluster, OC).

35.8.17 Model Detail Views for O-Cluster

Model detail views for O-Cluster (OC) contain information about OC models.

The following views contain information that is not in the clustering views for an O-Cluster model. For the clustering views, refer to “Model Detail Views for Clustering Algorithms”. The OC algorithm uses the same descriptive statistics views as Expectation Maximization (EM) and k-Means (KM). The following are the statistics views:

- Cluster description DM$VD$model_name
- Attribute statistics DM$VA$model_name
- Rule statistics DM$VR$model_name
- Histogram statistics DM$VH$model_name
The cluster description view $\text{DMVD}model\_name$ describes the O-Cluster components. The cluster description view has additional fields that specify the split predicate. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>VARCHAR2(2)</td>
</tr>
<tr>
<td>VALUE</td>
<td>SYS.XMLTYPE</td>
</tr>
</tbody>
</table>

Table 35-59  Description View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>OPERATOR</td>
<td>Split operator</td>
</tr>
<tr>
<td>VALUE</td>
<td>List of split values</td>
</tr>
</tbody>
</table>

The structure of the SYS.XMLTYPE is as follows:

<Element>splitval1</Element>

The OC algorithm uses a histogram view $\text{DMVH}model\_name$ with different columns than EM and KM. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>LABEL</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>COUNT</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-60  Histogram Component View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>Unique identifier of a component</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>Unique identifier</td>
</tr>
<tr>
<td>LABEL</td>
<td>Bin label</td>
</tr>
</tbody>
</table>
### Table 35-60  (Cont.) Histogram Component View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>Bin histogram count</td>
</tr>
</tbody>
</table>

The following table describes the global view for O-Cluster.

### Table 35-61  O-Cluster Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>

**Related Topics**

- [Model Detail Views for Clustering Algorithms](#)
  Oracle Machine Learning for SQL supports these clustering algorithms: Expectation Maximization (EM), \(k\)-Means (KM), and orthogonal partitioning clustering (O-Cluster, OC).

### 35.8.18 Model Detail Views for CUR Matrix Decomposition

Model detail views for CUR Matrix Decomposition contain information about the scores and ranks of attributes and rows.

CUR Matrix Decomposition models have the following views:

- Attribute importance and rank: \(\text{DM\$VC} model\_name\)
- Row importance and rank: \(\text{DM\$VR} model\_name\)
- Global statistics: \(\text{DM\$VG}\)

The attribute importance and rank view \(\text{DM\$VC} model\_name\) has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ATTRIBUTE_RANK</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

### Table 35-62  Attribute Importance and Rank View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Attribute subname. The value is null for non-nested columns.</td>
</tr>
</tbody>
</table>
Table 35-62  (Cont.) Attribute Importance and Rank View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Value of the attribute</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>Attribute leverage score</td>
</tr>
<tr>
<td>ATTRIBUTE_RANK</td>
<td>Attribute rank based on leverage score</td>
</tr>
</tbody>
</table>

The view DM$VR$model$\_name exposes the leverage scores and ranks of all selected rows through a view. This view is created when users decide to perform row importance and the CASE_ID column is present. The view has the following columns:

| Name                      | Type                                              |
|---------------------------|                                                  |
| PARTITION_NAME            | VARCHAR2(128)                                    |
| CASE_ID                   | Original cid data types, including NUMBER, VARCHAR2, DATE, TIMESTAMP, TIMESTAMP WITH TIME ZONE, TIMESTAMP WITH LOCAL TIME ZONE |
| ROW_IMPORTANCE            | NUMBER                                            |
| ROW_RANK                  | NUMBER                                            |

Table 35-63  Row Importance and Rank View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>Case ID. The supported case ID types are the same as that supported for GLM, SVD, and ESA algorithms.</td>
</tr>
<tr>
<td>ROW_IMPORTANCE</td>
<td>Row leverage score</td>
</tr>
<tr>
<td>ROW_RANK</td>
<td>Row rank based on leverage score</td>
</tr>
</tbody>
</table>

The following table describes global statistics for CUR Matrix Decomposition.

Table 35-64  CUR Matrix Decomposition Statistics Information In Model Global View.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_COMPONENTS</td>
<td>Number of SVD components (SVD rank)</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows used in the model build</td>
</tr>
</tbody>
</table>

35.8.19 Model Detail Views for Explicit Semantic Analysis

Model detail views for Explicit Semantic Analysis (ESA) contain information about attribute statistics and features.

ESA algorithm has the following views:
Explicit Semantic Analysis Matrix $\text{DM$VA_{model\_name}$}: This view has different columns for feature extraction and classification. For feature extraction, this view contains model attribute coefficients per feature. For classification, this view contains model attribute coefficients per target class.

Explicit Semantic Analysis Features $\text{DM$VF_{model\_name}$}: This view is applicable only for feature extraction.

The view $\text{DM$VA_{model\_name}$} has the following columns for feature extraction:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER/VARCHAR2, DATE, TIMESTAMP, TIMESTAMP WITH TIME ZONE, TIMESTAMP WITH LOCAL TIME ZONE</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-65  Explicit Semantic Analysis Matrix for Feature Extraction

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>Unique identifier of a feature as it appears in the training data</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>A measure of the weight of the attribute with respect to the feature</td>
</tr>
</tbody>
</table>

The $\text{DM$VA_{model\_name}$} view comprises attribute coefficients for all target classes.

The view $\text{DM$VA_{model\_name}$} has the following columns for classification:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TARGET_VALUE</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-66  Explicit Semantic Analysis Matrix for Classification

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
</tbody>
</table>
Table 35-66  (Cont.) Explicit Semantic Analysis Matrix for Classification

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARGET_VALUE</td>
<td>Value of the target</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>A measure of the weight of the attribute with respect to the feature</td>
</tr>
</tbody>
</table>

The view $DM\$VPmodel_name$ has a unique row for every feature in one view. This feature is helpful if the model was pre-built and the source training data are not available. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER/VARCHAR2, DATE, TIMESTAMP, TIMESTAMP WITH TIME ZONE, TIMESTAMP WITH LOCAL TIME ZONE</td>
</tr>
</tbody>
</table>

Table 35-67  Explicit Semantic Analysis Features for Explicit Semantic Analysis

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>Unique identifier of a feature as it appears in the training data</td>
</tr>
</tbody>
</table>

The following table describes the global view for ESA.

Table 35-68  Explicit Semantic Analysis Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_ROWS</td>
<td>The total number of input rows</td>
</tr>
<tr>
<td>REMOVED_ROWS_BY_FILTERS</td>
<td>Number of rows removed by filters</td>
</tr>
</tbody>
</table>

35.8.20 Model Detail Views for Exponential Smoothing

Model detail views for Exponential Smoothing (ESM) contain information about the model output and global information.

An ESM model has the following views:

- Model output: $DM\$VPmodel_name$
- Model global information: $DM\$VGmodel_name$
Model output: This view contains the result of an ESM model. The output has a set of records such as partition, \textit{CASE\_ID}, value, prediction, lower, upper, and so on and ordered by partition and \textit{CASE\_ID} (time). Each partition has a separate smoothing model. For a given partition, for each time (\textit{CASE\_ID}) point that the input time series covers, the value is the observed or accumulated value at the time point, and the prediction is the one-step-ahead forecast at that time point. For each time point (future prediction) beyond the range of input time series, the value is \texttt{NULL}, and the prediction is the model forecast for that time point. Lower and upper are the lower bound and upper bound of the user specified confidence interval for the prediction.

Model global Information: This view contains the global information of the model along with the estimated smoothing constants, the estimated initial state, and global diagnostic measures.

Depending on the type of model, the global diagnostics include some or all of the following for Exponential Smoothing.

\begin{table}[h]
\centering
\begin{tabular}{ll}
\hline
Name & Description \\
\hline
$-2$ LOG-LIKELIHOOD & Negative log-likelihood of model \\
ALPHA & Smoothing constant \\
AIC & Akaike information criterion \\
AICC & Corrected Akaike information criterion \\
AMSE & Average mean square error over user-specified time window \\
BETA & Trend smoothing constant \\
BIC & Bayesian information criterion \\
GAMMA & Seasonal smoothing constant \\
INITIAL LEVEL & Model estimate of value one time interval prior to start of observed series \\
INITIAL SEASON i & Model estimate of seasonal effect for season \textit{i} one time interval prior to start of observed series \\
INITIAL TREND & Model estimate of trend one time interval prior to start of observed series \\
MAE & Model mean absolute error \\
MSE & Model mean square error \\
PHI & Damping parameter \\
STD & Model standard error \\
SIGMA & Model standard deviation of residuals \\
\hline
\end{tabular}
\caption{Exponential Smoothing Model Statistics Information In Model Global View}
\end{table}

35.8.21 Model Detail Views for Non-Negative Matrix Factorization

Model detail views for Non-Negative Matrix Factorization (NMF) contain information about the encoding H matrix and H inverse matrix.

The NMF algorithm has two matrix content views:
• Encoding (H) matrix $\text{DM}_\text{VE} model_name$

• $H$ inverse matrix $\text{DM}_\text{VI} model_name$

The view $\text{DM}_\text{VE} model_name$ describes the encoding (H) matrix of an NMF model. The
$\text{FEATURE_NAME}$ column type may be either NUMBER or VARCHAR2. The view has the following
columns.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-70  Encoding H Matrix View for Non-Negative Matrix Factorization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>The ID of a feature in the model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Specifies the value of attribute</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>The attribute encoding that represents its contribution to the feature</td>
</tr>
</tbody>
</table>

The view $\text{DM}_\text{VI} model_view$ describes the inverse H matrix of an NMF model. The
$\text{FEATURE_NAME}$ column type may be either NUMBER or VARCHAR2. The view has the following
schema:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-71  Inverse H Matrix View for Non-Negative Matrix Factorization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
</tbody>
</table>
Table 35-71  (Cont.) Inverse H Matrix View for Non-Negative Matrix Factorization

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEATURE_ID</td>
<td>The ID of a feature in the model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Specifies the value of attribute</td>
</tr>
<tr>
<td>COEFFICIENT</td>
<td>The attribute encoding that represents its contribution to the feature</td>
</tr>
</tbody>
</table>

The following table describes the global statistics for NMF.

Table 35-72  Non-Negative Matrix Factorization Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONV_ERROR</td>
<td>Convergence error</td>
</tr>
<tr>
<td>CONVERGED</td>
<td>Indicates whether the model build process has converged to specified tolerance. The following are the possible values:</td>
</tr>
<tr>
<td></td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>ITERATIONS</td>
<td>Number of iterations performed during build</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>Number of rows used in the build input data set</td>
</tr>
<tr>
<td>SAMPLE_SIZE</td>
<td>Number of rows used by the build</td>
</tr>
</tbody>
</table>

35.8.22 Model Detail Views for Singular Value Decomposition

Model detail views for Singular Value Decomposition (SVD) contain information about the S matrix, right-singular vectors, and left-singular vectors.

The `DMsVEmodel_name` view leverages the fact that each singular value in the SVD model has a corresponding principal component in the associated Principal Components Analysis (PCA) model to relate a common set of information for both classes of models. For an SVD model, it describes the content of the S matrix. When PCA scoring is selected as a build setting, the variance and percentage cumulative variance for the corresponding principal components are shown as well. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2 (128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
VARIANCE: BINARY_DOUBLE
PCT_CUM_VARIANCE: BINARY_DOUBLE

### Table 35-73  S Matrix View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>The ID of a feature in the model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>VALUE</td>
<td>The matrix entry value</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>The variance explained by a component. This column is only present for SVD models with setting dbms_data_mining.svds_scoring_mode set to dbms_data_mining.svds_scoring_pca. This column is non-null only if the build data is centered, either manually or because of the following setting:dbms_data_mining.prep_auto is set to dbms_data_mining.prep_auto_on.</td>
</tr>
<tr>
<td>PCT_CUM_VARIANCE</td>
<td>The percent cumulative variance explained by the components thus far. The components are ranked by the explained variance in descending order. This column is only present for SVD models with setting dbms_data_mining.svds_scoring_mode set to dbms_data_mining.svds_scoring_pca. This column is non-null only if the build data is centered, either manually or because of the following setting:dbms_data_mining.prep_auto is set to dbms_data_mining.prep_auto_on.</td>
</tr>
</tbody>
</table>

The SVD DM$VVmodel_view describes the right-singular vectors of an SVD model. For a PCA model it describes the principal components (eigenvectors). The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

### Table 35-74  Right-singular Vectors of Singular Value Decomposition

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>The ID of a feature in the model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>The name of a feature in the model</td>
</tr>
</tbody>
</table>
Table 35-74  (Cont.) Right-singular Vectors of Singular Value Decomposition

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical attribute value. For numerical attributes, ATTRIBUTE_VALUE is null.</td>
</tr>
<tr>
<td>VALUE</td>
<td>The matrix entry value</td>
</tr>
</tbody>
</table>

The view `DM$VUmodel_name` describes the left-singular vectors of an SVD model. For a PCA model, it describes the projection of the data in the principal components. This view does not exist unless the settings `dbms_data_mining.svds_u_matrix_output` is set to `dbms_data_mining.svds_u_matrix_enable`. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>NUMBER/VARCHAR2, DATE, TIMESTAMP, TIMESTAMP WITH TIME ZONE, TIMESTAMP WITH LOCAL TIME ZONE</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>NUMBER/VARCHAR2</td>
</tr>
<tr>
<td>VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-75  Left-singular Vectors of Singular Value Decomposition or Projection Data in Principal Components

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>CASE_ID</td>
<td>Unique identifier of the row in the build data described by the U matrix projection.</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>The ID of a feature in the model</td>
</tr>
<tr>
<td>FEATURE_NAME</td>
<td>The name of a feature in the model</td>
</tr>
<tr>
<td>VALUE</td>
<td>The matrix entry value</td>
</tr>
</tbody>
</table>

Global Details for Singular Value Decomposition

The following table describes the global details for an SVD model.

Table 35-76  Global Details for Singular Value Decomposition

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_COMPONENTS</td>
<td>Number of features (components) produced by the model</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>
Table 35-76  (Cont.) Global Details for Singular Value Decomposition

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUGGESTED_CUTOFF</td>
<td>Suggested cutoff that indicates how many of the top computed features capture most of the variance in the model. Using only the features below this cutoff would be a reasonable strategy for dimensionality reduction.</td>
</tr>
</tbody>
</table>

Related Topics

- Oracle Database PL/SQL Packages and Types Reference

35.8.23 Model Detail Views for Minimum Description Length

Model detail views for Minimum Description :Length (MDL) (for calculating attribute importance) contain information about attribute importance models.

The attribute importance view $\text{DM}^2\text{V} \_\text{model_name}$ describes the attribute importance as well as the attribute importance rank. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE_VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ATTRIBUTE_RANK</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 35-77  Attribute Importance View for Minimum Description Length

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-nested columns.</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE_VALUE</td>
<td>Importance value</td>
</tr>
<tr>
<td>ATTRIBUTE_RANK</td>
<td>Rank based on importance</td>
</tr>
</tbody>
</table>

The following table describes the global view for MDL.

Table 35-78  Minimum Description Length Statistics Information In Model Global View

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_ROWS</td>
<td>The total number of rows used in the build</td>
</tr>
</tbody>
</table>
35.8.24 Model Detail Views for Binning

The binning view \texttt{DM$VB} describes the bin boundaries used in automatic data preparation.

The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>LOWER_BIN_BOUNDARY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>UPPER_BIN_BOUNDARY</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

**Table 35-79  Model Details View for Binning**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Specifies the attribute name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Specifies the attribute subname</td>
</tr>
<tr>
<td>BIN_ID</td>
<td>Bin ID (or bin identifier)</td>
</tr>
<tr>
<td>LOWER_BIN_BOUNDARY</td>
<td>Numeric lower bin boundary</td>
</tr>
<tr>
<td>UPPER_BIN_BOUNDARY</td>
<td>Numeric upper bin boundary</td>
</tr>
<tr>
<td>ATTRIBUTE_VALUE</td>
<td>Categorical value</td>
</tr>
</tbody>
</table>

35.8.25 Model Detail Views for Global Information

Model detail views for global information contain information about global statistics, alerts, and computed settings.

The global statistics view \texttt{DM$VG} \texttt{model_name} describes global statistics related to the model build. Examples include the number of rows used in the build, the convergence status, and the model quality metrics. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>NAME</td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>NUMERIC_VALUE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>STRING_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>
Table 35-80  Global Statistics View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>NAME</td>
<td>Name of the statistic</td>
</tr>
<tr>
<td>NUMERIC_VALUE</td>
<td>Numeric value of the statistic</td>
</tr>
<tr>
<td>STRING_VALUE</td>
<td>Categorical value of the statistic</td>
</tr>
</tbody>
</table>

The alert view $\text{DM}$\$V$\$\text{model_name}$ lists alerts issued during the model build. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ERROR_NUMBER</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>ERROR_TEXT</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

Table 35-81  Alert View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>ERROR_NUMBER</td>
<td>Error number (valid when event is Error)</td>
</tr>
<tr>
<td>ERROR_TEXT</td>
<td>Error message</td>
</tr>
</tbody>
</table>

The computed settings view $\text{DM}$\$VS$\$\text{model_name}$ lists the algorithm computed settings. The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>SETTING_NAME</td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>SETTING_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

Table 35-82  Computed Settings View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>Partition name in a partitioned model</td>
</tr>
<tr>
<td>SETTING_NAME</td>
<td>Name of the setting</td>
</tr>
<tr>
<td>SETTING_VALUE</td>
<td>Value of the setting</td>
</tr>
</tbody>
</table>

35.8.26 Model Detail Views for Normalization and Missing Value Handling

The Normalization and Missing Value Handling view $\text{DM}$\$VN$ describes the normalization parameters used in Automatic Data Preparation (ADP) and the missing value replacement
when a NULL value is encountered. Missing value replacement applies only to the two-dimensional columns and does not apply to the nested columns.

The view has the following columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>NUMERIC_MISSING_VALUE</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>CATEGORICAL_MISSING_VALUE</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>NORMALIZATION_SHIFT</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>NORMALIZATION_SCALE</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Table 35-83  Normalization and Missing Value Handling View

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>Column name</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>Nested column subname. The value is null for non-</td>
</tr>
<tr>
<td></td>
<td>nested columns.</td>
</tr>
<tr>
<td>NUMERIC_MISSING_VALUE</td>
<td>Numeric missing value replacement</td>
</tr>
<tr>
<td>CATEGORICAL_MISSING_VALUE</td>
<td>Categorical missing value replacement</td>
</tr>
<tr>
<td>NORMALIZATION_SHIFT</td>
<td>Normalization shift value</td>
</tr>
<tr>
<td>NORMALIZATION_SCALE</td>
<td>Normalization scale value</td>
</tr>
</tbody>
</table>
Scoring and Deployment

Explains the scoring and deployment features of Oracle Machine Learning for SQL.

- About Scoring and Deployment
- Use the Oracle Machine Learning for SQL Functions
- Prediction Details
- Real-Time Scoring
- Dynamic Scoring
- Cost-Sensitive Decision Making
- DBMS_DATA_MINING.Apply

36.1 About Scoring and Deployment

**Scoring** is the application of models to new data. In Oracle Machine Learning for SQL, scoring is performed by SQL language functions.

Predictive functions perform classification, regression, or anomaly detection. Clustering functions assign rows to clusters. Feature extraction functions transform the input data to a set of higher order predictors. A scoring procedure is also available in the DBMS_DATA_MINING PL/SQL package.

**Deployment** refers to the use of models in a target environment. Once the models have been built, the challenges come in deploying them to obtain the best results, and in maintaining them within a production environment. Deployment can be any of the following:

- Scoring data either for batch or real-time results. Scores can include predictions, probabilities, rules, and other statistics.
- Extracting model details to produce reports. For example: clustering rules, decision tree rules, or attribute rankings from an Attribute Importance model.
- Extending the business intelligence infrastructure of a data warehouse by incorporating machine learning results in applications or operational systems.
- Moving a model from the database where it was built to the database where it used for scoring (export/import)

OML4SQL supports all of these deployment scenarios.
Note:

OML4SQL scoring operations support parallel execution. When parallel execution is enabled, multiple CPU and I/O resources are applied to the execution of a single database operation.

Parallel execution offers significant performance improvements, especially for operations that involve complex queries and large databases typically associated with decision support systems (DSS) and data warehouses.

Related Topics

- Oracle Database VLDB and Partitioning Guide
- Oracle Machine Learning for SQL Concepts
- Export and Import Oracle Machine Learning for SQL Models

You can export machine learning models to flat files to back up work in progress or to move models to a different instance of Oracle Database Enterprise Edition (such as from a development database to a test database).

36.2 Use the Oracle Machine Learning for SQL Functions

Some of the benefits of using SQL functions for Oracle Machine Learning for SQL are listed.

The OML4SQL functions provide the following benefits:

- Models can be easily deployed within the context of existing SQL applications.
- Scoring operations take advantage of existing query execution functionality. This provides performance benefits.
- Scoring results are pipelined, enabling the rows to be processed without requiring materialization.

The machine learning functions produce a score for each row in the selection. The functions can apply a machine learning model schema object to compute the score, or they can score dynamically without a pre-defined model, as described in "Dynamic Scoring".

Related Topics

- Dynamic Scoring
  You can perform dynamic scoring if, for some reason, you do not want to apply a predefined model.
- Scoring Requirements
  Learn how scoring is done in Oracle Machine Learning for SQL.
- Oracle Machine Learning for SQL Scoring Functions
  Understand the different OML4SQL scoring functions.
- Oracle Database SQL Language Reference
36.2.1 Choose the Predictors

You can select different attributes as predictors in a `PREDICTION` function through a `USING` clause.

The OML4SQL functions support a `USING` clause that specifies which attributes to use for scoring. You can specify some or all of the attributes in the selection and you can specify expressions. The following examples all use the `PREDICTION` function to find the customers who are likely to use an affinity card, but each example uses a different set of predictors.

The query in Example 36-1 uses all the predictors.

The query in Example 36-2 uses only gender, marital status, occupation, and income as predictors.

The query in Example 36-3 uses three attributes and an expression as predictors. The prediction is based on gender, marital status, occupation, and the assumption that all customers are in the highest income bracket.

**Example 36-1 Using All Predictors**

The `dt_sh_clas_sample` model is created by the `oml4sql-classification-decision-tree.sql` example.

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION(dt_sh_clas_sample USING *) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th>C</th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>25</td>
<td>38</td>
</tr>
<tr>
<td>M</td>
<td>213</td>
<td>43</td>
</tr>
</tbody>
</table>

**Example 36-2 Using Some Predictors**

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION(dt_sh_clas_sample USING cust_gender, cust_marital_status, occupation, cust_income_level) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th>C</th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>30</td>
<td>38</td>
</tr>
<tr>
<td>M</td>
<td>186</td>
<td>43</td>
</tr>
</tbody>
</table>

**Example 36-3 Using Some Predictors and an Expression**

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION(dt_sh_clas_sample USING cust_gender, cust_marital_status, occupation, 'L: 300,000 and above' AS cust_income_level) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```
C        CNT    AVG_AGE
- ---------- ----------
F         30         38
M        186         43

36.2.2 Single-Record Scoring

Learn how a score of 0 and 1 is used in predicting customers who are likely to use affinity card.

The Oracle Machine Learning for SQL functions can produce a score for a single record, as shown in Example 36-4 and Example 36-5.

Example 36-4 returns a prediction for customer 102001 by applying the classification model NB_SH_Clas_sample. The resulting score is 0, meaning that this customer is unlikely to use an affinity card. The NB_SH_Clas_Sample model is created by the oml4sql-classification-naive-bayes.sql example.

Example 36-5 returns a prediction for 'Affinity card is great' as the comments attribute by applying the text machine learning model T_SVM_Clas_sample. The resulting score is 1, meaning that this customer is likely to use an affinity card. The T_SVM_Clas_sample model is created by the oml4sql-classification-text-analysis-svm.sql example.

Example 36-4 Scoring a Single Customer or a Single Text Expression

```
SELECT PREDICTION (NB_SH_Clas_Sample USING *)
FROM sh.customers where cust_id = 102001;
```

```
PREDICTION(NB_SH_CLAS_SAMPLEUSING*)
-----------------------------------
0
```

Example 36-5 Scoring a Single Text Expression

```
SELECT
  PREDICTION(T_SVM_Clas_sample USING 'Affinity card is great' AS comments)
FROM DUAL;
```

```
PREDICTION(T_SVM_CLAS_SAMPLEUSING'AFFINITYCARDISGREAT'ASCOMMENTS)
-----------------------------------------------------------------
1
```

36.3 Prediction Details

Prediction details are XML strings that provide information about the score.

Details are available for all types of scoring: clustering, feature extraction, classification, regression, and anomaly detection. Details are available whether scoring is dynamic or the result of model apply.

The details functions, CLUSTER_DETAILS, FEATURE_DETAILS, and PREDICTION_DETAILS return the actual value of attributes used for scoring and the relative importance of the attributes in determining the score. By default, the functions return the five most important attributes in descending order of importance.
36.3.1 Cluster Details

Shows an example of the CLUSTER_DETAILS function.

For the most likely cluster assignments of customer 100955 (probability of assignment > 20%), the query in the following example produces the five attributes that have the most impact for each of the likely clusters. The clustering functions apply an Expectation Maximization model named em_sh_clus_sample to the data selected from mining_data_apply_v. The “5” specified in CLUSTER_DETAILS is not required, because five attributes are returned by default. The em_sh_clus_sample model is created by the oml4sql-singular-value-decomposition.sql example.

Example 36-6  Cluster Details

```sql
SELECT S.cluster_id, probability prob,
       CLUSTER_DETAILS(em_sh_clus_sample, S.cluster_id, 5 USING T.*) det
FROM
  (SELECT v.*, CLUSTER_SET(em_sh_clus_sample, NULL, 0.2 USING *) pset
   FROM mining_data_apply_v v
   WHERE cust_id = 100955) T,
  TABLE(T.pset) S
ORDER BY 2 DESC;
```

<table>
<thead>
<tr>
<th>CLUSTER_ID</th>
<th>PROB</th>
<th>DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>.6761</td>
<td>&lt;Details algorithm=&quot;Expectation Maximization&quot; cluster=&quot;14&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AGE&quot; actualValue=&quot;51&quot; weight=&quot;.676&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.557&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;0&quot; weight=&quot;.412&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.171&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;BOOKKEEPING_APPLICATION&quot; actualValue=&quot;1&quot; weight=&quot;-.003&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
<tr>
<td>3</td>
<td>.3227</td>
<td>&lt;Details algorithm=&quot;Expectation Maximization&quot; cluster=&quot;3&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;3&quot; weight=&quot;.323&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;BULK_PACK_DISKETTES&quot; actualValue=&quot;1&quot; weight=&quot;.265&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;EDUCATION&quot; actualValue=&quot;HS-grad&quot; weight=&quot;.172&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.125&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;OCCUPATION&quot; actualValue=&quot;Crafts&quot; weight=&quot;.055&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
</tbody>
</table>

36.3.2 Feature Details

Shows an example of the FEATURE_DETAILS function.

The query in the following example returns the three attributes that have the greatest impact on the top Principal Components Analysis (PCA) projection for customer 101501. The FEATURE_DETAILS function applies a Singular Value Decomposition (SVD) model named svd_sh_sample to the data selected from the svd_sh_sample_build_num table. The table and model are created by the oml4sql-singular-value-decomposition.sql example.

Example 36-7  Feature Details

```sql
SELECT FEATURE_DETAILS(svd_sh_sample, 1, 3 USING *) projdet
FROM svd_sh_sample_build_num
WHERE CUST_ID = 101501;
```
36.3.3 Prediction Details

Shows an example of the `PREDICTION_DETAILS` function.

The query in the following example returns the attributes that are most important in predicting the age of customer 100010. The prediction functions apply a Generalized Linear Model regression model named `GLMR_SH_Regr_sample` to the data selected from `mining_data_apply_v`. The `GLMR_SH_Regr_sample` model is created by the `oml4sql-regression-glm.sql` example.

Example 36-8 Prediction Details for Regression

```
SELECT cust_id, PREDICTION(GLMR_SH_Regr_sample USING *) pr, PREDICTION_DETAILS(GLMR_SH_Regr_sample USING *) pd
FROM mining_data_apply_v
WHERE CUST_ID = 100010;
```

```
CUST_ID    PR PD
------- -----  -----------
100010 25.45 <Details algorithm="Generalized Linear Model">
  <Attribute name="FLAT_PANEL_MONITOR" actualValue="1" weight=".025" rank="1"/>
  <Attribute name="OCCUPATION" actualValue="Crafts" weight=".019" rank="2"/>
  <Attribute name="AFFINITY_CARD" actualValue="0" weight=".01" rank="3"/>
  <Attribute name="OS_DOC_SET_KANJI" actualValue="0" weight="0" rank="4"/>
  <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight="-.004" rank="5"/>
</Details>
```

The query in the following example returns the customers who work in Tech Support and are likely to use an affinity card (with more than 85% probability). The prediction functions apply an Support Vector Machine (SVM) classification model named `svmc_sh_clas_sample` to the data selected from `mining_data_apply_v`. The query includes the prediction details, which show that education is the most important predictor. The `svmc_sh_clas_sample` model is created by the `oml4sql-classification-svm.sql` example.

Example 36-9 Prediction Details for Classification

```
SELECT cust_id, PREDICTION_DETAILS(svmc_sh_clas_sample, 1 USING *) PD
FROM mining_data_apply_v
WHERE PREDICTION_PROBABILITY(svmc_sh_clas_sample, 1 USING *) > 0.85
  AND occupation = 'TechSup'
ORDER BY cust_id;
```

```
CUST_ID PD
-------  ---------------------------------------------------------------------------------------
100029 <Details algorithm="Support Vector Machines" class="1">
  <Attribute name="EDUCATION" actualValue="Assoc-A" weight=".199" rank="1"/>
  <Attribute name="CUST_INCOME_LEVEL" actualValue="I: 170,000 - 189,999" weight=".044" rank="2"/>
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".028" rank="3"/>
</Details>
```
The query in the following example returns the two customers that differ the most from the rest of the customers. The prediction functions apply an anomaly detection model named `SVMO_SH_Clas_sample` to the data selected from `mining_data_apply_v`. Anomaly detection uses a one-class SVM classifier. The model is created by the `oml4sql-singular-value-decomposition.sql` example.

Example 36-10 Prediction Details for Anomaly Detection

```
SELECT cust_id, pd FROM  
 (SELECT cust_id,  
  PREDICTION_DETAILS(SVMO_SH_Clas_sample, 0 USING *) pd,  
  RANK() OVER (ORDER BY prediction_probability(  
    SVMO_SH_Clas_sample, 0 USING *) DESC, cust_id) rnk  
  FROM mining_data_one_class_v)  
WHERE rnk <= 2  
ORDER BY rnk;
```

CUST_ID PD
---------- -----------------------------------------------------------------------------------
100378 <Details algorithm="Support Vector Machines" class="1">  
  <Attribute name="EDUCATION" actualValue="Assoc-A" weight=".21" rank="1"/>  
  <Attribute name="CUST_INCOME_LEVEL" actualValue="B: 30,000 - 49,999" weight=".047" rank="2"/>  
  <Attribute name="FLAT_PANEL_MONITOR" actualValue="0" weight=".043" rank="3"/>  
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".03" rank="4"/>  
  <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight=".023" rank="5"/>  
</Details>

100508 <Details algorithm="Support Vector Machines" class="1">  
  <Attribute name="EDUCATION" actualValue="Bach." weight=".19" rank="1"/>  
  <Attribute name="CUST_INCOME_LEVEL" actualValue="L: 300,000 and above" weight=".046" rank="2"/>  
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".031" rank="3"/>  
  <Attribute name="BULK_PACK_DISKETTES" actualValue="1" weight=".026" rank="4"/>  
  <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight=".02" rank="5"/>  
</Details>

100980 <Details algorithm="Support Vector Machines" class="1">  
  <Attribute name="EDUCATION" actualValue="Assoc-A" weight=".19" rank="1"/>  
  <Attribute name="FLAT_PANEL_MONITOR" actualValue="0" weight=".038" rank="2"/>  
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".026" rank="3"/>  
  <Attribute name="BULK_PACK_DISKETTES" actualValue="1" weight=".022" rank="4"/>  
  <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight=".024" rank="5"/>  
</Details>

---

36-7
36.3.4 GROUPING Hint

OML4SQL functions include PREDICTION*, CLUSTER*, FEATURE*, and ORA_DM*. The GROUPING hint is an optional hint that applies to machine learning scoring functions when scoring partitioned models.

This hint results in partitioning the input data set into distinct data slices so that each partition is scored in its entirety before advancing to the next partition. However, parallelism by partition is still available. Data slices are determined by the partitioning key columns used when the model was built. This method can be used with any machine learning function against a partitioned model. The hint may yield a query performance gain when scoring large data that is associated with many partitions but may negatively impact performance when scoring large data with few partitions on large systems. Typically, there is no performance gain if you use the hint for single row queries.

Enhanced PREDICTION Function Command Format

```
<prediction function> ::=  
    PREDICTION <left paren> /*+ GROUPING */ <prediction model>
    [ <comma> <class value> [ <comma> <top N> ] ]  
    USING <machine learning attribute list> <right paren>
```

The syntax for only the PREDICTION function is given but it is applicable to any machine learning function in which PREDICTION, CLUSTERING, and FEATURE_EXTRACTION scoring functions occur.

Example 36-11  Example

```
SELECT PREDICTION(/*+ GROUPING */my_model USING *) pred FROM <input table>;
```

Related Topics

- Oracle Database SQL Language Reference

36.4 Real-Time Scoring

You can perform real-time scoring by running a SQL query. An example shows a real-time query using PREDICTION_PROBABILITY function. Based on the result, a customer representative can offer a value card to the customer.

Oracle Machine Learning for SQL functions enable prediction, clustering, and feature extraction analysis to be easily integrated into live production and operational systems. Because machine learning results are returned within SQL queries, machine learning can occur in real time.

With real-time scoring, point-of-sales database transactions can be mined. Predictions and rule sets can be generated to help front-line workers make better analytical
decisions. Real-time scoring enables fraud detection, identification of potential liabilities, and recognition of better marketing and selling opportunities.

The query in the following example uses a Decision Tree model named `dt_sh_clas_sample` to predict the probability that customer 101488 uses an affinity card. A customer representative can retrieve this information in real time when talking to this customer on the phone. Based on the query result, the representative can offer an extra-value card, since there is a 73% chance that the customer uses a card. The model is created by the `oml4sql-classification-decision-tree.sql` example.

**Example 36-12  Real-Time Query with Prediction Probability**

```sql
SELECT PREDICTION_PROBABILITY(dt_sh_clas_sample, 1 USING *) cust_card_prob
FROM mining_data_apply_v
WHERE cust_id = 101488;
```

<table>
<thead>
<tr>
<th>CUST_CARD_PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>.72764</td>
</tr>
</tbody>
</table>

### 36.5 Dynamic Scoring

You can perform dynamic scoring if, for some reason, you do not want to apply a predefined model.

The Oracle Machine Learning for SQL functions operate in two modes: by applying a predefined model, or by executing an analytic clause. If you supply an analytic clause instead of a model name, the function builds one or more transient models and uses them to score the data.

The ability to score data dynamically without a predefined model extends the application of basic embedded machine learning techniques into environments where models are not available. Dynamic scoring, however, has limitations. The transient models created during dynamic scoring are not available for inspection or fine tuning. Applications that require model inspection, the correlation of scoring results with the model, special algorithm settings, or multiple scoring queries that use the same model, require a predefined model.

The following example shows a dynamic scoring query. The example identifies the rows in the input data that contain unusual customer age values.

**Example 36-13  Dynamic Prediction**

```sql
SELECT cust_id, age, pred_age, age-pred_age age_diff, pred_det FROM
(SELECT cust_id, age, pred_age, pred_det,
 RANK() OVER (ORDER BY ABS(age-pred_age) DESC) rnk FROM
(SELECT cust_id, age,
 PREDICTION(FOR age USING *) OVER () pred_age,
 PREDICTION_DETAILS(FOR age ABS USING *) OVER () pred_det
 FROM mining_data_apply_v))
WHERE rnk <= 5;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>AGE</th>
<th>PRED_AGE</th>
<th>AGE_DIFF</th>
<th>PRED_DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>100910</td>
<td>80</td>
<td>40.66865</td>
<td>39.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot;/&gt;</td>
</tr>
</tbody>
</table>
Chapter 36

Dynamic Scoring

101285 79 42.1753571 36.82 <Details algorithm="Support Vector Machines">
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1"
    weight='.059' rank='1'/>
  <Attribute name="HOUSEHOLD_SIZE" actualValue="2" weight='.059'
    rank='2'/>
  <Attribute name="CUST_MARITAL_STATUS" actualValue="Mabsent"
    weight='.059' rank='3'/>
  <Attribute name="Y_BOX_GAMES" actualValue="0" weight='.059'
    rank='4'/>
  <Attribute name="CUST_GENDER" actualValue="F" weight='.059'
    rank='5'/>
</Details>

100694 77 41.0396722 35.96 <Details algorithm="Support Vector Machines">
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1"
    weight='.059' rank='1'/>
  <Attribute name="EDUCATION" actualValue="&lt; Bach." weight='.059'
    rank='2'/>
  <Attribute name="Y_BOX_GAMES" actualValue="0" weight='.059'
    rank='3'/>
  <Attribute name="CUST_ID" actualValue="100694" weight='.059'
    rank='4'/>
  <Attribute name="COUNTRY_NAME" actualValue="United States of America"
    weight='.059' rank='5'/>
</Details>

100308 81 45.3252491 35.67 <Details algorithm="Support Vector Machines">
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1"
    weight='.059' rank='1'/>
  <Attribute name="Y_BOX_GAMES" actualValue="0" weight='.059'
    rank='2'/>
  <Attribute name="HOUSEHOLD_SIZE" actualValue="2" weight='.059'
    rank='3'/>
  <Attribute name="FLAT_PANEL_MONITOR" actualValue="1"
    weight='.059' rank='4'/>
  <Attribute name="CUST_GENDER" actualValue="F" weight='.059'
    rank='5'/>
</Details>

101256 90 54.3862214 35.61 <Details algorithm="Support Vector Machines">
  <Attribute name="YRS_RESIDENCE" actualValue="9" weight='.059'
    rank='1'/>
  <Attribute name="HOME_THEATER_PACKAGE" actualValue="1"
    weight='.059' rank='2'/>
  <Attribute name="EDUCATION" actualValue="&lt; Bach." weight='.059'
    rank='3'/>
  <Attribute name="Y_BOX_GAMES" actualValue="0" weight='.059'
    rank='4'/>
  <Attribute name="COUNTRY_NAME" actualValue="United States of America"
    weight='.059' rank='5'/>
</Details>
36.6 Cost-Sensitive Decision Making

Costs are user-specified numbers that bias classification. The algorithm uses positive numbers to penalize more expensive outcomes over less expensive outcomes. Higher numbers indicate higher costs.

The algorithm uses negative numbers to favor more beneficial outcomes over less beneficial outcomes. Lower negative numbers indicate higher benefits.

All classification algorithms can use costs for scoring. You can specify the costs in a cost matrix table, or you can specify the costs inline when scoring. If you specify costs inline and the model also has an associated cost matrix, only the inline costs are used. The `PREDICTION`, `PREDICTION_SET`, and `PREDICTION_COST` functions support costs.

Only the Decision Tree algorithm can use costs to bias the model build. If you want to create a Decision Tree model with costs, create a cost matrix table and provide its name in the `CLAS_COST_TABLE_NAME` setting for the model. If you specify costs when building the model, the cost matrix used to create the model is used when scoring. If you want to use a different cost matrix table for scoring, first remove the existing cost matrix table then add the new one.

A sample cost matrix table is shown in the following table. The cost matrix specifies costs for a binary target. The matrix indicates that the algorithm must treat a misclassified 0 as twice as costly as a misclassified 1.

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Example 36-14  Sample Queries With Costs**

The table `nbmodel_costs` contains the cost matrix described in Table 36-1.

```sql
SELECT * from nbmodel_costs;
```

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The following statement associates the cost matrix with a Naive Bayes model called `nbmodel`.

```sql
BEGIN
    dbms_data_mining.add_cost_matrix('nbmodel', 'nbmodel_costs');
END;
/
The following query takes the cost matrix into account when scoring `mining_data_apply_v`. The output is restricted to those rows where a prediction of 1 is less costly than a prediction of 0.

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION (nbmodel COST MODEL USING cust_marital_status, education, household_size) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th></th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>25</td>
<td>38</td>
</tr>
<tr>
<td>M</td>
<td>208</td>
<td>43</td>
</tr>
</tbody>
</table>

You can specify costs inline when you invoke the scoring function. If you specify costs inline and the model also has an associated cost matrix, only the inline costs are used. The same query is shown below with different costs specified inline. Instead of the “2” shown in the cost matrix table (Table 36-1), “10” is specified in the inline costs.

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION (nbmodel COST (0,1) values ((0, 10),
(1, 0))
USING cust_marital_status, education, household_size) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th></th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>74</td>
<td>39</td>
</tr>
<tr>
<td>M</td>
<td>581</td>
<td>43</td>
</tr>
</tbody>
</table>

The same query based on probability instead of costs is shown below.

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION (nbmodel USING cust_marital_status, education, household_size) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th></th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>73</td>
<td>39</td>
</tr>
<tr>
<td>M</td>
<td>577</td>
<td>44</td>
</tr>
</tbody>
</table>

### Related Topics
- Example 32-1

### 36.7 DBMS_DATA_MINING.APPLY

The **APPLY** procedure in **DBMS_DATA_MINING** is a batch apply operation that writes the results of scoring directly to a table.

The columns in the table are machine learning function-dependent.
Scoring with **APPLY** generates the same results as scoring with the SQL scoring functions. Classification produces a prediction and a probability for each case; clustering produces a cluster ID and a probability for each case, and so on. The difference lies in the way that scoring results are captured and the mechanisms that can be used for retrieving them.

**APPLY** creates an output table with the columns shown in the following table:

<table>
<thead>
<tr>
<th>Machine Learning Technique</th>
<th>Output Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>classification</td>
<td>CASE_ID, PREDICTION, PROBABILITY</td>
</tr>
<tr>
<td>regression</td>
<td>CASE_ID, PREDICTION</td>
</tr>
<tr>
<td>anomaly detection</td>
<td>CASE_ID, PREDICTION, PROBABILITY</td>
</tr>
<tr>
<td>clustering</td>
<td>CASE_ID, CLUSTER_ID, PROBABILITY</td>
</tr>
<tr>
<td>feature extraction</td>
<td>CASE_ID, FEATURE_ID, MATCH_QUALITY</td>
</tr>
</tbody>
</table>

Since **APPLY** output is stored separately from the scoring data, it must be joined to the scoring data to support queries that include the scored rows. Thus any model that is used with **APPLY** must have a case ID.

A case ID is not required for models that are applied with SQL scoring functions. Likewise, storage and joins are not required, since scoring results are generated and consumed in real time within a SQL query.

The following example illustrates anomaly detection with **APPLY**. The query of the **APPLY** output table returns the ten first customers in the table. Each has a a probability for being typical (1) and a probability for being anomalous (0). The **SVMO_SH_Clas_sample** model is created by the `oml4sql-singular-value-decomposition.sql` example.

**Example 36-15  Anomaly Detection with DBMS_DATA_MINING.APPLY**

```sql
EXEC dbms_data_mining.apply
  ('SVMO_SH_Clas_sample','svmo_sh_sample_prepared',
  'cust_id', 'one_class_output');
SELECT * from one_class_output where rownum < 11;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PREDICTION</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>101798</td>
<td>1</td>
<td>.567389309</td>
</tr>
<tr>
<td>101798</td>
<td>0</td>
<td>.432610691</td>
</tr>
<tr>
<td>102276</td>
<td>1</td>
<td>.564922469</td>
</tr>
<tr>
<td>102276</td>
<td>0</td>
<td>.435077531</td>
</tr>
<tr>
<td>102404</td>
<td>1</td>
<td>.51213544</td>
</tr>
<tr>
<td>Index</td>
<td>Value</td>
<td>Probability</td>
</tr>
<tr>
<td>--------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>102404</td>
<td>0</td>
<td>.48786456</td>
</tr>
<tr>
<td>101891</td>
<td>1</td>
<td>.563474346</td>
</tr>
<tr>
<td>101891</td>
<td>0</td>
<td>.436525654</td>
</tr>
<tr>
<td>102815</td>
<td>0</td>
<td>.500663683</td>
</tr>
<tr>
<td>102815</td>
<td>1</td>
<td>.499336317</td>
</tr>
</tbody>
</table>

**Related Topics**

- *Oracle Database PL/SQL Packages and Types Reference*
37

Machine Learning Operations on Unstructured Text

Explains how to use Oracle Machine Learning for SQL to operate on unstructured text.

- About Unstructured Text
- About Machine Learning and Oracle Text
- Model Detail Views for Text Features
- Create a Model that Includes Machine Learning Operations on Text
- Create a Text Policy
- Configure a Text Attribute

37.1 About Unstructured Text

Unstructured text may contain important information that is critical to the success of a business.

Machine learning algorithms act on data that is numerical or categorical. Numerical data is ordered. It is stored in columns that have a numeric data type, such as NUMBER or FLOAT. Categorical data is identified by category or classification. It is stored in columns that have a character data type, such as VARCHAR2 or CHAR.

Unstructured text data is neither numerical nor categorical. Unstructured text includes items such as web pages, document libraries, Power Point presentations, product specifications, emails, comment fields in reports, and call center notes. It has been said that unstructured text accounts for more than three quarters of all enterprise data. Extracting meaningful information from unstructured text can be critical to the success of a business.

37.2 About Machine Learning and Oracle Text

Understand machine learning operations on text and Oracle Text.

Machine learning operations on text is the process of applying machine learning techniques to text terms, also called text features or tokens. Text terms are words or groups of words that have been extracted from text documents and assigned numeric weights. Text terms are the fundamental unit of text that can be manipulated and analyzed.

Oracle Text is an Oracle Database technology that provides term extraction, word and theme searching, and other utilities for querying text. When columns of text are present in the training data, Oracle Machine Learning for SQL uses Oracle Text utilities and term weighting strategies to transform the text for machine learning operations. OML4SQL passes configuration information supplied by you to Oracle Text and uses the results in the model creation process.

Related Topics
- Oracle Text Application Developer's Guide
37.3 Model Detail Views for Text Features

The model details view for text features is DM$VX$\textit{model_name}.

The text feature view DM$VX$\textit{model_name} describes the extracted text features if there are text attributes present. The view has the following schema:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>COLUMN_NAME</td>
<td>VARCHAR2(128)</td>
</tr>
<tr>
<td>TOKEN</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>DOCUMENT FREQUENCY</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

Table 37-1  Text Feature View for Extracted Text Features

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTITION_NAME</td>
<td>A partition in a partitioned model to retrieve details</td>
</tr>
<tr>
<td>COLUMN_NAME</td>
<td>Name of the identifier column</td>
</tr>
<tr>
<td>TOKEN</td>
<td>Text token which is usually a word or stemmed word</td>
</tr>
<tr>
<td>DOCUMENT_FREQ</td>
<td>A measure of token frequency in the entire training set</td>
</tr>
</tbody>
</table>

37.4 Create a Model that Includes Machine Learning Operations on Text

Learn how to create a model that includes machine learning operations on text.

Oracle Machine Learning for SQL supports unstructured text within columns of VARCHAR2, CHAR, CLOB, BLOB, and BFILE, as described in the following table:

Table 37-2  Column Data Types That May Contain Unstructured Text

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFILE and BLOB</td>
<td>Oracle Machine Learning for SQL interprets BLOB and BFILE as text only if you identify the columns as text when you create the model. If you do not identify the columns as text, then CREATE_MODEL returns an error.</td>
</tr>
<tr>
<td>CLOB</td>
<td>OML4SQL interprets CLOB as text.</td>
</tr>
<tr>
<td>CHAR</td>
<td>OML4SQL interprets CHAR as categorical by default. You can identify columns of CHAR as text when you create the model.</td>
</tr>
<tr>
<td>VARCHAR2</td>
<td>OML4SQL interprets VARCHAR2 with data length &gt; 4000 as text. OML4SQL interprets VARCHAR2 with data length &lt;= 4000 as categorical by default. You can identify these columns as text when you create the model.</td>
</tr>
</tbody>
</table>
The settings described in the following table control the term extraction process for text attributes in a model. Instructions for specifying model settings are in "Specifying Model Settings".

### Table 37-3  Model Settings for Text

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Data Type</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODMS_TEXT_POLICY_NAME</td>
<td>VARCHAR2</td>
<td>Name of an Oracle Text policy object created with CTX_DDL.CREATE_POLICY</td>
<td>Affects how individual tokens are extracted from unstructured text.</td>
</tr>
<tr>
<td>ODMS_TEXT_MAX_FEATURES</td>
<td>INTEGER</td>
<td>1 &lt;= value &lt;= 100000</td>
<td>Maximum number of features to use from the document set (across all documents of each text column) passed to CREATE_MODEL. Default is 3000.</td>
</tr>
</tbody>
</table>

A model can include one or more text attributes. A model with text attributes can also include categorical and numerical attributes.

**To create a model that includes text attributes:**

1. Create an Oracle Text policy object.
2. Specify the model configuration settings that are described in "Table 37-3".
3. Specify which columns must be treated as text and, optionally, provide text transformation instructions for individual attributes.
4. Pass the model settings and text transformation instructions to `DBMS_DATA_MINING.CREATE_MODEL2` or `DBMS_DATA_MINING.CREATE_MODEL`.

**Note:**

All algorithms except O-Cluster can support columns of unstructured text.

The use of unstructured text is not recommended for association rules (Apriori).

In the following example, an SVM model is used to predict customers that are most likely to be positive responders to an Affinity Card loyalty program. The data comes with a text column that contains user generated comments. By creating an Oracle Text policy and specifying model settings, the algorithm automatically uses the text column and builds the model on both the structured data and unstructured text.

This example uses a view called `mining_data` which is created from `SH.SALES` table. A training data set called `mining_train_text` is also created.
The following queries show you how to create an Oracle Text policy followed by building a model using `CREATE_MODEL2` procedure.

```sql
%script
BEGIN
EXECUTE ctx_ddl.create_policy('dmdemo_svm_policy');
PL/SQL procedure successfully completed.
---------------------------

PL/SQL procedure successfully completed.

%script
BEGIN DBMS_DATA_MINING.DROP_MODEL('T_SVM_Clas_sample');
EXCEPTION WHEN OTHERS THEN NULL; END;
/
DECLARE
  v_setlst DBMS_DATA_MINING.SETTING_LIST;
  xformlist dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  v_setlst(dbms_data_mining.algo_name) :=
  dbms_data_mining.algo_support_vector_machines;
  v_setlst(dbms_data_mining.prep_auto) := dbms_data_mining.prep_auto_on;
  v_setlst(dbms_data_mining.svms_kernel_function) :=
  dbms_data_mining.svms_linear;
  v_setlst(dbms_data_mining.svms_complexity_factor) := '100';
  v_setlst(dbms_data_mining.odms_text_policy_name) := 'DMDEMO_SVM_POLICY';
  v_setlst(dbms_data_mining.svms_solver) := dbms_data_mining.svms_solver_sgd;
  dbms_data_mining_transform.SET_TRANSFORM(
    xformlist, 'comments', null, 'comments', null, 'TEXT');
  DBMS_DATA_MINING.CREATE_MODEL2(
    model_name          => 'T_SVM_Clas_sample',
    mining_function     => dbms_data_mining.classification,
    data_query          => 'select * from mining_train_text',
    set_list            => v_setlst,
    case_id_column_name => 'cust_id',
    target_column_name  => 'affinity_card',
    xform_list           => xformlist);
END;
/

PL/SQL procedure successfully completed.
---------------------------

PL/SQL procedure successfully completed.
---------------------------
```
Related Topics

- **Specify Model Settings**
  Understand how to configure machine learning models at build time.

- **Create a Text Policy**
  An Oracle Text policy specifies how text content must be interpreted. You can provide a text policy to govern a model, an attribute, or both the model and individual attributes.

- **Configure a Text Attribute**
  Provide transformation instructions for text attribute or unstructured text by explicitly identifying the column datatypes.

- **Embed Transformations in a Model**
  You can specify your own transformations and embed them in a model by creating a transformation list and passing it to `DBMS_DATA_MINING.CREATE_MODEL2` or `DBMS_DATA_MINING.CREATE_MODEL`.

37.5 Create a Text Policy

An Oracle Text policy specifies how text content must be interpreted. You can provide a text policy to govern a model, an attribute, or both the model and individual attributes.

If a model-specific policy is present and one or more attributes have their own policies, Oracle Machine Learning for SQL uses the attribute policies for the specified attributes and the model-specific policy for the other attributes.

The **CTX_DDL.CREATE_POLICY** procedure creates a text policy.

```sql
CTX_DDL.CREATE_POLICY(
    policy_name    IN VARCHAR2,
    filter         IN VARCHAR2 DEFAULT NULL,
    section_group  IN VARCHAR2 DEFAULT NULL,
    lexer          IN VARCHAR2 DEFAULT NULL,
    stoplist       IN VARCHAR2 DEFAULT NULL,
    wordlist       IN VARCHAR2 DEFAULT NULL);
```

The parameters of **CTX_DDL.CREATE_POLICY** are described in the following table.

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>policy_name</td>
<td>Name of the new policy object. Oracle Text policies and text indexes share the same namespace.</td>
</tr>
<tr>
<td>filter</td>
<td>Specifies how the documents must be converted to plain text for indexing. Examples are: CHARSET_FILTER for character sets and NULL_FILTER for plain text, HTML and XML. For filter values, see &quot;Filter Types&quot; in Oracle Text Reference.</td>
</tr>
<tr>
<td>section_group</td>
<td>Identifies sections within the documents. For example, HTML_SECTION_GROUP defines sections in HTML documents. For section_group values, see &quot;Section Group Types&quot; in Oracle Text Reference. Note: You can specify any section group that is supported by CONTEXT indexes.</td>
</tr>
</tbody>
</table>
Table 37-4 (Cont.) CTX_DDL.CREATE_POLICY Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lexer</td>
<td>Identifies the language that is being indexed. For example, BASIC_LEXER is the lexer for extracting terms from text in languages that use white space delimited words (such as English and most western European languages). For lexer values, see &quot; Lexer Types&quot; in Oracle Text Reference.</td>
</tr>
<tr>
<td>stoplist</td>
<td>Specifies words and themes to exclude from term extraction. For example, the word &quot;the&quot; is typically in the stoplist for English language documents. The system-supplied stoplist is used by default. See &quot;Stoplists&quot; in Oracle Text Reference.</td>
</tr>
<tr>
<td>wordlist</td>
<td>Specifies how stems and fuzzy queries must be expanded. A stem defines a root form of a word so that different grammatical forms have a single representation. A fuzzy query includes common misspellings in the representation of a word. See &quot;BASIC_WORDLIST&quot; in Oracle Text Reference.</td>
</tr>
</tbody>
</table>

Related Topics

- Oracle Text Reference

37.6 Configure a Text Attribute

Provide transformation instructions for text attribute or unstructured text by explicitly identifying the column datatypes.

As shown in Table 37-2, you can identify columns of CHAR, shorter VARCHAR2 (<=4000), BFILE, and BLOB as text attributes. If CHAR and shorter VARCHAR2 columns are not explicitly identified as unstructured text, then CREATE_MODEL processes them as categorical attributes. If BFILE and BLOB columns are not explicitly identified as unstructured text, then CREATE_MODEL returns an error.

To identify a column as a text attribute, supply the keyword TEXT in an Attribute specification. The attribute specification is a field (attribute_spec) in a transformation record (transform_rec). Transformation records are components of transformation lists (xform_list) that can be passed to CREATE_MODEL or CREATE_MODEL2.

**Note:**

An attribute specification can also include information that is not related to text. Instructions for constructing an attribute specification are in "Embedding Transformations in a Model".

You can provide transformation instructions for any text attribute by qualifying the TEXT keyword in the attribute specification with the subsettings described in the following table.
### Table 37-5  Attribute-Specific Text Transformation Instructions

<table>
<thead>
<tr>
<th>Subsetting Name</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIGRAM</td>
<td>A sequence of two adjacent elements from a string of tokens, which are typically letters, syllables, or words. Here, NORMAL tokens are mixed with their bigrams.</td>
<td>(TOKEN_TYPE:BIGRAM)</td>
</tr>
<tr>
<td>POLICY_NAME</td>
<td>Name of an Oracle Text policy object created with CTX_DDL.CREATE_POLICY</td>
<td>(POLICY_NAME:my_policy)</td>
</tr>
<tr>
<td>STEM_BIGRAM</td>
<td>Here, STEM tokens are extracted first and then stem bigrams are formed.</td>
<td>(TOKEN_TYPE:STEM_BIGRAM)</td>
</tr>
<tr>
<td>SYNONYM</td>
<td>Oracle Machine Learning for SQL supports synonyms. The following is an optional parameter: <code>&lt;thesaurus&gt;</code> where <code>&lt;thesaurus&gt;</code> is the name of the thesaurus defining synonyms. If SYNONYM is used without this parameter, then the default thesaurus is used.</td>
<td>(TOKEN_TYPE:SYNONYM)</td>
</tr>
<tr>
<td>TOKEN_TYPE</td>
<td>The following values are supported: NORMAL (the default), STEM, THEME</td>
<td>(TOKEN_TYPE:THEME)</td>
</tr>
<tr>
<td>MAX_FEATURES</td>
<td>Maximum number of features to use from the attribute.</td>
<td>(MAX_FEATURES:3000)</td>
</tr>
</tbody>
</table>

#### Note:

The **TEXT** keyword is only required for **CLOB** and longer **VARCHAR2** (>4000) when you specify transformation instructions. The **TEXT** keyword is always required for **CHAR**, **shorter VARCHAR2**, **BFILE**, and **BLOB** — whether or not you specify transformation instructions.

#### Tip:

You can view attribute specifications in the data dictionary view **ALL_MINING_MODEL_ATTRIBUTES**, as shown in *Oracle Database Reference*.

### Token Types in an Attribute Specification

When stems or themes are specified as the token type, the lexer preference for the text policy must support these types of tokens.

The following example adds themes and English stems to **BASIC_LEXER**.

```sql
BEGIN
    CTX_DDL.CREATE_PREFERENCE('my_lexer', 'BASIC_LEXER');
```
Example 37-1  A Sample Attribute Specification for Text

This expression specifies that text transformation for the attribute must use the text policy named `my_policy`. The token type is `THEME`, and the maximum number of features is 3000.

"TEXT(POLICY_NAME:my_policy)(TOKEN_TYPE:THEME)(MAX_FEATURES:3000)"

Related Topics

- **Embed Transformations in a Model**
  You can specify your own transformations and embed them in a model by creating a transformation list and passing it to `DBMS_DATA_MINING.CREATE_MODEL2` or `DBMS_DATA_MINING CREATE MODEL`.

- **Specify Transformation Instructions for an Attribute**
  You can pass transformation instructions for an attribute by defining a transformation list.

- *Oracle Database PL/SQL Packages and Types Reference*

- *ALL_MINING_MODEL_ATTRIBUTES*
Administrative Tasks for Oracle Machine Learning for SQL

Explains how to perform administrative tasks related to Oracle Machine Learning for SQL.

- Install and Configure a Database for Oracle Machine Learning for SQL
- Upgrade or Downgrade Oracle Machine Learning for SQL
- Export and Import Oracle Machine Learning for SQL Models
- Control Access to Oracle Machine Learning for SQL Models and Data
- Audit and Add Comments to Oracle Machine Learning for SQL Models

38.1 Install and Configure a Database for Oracle Machine Learning for SQL

You can install and configure a database for Oracle Machine Learning for SQL by following the listed steps.

- About Installation
- Enabling or Disabling a Database Option
- Database Tuning Considerations for Oracle Machine Learning for SQL

38.1.1 About Installation

Oracle Machine Learning for SQL is a component of the Oracle Database Enterprise Edition.

To install Oracle Database, follow the installation instructions for your platform. Choose a Data Warehousing configuration during the installation.

Oracle Data Miner, the graphical user interface to Oracle Machine Learning for SQL, is an extension to Oracle SQL Developer. Instructions for downloading SQL Developer and installing the Data Miner repository are available on the Oracle Technology Network.

To perform machine learning activities, you must be able to log on to the Oracle database, and your user ID must have the database privileges described in Grant Privileges for Oracle Machine Learning for SQL.

Related Topics
- Oracle Data Miner
38.1.2 Enable or Disable a Database Option

You can enable or disable the Oracle Advanced Analytics option after the installation. The Oracle Advanced Analytics option is enabled by default during the installation of Oracle Database Enterprise Edition.

After installation, you can use the command-line utility `chopt` to enable or disable a database option.

38.1.3 Database Tuning Considerations for Oracle Machine Learning for SQL

Standard administrative practices can be followed to manage workload on the system when machine learning activities are running.

DBAs managing production databases that support Oracle Machine Learning for SQL must follow standard administrative practices as described in Oracle Database Administrator’s Guide.

Building machine learning models and batch scoring of machine learning models tend to put a DSS-like workload on the system. Single-row scoring tends to put an OLTP-like workload on the system.

Database memory management can have a major impact on machine learning. The correct sizing of Program Global Area (PGA) memory is very important for model building, complex queries, and batch scoring. From a machine learning perspective, the System Global Area (SGA) is generally less of a concern. However, the SGA must be sized to accommodate real-time scoring, which loads models into the shared cursor in the SGA. In most cases, you can configure the database to manage memory automatically. To do so, specify the total maximum memory size in the tuning parameter `MEMORY_TARGET`. With automatic memory management, Oracle Database dynamically exchanges memory between the SGA and the instance PGA as needed to meet processing demands.

Most machine learning algorithms can take advantage of parallel execution when it is enabled in the database. Parameters in `INIT.ORA` control the behavior of parallel execution.

Related Topics

- Oracle Database Administrator’s Guide
- Scoring and Deployment
  - Explains the scoring and deployment features of Oracle Machine Learning for SQL.
- Oracle Database Administrator’s Guide
- Part I Database Performance Fundamentals
38.2 Upgrade or Downgrade Oracle Machine Learning for SQL

Upgrade and downgrade Oracle Machine Learning for SQL by following the steps listed.

- Pre-Upgrade Steps
- Upgrade Oracle Machine Learning for SQL
- Post Upgrade Steps
- Downgrade Oracle Machine Learning for SQL

38.2.1 Pre-Upgrade Steps

Pre-upgrade considerations.

Before upgrading, you must drop any machine learning models and machine learning activities that were created in Oracle Data Miner.

38.2.2 Upgrade Oracle Machine Learning for SQL

You can upgrade your database by using the Database Upgrade Assistant (DBUA) or you can perform a manual upgrade using export/import utilities.

All models and machine learning metadata are fully integrated with the Oracle Database upgrade process whether you are upgrading from 19c or from earlier releases.

Upgraded models continue to work as they did in prior releases. Both upgraded models and new models that you create in the upgraded environment can make use of the new machine learning functionality introduced in the new release.

Related Topics

- Pre-Upgrade Steps
  Pre-upgrade considerations.
- Oracle Database Upgrade Guide

38.2.2.1 Use Database Upgrade Assistant to Upgrade Oracle Machine Learning for SQL

Oracle Database Upgrade Assistant provides a graphical user interface that guides you interactively through the upgrade process.

On Windows platforms, follow these steps to start the Upgrade Assistant:

1. Go to the Windows Start menu and choose the Oracle home directory.
2. Choose the Configuration and Migration Tools menu.
3. Launch the Upgrade Assistant.

On Linux platforms, run the DBUA utility to upgrade Oracle Database.
38.2.2.2 Use Export/Import to Upgrade Machine Learning Models

Use Export and Import functions of the Oracle Database to export the previously created models and import the models in an instance of Oracle Database version.

If required, you can use a less automated approach to upgrading machine learning models. You can export the models created in a previous version of Oracle Database and import them into an instance of the Oracle Database version.

38.2.2.1 Export/Import Oracle Machine Learning for SQL Models

Export and import Oracle Machine Learning for SQL models.

To export models from an instance of a previous release of Oracle Database to a dump file, follow the instructions in Export and Import Oracle Machine Learning for SQL Models.

To import the dump file into the Oracle Database database:

```bash
%ORACLE_HOME\bin\impdp system\<password>
dumpfile=<dumpfile_name>
directory=<directory_name>
logfile=<logfile_name> ..... 
SQL>CONNECT / as sysdba;
SQL>EXECUTE dmp_sys.upgrade_models();
SQL>ALTER SYSTEM flush shared_pool;
SQL>ALTER SYSTEM flush buffer_cache;
SQL>EXIT;
```

**ALTER SYSTEM Statement**

You can flush the Database Smart Flash Cache by issuing an `ALTER SYSTEM FLUSH FLASH_CACHE` statement. Flushing the Database Smart Flash Cache can be useful if you need to measure the performance of rewritten queries or a suite of queries from identical starting points.

38.2.3 Post Upgrade Steps

Perform steps to view the upgraded database.

After upgrading the database, check the `DBA_MINING_MODELS` view in the upgraded database. The newly upgraded machine learning models must be listed in this view.

After you have verified the upgrade and confirmed that there is no need to downgrade, you must set the initialization parameter `COMPATIBLE` to `21.0.0`. In Oracle Database 21c, when the `COMPATIBLE` initialization parameter is not set in your parameter file, the `COMPATIBLE` parameter value defaults to `21.0.0`.
Note:
The CREATE MINING MODEL privilege must be granted to Oracle Machine Learning for SQL user accounts that are used to create machine learning models.

Related Topics
• Create an Oracle Machine Learning for SQL User
  An OML4SQL user is a database user account that has privileges for performing machine learning activities.
• Control Access to Oracle Machine Learning for SQL Models and Data
  You can create a Oracle Machine Learning for SQL user and grant necessary privileges by following the steps listed.

38.2.4 Downgrade Oracle Machine Learning for SQL

Before downgrading the Oracle database back to the previous version, ensure that no models are present.

Use the DBMS_DATA_MINING.DROP_MODEL routine to drop the models before downgrading. If you do not do this, the database downgrade process terminates.

Issue the following SQL statement in SYS to verify the downgrade:

```
SQL> SELECT o.name FROM sys.model$ m, sys.obj$ o
WHERE m.obj#=o.obj# AND m.version=2;
```

38.3 Export and Import Oracle Machine Learning for SQL Models

You can export machine learning models to flat files to back up work in progress or to move models to a different instance of Oracle Database Enterprise Edition (such as from a development database to a test database).

All methods for exporting and importing models are based on Oracle Data Pump technology.

The DBMS_DATA_MINING package includes the EXPORT_MODEL and IMPORT_MODEL procedures for exporting and importing individual machine learning models. EXPORT_MODEL and IMPORT_MODEL use the export and import facilities of Oracle Data Pump.

• About Oracle Data Pump
• Options for Exporting and Importing Oracle Machine Learning for SQL Models
• Directory Objects for EXPORT_MODEL and IMPORT_MODEL
• Use EXPORT_MODEL and IMPORT_MODEL
• EXPORT and IMPORT Serialized Models
• Import From PMML

Related Topics
• EXPORT_MODEL
38.3.1 About Oracle Data Pump

Learn to use Oracle Data Pump export utility.

Oracle Data Pump consists of two command-line clients and two PL/SQL packages. The command-line clients, `expdp` and `impdp`, provide an easy-to-use interface to the Data Pump export and import utilities. You can use `expdp` and `impdp` to export and import entire schemas or databases.

The Data Pump export utility writes the schema objects, including the tables and metadata that constitute machine learning models, to a dump file set. The Data Pump import utility retrieves the schema objects, including the model tables and metadata, from the dump file set and restores them in the target database.

`expdp` and `impdp` cannot be used to export/import individual machine learning models.

See Also:

`Oracle Database Utilities` for information about Oracle Data Pump and the `expdp` and `impdp` utilities.

38.3.2 Options for Exporting and Importing Oracle Machine Learning for SQL Models

Lists options for exporting and importing machine learning models.

Options for exporting and importing machine learning models are described in the following table.

Table 38-1 Export and Import Options for Oracle Machine Learning for SQL

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export or import a full database</td>
<td>(DBA only) Use <code>expdp</code> to export a full database and <code>impdp</code> to import a full database. All machine learning models in the database are included.</td>
</tr>
<tr>
<td>Export or import a schema</td>
<td>Use <code>expdp</code> to export a schema and <code>impdp</code> to import a schema. All machine learning models in the schema are included.</td>
</tr>
</tbody>
</table>
Table 38-1  (Cont.) Export and Import Options for Oracle Machine Learning for SQL

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
</table>
| Export or import individual models within a database | Use DBMS_DATA_MINING.EXPORT_MODEL to export individual models and DBMS_DATA_MINING.IMPORT_MODEL to import individual models. These procedures can export and import a single machine learning model, all machine learning models, or machine learning models that match specific criteria.  
By default, IMPORT_MODEL imports models back into the schema from which they were exported. You can specify the schema_remap parameter to import models into a different schema. You can specify tablespace_remap with schema_remap to import models into a schema that uses a different tablespace.  
You may need special privileges in the database to import models into a different schema. These privileges are granted by the EXP_FULL_DATABASE and IMP_FULL_DATABASE roles, which are only available to privileged users (such as SYS or a user with the DBA role). You do not need these roles to export or import models within your own schema.  
To import models, you must have the same database privileges as the user who created the dump file set. Otherwise, a DBA with full system privileges must import the models. |
| Export or import individual models to or from a remote database | Use a database link to export individual models to a remote database or import individual models from a remote database. A database link is a schema object in one database that enables access to objects in a different database. The link must be created before you run EXPORT_MODEL or IMPORT_MODEL.  
To create a private database link, you must have the CREATE DATABASE LINK system privilege. To create a public database link, you must have the CREATE PUBLIC DATABASE LINK system privilege. Also, you must have the CREATE SESSION system privilege on the remote Oracle Database. Oracle Net must be installed on both the local and remote Oracle Databases.  
 Related Topics  
• IMPORT_MODEL Procedure  
• EXPORT_MODEL Procedure  
• Oracle Database SQL Language Reference |

38.3.3 Directory Objects for EXPORT_MODEL and IMPORT_MODEL

Learn how to use directory objects to identify the location of the dump file set.  
EXPORT_MODEL and IMPORT_MODEL use a directory object to identify the location of the dump file set. A directory object is a logical name in the database for a physical directory on the host computer.  
To export machine learning models, you must have write access to the directory object and to the file system directory that it represents. To import machine learning models, you must have read access to the directory object and to the file system directory. Also, the database itself must have access to file system directory. You must have the CREATE ANY DIRECTORY privilege to create directory objects.  
The following SQL command creates a directory object named oml_user_dir. The file system directory that it represents must already exist and have shared read/write access rights granted by the operating system.  
CREATE OR REPLACE DIRECTORY oml_user_dir AS '/dm_path/dm_mining';
The following SQL command gives user oml_user both read and write access to oml_user_dir.

```
GRANT READ,WRITE ON DIRECTORY oml_user_dir TO oml_user;
```

### Related Topics
- Oracle Database SQL Language Reference

### 38.3.4 Use EXPORT_MODEL and IMPORT_MODEL

The examples illustrate various export and import scenarios with EXPORT_MODEL and IMPORT_MODEL.

The examples use the directory object dmdir shown in Example 38-1 and two schemas, dm1 and dm2. Both schemas have machine learning privileges. dm1 has two models. dm2 has one model.

The EM_SH_CLUS_SAMPLE model is created by the oml4sql-clustering-expectation-maximization.sql example. The DT_SH_CLAS_SAMPLE model is created by the oml4sql-classification-decision-tree.sql example. The SVD_SH_SAMPLE model is created by the oml4sql-singular-value-decomposition.sql example.

```
SELECT owner, model_name, mining_function, algorithm FROM all_mining_models;
```

<table>
<thead>
<tr>
<th>OWNER</th>
<th>MODEL_NAME</th>
<th>MINING_FUNCTION</th>
<th>ALGORITHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM1</td>
<td>EM_SH_CLUS_SAMPLE</td>
<td>CLUSTERING</td>
<td>EXPECTATION_MAXIMIZATION</td>
</tr>
<tr>
<td>DM1</td>
<td>DT_SH_CLAS_SAMPLE</td>
<td>CLASSIFICATION</td>
<td>DECISION_TREE</td>
</tr>
<tr>
<td>DM2</td>
<td>SVD_SH_SAMPLE</td>
<td>FEATURE_EXTRACTION</td>
<td>SINGULAR_VALUE_DECOMP</td>
</tr>
</tbody>
</table>

**Example 38-1 Creating the Directory Object**

```
-- connect as system user
CREATE OR REPLACE DIRECTORY dmdir AS '/scratch/oml_user/expimp';
GRANT READ,WRITE ON DIRECTORY dmdir TO dm1;
GRANT READ,WRITE ON DIRECTORY dmdir TO dm2;
SELECT * FROM all_directories WHERE directory_name IN 'DMDIR';
```

<table>
<thead>
<tr>
<th>OWNER</th>
<th>DIRECTORY_NAME</th>
<th>DIRECTORY_PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS</td>
<td>DMDIR</td>
<td>/scratch/oml_user/expimp</td>
</tr>
</tbody>
</table>

**Example 38-2 Exporting All Models From DM1**

```
-- connect as dm1
BEGIN
   dbms_data_mining.export_model (filename => 'all_dm1', directory => 'dmdir');
END;
/
```

A log file and a dump file are created in /scratch/oml_user/expimp, the physical directory associated with dmdir. The name of the log file is dm1_exp_11.log. The name of the dump file is all_dm101.dmp.
Example 38-3 Importing the Models Back Into DM1

The models that were exported in Example 38-2 still exist in dm1. Since an import does not overwrite models with the same name, you must drop the models before importing them back into the same schema.

```
BEGIN
    dbms_data_mining.drop_model('EM_SH_CLUS_SAMPLE');
    dbms_data_mining.drop_model('DT_SH_CLAS_SAMPLE');
    dbms_data_mining.import_model(
        filename => 'all_dm101.dmp',
        directory => 'DMDIR');
END;
/
```

```
SELECT model_name FROM user_mining_models;
```

```
MODEL_NAME
-------------------------------
DT_SH_CLAS_SAMPLE
EM_SH_CLUS_SAMPLE
```

Example 38-4 Importing Models Into a Different Schema

In this example, the models that were exported from dm1 in Example 38-2 are imported into dm2. The dm1 schema uses the example tablespace; the dm2 schema uses the sysaux tablespace.

```
-- CONNECT as sysdba
BEGIN
    dbms_data_mining.import_model(
        filename => 'all_d101.dmp',
        directory => 'DMDIR',
        schema_remap => 'DM1:DM2',
        tablespace_remap => 'EXAMPLE:SYSAUX');
END;
/
```

```
-- CONNECT as dm2
SELECT model_name from user_mining_models;
```

```
MODEL_NAME
--------------------------------------------------------------------------------
SVD_SH_SAMPLE
EM_SH_CLUS_SAMPLE
DT_SH_CLAS_SAMPLE
```

Example 38-5 Exporting Specific Models

You can export a single model, a list of models, or a group of models that share certain characteristics.

```
-- Export the model named dt_sh_clas_sample
EXECUTE dbms_data_mining.export_model(
    filename => 'one_model',
    directory => 'DMDIR',
    model_filter => 'name in (''DT_SH_CLAS_SAMPLE'')');
```

```
-- one_model01.dmp and dm1_exp_37.log are created in /scratch/oml_user/expimp
```

```
-- Export Decision Tree models
EXECUTE dbms_data_mining.export_model(
    filename => 'algo_models',
    directory => 'DMDIR',
);
model_filter => 'ALGORITHM_NAME IN (''DECISION_TREE'')');
-- algo_model01.dmp and dml_exp_410.log are created in /scratch/oml_user/expimp

-- Export clustering models
EXECUTE dbms_data_mining.export_model(
  _filename => 'func_models',
  directory => 'DMDIR',
  model_filter => 'FUNCTION_NAME = ''CLUSTERING''');
-- func_model01.dmp and dml_exp_513.log are created in /scratch/oml_user/expimp

Related Topics
• Oracle Database PL/SQL Packages and Types Reference

38.3.5 EXPORT and IMPORT Serialized Models

From Oracle Database Release 18c onwards, EXPORT_SERMODEL and IMPORT_SERMODEL procedures are available to export and import serialized models.

The serialized format allows the models to be moved to another platform (outside the database) for scoring. The model is exported in a BLOB that can be saved in a BFILE. The import routine takes the serialized content in the BLOB and the name of the model to be created with the content.

Related Topics
• EXPORT_SERMODEL Procedure
• IMPORT_SERMODEL Procedure

38.3.6 Import From PMML

You can import regression models represented in Predictive Model Markup Language (PMML).

PMML is an XML-based standard specified by the Data Mining Group (https://www.dmg.org). Applications that are PMML-compliant can deploy PMML-compliant models that were created by any vendor. Oracle Machine Learning for SQL supports the core features of PMML 3.1 for regression models.

You can import regression models represented in PMML. The models must be of type RegressionModel, either linear regression or binary logistic regression.

Related Topics
• Oracle Database PL/SQL Packages and Types Reference

38.4 Control Access to Oracle Machine Learning for SQL Models and Data

You can create a Oracle Machine Learning for SQL user and grant necessary privileges by following the steps listed.

• Create an Oracle Machine Learning for SQL User
• System Privileges for Oracle Machine Learning for SQL
38.4.1 Create an Oracle Machine Learning for SQL User

An OML4SQL user is a database user account that has privileges for performing machine learning activities.

Example 38-6 shows how to create a database user. Example 38-7 shows how to assign machine learning privileges to the user.

**Note:**

To create a user for the OML4SQL examples, you must run two configuration scripts as described in Oracle Machine Learning for SQL Examples.

**Example 38-6 Creating a Database User in SQL*Plus**

1. Log in to SQL*Plus with system privileges.

   Enter user-name: sys as sysdba
   Enter password: password

2. To create a user named `oml_user`, type these commands. Specify a password of your choosing.

   ```sql
   CREATE USER oml_user IDENTIFIED BY password
   DEFAULT TABLESPACE USERS
   TEMPORARY TABLESPACE TEMP
   QUOTA UNLIMITED ON USERS;
   Commit;
   ```

   The `USERS` and `TEMP` tablespaces are included in Oracle Database. `USERS` is used mostly by demo users; it is appropriate for running the examples described in Oracle Machine Learning for SQL Examples. `TEMP` is the temporary tablespace that is shared by most database users.

**Note:**

Tablespaces for OML4SQL users must be assigned according to standard DBA practices, depending on system load and system resources.

3. To log in as `oml_user`, enter the following.

   ```sql
   CONNECT oml_user
   Enter password: password
   ```

**See Also:**

*Oracle Database SQL Language Reference* for the complete syntax of the `CREATE USER` statement.
38.4.1.1 Grant Privileges for Oracle Machine Learning for SQL

The **CREATE MINING MODEL** is a privilege that you must have to create and perform operations on your model. Some other machine learning privileges can be assigned by issuing `GRANT` statements.

You must have the **CREATE MINING MODEL** privilege to create models in your own schema. You can perform any operation on models that you own. This includes applying the model, adding a cost matrix, renaming the model, and dropping the model.

The `GRANT` statements in the following example assign a set of basic machine learning privileges to the `oml_user` account. Some of these privileges are not required for all machine learning activities, however it is prudent to grant them all as a group.

Additional system and object privileges are required for enabling or restricting specific machine learning activities.

The following table lists the system privileges required for running the OML4SQL examples.

### Table 38-2 System Privileges Granted by `dmshgrants.sql` to the OML4SQL User

<table>
<thead>
<tr>
<th>Privilege</th>
<th>Allows the OML4SQL User To</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE SESSION</td>
<td>Log in to a database session</td>
</tr>
<tr>
<td>CREATE TABLE</td>
<td>Create tables, such as the settings tables for <code>CREATE_MODEL</code></td>
</tr>
<tr>
<td>CREATE VIEW</td>
<td>Create views, such as the views of tables in the <code>SH</code> schema</td>
</tr>
<tr>
<td>CREATE MINING MODEL</td>
<td>Create OML4SQL models</td>
</tr>
<tr>
<td>EXECUTE ON ctxsys.ctx_ddl</td>
<td>Execute procedures in the <code>ctxsys.ctx_ddl</code> PL/SQL package; required for text mining</td>
</tr>
</tbody>
</table>

**Example 38-7 Privileges Required for Machine Learning**

This example grants the required privileges to the user `oml_user`.

```sql
GRANT CREATE SESSION TO oml_user;
GRANT CREATE TABLE TO oml_user;
GRANT CREATE VIEW TO oml_user;
GRANT CREATE MINING MODEL TO oml_user;
GRANT EXECUTE ON CTXSYS.CTX_DDL TO oml_user;
```

**READ** or **SELECT** privileges are required for data that is not in your schema. For example, the following statement grants **SELECT** access to the `sh.customers` table.

```sql
GRANT SELECT ON sh.customers TO oml_user;
```
38.4.2 System Privileges for Oracle Machine Learning for SQL

A system privilege confers the right to perform a particular action in the database or to perform an action on a type of schema objects. For example, the privileges to create tablespaces and to delete the rows of any table in a database are system privileges.

You can perform specific operations on machine learning models in other schemas if you have the appropriate system privileges. For example, CREATE ANY MINING MODEL enables you to create models in other schemas. SELECT ANY MINING MODEL enables you to apply models that reside in other schemas. You can add comments to models if you have the COMMENT ANY MINING MODEL privilege.

To grant a system privilege, you must either have been granted the system privilege with the ADMIN OPTION or have been granted the GRANT ANY PRIVILEGE system privilege.

The system privileges listed in the following table control operations on machine learning models.

Table 38-3 System Privileges for Oracle Machine Learning for SQL

<table>
<thead>
<tr>
<th>System Privilege</th>
<th>Allows you to...</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE MINING MODEL</td>
<td>Create machine learning models in your own schema.</td>
</tr>
<tr>
<td>CREATE ANY MINING MODEL</td>
<td>Create machine learning models in any schema.</td>
</tr>
<tr>
<td>ALTER ANY MINING MODEL</td>
<td>Change the name or cost matrix of any machine learning model in any schema.</td>
</tr>
<tr>
<td>DROP ANY MINING MODEL</td>
<td>Drop any machine learning model in any schema.</td>
</tr>
<tr>
<td>SELECT ANY MINING MODEL</td>
<td>Apply a machine learning model in any schema, also view model details in any schema.</td>
</tr>
<tr>
<td>COMMENT ANY MINING MODEL</td>
<td>Add a comment to any machine learning model in any schema.</td>
</tr>
<tr>
<td>AUDIT_ADMIN role</td>
<td>Generate an audit trail for any machine learning model in any schema. (See Oracle Database Security Guide for details.)</td>
</tr>
</tbody>
</table>

Example 38-8 Grant System Privileges for Oracle Machine Learning for SQL

The following statements allow oml_user to score data and view model details in any schema as long as SELECT access has been granted to the data. However, oml_user can only create models in the oml_user schema.

GRANT CREATE MINING MODEL TO oml_user;
GRANT SELECT ANY MINING MODEL TO oml_user;

The following statement revokes the privilege of scoring or viewing model details in other schemas. When this statement is run, oml_user can only perform machine learning activities in the oml_user schema.

REVOKE SELECT ANY MINING MODEL FROM oml_user;

Related Topics

- Add a Comment to an Oracle Machine Learning for SQL Model
  You can add a comment to an OML4SQL model object using SQL COMMENT statement.
38.4.3 Object Privileges for Oracle Machine Learning for SQL Models

Learn about machine learning object privileges.

An object privilege confers the right to perform a particular action on a specific schema object. For example, the privilege to delete rows from the \texttt{SH.PRODUCTS} table is an example of an object privilege.

You automatically have all object privileges for schema objects in your own schema. You can grant object privilege on objects in your own schema to other users or roles.

The object privileges listed in the following table control operations on specific machine learning models.

\textbf{Table 38-4} Object Privileges for Oracle Machine Learning for SQL Models

<table>
<thead>
<tr>
<th>Object Privilege</th>
<th>Allows you to....</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{ALTER MINING MODEL}</td>
<td>Change the name or cost matrix of the specified machine learning model object.</td>
</tr>
<tr>
<td>\texttt{SELECT MINING MODEL}</td>
<td>Apply the specified machine learning model object and view its model details.</td>
</tr>
</tbody>
</table>

\textbf{Example 38-9} Grant Object Privileges on Oracle Machine Learning for SQL Models

The following statements allow \texttt{oml_user} to apply the model \texttt{testmodel} to the \texttt{sales} table, specifying different cost matrixes with each apply. The user \texttt{oml_user} can also rename the model \texttt{testmodel}. The \texttt{testmodel} model and \texttt{sales} table are in the \texttt{sh} schema, not in the \texttt{oml_user} schema.

\begin{verbatim}
GRANT SELECT ON MINING MODEL sh.testmodel TO oml_user;
GRANT ALTER ON MINING MODEL sh.testmodel TO oml_user;
GRANT SELECT ON sh.sales TO oml_user;
\end{verbatim}

The following statement prevents \texttt{oml_user} from renaming or changing the cost matrix of \texttt{testmodel}. However, \texttt{oml_user} can still apply \texttt{testmodel} to the \texttt{sales} table.

\begin{verbatim}
REVOKE ALTER ON MINING MODEL sh.testmodel FROM oml_user;
\end{verbatim}

38.5 Audit and Add Comments to Oracle Machine Learning for SQL Models

Perform audit of Oracle Machine Learning for SQL model objects through SQL statements.

\texttt{OML4SQL} model objects support SQL \texttt{COMMENT} and \texttt{AUDIT} statements.
38.5.1 Add a Comment to an Oracle Machine Learning for SQL Model

You can add a comment to an OML4SQL model object using SQL `COMMENT` statement. Comments can be used to associate descriptive information with a database object. You can associate a comment with a machine learning model using a SQL `COMMENT` statement.

```
COMMENT ON MINING MODEL schema_name.model_name IS string;
```

**Note:**
To add a comment to a model in another schema, you must have the `COMMENT ANY MINING MODEL` system privilege.

To drop a comment, set it to the empty '' string.

The following statement adds a comment to the model `DT_SH_CLAS_SAMPLE` in your own schema.

```
COMMENT ON MINING MODEL dt_sh_clas_sample IS 'Decision Tree model predicts promotion response';
```

You can view the comment by querying the catalog view `USER_MINING_MODELS`.

```
SELECT model_name, mining_function, algorithm, comments FROM user_mining_models;
```

<table>
<thead>
<tr>
<th>MODEL_NAME</th>
<th>MINING_FUNCTION</th>
<th>ALGORITHM</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT_SH_CLAS_SAMPLE</td>
<td>CLASSIFICATION</td>
<td>DECISION_TREE</td>
<td>Decision Tree model predicts promotion response</td>
</tr>
</tbody>
</table>

To drop this comment from the database, issue the following statement:

```
COMMENT ON MINING MODEL dt_sh_clas_sample '';
```

**See Also:**
- Table 38-3
- *Oracle Database SQL Language Reference* for details about SQL `COMMENT` statements

38.5.2 Audit Oracle Machine Learning for SQL Models

Use Oracle Database auditing system to audit models to track operations on machine learning models.

The Oracle Database auditing system is a powerful, highly configurable tool for tracking operations on schema objects in a production environment. The auditing system can be used to track operations on machine learning models.
To audit machine learning models, you must have the AUDIT_ADMIN role.

Unified auditing is documented in Oracle Database Security Guide. However, the full unified auditing system is not enabled by default. Instructions for migrating to unified auditing are provided in Oracle Database Upgrade Guide.

**See Also:**

- "Auditing Oracle Machine Learning for SQL Events" in Oracle Database Security Guide for details about auditing machine learning models
- "Monitoring Database Activity with Auditing" in Oracle Database Security Guide for a comprehensive discussion of unified auditing in Oracle Database
- "About the Unified Auditing Migration Process for Oracle Database" in Oracle Database Upgrade Guide for information about migrating to unified auditing
- Oracle Database Upgrade Guide
39

Oracle Machine Learning for SQL Examples

Describes the OML4SQL examples.

- About the OML4SQL Examples
- Install the OML4SQL Examples
- OML4SQL Sample Data

39.1 About the OML4SQL Examples

The OML4SQL examples illustrate typical approaches to data preparation, algorithm selection, algorithm tuning, testing, and scoring.

You can learn a great deal about the OML4SQL application programming interface from the OML4SQL examples. The examples are simple. They include extensive inline comments to help you understand the code. They delete all temporary objects on exit so that you can run the examples repeatedly without setup or cleanup.

The OML4SQL examples are available on GitHub at https://github.com/oracle/oracle-db-examples/tree/master/machine-learning/sql/21c.

The OML4SQL examples create a set of machine learning models in the user's schema. The following table lists the file name of the example and the `mining_function` value and algorithm the example uses.

<table>
<thead>
<tr>
<th>File Name</th>
<th>MINING_FUNCTION</th>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>oml4sql-association-rules.sql</td>
<td>ASSOCIATION</td>
<td>ALGO_APRIORI_ASSOCIATION_RULES</td>
</tr>
<tr>
<td>oml4sql-feature-extraction-cur.sql</td>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>ALGO_CUR_DECOMPOSITION</td>
</tr>
<tr>
<td>oml4sql-classification-decision-tree.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_DECISION_TREE</td>
</tr>
<tr>
<td>oml4sql-cross-validation-decision-tree.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_DECISION_TREE</td>
</tr>
<tr>
<td>oml4sql-classification-glm.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_GENERALIZED_LINEAR_MODEL</td>
</tr>
<tr>
<td>oml4sql-time-series-mset.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_MSET_SPRT</td>
</tr>
<tr>
<td>oml4sql-classification-naive-bayes.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_NAIVE_BAYES</td>
</tr>
<tr>
<td>oml4sql-classification-neural-networks.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_NEURAL_NETWORK</td>
</tr>
<tr>
<td>oml4sql-classification-random-forest.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_RANDOM_FOREST</td>
</tr>
</tbody>
</table>
Another example is `oml4sql-attribute-importance.sql`, which uses the `DBMS_PREDICTIVE_ANALYTICS.EXPLAIN` procedure to find the importance of attributes that independently impact the target attribute.

Another set of examples demonstrates the use of the `ALGO_EXTENSIBLE_LANG` algorithm to register R language functions and create R models. The following table lists the R Extensibility examples. It shows the file name of the example and the `MINING_FUNCTION` value and R function used.

### Table 39-1  (Cont.) Models Created by Examples

<table>
<thead>
<tr>
<th>File Name</th>
<th>MINING_FUNCTION</th>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>oml4sql-anomaly-detection-lcsvm.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
</tr>
<tr>
<td>oml4sql-classification-svm.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
</tr>
<tr>
<td>oml4sql-classification-text-analysis-svm.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
</tr>
<tr>
<td>oml4sql-partitioned-models-svm.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
</tr>
<tr>
<td>oml4sql-classification-regression-xgboost.sql</td>
<td>CLASSIFICATION</td>
<td>ALGO_XGBOOST</td>
</tr>
<tr>
<td>oml4sql-clustering-expectation-maximization.sql</td>
<td>CLUSTERING</td>
<td>ALGO_EXPECTATION_MAXIMIZATION</td>
</tr>
<tr>
<td>oml4sql-clustering-kmeans.sql</td>
<td>CLUSTERING</td>
<td>ALGO_KMEANS</td>
</tr>
<tr>
<td>oml4sql-clustering-kmeans-star-schema.sql</td>
<td>CLUSTERING</td>
<td>ALGO_KMEANS</td>
</tr>
<tr>
<td>oml4sql-clustering-o-cluster.sql</td>
<td>CLUSTERING</td>
<td>ALGO_O_CLUSTER</td>
</tr>
<tr>
<td>oml4sql-feature-extraction-text-analysis-esa.sql</td>
<td>FEATURE_EXTRACTION</td>
<td>ALGO_EXPLICIT SEMANTIC ANALYS</td>
</tr>
<tr>
<td>oml4sql-feature-extraction-nmf.sql</td>
<td>FEATURE_EXTRACTION</td>
<td>ALGO_NONNEGATIVE MATRIX_FACTOR</td>
</tr>
<tr>
<td>oml4sql-feature-extraction-nmf.sql</td>
<td>FEATURE_EXTRACTION</td>
<td>ALGO_NONNEGATIVE MATRIX_FACTOR</td>
</tr>
<tr>
<td>oml4sql-singular-value-decomposition.sql</td>
<td>FEATURE_EXTRACTION</td>
<td>ALGO_SINGULAR_VALUE_DECOMP</td>
</tr>
<tr>
<td>oml4sql-regression-glm.sql</td>
<td>REGRESSION</td>
<td>ALGO_GENERALIZED_LINEAR_MODEL</td>
</tr>
<tr>
<td>oml4sql-regression-neural-networks.sql</td>
<td>REGRESSION</td>
<td>ALGO_NEURAL_NETWORK</td>
</tr>
<tr>
<td>oml4sql-regression-random-forest.sql</td>
<td>REGRESSION</td>
<td>ALGO_RANDOM_FOREST</td>
</tr>
<tr>
<td>oml4sql-regression-svm.sql</td>
<td>REGRESSION</td>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
</tr>
<tr>
<td>oml4sql-classification-regression-xgboost.sql</td>
<td>REGRESSION</td>
<td>ALGO_XGBOOST</td>
</tr>
<tr>
<td>oml4sql-time-series-exponential-smoothing.sql</td>
<td>TIME_SERIES</td>
<td>ALGO_EXPONENTIAL SMOOTHING</td>
</tr>
</tbody>
</table>
39.2 Install the OML4SQL Examples

Learn how to install OML4SQL examples.

The OML4SQL examples require:

- Oracle Database (on-premises, Oracle Database Cloud Service, or Oracle Autonomous Database)
- Oracle Database sample schemas
- A user account with the privileges described in Grant Privileges for Oracle Machine Learning for SQL.
- Execution of `dmshgrants.sql` by a system administrator
- Execution of `dmsh.sql` by the OML4SQL user

Follow these steps to install the OML4SQL examples:

1. Install or obtain access to an Oracle Database 21c instance. To install the database, see the installation instructions for your platform at Oracle Database 21c.
2. Ensure that the sample schemas are installed in the database. See Oracle Database Sample Schemas for details about the sample schemas.
3. Download the example code files from GitHub at https://github.com/oracle/oracle-db-examples/tree/master/machine-learning/sql/21c. Place the files in a directory to which you have access on the Oracle Database server.
4. Verify that your user account has the required privileges described in Grant Privileges for Oracle Machine Learning for SQL.
5. Ask your system administrator to run the `dmshgrants.sql` script, or run it yourself if you have administrative privileges. The script grants the privileges that are required for running the examples. These include SELECT access to tables in the SH schema as
described in OML4SQL Sample Data and the system privileges listed in the following table.

Pass the name of the OML4SQL user to `dmshgrants`.

```
SQL> CONNECT sys / as sysdba
Enter password: sys_password
Connected.
SQL> @<location_of_examples>/dmshgrants oml_user
```

6. Connect to the database and run the `dmsh.sql` script. This script creates views of the sample data in the schema of the OML4SQL user.

```
SQL> CONNECT oml_user
Enter password: oml_user_password
Connected.
SQL> @<location_of_examples>/dmsh
```

Related Topics

- Oracle Database Sample Schemas

### 39.3 OML4SQL Sample Data

The data used by the OML4SQL examples is based on these tables in the `SH` schema.

Those tables are:

- `SH.CUSTOMERS`
- `SH.SALES`
- `SH.PRODUCTS`
- `SH.SUPPLEMENTARY_DEMOGRAPHICS`
- `SH.COUNTRIES`

The `dmshgrants` script grants `SELECT` access to the tables in the `SH` schema. The `dmsh.sql` script creates views of the `SH` tables in the schema of the OML4SQL user. The views are described in the following table.

#### Table 39-2 Views Created by `dmsh.sql`

<table>
<thead>
<tr>
<th>View Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINING_DATA</td>
<td>Joins and filters data</td>
</tr>
<tr>
<td>MINING_DATA_BUILD_V</td>
<td>Data for building models</td>
</tr>
<tr>
<td>MINING_DATA_TEST_V</td>
<td>Data for testing models</td>
</tr>
<tr>
<td>MINING_DATA_APPLY_V</td>
<td>Data to be scored</td>
</tr>
<tr>
<td>MINING_BUILD_TEXT</td>
<td>Data for building models that include text</td>
</tr>
<tr>
<td>MINING_TEST_TEXT</td>
<td>Data for testing models that include text</td>
</tr>
<tr>
<td>MINING_APPLY_TEXT</td>
<td>Data, including text columns, to be scored</td>
</tr>
<tr>
<td>MINING_DATA_ONE_CLASS_V</td>
<td>Data for anomaly detection</td>
</tr>
</tbody>
</table>

The association rules example creates its own transactional data.
Learn about Oracle Machine Learning for SQL PL/SQL packages, data dictionary views, and machine learning SQL scoring functions.

- PL/SQL Packages
- Data Dictionary Views
- SQL Scoring Functions
Learn how to create, evaluate, and query machine learning models through Oracle Machine Learning for SQL PL/SQL packages.

- **DBMS_DATA_MINING**
- **DBMS_DATA_MINING_TRANSFORM**
- **DBMS_PREDICTIVE_ANALYTICS**

### 40.1 DBMS_DATA_MINING

The **DBMS_DATA_MINING** package is the application programming interface for creating, evaluating, and querying Oracle Machine Learning for SQL models.

In Oracle Database Release 21c, Oracle Data Mining has been rebranded to Oracle Machine Learning for SQL (OML4SQL). The PL/SQL package name, however, has not changed and remains **DBMS_DATA_MINING**.

This chapter contains the following topics:

- Overview
- Security Model
- Mining Functions
- Model Settings
- Solver Settings
- Datatypes
- Summary of DBMS_DATA_MINING Subprograms

**See Also:**

- Oracle Machine Learning for SQL Concepts
- Oracle Machine Learning for SQL User’s Guide
- DBMS_DATA_MINING_TRANSFORM
- DBMS_PREDICTIVE_ANALYTICS

### 40.1.1 Using DBMS_DATA_MINING

This section contains topics that relate to using the **DBMS_DATA_MINING** package.

- Overview
- Security Model
Oracle Machine Learning for SQL supports both supervised and unsupervised machine learning. Supervised machine learning predicts a target value based on historical data. Unsupervised machine learning discovers natural groupings and does not use a target. You can use OML4SQL procedures on structured data and unstructured text.

Supervised machine learning techniques include:
- Classification
- Regression
- Feature Selection (Attribute Importance)

Unsupervised machine learning techniques include:
- Clustering
- Association
- Feature Extraction
- Anomaly Detection

The steps you use to build and apply a machine learning model depend on the machine learning technique and the algorithm being used. The algorithms supported by Oracle Machine Learning for SQL are listed in Table 40-1.

Table 40-1  OML4SQL Algorithms

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Abbreviation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apriori</td>
<td>AR</td>
<td>Association</td>
</tr>
<tr>
<td>CUR Matrix Decomposition</td>
<td>CUR</td>
<td>Attribute importance</td>
</tr>
<tr>
<td>Decision Tree</td>
<td>DT</td>
<td>Classification</td>
</tr>
<tr>
<td>Expectation Maximization</td>
<td>EM</td>
<td>Clustering</td>
</tr>
<tr>
<td>Explicit Semantic Analysis</td>
<td>ESA</td>
<td>Feature extraction, classification</td>
</tr>
<tr>
<td>Exponential Smoothing</td>
<td>ESM</td>
<td>Time series</td>
</tr>
<tr>
<td>Generalized Linear Model</td>
<td>GLM</td>
<td>Classification, regression</td>
</tr>
<tr>
<td>k-Means</td>
<td>KM</td>
<td>Clustering</td>
</tr>
<tr>
<td>Minimum Descriptor Length</td>
<td>MDL</td>
<td>Attribute importance</td>
</tr>
<tr>
<td>Multivariate State Estimation Technique - Sequential Probability Ratio Test</td>
<td>MSET-SPRT</td>
<td>Anomaly detection, classification</td>
</tr>
<tr>
<td>Naive Bayes</td>
<td>NB</td>
<td>Classification</td>
</tr>
<tr>
<td>Neural Networks</td>
<td>NN</td>
<td>Classification, regression</td>
</tr>
<tr>
<td>Non-Negative Matrix Factorization</td>
<td>NMF</td>
<td>Feature extraction</td>
</tr>
<tr>
<td>Orthogonal Partitioning Clustering</td>
<td>O-Cluster</td>
<td>Clustering</td>
</tr>
</tbody>
</table>
OML4SQL supports more than one algorithm for the classification, regression, clustering, and feature extraction machine learning techniques. Each of these machine learning techniques has a default algorithm, as shown in Table 40-2.

<table>
<thead>
<tr>
<th>Mining Function</th>
<th>Default Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>Naive Bayes</td>
</tr>
<tr>
<td>Clustering</td>
<td>k-Means</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>Non-Negative Matrix Factorization</td>
</tr>
<tr>
<td>Feature Selection</td>
<td>Minimum Descriptor Length</td>
</tr>
<tr>
<td>Regression</td>
<td>Support Vector Machine</td>
</tr>
<tr>
<td>Time Series</td>
<td>Exponential Smoothing</td>
</tr>
</tbody>
</table>

### 40.1.1.2 DBMS_DATA_MINING Security Model

The DBMS_DATA_MINING package is owned by user SYS and is installed as part of database installation. Execution privilege on the package is granted to public. The routines in the package are run with invokers' rights (run with the privileges of the current user).

The DBMS_DATA_MINING package exposes APIs that are leveraged by the Oracle Machine Learning for SQL. Users who wish to create machine learning models in their own schema require the CREATE MINING MODEL system privilege. Users who wish to create machine learning models in other schemas require the CREATE ANY MINING MODEL system privilege.

Users have full control over managing models that exist within their own schema. Additional system privileges necessary for managing machine learning models in other schemas include ALTER ANY MINING MODEL, DROP ANY MINING MODEL, SELECT ANY MINING MODEL, COMMENT ANY MINING MODEL, and AUDIT ANY.

Individual object privileges on machine learning models, ALTER MINING MODEL and SELECT MINING MODEL, can be used to selectively grant privileges on a model to a different user.

See Also:

Oracle Data Mining User's Guide for more information about the security features of OML4SQL.
40.1.3 DBMS_DATA_MINING — Machine Learning Functions

A machine learning function refers to the methods for solving a given class of machine learning problems.

The machine learning function must be specified when a model is created. You specify a machine learning function with the mining_function parameter of the CREATE_MODEL Procedure or the CREATE_MODEL2 Procedure.

Table 40-3    Machine Learning Functions

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATION</td>
<td>Association is a descriptive machine learning function. An association model identifies relationships and the probability of their occurrence within a data set. Association models use the Apriori algorithm.</td>
</tr>
<tr>
<td>ATTRIBUTE_IMPORTANCE</td>
<td>Attribute importance is a predictive machine learning function, also known as feature selection. An attribute importance model identifies the relative importance of an attribute in predicting a given outcome. Attribute importance models can use Minimum Description Length (MDL) or CUR Matrix Decomposition. MDL is the default.</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
<td>Classification is a predictive machine learning function. A classification model uses historical data to predict a categorical target. Classification models can use: Decision Tree, logistic regression, Multivariate State Estimation Technique - Sequential Probability Ratio Test, Naïve Bayes, Support Vector Machine (SVM), or XGBoost. The default is Naïve Bayes. The classification function can also be used for anomaly detection. For anomaly detection, you can use the Multivariate State Estimation Technique - Sequential Probability Ratio Test algorithm or the SVM algorithm with a null target (One-Class SVM).</td>
</tr>
<tr>
<td>CLUSTERING</td>
<td>Clustering is a descriptive machine learning function. A clustering model identifies natural groupings within a data set. Clustering models can use k-Means, O-Cluster, or Expectation Maximization. The default is k-Means.</td>
</tr>
<tr>
<td>FEATURE_EXTRACTION</td>
<td>Feature extraction is a descriptive machine learning function. A feature extraction model creates an optimized data set on which to base a model. Feature extraction models can use Explicit Semantic Analysis, Non-Negative Matrix Factorization, Singular Value Decomposition, or Principal Component Analysis. Non-Negative Matrix Factorization is the default.</td>
</tr>
<tr>
<td>REGRESSION</td>
<td>Regression is a predictive machine learning function. A regression model uses historical data to predict a numerical target. Regression models can use linear regression, Support Vector Machine, or XGBoost. The default is Support Vector Machine.</td>
</tr>
</tbody>
</table>
Table 40-3 (Cont.) Machine Learning Functions

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME_SERIES</td>
<td>Time series is a predictive machine learning function. A time series model forecasts the future values of a time-ordered series of historical numeric data over a user-specified time window. Time series models use the Exponential Smoothing algorithm.</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for more information about mining functions

40.1.2 DBMS_DATA_MINING — Model Settings

Oracle Machine Learning for SQL uses settings to specify the algorithm and other characteristics of a model. Some settings are general, some are specific to a machine learning function, and some are specific to an algorithm.

All settings have default values. If you want to override one or more of the settings for a model, then you must create a settings table. The settings table must have the column names and data types shown in the following table.

Table 40-4 Required Columns in the Model Settings Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SETTING_NAME</td>
<td>VARCHAR2 (30)</td>
</tr>
<tr>
<td>SETTING_VALUE</td>
<td>VARCHAR2 (4000)</td>
</tr>
</tbody>
</table>

The information you provide in the settings table is used by the model at build time. The name of the settings table is an optional argument to the `CREATE_MODEL` Procedure.

You can find the settings used by a model by querying the data dictionary view `ALL_MINING_MODEL_SETTINGS`. This view lists the model settings used by the machine learning models to which you have access. All the setting values are included in the view, whether default or user-specified.

See Also:

- `ALL_MINING_MODEL_SETTINGS` in *Oracle Database Reference*
- *Oracle Machine Learning for SQL User’s Guide* for information about specifying model settings
### 40.1.2.1 DBMS_DATA_MINING — Algorithm Names

The `ALGO_NAME` setting specifies the model algorithm.

The values for the `ALGO_NAME` setting are listed in the following table.

<table>
<thead>
<tr>
<th>ALGO_NAME Value</th>
<th>Description</th>
<th>Machine Learning Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGO_AI_MDL</td>
<td>Minimum Description Length</td>
<td>Attribute importance</td>
</tr>
<tr>
<td>ALGO_APRIORI_ASSOCIATION_RULES</td>
<td>Apriori</td>
<td>Association rules</td>
</tr>
<tr>
<td>ALGO_CUR_DECOMPOSITION</td>
<td>CUR Matrix Decomposition</td>
<td>Attribute importance</td>
</tr>
<tr>
<td>ALGO_DECISION_TREE</td>
<td>Decision Tree</td>
<td>Classification</td>
</tr>
<tr>
<td>ALGOEXPECTATION_MAXIMIZATION</td>
<td>Expectation Maximization</td>
<td>Clustering</td>
</tr>
<tr>
<td>ALGO_EXPLICITSemantic_ANALYSIS</td>
<td>Explicit Semantic Analysis</td>
<td>Feature extraction</td>
</tr>
<tr>
<td>ALGO_EXPONENTIAL_SMOOTHING</td>
<td>Exponential Smoothing</td>
<td>Time series</td>
</tr>
<tr>
<td>ALGO_EXTENSIBLE_LANG</td>
<td>Language used for extensible algorithm</td>
<td>All mining functions supported</td>
</tr>
<tr>
<td>ALGO_GENERALIZED_LINEAR_MODEL</td>
<td>Generalized Linear Model</td>
<td>Classification, regression; also feature selection and generation</td>
</tr>
<tr>
<td>ALGO_KMEANS</td>
<td>Enhanced k-Means</td>
<td>Clustering</td>
</tr>
<tr>
<td>ALGO_MSET_SPRT</td>
<td>Multivariate State Estimation Technique - Sequential Probability Ratio Test</td>
<td>Classification</td>
</tr>
<tr>
<td>ALGO_NAIVE_BAYES</td>
<td>Naive Bayes</td>
<td>Classification</td>
</tr>
<tr>
<td>ALGO_NEURAL_NETWORK</td>
<td>Neural Network</td>
<td>Classification</td>
</tr>
<tr>
<td>ALGO_NONNEGATIVE_MATRIX_FACTOR</td>
<td>Non-Negative Matrix Factorization</td>
<td>Feature extraction</td>
</tr>
<tr>
<td>ALGO_O_CLUSTER</td>
<td>O-Cluster</td>
<td>Clustering</td>
</tr>
<tr>
<td>ALGO_RANDOM_FOREST</td>
<td>Random Forest</td>
<td>Classification</td>
</tr>
<tr>
<td>ALGO_SINGULAR_VALUE_DECOMP</td>
<td>Singular Value Decomposition</td>
<td>Feature extraction</td>
</tr>
<tr>
<td>ALGO_SUPPORT VECTOR MACHINES</td>
<td>Support Vector Machine</td>
<td>Classification and regression</td>
</tr>
<tr>
<td>ALGO_XGBOOST</td>
<td>XGBoost</td>
<td>Classification and regression</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for information about algorithms
40.1.2.2 DBMS_DATA_MINING — Automatic Data Preparation

Oracle Machine Learning for SQL supports fully Automatic Data Preparation (ADP), user-directed general data preparation, and user-specified embedded data preparation. The PREP_* settings enable the user to request fully automated or user-directed general data preparation. By default, fully Automatic Data Preparation (PREP_AUTO_ON) is enabled.

When you enable ADP, the model uses heuristics to transform the build data according to the requirements of the algorithm. Instead of fully ADP, the user can request that the data be shifted and/or scaled with the PREP_SCALE* and PREP_SHIFT* settings. The transformation instructions are stored with the model and reused whenever the model is applied. The model settings can be viewed in USER_MINING_MODEL_SETTINGS.

You can choose to supplement Automatic Data Preparations by specifying additional transformations in the xform_list parameter when you build the model. See "CREATE_MODEL Procedure" and "CREATE_MODEL2 Procedure".

If you do not use ADP and do not specify transformations in the xform_list parameter to CREATE_MODEL, you must implement your own transformations separately in the build, test, and scoring data. You must take special care to implement the exact same transformations in each data set.

If you do not use ADP, but you do specify transformations in the xform_list parameter to CREATE_MODEL, OML4SQL embeds the transformation definitions in the model and prepares the test and scoring data to match the build data.

The values for the PREP_* setting are described in the following table.

**Table 40-6  PREP_* Setting**

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| PREP_AUTO    | • PREP_AUTO_ON  
               • PREP_AUTO_OFF | This setting enables fully automated data preparation. The default is PREP_AUTO_ON. |
| PREP_SCALE_2DNUM | • PREP_SCALE_STDDEV  
                     • PREP_SCALE_RANGE | This setting enables scaling data preparation for two-dimensional numeric columns. PREP_AUTO must be OFF for this setting to take effect. The following are the possible values: |
| PREP_SCALE_NNUM | PREP_SCALE_MAXABS | This setting enables scaling data preparation for nested numeric columns. PREP_AUTO must be OFF for this setting to take effect. If specified, then the valid value for this setting is PREP_SCALE_MAXABS, which yields data in the range of [-1,1]. |
Table 40-6  (Cont.) PREP_* Setting

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREP SHIFT_2DNUM</td>
<td>• PREP SHIFT_MEAN</td>
<td>This setting enables centering data preparation for two-dimensional numeric columns. PREP_AUTO must be OFF for this setting to take effect. The following are the possible values: • PREP SHIFT_MEAN: Results in subtracting the average of the column from each value. • PREP SHIFT_MIN: Results in subtracting the minimum of the column from each value.</td>
</tr>
<tr>
<td>• PREP SHIFT_MIN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Also:

Oracle Machine Learning for SQL User’s Guide for information about data transformations

40.1.2.3 DBMS_DATA_MINING — Machine Learning Function Settings

The settings described in this table apply to a machine learning function.

Table 40-7  Machine Learning Function Settings

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association</td>
<td>ASSO_MAX_RULE_LENGTH</td>
<td>TO_CHAR( 2&lt;=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>numeric_exp</td>
<td>Maximum rule length for association rules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>r &lt;=20)</td>
<td>Default is 4.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_MIN_CONFIDENCE</td>
<td>TO_CHAR( 0&lt;=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>numeric_exp</td>
<td>Minimum confidence for association rules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>r &lt;=1)</td>
<td>Default is 0.1.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_MIN_SUPPORT</td>
<td>TO_CHAR( 0&lt;=</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>numeric_exp</td>
<td>Minimum support for association rules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>r &lt;=1)</td>
<td>Default is 0.1.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_MIN_SUPPORT_INT</td>
<td>a positive</td>
<td>Minimum absolute support that each rule must</td>
</tr>
<tr>
<td></td>
<td></td>
<td>integer</td>
<td>satisfy. The value must be an integer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The default is 1.</td>
</tr>
</tbody>
</table>
Table 40-7  (Cont.) Machine Learning Function Settings

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association</td>
<td>ASSO_MIN_REV_CONFIDENCE</td>
<td>TO_CHAR( 0&lt;numeric_expr &lt;=1)</td>
<td>Sets the Minimum Reverse Confidence that each rule should satisfy. The Reverse Confidence of a rule is defined as the number of transactions in which the rule occurs divided by the number of transactions in which the consequent occurs. The value is a real number between 0 and 1. The default is 0.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_IN_RULES</td>
<td>NULL</td>
<td>Sets Including Rules applied for each association rule: it specifies the list of items that at least one of them must appear in each reported association rule, either as antecedent or as consequent. It is a comma separated string containing the list of including items. If not set, the default behavior is, the filtering is not applied.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_EX_RULES</td>
<td>NULL</td>
<td>Sets Excluding Rules applied for each association rule: it specifies the list of items that none of them can appear in each reported association rules. It is a comma separated string containing the list of excluded items. No rule can contain any item in the list. The default is NULL.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_ANT_IN_RULES</td>
<td>NULL</td>
<td>Sets Including Rules for the antecedent: it specifies the list of items that at least one of them must appear in the antecedent part of each reported association rule. It is a comma separated string containing the list of including items. The antecedent part of each rule must contain at least one item in the list. The default is NULL.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_ANT_EX_RULES</td>
<td>NULL</td>
<td>Sets Excluding Rules for the antecedent: it specifies the list of items that none of them can appear in the antecedent part of each reported association rule. It is a comma separated string containing the list of excluded items. No rule can contain any item in the list in its antecedent part. The default is NULL.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_CONS_IN_RULES</td>
<td>NULL</td>
<td>Sets Including Rules for the consequent: it specifies the list of items that at least one of them must appear in the consequent part of each reported association rule. It is a comma separated string containing the list of including items. The consequent of each rule must be an item in the list. The default is NULL.</td>
</tr>
</tbody>
</table>
### Table 40-7  (Cont.) Machine Learning Function Settings

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association</td>
<td>ASSO_CONS_EX_RULES</td>
<td>NULL</td>
<td>Sets Excluding Rules for the consequent: it specifies the list of items that none of them can appear in the consequent part of each reported association rule. It is a comma separated string containing the list of excluded items. No rule can have any item in the list as its consequent. The excluding rule can be used to reduce the data that must be stored, but the user may be required to build an extra model for executing different including or Excluding Rules. The default is NULL.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_AGGREGATES</td>
<td>NULL</td>
<td>Specifies the columns to be aggregated. It is a comma separated string containing the names of the columns for aggregation. The number of columns in the list must be &lt;= 10. You can set ASSO_AGGREGATES if ODMS_ITEM_ID_COLUMN_NAME is set indicating transactional input data. See DBMS_DATA_MINING - Global Settings. The data table must have valid column names such as ITEM_ID and CASE_ID which are derived from ODMS_ITEM_ID_COLUMN_NAME and case_id_column_name respectively. ITEM_VALUE is not a mandatory value. The default is NULL. For each item, the user may supply several columns to aggregate. It requires more memory to buffer the extra data. Also, the performance impact can be seen because of the larger input data set and more operation.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_ABS_ERROR</td>
<td>0&lt;ASSO_ABS_ERRORMAX(ASSO_MIN_SUPPORT, ASSO_MIN_CONFIDENCE)</td>
<td>Specifies the absolute error for the association rules sampling. A smaller value of ASSO_ABS_ERROR obtains a larger sample size which gives accurate results but takes longer computational time. Set a reasonable value for ASSO_ABS_ERROR, such as its default value, to avoid large sample size. The default value is $0.5 \times \max(\text{ASSO_MIN_SUPPORT}, \text{ASSO_MIN_CONFIDENCE})$.</td>
</tr>
<tr>
<td>Association</td>
<td>ASSO_CONF_LEVEL</td>
<td>0&lt;ASSO_CONF_LEVEL 1</td>
<td>Specifies the confidence level for an association rules sample. A larger value of ASSO_CONF_LEVEL obtains a larger sample size. Any value between 0.9 and 1 is suitable. The default value is 0.95.</td>
</tr>
</tbody>
</table>
Table 40-7 (Cont.) Machine Learning Function Settings

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>CLAS_COST_TABLE_NAME</td>
<td>table_name</td>
<td>(Decision tree only) Name of a table that stores a cost matrix to be used by the algorithm in building the model. The cost matrix specifies the costs associated with misclassifications. Only decision tree models can use a cost matrix at build time. All classification algorithms can use a cost matrix at apply time. The cost matrix table is user-created. See &quot;ADD_COST_MATRIX Procedure&quot; for the column requirements. See Oracle Machine Learning for SQL Concepts for information about costs.</td>
</tr>
<tr>
<td>Classification</td>
<td>CLAS_PRIORS_TABLE_NAME</td>
<td>table_name</td>
<td>(Naive Bayes) Name of a table that stores prior probabilities to offset differences in distribution between the build data and the scoring data. The priors table is user-created. See Oracle Machine Learning for SQL User’s Guide for the column requirements. See Oracle Machine Learning for SQL Concepts for additional information about priors.</td>
</tr>
<tr>
<td>Classification</td>
<td>CLAS_WEIGHTS_TABLE_NAME</td>
<td>table_name</td>
<td>(GLM and SVM only) Name of a table that stores weighting information for individual target values in SVM classification and GLM logistic regression models. The weights are used by the algorithm to bias the model in favor of higher weighted classes. The class weights table is user-created. See Oracle Machine Learning for SQL User’s Guide for the column requirements. See Oracle Machine Learning for SQL Concepts for additional information about class weights.</td>
</tr>
<tr>
<td>Classification</td>
<td>CLAS_WEIGHTS_BALANCED</td>
<td>ON/OFF</td>
<td>This setting indicates that the algorithm must create a model that balances the target distribution. This setting is most relevant in the presence of rare targets, as balancing the distribution may enable better average accuracy (average of per-class accuracy) instead of overall accuracy (which favors the dominant class). The default value is OFF.</td>
</tr>
</tbody>
</table>
## Table 40-7  (Cont.) Machine Learning Function Settings

<table>
<thead>
<tr>
<th>Machine Learning Function</th>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>CLAS_MAX_SUP_BINS</td>
<td>For Decision Tree: 2 &lt;= a number &lt;= 2147483647</td>
<td>This parameter specifies the maximum number of bins for each attribute. The default value is 32. See, DBMS_DATA_MINING — Automatic Data Preparation</td>
</tr>
<tr>
<td>Clustering</td>
<td>CLUS_NUM_CLUSTERS</td>
<td>TO_CHAR(numeric_expr&gt;=1)</td>
<td>The maximum number of leaf clusters generated by a clustering algorithm. The algorithm may return fewer clusters, depending on the data. Enhanced k-Means usually produces the exact number of clusters specified by CLUS_NUM_CLUSTERS, unless there are fewer distinct data points. Expectation maximization (EM) may return fewer clusters than the number specified by CLUS_NUM_CLUSTERS depending on the data. The number of clusters returned by EM cannot be greater than the number of components, which is governed by algorithm-specific settings. (See Expectation Maximization Settings for Learning table) Depending on these settings, there may be fewer clusters than components. If component clustering is disabled, the number of clusters equals the number of components. For EM, the default value of CLUS_NUM_CLUSTERS is system-determined. For k-Means and O-Cluster, the default is 10.</td>
</tr>
<tr>
<td>Feature extraction</td>
<td>FEAT_NUM_FEATURES</td>
<td>TO_CHAR(numeric_expr&gt;=1)</td>
<td>The number of features to be extracted by a feature extraction model. The default is estimated from the data by the algorithm. If the matrix rank is smaller than this number, fewer features will be returned. For CUR Matrix Decomposition, the FEAT_NUM_FEATURES value is the same as the CURS_SVD_RANK value.</td>
</tr>
</tbody>
</table>

### See Also:

Oracle Machine Learning for SQL Concepts for information about machine learning functions
40.1.2.4 DBMS_DATA_MINING — Global Settings

The configuration settings in this table are applicable to any type of model, but are currently only implemented for specific algorithms.

Table 40-8   Global Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| ODMS_ITEM_ID_COLUMN_NAME      | column_name   | (Association rules only) Name of a column that contains the items in a transaction. When this setting is specified, the algorithm expects the data to be presented in a native transactional format, consisting of two columns:  
  • Case ID, either categorical or numeric  
  • Item ID, either categorical or numeric  
  A typical example of transactional data is market basket data, wherein a case represents a basket that may contain many items. Each item is stored in a separate row, and many rows may be needed to represent a case. The case ID values do not uniquely identify each row. Transactional data is also called multi-record case data.  
  Association rules function is normally used with transactional data, but it can also be applied to single-record case data (similar to other algorithms).  
  For more information about single-record and multi-record case data, see Oracle SQL Developer Data Modeler User's Guide. |
| ODMS_ITEM_VALUE_COLUMN_NAME   | column_name   | (Association rules only) Name of a column that contains a value associated with each item in a transaction. This setting is only used when a value has been specified for ODMS_ITEM_ID_COLUMN_NAME indicating that the data is presented in native transactional format.  
  If ASSO_AGGREGATES is used, then the build data must include the following three columns and the columns specified in the AGGREGATES setting:  
  • Case ID, either categorical or numeric  
  • Item ID, either categorical or numeric, specified by ODMS_ITEM_ID_COLUMN_NAME  
  • Item value, either categorical or numeric, specified by ODMS_ITEM_VALUE_COLUMN_NAME  
  If ASSO_AGGREGATES, Case ID, and Item ID column are present, then the Item Value column may or may not appear.  
  The Item Value column may specify information such as the number of items (for example, three apples) or the type of the item (for example, macintosh apples).  
  For details on ASSO_AGGREGATES, see DBMS_DATA_MINING - Mining Function Settings. |
### Table 40-8  (Cont.) Global Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODMS_MISSING_VALUE_TREATMENT</td>
<td>ODMS_MISSING_VALUE_MEAN_MODE</td>
<td>Indicates how to treat missing values in the training data. This setting does not affect the scoring data. The default value is ODMS_MISSING_VALUE_AUTO.</td>
</tr>
<tr>
<td></td>
<td>ODMS_MISSING_VALUE_DELETE_ROW</td>
<td>ODMS_MISSING_VALUE_MEAN_MODE replaces missing values with the mean (numeric attributes) or the mode (categorical attributes) both at build time and apply time where appropriate. ODMS_MISSING_VALUE_AUTO performs different strategies for different algorithms.</td>
</tr>
<tr>
<td></td>
<td>ODMS_MISSING_VALUE_AUTO</td>
<td>When ODMS_MISSING_VALUE_TREATMENT is set to ODMS_MISSING_VALUE_DELETE_ROW, the rows in the training data that contain missing values are deleted. However, if you want to replicate this missing value treatment in the scoring data, then you must perform the transformation explicitly. The value ODMS_MISSING_VALUE_DELETE_ROW applies to all algorithms.</td>
</tr>
<tr>
<td>ODMS_ROW_WEIGHT_COLUMN_NAME</td>
<td>column_name</td>
<td>(GLM only) Name of a column in the training data that contains a weighting factor for the rows. The column data type must be NUMBER. Row weights can be used as a compact representation of repeated rows, as in the design of experiments where a specific configuration is repeated several times. Row weights can also be used to emphasize certain rows during model construction. For example, to bias the model towards rows that are more recent and away from potentially obsolete data.</td>
</tr>
<tr>
<td>ODMS_TEXT_POLICY_NAME</td>
<td>The name of an Oracle Text POLICY created using CTX_DDL.CREATE_POLICY.</td>
<td>Affects how individual tokens are extracted from unstructured text. For details about CTX_DDL.CREATE_POLICY, see Oracle Text Reference.</td>
</tr>
<tr>
<td>ODMS_TEXT_MAX_FEATURES</td>
<td>1 &lt;= value</td>
<td>The maximum number of distinct features, across all text attributes, to use from a document set passed to CREATE_MODEL. The default is 3000. ESA has the default value of 300000.</td>
</tr>
<tr>
<td>ODMS_TEXT_MIN_DOCUMENTS</td>
<td>Non-negative value</td>
<td>This is a text processing setting that controls how many documents a token needs to appear to be used as a feature. The default is 1. ESA has a default of 3.</td>
</tr>
<tr>
<td>ODMS_PARTITION_COLUMNS</td>
<td>Comma separated list of machine learning attributes</td>
<td>This setting indicates a request to build a partitioned model. The setting value is a comma-separated list of the machine learning attributes to be used to determine the in-list partition key values. These machine learning attributes are taken from the input columns unless an XFORM_LIST parameter is passed to CREATE_MODEL. If the XFORM_LIST parameter is passed to CREATE_MODEL, then the machine learning attributes are taken from the attributes produced by these transformations.</td>
</tr>
<tr>
<td>Setting Name</td>
<td>Setting Value</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ODMS_MAX_PARTITIONS</td>
<td>1&lt; value &lt;= 1000000</td>
<td>This setting indicates the maximum number of partitions allowed for the model. The default is 1000.</td>
</tr>
<tr>
<td>ODMS_SAMPLING</td>
<td>ODMS_SAMPLING_ENABLE</td>
<td>This setting allows the user to request a sampling of the build data. The default is ODMS_SAMPLING_DISABLE.</td>
</tr>
<tr>
<td></td>
<td>ODMS_SAMPLING_DISABLE</td>
<td></td>
</tr>
<tr>
<td>ODMS_SAMPLE_SIZE</td>
<td>0 &lt; Value</td>
<td>This setting determines how many rows will be sampled (approximately). It can be set only if ODMS_SAMPLING is enabled. The default value is the system determined.</td>
</tr>
<tr>
<td>ODMS_PARTITION_BUILD_TYPE</td>
<td>ODMS_PARTITION_BUILD_INTRA</td>
<td>This setting controls the parallel build of partitioned models.</td>
</tr>
<tr>
<td></td>
<td>ODMS_PARTITION_BUILD_INTER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ODMS_PARTITION_BUILD_HYBRID</td>
<td></td>
</tr>
<tr>
<td>ODMS_TABLESPACE_NAME</td>
<td>tablespace_name</td>
<td>This setting controls the storage specifications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If you explicitly sets this to the name of a tablespace (for which you have sufficient quota), then the specified tablespace storage creates the resulting model content. If you do not provide this setting, then the default tablespace of the user creates the resulting model content.</td>
</tr>
<tr>
<td>ODMS_RANDOM_SEED</td>
<td>The value must be a non-negative integer</td>
<td>The hash function with a random number seed generates a random number with uniform distribution. Users can control the random number seed by this setting. The default is 0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This setting is used by Random Forest, Neural Network, and CUR Matrix Decomposition.</td>
</tr>
<tr>
<td>ODMS_DETAILS</td>
<td>• ODMS_ENABLE</td>
<td>This setting reduces the space that is used while creating a model, especially a partitioned model. The default value is ODMS_ENABLE.</td>
</tr>
<tr>
<td></td>
<td>• ODMS_DISABLE</td>
<td>When the setting is ODMS_ENABLE, it creates model tables and views when the model is created. You can query the model with SQL. When the setting is ODMS_DISABLE, model views are not created and tables relevant to model details are not created either. The reduction in space depends on the model. Reduction on the order of 10x can be achieved.</td>
</tr>
</tbody>
</table>
See Also:

 Oracle Machine Learning for SQL Concepts for information about GLM
 Oracle Machine Learning for SQL Concepts for information about association rules
 Oracle Machine Learning for SQL User's Guide for information about machine learning unstructured text

40.1.2.5 DBMS_DATA_MINING — Algorithm Settings:
ALGO_EXTENSIBLE_LANG

The settings listed in the following table configure the behavior of the machine learning model with an extensible algorithm. The model is built in the R language.

The RALG_*_FUNCTION specifies the R script that is used to build, score, and view an R model and must be registered in the Oracle Machine Learning for R script repository. The R scripts are registered through OML4R with special privileges. When ALGO_EXTENSIBLE_LANG is set to R in the MINING_MODEL_SETTING table, the machine learning model is built in the R language. After the R model is built, the names of the R scripts are recorded in the MINING_MODEL_SETTING table in the SYS schema. The scripts must exist in the script repository for the R model to function. The amount of R memory used to build, score, and view the R model through these R scripts can be controlled by OML4R.

All algorithm-independent DBMS_DATA_MINING subprograms can operate on an R model for machine learning functions such as association, attribute importance, classification, clustering, feature extraction, and regression.

The supported DBMS_DATA_MINING subprograms include, but are not limited, to the following:

- ADD_COST_MATRIX Procedure
- COMPUTE_CONFUSION_MATRIX Procedure
- COMPUTE_LIFT Procedure
- COMPUTE_ROC Procedure
- CREATE_MODEL Procedure
- DROP_MODEL Procedure
- EXPORT_MODEL Procedure
- GET_MODEL_COST_MATRIX Function
- IMPORT_MODEL Procedure
- REMOVE_COST_MATRIX Procedure
- RENAME_MODEL Procedure
### Table 40-9  ALGO_EXTENSIBLE_LANG Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RALG_BUILD_FUNCTION</strong></td>
<td>R_BUILD_FUNCTION_SCRIPT_NAME</td>
<td>Specifies the name of an existing registered R script for the R algorithm machine learning model build function. The R script defines an R function for the first input argument for training data and returns an R model object. For clustering and feature extraction machine learning function model build, the R attributes <code>dm$nclus</code> and <code>dm$nfeat</code> must be set on the R model to indicate the number of clusters and features respectively. The <strong>RALG_BUILD_FUNCTION</strong> must be set along with <strong>ALGO_EXTENSIBLE_LANG</strong> in the model_SETTING_TABLE.</td>
</tr>
<tr>
<td><strong>RALG_BUILD_PARAMETER</strong></td>
<td>SELECT value param_name, ...FROM DUAL</td>
<td>Specifies a list of numeric and string scalar for optional input parameters of the model build function.</td>
</tr>
<tr>
<td><strong>RALG_SCORE_FUNCTION</strong></td>
<td>R_SCORE_FUNCTION_SCRIPT_NAME</td>
<td>Specifies the name of an existing registered R script to score data. The script returns a data.frame containing the corresponding prediction results. The setting is used to score data for machine learning functions such as regression, classification, clustering, and feature extraction. This setting does not apply to the association and the attribute importance functions.</td>
</tr>
<tr>
<td><strong>RALG_WEIGHT_FUNCTION</strong></td>
<td>R_WEIGHT_FUNCTION_SCRIPT_NAME</td>
<td>Specifies the name of an existing registered R script for the R algorithm that computes the weight (contribution) for each attribute in scoring. The script returns a data.frame containing the contributing weight for each attribute in a row. This function setting is needed for the PREDICTION_DETAILS SQL function.</td>
</tr>
<tr>
<td><strong>RALG_DETAILS_FUNCTION</strong></td>
<td>R_DETAILS_FUNCTION_SCRIPT_NAME</td>
<td>Specifies the name of an existing registered R script for the R algorithm that produces the model information. This setting is required to generate a model view.</td>
</tr>
<tr>
<td><strong>RALG_DETAILS_FORMAT</strong></td>
<td>SELECT type_value column_name, ... FROM DUAL</td>
<td>Specifies the SELECT query for the list of numeric and string scalars for the output column type and the column name of the generated model view. This setting is required to generate a model view.</td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL User’s Guide*
40.1.2.6 DBMS_DATA_MINING — Algorithm Settings: CUR Matrix Decomposition

The following settings affect the behavior of the CUR Matrix Decomposition algorithm.

Table 40-10  CUR Matrix Decomposition Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURS_APPROX_ATTR_NUM</td>
<td>The value must be a</td>
<td>Defines the approximate number of attributes to be selected.</td>
</tr>
<tr>
<td></td>
<td>positive integer</td>
<td>The default value is the number of attributes.</td>
</tr>
<tr>
<td>CURS_ROW_IMPORTANCE</td>
<td>CURS_ROW_IMP_ENABLE</td>
<td>Defines the flag indicating whether or not to perform row selection.</td>
</tr>
<tr>
<td></td>
<td>CURS_ROW_IMP_DISABLE</td>
<td>The default value is CURS_ROW_IMP_DISABLE.</td>
</tr>
<tr>
<td>CURS_APPROX_ROW_NUM</td>
<td>The value must be a</td>
<td>Defines the approximate number of rows to be selected. This parameter is</td>
</tr>
<tr>
<td></td>
<td>positive integer</td>
<td>only used when users decide to perform row selection (CURS_ROW_IMP_ENABLE).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default value is the total number of rows.</td>
</tr>
<tr>
<td>CURS_SVD_RANK</td>
<td>The value must be a</td>
<td>Defines the rank parameter used in the column/row leverage score calculation.</td>
</tr>
<tr>
<td></td>
<td>positive integer</td>
<td>If users do not provide an input value, the value is determined by the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>system.</td>
</tr>
</tbody>
</table>

See Also:
Oracle Machine Learning for SQL Concepts

40.1.2.7 DBMS_DATA_MINING — Algorithm Settings: Decision Tree

These settings configure the behavior of the Decision Tree algorithm. Note that the Decision Tree settings are also used to configure the behavior of Random Forest as it constructs each individual decision tree.

Table 40-11  Decision Tree Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TREE_IMPURITY_METRIC</td>
<td>TREE_IMPURITY_ENTROPY</td>
<td>Tree impurity metric for Decision Tree.</td>
</tr>
<tr>
<td></td>
<td>TREE_IMPURITY_GINI</td>
<td>Tree algorithms seek the best test question for splitting data at each node.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The best splitter and split values are those that result in the largest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>increase in target value homogeneity (purity) for the entities in the node.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Purity is by a metric. Decision trees can use either Gini</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(TREE_IMPURITY_GINI) or entropy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(TREE_IMPURITY_ENTROPY) as the purity metric. By default, the algorithm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>uses TREE_IMPURITY_GINI.</td>
</tr>
</tbody>
</table>
### Table 40-11  (Cont.) Decision Tree Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TREE_TERM_MAX_DEPTH</td>
<td>For Decision Tree:</td>
<td>Criteria for splits: maximum tree depth (the maximum number of nodes between the root and any leaf node, including the leaf node).</td>
</tr>
<tr>
<td></td>
<td>$2 \leq a\ number \leq 20$</td>
<td>For Decision Tree, the default is 7.</td>
</tr>
<tr>
<td></td>
<td>For Random Forest:</td>
<td>For Random Forest, the default is 16.</td>
</tr>
<tr>
<td></td>
<td>$2 \leq a\ number \leq 100$</td>
<td></td>
</tr>
<tr>
<td>TREE_TERM_MINPCT_NODE</td>
<td>$0 \leq a\ number \leq 10$</td>
<td>The minimum number of training rows in a node expressed as a percentage of the rows in the training data. Default is 0.05, indicating 0.05%.</td>
</tr>
<tr>
<td>TREE_TERM_MINPCT_SPLIT</td>
<td>$0 &lt; a\ number \leq 20$</td>
<td>The minimum number of rows required to consider splitting a node expressed as a percentage of the training rows. Default is 0.1, indicating 0.1%.</td>
</tr>
<tr>
<td>TREE_TERM_MINREC_NODE</td>
<td>$a\ number \geq 0$</td>
<td>The minimum number of rows in a node. Default is 10.</td>
</tr>
<tr>
<td>TREE_TERM_MINREC_SPLIT</td>
<td>$a\ number &gt; 1$</td>
<td>Criteria for splits: minimum number of records in a parent node expressed as a value. No split is attempted if the number of records is below this value. Default is 20.</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for information about Decision Tree

### 40.1.2.8 DBMS_DATA_MINING — Algorithm Settings: Expectation Maximization

These algorithm settings configure the behavior of the Expectation Maximization algorithm.

- Table 40-12
- Table 40-13
- Table 40-14
- Table 40-15

See Also:

*Oracle Data Mining Concepts* for information about Expectation Maximization
### Table 40-12  Expectation Maximization Settings for Data Preparation and Analysis

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMCS_ATTRIBUTE_FILTER</td>
<td>EMCS_ATTR_FILTER_ENABLE</td>
<td>Whether or not to include uncorrelated attributes in the model. When EMCS_ATTRIBUTE_FILTER is enabled, uncorrelated attributes are not included.</td>
</tr>
<tr>
<td></td>
<td>EMCS_ATTR_FILTER_DISABLED</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This setting applies only to attributes that are not nested.</td>
</tr>
<tr>
<td>EMCS_MAX_NUM_ATTR_2D</td>
<td>TO_CHAR(numeric_expr &gt;= 1)</td>
<td>Maximum number of correlated attributes to include in the model. Note: This setting applies only to attributes that are not nested (2D). Default is 50.</td>
</tr>
<tr>
<td>EMCS_NUM_DISTRIBUTION</td>
<td>EMCS_NUM_DISTR_BERNOULLI</td>
<td>The distribution for modeling numeric attributes. Applies to the input table or view as a whole and does not allow per-attribute specifications.</td>
</tr>
<tr>
<td></td>
<td>EMCS_NUM_DISTR_GAUSSIAN</td>
<td>The options include Bernoulli, Gaussian, or system-determined distribution. When Bernoulli or Gaussian distribution is chosen, all numeric attributes are modeled using the same type of distribution. When the distribution is system-determined, individual attributes may use different distributions (either Bernoulli or Gaussian), depending on the data. Default is EMCS_NUM_DISTR_SYSTEM.</td>
</tr>
<tr>
<td></td>
<td>EMCS_NUM_DISTR_SYSTEM</td>
<td></td>
</tr>
<tr>
<td>EMCS_NUM_EQUIWIDTH_BINS</td>
<td>TO_CHAR(1 &lt; numeric_expr &lt;= 255)</td>
<td>Number of equi-width bins that will be used for gathering cluster statistics for numeric columns. Default is 11.</td>
</tr>
<tr>
<td>EMCS_NUM_PROJECTIONS</td>
<td>TO_CHAR(numeric_expr &gt;= 1)</td>
<td>Specifies the number of projections that will be used for each nested column. If a column has fewer distinct attributes than the specified number of projections, the data will not be projected. The setting applies to all nested columns. Default is 50.</td>
</tr>
<tr>
<td>EMCS_NUM_QUANTILE_BINS</td>
<td>TO_CHAR(1 &lt; numeric_expr &lt;= 255)</td>
<td>Specifies the number of quantile bins that will be used for modeling numeric columns with multivalued Bernoulli distributions. Default is system-determined.</td>
</tr>
<tr>
<td>EMCS_NUM_TOPN_BINS</td>
<td>TO_CHAR(1 &lt; numeric_expr &lt;= 255)</td>
<td>Specifies the number of top-N bins that will be used for modeling categorical columns with multivalued Bernoulli distributions. Default is system-determined.</td>
</tr>
</tbody>
</table>
### Table 40-13  Expectation Maximization Settings for Learning

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMCS_CONVERGENCE_CRITERION</td>
<td>EMCS_CONV_CRIT_HELDASIDE</td>
<td>The convergence criterion for EM. The convergence criterion may be based on a held-aside data set, or it may be Bayesian Information Criterion. Default is system determined.</td>
</tr>
<tr>
<td></td>
<td>EMCS_CONV_CRIT_BIC</td>
<td></td>
</tr>
<tr>
<td>EMCS_LOGLIKE_IMPROVEMENT</td>
<td>TO_CHAR( 0 &lt; numeric_expr &lt; 1)</td>
<td>When the convergence criterion is based on a held-aside data set (EMCS_CONVERGENCE_CRITERION = EMCS_CONV_CRIT_HELDASIDE), this setting specifies the percentage improvement in the value of the log likelihood function that is required for adding a new component to the model. Default value is 0.001.</td>
</tr>
<tr>
<td>EMCS_NUM_COMPONENTS</td>
<td>TO_CHAR( numeric_expr &gt;=1)</td>
<td>Maximum number of components in the model. If model search is enabled, the algorithm automatically determines the number of components based on improvements in the likelihood function or based on regularization, up to the specified maximum. The number of components must be greater than or equal to the number of clusters. Default is 20.</td>
</tr>
<tr>
<td>EMCS_NUM_ITERATIONS</td>
<td>TO_CHAR( numeric_expr &gt;=1)</td>
<td>Specifies the maximum number of iterations in the EM algorithm. Default is 100.</td>
</tr>
<tr>
<td>EMCS_MODEL_SEARCH</td>
<td>EMCS_MODEL_SEARCH_ENABLE</td>
<td>This setting enables model search in EM where different model sizes are explored and a best size is selected. The default is EMCS_MODEL_SEARCH_DISABLE.</td>
</tr>
<tr>
<td></td>
<td>EMCS_MODEL_SEARCH_DISABLE</td>
<td></td>
</tr>
<tr>
<td>EMCS_REMOVE_COMPONENTS</td>
<td>EMCS_REMOVE_COMPS_ENABLE</td>
<td>This setting allows the EM algorithm to remove a small component from the solution. The default is EMCS_REMOVE_COMPS_ENABLE.</td>
</tr>
<tr>
<td></td>
<td>EMCS_REMOVE_COMPS_DISABLE</td>
<td></td>
</tr>
<tr>
<td>EMCS_RANDOM_SEED</td>
<td>Non-negative integer</td>
<td>This setting controls the seed of the random generator used in EM. The default is 0.</td>
</tr>
</tbody>
</table>

### Table 40-14  Expectation Maximization Settings for Component Clustering

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMCS_CLUSTER_COMPONENTS</td>
<td>EMCS_CLUSTER_COMP_ENABLE</td>
<td>Enables or disables the grouping of EM components into high-level clusters. When disabled, the components themselves are treated as clusters. When component clustering is enabled, model scoring through the SQL CLUSTER function will produce assignments to the higher level clusters. When clustering is disabled, the CLUSTER function will produce assignments to the original components. Default is EMCS_CLUSTER_COMP_ENABLE.</td>
</tr>
<tr>
<td></td>
<td>EMCS_CLUSTER_COMP_DISABLE</td>
<td></td>
</tr>
</tbody>
</table>
### Table 40-14  (Cont.) Expectation Maximization Settings for Component Clustering

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMCS_CLUSTER_THRESH</td>
<td>TO_CHAR(numeric_expr &gt;=1)</td>
<td>Dissimilarity threshold that controls the clustering of EM components. When the dissimilarity measure is less than the threshold, the components are combined into a single cluster. A lower threshold may produce more clusters that are more compact. A higher threshold may produce fewer clusters that are more spread out. Default is 2.</td>
</tr>
<tr>
<td>EMCS_LINKAGE_FUNCTION</td>
<td>EMCS_LINKAGE_SINGLE</td>
<td>Allows the specification of a linkage function for the agglomerative clustering step. EMCS_LINKAGE_SINGLE uses the nearest distance within the branch. The clusters tend to be larger and have arbitrary shapes. EMCS_LINKAGE_AVERAGE uses the average distance within the branch. There is less chaining effect and the clusters are more compact. EMCS_LINKAGE_COMPLETE uses the maximum distance within the branch. The clusters are smaller and require strong component overlap. Default is EMCS_LINKAGE_SINGLE.</td>
</tr>
</tbody>
</table>

### Table 40-15  Expectation Maximization Settings for Cluster Statistics

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMCS_CLUSTER_STATISTICS</td>
<td>EMCS_CLUS_STATS_ENABLE</td>
<td>Enables or disables the gathering of descriptive statistics for clusters (centroids, histograms, and rules). When statistics are disabled, model size is reduced, and GET_MODEL_DETAILS_EM only returns taxonomy (hierarchy) and cluster counts. Default is EMCS_CLUS_STATS_ENABLE.</td>
</tr>
<tr>
<td>EMCS_MIN_PCT_ATTR_SUPPORT</td>
<td>TO_CHAR(0 &lt; numeric_expr &lt; 1)</td>
<td>Minimum support required for including an attribute in the cluster rule. The support is the percentage of the data rows assigned to a cluster that must have non-null values for the attribute. Default is 0.1.</td>
</tr>
</tbody>
</table>

### 40.1.2.9 DBMS_DATA_MINING — Algorithm Settings: Explicit Semantic Analysis

Explicit Semantic Analysis (ESA) is a useful technique for extracting meaningful and interpretable features.

The settings listed in the following table configure the ESA values.
40.1.2.10 DBMS_DATA_MINING — Algorithm Settings: Exponential Smoothing

Exponential Smoothing (ESM) is a useful technique for extracting meaningful and interpretable features.

The settings listed in the following table configure Exponential Smoothing values.

### Table 40-16  Explicit Semantic Analysis Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESAS_VALUE_THRESHOLD</td>
<td>Non-negative number</td>
<td>This setting thresholds a small value for attribute weights in the transformed build data. The default is 1e-8.</td>
</tr>
<tr>
<td>ESAS_MIN_ITEMS</td>
<td>Text input 100</td>
<td>This setting determines the minimum number of non-zero entries that need to be present in an input row. The default is 100 for text input and 0 for non-text input.</td>
</tr>
<tr>
<td></td>
<td>Non-text input is 0</td>
<td></td>
</tr>
<tr>
<td>ESAS_TOPN_FEATURES</td>
<td>A positive integer</td>
<td>This setting controls the maximum number of features per attribute. The default is 1000.</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for information about ESA.
<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXSM_MODEL</td>
<td>It can take value in set <code>{EXSM_SIMPLE, EXSM_SIMPLE_MULT, EXSM_HOLT, EXSM_HOLT_DMP, EXSM_MUL_TRND, EXSM_MULTRD_DMP, EXSM_SEAS_ADD, EXSM_SEAS_MUL, EXSM_HW, EXSM_HW_DMP, EXSM_HW_ADDSEA, EXSM_DHW_ADDSEA, EXSM_HWMT, EXSM_HWMT_DMP}</code></td>
<td>This setting specifies the model. EXSM_SIMPLE: Simple exponential smoothing model is applied. EXSM_SIMPLE_MULT: Simple exponential smoothing model with multiplicative error is applied. EXSM_HOLT: Holt linear exponential smoothing model is applied. EXSM_HOLT_DMP: Holt linear exponential smoothing model with damped trend is applied. EXSM_MUL_TRND: Exponential smoothing model with multiplicative trend is applied. EXSM_MULTRD_DMP: Exponential smoothing model with multiplicative damped trend is applied. EXSM_SEAS_ADD: Exponential smoothing with additive seasonality, but no trend, is applied. EXSM_SEAS_MUL: Exponential smoothing with multiplicative seasonality, but no trend, is applied. EXSM_HW: Holt-Winters triple exponential smoothing model, additive trend, multiplicative seasonality is applied. EXSM_HW_DMP: Holt-Winters multiplicative exponential smoothing model with damped trend, additive trend, multiplicative seasonality is applied. EXSM_HW_ADDSEA: Holt-Winters additive exponential smoothing model, additive trend, additive seasonality is applied. EXSM_DHW_ADDSEA: Holt-Winters additive exponential smoothing model with damped trend, additive trend, additive seasonality is applied. EXSM_HWMT: Holt-Winters multiplicative exponential smoothing model with multiplicative trend, multiplicative trend, multiplicative seasonality is applied. EXSM_HWMT_DMP: Holt-Winters multiplicative exponential smoothing model with damped multiplicative trend, multiplicative trend, multiplicative seasonality is applied. The default value is EXSM_SIMPLE.</td>
</tr>
</tbody>
</table>
### Table 40-17  (Cont.) Exponential Smoothing Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXSM_SEASONALITY</td>
<td>positive integer &gt; 1</td>
<td>This setting specifies a positive integer value as the length of seasonal cycle. The value it takes must be larger than 1. For example, setting value 4 means that every group of four observations forms a seasonal cycle. This setting is only applicable and must be provided for models with seasonality, otherwise the model throws an error. When EXSM_INTERVAL is not set, this setting applies to the original input time series. When EXSM_INTERVAL is set, this setting applies to the accumulated time series.</td>
</tr>
<tr>
<td>EXSM_INTERVAL</td>
<td>It can take value in set {EXSM_INTERVAL_YEAR, EXSM_INTERVAL_QTR, EXSM_INTERVAL_MONTH, EXSM_INTERVAL_WEEK, EXSM_INTERVAL_DAY, EXSM_INTERVAL_HOUR, EXSM_INTERVAL_MIN, EXSM_INTERVAL_SEC}</td>
<td>This setting only applies and must be provided when the time column (case_id column) has datetime type. It specifies the spacing interval of the accumulated equally spaced time series. The model throws an error if the time column of input table is of datetime type and setting EXSM_INTERVAL is not provided. The model throws an error if the time column of input table is of oracle number type and setting EXSM_INTERVAL is provided.</td>
</tr>
<tr>
<td>EXSM_ACCUMULATE</td>
<td>It can take value in set {EXSM_ACCU_TOTAL, EXSM_ACCU_STD, EXSM_ACCU_MAX, EXSM_ACCU_MIN, EXSM_ACCU_AVG, EXSM_ACCU_MEDIAN, EXSM_ACCU_COUNT}</td>
<td>This setting only applies and must be provided when the time column has datetime type. It specifies how to generate the value of the accumulated time series from the input time series.</td>
</tr>
</tbody>
</table>
Table 40-17  (Cont.) Exponential Smoothing Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXSM_SETMISSING</td>
<td>It can also specify an option taking value in set {EXSM_MISS_MIN, EXSM_MISS_MAX, EXSM_MISS_AVG, EXSM_MISS_MEDIAN, EXSM_MISS_LAST, EXSM_MISS_FIRST, EXSM_MISS_PREV, EXSM_MISS_NEXT, EXSM_MISS_AUTO}.</td>
<td>This setting specifies how to handle missing values, which may come from input data and/or the accumulation process of time series. You can specify either a number or an option. If a number is specified, all the missing values are set to that number. EXSM_MISS_MIN: Replaces missing value with minimum of the accumulated time series. EXSM_MISS_MAX: Replaces missing value with maximum of the accumulated time series. EXSM_MISS_AVG: Replaces missing value with average of the accumulated time series. EXSM_MISS_MEDIAN: Replaces missing value with median of the accumulated time series. EXSM_MISS_LAST: Replaces missing value with last non-missing value of the accumulated time series. EXSM_MISS_FIRST: Replaces missing value with first non-missing value of the accumulated time series. EXSM_MISS_PREV: Replaces missing value with the previous non-missing value of the accumulated time series. EXSM_MISS_NEXT: Replaces missing value with the next non-missing value of the accumulated time series. EXSM_MISS_AUTO: EXSM model treats the input data as an irregular (non-uniformly spaced) time series. If this setting is not provided, EXSM_MISS_AUTO is the default value. In such a case, the model treats the input time series as irregular time series, viewing missing values as gaps.</td>
</tr>
<tr>
<td>EXSM_PREDICTION_STEP</td>
<td>It must be set to a number between 1-30.</td>
<td>This setting specifies how many steps ahead the predictions are to be made. If it is not set, the default value is 1: the model gives one-step-ahead prediction. A value greater than 30 results in an error.</td>
</tr>
<tr>
<td>EXSM_CONFIDENCE_LEVEL</td>
<td>It must be a number between 0 and 1, exclusive.</td>
<td>This setting specifies the desired confidence level for prediction. The lower and upper bounds of the specified confidence interval is reported. If this setting is not specified, the default confidence level is 95%.</td>
</tr>
</tbody>
</table>
The settings listed in the following table configure the behavior of the Generalized Linear Model algorithm.

### Table 40-18  DBMS_DATA_MINING GLM Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLMS_CONF_LEVEL</td>
<td>TO_CHAR(0&lt;numeric_expr&lt;1)</td>
<td>The confidence level for coefficient confidence intervals. The default confidence level is 0.95.</td>
</tr>
<tr>
<td>GLMS_FTR_GEN_METHOD</td>
<td>GLMS_FTR_GEN_QUADRATIC, GLMS_FTR_GEN_CUBIC</td>
<td>Whether feature generation is quadratic or cubic. When feature generation is enabled, the algorithm automatically chooses the most appropriate feature generation method based on the data.</td>
</tr>
<tr>
<td>GLMS_FTR_GENERATION</td>
<td>GLMS_FTR_GENERATION_ENABLE, GLMS_FTR_GENERATION_DISABLE</td>
<td>Whether or not feature generation is enabled for GLM. By default, feature generation is not enabled. Note: Feature generation can only be enabled when feature selection is also enabled.</td>
</tr>
<tr>
<td>Setting Name</td>
<td>Setting Value</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>GLMS_FTR_SEL_CRIT</td>
<td>GLMS_FTR_SEL_AIC GLMS_FTR_SEL_BIC GLMS_FTR_SEL_RIC GLMS_FTR_SEL_ALPHA_INV</td>
<td>Feature selection penalty criterion for adding a feature to the model. When feature selection is enabled, the algorithm automatically chooses the penalty criterion based on the data.</td>
</tr>
<tr>
<td>GLMS_FTR_SELECTION</td>
<td>GLMS_FTR_SELECTION_ENABLE GLMS_FTR_SELECTION_DISABLE</td>
<td>Whether or not feature selection is enabled for GLM. By default, feature selection is not enabled.</td>
</tr>
<tr>
<td>GLMS_MAX_FEATURES</td>
<td>TO_CHAR(0 &lt; numeric_expr &lt;= 2000)</td>
<td>When feature selection is enabled, this setting specifies the maximum number of features that can be selected for the final model. By default, the algorithm limits the number of features to ensure sufficient memory.</td>
</tr>
<tr>
<td>GLMS_PRUNE_MODEL</td>
<td>GLMS_PRUNE_MODEL_ENABLE GLMS_PRUNE_MODEL_DISABLE</td>
<td>Prune enable or disable for features in the final model. Pruning is based on T-Test statistics for linear regression, or Wald Test statistics for logistic regression. Features are pruned in a loop until all features are statistically significant with respect to the full data. When feature selection is enabled, the algorithm automatically performs pruning based on the data.</td>
</tr>
<tr>
<td>GLMS_REFERENCE_CLASS_NAME</td>
<td>target_value</td>
<td>The target value used as the reference class in a binary logistic regression model. Probabilities are produced for the other class. By default, the algorithm chooses the value with the highest prevalence (the most cases) for the reference class.</td>
</tr>
<tr>
<td>GLMS_RIDGE_REGRESSION</td>
<td>GLMS_RIDGE_REG_ENABLE GLMS_RIDGE_REG_DISABLE</td>
<td>Enable or disable ridge regression. Ridge applies to both regression and classification machine learning functions. When ridge is enabled, prediction bounds are not produced by the PREDICTION_BOUNDS SQL function. <strong>Note:</strong> Ridge may only be enabled when feature selection is not specified, or has been explicitly disabled. If ridge regression and feature selection are both explicitly enabled, then an exception is raised.</td>
</tr>
<tr>
<td>GLMS_RIDGE_VALUE</td>
<td>TO_CHAR(numeric_expr &gt; 0)</td>
<td>The value of the ridge parameter. This setting is only used when the algorithm is configured to use ridge regression. If ridge regression is enabled internally by the algorithm, then the ridge parameter is determined by the algorithm.</td>
</tr>
<tr>
<td>GLMS_ROW_DIAGNOSTICS</td>
<td>GLMS_ROW_DIAG_ENABLE GLMS_ROW_DIAG_DISABLE (default)</td>
<td>Enable or disable row diagnostics.</td>
</tr>
</tbody>
</table>
Table 40-18 (Cont.) DBMS_DATA_MINING GLM Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLMS_CONV_TOLERANCE</td>
<td>The range is (0, 1) non-inclusive.</td>
<td>Convergence Tolerance setting of the GLM algorithm. The default value is system-determined.</td>
</tr>
<tr>
<td>GLMS_NUM_ITERATIONS</td>
<td>Positive integer</td>
<td>Maximum number of iterations for the GLM algorithm. The default value is system-determined.</td>
</tr>
<tr>
<td>GLMS_BATCH_ROWS</td>
<td>0 or Positive integer</td>
<td>Number of rows in a batch used by the SGD solver. The value of this parameter sets the size of the batch for the SGD solver. An input of 0 triggers a data driven batch size estimate. The default is 2000.</td>
</tr>
<tr>
<td>GLMS_SOLVER</td>
<td>GLMS_SOLVER_SGD (Stochastic Gradient Descent)</td>
<td>This setting allows the user to choose the GLM solver. The solver cannot be selected if GLMS_FTR_SELECTION setting is enabled. The default value is system determined.</td>
</tr>
<tr>
<td>GLMS_SOLVER Choirosky</td>
<td>GLMS_SOLVER_CHOL (Choleksy)</td>
<td></td>
</tr>
<tr>
<td>GLMS_SOLVER QR</td>
<td>GLMS_SOLVER_QR</td>
<td></td>
</tr>
<tr>
<td>GLMS_SOLVER LBFGS ADM</td>
<td>GLMS_SOLVER_LBFGS_ADM</td>
<td></td>
</tr>
<tr>
<td>GLMS_SPARSE_SOLVER</td>
<td>GLMS_SPARSE_SOLVER_ENABLE</td>
<td>This setting allows the user to use sparse solver if it is available. The default value is GLMS_SPARSE_SOLVER_DISABLE.</td>
</tr>
<tr>
<td></td>
<td>GLMS_SPARSE_SOLVER_DISABLE (default)</td>
<td></td>
</tr>
</tbody>
</table>

Related Topics

- **DBMS_DATA_MINING — Algorithm Settings: Neural Network**
  The settings listed in the following table configure the behavior of the Neural Network algorithm.

- **DBMS_DATA_MINING — Solver Settings: LBFGS**
  The settings listed in the following table configure the behavior of L-BFGS. Neural Network and Generalized Linear Model (GLM) use these settings.

- **DBMS_DATA_MINING — Solver Settings: ADMM**
  The settings listed in the following table configure the behavior of Alternating Direction Method of Multipliers (ADMM). The Generalized Linear Model (GLM) algorithm uses these settings.

- **Oracle Machine Learning for SQL Concepts**

> See Also:

*Oracle Machine Learning for SQL Concepts* for information about GLM.

40.1.2.12 DBMS_DATA_MINING — Algorithm Settings: k-Means

The settings listed in the following table configure the behavior of the k-Means algorithm.
<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KMNS_CONV_TOLERANCE</td>
<td>TO_CHAR(0&lt;numeric_expr&lt;1)</td>
<td>Minimum Convergence Tolerance for k-Means. The algorithm iterates until the minimum Convergence Tolerance is satisfied or until the maximum number of iterations, specified in KMNS_ITERATIONS, is reached. Decreasing the Convergence Tolerance produces a more accurate solution but may result in longer run times. The default Convergence Tolerance is 0.001.</td>
</tr>
<tr>
<td>KMNS_DISTANCE</td>
<td>KMNS_COSINE</td>
<td>Distance function for k-Means. The default distance function is KMNS_EUCLIDEAN.</td>
</tr>
<tr>
<td></td>
<td>KMNS_EUCLIDEAN</td>
<td></td>
</tr>
<tr>
<td>KMNS_ITERATIONS</td>
<td>TO_CHAR(positive_numeric_expr)</td>
<td>Maximum number of iterations for k-Means. The algorithm iterates until either the maximum number of iterations is reached or the minimum Convergence Tolerance, specified in KMNS_CONV_TOLERANCE, is satisfied. The default number of iterations is 20.</td>
</tr>
<tr>
<td>KMNS_MIN_PCT_ATTR_SUPPORT</td>
<td>TO_CHAR(0&lt;=numeric_expr&lt;=1)</td>
<td>Minimum percentage of attribute values that must be non-null in order for the attribute to be included in the rule description for the cluster. If the data is sparse or includes many missing values, a minimum support that is too high can cause very short rules or even empty rules. The default minimum support is 0.1.</td>
</tr>
<tr>
<td>KMNS_NUM_BINS</td>
<td>TO_CHAR(numeric_expr&gt;0)</td>
<td>Number of bins in the attribute histogram produced by k-means. The bin boundaries for each attribute are computed globally on the entire training data set. The binning method is equi-width. All attributes have the same number of bins with the exception of attributes with a single value that have only one bin. The default number of histogram bins is 11.</td>
</tr>
<tr>
<td>KMNS_SPLIT_CRITERION</td>
<td>KMNS_SIZE</td>
<td>Split criterion for k-means. The split criterion controls the initialization of new k-Means clusters. The algorithm builds a binary tree and adds one new cluster at a time. When the split criterion is based on size, the new cluster is placed in the area where the largest current cluster is located. When the split criterion is based on the variance, the new cluster is placed in the area of the most spread-out cluster. The default split criterion is the KMNS_VARIANCE.</td>
</tr>
<tr>
<td></td>
<td>KMNS_VARIANCE</td>
<td></td>
</tr>
<tr>
<td>KMNS_RANDOM_SEED</td>
<td>Non-negative integer</td>
<td>This setting controls the seed of the random generator used during the k-Means initialization. It must be a non-negative integer value. The default is 0.</td>
</tr>
</tbody>
</table>
### Table 40-19 (Cont.) k-Means Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KMNS_DETAILS</td>
<td>KMNS_DETAILS_NONE</td>
<td>This setting determines the level of cluster detail that are computed during the build.</td>
</tr>
<tr>
<td>KMNS_DETAILS</td>
<td>KMNS_DETAILS_HIERARCHY</td>
<td>KMNS_DETAILS_NONE: No cluster details are computed. Only the scoring information is persisted.</td>
</tr>
<tr>
<td>KMNS_DETAILS</td>
<td>KMNS_DETAILS_ALL</td>
<td>KMNS_DETAILS_HIERARCHY: Cluster hierarchy and cluster record counts are computed. This is the default value.</td>
</tr>
<tr>
<td></td>
<td>KMNS_DETAILS_ALL</td>
<td>KMNS_DETAILS_ALL: Cluster hierarchy, record counts, descriptive statistics (means, variances, modes, histograms, and rules) are computed.</td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL Concepts* for information about k-Means

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### 40.1.2.13 DBMS_DATA_MINING - Algorithm Settings: Multivariate State Estimation Technique - Sequential Probability Ratio Test

Settings that configure the training calibration behavior of the Multivariate State Estimation Technique - Sequential Probability Ratio Test algorithm.

#### Table 40-20 MSET-SPRT Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSET_ADB_HEIGHT</td>
<td>A positive double</td>
<td>Estimates the band within which signal values normally oscillate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default value is 0.05.</td>
</tr>
<tr>
<td>MSET_ALERT_COUNT</td>
<td>A positive integer</td>
<td>The number of the last ( n ) signals (the alert window) that should have passed the threshold to raise an alert. The alert count should be lower or equal to the alert window.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default value is 5.</td>
</tr>
<tr>
<td>MSET_ALERT_WINDOW</td>
<td>A positive integer greater than or equal to MSET_ALERT_COUNT</td>
<td>The number of signals to consider in the SPRT hypothesis consolidation logic. The default value is 5.</td>
</tr>
<tr>
<td>MSET_ALPHA_PROB</td>
<td>A positive double between 0 and 1</td>
<td>False Alarm Probability FAP (false positive).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default is 0.01.</td>
</tr>
<tr>
<td>MSET_BETA_PROB</td>
<td>A positive double between 0 and 1</td>
<td>Missed Alarm Probability MAP (false negative).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default is 0.10.</td>
</tr>
</tbody>
</table>
### Table 40-20  (Cont.) MSET-SPRT Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSET_HELDASIDE</td>
<td>A positive integer</td>
<td>The approximate number of data rows used for MSET model calibration.  You can use ODMS_RANDOM_SEED to change the held-aside sample.  The default value is 10000.</td>
</tr>
<tr>
<td>MSET_MEMORY_VECTORS</td>
<td>A positive integer</td>
<td>The default value is data driven.</td>
</tr>
<tr>
<td>MSET_PROJECTION_THRESHOLD</td>
<td>A positive integer &gt;0, &lt;=10000</td>
<td>Specifies whether to use random projections. When the number of sensors exceeds the setting value, random projections are used. To turn off random projections, set the threshold to a value that is equal to or greater than the number of sensors.  The default value is 500.</td>
</tr>
<tr>
<td>MSET_STD_TOLERANCE</td>
<td>A positive integer</td>
<td>The tolerance in standard deviations used in the SPRT calculation.  The default value is 3.</td>
</tr>
</tbody>
</table>

### 40.1.2.14 DBMS_DATA_MINING — Algorithm Settings: Naive Bayes

The settings listed in the following table configure the behavior of the Naive Bayes algorithm.

### Table 40-21  Naive Bayes Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NABS_PAIRWISE_THRESHLD</td>
<td>TO_CHAR(0&lt;= numeric_expr &lt;=1)</td>
<td>Value of pairwise threshold for NB algorithm  Default is 0.</td>
</tr>
<tr>
<td>NABS_SINGLETON_THRESHLD</td>
<td>TO_CHAR(0&lt;= numeric_expr &lt;=1)</td>
<td>Value of singleton threshold for NB algorithm  Default value is 0.</td>
</tr>
</tbody>
</table>

*See Also:*

Oracle Machine Learning for SQL Concepts for information about Naive Bayes

### 40.1.2.15 DBMS_DATA_MINING — Algorithm Settings: Neural Network

The settings listed in the following table configure the behavior of the Neural Network algorithm.
### Table 40-22  DBMS_DATA_MINING Neural Network Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNET_SOLVER</td>
<td>One of the following strings:</td>
<td>Specifies the method of optimization. The default value is system determined.</td>
</tr>
<tr>
<td></td>
<td>• NNET_SOLVER_ADAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_SOLVER_LBFGS</td>
<td></td>
</tr>
<tr>
<td>NNET_ACTIVATIONS</td>
<td>One or more of the following strings:</td>
<td>Specifies the activation functions for the hidden layers. You can specify a single activation function, which is then applied to each hidden layer, or you can specify an activation function for each layer individually. Different layers can have different activation functions. To apply a different activation function to one or more of the layers, you must specify an activation function for each layer. The number of activation functions you specify must be consistent with the <code>NNET_HIDDEN_LAYERS</code> and <code>NNET_NODES_PER_LAYER</code> values. For example, if you have three hidden layers, you could specify the use of the same activation function for all three layers with the following settings value: (<code>'NNET_ACTIVATIONS', 'NNET_ACTIVATIONS_TANH'</code>) The following settings value specifies a different activation function for each layer: (<code>'NNET_ACTIVATIONS', 'NNET_ACTIVATIONS_TANH', 'NNET_ACTIVATIONS_LOG_SIG', 'NNET_ACTIVATIONS_ARCTAN'</code>)</td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_ARCTAN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_BIPOLAR_SIG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_LINEAR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_LOG_SIG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_RELU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_ACTIVATIONS_TANH</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

You specify the different activation functions as strings within a single string. All quotes are single and two single quotes are used to escape a single quote in SQL statements and PL/SQL blocks. The default value is `NNET_ACTIVATIONS_LOG_SIG`. 
Table 40-22  (Cont.) DBMS_DATA_MINING Neural Network Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNET_HELDASIDE_MAX_FAIL</td>
<td>A positive integer</td>
<td>With NNET_REGULARIZER_HELDASIDE, the training process is stopped early if the network performance on the validation data fails to improve or remains the same for NNET_HELDASIDE_MAX_FAIL epochs in a row. The default value is 6.</td>
</tr>
<tr>
<td>NNET_HELDASIDE_RATIO</td>
<td>0 &lt;= numeric_expr &lt;=1</td>
<td>Define the held ratio for the held-aside method. The default value is 0.25.</td>
</tr>
<tr>
<td>NNET_HIDDEN_LAYERS</td>
<td>A positive integer</td>
<td>Defines the topology by the number of hidden layers. The default value is 1.</td>
</tr>
<tr>
<td>NNET_ITERATIONS</td>
<td>A positive integer</td>
<td>Specifies the maximum number of iterations in the Neural Network algorithm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For the DMSSET_NN_SOLVER_LBFGS solver, the default value is 200.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For the DMSSET_NN_SOLVER_ADAM solver, the default value is 10000.</td>
</tr>
<tr>
<td>NNET_NODES_PER_LAYER</td>
<td>A positive integer or a list of positive integers</td>
<td>Defines the topology by the number of nodes per layer. To specify the same number of nodes for each layer, you can provide a single value, which is then applied to each layer. To specify a different number of nodes for one or more layers, provide a list of comma-separated positive integers, one for each layer. For example, '10, 20, 5' for three layers. The setting values must be consistent with the NNET_HIDDEN_LAYERS value. The default number of nodes per layer is the number of attributes or 50 (if the number of attributes &gt; 50).</td>
</tr>
<tr>
<td>NNET_REG_LAMBDA</td>
<td>TO_CHAR(numeric_expr &gt;=0)</td>
<td>Defines the L2 regularization parameter lambda. This can not be set together with NNET_REGULARIZER_HELDASIDE. The default value is 1.</td>
</tr>
<tr>
<td>NNET_REGULARIZER</td>
<td>One of the following strings:</td>
<td>Regularization setting for Neural Network algorithm. If the total number of training rows is greater than 50000, the default is NNET_REGULARIZER_HELDASIDE. If the total number of training rows is less than or equal to 50000, the default is NNET_REGULARIZER_NONE.</td>
</tr>
<tr>
<td></td>
<td>• NNET_REGULARIZER_HELDASIDE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_REGULARIZER_L2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• NNET_REGULARIZER_NONE</td>
<td></td>
</tr>
<tr>
<td>NNET_TOLERANCE</td>
<td>TO_CHAR(0&lt; numeric_expr &lt;1)</td>
<td>Defines the convergence tolerance setting of the Neural Network algorithm. The default value is 0.000001.</td>
</tr>
</tbody>
</table>
Table 40-22  (Cont.) DBMS_DATA_MINING Neural Network Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| NNET_WEIGHT_LOWER_BOUND       | A real number | The setting specifies the lower bound of the region where weights are randomly initialized. NNET_WEIGHT_LOWER_BOUND and NNET_WEIGHT_UPPER_BOUND must be set together. Setting one and not setting the other raises an error. NNET_WEIGHT_LOWER_BOUND must not be greater than NNET_WEIGHT_UPPER_BOUND. The default value is \(-\sqrt{6/(l\_nodes+r\_nodes)}\). The value of \(l\_nodes\) for:
  - input layer dense attributes is \((1+\text{number of dense attributes})\)
  - input layer sparse attributes is \(\text{number of sparse attributes}\)
  - each hidden layer is \((1+\text{number of nodes in that hidden layer})\)

The value of \(r\_nodes\) is the number of nodes in the layer that the weight is connecting to. |
| NNET_WEIGHT_UPPER_BOUND      | A real number | This setting specifies the upper bound of the region where weights are initialized. It should be set in pairs with NNET_WEIGHT_LOWER_BOUND and its value must not be smaller than the value of NNET_WEIGHT_LOWER_BOUND. If not specified, the values of NNET_WEIGHT_LOWER_BOUND and NNET_WEIGHT_UPPER_BOUND are system determined. The default value is \(\sqrt{6/(l\_nodes+r\_nodes)}\). See NNET_WEIGHT_LOWER_BOUND. |

Related Topics

- **DBMS_DATA_MINING — Solver Settings: LBFGS**
  The settings listed in the following table configure the behavior of L-BFGS. Neural Network and Generalized Linear Model (GLM) use these settings.

  **See Also:**

  *Oracle Machine Learning for SQL Concepts* for information about Neural Network.

40.1.2.16 DBMS_DATA_MINING — Algorithm Settings: Non-Negative Matrix Factorization

The settings listed in the following table configure the behavior of the Non-negative Matrix Factorization algorithm.

You can query the data dictionary view *MINING_MODEL_SETTINGS* (using the ALL, USER, or DBA prefix) to find the setting values for a model. See *Oracle Database Reference* for information about *MINING_MODEL_SETTINGS*. 

---
Table 40-23  NMF Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMFS_CONV_TOLERANCE</td>
<td>TO_CHAR(0&lt; numeric_expr &lt;=0.5)</td>
<td>Convergence tolerance for NMF algorithm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is 0.05</td>
</tr>
<tr>
<td>NMFS_NONNEGATIVE_SCORING</td>
<td>NMFS_NONNEG_SCORING_ENABLE</td>
<td>Whether negative numbers should be allowed in scoring results.</td>
</tr>
<tr>
<td></td>
<td>NMFS_NONNEG_SCORING_DISABLE</td>
<td>When set to NMFS_NONNEG_SCORING_ENABLE, negative feature values will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>replaced with zeros. When set to NMFS_NONNEG_SCORING_DISABLE, negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>feature values will be allowed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is NMFS_NONNEG_SCORING_ENABLE</td>
</tr>
<tr>
<td>NMFS_NUM_ITERATIONS</td>
<td>TO_CHAR(1 &lt;= numeric_expr &lt;=500)</td>
<td>Number of iterations for NMF algorithm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is 50</td>
</tr>
<tr>
<td>NMFS_RANDOM_SEED</td>
<td>TO_CHAR(numeric_expr)</td>
<td>Random seed for NMF algorithm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is -1</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for information about NMF

40.1.2.17 DBMS_DATA_MINING — Algorithm Settings: O-Cluster

The settings in the table configure the behavior of the O-Cluster algorithm.

Table 40-24  O-CLuster Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCLT_SENSITIVITY</td>
<td>TO_CHAR(0 &lt;= numeric_expr &lt;=1)</td>
<td>A fraction that specifies the peak density required for separating a new</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cluster. The fraction is related to the global uniform density.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is 0.5</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL Concepts* for information about O-Cluster
40.1.2.18 DBMS_DATA_MINING — Algorithm Settings: Random Forest

These settings configure the behavior of the Random Forest algorithm. Random Forest makes use of the Decision Tree settings to configure the construction of individual trees.

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFOR_MTRY</td>
<td>a number &gt;= 0</td>
<td>Size of the random subset of columns to be considered when choosing a split at a node. For each node, the size of the pool remains the same, but the specific candidate columns change. The default is half of the columns in the model signature. The special value 0 indicates that the candidate pool includes all columns.</td>
</tr>
<tr>
<td>RFOR_NUM_TREES</td>
<td>1&lt;= a number &lt;=65535</td>
<td>Number of trees in the forest Default is 20.</td>
</tr>
<tr>
<td>RFOR_SAMPLING_RATIO</td>
<td>0&lt; a fraction&lt;1</td>
<td>Fraction of the training data to be randomly sampled for use in the construction of an individual tree. The default is half of the number of rows in the training data.</td>
</tr>
</tbody>
</table>

Related Topics

- DBMS_DATA_MINING — Algorithm Settings: Decision Tree
  These settings configure the behavior of the Decision Tree algorithm. Note that the Decision Tree settings are also used to configure the behavior of Random Forest as it constructs each individual decision tree.

See Also:

Oracle Machine Learning for SQL Concepts for information about Random Forest

40.1.2.19 DBMS_DATA_MINING — Algorithm Constants and Settings: Singular Value Decomposition

The following constant affects the behavior of the Singular Value Decomposition algorithm.

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Constant Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVDS_MAX_NUM_FEATURES</td>
<td>2500</td>
<td>The maximum number of features supported by SVD.</td>
</tr>
</tbody>
</table>

The following settings configure the behavior of the Singular Value Decomposition algorithm.
### Table 40-27  Singular Value Decomposition Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVDS_U_MATRIX_OUTPUT</td>
<td>SVDS_U_MATRIX_ENABLE</td>
<td>Indicates whether or not to persist the U Matrix produced by SVD. The U matrix in SVD has as many rows as the number of rows in the build data. To avoid creating a large model, the U matrix is persisted only when SVDS_U_MATRIX_OUTPUT is enabled. When SVDS_U_MATRIX_OUTPUT is enabled, the build data must include a case ID. If no case ID is present and the U matrix is requested, then an exception is raised. Default is SVDS_U_MATRIX_DISABLE.</td>
</tr>
<tr>
<td>SVDS_SCORING_MODE</td>
<td>SVDS_SCORING_SVD</td>
<td>Whether to use SVD or PCA scoring for the model. When the build data is scored with SVD, the projections will be the same as the U matrix. When the build data is scored with PCA, the projections will be the product of the U and S matrices. Default is SVDS_SCORING_SVD.</td>
</tr>
<tr>
<td>SVDS_SOLVER</td>
<td>SVDS_SOLVER_TSSVD</td>
<td>This setting indicates the solver to be used for computing SVD of the data. In the case of PCA, the solver setting indicates the type of SVD solver used to compute the PCA for the data. When this setting is not specified the solver type selection is data driven. If the number of attributes is greater than 3240, then the default wide solver is used. Otherwise, the default narrow solver is selected. The following are the group of solvers:</td>
</tr>
<tr>
<td></td>
<td>SVDS_SOLVER_TSEIGEN</td>
<td>Narrow data solvers: for matrices with up to 11500 attributes (TSEIGEN) or up to 8100 attributes (TSSVD).</td>
</tr>
<tr>
<td></td>
<td>SVDS_SOLVER_SSVD</td>
<td>Wide data solvers: for matrices up to 1 million attributes. For narrow data solvers:</td>
</tr>
<tr>
<td></td>
<td>SVDS_SOLVER_STEIGEN</td>
<td>Tall-Skinny SVD uses QR computation TSVD (SVDS_SOLVER_TSSVD).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tall-Skinny SVD uses eigenvalue computation, TSEIGEN (SVDS_SOLVER_TSEIGEN), is the default solver for narrow data. For wide data solvers:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stochastic SVD uses QR computation SSVD (SVDS_SOLVER_SSVD), is the default solver for wide data solvers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stochastic SVD uses eigenvalue computations, STEIGEN (SVDS_SOLVER_STEIGEN).</td>
</tr>
<tr>
<td>SVDS_TOLERANCE</td>
<td>Range [0, 1]</td>
<td>This setting is used to prune features. Define the minimum value the eigenvalue of a feature as a share of the first eigenvalue to not to prune. Default value is data driven.</td>
</tr>
<tr>
<td>SVDS_RANDOM_SEED</td>
<td>Range [0 - 4,294,967,296]</td>
<td>The random seed value is used for initializing the sampling matrix used by the Stochastic SVD solver. The default is 0. The SVD Solver must be set to SSVD or STEIGEN.</td>
</tr>
<tr>
<td>SVDS_OVER_SAMPLING</td>
<td>Range [1, 5000]</td>
<td>This setting is configures the number of columns in the sampling matrix used by the Stochastic SVD solver. The number of columns in this matrix is equal to the requested number of features plus the oversampling setting. The SVD Solver must be set to SSVD or STEIGEN.</td>
</tr>
</tbody>
</table>
### Table 40-27 (Cont.) Singular Value Decomposition Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVDS_POWER_ITERATIONS</td>
<td>Range [0, 20]</td>
<td>The power iteration setting improves the accuracy of the SSVD solver. The default is 2. The SVD Solver must be set to SSVD or STEIGEN.</td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL Concepts*

#### 40.1.2.20 DBMS_DATA_MINING — Algorithm Settings: Support Vector Machine

The settings listed in the following table configure the behavior of the Support Vector Machine algorithm.

### Table 40-28 SVM Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVMS_COMPLEXITY_FACTOR</td>
<td>TO_CHAR(numeric_expr &gt;0)</td>
<td>Regularization setting that balances the complexity of the model against model robustness to achieve good generalization on new data. SVM uses a data-driven approach to finding the complexity factor. Value of complexity factor for SVM algorithm (both classification and regression). Default value estimated from the data by the algorithm.</td>
</tr>
<tr>
<td>SVMS_CONV_TOLERANCE</td>
<td>TO_CHAR(numeric_expr &gt;0)</td>
<td>Convergence tolerance for SVM algorithm. Default is 0.0001.</td>
</tr>
<tr>
<td>SVMS_EPSILON</td>
<td>TO_CHAR(numeric_expr &gt;0)</td>
<td>Regularization setting for regression, similar to complexity factor. Epsilon specifies the allowable residuals, or noise, in the data. Value of epsilon factor for SVM regression. Default is 0.1.</td>
</tr>
<tr>
<td>SVMSKERNEL_FUNCTION</td>
<td>SVMS_LINEAR, SVMS_GAUSSIAN</td>
<td>Kernel for Support Vector Machine. Linear or Gaussian. The default value is SVMS_LINEAR.</td>
</tr>
<tr>
<td>SVMS_OUTLIER_RATE</td>
<td>TO_CHAR(0 &lt; numeric_expr &lt;1)</td>
<td>The desired rate of outliers in the training data. Valid for One-Class SVM models only (anomaly detection). Default is 0.01.</td>
</tr>
<tr>
<td>SVMS_STD_DEV</td>
<td>TO_CHAR(numeric_expr &gt;0)</td>
<td>Controls the spread of the Gaussian kernel function. SVM uses a data-driven approach to find a standard deviation value that is on the same scale as distances between typical cases. Value of standard deviation for SVM algorithm. This is applicable only for Gaussian kernel. Default value estimated from the data by the algorithm.</td>
</tr>
</tbody>
</table>
### Table 40-28  (Cont.) SVM Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVMS_NUM_ITERATIONS</td>
<td>Positive integer</td>
<td>This setting sets an upper limit on the number of SVM iterations. The default is system determined because it depends on the SVM solver.</td>
</tr>
<tr>
<td>SVMS_NUM_PIVOTS</td>
<td>Range $[1; 10000]$</td>
<td>This setting sets an upper limit on the number of pivots used in the Incomplete Cholesky decomposition. It can be set only for non-linear kernels. The default value is 200.</td>
</tr>
<tr>
<td>SVMS_BATCH_ROWS</td>
<td>Positive integer</td>
<td>This setting applies to SVM models with linear kernel. This setting sets the size of the batch for the SGD solver. An input of 0 triggers a data driven batch size estimate. The default is 20000.</td>
</tr>
<tr>
<td>SVMS_REGULARIZER</td>
<td>SVMS_REGULARIZER_L</td>
<td>This setting controls the type of regularization that the SGD SVM solver uses. The setting can be used only for linear SVM models. The default is system determined because it depends on the potential model size.</td>
</tr>
<tr>
<td></td>
<td>SVMS_REGULARIZER_L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>SVMS_SOLVER</td>
<td>SVMS_SOLVER_SGD</td>
<td>This setting allows the user to choose the SVM solver. The SGD solver cannot be selected if the kernel is non-linear. The default value is system determined.</td>
</tr>
<tr>
<td></td>
<td>(Sub-Gradient Descend)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SVMS_SOLVER_IPM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Interior Point Method)</td>
<td></td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL Concepts* for information about SVM

### 40.1.2.21 DBMS_DATA_MINING — Algorithm Settings: XGBoost

Settings that configure the behavior of the XGBoost gradient boosting algorithm.

The XGBoost settings are case sensitive. Enter the settings as they appear in the settings table. These settings match the XGBoost settings available in open source.

### Table 40-29  General Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| booster      | A string that is one of the following: dart, gblinear, gbtree | The booster to use:  
  * dart  
  * gblinear  
  * gbtree  
  The *dart* and *gbtree* boosters use tree-based models whereas *gblinear* uses linear functions.  
  The default value is *gbtree*. |
| num_round    | A non-negative integer.                           | The number of rounds for boosting.  
  The default value is 10. |
Table 40-30  Settings for Tree Boosting

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>A non-negative number</td>
<td>L1 regularization term on weights. Increasing this value makes the model more conservative. The default value is 0.</td>
</tr>
<tr>
<td>colsample_bylevel</td>
<td>A number in the range (0, 1]</td>
<td>Subsample ratio of columns for each split, in each level. Subsampling occurs each time a new split is made. This parameter has no effect when tree_method is set to hist. The default value is 1.</td>
</tr>
<tr>
<td>colsample_bynode</td>
<td>A number in the range (0, 1]</td>
<td>The subsample ratio of columns for each node (split). Subsampling occurs once every time a new split is evaluated. Columns are subsampled from the set of columns chosen for the current level. The default value is 1.</td>
</tr>
<tr>
<td>colsample_bytree</td>
<td>A number in the range (0, 1]</td>
<td>Subsample ratio of columns when constructing each tree. Subsampling occurs once in every boosting iteration. The default value is 1.</td>
</tr>
<tr>
<td>eta</td>
<td>A number in the range [0, 1]</td>
<td>Step-size shrinkage used in the update step to prevent overfitting. After each boosting step, eta shrinks the feature weights to make the boosting process more conservative. The default value is 0.3.</td>
</tr>
<tr>
<td>gamma</td>
<td>A number in the range [0, ∞]</td>
<td>Minimum loss reduction required to make a further partition on a leaf node of the tree. The larger gamma value is, the more conservative the algorithm is. The default value is 0.</td>
</tr>
<tr>
<td>grow_policy</td>
<td>A string; one of the following: depthwise, lossguide</td>
<td>Controls the way new nodes are added to the tree: depthwise splits at nodes closest to the root. lossguide splits at nodes with the highest loss change. Valid only if tree_method is set to hist. The default value is depthwise.</td>
</tr>
<tr>
<td>lambda</td>
<td>A non-negative number</td>
<td>L2 regularization term on weights. The default value is 1.</td>
</tr>
<tr>
<td>max_bin</td>
<td>A non-negative integer</td>
<td>Maximum number of discrete bins to bucket continuous features. Increasing this number improves the optimality of splits at the cost of higher computation time. This parameter is valid only when tree_method is set to hist. The default value is 256.</td>
</tr>
</tbody>
</table>
### Table 40-30  (Cont.) Settings for Tree Boosting

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>max_delta_step</td>
<td>A number in the range $[0, \infty]$</td>
<td>Maximum delta step allowed for each leaf output. Setting this to a positive value can help make the update step more conservative. Usually this parameter is not needed, but it might help in logistic regression when the class is extremely imbalanced. Setting it to value from 1 to 10 might help control the update. The default value is 0, which means there is no constraint.</td>
</tr>
<tr>
<td>max_depth</td>
<td>An integer in the range $[0, \infty]$</td>
<td>Maximum depth of a tree. Increasing this value makes the model more complex and more likely to overfit. Setting this to 0 indicates no limit.</td>
</tr>
<tr>
<td>max_leaves</td>
<td>A non-negative number</td>
<td>Maximum number of nodes to add. Use this setting only when <code>grow_policy</code> is set to <code>lossguide</code>. The default value is 0.</td>
</tr>
<tr>
<td>min_child_weight</td>
<td>A number in the range $[0, \infty]$</td>
<td>Minimum sum of instance weight (hessian) needed in a child. If the tree partition step results in a leaf node with a sum of instance weight less than <code>min_child_weight</code>, then the building process stops partitioning. In a linear regression task, this corresponds to the minimum number of instances needed in each node. The larger <code>min_child_weight</code> is, the more conservative the algorithm is. The default value is 1.</td>
</tr>
<tr>
<td>num_parallel_tree</td>
<td>A non-negative integer</td>
<td>Number of parallel trees constructed during each iteration. Use this option to support a boosted random forest. The default value is 1.</td>
</tr>
<tr>
<td>Setting Name</td>
<td>Setting Value</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>scale_pos_weight</td>
<td>A non-negative number</td>
<td>Controls the balance of positive and negative weights, which is useful for unbalanced classes. A typical value to consider: ( \text{sum(negative cases)} / \text{sum(positive cases)} ). The default value is 1.</td>
</tr>
<tr>
<td>sketch_eps</td>
<td>A number in the range (0, 1]</td>
<td>Increases enumeration accuracy. Valid only for the approximate greedy tree method. Compared to directly selecting the number of bins, this setting comes with a theoretical guarantee with sketch accuracy. You usually do not need to change this setting, but you might consider setting a lower number for more accurate enumeration. The default value is 0.03.</td>
</tr>
<tr>
<td>subsample</td>
<td>A number in the range (0, 1]</td>
<td>Subsample ratio of the training instances. A setting of 0.5 means that XGBoost randomly samples half of the training data prior to growing trees, which prevents overfitting. Subsampling occurs once in every boosting iteration. The default value is 1.</td>
</tr>
<tr>
<td>tree_method</td>
<td>A string that is one of the following: • approx • auto • exact • hist</td>
<td>Tree construction algorithm used in XGBoost: • approx: Approximate greedy algorithm using sketching and histogram. • auto: Use a heuristic to choose the faster algorithm: – For a small to medium sized data set, uses the exact greedy algorithm. – For a very large data set, uses the approximate greedy algorithm. • exact: Exact greedy algorithm. • hist: Fast histogram optimized approximate greedy algorithm; uses some performance improvements such as bins caching. The default value is auto.</td>
</tr>
</tbody>
</table>
### Table 40-30 Settings for Tree Boosting

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>updater</td>
<td>A comma-separated string; one or more of the following: <code>· grow_colmaker</code> <code>· grow_histmaker</code> <code>· grow_local_histmaker</code> <code>· grow_skemaker</code> <code>· grow_quantile_histmaker</code> <code>· prune</code> <code>· sync</code></td>
<td>Defines the sequence of tree updaters to run, which provides a modular way to construct and to modify the trees. This is an advanced parameter that is usually set automatically, depending on some other parameters. However, you can also explicitly specify a setting. The setting values are: <code>· grow_colmaker</code>: Non-distributed column-based construction of trees. <code>· grow_histmaker</code>: Distributed tree construction with row-based data splitting based on a global proposal of histogram counting. <code>· grow_local_histmaker</code>: Based on local histogram counting. <code>· grow_skemaker</code>: Uses the approximate sketching algorithm. <code>· grow_quantile_histmaker</code>: Grow tree using quantized histogram. <code>· prune</code>: Prunes the splits where loss &lt; min_split_loss (or gamma). <code>· sync</code>: Synchronizes trees in all distributed nodes.</td>
</tr>
</tbody>
</table>

### Table 40-31 Settings for the Dart Booster

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>one_drop</td>
<td>A number that is 0 or 1</td>
<td>When set to 1, at least one tree is always dropped during the dropout. When set to 0, at least one tree is not always dropped during the dropout. The default value is 0.</td>
</tr>
</tbody>
</table>
| normalize_type | A string; either: `· forest` `· tree` | Type of normalization algorithm: `· forest`: New trees have the same weight as the sum of the dropped trees (forest):  
  - The weight of new trees is $\frac{1}{1 + \text{learning_rate}}$  
  - Dropped trees are scaled by a factor of $\frac{1}{1 + \text{learning_rate}}$  
`· tree`: New trees have the same weight as dropped trees:  
  - The weight of new trees is $\frac{1}{k + \text{learning_rate}}$  
  - Dropped trees are scaled by a factor of $\frac{k}{k + \text{learning_rate}}$  
The default value is `tree`. |
| rate_drop    | A number in the range [0.0, 1.0] | Dropout rate (a fraction of the previous trees to drop during the dropout). The default value is 0.0. |
### Table 40-31  (Cont.) Settings for the Dart Booster

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample_type</td>
<td>A string; either:</td>
<td>Type of sampling algorithm:</td>
</tr>
<tr>
<td></td>
<td>• uniform</td>
<td>• uniform: Dropped trees are selected uniformly</td>
</tr>
<tr>
<td></td>
<td>• weighted</td>
<td>• weighted: Dropped trees are selected in proportion to weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default value is uniform.</td>
</tr>
<tr>
<td>skip_drop</td>
<td>A number in the range [0.0, 1.0]</td>
<td>Probability of skipping the dropout procedure during a boosting iteration. If a dropout is skipped, new trees are added in the same manner as gbtree. A non-zero skip_drop has higher priority than rate_drop or one_drop. The default value is 0.0.</td>
</tr>
</tbody>
</table>

### Table 40-32  Settings for the Linear Booster

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>A non-negative number</td>
<td>L1 regularization term on weights, normalized to the number of training examples. Increasing this value makes the model more conservative. The default value is 0.</td>
</tr>
<tr>
<td>feature_selector</td>
<td>A string that is one of the following:</td>
<td>Feature selection and ordering method:</td>
</tr>
<tr>
<td></td>
<td>• cyclic</td>
<td>• cyclic: Deterministic selection by cycling through the features one at a time.</td>
</tr>
<tr>
<td></td>
<td>• greedy</td>
<td>• greedy: Selects the coordinate with the greatest gradient magnitude. This method:</td>
</tr>
<tr>
<td></td>
<td>• random</td>
<td>- Has $O(num_feature^2)$ complexity</td>
</tr>
<tr>
<td></td>
<td>• shuffle</td>
<td>- Is fully deterministic</td>
</tr>
<tr>
<td></td>
<td>• thrifty</td>
<td>- Allows restricting the selection to the top_k features per group with the largest magnitude of univariate weight change, by setting the top_k parameter; doing so reduces the complexity to $O(num_feature*top_k)$.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• random: A random (with replacement) coordinate selector.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• shuffle: Similar to cyclic but with random feature shuffling prior to each update.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• thrifty: Thrifty, approximately-greedy feature selector. Prior to cyclic updates, reorders features in descending magnitude of their univariate weight changes. This operation is multithreaded and is a linear complexity approximation of the quadratic greedy selection. Restricts the selection per group to the top_k features with the largest magnitude of univariate weight change. The default value is cyclic.</td>
</tr>
</tbody>
</table>
Table 40-32  (Cont.) Settings for the Linear Booster

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lambda</td>
<td>A non-negative number</td>
<td>L2 regularization term on weights, normalized to the number of training examples. Increasing this value makes the model more conservative. The default value is 0.</td>
</tr>
<tr>
<td>top_k</td>
<td>A non-negative integer</td>
<td>Number of top features to select for the greedy or thrifty feature selector. The value of 0 uses all of the features. The default value is 0.</td>
</tr>
<tr>
<td>updater</td>
<td>A string that is one of the following: · coord_descent · shotgun</td>
<td>Algorithm to fit the linear model: · coord_descent: Ordinary coordinate descent algorithm; multithreaded but still produces a deterministic solution. · shotgun: Parallel coordinate descent algorithm based on the shotgun algorithm; uses “hogwild” parallelism and therefore produces a nondeterministic solution on each run. The default value is shotgun.</td>
</tr>
</tbody>
</table>

Table 40-33  Settings for Tweedie Regression

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tweedie_variance_power</td>
<td>A number in the range (1, 2)</td>
<td>Controls the variance of the Tweedie distribution ( \text{var}(y) \sim \text{E}(y)^{\text{tweedie_variance_power}} ). A setting closer to 1 shifts towards a Poisson distribution. A setting closer to 2 shifts towards a gamma distribution. The default value is 1.5.</td>
</tr>
</tbody>
</table>

Some XGBoost objectives apply only to classification function models and other objectives apply only to regression function models. If you specify an incompatible objective value, an error is raised. In the `DBMS_DATA_MINING.CREATE_MODEL` procedure, if you specify `DBMS_DATA_MINING.CLASSIFICATION` as the function, then the only objective values that you can use are the binary and multi values. The one exception is binary: logitraw, which produces a continuous value and applies only to a regression model. If you specify `DBMS_DATA_MINING.REGRESSION` as the function, then you can specify binary: logitraw or any of the count, rank, reg, and survival values as the objective.
<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
| objective    | For a classification model, a string that is one of the following:  
  - binary:hinge  
  - binary:logistic  
  - multi:softmax  
  - multi:softprob  
  For a regression model, a string that is one of the following:  
  - binary:logitraw  
  - count:poisson  
  - rank:map  
  - rank:ndcg  
  - rank:pairwise  
  - reg:gamma  
  - reg:logistic  
  - reg:tweedie  
  - survival:cox  
  - reg:squarederror  
  - reg:squaredlogerror | |
|              | Settings for a Classification model:  
  - binary:hinge: Hinge loss for binary classification. This setting makes predictions of 0 or 1, rather than producing probabilities.  
  - binary:logistic: Logistic regression for binary classification. The output is the probability.  
  - multi:softmax: Performs multiclass classification using the softmax objective; you must also set num_class(number_of_classes).  
  - multi:softprob:: Same as softmax, except the output is a vector of n\text{data} \times n\text{class}, which can be further reshaped to an n\text{data} \times n\text{class} matrix. The result contains the predicted probability of each data point belonging to each class.  
  The default objective value for classification is multi:softprob.  
|              | Settings for a Regression model:  
  - binary:logitraw: Logistic regression for binary classification; the output is the score before logistic transformation.  
  - count:poisson: Poisson regression for count data; the output is the mean of the Poisson distribution. The max_delta_step value is set to 0.7 by default in Poisson regression to safeguard optimization.  
  - rank:map: Using LambdaMART, performs listwise ranking in which the Mean Average Precision (MAP) is maximized.  
  - rank:ndcg: Using LambdaMART, performs listwise ranking in which the Normalized Discounted Cumulative Gain (NDCG) is maximized.  
  - rank:pairwise: Performs ranking by minimizing the pairwise loss.  
  - reg:gamma: Gamma regression with log-link; the output is the mean of the gamma distribution. This setting might be useful for any outcome that might be gamma-distributed, such as modeling insurance claims severity.  
  - reg:logistic: Logistic regression.  
  - reg:tweedie: Tweedie regression with log-link. This setting might be useful for any outcome that might be Tweedie-distributed, such as modeling total loss in insurance.  
  - survival:cox: Cox regression for right-censored survival time data (negative values are considered right-censored). Predictions are returned on the hazard ratio scale (that is, as $HR = \exp(marginal\_prediction)$ in the |
Table 40-34  (Cont.) Settings for Learning Tasks

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>proportional hazard function $h(t) = h_0(t) \times HR$.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- reg:squarederror: Regression with squared loss.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- reg:squaredlogerror: Regression with squared log loss. All input labels must be greater than -1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The default objective value for regression is reg:squarederror.</td>
</tr>
<tr>
<td>base_score</td>
<td>A number</td>
<td>Initial prediction score of all instances, global bias. For a sufficient number of iterations, changing this value does not have much effect. The default value is 0.5.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eval_metric</td>
<td>A comma-separated string; one or more of the following:</td>
<td>Evaluation metrics for validation data. You can specify one or more of these evaluation metrics:</td>
</tr>
<tr>
<td></td>
<td>• auc</td>
<td>• auc: Area under the curve.</td>
</tr>
<tr>
<td></td>
<td>• aucpr</td>
<td>• aucpr: Area under the PR curve.</td>
</tr>
<tr>
<td></td>
<td>• cox-nloglik</td>
<td>• cox-nloglik: Negative partial log-likelihood for Cox proportional hazards regression.</td>
</tr>
<tr>
<td></td>
<td>• error</td>
<td>• error: Binary classification error rate, calculated as the number of wrong cases divided by the number of all cases. For the predictions, the evaluation regards the instances with a prediction value larger than 0.5 as positive instances, and the others as negative instances.</td>
</tr>
<tr>
<td></td>
<td>• error@t</td>
<td>• error@t: You can specify a binary classification threshold value other than 0.5 by specifying a numerical value t; for example, error@0.8.</td>
</tr>
<tr>
<td></td>
<td>• gamma-deviance</td>
<td>• gamma-deviance: Residual deviance for gamma regression.</td>
</tr>
<tr>
<td></td>
<td>• gamma-nloglik</td>
<td>• gamma-nloglik: Negative log-likelihood for gamma regression.</td>
</tr>
<tr>
<td></td>
<td>• logloss</td>
<td>• logloss: Negative log-likelihood.</td>
</tr>
<tr>
<td></td>
<td>• mae</td>
<td>• mae: Mean absolute error.</td>
</tr>
<tr>
<td></td>
<td>• map</td>
<td>• map: Mean average precision.</td>
</tr>
<tr>
<td></td>
<td>• map@n</td>
<td>• map@n: Assigns the integer n as the cut-off value for the top positions in the lists for evaluation.</td>
</tr>
<tr>
<td></td>
<td>• merror</td>
<td>• merror: Multiclass classification error rate calculated as the number of wrong cases divided by the number of all cases; the objective must be multi:softprob or multi:softmax.</td>
</tr>
<tr>
<td></td>
<td>• mlogloss</td>
<td>• mlogloss: Multiclass logloss; the objective must be multi:softprob or multi:softmax.</td>
</tr>
<tr>
<td></td>
<td>• ndcg</td>
<td>• ndcg: Normalized Discounted Cumulative Gain.</td>
</tr>
<tr>
<td></td>
<td>• ndcg@n</td>
<td>• ndcg@n: Assigns the integer n as the cut-off value for the top positions in the lists for evaluation.</td>
</tr>
<tr>
<td></td>
<td>• poisson-nloglik</td>
<td>• poisson-nloglik: Negative log-likelihood for Poisson regression</td>
</tr>
<tr>
<td></td>
<td>• rmse</td>
<td>• rmse: Root Mean Square Error.</td>
</tr>
<tr>
<td></td>
<td>• tweedie-nloglik@rho</td>
<td>• tweedie-nloglik@rho: Negative log-likelihood for Tweedie regression (at a specified value rho of the tweedie_variance_power parameter); rho must be a number in the range (1, 2); for example, tweedie-nloglik@1.8.</td>
</tr>
<tr>
<td></td>
<td>• ndcg-</td>
<td>• ndcg- and map-: In XGBoost, NDCG and MAP will evaluate the score of a list without any positive samples as 1. By adding &quot;-&quot; in the evaluation metric XGBoost will evaluate these score as 0 to be consistent under some conditions.</td>
</tr>
<tr>
<td></td>
<td>• map-</td>
<td>• map-: It is root mean square log error. This is the default metric of reg:squaredlogerror</td>
</tr>
<tr>
<td></td>
<td>• rmsle</td>
<td></td>
</tr>
</tbody>
</table>
### Table 40-34 (Cont.) Settings for Learning Tasks

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
</table>
|              |               | objective. This metric reduces errors generated by outliers in dataset. But because log function is employed, rmsle might output nan when prediction value is less than -1. A default metric is assigned according to the objective:  
  - error for classification  
  - mean average precision for ranking  
  - rmse for regression |
| seed         | A non-negative integer | Random number seed. The default value is 0. |

#### See Also:

https://github.com/oracle/oracle-db-examples/tree/master/machine-learning/sql/20c GitHub repository for an example of XGBoost.

### 40.1.3 DBMS_DATA_MINING — Solver Settings

Oracle Machine Learning for SQL algorithms can use different solvers. Solver settings can be provided at build time in the settings table.

**Related Topics**

- **DBMS_DATA_MINING - Solver Settings: Adam**
  These settings configure the behavior of the Adaptive Moment Estimation (Adam) solver.

- **DBMS_DATA_MINING — Solver Settings: ADMM**
  The settings listed in the following table configure the behavior of Alternating Direction Method of Multipliers (ADMM). The Generalized Linear Model (GLM) algorithm uses these settings.

- **DBMS_DATA_MINING — Solver Settings: LBFGS**
  The settings listed in the following table configure the behavior of L-BFGS. Neural Network and Generalized Linear Model (GLM) use these settings.

### 40.1.3.1 DBMS_DATA_MINING - Solver Settings: Adam

These settings configure the behavior of the Adaptive Moment Estimation (Adam) solver.

Neural Network models use these settings.
Table 40-35  DBMS_DATA_MINING Adam Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADAM_ALPHA</td>
<td>A non-negative double precision floating point number in the interval (0; 1]</td>
<td>The learning rate for Adam. The default value is 0.001.</td>
</tr>
<tr>
<td>ADAM_BATCH_ROWS</td>
<td>A positive integer</td>
<td>The number of rows per batch. The default value is 10000.</td>
</tr>
<tr>
<td>ADAM_BETA1</td>
<td>A positive double precision floating point number in the interval ([0; 1)]</td>
<td>The exponential decay rate for the 1st moment estimates. The default value is 0.9.</td>
</tr>
<tr>
<td>ADAM_BETA2</td>
<td>A positive double precision floating point number in the interval ([0; 1)]</td>
<td>The exponential decay rate for the 2nd moment estimates. The default value is 0.99.</td>
</tr>
<tr>
<td>ADAM_GRADIENT_TOLERANCE</td>
<td>A positive double precision floating point number</td>
<td>The gradient infinity norm tolerance for Adam. The default value is 1E-9.</td>
</tr>
</tbody>
</table>

40.1.3.2 DBMS_DATA_MINING — Solver Settings: ADMM

The settings listed in the following table configure the behavior of Alternating Direction Method of Multipliers (ADMM). The Generalized Linear Model (GLM) algorithm uses these settings.

Table 40-36  DBMS_DATA_MINING ADMM Settings

<table>
<thead>
<tr>
<th>Settings Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMM_CONSENSUS</td>
<td>A positive integer</td>
<td>It is a ADMM's consensus parameter. The value must be a positive number. The default value is 0.1.</td>
</tr>
<tr>
<td>ADMM_ITERATIONS</td>
<td>A positive integer</td>
<td>The number of ADMM iterations. The value must be a positive integer. The default value is 50.</td>
</tr>
<tr>
<td>ADMM_TOLERANCE</td>
<td>A positive integer</td>
<td>It is a tolerance parameter. The value must be a positive number. The default value is 0.0001.</td>
</tr>
</tbody>
</table>

Related Topics

- Oracle Machine Learning for SQL Concepts

See Also:

Oracle Machine Learning for SQL Concepts for information about neural network
40.1.3.3 DBMS_DATA_MINING — Solver Settings: LBFGS

The settings listed in the following table configure the behavior of L-BFGS. Neural Network and Generalized Linear Model (GLM) use these settings.

Table 40-37  DBMS_DATA_MINING L-BFGS Settings

<table>
<thead>
<tr>
<th>Setting Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBFGS_GRADIENT_TOLERANCE</td>
<td>TO_CHAR (numeric_expr &gt;0)</td>
<td>Defines gradient infinity norm tolerance for L-BFGS. Default value is 1E-9.</td>
</tr>
<tr>
<td>LBFGS_HISTORY_DEPTH</td>
<td>The value must be a positive integer.</td>
<td>Defines the number of historical copies kept in L-BFGS solver. The default value is 20.</td>
</tr>
<tr>
<td>LBFGS_SCALE_HESSIAN</td>
<td>LBFGS_SCALE_HESSIAN_ENABLE</td>
<td>Defines whether to scale Hessian in L-BFGS or not. Default value is LBFGS_SCALE_HESSIAN_ENABLE.</td>
</tr>
<tr>
<td></td>
<td>LBFGS_SCALE_HESSIAN_DISABLE</td>
<td></td>
</tr>
</tbody>
</table>

See Also:

Oracle Machine Learning for SQL Concepts for information about neural network

40.1.4 DBMS_DATA_MINING Datatypes

The DBMS_DATA_MINING package defines object data types for processing transactional data. The package also defines a type for user-specified transformations. These types are called DM_NESTED_\(n\), where \(n\) identifies the Oracle data type of the nested attributes.

The Oracle Machine Learning for SQL object data types are described in the following table:

Table 40-38  DBMS_DATA_MINING Summary of Data Types

<table>
<thead>
<tr>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_NESTED_BINARY_DOUBLE</td>
<td>The name and value of a numerical attribute of type BINARY_DOUBLE.</td>
</tr>
<tr>
<td>DM_NESTED_BINARY.DOUBLES</td>
<td>A collection of DM_NESTED_BINARY_DOUBLE.</td>
</tr>
<tr>
<td>DM_NESTED_BINARY_FLOAT</td>
<td>The name and value of a numerical attribute of type BINARY_FLOAT.</td>
</tr>
<tr>
<td>DM_NESTED_BINARY.FLOATS</td>
<td>A collection of DM_NESTED_BINARY_FLOAT.</td>
</tr>
<tr>
<td>DM_NESTED_CATEGORICAL</td>
<td>The name and value of a categorical attribute of type CHAR, VARCHAR, or VARCHAR2.</td>
</tr>
<tr>
<td>DM_NESTED_CATEGORICALS</td>
<td>A collection of DM_NESTED_CATEGORICAL.</td>
</tr>
</tbody>
</table>
### Table 40-38  DBMS_DATA_MINING Summary of Data Types (Cont.)

<table>
<thead>
<tr>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_NESTED_NUMERICAL</td>
<td>The name and value of a numerical attribute of type NUMBER or FLOAT.</td>
</tr>
<tr>
<td>DM_NESTED_NUMERICALS</td>
<td>A collection of DM_NESTED_NUMERICAL.</td>
</tr>
<tr>
<td>ORA_MINING_VARCHAR2_NT</td>
<td>A table of VARCHAR2(4000).</td>
</tr>
<tr>
<td>TRANSFORM_LIST</td>
<td>A list of user-specified transformations for a model. Accepted as a parameter by the CREATE_MODEL Procedure.</td>
</tr>
<tr>
<td></td>
<td>This collection type is defined in the DBMS_DATA_MINING_TRANSFORM package.</td>
</tr>
</tbody>
</table>

For more information about processing nested data, see Oracle Machine Learning for SQL User’s Guide.

**Note:**

Starting from Oracle Database 12c Release 2, GET_MODEL_DETAILS are deprecated and are replaced with Model Detail Views. See Oracle Machine Learning for SQL User’s Guide.

#### 40.1.4.1 Deprecated Types

This topic contains tables listing deprecated types.

The DBMS_DATA_MINING package defines object datatypes for storing information about model attributes. Most of these types are returned by the table functions GET_n, where n identifies the type of information to return. These functions take a model name as input and return the requested information as a collection of rows.

For a list of the GET functions, see "Summary of DBMS_DATA_MINING Subprograms".

All the table functions use pipelining, which causes each row of output to be materialized as it is read from model storage, without waiting for the generation of the complete table object. For more information on pipelined, parallel table functions, consult the Oracle Database PL/SQL Language Reference.

### Table 40-39  DBMS_DATA_MINING Summary of Deprecated Datatypes

<table>
<thead>
<tr>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_CENTROID</td>
<td>The centroid of a cluster.</td>
</tr>
<tr>
<td>DM_CENTROIDS</td>
<td>A collection of DM_CENTROID. A member of DM_CLUSTER.</td>
</tr>
<tr>
<td>DM_CHILD</td>
<td>A child node of a cluster.</td>
</tr>
<tr>
<td>DM_CHILDREN</td>
<td>A collection of DM_CHILD. A member of DM_CLUSTER.</td>
</tr>
</tbody>
</table>
Table 40-39  (Cont.) DBMS_DATA_MINING Summary of Deprecated Datatypes

<table>
<thead>
<tr>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_CLUSTER</td>
<td>A cluster. A cluster includes DM_PREDICATES, DM_CHILDREN, DM_CENTROIDS, and DM_HISTOGRAMS. It also includes a DM_RULE.</td>
</tr>
<tr>
<td></td>
<td>See also, DM_CLUSTERS Fields.</td>
</tr>
<tr>
<td></td>
<td>See also, DM_CLUSTERS Fields.</td>
</tr>
<tr>
<td>DM_CONDITIONAL</td>
<td>The conditional probability of an attribute in a Naive Bayes model.</td>
</tr>
<tr>
<td>DM_CONDITIONALS</td>
<td>A collection of DM_CONDITIONAL. Returned by GET_MODEL_DETAILS_NB Function.</td>
</tr>
<tr>
<td>DM_COST_ELEMENT</td>
<td>The actual and predicted values in a cost matrix.</td>
</tr>
<tr>
<td>DM_COST_MATRIX</td>
<td>A collection of DM_COST_ELEMENT. Returned by GET_MODEL_COST_MATRIX Function.</td>
</tr>
<tr>
<td>DM_EM_COMPONENT</td>
<td>A component of an Expectation Maximization model.</td>
</tr>
<tr>
<td>DM_EM_PROJECTION</td>
<td>A projection of an Expectation Maximization model.</td>
</tr>
<tr>
<td>DM_GLM_COEFF</td>
<td>The coefficient and associated statistics of an attribute in a Generalized Linear Model.</td>
</tr>
<tr>
<td>DM_GLM_COEFF_SET</td>
<td>A collection of DM_GLM_COEFF. Returned by GET_MODEL_DETAILS_GLM Function.</td>
</tr>
<tr>
<td>DM_HISTOGRAM_BIN</td>
<td>A histogram associated with a cluster.</td>
</tr>
<tr>
<td>DM_HISTOGRAMS</td>
<td>A collection of DM_HISTOGRAM_BIN. A member of DM_CLUSTER. See also, DM_CLUSTERS Fields.</td>
</tr>
<tr>
<td>DM_ITEM</td>
<td>An item in an association rule.</td>
</tr>
<tr>
<td>DM_ITEMS</td>
<td>A collection of DM_ITEM.</td>
</tr>
<tr>
<td>DM_ITEMSET</td>
<td>A collection of DM_ITEMS.</td>
</tr>
<tr>
<td>DM_ITEMSETS</td>
<td>A collection of DM_ITEMSET. Returned by GET_FREQUENT_ITEMSETS Function.</td>
</tr>
<tr>
<td>DM_MODEL_GLOBAL_DETAIL</td>
<td>High-level statistics about a model.</td>
</tr>
<tr>
<td>DM_NB_DETAIL</td>
<td>Information about an attribute in a Naive Bayes model.</td>
</tr>
<tr>
<td>DM_NMF_ATTRIBUTE</td>
<td>An attribute in a feature of a Non-Negative Matrix Factorization model.</td>
</tr>
</tbody>
</table>
Table 40-39  (Cont.) DBMS_DATA_MINING Summary of Deprecated Datatypes

<table>
<thead>
<tr>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_NMF_ATTRIBUTE_SET</td>
<td>A collection of DM_NMF_ATTRIBUTE. A member of DM_NMF_FEATURE.</td>
</tr>
<tr>
<td>DM_NMF_FEATURE</td>
<td>A feature in a Non-Negative Matrix Factorization model.</td>
</tr>
<tr>
<td>DM_NMF_FEATURE_SET</td>
<td>A collection of DM_NMF_FEATURE. Returned by GET_MODEL_DETAILS_NMF Function.</td>
</tr>
<tr>
<td>DM_PREDICATE</td>
<td>Antecedent and consequent in a rule.</td>
</tr>
<tr>
<td>DM_PREDICATES</td>
<td>A collection of DM_PREDICATE. A member of DM_RULE and DM_CLUSTER. Predicates are returned by GET_ASSOCIATION_RULES Function, GET_MODEL-details_EM Function, GET_MODEL-details_KM Function, and GET_MODEL-details_OC Function. See also, DM_CLUSTER Fields.</td>
</tr>
<tr>
<td>DM_RANKED_ATTRIBUTE</td>
<td>An attribute ranked by its importance in an Attribute Importance model.</td>
</tr>
<tr>
<td>DM_RANKED_ATTRIBUTES</td>
<td>A collection of DM_RANKED_ATTRIBUTE. Returned by GET_MODEL_DETAILS_AI Function.</td>
</tr>
<tr>
<td>DM_RULE</td>
<td>A rule that defines a conditional relationship. The rule can be one of the association rules returned by GET_ASSOCIATION_RULES Function, or it can be a rule associated with a cluster in the collection of clusters returned by GET_MODEL_DETAILS_KM Function and GET_MODEL-details_OC Function. See also, DM_CLUSTER Fields.</td>
</tr>
<tr>
<td>DM_RULES</td>
<td>A collection of DM_RULE. Returned by GET_ASSOCIATION_RULES Function. See also, DM_CLUSTER Fields.</td>
</tr>
<tr>
<td>DM_SVD_MATRIX</td>
<td>A factorized matrix S, V, or U returned by a Singular Value Decomposition model.</td>
</tr>
<tr>
<td>DM_SVD_MATRIX_SET</td>
<td>A collection of DM_SVD_MATRIX. Returned by GET_MODEL_DETAILS_SVD Function.</td>
</tr>
<tr>
<td>DM_SVM_ATTRIBUTE</td>
<td>The name, value, and coefficient of an attribute in a Support Vector Machine model.</td>
</tr>
<tr>
<td>DM_SVM_ATTRIBUTE_SET</td>
<td>A collection of DM_SVM_ATTRIBUTE. Returned by GET_MODEL_DETAILS_SVM Function. Also a member of DM_SVM_LINEAR_COEFF.</td>
</tr>
<tr>
<td>DM_SVM_LINEAR_COEFF</td>
<td>The linear coefficient of each attribute in a Support Vector Machine model.</td>
</tr>
<tr>
<td>DM_SVM_LINEAR_COEFF_SET</td>
<td>A collection of DM_SVM_LINEAR_COEFF. Returned by GET_MODEL_DETAILS_SVM Function for an SVM model built using the linear kernel.</td>
</tr>
<tr>
<td>DM_TRANSFORM</td>
<td>The transformation and reverse transformation expressions for an attribute.</td>
</tr>
<tr>
<td>DM_TRANSFORMS</td>
<td>A collection of DM_TRANSFORM. Returned by GET_MODEL_TRANSFORMATIONS Function.</td>
</tr>
</tbody>
</table>
Return Values for Clustering Algorithms

The table contains description of DM_CLUSTER return value columns, nested table columns, and rows.

Table 40-40  DM_CLUSTER Return Values for Clustering Algorithms

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_CLUSTERS</td>
<td>A set of rows of type DM_CLUSTER. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(id               NUMBER,</td>
</tr>
<tr>
<td></td>
<td>cluster_id       VARCHAR2(4000),</td>
</tr>
<tr>
<td></td>
<td>record_count     NUMBER,</td>
</tr>
<tr>
<td></td>
<td>parent           NUMBER,</td>
</tr>
<tr>
<td></td>
<td>tree_level       NUMBER,</td>
</tr>
<tr>
<td></td>
<td>dispersion       NUMBER,</td>
</tr>
<tr>
<td></td>
<td>split_predicate  DM_PREDICATES,</td>
</tr>
<tr>
<td></td>
<td>child            DM_CHILDREN,</td>
</tr>
<tr>
<td></td>
<td>centroid         DM_CENTROIDS,</td>
</tr>
<tr>
<td></td>
<td>histogram        DM_HISTOGRAMS,</td>
</tr>
<tr>
<td></td>
<td>rule             DM_RULE)</td>
</tr>
<tr>
<td>DM_PREDICATE</td>
<td>The antecedent and consequent columns each return nested tables of type DM_PREDICATES. The rows, of type DM_PREDICATE, have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(attribute_name           VARCHAR2(4000),</td>
</tr>
<tr>
<td></td>
<td>attribute_subname        VARCHAR2(4000),</td>
</tr>
<tr>
<td></td>
<td>conditional_operator     CHAR(2)/<em>=,&lt;,&gt;,&lt;,&lt;=,&gt;=</em>/,</td>
</tr>
<tr>
<td></td>
<td>attribute_num_value      NUMBER,</td>
</tr>
<tr>
<td></td>
<td>attribute_str_value      VARCHAR2(4000),</td>
</tr>
<tr>
<td></td>
<td>attribute_support        NUMBER,</td>
</tr>
<tr>
<td></td>
<td>attribute_confidence     NUMBER)</td>
</tr>
</tbody>
</table>

DM_CLUSTER Fields

The following table describes DM_CLUSTER fields.

Table 40-41  DM_CLUSTER Fields

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>Cluster identifier</td>
</tr>
<tr>
<td>cluster_id</td>
<td>The ID of a cluster in the model</td>
</tr>
<tr>
<td>record_count</td>
<td>Specifies the number of records</td>
</tr>
<tr>
<td>parent</td>
<td>Parent ID</td>
</tr>
<tr>
<td>tree_level</td>
<td>Specifies the number of splits from the root</td>
</tr>
<tr>
<td>dispersion</td>
<td>A measure used to quantify whether a set of observed occurrences are dispersed compared to a standard statistical model.</td>
</tr>
</tbody>
</table>
### Table 40-41  (Cont.) DM_CLUSTER Fields

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>split_predicate</strong></td>
<td>The split_predicate column of DM_CLUSTER returns a nested table of type DM_PREDICATES. Each row, of type DM_PREDICATE, has the following columns:  &lt;br&gt; (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), conditional_operator CHAR(2) / *=,&lt;,&gt;,&lt;,&gt;=, != /, attribute_num_value NUMBER, attribute_str_value VARCHAR2(4000), attribute_support NUMBER, attribute_confidence NUMBER)  &lt;br&gt; Note: The Expectation Maximization algorithm uses all the fields except dispersion and split_predicate.</td>
</tr>
<tr>
<td><strong>child</strong></td>
<td>The child column of DM_CLUSTER returns a nested table of type DM_CHILDREN. The rows, of type DM_CHILD, have a single column of type NUMBER, which contains the identifiers of each child.</td>
</tr>
<tr>
<td><strong>centroid</strong></td>
<td>The centroid column of DM_CLUSTER returns a nested table of type DM_CENTROIDS. The rows, of type DM_CENTROID, have the following columns:  &lt;br&gt; (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), mean NUMBER, mode_value VARCHAR2(4000), variance NUMBER)</td>
</tr>
<tr>
<td><strong>histogram</strong></td>
<td>The histogram column of DM_CLUSTER returns a nested table of type DM_HISTOGRAMS. The rows, of type DM_HISTOGRAM_BIN, have the following columns:  &lt;br&gt; (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), bin_id NUMBER, lower_bound NUMBER, upper_bound NUMBER, label VARCHAR2(4000), count NUMBER)</td>
</tr>
<tr>
<td><strong>rule</strong></td>
<td>The rule column of DM_CLUSTER returns a single row of type DM_RULE. The columns are:  &lt;br&gt; (rule_id INTEGER, antecedent DM_PREDICATES, consequent DM_PREDICATES, rule_support NUMBER, rule_confidence NUMBER, rule_lift NUMBER, antecedent_support NUMBER, consequent_support NUMBER, number_of_items INTEGER)</td>
</tr>
</tbody>
</table>
Usage Notes

- The table function pipes out rows of type DM_CLUSTER. For information on Oracle Machine Learning for SQL data types and piped output from table functions, see "Data Types".
- For descriptions of predicates (DM_PREDICATE) and rules (DM_RULE), see GET_ASSOCIATION_RULES Function.

40.1.5 Summary of DBMS_DATA_MINING Subprograms

This table summarizes the subprograms included in the DBMS_DATA_MINING package.

The GET_* interfaces are replaced by model views. Oracle recommends that users leverage model detail views instead. For more information, refer to Model Detail Views in Oracle Machine Learning for SQL User’s Guide and Static Data Dictionary Views: ALL_ALL_TABLES to ALL_OUTLINES in Oracle Database Reference.

Table 40-42  DBMS_DATA_MINING Package Subprograms

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD_COST_MATRIX Procedure</td>
<td>Adds a cost matrix to a classification model</td>
</tr>
<tr>
<td>ADD_PARTITION Procedure</td>
<td>Adds single or multiple partitions in an existing partition model</td>
</tr>
<tr>
<td>ALTER_REVERSE_EXPRESSION Procedure</td>
<td>Changes the reverse transformation expression to an expression that you specify</td>
</tr>
<tr>
<td>APPLY Procedure</td>
<td>Applies a model to a data set (scores the data)</td>
</tr>
<tr>
<td>COMPUTE_CONFUSION_MATRIX Procedure</td>
<td>Computes the confusion matrix for a classification model</td>
</tr>
<tr>
<td>COMPUTE_CONFUSION_MATRIX_PART Procedure</td>
<td>Computes the evaluation matrix for partitioned models</td>
</tr>
<tr>
<td>COMPUTE_LIFT Procedure</td>
<td>Computes lift for a classification model</td>
</tr>
<tr>
<td>COMPUTE_LIFT_PART Procedure</td>
<td>Computes lift for partitioned models</td>
</tr>
<tr>
<td>COMPUTE_ROC Procedure</td>
<td>Computes Receiver Operating Characteristic (ROC) for a classification model</td>
</tr>
<tr>
<td>COMPUTE_ROC_PART Procedure</td>
<td>Computes Receiver Operating Characteristic (ROC) for a partitioned model</td>
</tr>
<tr>
<td>CREATE_MODEL Procedure</td>
<td>Creates a model</td>
</tr>
<tr>
<td>CREATE_MODEL2 Procedure</td>
<td>Creates a model without extra persistent stages</td>
</tr>
<tr>
<td>Create Model Using Registration Information</td>
<td>Fetches setting information from JSON object</td>
</tr>
<tr>
<td>DROP_ALGORITHM Procedure</td>
<td>Drops the registered algorithm information.</td>
</tr>
<tr>
<td>DROP_PARTITION Procedure</td>
<td>Drops a single partition</td>
</tr>
<tr>
<td>DROP_MODEL Procedure</td>
<td>Drops a model</td>
</tr>
<tr>
<td>EXPORT_MODEL Procedure</td>
<td>Exports a model to a dump file</td>
</tr>
<tr>
<td>EXPORT_SERMODEL Procedure</td>
<td>Exports a model in a serialized format</td>
</tr>
<tr>
<td>FETCH_JSON_SCHEMA Procedure</td>
<td>Fetches and reads JSON schema from all_mining_algorithms view</td>
</tr>
</tbody>
</table>
## Table 40-42  (Cont.) DBMS_DATA_MINING Package Subprograms

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET_MODEL_COST_MATRIX Function</td>
<td>Returns the cost matrix for a model</td>
</tr>
<tr>
<td>IMPORT_MODEL Procedure</td>
<td>Imports a model into a user schema</td>
</tr>
<tr>
<td>IMPORT_SERMODEL Procedure</td>
<td>Imports a serialized model back into the database</td>
</tr>
<tr>
<td>JSON Schema for R Extensible Algorithm</td>
<td>Displays flexibility in creating JSON schema for R Extensible</td>
</tr>
<tr>
<td>REGISTER_ALGORITHM Procedure</td>
<td>Registers a new algorithm</td>
</tr>
<tr>
<td>RANK APPLY Procedure</td>
<td>Ranks the predictions from the APPLY results for a classification model</td>
</tr>
<tr>
<td>REMOVE_COST_MATRIX Procedure</td>
<td>Removes a cost matrix from a model</td>
</tr>
<tr>
<td>RENAME_MODEL Procedure</td>
<td>Renames a model</td>
</tr>
</tbody>
</table>

### Deprecated GET_MODEL_DETAILS

Starting from Oracle Database 12c Release 2, the following `GET_MODEL_DETAILS` are deprecated:

## Table 40-43  Deprecated GET_MODEL_DETAILS Functions

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET_ASSOCIATION_RULES Function</td>
<td>Returns the rules from an association model</td>
</tr>
<tr>
<td>GET_FREQUENT_ITEMSETS Function</td>
<td>Returns the frequent itemsets for an association model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_AI Function</td>
<td>Returns details about an attribute importance model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_EM Function</td>
<td>Returns details about an Expectation Maximization model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_EM_COMP Function</td>
<td>Returns details about the parameters of an Expectation Maximization model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_EM_PROJ Function</td>
<td>Returns details about the projects of an Expectation Maximization model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_GLM Function</td>
<td>Returns details about a Generalized Linear Model model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_GLOBAL Function</td>
<td>Returns high-level statistics about a model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_KM Function</td>
<td>Returns details about a k-Means model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_NB Function</td>
<td>Returns details about a Naive Bayes model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_NMF Function</td>
<td>Returns details about a Non-Negative Matrix Factorization model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_OC Function</td>
<td>Returns details about an O-Cluster model</td>
</tr>
<tr>
<td>GET_MODEL_SETTINGS Function</td>
<td>Returns the settings used to build the given model</td>
</tr>
</tbody>
</table>

*This function is replaced with `USER/ALL/DBA_MINING_MODEL_SETTINGS`*
### Table 40-43  (Cont.) Deprecated GET_MODEL_DETAILS Functions

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET_MODEL_SIGNATURE Function</td>
<td>Returns the list of columns from the build input table</td>
</tr>
<tr>
<td></td>
<td>This function is replaced with USER/ALL/DBA_MINING_MODEL_ATTRIBUTES</td>
</tr>
<tr>
<td>GET_MODELDETAILS_SVD Function</td>
<td>Returns details about a Singular Value Decomposition model</td>
</tr>
<tr>
<td>GET_MODELDETAILS_SVM Function</td>
<td>Returns details about a Support Vector Machine model with a linear kernel</td>
</tr>
<tr>
<td>GET_MODELTRANSFORMATIONS Function</td>
<td>Returns the transformations embedded in a model</td>
</tr>
<tr>
<td></td>
<td>This function is replaced with USER/ALL/DBA_MINING_MODEL_XFORMS</td>
</tr>
<tr>
<td>GET_MODELDETAILS_XML Function</td>
<td>Returns details about a Decision Tree model</td>
</tr>
<tr>
<td>GET_TRANSFORM_LIST Procedure</td>
<td>Converts between two different transformation specification formats</td>
</tr>
</tbody>
</table>

### Related Topics

- Oracle Machine Learning for SQL User’s Guide
- Oracle Database Reference

#### 40.1.5.1 ADD_COST_MATRIX Procedure

The `ADD_COST_MATRIX` procedure associates a cost matrix table with a classification model. The cost matrix biases the model by assigning costs or benefits to specific model outcomes.

The cost matrix is stored with the model and taken into account when the model is scored.

You can also specify a cost matrix inline when you invoke an Oracle Machine Learning for SQL function for scoring. To view the scoring matrix for a model, query the `DM$VC` prefixed model view. Refer to Model Detail View for Classification Algorithm.

To obtain the default scoring matrix for a model, query the `DM$VC` prefixed model view. To remove the default scoring matrix from a model, use the `REMOVE_COST_MATRIX` procedure. See `REMOVE_COST_MATRIX` Procedure.

### See Also:

- "Biasing a Classification Model" in Oracle Machine Learning for SQL Concepts for more information about costs
- Oracle Database SQL Language Reference for syntax of inline cost matrix
- Specifying Costs in Oracle Machine Learning for SQL User’s Guide
Syntax

```sql
DBMS_DATA_MINING.ADD_COST_MATRIX (  
    model_name                IN VARCHAR2,  
    cost_matrix_table_name    IN VARCHAR2,  
    cost_matrix_schema_name   IN VARCHAR2 DEFAULT NULL);  
    partition_name            IN VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-44  ADD_COST_MATRIX Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name].model_name. If you do not specify a schema, then your own schema is assumed.</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>Name of the cost matrix table (described in Table 40-45).</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Schema of the cost matrix table. If no schema is specified, then the current schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Name of the partition in a partitioned model</td>
</tr>
</tbody>
</table>

Usage Notes

1. If the model is not in your schema, then `ADD_COST_MATRIX` requires the `ALTER ANY MINING MODEL` system privilege or the `ALTER` object privilege for the machine learning model.

2. The cost matrix table must have the columns shown in Table 40-45.

Table 40-45  Required Columns in a Cost Matrix Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTUAL_TARGET_VALUE</td>
<td>Valid target data type</td>
</tr>
<tr>
<td>PREDICTED_TARGET_VALUE</td>
<td>Valid target data type</td>
</tr>
<tr>
<td>COST</td>
<td>NUMBER, FLOAT, BINARY_DOUBLE, or BINARY_FLOAT</td>
</tr>
</tbody>
</table>

See Also:

*Oracle Machine Learning for SQL User’s Guide* for valid target data types

3. The types of the actual and predicted target values must be the same as the type of the model target. For example, if the target of the model is `BINARY_DOUBLE`, then the actual and predicted values must be `BINARY_DOUBLE`. If the actual and predicted values are `CHAR` or `VARCHAR`, then `ADD_COST_MATRIX` treats them as `VARCHAR2` internally.

If the types do not match, or if the actual or predicted value is not a valid target value, then the `ADD_COST_MATRIX` procedure raises an error.
4. Since a benefit can be viewed as a negative cost, you can specify a benefit for a given outcome by providing a negative number in the costs column of the cost matrix table.

5. All classification algorithms can use a cost matrix for scoring. The Decision Tree algorithm can also use a cost matrix at build time. If you want to build a Decision Tree model with a cost matrix, specify the cost matrix table name in the CLAS_COST_TABLE_NAME setting in the settings table for the model. See Table 40-7.

   The cost matrix used to create a Decision Tree model becomes the default scoring matrix for the model. If you want to specify different costs for scoring, use the REMOVE_COST_MATRIX procedure to remove the cost matrix and the ADD_COST_MATRIX procedure to add a new one.

6. Scoring on a partitioned model is partition-specific. Scoring cost matrices can be added to or removed from an individual partition in a partitioned model. If PARTITION_NAME is NOT NULL, then the model must be a partitioned model. The COST_MATRIX is added to that partition of the partitioned model.

   If the PARTITION_NAME is NULL, but the model is a partitioned model, then the COST_MATRIX table is added to every partition in the model.

Example

This example creates a cost matrix table called COSTS_NB and adds it to a Naive Bayes model called NB_SH_CLAS_SAMPLE. The model has a binary target: 1 means that the customer responds to a promotion; 0 means that the customer does not respond. The cost matrix assigns a cost of .25 to misclassifications of customers who do not respond and a cost of .75 to misclassifications of customers who do respond. This means that it is three times more costly to misclassify responders than it is to misclassify non-responders.

```
CREATE TABLE costs_nb (  
  actual_target_value NUMBER,  
  predicted_target_value NUMBER,  
  cost NUMBER);  
INSERT INTO costs_nb values (0, 0, 0);  
INSERT INTO costs_nb values (0, 1, .25);  
INSERT INTO costs_nb values (1, 0, .75);  
INSERT INTO costs_nb values (1, 1, 0);  
COMMIT;
```

```
EXEC dbms_data_mining.add_cost_matrix('nb_sh_clas_sample', 'costs_nb');
```

```
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age  
  FROM mining_data_apply_v
```
WHERE PREDICTION(nb_sh_clas_sample COST MODEL
    USING cust_marital_status, education, household_size) = 1
GROUP BY cust_gender
ORDER BY cust_gender;

<table>
<thead>
<tr>
<th>C</th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>72</td>
<td>39</td>
</tr>
<tr>
<td>M</td>
<td>555</td>
<td>44</td>
</tr>
</tbody>
</table>

40.1.5.2 ADD_PARTITION Procedure

ADD_PARTITION procedure supports a single or multiple partition addition to an existing partitioned model.

The ADD_PARTITION procedure derives build settings and user-defined expressions from the existing model. The target column must exist in the input data query when adding partitions to a supervised model.

Syntax

```
DBMS_DATA_MINING.ADD_PARTITION (
    model_name                IN VARCHAR2,
    data_query                IN CLOB,
    add_options               IN VARCHAR2 DEFAULT ERROR);
```

Parameters

Table 40-46  ADD_PARTITION Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>data_query</td>
<td>An arbitrary SQL statement that provides data to the model build. The user must have privilege to evaluate this query.</td>
</tr>
<tr>
<td>add_options</td>
<td>Allows users to control the conditional behavior of ADD for cases where rows in the input dataset conflict with existing partitions in the model. The following are the possible values:</td>
</tr>
<tr>
<td></td>
<td>• REPLACE: Replaces the existing partition for which the conflicting keys are found.</td>
</tr>
<tr>
<td></td>
<td>• ERROR: Terminates the ADD operation without adding any partitions.</td>
</tr>
<tr>
<td></td>
<td>• IGNORE: Eliminates the rows having the conflicting keys.</td>
</tr>
</tbody>
</table>

Note:

For better performance, Oracle recommends using DROP_PARTITION followed by the ADD_PARTITION instead of using the REPLACE option.
40.1.5.3 ALTER_REVERSE_EXPRESSION Procedure

This procedure replaces a reverse transformation expression with an expression that you specify. If the attribute does not have a reverse expression, the procedure creates one from the specified expression.

You can also use this procedure to customize the output of clustering, feature extraction, and anomaly detection models.

Syntax

```
DBMS_DATA_MINING.ALTER_REVERSE_EXPRESSION ( 
    model_name             VARCHAR2, 
    expression             CLOB, 
    attribute_name         VARCHAR2 DEFAULT NULL, 
    attribute_subname      VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-47 ALTER_REVERSE_EXPRESSION Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form <code>[schema_name]model_name</code>. If you do not specify a schema, your own schema is used.</td>
</tr>
<tr>
<td>expression</td>
<td>An expression to replace the reverse transformation associated with the attribute.</td>
</tr>
<tr>
<td>attribute_name</td>
<td>Name of the attribute. Specify NULL if you wish to apply expression to a cluster, feature, or One-Class SVM prediction.</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>Name of the nested attribute if attribute_name is a nested column, otherwise NULL.</td>
</tr>
</tbody>
</table>

Usage Notes

1. For purposes of model transparency, Oracle Machine Learning for SQL provides reverse transformations for transformations that are embedded in a model. Reverse transformations are applied to the attributes returned in model detail views and to the scored target of predictive models.

2. If you alter the reverse transformation for the target of a model that has a cost matrix, you must specify a transformation expression that has the same type as the actual and predicted values in the cost matrix. Also, the reverse transformation that you specify must result in values that are present in the cost matrix.
3. To prevent reverse transformation of an attribute, you can specify `NULL` for `expression`.

4. The reverse transformation expression can contain a reference to a PL/SQL function that returns a valid Oracle data type. For example, you could define a function like the following for a categorical attribute named `blood_pressure` that has values 'Low', 'Medium' and 'High'.

   ```sql
   CREATE OR REPLACE FUNCTION numx(c char) RETURN NUMBER IS
       BEGIN
       CASE c WHEN 'Low' THEN RETURN 1;
       WHEN 'Medium' THEN RETURN 2;
       WHEN 'High' THEN RETURN 3;
       ELSE RETURN null;
       END CASE;
       END numx;
   
   Then you could invoke `ALTER_REVERSE_EXPRESSION` for `blood_pressure` as follows.
   ```
   EXEC dbms_data_mining.alter_reverse_expression(  
       '<model_name>', 'NUMX(blood_pressure)', 'blood_pressure');
   ```

5. You can use `ALTER_REVERSE_EXPRESSION` to label clusters produced by clustering models and features produced by feature extraction.

You can use `ALTER_REVERSE_EXPRESSION` to replace the zeros and ones returned by anomaly-detection models. By default, anomaly-detection models label anomalous records with 0 and all other records with 1.

### Examples

1. In this example, the target (`affinity_card`) of the model `CLASS_MODEL` is manipulated internally as `yes` or `no` instead of 1 or 0 but returned as 1s and 0s when scored. The `ALTER_REVERSE_EXPRESSION` procedure causes the target values to be returned as `TRUE` or `FALSE`.

   ```sql
   DECLARE
     v_xlst dbms_data_mining_transform.TRANSFORM_LIST;
   BEGIN
     dbms_data_mining_transform.SET_TRANSFORM(v_xlst,  
         'affinity_card', NULL,  
         'decode(affinity_card, 1, ''yes'', ''no'')',  
         'decode(affinity_card, ''yes'', 1, 0)');
     dbms_data_mining.CREATEG_MODEL(  
         model_name => 'CLASS_MODEL',  
         mining_function => dbms_data_mining.classification,  
         data_table_name => 'mining_data_build';
   ```

See Also:

"ADD_COST_MATRIX Procedure" and Oracle Machine Learning for SQL Concepts for information about cost matrices.
SELECT cust_income_level, occupation, 
PREDICTION(CLASS_MODEL USING *) predict_response 
FROM mining_data_test WHERE age = 60 AND cust_gender IN 'M' 
ORDER BY cust_income_level;

<table>
<thead>
<tr>
<th>CUST_INCOME_LEVEL</th>
<th>OCCUPATION</th>
<th>PREDICT_RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Below 30,000</td>
<td>Transp.</td>
<td>1</td>
</tr>
<tr>
<td>E: 90,000 - 109,999</td>
<td>Transp.</td>
<td>1</td>
</tr>
<tr>
<td>E: 90,000 - 109,999</td>
<td>Sales</td>
<td>1</td>
</tr>
<tr>
<td>G: 130,000 - 149,999</td>
<td>Handler</td>
<td>0</td>
</tr>
<tr>
<td>G: 130,000 - 149,999</td>
<td>Crafts</td>
<td>0</td>
</tr>
<tr>
<td>H: 150,000 - 169,999</td>
<td>Prof.</td>
<td>1</td>
</tr>
<tr>
<td>J: 190,000 - 249,999</td>
<td>Prof.</td>
<td>1</td>
</tr>
<tr>
<td>J: 190,000 - 249,999</td>
<td>Sales</td>
<td>1</td>
</tr>
</tbody>
</table>

BEGIN 
  dbms_data_mining.ALTER_REVERSE_EXPRESSION ( 
    model_name => 'CLASS_MODEL', 
    expression => 'decode(affinity_card, ''yes'', ''TRUE'', 
                    ''FALSE'')', 
    attribute_name => 'affinity_card'); 
END; 
/

2. This example specifies labels for the clusters that result from the sh_clus model. 
The labels consist of the word "Cluster" and the internal numeric identifier for the cluster.

BEGIN 
  dbms_data_mining.ALTER_REVERSE_EXPRESSION('sh_clus', 
    'Cluster ' || value'); 
END; 
/

SELECT cust_id, cluster_id(sh_clus using *) cluster_id 
FROM sh_aprep_num
WHERE cust_id < 100011
ORDER by cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CLUSTER_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100001</td>
<td>Cluster 18</td>
</tr>
<tr>
<td>100002</td>
<td>Cluster 14</td>
</tr>
<tr>
<td>100003</td>
<td>Cluster 14</td>
</tr>
<tr>
<td>100004</td>
<td>Cluster 18</td>
</tr>
<tr>
<td>100005</td>
<td>Cluster 19</td>
</tr>
<tr>
<td>100006</td>
<td>Cluster 7</td>
</tr>
<tr>
<td>100007</td>
<td>Cluster 18</td>
</tr>
<tr>
<td>100008</td>
<td>Cluster 14</td>
</tr>
<tr>
<td>100009</td>
<td>Cluster 8</td>
</tr>
<tr>
<td>100010</td>
<td>Cluster 8</td>
</tr>
</tbody>
</table>

40.1.5.4 APPLY Procedure

The APPLY procedure applies a machine learning model to the data of interest, and generates the results in a table. The APPLY procedure is also referred to as scoring.

For predictive machine learning functions, the APPLY procedure generates predictions in a target column. For descriptive machine learning functions such as Clustering, the APPLY process assigns each case to a cluster with a probability.

In Oracle Machine Learning for SQL, the APPLY procedure is not applicable to Association models and Attribute Importance models.

Note:

Scoring can also be performed directly in SQL using the OML4SQL functions. See

- Oracle Machine Learning for SQL Functions in Oracle Database SQL Language Reference
- Scoring and Deployment in Oracle Machine Learning for SQL User’s Guide

Syntax

```sql
DBMS_DATA_MINING.APPLY (  
  model_name           IN VARCHAR2,  
  data_table_name      IN VARCHAR2,  
  case_id_column_name  IN VARCHAR2,  
  result_table_name    IN VARCHAR2,  
  data_schema_name     IN VARCHAR2 DEFAULT NULL);
```

Parameters

**Table 40-48  APPLY Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form <code>[schema_name.]model_name</code>. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of table or view containing the data to be scored</td>
</tr>
</tbody>
</table>
### Table 40-48  (Cont.) APPLY Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>case_id_column_name</td>
<td>Name of the case identifier column</td>
</tr>
<tr>
<td>result_table_name</td>
<td>Name of the table in which to store apply results</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Name of the schema containing the data to be scored</td>
</tr>
</tbody>
</table>

#### Usage Notes

1. The data provided for APPLY must undergo the same preprocessing as the data used to create and test the model. When you use Automatic Data Preparation, the preprocessing required by the algorithm is handled for you by the model: both at build time and apply time. (See "Automatic Data Preparation").

2. APPLY creates a table in the user's schema to hold the results. The columns are algorithm-specific.

   The columns in the results table are listed in Table 40-49 through Table 40-53. The case ID column name in the results table will match the case ID column name provided by you. The type of the incoming case ID column is also preserved in APPLY output.

   **Note:**
   
   Make sure that the case ID column does not have the same name as one of the columns that will be created by APPLY. For example, when applying a Classification model, the case ID in the scoring data must not be PREDICTION or PROBABILITY (See Table 40-49).

3. The data type for the PREDICTION, CLUSTER_ID, and FEATURE_ID output columns is influenced by any reverse expression that is embedded in the model by the user. If the user does not provide a reverse expression that alters the scored value type, then the types will conform to the descriptions in the following tables. See "ALTER_REVERSE_EXPRESSION Procedure".

4. If the model is partitioned, the result_table_name can contain results from different partitions depending on the data from the input data table. An additional column called PARTITION_NAME is added to the result table indicating the partition name that is associated with each row.

   For a non-partitioned model, the behavior does not change.

#### Classification

The results table for Classification has the columns described in Table 40-49. If the target of the model is categorical, the PREDICTION column will have a VARCHAR2 data type. If the target has a binary type, the PREDICTION column will have the binary type of the target.
Table 40-49  APPLY Results Table for Classification

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>Type of the case ID</td>
</tr>
<tr>
<td>PREDICTION</td>
<td>Type of the target</td>
</tr>
<tr>
<td>PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Anomaly Detection

The results table for Anomaly Detection has the columns described in Table 40-50.

Table 40-50  APPLY Results Table for Anomaly Detection

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>Type of the case ID</td>
</tr>
<tr>
<td>PREDICTION</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Regression

The results table for Regression has the columns described in APPLY Procedure.

Table 40-51  APPLY Results Table for Regression

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>Type of the case ID</td>
</tr>
<tr>
<td>PREDICTION</td>
<td>Type of the target</td>
</tr>
</tbody>
</table>

Clustering

Clustering is an unsupervised machine learning function, and hence there are no targets. The results of an APPLY procedure contain simply the cluster identifier corresponding to a case, and the associated probability. The results table has the columns described in Table 40-52.

Table 40-52  APPLY Results Table for Clustering

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>Type of the case ID</td>
</tr>
<tr>
<td>CLUSTER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PROBABILITY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

Feature Extraction

Feature Extraction is also an unsupervised machine learning function, hence there are no targets. The results of an APPLY procedure will contain simply the feature identifier corresponding to a case, and the associated match quality. The results table has the columns described in Table 40-53.
### Table 40-53 APPLY Results Table for Feature Extraction

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>Type of the case ID</td>
</tr>
<tr>
<td>FEATURE_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>MATCH_QUALITY</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

#### Examples

This example applies the GLM Regression model `GLMR_SH_REGR_SAMPLE` to the data in the `MINING_DATA_APPLY_V` view. The APPLY results are output of the table `REGRESSION_APPLY_RESULT`.

```sql
SQL> BEGIN
  2   DBMS_DATA_MINING.APPLY (model_name     => 'glmr_sh_regr_sample',
  3                     data_table_name     => 'mining_data_apply_v',
  4                     case_id_column_name => 'cust_id',
  5                     result_table_name   => 'regression_apply_result');
END;
/

SQL> SELECT * FROM regression_apply_result WHERE cust_id > 101485;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PREDICTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>101486</td>
<td>22.8048824</td>
</tr>
<tr>
<td>101487</td>
<td>25.0261101</td>
</tr>
<tr>
<td>101488</td>
<td>48.6146619</td>
</tr>
<tr>
<td>101489</td>
<td>51.82595</td>
</tr>
<tr>
<td>101490</td>
<td>22.6220748</td>
</tr>
<tr>
<td>101491</td>
<td>61.3856816</td>
</tr>
<tr>
<td>101492</td>
<td>24.1400748</td>
</tr>
<tr>
<td>101493</td>
<td>58.034631</td>
</tr>
<tr>
<td>101494</td>
<td>45.7253149</td>
</tr>
<tr>
<td>101495</td>
<td>26.9763318</td>
</tr>
<tr>
<td>101496</td>
<td>48.1433425</td>
</tr>
<tr>
<td>101497</td>
<td>32.0573434</td>
</tr>
<tr>
<td>101498</td>
<td>49.8965531</td>
</tr>
<tr>
<td>101499</td>
<td>56.270656</td>
</tr>
<tr>
<td>101500</td>
<td>21.1153047</td>
</tr>
</tbody>
</table>

#### 40.1.5.5 COMPUTE_CONFUSION_MATRIX Procedure

This procedure computes a confusion matrix, stores it in a table in the user's schema, and returns the model accuracy.

A confusion matrix is a test metric for classification models. It compares the predictions generated by the model with the actual target values in a set of test data. The confusion matrix lists the number of times each class was correctly predicted and the number of times it was predicted to be one of the other classes.

`COMPUTE_CONFUSION_MATRIX` accepts three input streams:

- The predictions generated on the test data. The information is passed in three columns:
– Case ID column  
– Prediction column  
– Scoring criterion column containing either probabilities or costs

- The known target values in the test data. The information is passed in two columns:  
  - Case ID column  
  - Target column containing the known target values

- (Optional) A cost matrix table with predefined columns. See the Usage Notes for the column requirements.

**See Also:**

*Oracle Machine Learning for SQL Concepts* for more details about confusion matrixes and other test metrics for classification

"COMPUTE_LIFT Procedure"

"COMPUTE_ROC Procedure"

**Syntax**

```sql
DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX (  
  accuracy                     OUT NUMBER,  
  apply_result_table_name      IN  VARCHAR2,  
  target_table_name            IN  VARCHAR2,  
  case_id_column_name          IN  VARCHAR2,  
  target_column_name           IN  VARCHAR2,  
  confusion_matrix_table_name  IN  VARCHAR2,  
  score_column_name            IN  VARCHAR2 DEFAULT 'PREDICTION',  
  score_criterion_column_name  IN  VARCHAR2 DEFAULT 'PROBABILITY',  
  cost_matrix_table_name       IN  VARCHAR2 DEFAULT NULL,  
  apply_result_schema_name     IN  VARCHAR2 DEFAULT NULL,  
  target_schema_name           IN  VARCHAR2 DEFAULT NULL,  
  cost_matrix_schema_name      IN  VARCHAR2 DEFAULT NULL,  
  score_criterion_type         IN  VARCHAR2 DEFAULT 'PROBABILITY');
```

**Parameters**

**Table 40-54  COMPUTE_CONFUSION_MATRIX Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>accuracy</td>
<td>Output parameter containing the overall percentage accuracy of the predictions.</td>
</tr>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions.</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier in the targets table.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from the test data.</td>
</tr>
</tbody>
</table>
### Table 40-54  (Cont.) COMPUTE_CONFUSION_MATRIX Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>confusion_matrix_table_name</td>
<td>Table containing the confusion matrix. The table will be created by the procedure in the user's schema. The columns in the confusion matrix table are described in the Usage Notes.</td>
</tr>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is PREDICTION, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains either the probabilities or the costs that determine the predictions. By default, scoring is based on probability; the class with the highest probability is predicted for each case. If scoring is based on cost, the class with the lowest cost is predicted. The score_criterion_type parameter indicates whether probabilities or costs will be used for scoring. The default column name is 'PROBABILITY', which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;). See the Usage Notes for additional information.</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>(Optional) Table that defines the costs associated with misclassifications. If a cost matrix table is provided and the score_criterion_type parameter is set to 'COSTS', the costs in this table will be used as the scoring criteria. The columns in a cost matrix table are described in the Usage Notes.</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Schema of the cost matrix table, if one is provided. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>score_criterion_type</td>
<td>Whether to use probabilities or costs as the scoring criterion. Probabilities or costs are passed in the column identified in the score_criterion_column_name parameter. The default value of score_criterion_type is 'PROBABILITY'. To use costs as the scoring criterion, specify 'COST'. If score_criterion_type is set to 'COST' but no cost matrix is provided and if there is a scoring cost matrix associated with the model, then the associated costs are used for scoring. See the Usage Notes and the Examples.</td>
</tr>
</tbody>
</table>
Usage Notes

- The predictive information you pass to `COMPUTE_CONFUSION_MATRIX` may be generated using SQL `PREDICTION` functions, the `DBMS_DATA_MINING.APPLY` procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the confusion matrix.

- Instead of passing a cost matrix to `COMPUTE_CONFUSION_MATRIX`, you can use a scoring cost matrix associated with the model. A scoring cost matrix can be embedded in the model or it can be defined dynamically when the model is applied. To use a scoring cost matrix, invoke the SQL `PREDICTION_COST` function to populate the score criterion column.

- The predictions that you pass to `COMPUTE_CONFUSION_MATRIX` are in a table or view specified in `apply_result_table_name`.

```sql
CREATE TABLE apply_result_table_name AS (
  case_id_column_name VARCHAR2,
  score_column_name VARCHAR2,
  score_criterion_column_name VARCHAR2);
```

- A cost matrix must have the columns described in Table 40-55.

**Table 40-55  Columns in a Cost Matrix**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>Type of the target column in the build data</td>
</tr>
<tr>
<td>predicted_target_value</td>
<td>Type of the predicted target in the test data. The type of the predicted target must be the same as the type of the actual target unless the predicted target has an associated reverse transformation.</td>
</tr>
<tr>
<td>cost</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

**See Also:**

- Oracle Machine Learning for SQL User’s Guide for valid target data types
- Oracle Machine Learning for SQL Concepts for more information about cost matrixes

- The confusion matrix created by `COMPUTE_CONFUSION_MATRIX` has the columns described in Table 40-56.

**Table 40-56  Columns in a Confusion Matrix**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>Type of the target column in the build data</td>
</tr>
<tr>
<td>predicted_target_value</td>
<td>Type of the predicted target in the test data. The type of the predicted target is the same as the type of the actual target unless the predicted target has an associated reverse transformation.</td>
</tr>
<tr>
<td>value</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>
Examples

These examples use the Naive Bayes model `nb_sh_clas_sample`.

Compute a Confusion Matrix Based on Probabilities

The following statement applies the model to the test data and stores the predictions and probabilities in a table.

```sql
CREATE TABLE nb_apply_results AS
    SELECT cust_id,
           PREDICTION(nb_sh_clas_sample USING *) prediction,
           PREDICTION_PROBABILITY(nb_sh_clas_sample USING *) probability
    FROM mining_data_test_v;
```

Using probabilities as the scoring criterion, you can compute the confusion matrix as follows.

```sql
DECLARE
  v_accuracy NUMBER;
BEGIN
  DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX (  
    accuracy => v_accuracy,
    apply_result_table_name => 'nb_apply_results',
    target_table_name => 'mining_data_test_v',
    case_id_column_name => 'cust_id',
    target_column_name => 'affinity_card',
    confusion_matrix_table_name => 'nb_confusion_matrix',
    score_column_name => 'PREDICTION',
    score_criterion_column_name => 'PROBABILITY',
    cost_matrix_table_name => null,
    apply_result_schema_name => null,
    target_schema_name => null,
    cost_matrix_schema_name => null,
    score_criterion_type => 'PROBABILITY');
  DBMS_OUTPUT.PUT_LINE('**** MODEL ACCURACY ****: ' ||  
    ROUND(v_accuracy,4));
END;
/```

The confusion matrix and model accuracy are shown as follows.

```
**** MODEL ACCURACY ****: .7847
```

```
SQL>SELECT * from nb_confusion_matrix;
ACTUAL_TARGET_VALUE PREDICTED_TARGET_VALUE VALUE
 nw
 1           0                60
 0           0                891
 1           1                286
 0           1                263
```

Compute a Confusion Matrix Based on a Cost Matrix Table
The confusion matrix in the previous example shows a high rate of false positives. For 263 cases, the model predicted 1 when the actual value was 0. You could use a cost matrix to minimize this type of error.

The cost matrix table `nb_cost_matrix` specifies that a false positive is 3 times more costly than a false negative.

SQL> SELECT * from nb_cost_matrix;
ACTUAL_TARGET_VALUE PREDICTED_TARGET_VALUE       COST
------------------- ---------------------- ----------
0                      0          0
0                      1        .75
1                      0        .25
1                      1          0

This statement shows how to generate the predictions using `APPLY`.

```
BEGIN
    DBMS_DATA_MINING.APPLY(
        model_name          => 'nb_sh_clas_sample',
        data_table_name     => 'mining_data_test_v',
        case_id_column_name => 'cust_id',
        result_table_name   => 'nb_apply_results');
END;
/
```

This statement computes the confusion matrix using the cost matrix table. The score criterion column is named `PROBABILITY`, which is the name generated by `APPLY`.

```
DECLARE
    v_accuracy    NUMBER;
BEGIN
    DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX (
        accuracy                     => v_accuracy,
        apply_result_table_name      => 'nb_apply_results',
        target_table_name            => 'mining_data_test_v',
        case_id_column_name          => 'cust_id',
        target_column_name           => 'affinity_card',
        confusion_matrix_table_name  => 'nb_confusion_matrix',
        score_column_name            => 'PREDICTION',
        score_criterion_column_name  => 'PROBABILITY',
        cost_matrix_table_name       => 'nb_cost_matrix',
        apply_result_schema_name     => null,
        target_schema_name           => null,
        cost_matrix_schema_name      => null,
        score_criterion_type         => 'COST');
    DBMS_OUTPUT.PUT_LINE('**** MODEL ACCURACY ****: ' || ROUND(v_accuracy,4));
END;
/
```

The resulting confusion matrix shows a decrease in false positives (212 instead of 263).

```
SQL> SELECT * FROM nb_confusion_matrix;
ACTUAL_TARGET_VALUE PREDICTED_TARGET_VALUE      VALUE
------------------- ---------------------- ----------
1                      0         91
0                      0        942
1                      1        255
0                      1        212
```

The confusion matrix shows that the model has decreased the false positives significantly.
Compute a Confusion Matrix Based on Embedded Costs

You can use the ADD_COST_MATRIX procedure to embed a cost matrix in a model. The embedded costs can be used instead of probabilities for scoring. This statement adds the previously-defined cost matrix to the model.

```
BEGIN
  DBMS_DATA_MINING.ADD_COST_MATRIX ('nb_sh_clas_sample',
  'nb_cost_matrix');
END;
```

The following statement applies the model to the test data using the embedded costs and stores the results in a table.

```
CREATE TABLE nb_apply_results AS
  SELECT cust_id,
  PREDICTION(nb_sh_clas_sample COST MODEL USING *) prediction,
  PREDICTION_COST(nb_sh_clas_sample COST MODEL USING *) cost
  FROM mining_data_test_v;
```

You can compute the confusion matrix using the embedded costs.

```
DECLARE
  v_accuracy NUMBER;
BEGIN
  DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX (
    accuracy                     => v_accuracy,
    apply_result_table_name      => 'nb_apply_results',
    target_table_name            => 'mining_data_test_v',
    case_id_column_name          => 'cust_id',
    target_column_name           => 'affinity_card',
    confusion_matrix_table_name  => 'nb_confusion_matrix',
    score_column_name            => 'PREDICTION',
    score_criterion_column_name  => 'COST',
    cost_matrix_table_name       => null,
    apply_result_schema_name     => null,
    target_schema_name           => null,
    score_criterion_type         => 'COST');
END;
```

The results are:

```
**** MODEL ACCURACY ****: .798
```

```
SQL> SELECT * FROM nb_confusion_matrix;
```

```
<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>942</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>212</td>
</tr>
</tbody>
</table>
```

40.1.5.6 COMPUTE_CONFUSION_MATRIX_PART Procedure

The COMPUTE_CONFUSION_MATRIX_PART procedure computes a confusion matrix, stores it in a table in the user's schema, and returns the model accuracy.

```
COMPUTE_CONFUSION_MATRIX_PART provides support to computation of evaluation metrics per-partition for partitioned models. For non-partitioned models, refer to COMPUTE_CONFUSION_MATRIX Procedure.
```

ORACLE
A confusion matrix is a test metric for classification models. It compares the predictions generated by the model with the actual target values in a set of test data. The confusion matrix lists the number of times each class was correctly predicted and the number of times it was predicted to be one of the other classes.

**COMPUTE_CONFUSION_MATRIX_PART** accepts three input streams:

- The predictions generated on the test data. The information is passed in three columns:
  - Case ID column
  - Prediction column
  - Scoring criterion column containing either probabilities or costs
- The known target values in the test data. The information is passed in two columns:
  - Case ID column
  - Target column containing the known target values
- (Optional) A cost matrix table with predefined columns. See the Usage Notes for the column requirements.

**See Also:**

- *Oracle Machine Learning for SQL Concepts* for more details about confusion matrixes and other test metrics for classification
- "COMPUTE_LIFT_PART Procedure"
- "COMPUTE_ROC_PART Procedure"

**Syntax**

```sql
DBMS_DATA_MINING.compute_confusion_matrix_part(
    accuracy OUT DM_NESTED_NUMERICALS,
    apply_result_table_name   IN  VARCHAR2,
    target_table_name         IN  VARCHAR2,
    case_id_column_name       IN  VARCHAR2,
    target_column_name        IN  VARCHAR2,
    confusion_matrix_table_name IN VARCHAR2,
    score_column_name         IN  VARCHAR2 DEFAULT 'PREDICTION',
    score_criterion_column_name IN VARCHAR2 DEFAULT 'PROBABILITY',
    score_partition_column_name IN VARCHAR2 DEFAULT 'PARTITION_NAME',
    cost_matrix_table_name    IN  VARCHAR2 DEFAULT NULL,
    apply_result_schema_name  IN  VARCHAR2 DEFAULT NULL,
    target_schema_name        IN  VARCHAR2 DEFAULT NULL,
    cost_matrix_schema_name   IN  VARCHAR2 DEFAULT NULL,
    score_criterion_type      IN  VARCHAR2 DEFAULT NULL);
```
### Parameters

**Table 40-57  COMPUTE_CONFUSION_MATRIX_PART Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>accuracy</td>
<td>Output parameter containing the overall percentage accuracy of the predictions. The output argument is changed from NUMBER to DM_NESTED_NUMERICALS.</td>
</tr>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions.</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier in the targets table.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from the test data.</td>
</tr>
<tr>
<td>confusion_matrix_table_name</td>
<td>Table containing the confusion matrix. The table will be created by the procedure in the user's schema. The columns in the confusion matrix table are described in the Usage Notes.</td>
</tr>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is PREDICTION, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains either the probabilities or the costs that determine the predictions. By default, scoring is based on probability; the class with the highest probability is predicted for each case. If scoring is based on cost, then the class with the lowest cost is predicted. The score_criterion_type parameter indicates whether probabilities or costs will be used for scoring. The default column name is PROBABILITY, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_partition_column_name</td>
<td>(Optional) Parameter indicating the column which contains the name of the partition. This column slices the input test results such that each partition has independent evaluation matrices computed.</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>(Optional) Table that defines the costs associated with misclassifications. If a cost matrix table is provided and the score_criterion_type parameter is set to COSTS, the costs in this table will be used as the scoring criteria. The columns in a cost matrix table are described in the Usage Notes.</td>
</tr>
</tbody>
</table>
Table 40-57 (Cont.) COMPUTE_CONFUSION_MATRIX_PART Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Schema of the cost matrix table, if one is provided. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>score_criterion_type</td>
<td>Whether to use probabilities or costs as the scoring criterion. Probabilities or costs are passed in the column identified in the score_criterion_column_name parameter. The default value of score_criterion_type is PROBABILITY. To use costs as the scoring criterion, specify COST. If score_criterion_type is set to COST but no cost matrix is provided and if there is a scoring cost matrix associated with the model, then the associated costs are used for scoring. See the Usage Notes and the Examples.</td>
</tr>
</tbody>
</table>

Usage Notes

- The predictive information you pass to COMPUTE_CONFUSION_MATRIX_PART may be generated using SQL PREDICTION functions, the DBMS_DATA_MINING.APPLY procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the confusion matrix.

- Instead of passing a cost matrix to COMPUTE_CONFUSION_MATRIX_PART, you can use a scoring cost matrix associated with the model. A scoring cost matrix can be embedded in the model or it can be defined dynamically when the model is applied. To use a scoring cost matrix, invoke the SQL PREDICTION_COST function to populate the score criterion column.

- The predictions that you pass to COMPUTE_CONFUSION_MATRIX_PART are in a table or view specified in apply_result_table_name.

```sql
CREATE TABLE apply_result_table_name AS (
    case_id_column_name VARCHAR2,
    score_column_name VARCHAR2,
    score_criterion_column_name VARCHAR2);
```

- A cost matrix must have the columns described in Table 40-55.

Table 40-58 Columns in a Cost Matrix

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>Type of the target column in the test data</td>
</tr>
</tbody>
</table>
Table 40-58  (Cont.) Columns in a Cost Matrix

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>predicted_target_value</td>
<td>Type of the predicted target in the test data. The type of the predicted target must be the same as the type of the actual target unless the predicted target has an associated reverse transformation.</td>
</tr>
<tr>
<td>cost</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

See Also:

Oracle Machine Learning for SQL User’s Guide for valid target data types
Oracle Machine Learning for SQL Concepts for more information about cost matrixes

- The confusion matrix created by COMPUTE_CONFUSION_MATRIX_PART has the columns described in Table 40-56.

Table 40-59  Columns in a Confusion Matrix Part

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>Type of the target column in the test data</td>
</tr>
<tr>
<td>predicted_target_value</td>
<td>Type of the predicted target in the test data. The type of the predicted target is the same as the type of the actual target unless the predicted target has an associated reverse transformation.</td>
</tr>
<tr>
<td>value</td>
<td>BINARY_DOUBLE</td>
</tr>
</tbody>
</table>

See Also:

Oracle Machine Learning for SQL Concepts for more information about confusion matrixes

Examples

These examples use the Naive Bayes model nb_sh_clas_sample.

Compute a Confusion Matrix Based on Probabilities

The following statement applies the model to the test data and stores the predictions and probabilities in a table.

```sql
CREATE TABLE nb_apply_results AS
SELECT cust_id,
       PREDICTION(nb_sh_clas_sample USING *) prediction,
       PREDICTION_PROBABILITY(nb_sh_clas_sample USING *) probability
FROM mining_data_test_v;
```
Using probabilities as the scoring criterion, you can compute the confusion matrix as follows.

```sql
DECLARE
    v_accuracy NUMBER;
BEGIN
    DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX_PART (
        accuracy => v_accuracy,
        apply_result_table_name => 'nb_apply_results',
        target_table_name => 'mining_data_test_v',
        case_id_column_name => 'cust_id',
        target_column_name => 'affinity_card',
        confusion_matrix_table_name => 'nb_confusion_matrix',
        score_column_name => 'PREDICTION',
        score_criterion_column_name => 'PROBABILITY',
        score_partition_column_name => null,
        cost_matrix_table_name => null,
        apply_result_schema_name => null,
        target_schema_name => null,
        cost_matrix_schema_name => null,
        score_criterion_type => 'PROBABILITY');
    DBMS_OUTPUT.PUT_LINE('**** MODEL ACCURACY ****: ' || ROUND(v_accuracy,4));
END;
/
```

The confusion matrix and model accuracy are shown as follows.

```
**** MODEL ACCURACY ****: .7847
```

```
SELECT * FROM NB_CONFUSION_MATRIX;
ACTUAL_TARGET_VALUE PREDICTED_TARGET_VALUE      VALUE
------------------- ---------------------- ----------
     1                0         60
     0                0        891
     1                1        286
     0                1        263
```

**Compute a Confusion Matrix Based on a Cost Matrix Table**

The confusion matrix in the previous example shows a high rate of false positives. For 263 cases, the model predicted 1 when the actual value was 0. You could use a cost matrix to minimize this type of error.

The cost matrix table `nb_cost_matrix` specifies that a false positive is 3 times more costly than a false negative.

```
SELECT * from NB_COST_MATRIX;
ACTUAL_TARGET_VALUE PREDICTED_TARGET_VALUE       COST
------------------- ---------------------- ----------
     0                0          0
     0                1        .75
     1                0        .25
     1                1          0
```

This statement shows how to generate the predictions using `APPLY`.

```sql
BEGIN
    DBMS_DATA_MINING.APPLY(
        model_name => 'nb_sh_clas_sample',
        data_table_name => 'mining_data_test_v',
        case_id_column_name => 'cust_id',
        result_table_name => 'nb_apply_results');
END;
/
```
This statement computes the confusion matrix using the cost matrix table. The score criterion column is named 'PROBABILITY', which is the name generated by APPLY.

DECLARE 
v_accuracy NUMBER;
BEGIN
  DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX_PART (accuracy => v_accuracy,
                                                  apply_result_table_name => 'nb_apply_results',
                                                  target_table_name => 'mining_data_test_v',
                                                  case_id_column_name => 'cust_id',
                                                  target_column_name => 'affinity_card',
                                                  confusion_matrix_table_name => 'nb_confusion_matrix',
                                                  score_column_name => 'PREDICTION',
                                                  score_criterion_column_name => 'PROBABILITY',
                                                  score_partition_column_name => 'PARTITION_NAME',
                                                  cost_matrix_table_name => 'nb_cost_matrix',
                                                  apply_result_schema_name => null,
                                                  target_schema_name => null,
                                                  cost_matrix_schema_name => null,
                                                  score_criterion_type => 'COST');
  DBMS_OUTPUT.PUT_LINE('**** MODEL ACCURACY ****: ' || ROUND(v_accuracy,4));
END;
/

The resulting confusion matrix shows a decrease in false positives (212 instead of 263).

**** MODEL ACCURACY ****: .798

SELECT * FROM NB_CONFUSION_MATRIX;
ACTUAL_TARGET_VALUE  PREDICTED_TARGET_VALUE  VALUE
--------------------  ----------------------  --------
     1                  0                        91
     0                  0                        942
     1                  1                        255
     0                  1                        212

Compute a Confusion Matrix Based on Embedded Costs

You can use the ADD_COST_MATRIX procedure to embed a cost matrix in a model. The embedded costs can be used instead of probabilities for scoring. This statement adds the previously-defined cost matrix to the model.

BEGIN
  DBMS_DATA_MINING.ADD_COST_MATRIX ('nb_sh_clas_sample', 'nb_cost_matrix');
END;/

The following statement applies the model to the test data using the embedded costs and stores the results in a table.

CREATE TABLE nb_apply_results AS
  SELECT cust_id,
         PREDICTION(nb_sh_clas_sample COST MODEL USING *) prediction,
         PREDICTION_COST(nb_sh_clas_sample COST MODEL USING *) cost
  FROM mining_data_test_v;

You can compute the confusion matrix using the embedded costs.
DECLARE
  v_accuracy    NUMBER;
BEGIN
  DBMS_DATA_MINING.COMPUTE_CONFUSION_MATRIX_PART (v_accuracy => v_accuracy,
                                               apply_result_table_name => 'nb_apply_results',
                                               target_table_name => 'mining_data_test_v',
                                               case_id_column_name => 'cust_id',
                                               target_column_name => 'affinity_card',
                                               confusion_matrix_table_name => 'nb_confusion_matrix',
                                               score_column_name => 'PREDICTION',
                                               score_criterion_column_name => 'COST',
                                               score_partition_column_name => 'PARTITION_NAME',
                                               cost_matrix_table_name => null,
                                               apply_result_schema_name => null,
                                               target_schema_name => null,
                                               cost_matrix_schema_name => null,
                                               score_criterion_type => 'COST');
END;
/

The results are:

**** MODEL ACCURACY ****: .798

SELECT * FROM NB_CONFUSION_MATRIX;

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>942</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>212</td>
</tr>
</tbody>
</table>

40.1.5.7 COMPUTE_LIFT Procedure

This procedure computes lift and stores the results in a table in the user's schema.

Lift is a test metric for binary classification models. To compute lift, one of the target values must be designated as the positive class. COMPUTE_LIFT compares the predictions generated by the model with the actual target values in a set of test data. Lift measures the degree to which the model's predictions of the positive class are an improvement over random chance.

Lift is computed on scoring results that have been ranked by probability (or cost) and divided into quantiles. Each quantile includes the scores for the same number of cases.

COMPUTE_LIFT calculates quantile-based and cumulative statistics. The number of quantiles and the positive class are user-specified. Additionally, COMPUTE_LIFT accepts three input streams:

- The predictions generated on the test data. The information is passed in three columns:
  - Case ID column
  - Prediction column
  - Scoring criterion column containing either probabilities or costs associated with the predictions
- The known target values in the test data. The information is passed in two columns:
  - Case ID column
SYNTAX

```sql
DBMS_DATA_MINING.COMPUTE_LIFT (  
    apply_result_table_name      IN VARCHAR2,  
    target_table_name            IN VARCHAR2,  
    case_id_column_name          IN VARCHAR2,  
    target_column_name           IN VARCHAR2,  
    lift_table_name              IN VARCHAR2,  
    positive_target_value        IN VARCHAR2,  
    score_column_name            IN VARCHAR2 DEFAULT 'PREDICTION',  
    score_criterion_column_name  IN VARCHAR2 DEFAULT 'PROBABILITY',  
    num_quantiles                IN NUMBER DEFAULT 10,  
    cost_matrix_table_name       IN VARCHAR2 DEFAULT NULL,  
    apply_result_schema_name     IN VARCHAR2 DEFAULT NULL,  
    target_schema_name           IN VARCHAR2 DEFAULT NULL,  
    cost_matrix_schema_name      IN VARCHAR2 DEFAULT NULL,  
    score_criterion_type         IN VARCHAR2 DEFAULT 'PROBABILITY');
```

PARAMETERS

**Table 40-60  COMPUTE_LIFT Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions.</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier in the targets table.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from the test data.</td>
</tr>
<tr>
<td>lift_table_name</td>
<td>Table containing the lift statistics. The table will be created by the procedure in the user's schema. The columns in the lift table are described in the Usage Notes.</td>
</tr>
<tr>
<td>positive_target_value</td>
<td>The positive class. This should be the class of interest, for which you want to calculate lift. If the target column is a NUMBER, you can use the TO_CHAR() operator to provide the value as a string.</td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL Concepts* for more details about lift and test metrics for classification

"COMPUTE_CONFUSION_MATRIX Procedure"

"COMPUTE_ROC Procedure"
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is 'PREDICTION', which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains either the probabilities or the costs that determine the predictions. By default, scoring is based on probability; the class with the highest probability is predicted for each case. If scoring is based on cost, the class with the lowest cost is predicted. The score_criterion_type parameter indicates whether probabilities or costs will be used for scoring. The default column name is 'PROBABILITY', which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;). See the Usage Notes for additional information.</td>
</tr>
<tr>
<td>num_quantiles</td>
<td>Number of quantiles to be used in calculating lift. The default is 10.</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>(Optional) Table that defines the costs associated with misclassifications. If a cost matrix table is provided and the score_criterion_type parameter is set to 'COST', the costs will be used as the scoring criteria. The columns in a cost matrix table are described in the Usage Notes.</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Schema of the cost matrix table, if one is provided. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>score_criterion_type</td>
<td>Whether to use probabilities or costs as the scoring criterion. Probabilities or costs are passed in the column identified in the score_criterion_column_name parameter. The default value of score_criterion_type is 'PROBABILITY'. To use costs as the scoring criterion, specify 'COST'. If score_criterion_type is set to 'COST' but no cost matrix is provided and if there is a scoring cost matrix associated with the model, then the associated costs are used for scoring. See the Usage Notes and the Examples.</td>
</tr>
</tbody>
</table>
Usage Notes

- The predictive information you pass to `COMPUTE_LIFT` may be generated using SQL `PREDICTION` functions, the `DBMS_DATA_MINING.APPLY` procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the lift.

- Instead of passing a cost matrix to `COMPUTE_LIFT`, you can use a scoring cost matrix associated with the model. A scoring cost matrix can be embedded in the model or it can be defined dynamically when the model is applied. To use a scoring cost matrix, invoke the SQL `PREDICTION_COST` function to populate the score criterion column.

- The predictions that you pass to `COMPUTE_LIFT` are in a table or view specified in `apply_results_table_name`.

```
CREATE TABLE apply_result_table_name AS (
    case_id_column_name VARCHAR2,
    score_column_name VARCHAR2,
    score_criterion_column_name VARCHAR2);
```

- A cost matrix must have the columns described in Table 40-61.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual_target_value</td>
<td>Type of the target column in the build data</td>
</tr>
<tr>
<td>predicted_target_value</td>
<td>Type of the predicted target in the test data. The type of the predicted target must be the same as the type of the actual target unless the predicted target has an associated reverse transformation.</td>
</tr>
<tr>
<td>cost</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

See Also:

`Oracle Machine Learning for SQL Concepts` for more information about cost matrices

- The table created by `COMPUTE_LIFT` has the columns described in Table 40-62.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>quantile_number</td>
<td>NUMBER</td>
</tr>
<tr>
<td>probability_threshold</td>
<td>NUMBER</td>
</tr>
<tr>
<td>gain_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>quantile_total_count</td>
<td>NUMBER</td>
</tr>
<tr>
<td>quantile_target_count</td>
<td>NUMBER</td>
</tr>
<tr>
<td>percent_records_cumulative</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>
### Table 40-62  (Cont.) Columns in a Lift Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>lift_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>target_density_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>targets_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>non_targets_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>lift_quantile</td>
<td>NUMBER</td>
</tr>
<tr>
<td>target_density</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

**See Also:**

*Oracle Machine Learning for SQL Concepts* for details about the information in the lift table.

- When a cost matrix is passed to `COMPUTE_LIFT`, the cost threshold is returned in the `probability_threshold` column of the lift table.

**Examples**

This example uses the Naive Bayes model `nb_sh_clas_sample`.

The example illustrates lift based on probabilities. For examples that show computation based on costs, see "COMPUTE_CONFUSION_MATRIX Procedure".

The following statement applies the model to the test data and stores the predictions and probabilities in a table.

```sql
CREATE TABLE nb_apply_results AS
    SELECT cust_id, t.prediction, t.probability
    FROM mining_data_test_v, TABLE(PREDICTION_SET(nb_sh_clas_sample USING *)) t;
```

Using probabilities as the scoring criterion, you can compute lift as follows.

```sql
BEGIN
    DBMS_DATA_MINING.COMPUTE_LIFT (
        apply_result_table_name            => 'nb_apply_results',
        target_table_name                  => 'mining_data_test_v',
        case_id_column_name                => 'cust_id',
        target_column_name                 => 'affinity_card',
        lift_table_name                    => 'nb_lift',
        positive_target_value              => to_char(1),
        score_column_name                  => 'PREDICTION',
        score_criterion_column_name        => 'PROBABILITY',
        num_quantiles                      => 10,
        cost_matrix_table_name             => null,
        apply_result_schema_name           => null,
        target_schema_name                 => null,
        cost_matrix_schema_name            => null,
        score_criterion_type               => 'PROBABILITY');
END;
/
```

This query displays some of the statistics from the resulting lift table.
SQL> SELECT quantile_number, probability_threshold, gain_cumulative, quantile_total_count
       FROM nb_lift;

+-----------------+----------------+-------------------+-------------------+
<table>
<thead>
<tr>
<th>QUANTILE_NUMBER</th>
<th>PROBABILITY_THRESHOLD</th>
<th>GAIN_CUMULATIVE</th>
<th>QUANTILE_TOTAL_COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.989335775</td>
<td>.15034965</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>.980534911</td>
<td>.26048951</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>.968506098</td>
<td>.374125874</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>.958975196</td>
<td>.493006993</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>.946705997</td>
<td>.587412587</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>.927454174</td>
<td>.66958042</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>.904403627</td>
<td>.748251748</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>.836482525</td>
<td>.839160839</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>.500184953</td>
<td>1</td>
<td>54</td>
</tr>
</tbody>
</table>

40.1.5.8 COMPUTE_LIFT_PART Procedure

The COMPUTE_LIFT_PART procedure computes lift and stores the results in a table in the user's schema. This procedure provides support to the computation of evaluation metrics per-partition for partitioned models.

Lift is a test metric for binary classification models. To compute lift, one of the target values must be designated as the positive class. COMPUTE_LIFT_PART compares the predictions generated by the model with the actual target values in a set of test data. Lift measures the degree to which the model's predictions of the positive class are an improvement over random chance.

Lift is computed on scoring results that have been ranked by probability (or cost) and divided into quantiles. Each quantile includes the scores for the same number of cases.

COMPUTE_LIFT_PART calculates quantile-based and cumulative statistics. The number of quantiles and the positive class are user-specified. Additionally, COMPUTE_LIFT_PART accepts three input streams:

- The predictions generated on the test data. The information is passed in three columns:
  - Case ID column
  - Prediction column
  - Scoring criterion column containing either probabilities or costs associated with the predictions
- The known target values in the test data. The information is passed in two columns:
  - Case ID column
  - Target column containing the known target values
- (Optional) A cost matrix table with predefined columns. See the Usage Notes for the column requirements.
Syntax

```
DBMS_DATA_MINING.COMPUTE_LIFT_PART (
    apply_result_table_name     IN VARCHAR2,
    target_table_name           IN VARCHAR2,
    case_id_column_name         IN VARCHAR2,
    target_column_name          IN VARCHAR2,
    lift_table_name             IN VARCHAR2,
    positive_target_value       IN VARCHAR2,
    score_column_name           IN VARCHAR2 DEFAULT 'PREDICTION',
    score_criterion_column_name IN VARCHAR2 DEFAULT 'PROBABILITY',
    score_partition_column_name IN VARCHAR2 DEFAULT 'PARTITION_NAME',
    num_quantiles               IN NUMBER   DEFAULT 10,
    cost_matrix_table_name      IN VARCHAR2 DEFAULT NULL,
    apply_result_schema_name    IN VARCHAR2 DEFAULT NULL,
    target_schema_name          IN VARCHAR2 DEFAULT NULL,
    cost_matrix_schema_name     IN VARCHAR2 DEFAULT NULL,
    score_criterion_type        IN VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-63  COMPUTE_LIFT_PART Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from</td>
</tr>
<tr>
<td></td>
<td>the test data.</td>
</tr>
<tr>
<td>lift_table_name</td>
<td>Table containing the Lift statistics. The table will be created by the</td>
</tr>
<tr>
<td></td>
<td>procedure in the user's schema. The columns in the Lift table are</td>
</tr>
<tr>
<td></td>
<td>described in the Usage Notes.</td>
</tr>
<tr>
<td>positive_target_value</td>
<td>The positive class. This should be the class of interest, for which you</td>
</tr>
<tr>
<td></td>
<td>want to calculate Lift. If the target column is a NUMBER, then you can use</td>
</tr>
<tr>
<td></td>
<td>the TO_CHAR() operator to provide the value as a string.</td>
</tr>
</tbody>
</table>
### Table 40-63  (Cont.) COMPUTE_LIFT_PART Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is PREDICTION, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains either the probabilities or the costs that determine the predictions. By default, scoring is based on probability; the class with the highest probability is predicted for each case. If scoring is based on cost, then the class with the lowest cost is predicted. The score_criterion_type parameter indicates whether probabilities or costs will be used for scoring. The default column name is PROBABILITY, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;). See the Usage Notes for additional information.</td>
</tr>
<tr>
<td>score_partition_column_name</td>
<td>Optional parameter indicating the column containing the name of the partition. This column slices the input test results such that each partition has independent evaluation matrices computed.</td>
</tr>
<tr>
<td>num_quantiles</td>
<td>Number of quantiles to be used in calculating Lift. The default is 10.</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>(Optional) Table that defines the costs associated with misclassifications. If a cost matrix table is provided and the score_criterion_type parameter is set to COST, then the costs will be used as the scoring criteria. The columns in a cost matrix table are described in the Usage Notes.</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Schema of the cost matrix table, if one is provided. If null, then the user's schema is assumed.</td>
</tr>
<tr>
<td>score_criterion_type</td>
<td>Whether to use probabilities or costs as the scoring criterion. Probabilities or costs are passed in the column identified in the score_criterion_column_name parameter. The default value of score_criterion_type is PROBABILITY. To use costs as the scoring criterion, specify COST. If score_criterion_type is set to COST but no cost matrix is provided and if there is a scoring cost matrix associated with the model, then the associated costs are used for scoring. See the Usage Notes and the Examples.</td>
</tr>
</tbody>
</table>
Usage Notes

- The predictive information you pass to `COMPUTE_LIFT_PART` may be generated using SQL PREDICTION functions, the DBMS_DATA_MINING.APPLY procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the Lift.

- Instead of passing a cost matrix to `COMPUTE_LIFT_PART`, you can use a scoring cost matrix associated with the model. A scoring cost matrix can be embedded in the model or it can be defined dynamically when the model is applied. To use a scoring cost matrix, invoke the SQL `PREDICTION_COST` function to populate the score criterion column.

- The predictions that you pass to `COMPUTE_LIFT_PART` are in a table or view specified in `apply_results_table_name`.

```sql
CREATE TABLE apply_result_table_name AS (  
  case_id_column_name VARCHAR2,  
  score_column_name VARCHAR2,  
  score_criterion_column_name VARCHAR2);
```

- A cost matrix must have the columns described in Table 40-61.

<table>
<thead>
<tr>
<th>Table 40-64    Columns in a Cost Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Name</td>
</tr>
<tr>
<td>actual_target_value</td>
</tr>
<tr>
<td>predicted_target_value</td>
</tr>
<tr>
<td>cost</td>
</tr>
</tbody>
</table>

* See Also:*

Oracle Machine Learning for SQL Concepts for more information about cost matrices

- The table created by `COMPUTE_LIFT_PART` has the columns described in Table 40-62

<table>
<thead>
<tr>
<th>Table 40-65    Columns in a COMPUTE_LIFT_PART Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Name</td>
</tr>
<tr>
<td>quantile_number</td>
</tr>
<tr>
<td>probability_threshold</td>
</tr>
<tr>
<td>gain_cumulative</td>
</tr>
<tr>
<td>quantile_total_count</td>
</tr>
<tr>
<td>quantile_target_count</td>
</tr>
<tr>
<td>percent_records_cumulative</td>
</tr>
<tr>
<td>lift_cumulative</td>
</tr>
</tbody>
</table>
Table 40-65  (Cont.) Columns in a COMPUTE_LIFT_PART Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>target_density_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>targets_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>non_targets_cumulative</td>
<td>NUMBER</td>
</tr>
<tr>
<td>lift_quantile</td>
<td>NUMBER</td>
</tr>
<tr>
<td>target_density</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

See Also:
Oracle Machine Learning for SQL Concepts for details about the information in the Lift table

- When a cost matrix is passed to COMPUTE_LIFT_PART, the cost threshold is returned in the probability_threshold column of the Lift table.

Examples

This example uses the Naive Bayes model nb_sh_clas_sample.

The example illustrates Lift based on probabilities. For examples that show computation based on costs, see "COMPUTE_CONFUSION_MATRIX Procedure".

For a partitioned model example, see "COMPUTE_CONFUSION_MATRIX_PART Procedure".

The following statement applies the model to the test data and stores the predictions and probabilities in a table.

```
CREATE TABLE nb_apply_results AS
  SELECT cust_id, t.prediction, t.probability
  FROM mining_data_test_v, TABLE(PREDICTION_SET(nb_sh_clas_sample USING *)) t;
```

Using probabilities as the scoring criterion, you can compute Lift as follows.

```
BEGIN
  DBMS_DATA_MINING.COMPUTE_LIFT_PART (  
    apply_result_table_name => 'nb_apply_results',
    target_table_name => 'mining_data_test_v',
    case_id_column_name => 'cust_id',
    target_column_name => 'affinity_card',
    lift_table_name => 'nb_lift',
    positive_target_value => to_char(1),
    score_column_name => 'PREDICTION',
    score_criterion_column_name => 'PROBABILITY',
    score_partition_column_name => 'PARTITION_NAME',
    num_quantiles => 10,
    cost_matrix_table_name => null,
    apply_result_schema_name => null,
    target_schema_name => null,
  );
END;
```
This query displays some of the statistics from the resulting Lift table.

```
SELECT quantile_number, probability_threshold, gain_cumulative, quantile_total_count
FROM nb_lift;
```

<table>
<thead>
<tr>
<th>QUANTILE_NUMBER</th>
<th>PROBABILITY_THRESHOLD</th>
<th>GAIN_CUMULATIVE</th>
<th>QUANTILE_TOTAL_COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.989335775</td>
<td>.15034965</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>.980534911</td>
<td>.26048951</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>.968506098</td>
<td>.374125874</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>.958975196</td>
<td>.493006993</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>.946705197</td>
<td>.587412587</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>.927454174</td>
<td>.66958042</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>.904403627</td>
<td>.748251748</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>.836482525</td>
<td>.839160839</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>.500184953</td>
<td>1</td>
<td>54</td>
</tr>
</tbody>
</table>

40.1.5.9 COMPUTE_ROC Procedure

This procedure computes the receiver operating characteristic (ROC), stores the results in a table in the user's schema, and returns a measure of the model accuracy.

ROC is a test metric for binary classification models. To compute ROC, one of the target values must be designated as the positive class. COMPUTE_ROC compares the predictions generated by the model with the actual target values in a set of test data.

ROC measures the impact of changes in the probability threshold. The probability threshold is the decision point used by the model for predictions. In binary classification, the default probability threshold is 0.5. The value predicted for each case is the one with a probability greater than 50%.

ROC can be plotted as a curve on an X-Y axis. The false positive rate is placed on the X axis. The true positive rate is placed on the Y axis. A false positive is a positive prediction for a case that is negative in the test data. A true positive is a positive prediction for a case that is positive in the test data.

COMPUTE_ROC accepts two input streams:

- The predictions generated on the test data. The information is passed in three columns:
  - Case ID column
  - Prediction column
  - Scoring criterion column containing probabilities
- The known target values in the test data. The information is passed in two columns:
  - Case ID column
  - Target column containing the known target values
See Also:

Oracle Machine Learning for SQL Concepts for more details about ROC and test metrics for classification

"COMPUTE_CONFUSION_MATRIX Procedure"
"COMPUTE_LIFT Procedure"

Syntax

```sql
DBMS_DATA_MINING.COMPUTE_ROC (
    roc_area_under_curve OUT NUMBER,
    apply_result_table_name IN VARCHAR2,
    target_table_name IN VARCHAR2,
    case_id_column_name IN VARCHAR2,
    target_column_name IN VARCHAR2,
    roc_table_name IN VARCHAR2,
    positive_target_value IN VARCHAR2,
    score_column_name IN VARCHAR2 DEFAULT 'PREDICTION',
    score_criterion_column_name IN VARCHAR2 DEFAULT 'PROBABILITY',
    apply_result_schema_name IN VARCHAR2 DEFAULT NULL,
    target_schema_name IN VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-66  COMPUTE_ROC Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roc_area_under_the_curve</td>
<td>Output parameter containing the area under the ROC curve (AUC). The AUC measures the likelihood that an actual positive will be predicted as positive. The greater the AUC, the greater the flexibility of the model in accommodating trade-offs between positive and negative class predictions. AUC can be especially important when one target class is rarer or more important to identify than another.</td>
</tr>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions.</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier in the targets table.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from the test data.</td>
</tr>
<tr>
<td>roc_table_name</td>
<td>Table containing the ROC output. The table will be created by the procedure in the user’s schema. The columns in the ROC table are described in the Usage Notes.</td>
</tr>
<tr>
<td>positive_target_value</td>
<td>The positive class. This should be the class of interest, for which you want to calculate ROC. If the target column is a NUMBER, you can use the TO_CHAR() operator to provide the value as a string.</td>
</tr>
</tbody>
</table>
Table 40-66  (Cont.) COMPUTE_ROC Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is 'PREDICTION', which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains the probabilities that determine the predictions. The default column name is 'PROBABILITY', which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, the user's schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, the user's schema is assumed.</td>
</tr>
</tbody>
</table>

Usage Notes

- The predictive information you pass to COMPUTE_ROC may be generated using SQL PREDICTION functions, the DBMS_DATA_MINING.APPLY procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the receiver operating characteristic.
- The predictions that you pass to COMPUTE_ROC are in a table or view specified in apply_results_table_name.

```
CREATE TABLE apply_result_table_name AS (  
    case_id_column_name VARCHAR2,  
    score_column_name VARCHAR2,  
    score_criterion_column_name VARCHAR2);  
```
- The table created by COMPUTE_ROC has the columns shown in Table 40-67.

Table 40-67  COMPUTE_ROC Output

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
</tr>
</thead>
<tbody>
<tr>
<td>probability</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>true_positives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_negatives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_positives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>true_negatives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>true_positive_fraction</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_positive_fraction</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>
ROC is typically used to determine the most desirable probability threshold. This can be done by examining the true positive fraction and the false positive fraction. The true positive fraction is the percentage of all positive cases in the test data that were correctly predicted as positive. The false positive fraction is the percentage of all negative cases in the test data that were incorrectly predicted as positive.

Given a probability threshold, the following statement returns the positive predictions in an apply result table ordered by probability.

```sql
SELECT case_id_column_name FROM apply_result_table_name WHERE probability > probability_threshold ORDER BY probability DESC;
```

There are two approaches to identifying the most desirable probability threshold. Which approach you use depends on whether or not you know the relative cost of positive versus negative class prediction errors.

If the costs are known, you can apply the relative costs to the ROC table to compute the minimum cost probability threshold. Suppose the relative cost ratio is: Positive Class Error Cost / Negative Class Error Cost = 20. Then execute a query like this.

```sql
WITH cost AS (
    SELECT probability_threshold, 20 * false_negatives + false_positives AS cost
    FROM ROC_table
    GROUP BY probability_threshold),
    minCost AS (
    SELECT min(cost) minCost
    FROM cost)
    SELECT max(probability_threshold) AS probability_threshold
    FROM cost, minCost
    WHERE cost = minCost;
```

If relative costs are not well known, you can simply scan the values in the ROC table (in sorted order) and make a determination about which of the displayed trade-offs (misclassified positives versus misclassified negatives) is most desirable.

```sql
SELECT * FROM ROC_table ORDER BY probability_threshold;
```

**Examples**

This example uses the Naive Bayes model `nb_sh_clas_sample`.

The following statement applies the model to the test data and stores the predictions and probabilities in a table.
CREATE TABLE nb_apply_results AS
    SELECT cust_id, t.prediction, t.probability
    FROM mining_data_test_v, TABLE(PREDICTION_SET(nb_sh_clas_sample USING *)) t;

Using the predictions and the target values from the test data, you can compute ROC as follows.

DECLARE
    v_area_under_curve NUMBER;
BEGIN
    DBMS_DATA_MINING.COMPUTE_ROC (
        roc_area_under_curve        => v_area_under_curve,
        apply_result_table_name     => 'nb_apply_results',
        target_table_name           => 'mining_data_test_v',
        case_id_column_name         => 'cust_id',
        target_column_name          => 'mining_data_test_v',
        roc_table_name              => 'nb_roc',
        positive_target_value       => '1',
        score_column_name           => 'PREDICTION',
        score_criterion_column_name => 'PROBABILITY');
    DBMS_OUTPUT.PUT_LINE('**** AREA UNDER ROC CURVE ****: ' ||
        ROUND(v_area_under_curve,4));
END;
/

The resulting AUC and a selection of columns from the ROC table are shown as follows.

**** AREA UNDER ROC CURVE ****: .8212

SELECT PROBABILITY, TRUE_POSITIVE_FRACTION, FALSE_POSITIVE_FRACTION
FROM NB_ROC;

<table>
<thead>
<tr>
<th>PROBABILITY</th>
<th>TRUE_POSITIVE_FRACTION</th>
<th>FALSE_POSITIVE_FRACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>.00000</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>.50018</td>
<td>.826589595</td>
<td>.227902946</td>
</tr>
<tr>
<td>.53851</td>
<td>.823699422</td>
<td>.221837088</td>
</tr>
<tr>
<td>.54991</td>
<td>.820809249</td>
<td>.217504333</td>
</tr>
<tr>
<td>.55628</td>
<td>.815028902</td>
<td>.215771231</td>
</tr>
<tr>
<td>.55628</td>
<td>.817919075</td>
<td>.215771231</td>
</tr>
<tr>
<td>.57563</td>
<td>.800578035</td>
<td>.214904679</td>
</tr>
<tr>
<td>.57563</td>
<td>.812138728</td>
<td>.214904679</td>
</tr>
</tbody>
</table>

40.1.5.10 COMPUTE_ROC_PART Procedure

The **COMPUTE_ROC_PART** procedure computes Receiver Operating Characteristic (ROC), stores the results in a table in the user’s schema, and returns a measure of the model accuracy. This procedure provides support to computation of evaluation metrics per-partition for partitioned models.

ROC is a test metric for binary classification models. To compute ROC, one of the target values must be designated as the positive class. **COMPUTE_ROC_PART** compares the predictions generated by the model with the actual target values in a set of test data.
ROC measures the impact of changes in the probability threshold. The probability threshold is the decision point used by the model for predictions. In binary classification, the default probability threshold is 0.5. The value predicted for each case is the one with a probability greater than 50%.

ROC can be plotted as a curve on an x-y axis. The false positive rate is placed on the x-axis. The true positive rate is placed on the y-axis. A false positive is a positive prediction for a case that is negative in the test data. A true positive is a positive prediction for a case that is positive in the test data.

**COMPUTE_ROC_PART** accepts two input streams:

- The predictions generated on the test data. The information is passed in three columns:
  - Case ID column
  - Prediction column
  - Scoring criterion column containing probabilities

- The known target values in the test data. The information is passed in two columns:
  - Case ID column
  - Target column containing the known target values

**See Also:**

*Oracle Machine Learning for SQL Concepts* for more details about ROC and test metrics for Classification

"COMPUTE_ROC Procedure"

"COMPUTE_CONFUSION_MATRIX Procedure"

"COMPUTE_LIFT_PART Procedure"

"COMPUTE_LIFT Procedure"

**Syntax**

```sql
DBMS_DATA_MINING.compute_roc_part(
    roc_area_under_curve OUT DM_NESTED_NUMERICALS,
    apply_result_table_name IN VARCHAR2,
    target_table_name IN VARCHAR2,
    case_id_column_name IN VARCHAR2,
    target_column_name IN VARCHAR2,
    roc_table_name IN VARCHAR2,
    positive_target_value IN VARCHAR2,
    score_column_name IN VARCHAR2 DEFAULT 'PREDICTION',
    score_criterion_column_name IN VARCHAR2 DEFAULT 'PROBABILITY',
    score_partition_column_name IN VARCHAR2 DEFAULT 'PARTITION_NAME',
    apply_result_schema_name IN VARCHAR2 DEFAULT NULL,
    target_schema_name IN VARCHAR2 DEFAULT NULL);
```
### Parameters

Table 40-68  COMPUTE_ROC_PART Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roc_area_under_the_curve</td>
<td>Output parameter containing the area under the ROC curve (AUC). The AUC measures the likelihood that an actual positive will be predicted as positive. The greater the AUC, the greater the flexibility of the model in accommodating trade-offs between positive and negative class predictions. AUC can be especially important when one target class is rarer or more important to identify than another. The output argument is changed from NUMBER to DM_NESTED_NUMERICALS.</td>
</tr>
<tr>
<td>apply_result_table_name</td>
<td>Table containing the predictions.</td>
</tr>
<tr>
<td>target_table_name</td>
<td>Table containing the known target values from the test data.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case ID column in the apply results table. Must match the case identifier in the targets table.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Target column in the targets table. Contains the known target values from the test data.</td>
</tr>
<tr>
<td>roc_table_name</td>
<td>Table containing the ROC output. The table will be created by the procedure in the user’s schema. The columns in the ROC table are described in the Usage Notes.</td>
</tr>
<tr>
<td>positive_target_value</td>
<td>The positive class. This should be the class of interest, for which you want to calculate ROC. If the target column is a NUMBER, then you can use the TO_CHAR() operator to provide the value as a string.</td>
</tr>
<tr>
<td>score_column_name</td>
<td>Column containing the predictions in the apply results table. The default column name is PREDICTION, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Column containing the scoring criterion in the apply results table. Contains the probabilities that determine the predictions. The default column name is PROBABILITY, which is the default name created by the APPLY procedure (See &quot;APPLY Procedure&quot;).</td>
</tr>
<tr>
<td>score_partition_column_name</td>
<td>Optional parameter indicating the column which contains the name of the partition. This column slices the input test results such that each partition has independent evaluation matrices computed.</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Schema of the apply results table. If null, then the user’s schema is assumed.</td>
</tr>
<tr>
<td>target_schema_name</td>
<td>Schema of the table containing the known targets. If null, then the user’s schema is assumed.</td>
</tr>
</tbody>
</table>
Usage Notes

- The predictive information you pass to `COMPUTE_ROC_PART` may be generated using SQL `PREDICTION` functions, the `DBMS_DATA_MINING.APPLY` procedure, or some other mechanism. As long as you pass the appropriate data, the procedure can compute the receiver operating characteristic.

- The predictions that you pass to `COMPUTE_ROC_PART` are in a table or view specified in `apply_results_table_name`.

  ```sql
  CREATE TABLE apply_result_table_name AS (
    case_id_column_name VARCHAR2,
    score_column_name VARCHAR2,
    score_criterion_column_name VARCHAR2);
  ```

- The `COMPUTE_ROC_PART` table has the following columns:

<table>
<thead>
<tr>
<th>Column</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>probability</td>
<td>BINARY_DOUBLE</td>
</tr>
<tr>
<td>true_positives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_negatives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_positives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>true_negatives</td>
<td>NUMBER</td>
</tr>
<tr>
<td>true_positive_fraction</td>
<td>NUMBER</td>
</tr>
<tr>
<td>false_positive_fraction</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

  **See Also:**

  *Oracle Machine Learning for SQL Concepts* for details about the output of `COMPUTE_ROC_PART`.

- ROC is typically used to determine the most desirable probability threshold. This can be done by examining the true positive fraction and the false positive fraction. The true positive fraction is the percentage of all positive cases in the test data that were correctly predicted as positive. The false positive fraction is the percentage of all negative cases in the test data that were incorrectly predicted as positive.

  Given a probability threshold, the following statement returns the positive predictions in an apply result table ordered by probability.

  ```sql
  SELECT case_id_column_name
  FROM apply_result_table_name
  WHERE probability > probability_threshold
  ORDER BY probability DESC;
  ```

- There are two approaches to identify the most desirable probability threshold. The approach you use depends on whether you know the relative cost of positive versus negative class prediction errors.
If the costs are known, then you can apply the relative costs to the ROC table to compute the minimum cost probability threshold. Suppose the relative cost ratio is: Positive Class Error Cost / Negative Class Error Cost = 20. Then execute a query as follows:

```sql
WITH cost AS (
    SELECT probability_threshold, 20 * false_negatives + false_positives cost
    FROM ROC_table
    GROUP BY probability_threshold),
    minCost AS (
    SELECT min(cost) minCost
    FROM cost)
    SELECT max(probability_threshold) probability_threshold
    FROM cost, minCost
    WHERE cost = minCost;
```

If relative costs are not well known, then you can simply scan the values in the ROC table (in sorted order) and make a determination about which of the displayed trade-offs (misclassified positives versus misclassified negatives) is most desirable.

```sql
SELECT * FROM ROC_table
ORDER BY probability_threshold;
```

**Examples**

This example uses the Naive Bayes model `nb_sh_clas_sample`.

The following statement applies the model to the test data and stores the predictions and probabilities in a table.

```sql
CREATE TABLE nb_apply_results AS
    SELECT cust_id, t.prediction, t.probability
    FROM mining_data_test_v, TABLE(PREDICTION_SET(nb_sh_clas_sample USING *)) t;
```

Using the predictions and the target values from the test data, you can compute ROC as follows.

```sql
DECLARE
    v_area_under_curve NUMBER;
BEGIN
    DBMS_DATA_MINING.COMPUTE_ROC_PART (v_area_under_curve, 'nb_apply_results', 'mining_data_test_v', 'cust_id', 'affinity_card', 'nb_roc', '1', 'PREDICTION', 'PROBABILITY', 'PARTITION_NAME', DBMS_OUTPUT.PUT_LINE('**** AREA UNDER ROC CURVE ****: ' || ROUND(v_area_under_curve,4)));
END;
/
```

The resulting AUC and a selection of columns from the ROC table are shown as follows.
40.1.5.11 CREATE_MODEL Procedure

This procedure creates an Oracle Machine Learning for SQL model with a given machine learning function.

Syntax

```sql
DBMS_DATA_MINING.CREATE_MODEL (  
    model_name            IN VARCHAR2,  
    mining_function       IN VARCHAR2,  
    data_table_name       IN VARCHAR2,  
    case_id_column_name   IN VARCHAR2,  
    target_column_name    IN VARCHAR2 DEFAULT NULL,  
    settings_table_name   IN VARCHAR2 DEFAULT NULL,  
    data_schema_name      IN VARCHAR2 DEFAULT NULL,  
    settings_schema_name  IN VARCHAR2 DEFAULT NULL,  
    xform_list            IN TRANSFORM_LIST DEFAULT NULL);
```

Parameters

Table 40-70  CREATE_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used. See the Usage Notes for model naming restrictions.</td>
</tr>
<tr>
<td>mining_function</td>
<td>The machine learning function. Values are listed in Table 40-3.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Table or view containing the build data</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case identifier column in the build data</td>
</tr>
<tr>
<td>target_column_name</td>
<td>For supervised models, the target column in the build data. NULL for unsupervised models.</td>
</tr>
<tr>
<td>settings_table_name</td>
<td>Table containing build settings for the model. NULL if there is no settings table (only default settings are used).</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema hosting the build data. If NULL, then the user's schema is assumed.</td>
</tr>
</tbody>
</table>
Table 40-70  (Cont.) CREATE_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>settings_schema_name</td>
<td>Schema hosting the settings table. If NULL then the user's schema is assumed.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A list of transformations to be used in addition to or instead of automatic transformations, depending on the value of the PREP_AUTO setting. (See &quot;Automatic Data Preparation&quot;). The datatype of xform_list is TRANSFORM_LIST, which consists of records of type TRANSFORM_REC. Each TRANSFORM_REC specifies the transformation information for a single attribute. TYPE TRANSFORM_REC IS RECORD (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), expression EXPRESSION_REC, reverse_expression EXPRESSION_REC, attribute_spec VARCHAR2(4000)); The expression field stores a SQL expression for transforming the attribute. The reverse_expression field stores a SQL expression for reversing the transformation in model details and, if the attribute is a target, in the results of scoring. The SQL expressions are manipulated by routines in the DBMS_DATA_MINING_TRANSFORM package: • SET_EXPRESSION Procedure • GET_EXPRESSION Function • SET_TRANSFORM Procedure The attribute_spec field identifies individualized treatment for the attribute. See the Usage Notes for details. See Table 40-122 for details about the TRANSFORM_REC type.</td>
</tr>
</tbody>
</table>

Usage Notes

1. You can use the attribute_spec field of the xform_list argument to identify an attribute as unstructured text or to disable Automatic Data Preparation for the attribute. The attribute_spec can have the following values:

   - TEXT: Indicates that the attribute contains unstructured text. The TEXT value may optionally be followed by POLICY_NAME, TOKEN_TYPE, MAX_FEATURES, and MIN_DOCUMENTS parameters. TOKEN_TYPE has the following possible values: NORMAL, STEM, THEME, SYNONYM, BIGRAM, STEM_BIGRAM. SYNONYM may be optionally followed by a thesaurus name in square brackets.

   - MAX_FEATURES specifies the maximum number of tokens extracted from the text.

   - MIN_DOCUMENTS specifies the minimal number of documents in which every selected token shall occur. (For information about creating a text policy, see CTX_DDL.CREATE_POLICY in Oracle Text Reference).

   Oracle Machine Learning for SQL can process columns of VARCHAR2/CHAR, CLOB, BLOB, and BFILE as text. If the column is VARCHAR2/CHAR and you do not specify TEXT, then OML4SQL processes the column as categorical data. If the column is
CLOB, then OML4SQL processes it as text by default (You do not need to specify it as TEXT. However, you do need to provide an Oracle Text Policy in the settings). If the column is BLOB or BFILE, then you must specify it as TEXT, otherwise CREATE_MODEL returns an error.

If you specify TEXT for a nested column or for an attribute in a nested column, then CREATE_MODEL returns an error.

- NOPREP: Disables ADP for the attribute. When ADP is OFF, the NOPREP value is ignored.

You can specify NOPREP for a nested column, but not for an attribute in a nested column. If you specify NOPREP for an attribute in a nested column when ADP is on, then CREATE_MODEL will return an error.

2. You can obtain information about a model by querying the Data Dictionary views.

   ALL/USER/DBA_MINING_MODELS
   ALL/USER/DBA_MINING_MODEL_ATTRIBUTES
   ALL/USER/DBA_MINING_MODEL_SETTINGS
   ALL/USER/DBA_MINING_MODEL_VIEWS
   ALL/USER/DBA_MINING_MODEL_PARTITIONS
   ALL/USER/DBA_MINING_MODEL_XFORMS

You can obtain information about model attributes by querying the model details through model views. Refer to Oracle Machine Learning for SQL User’s Guide.

3. The naming rules for models are more restrictive than the naming rules for most database schema objects. A model name must satisfy the following additional requirements:

   - It must be 123 or fewer characters long.
   - It must be a nonquoted identifier. Oracle requires that nonquoted identifiers contain only alphanumeric characters, the underscore (_), dollar sign ($), and pound sign (#); the initial character must be alphabetic. Oracle strongly discourages the use of the dollar sign and pound sign in nonquoted literals.

Naming requirements for schema objects are fully documented in Oracle Database SQL Language Reference.

4. To build a partitioned model, you must provide additional settings.

   The setting for partitioning columns are as follows:

   ```sql
   INSERT INTO settings_table VALUES ('ODMS_PARTITION_COLUMNS', 'GENDER, AGE');
   ```

   To set user-defined partition number for a model, the setting is as follows:

   ```sql
   INSERT INTO settings_table VALUES ('ODMS_MAX_PARTITIONS', '10');
   ```

   The default value for maximum number of partitions is 1000.

5. By passing an xform_list to CREATE_MODEL, you can specify a list of transformations to be performed on the input data. If the PREP_AUTO setting is ON, the transformations are used in addition to the automatic transformations. If the PREP_AUTO setting is OFF, the specified transformations are the only ones implemented by the model. In both cases, transformation definitions are
embedded in the model and executed automatically whenever the model is applied. See "Automatic Data Preparation". Other transforms that can be specified with xform_list include FORCE_IN. Refer to Oracle Machine Learning for SQL User’s Guide.

Examples

The first example builds a classification model using the Support Vector Machine algorithm.

```sql
-- Create the settings table
CREATE TABLE svm_model_settings (  
    setting_name  VARCHAR2(30),  
    setting_value VARCHAR2(30));

-- Populate the settings table
-- Specify SVM. By default, Naive Bayes is used for classification.
-- Specify ADP. By default, ADP is not used.
BEGIN
    INSERT INTO svm_model_settings (setting_name, setting_value) VALUES  
        (dbms_data_mining.algo_name, dbms_data_mining.algo_support_vector_machines);  
    INSERT INTO svm_model_settings (setting_name, setting_value) VALUES  
        (dbms_data_mining.prep_auto,dbms_data_mining.prep_auto_on);
    COMMIT;
END;
/

-- Create the model using the specified settings
BEGIN
    DBMS_DATA_MINING.CREATE_MODEL(  
        model_name => 'svm_model',  
        mining_function => dbms_data_mining.classification,  
        data_table_name => 'mining_data_build_v',  
        case_id_column_name => 'cust_id',  
        target_column_name => 'affinity_card',  
        settings_table_name => 'svm_model_settings');
END;
/

You can display the model settings with the following query:

```sql
SELECT * FROM user_mining_model_settings  
WHERE model_name IN 'SVM_MODEL';
```

<table>
<thead>
<tr>
<th>MODEL_NAME</th>
<th>SETTING_NAME</th>
<th>SETTING_VALUE</th>
<th>SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVM_MODEL</td>
<td>ALGO_NAME</td>
<td>ALGO_SUPPORT_VECTOR_MACHINES</td>
<td>INPUT</td>
</tr>
<tr>
<td>SVM_MODEL</td>
<td>SVMS_STD_DEV</td>
<td>3.004524</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVM_MODEL</td>
<td>PREP_AUTO</td>
<td>ON</td>
<td>INPUT</td>
</tr>
<tr>
<td>SVM_MODEL</td>
<td>SVMS_COMPLEXITY_FACTOR</td>
<td>1.887389</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVM_MODEL</td>
<td>SVMS_KERNEL_FUNCTION</td>
<td>SVMS_LINEAR</td>
<td>DEFAULT</td>
</tr>
<tr>
<td>SVM_MODEL</td>
<td>SVMS_CONV_TOLERANCE</td>
<td>.001</td>
<td>DEFAULT</td>
</tr>
</tbody>
</table>

The following is an example of querying a model view instead of the older GEL_MODEL_DETAILS_SVM routine.

```sql
SELECT target_value, attribute_name, attribute_value, coefficient  
FROM DM$VLSVM_MODEL;
```
The second example creates an anomaly detection model. Anomaly detection uses SVM classification without a target. This example uses the same settings table created for the SVM classification model in the first example.

BEGIN
  DBMS_DATA_MINING.CREATE_MODEL(
    model_name          => 'anomaly_detect_model',
    mining_function     => dbms_data_mining.classification,
    data_table_name     => 'mining_data_build_v',
    case_id_column_name => 'cust_id',
    target_column_name  => null,
    settings_table_name => 'svm_model_settings');
END;
/

This query shows that the models created in these examples are the only ones in your schema.

SELECT model_name, mining_function, algorithm FROM user_mining_models;

MODEL_NAME              MINING_FUNCTION      ALGORITHM
----------------------  -------------------- ------------------------------
SVM_MODEL               CLASSIFICATION       SUPPORT_VECTOR_MACHINES
ANOMALY_DETECT_MODEL    CLASSIFICATION       SUPPORT_VECTOR_MACHINES

This query shows that only the SVM classification model has a target.

SELECT model_name, attribute_name, attribute_type, target
FROM user_mining_model_attributes
WHERE target = 'YES';

MODEL_NAME          ATTRIBUTE_NAME   ATTRIBUTE_TYPE     TARGET
------------------  ---------------  -----------------  ------
SVM_MODEL           AFFINITY_CARD    CATEGORICAL         YES

40.1.5.12 CREATE_MODEL2 Procedure

The CREATE_MODEL2 procedure is an alternate procedure to the CREATE_MODEL procedure, which enables creating a model without extra persistence stages. In the CREATE_MODEL procedure, the input is a table or a view and if such an object is not already present, the user must create it. By using the CREATE_MODEL2 procedure, the user does not need to create such transient database objects.

Syntax

DBMS_DATA_MINING.CREATE_MODEL2 (model_name => VARCHAR2, mining_function => VARCHAR2, data_query => CLOB, set_list => SETTING_LIST, case_id_column_name => VARCHAR2 DEFAULT NULL, target_column_name => VARCHAR2 DEFAULT NULL, xform_list => TRANSFORM_LIST DEFAULT NULL);
Parameters

Table 40-71 CREATE_MODEL2 Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name]model_name. If you do not specify a schema, then the current schema is used. See the Usage Notes, CREATE_MODEL Procedure for model naming restrictions.</td>
</tr>
<tr>
<td>mining_function</td>
<td>The machine learning function. Values are listed in DBMS_DATA_MINING — Machine Learning Function Settings.</td>
</tr>
<tr>
<td>data_query</td>
<td>A query which provides training data for building the model.</td>
</tr>
<tr>
<td>set_list</td>
<td>Specifies the SETTING_LIST SETTING_LIST is a table of CLOB index by VARCHAR2(30); Where the index is the setting name and the CLOB is the setting value for that name.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Case identifier column in the build data.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>For supervised models, the target column in the build data. NULL for unsupervised models.</td>
</tr>
<tr>
<td>xform_list</td>
<td>Refer to CREATE_MODEL Procedure.</td>
</tr>
</tbody>
</table>

Usage Notes

Refer to CREATE_MODEL Procedure for Usage Notes.

Examples

The following example uses the Support Vector Machine algorithm.

declare
  v_setlst DBMS_DATA_MINING.SETTING_LIST;
BEGIN
  v_setlst(dbms_data_mining.algo_name) := dbms_data_mining.algo_support_vector_machines;
  v_setlst(dbms_data_mining.prep_auto) := dbms_data_mining.prep_auto_on;
  DBMS_DATA_MINING.CREATE_MODEL2(
    model_name => 'svm_model',
    mining_function => dbms_data_mining.classification,
    data_query => 'select * from mining_data_build_v',
    data_table_name => 'mining_data_build_v',
    case_id_column_name => 'cust_id',
    target_column_name => 'affinity_card',
    set_list => v_setlst,
    case_id_column_name => 'cust_id',
    target_column_name => 'affinity_card');
END;
/
40.1.5.13 Create Model Using Registration Information

Create model function fetches the setting information from JSON object.

Usage Notes

If an algorithm is registered, user can create model using the registered algorithm name. Since all R scripts and default setting values are already registered, providing the value through the setting table is not necessary. This makes the use of this algorithm easier.

Examples

The first example builds a Classification model using the GLM algorithm.

```sql
CREATE TABLE GLM_RDEMO_SETTINGS_CL (
  setting_name  VARCHAR2(30),
  setting_value VARCHAR2(4000));
BEGIN
  INSERT INTO GLM_RDEMO_SETTINGS_CL VALUES
    ('ALGO_EXTENSIBLE_LANG', 'R');
  INSERT INTO GLM_RDEMO_SETTINGS_CL VALUES
    (dbms_data_mining.ralg_registration_algo_name, 't1');
  INSERT INTO GLM_RDEMO_SETTINGS_CL VALUES
    (dbms_data_mining.odms_formula,
     'AGE + EDUCATION + HOUSEHOLD_SIZE + OCCUPATION');
  INSERT INTO GLM_RDEMO_SETTINGS_CL VALUES
    ('RALG_PARAMETER_FAMILY', 'binomial(logit)');
END;
/
BEGIN
  DBMS_DATA_MINING.CREATE_MODEL(
    model_name                    =>    'GLM_RDEMO_CLASSIFICATION',
    mining_function               =>     dbms_data_mining.classification,
    data_table_name               =>    'mining_data_build_v',
    case_id_column_name           =>    'CUST_ID',
    target_column_name            =>    'AFFINITY_CARD',
    settings_table_name           =>    'GLM_RDEMO_SETTINGS_CL');
END;
/
```

40.1.5.14 DROP_ALGORITHM Procedure

This function is used to drop the registered algorithm information.

Syntax

```
DBMS_DATA_MINING.DROP_ALGORITHM (algorithm_name IN VARCHAR2(30),
  cascade IN BOOLEAN default FALSE)
```
Parameters

Table 40-72  DROP_ALGORITHM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>algorithm_name</td>
<td>Name of the algorithm.</td>
</tr>
<tr>
<td>cascade</td>
<td>If the cascade option is TRUE, all the models with this algorithms are forced to drop. There after, the algorithm is dropped. The default value is FALSE.</td>
</tr>
</tbody>
</table>

Usage Note

- To drop a machine learning model, you must be the owner or you must have the RQADMIN privilege. See Oracle Machine Learning for SQL User’s Guide for information about privileges for machine learning.
- Make sure a model is not built on the algorithm, then drop the algorithm from the system table.
- If you try to drop an algorithm with a model built on it, then an error is displayed.

40.1.5.15 DROP_PARTITION Procedure

Syntax

```sql
DBMS_DATA_MINING.DROP_PARTITION (    model_name                IN VARCHAR2,    partition_name            IN VARCHAR2);
```

Parameters

Table 40-73  DROP_PARTITION Procedure Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the machine learning model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Name of the partition that must be dropped.</td>
</tr>
</tbody>
</table>

40.1.5.16 DROP_MODEL Procedure

This procedure deletes the specified machine learning model.

Syntax

```sql
DBMS_DATA_MINING.DROP_MODEL (model_name IN VARCHAR2,    force IN BOOLEAN DEFAULT FALSE);
```
Parameters

Table 40-74  DROP_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the machine learning model in the form [schema_name].model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>force</td>
<td>Forces the machine learning model to be dropped even if it is invalid. A machine learning model may be invalid if a serious system error interrupted the model build process.</td>
</tr>
</tbody>
</table>

Usage Note

To drop a machine learning model, you must be the owner or you must have the DROP ANY MINING MODEL privilege. See Oracle Data Mining User’s Guide for information about privileges for Oracle Machine Learning for SQL.

Example

You can use the following command to delete a valid machine learning model named nb_sh_clas_sample that exists in your schema.

```sql
BEGIN
    DBMS_DATA_MINING.DROP_MODEL(model_name => 'nb_sh_clas_sample');
END;
/
```

40.1.5.17 EXPORT_MODEL Procedure

This procedure exports the specified machine learning models to a dump file set.

To import the models from the dump file set, use the IMPORT_MODEL Procedure. EXPORT_MODEL and IMPORT_MODEL use Oracle Data Pump technology.

When Oracle Data Pump is used to export/import an entire schema or database, the machine learning models in the schema or database are included. However, EXPORT_MODEL and IMPORT_MODEL are the only utilities that support the export/import of individual models.

See Also:

- Oracle Database Utilities for information about Oracle Data Pump
- Oracle Machine Learning for SQL User’s Guide for more information about exporting and importing machine learning models

Syntax

```sql
DBMS_DATA_MINING.EXPORT_MODEL (  
    filename IN VARCHAR2,
    directory IN VARCHAR2,
    model_filter IN VARCHAR2 DEFAULT NULL,
```
Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>Name of the dump file set to which the models should be exported. The name must be unique within the schema. The dump file set can contain one or more files. The number of files in a dump file set is determined by the size of the models being exported (both metadata and data) and a specified or estimated maximum file size. You can specify the file size in the <code>filesize</code> parameter, or you can use the <code>operation</code> parameter to cause Oracle Data Pump to estimate the file size. If the size of the models to export is greater than the maximum file size, one or more additional files are created. When the export operation completes successfully, the name of the dump file set is automatically expanded to <code>filename01.dmp</code>, even if there is only one file in the dump set. If there are additional files, they are named sequentially as <code>filename02.dmp</code>, <code>filename03.dmp</code>, and so forth.</td>
</tr>
<tr>
<td>directory</td>
<td>Name of a pre-defined directory object that specifies where the dump file set should be created. The exporting user must have read/write privileges on the directory object and on the file system directory that it identifies. See Oracle Database SQL Language Reference for information about directory objects.</td>
</tr>
<tr>
<td>model_filter</td>
<td>Optional parameter that specifies which model or models to export. If you do not specify a value for <code>model_filter</code>, all models in the schema are exported. You can also specify NULL (the default) or 'ALL' to export all models. You can export individual models by name and groups of models based on machine learning function or algorithm. For instance, you could export all regression models or all Naive Bayes models. Examples are provided in Table 40-76.</td>
</tr>
<tr>
<td>filesize</td>
<td>Optional parameter that specifies the maximum size of a file in the dump file set. The size may be specified in bytes, kilobytes (K), megabytes (M), or gigabytes (G). The default size is 50 MB. If the size of the models to export is larger than <code>filesize</code>, one or more additional files are created within the dump set. See the description of the <code>filename</code> parameter for more information.</td>
</tr>
<tr>
<td>operation</td>
<td>Optional parameter that specifies whether or not to estimate the size of the files in the dump set. By default the size is not estimated and the value of the <code>filesize</code> parameter determines the size of the files. You can specify either of the following values for <code>operation</code>: • 'EXPORT' — Export all or the specified models. (Default) • 'ESTIMATE' — Estimate the size of the exporting models.</td>
</tr>
</tbody>
</table>
Table 40-75 (Cont.) EXPORT_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>remote_link</td>
<td>Optional parameter that specifies the name of a database link to a remote system. The default value is NULL. A database link is a schema object in a local database that enables access to objects in a remote database. When you specify a value for remote_link, you can export the models in the remote database. The EXP_FULL_DATABASE role is required for exporting the remote models. The EXP_FULL_DATABASE privilege, the CREATE DATABASE LINK privilege, and other privileges may also be required.</td>
</tr>
<tr>
<td>jobname</td>
<td>Optional parameter that specifies the name of the export job. By default, the name has the form username_exp_nnnn, where nnnn is a number. For example, a job name in the SCOTT schema might be SCOTT_exp_134. If you specify a job name, it must be unique within the schema. The maximum length of the job name is 30 characters. A log file for the export job, named jobname.log, is created in the same directory as the dump file set.</td>
</tr>
</tbody>
</table>

Usage Notes

The model_filter parameter specifies which models to export. You can list the models by name, or you can specify all models that have the same machine learning function or algorithm. You can query the USER_MINING_MODELS view to list the models in your schema.

SQL> describe user_mining_models
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
MODEL_NAME                                NOT NULL VARCHAR2(30)
MINING_FUNCTION                                    VARCHAR2(30)
ALGORITHM                                          VARCHAR2(30)
CREATION_DATE                             NOT NULL DATE
BUILD_DURATION                                     NUMBER
MODEL_SIZE                                         NUMBER
COMMENTS                                           VARCHAR2(4000)

Examples of model filters are provided in Table 40-76.

<table>
<thead>
<tr>
<th>Sample Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>'mymodel'</td>
<td>Export the model named mymodel</td>
</tr>
<tr>
<td>'name= ''mymodel'''</td>
<td>Export the model named mymodel</td>
</tr>
<tr>
<td>'name IN (''mymodel2'',''mymodel3'')'</td>
<td>Export the models named mymodel2 and mymodel3</td>
</tr>
<tr>
<td>'ALGORITHM_NAME = ''NAIVE_BAYES'''</td>
<td>Export all Naive Bayes models. See Table 40-5 for a list of algorithm names.</td>
</tr>
<tr>
<td>'FUNCTION_NAME =''CLASSIFICATION'''</td>
<td>Export all classification models. See Table 40-3 for a list of machine learning functions.</td>
</tr>
</tbody>
</table>
Examples

1. The following statement exports all the models in the oml_user3 schema to a dump file set called models_out in the directory $ORACLE_HOME/rdbms/log. This directory is mapped to a directory object called DATA_PUMP_DIR. The oml_user3 user has read/write access to the directory and to the directory object.

   SQL>execute dbms_data_mining.export_model ('models_out', 'DATA_PUMP_DIR');

   You can exit SQL*Plus and list the resulting dump file and log file.

   SQL>EXIT
   >cd $ORACLE_HOME/rdbms/log
   >ls
   >oml_user3_exp_1027.log  models_out01.dmp

2. The following example uses the same directory object and is executed by the same user. This example exports the models called NMF_SHSAMPLE and SVMR_SH_REGR_SAMPLE to a different dump file set in the same directory.

   SQL>EXECUTE DBMS_DATA_MINING.EXPORT_MODEL ( 'models2_out', 'DATA_PUMP_DIR',
                     'name in (''NMF_SH_SAMPLE'', ''SVMR_SH_REGR_SAMPLE'')');

   SQL>EXIT
   >cd $ORACLE_HOME/rdbms/log
   >ls
   >oml_user3_exp_1027.log  models_out01.dmp
   oml_user3_exp_924.log  models2_out01.dmp

3. The following examples show how to export models with specific algorithm and machine learning function names.

   SQL>EXECUTE DBMS_DATA_MINING.EXPORT_MODEL('algo.dmp','DM_DUMP',
                     'ALGORITHM_NAME IN (''O_CLUSTER'', 'GENERALIZED_LINEAR_MODEL'',
                     'SUPPORT_VECTOR_MACHINES'', 'NAIVE_BAYES''');

   SQL>EXECUTE DBMS_DATA_MINING.EXPORT_MODEL('func.dmp', 'DM_DUMP',
                     'FUNCTION_NAME IN {CLASSIFICATION,CLUSTERING,FEATURE_EXTRACTION}');

40.1.5.18 EXPORT_SERMODEL Procedure

This procedure exports the model in a serialized format so that they can be moved to another platform for scoring.

When exporting a model in serialized format, the user must pass in an empty BLOB locator and specify the model name to be exported. If the model is partitioned, the user can optionally select an individual partition to export, otherwise all partitions are exported. The returned BLOB contains the content that can be deployed.

Syntax

DBMS_DATA_MINING.EXPORT_SERMODEL (  
   model_data IN OUT NOCOPY BLOB,
   model_name IN VARCHAR2,
   partition_name IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-77  EXPORT_SERMODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_data</td>
<td>Provides serialized model data.</td>
</tr>
<tr>
<td>model_name</td>
<td>Name of the machine learning model in the form [schema_name].model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Name of the partition that must be exported.</td>
</tr>
</tbody>
</table>

Examples

The following statement exports all of the models in a serialized format.

```sql
DECLARE
  v_blob blob;
BEGIN
  dbms_lob.createtemporary(v_blob, FALSE);
  dbms_data_mining.export_sermodel(v_blob, 'MY_MODEL');
  -- save v_blob somewhere (e.g., bfile, etc.)
  dbms_lob.freetemporary(v_blob);
END;
/
```

See Also:


40.1.5.19 FETCH_JSON_SCHEMA Procedure

User can fetch and read JSON schema from the ALL_MINING_ALGORITHMS view. This function returns the pre-registered JSON schema for R extensible algorithms.

Syntax

```sql
DBMS_DATA_MINING.FETCH_JSON_SCHEMA RETURN CLOB;
```

Parameters

Table 40-78  FETCH_JSON_SCHEMA Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN</td>
<td>This function returns the pre-registered JSON schema for R extensibility.</td>
</tr>
<tr>
<td></td>
<td>The default value is CLOB.</td>
</tr>
</tbody>
</table>
Usage Note

If a user wants to register a new algorithm using the algorithm registration function, they must fetch and follow the pre-registered JSON schema using this function, when they create the required JSON object metadata, and then pass it to the registration function.

40.1.5.20 GET_ASSOCIATION_RULES Function

The `GET_ASSOCIATION_RULES` function returns the rules produced by an association model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

You can specify filtering criteria to `GET_ASSOCIATION_RULES` to return a subset of the rules. Filtering criteria can improve the performance of the table function. If the number of rules is large, then the greatest performance improvement will result from specifying the `topn` parameter.

Syntax

```sql
DBMS_DATA_MINING.get_association_rules(
model_name       IN VARCHAR2,  
topn             IN NUMBER DEFAULT NULL,  
rule_id          IN INTEGER DEFAULT NULL,  
min_confidence   IN NUMBER DEFAULT NULL,  
min_support      IN NUMBER DEFAULT NULL,  
max_rule_length  IN INTEGER DEFAULT NULL,  
min_rule_length  IN INTEGER DEFAULT NULL,  
sort_order       IN ORA_MINING_VARCHAR2_NT DEFAULT NULL,  
antecedent_items IN DM_ITEMS DEFAULT NULL,  
consequent_items IN DM_ITEMS DEFAULT NULL,  
min_lift         IN NUMBER DEFAULT NULL,  
partition_name   IN VARCHAR2 DEFAULT NULL)
RETURN DM_Rules PIPELINED;
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form <code>[schema_name.]model_name</code>. If you do not specify a schema, then your own schema is used. This is the only required parameter of <code>GET_ASSOCIATION_RULES</code>. All other parameters specify optional filters on the rules to return.</td>
</tr>
<tr>
<td>topn</td>
<td>Returns the <code>n</code> top rules ordered by confidence and then support, both descending. If you specify a sort order, then the top <code>n</code> rules are derived after the sort is performed. If <code>topn</code> is specified and no maximum or minimum rule length is specified, then the only columns allowed in the sort order are <code>RULE_CONFIDENCE</code> and <code>RULE_SUPPORT</code>. If <code>topn</code> is specified and a maximum or minimum rule length is specified, then <code>RULE_CONFIDENCE</code>, <code>RULE_SUPPORT</code>, and <code>NUMBER_OF_ITEMS</code> are allowed in the sort order.</td>
</tr>
<tr>
<td>rule_id</td>
<td>Identifier of the rule to return. If you specify a value for <code>rule_id</code>, do not specify values for the other filtering parameters.</td>
</tr>
</tbody>
</table>
Table 40-79  (Cont.) GET_ASSOCIATION_RULES Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>min_confidence</td>
<td>Returns the rules with confidence greater than or equal to this number.</td>
</tr>
<tr>
<td>min_support</td>
<td>Returns the rules with support greater than or equal to this number.</td>
</tr>
<tr>
<td>max_rule_length</td>
<td>Returns the rules with a length less than or equal to this number.</td>
</tr>
<tr>
<td></td>
<td>Rule length refers to the number of items in the rule (See NUMBER_OF_ITEMS in Table 40-80). For example, in the rule A=&gt;B (if A, then B), the number of items is 2. If max_rule_length is specified, then the NUMBER_OF_ITEMS column is permitted in the sort order.</td>
</tr>
<tr>
<td>min_rule_length</td>
<td>Returns the rules with a length greater than or equal to this number.</td>
</tr>
<tr>
<td></td>
<td>See max_rule_length for a description of rule length.</td>
</tr>
<tr>
<td></td>
<td>If min_rule_length is specified, then the NUMBER_OF_ITEMS column is permitted in the sort order.</td>
</tr>
<tr>
<td>sort_order</td>
<td>Sorts the rules by the values in one or more of the returned columns. Specify one or more column names, each followed by ASC for ascending order or DESC for descending order. (See Table 40-80 for the column names.) For example, to sort the result set in descending order first by the NUMBER_OF_ITEMS column, then by the RULE_CONFIDENCE column, you must specify: ORA_MINING VARCHAR2 NT('NUMBER_OF_ITEMS DESC', 'RULE_CONFIDENCE DESC') If you specify topn, the results will vary depending on the sort order. By default, the results are sorted by Confidence in descending order, then by Support in descending order.</td>
</tr>
<tr>
<td>antecedent_items</td>
<td>Returns the rules with these items in the antecedent.</td>
</tr>
<tr>
<td>consequent_items</td>
<td>Returns the rules with this item in the consequent.</td>
</tr>
<tr>
<td>min_lift</td>
<td>Returns the rules with lift greater than or equal to this number.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Return Values

The object type returned by GET_ASSOCIATION_RULES is described in Table 40-80. For descriptions of each field, see the Usage Notes.
### GET_ASSOCIATION RULES Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_RULES</td>
<td>A set of rows of type DM_RULE. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(rule_id INTEGER, antecedent DM_PREDICATES, consequent DM_PREDICATES, rule_support NUMBER, rule_confidence NUMBER, rule_lift NUMBER, antecedent_support NUMBER, consequent_support NUMBER, number_of_items INTEGER)</td>
</tr>
<tr>
<td>DM_PREDICATES</td>
<td>The antecedent and consequent columns each return nested tables of type DM_PREDICATES. The rows, of type DM_PREDICATE, have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), conditional_operator CHAR(2)/<em>=,&lt;&gt;,&lt;,&gt;,&gt;=,&lt;=</em>/, attribute_num_value NUMBER, attribute_str_value VARCHAR2(4000), attribute_support NUMBER, attribute_confidence NUMBER)</td>
</tr>
</tbody>
</table>

#### Usage Notes

1. This table function pipes out rows of type DM_RULES. For information on machine learning data types and piped output from table functions, see "Datatypes".

2. The columns returned by GET_ASSOCIATION_RULES are described as follows:

<table>
<thead>
<tr>
<th>Column in DM_RULES</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rule_id</td>
<td>Unique identifier of the rule</td>
</tr>
<tr>
<td>antecedent</td>
<td>The independent condition in the rule. When this condition exists, the dependent condition in the consequent also exists. The condition is a combination of attribute values called a predicate (DM_PREDICATE). The predicate specifies a condition for each attribute. The condition may specify equality (=), inequality (&lt;&gt;, &gt;, &lt;, &gt;=, &lt;=) a given value. Support and Confidence for each attribute condition in the antecedent is returned in the predicate. Support is the number of transactions that satisfy the antecedent. Confidence is the likelihood that a transaction will satisfy the antecedent. Note: The occurrence of the attribute as a DM_PREDICATE indicates the presence of the item in the transaction. The actual value for attribute_num_value or attribute_str_value is meaningless. For example, the following predicate indicates that 'Mouse Pad' is present in the transaction even though the attribute value is NULL.</td>
</tr>
</tbody>
</table>

DM_PREDICATE('PROD_NAME', 'Mouse Pad', ' ', NULL, NULL, NULL, NULL) |
<table>
<thead>
<tr>
<th>Column in DM_RULES</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>consequent</td>
<td>The dependent condition in the rule. This condition exists when the antecedent exists. The consequent, like the antecedent, is a predicate (DM_PREDICATE). Support and confidence for each attribute condition in the consequent is returned in the predicate. Support is the number of transactions that satisfy the consequent. Confidence is the likelihood that a transaction will satisfy the consequent.</td>
</tr>
<tr>
<td>rule_support</td>
<td>The number of transactions that satisfy the rule.</td>
</tr>
<tr>
<td>rule_confidence</td>
<td>The likelihood of a transaction satisfying the rule.</td>
</tr>
<tr>
<td>rule_lift</td>
<td>The degree of improvement in the prediction over random chance when the rule is satisfied.</td>
</tr>
<tr>
<td>antecedent_support</td>
<td>The ratio of the number of transactions that satisfy the antecedent to the total number of transactions.</td>
</tr>
<tr>
<td>consequent_support</td>
<td>The ratio of the number of transactions that satisfy the consequent to the total number of transactions.</td>
</tr>
<tr>
<td>number_of_items</td>
<td>The total number of attributes referenced in the antecedent and consequent of the rule.</td>
</tr>
</tbody>
</table>

**Examples**

The following example demonstrates an association model build followed by several invocations of the GET_ASSOCIATION_RULES table function:

```sql
-- prepare a settings table to override default settings
CREATE TABLE market_settings AS
SELECT *
FROM TABLE(DBMS_DATA_MINING.GET_DEFAULT_SETTINGS)
WHERE setting_name LIKE 'ASSO-%';
BEGIN
-- update the value of the minimum confidence
UPDATE market_settings
SET setting_value = TO_CHAR(0.081)
WHERE setting_name = DBMS_DATA_MINING.asso_min_confidence;

-- build an AR model
DBMS_DATA_MINING.CREATE_MODEL(
  model_name => 'market_model',
  function => DBMS_DATA_MINING.ASSOCIATION,
  data_table_name => 'market_build',
  case_id_column_name => 'item_id',
  target_column_name => NULL,
  settings_table_name => 'market_settings');
END;
/

-- View the (unformatted) rules
SELECT rule_id, antecedent, consequent, rule_support, rule_confidence
FROM TABLE(DBMS_DATA_MINING.GET_ASSOCIATION_RULES('market_model'));
```

In the previous example, you view all rules. To view just the top 20 rules, use the following statement:

```sql
-- View the top 20 (unformatted) rules
SELECT rule_id, antecedent, consequent, rule_support,
```
The following query uses the association model AR_SH_SAMPLE:

```sql
SELECT * FROM TABLE (DBMS_DATA_MINING.GET_ASSOCIATION_RULES ('AR_SH_SAMPLE', 10, NULL, 0.5, 0.01, 2, 1, ORA_MINING.VARCHAR2_NT ( 'NUMBER_OF_ITEMS DESC', 'RULE_CONFIDENCE DESC', 'RULE_SUPPORT DESC'), DM_ITEMS(DM_ITEM('CUSTPRODS', 'Mouse Pad', 1, NULL), DM_ITEM('CUSTPRODS', 'Standard Mouse', 1, NULL)), DM_ITEMS(DM_ITEM('CUSTPRODS', 'Extension Cable', 1, NULL))));
```

The query returns three rules, shown as follows:

13  DM_PREDICATES(
    DM_PREDICATE('CUSTPRODS', 'Mouse Pad', ' = ', 1, NULL, NULL, NULL),
    DM_PREDICATE('CUSTPRODS', 'Standard Mouse', ' = ', 1, NULL, NULL, NULL))

11  DM_PREDICATES(
    DM_PREDICATE('CUSTPRODS', 'Standard Mouse', ' = ', 1, NULL, NULL, NULL))

9   DM_PREDICATES(
    DM_PREDICATE('CUSTPRODS', 'Mouse Pad', ' = ', 1, NULL, NULL, NULL))

See Also:
Table 40-80 for the DM_RULE column data types.

40.1.5.21 GET_FREQUENT_ITEMSETS Function

The GET_FREQUENT_ITEMSETS function returns a set of rows that represent the frequent itemsets from an association model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User's Guide.


Syntax

```sql
DBMS_DATA_MINING.get_frequent_itemsets(
    model_name IN VARCHAR2,
```
PARAMETERS

Table 40-81  GET_FREQUENT_ITEMSETS Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>topn</td>
<td>When not NULL, return the top $n$ rows ordered by support in descending order</td>
</tr>
<tr>
<td>max_itemset_length</td>
<td>Maximum length of an item set.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Note: The partition_name columns applies only when the model is partitioned.

Return Values

Table 40-82  GET_FREQUENT_ITEMSETS Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_ITEMSETS</td>
<td>A set of rows of type DM_ITEMSET. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(partition_name VARCHAR2(128),</td>
</tr>
<tr>
<td></td>
<td>itemsets_id NUMBER,</td>
</tr>
<tr>
<td></td>
<td>items DM_ITEMS,</td>
</tr>
<tr>
<td></td>
<td>support NUMBER,</td>
</tr>
<tr>
<td></td>
<td>number_of_items NUMBER)</td>
</tr>
</tbody>
</table>

Note: The partition_name columns applies only when the model is partitioned.

The items column returns a nested table of type DM_ITEM: The rows have type DM_ITEM:

| (attribute_name VARCHAR2(4000), |
| attribute_subname VARCHAR2(4000), |
| attribute_num_value NUMBER, |
| attribute_str_value VARCHAR2(4000)) |
Usage Notes

This table function pipes out rows of type `DM_ITEMSETS`. For information on machine learning data types and piped output from table functions, see "Data Types".

Examples

The following example demonstrates an association model build followed by an invocation of `GET_FREQUENT_ITEMSETS` table function from Oracle SQL.

```sql
-- prepare a settings table to override default settings
CREATE TABLE market_settings AS
SELECT *
FROM TABLE(DBMS_DATA_MINING.GET_DEFAULT_SETTINGS)
WHERE setting_name LIKE 'ASSO_%';
BEGIN
-- update the value of the minimum confidence
UPDATE market_settings
SET setting_value = TO_CHAR(0.081)
WHERE setting_name = DBMS_DATA_MINING.asso_min_confidence;
/* build a AR model */
DBMS_DATA_MINING.CREATE_MODEL(
  model_name           => 'market_model',
  function             => DBMS_DATA_MINING.ASSOCIATION,
  data_table_name      => 'market_build',
  case_id_column_name  => 'item_id',
  target_column_name   => NULL,
  settings_table_name  => 'market_settings');
END;
/
-- View the (unformatted) Itemsets from SQL*Plus
SELECT itemset_id, items, support, number_of_items
FROM TABLE(DBMS_DATA_MINING.GET_FREQUENT_ITEMSETS('market_model'));

In the example above, you view all itemsets. To view just the top 20 itemsets, use the following statement:

```sql
-- View the top 20 (unformatted) Itemsets from SQL*Plus
SELECT itemset_id, items, support, number_of_items
FROM TABLE(DBMS_DATA_MINING.GET_FREQUENT_ITEMSETS('market_model', 20));
```

40.1.5.22 GET_MODEL_COST_MATRIX Function

The `GET_*` interfaces are replaced by model views, and Oracle recommends that users leverage the views instead.

The `GET_MODEL_COST_MATRIX` function is replaced by the `DM$VC` prefixed view, Scoring Cost Matrix. The cost matrix used when building a Decision Tree is made available by the `DM$VM` prefixed view, Decision Tree build cost matrix.

Refer to Model Detail View for Classification Algorithm.

The `GET_MODEL_COST_MATRIX` function returns the rows of a cost matrix associated with the specified model.
By default, this function returns the scoring cost matrix that was added to the model with the `ADD_COST_MATRIX` procedure. If you wish to obtain the cost matrix used to create a model, specify `cost_matrix_type_create` as the `matrix_type`. See Table 40-83.

See also `ADD_COST_MATRIX` Procedure.

**Syntax**

```sql
DBMS_DATA_MINING.GET_MODEL_COST_MATRIX (  
    model_name      IN VARCHAR2,  
    matrix_type     IN VARCHAR2 DEFAULT cost_matrix_type_score,  
    partition_name  IN VARCHAR2 DEFAULT NULL)  
RETURN DM_COST_MATRIX PIPELINED;
```

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form <code>[schema_name.]model_name</code>. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>matrix_type</td>
<td>The type of cost matrix.</td>
</tr>
<tr>
<td></td>
<td>COST_MATRIX_TYPE_SCORE — cost matrix used for scoring. (Default.)</td>
</tr>
<tr>
<td></td>
<td>COST_MATRIX_TYPE_CREATE — cost matrix used to create the model (Decision Tree only).</td>
</tr>
<tr>
<td>partition_name</td>
<td>Name of the partition in a partitioned model</td>
</tr>
</tbody>
</table>

**Return Values**

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_COST_MATRIX</td>
<td>A set of rows of type <code>DM_COST_ELEMENT</code>. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>actual VARCHAR2(4000), NUMBER, predicted VARCHAR2(4000), cost NUMBER)</td>
</tr>
</tbody>
</table>

**Usage Notes**

Only Decision Tree models can be built with a cost matrix. If you want to build a Decision Tree model with a cost matrix, specify the cost matrix table name in the `CLAS_COST_TABLE_NAME` setting in the settings table for the model. See Table 40-7.

The cost matrix used to create a Decision Tree model becomes the default scoring matrix for the model. If you want to specify different costs for scoring, you can use the `REMOVE_COST_MATRIX` procedure to remove the cost matrix and the `ADD_COST_MATRIX` procedure to add a new one.

The `GET_MODEL_COST_MATRIX` may return either the build or scoring cost matrix defined for a model or model partition.
If you do not specify a partitioned model name, then an error is displayed.

Example

This example returns the scoring cost matrix associated with the Naive Bayes model NB_SH_CLAS_SAMPLE.

column actual format a10
column predicted format a10
SELECT *
FROM TABLE(dbms_data_mining.get_model_cost_matrix('nb_sh_clas_sample'))
ORDER BY predicted, actual;

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>PREDICTED</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>.00</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>.75</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>.25</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>.00</td>
</tr>
</tbody>
</table>

40.1.5.23 GET_MODELDETAILS_AI Function

The GET_MODELDETAILS_AI function returns a set of rows that provide the details of an attribute importance model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Syntax

DBMS_DATA_MINING.get_model_details_ai(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN dm_ranked_attributes pipelined;

Parameters

<table>
<thead>
<tr>
<th>Table 40-85</th>
<th>GET_MODELDETAILS_AI Function Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>
Return Values

Table 40-86  GET_MODEL_DETAILS_AI Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_RANKED_ATTRIBUTES</td>
<td>A set of rows of type DM_RANKED_ATTRIBUTE. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), importance_value NUMBER, rank NUMBER(38))</td>
</tr>
</tbody>
</table>

Examples

The following example returns model details for the attribute importance model AI_SH_sample, which was created by the sample program dmaidemo.sql.

```sql
SELECT attribute_name, importance_value, rank
FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_AI('AI_SH_sample'))
ORDER BY RANK;
```

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>IMPORTANCE_VALUE</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOUSEHOLD_SIZE</td>
<td>0.151685183</td>
<td>1</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>0.145294546</td>
<td>2</td>
</tr>
<tr>
<td>YRS_RESIDENCE</td>
<td>0.07838928</td>
<td>3</td>
</tr>
<tr>
<td>AGE</td>
<td>0.075027496</td>
<td>4</td>
</tr>
<tr>
<td>Y_BOX_GAMES</td>
<td>0.063039952</td>
<td>5</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>0.059605314</td>
<td>6</td>
</tr>
<tr>
<td>HOME_THEATER_PACKAGE</td>
<td>0.056458722</td>
<td>7</td>
</tr>
<tr>
<td>OCCUPATION</td>
<td>0.054652937</td>
<td>8</td>
</tr>
<tr>
<td>CUST_GENDER</td>
<td>0.035264741</td>
<td>9</td>
</tr>
<tr>
<td>BOOKKEEPING_APPLICATION</td>
<td>0.019204751</td>
<td>10</td>
</tr>
<tr>
<td>PRINTER_SUPPLIES</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>OS_DOC_SET_KANJI</td>
<td>-0.00050013</td>
<td>12</td>
</tr>
<tr>
<td>FLAT_PANEL_MONITOR</td>
<td>-0.00509564</td>
<td>13</td>
</tr>
<tr>
<td>BULK_PACK_DISKETTES</td>
<td>-0.00540822</td>
<td>14</td>
</tr>
<tr>
<td>COUNTRY_NAME</td>
<td>-0.01201116</td>
<td>15</td>
</tr>
<tr>
<td>CUST_INCOME_LEVEL</td>
<td>-0.03951311</td>
<td>16</td>
</tr>
</tbody>
</table>

40.1.5.24 GET_MODELDETAILS_EM Function

The GET_MODELDETAILS_EM function returns a set of rows that provide statistics about the clusters produced by an expectation maximization model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User's Guide.

By default, the EM algorithm groups components into high-level clusters, and GET_MODELDETAILS_EM returns only the high-level clusters with their hierarchies. Alternatively, you can configure EM model to disable the grouping of components into high-level clusters. In this case, GET_MODELDETAILS_EM returns the components themselves as clusters with their hierarchies. See Table 40-12.
Syntax

```sql
DBMS_DATA_MINING.get_model_details_em(
    model_name VARCHAR2,
    cluster_id NUMBER DEFAULT NULL,
    attribute VARCHAR2 DEFAULT NULL,
    centroid NUMBER DEFAULT 1,
    histogram NUMBER DEFAULT 1,
    rules NUMBER DEFAULT 2,
    attribute_subname VARCHAR2 DEFAULT NULL,
    topn_attributes NUMBER DEFAULT NULL,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN dm_clusters PIPELINED;
```

Parameters

Table 40-87  GET_MODELDETAILS_EM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name].model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>cluster_id</td>
<td>The ID of a cluster in the model. When a valid cluster ID is specified, only the details of this cluster are returned. Otherwise, the details for all clusters are returned.</td>
</tr>
<tr>
<td>attribute</td>
<td>The name of an attribute. When a valid attribute name is specified, only the details of this attribute are returned. Otherwise, the details for all attributes are returned.</td>
</tr>
<tr>
<td>centroid</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 1: Details about centroids are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 0: Details about centroids are not returned</td>
</tr>
<tr>
<td>histogram</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 1: Details about histograms are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 0: Details about histograms are not returned</td>
</tr>
<tr>
<td>rules</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 2: Details about rules are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 1: Rule summaries are returned</td>
</tr>
<tr>
<td></td>
<td>- 0: No information about rules is returned</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>The name of a nested attribute. The full name of a nested attribute has the form:</td>
</tr>
<tr>
<td></td>
<td>attribute_name.attribute_subname</td>
</tr>
<tr>
<td></td>
<td>where attribute_name is the name of the column and attribute_subname is the name of the nested attribute in that column. If the attribute is not nested, then attribute_subname is null.</td>
</tr>
<tr>
<td>topn_attributes</td>
<td>Restricts the number of attributes returned in the centroid, histogram, and rules objects. Only the n attributes with the highest confidence values in the rules are returned.</td>
</tr>
<tr>
<td></td>
<td>If the number of attributes included in the rules is less than topn, then, up to n additional attributes in alphabetical order are returned.</td>
</tr>
<tr>
<td></td>
<td>If both the attribute and topn_attributes parameters are specified, then topn_attributes is ignored.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>
Usage Notes

1. For information on Oracle Machine Learning for SQL data types and return values for Clustering algorithms piped output from table functions, see "Data Types".

2. GET_MODEL_DETAILS functions preserve model transparency by automatically reversing the transformations applied during the build process. Thus the attributes returned in the model details are the original attributes (or a close approximation of the original attributes) used to build the model.

3. When cluster statistics are disabled (EMCS_CLUSTER_STATISTICS is set to EMCS_CLUS_STATS_DISABLE), GET_MODEL_DETAILS_EM does not return centroids, histograms, or rules. Only taxonomy (hierarchy) and cluster counts are returned.

4. When the partition_name is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

40.1.5.25 GET_MODEL_DETAILS_EM_COMP Function

The GET_MODEL_DETAILS_EM_COMP table function returns a set of rows that provide details about the parameters of an expectation maximization model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_em_comp(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN DM_EM_COMPONENT_SET PIPELINED;
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model to retrieve details for.</td>
</tr>
</tbody>
</table>
Return Values

### Table 40-89 GET_MODELDETAILS_EM_COMP Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_EM_COMPONENT_SET</td>
<td>A set of rows of type DM_EM_COMPONENT. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(info_type VARCHAR2(30), component_id NUMBER, cluster_id NUMBER, attribute_name VARCHAR2(4000), covariate_name VARCHAR2(4000), attribute_value VARCHAR2(4000), value NUMBER )</td>
</tr>
</tbody>
</table>

**Usage Notes**

1. This table function pipes out rows of type DM_EM_COMPONENT. For information on Oracle Machine Learning for SQL data types and piped output from table functions, see “Data Types”.

The columns in each row returned by GET_MODELDETAILS_EM_COMP are described as follows:

<table>
<thead>
<tr>
<th>Column in DM_EM_COMPONENT</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>info_type</td>
<td>The type of information in the row. The following information types are supported:</td>
</tr>
<tr>
<td></td>
<td>• cluster • prior • mean • covariance • frequency</td>
</tr>
<tr>
<td>component_id</td>
<td>Unique identifier of a component</td>
</tr>
<tr>
<td>cluster_id</td>
<td>Unique identifier of the high-level leaf cluster for each component</td>
</tr>
<tr>
<td>attribute_name</td>
<td>Name of an original attribute or a derived feature ID. The derived feature ID is used in models built on data with nested columns. The derived feature definitions can be obtained from the GET_MODELDETAILS_EM_PROJ Function.</td>
</tr>
<tr>
<td>covariate_name</td>
<td>Name of an original attribute or a derived feature ID used in variance/covariance definition</td>
</tr>
<tr>
<td>attribute_value</td>
<td>Categorical value or bin interval for binned numerical attributes</td>
</tr>
</tbody>
</table>
Column in DM_EM_COMPONENT | Description
--- | ---
value | Encodes different information depending on the value of info_type, as follows:
  * cluster | The value field is NULL
  * prior | The value field returns the component prior
  * mean | The value field returns the mean of the attribute specified in attribute_name
  * covariance | The value field returns the covariance of the attributes specified in attribute_name and covariate_name. Using the same attribute in attribute_name and covariate_name, returns the variance.
  * frequency | The value field returns the multivalued Bernoulli frequency parameter for the attribute/value combination specified by attribute_name and attribute_value.

See Usage Note 2 for details.

2. The following table shows which fields are used for each info_type. The blank cells represent NULLs.

<table>
<thead>
<tr>
<th>info_type</th>
<th>component_id</th>
<th>cluster_id</th>
<th>attribute_name</th>
<th>covariate_name</th>
<th>attribute_value</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cluster</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>prior</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>mean</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>covariance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>frequency</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

3. GET_MODEL_DETAILS functions preserve model transparency by automatically reversing the transformations applied during the build process. Thus the attributes returned in the model details are the original attributes (or a close approximation of the original attributes) used to build the model.

4. When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

40.1.5.26 GET_MODELDETAILS_EM_PROJ Function

The GET_MODELDETAILS_EM_PROJ function returns a set of rows that provide statistics about the projections produced by an expectation maximization model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_em_proj(
   model_name IN VARCHAR2,
   partition_name IN VARCHAR2 DEFAULT NULL)
RETURN DM_EM_PROJECTION_SET PIPELINED;
```
Parameters

Table 40-90  GET_MODEL_DETAILS_EM_PROJ Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model</td>
</tr>
</tbody>
</table>

Return Values

Table 40-91  GET_MODEL_DETAILS_EM_PROJ Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_EM_PROJECTION_SET</td>
<td>A set of rows of type DM_EM_PROJECTION. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(feature_name VARCHAR2(4000), attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), attribute_value VARCHAR2(4000), coefficient NUMBER )</td>
</tr>
</tbody>
</table>

See Usage Notes for details.

Usage Notes

1. This table function pipes out rows of type DM_EM_PROJECTION. For information on machine learning data types and piped output from table functions, see "Datatypes".

   The columns in each row returned by GET_MODEL_DETAILS_EM_PROJ are described as follows:

<table>
<thead>
<tr>
<th>Column in DM_EM_PROJECTION</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>feature_name</td>
<td>Name of a derived feature. The feature maps to the attribute_name returned by the GET_MODEL_DETAILS_EM Function.</td>
</tr>
<tr>
<td>attribute_name</td>
<td>Name of a column in the build data</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>Subname in a nested column</td>
</tr>
<tr>
<td>attribute_value</td>
<td>Categorical value</td>
</tr>
<tr>
<td>coefficient</td>
<td>Projection coefficient. The representation is sparse; only the non-zero coefficients are returned.</td>
</tr>
</tbody>
</table>

2. GET_MODEL_DETAILS functions preserve model transparency by automatically reversing the transformations applied during the build process. Thus the attributes returned in the model details are the original attributes (or a close approximation of the original attributes) used to build the model.

   The coefficients are related to the transformed, not the original, attributes. When returned directly with the model details, the coefficients may not provide meaningful information.
3. When the value is **NULL** for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

**Related Topics**

- *Oracle Machine Learning for SQL User’s Guide*

### 40.1.5.27 GET_MODELDETAILS_GLM Function

The `GET_MODELDETAILS_GLM` function returns the coefficient statistics for a generalized linear model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in *Oracle Machine Learning for SQL User’s Guide*.

The same set of statistics is returned for both linear and logistic regression, but statistics that do not apply to the machine learning function are returned as **NULL**. For more details, see the Usage Notes.

**Syntax**

```
DBMS_DATA_MINING.get_model_details_glm(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN DM_GLM_Coeff_Set PIPELINED;
```

**Parameters**

**Table 40-92  GET_MODELDETAILS_GLM Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form <code>[schema_name.]model_name</code>. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model</td>
</tr>
</tbody>
</table>
Return Values

Table 40-93  GET_MODEL_DETAILS_GLM Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_GLM_COEFF_SET</td>
<td>A set of rows of type DM_GLM_COEFF. The rows have the following columns:</td>
</tr>
<tr>
<td>class</td>
<td>VARCHAR2(4000),</td>
</tr>
<tr>
<td>attribute_name</td>
<td>VARCHAR2(4000),</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>VARCHAR2(4000),</td>
</tr>
<tr>
<td>attribute_value</td>
<td>VARCHAR2(4000),</td>
</tr>
<tr>
<td>feature_expression</td>
<td>VARCHAR2(4000),</td>
</tr>
<tr>
<td>coefficient</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>std_error</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>test_statistic</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>p_value</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>VIF</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>std_coefficient</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>lower_coeff_limit</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>upper_coeff_limit</td>
<td>NUMBER,</td>
</tr>
<tr>
<td>exp_coefficient</td>
<td>BINARY_DOUBLE,</td>
</tr>
<tr>
<td>exp_lower_coeff_limit</td>
<td>BINARY_DOUBLE,</td>
</tr>
<tr>
<td>exp_upper_coeff_limit</td>
<td>BINARY_DOUBLE,</td>
</tr>
</tbody>
</table>

GET_MODEL_DETAILS_GLM returns a row of statistics for each attribute and one extra row for the intercept, which is identified by a null value in the attribute name. Each row has the DM_GLM_COEFF data type. The statistics are described in Table 40-94.

Table 40-94  DM_GLM_COEFF Data Type Description

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>class</td>
<td>The non-reference target class for logistic regression. The model is built to predict the probability of this class.</td>
</tr>
<tr>
<td></td>
<td>The other class (the reference class) is specified in the model setting GLMS_REFERENCE_CLASS_NAME. See Table 40-18.</td>
</tr>
<tr>
<td></td>
<td>For Linear Regression, class is null.</td>
</tr>
<tr>
<td>attribute_name</td>
<td>The attribute name when there is no subname, or first part of the attribute name when there is a subname. The value of attribute_name is also the name of the column in the case table that is the source for this attribute.</td>
</tr>
<tr>
<td></td>
<td>For the intercept, attribute_name is null. Intercepts are equivalent to the bias term in SVM models.</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>The name of an attribute in a nested table. The full name of a nested attribute has the form:</td>
</tr>
<tr>
<td></td>
<td>attribute_name.attribute_subname</td>
</tr>
<tr>
<td></td>
<td>where attribute_name is the name of the nested column in the case table that is the source for this attribute.</td>
</tr>
<tr>
<td></td>
<td>If the attribute is not nested, then attribute_subname is null. If the attribute is an intercept, then both the attribute_name and the</td>
</tr>
<tr>
<td></td>
<td>attribute_subname are null.</td>
</tr>
</tbody>
</table>
Table 40-94  (Cont.) DM_GLM_COEFF Data Type Description

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>attribute_value</td>
<td>The value of the attribute (categorical attribute only). For numeric attributes, attribute_value is null.</td>
</tr>
<tr>
<td>feature_expression</td>
<td>The feature name constructed by the algorithm when feature generation is enabled and higher-order features are found. If feature selection is not enabled, then the feature name is simply the fully-qualified attribute name (attribute_name.attribute_subname if the attribute is in a nested column). For categorical attributes, the algorithm constructs a feature name that has the following form: fully-qualified_attribute_name.attribute_value For numeric attributes, the algorithm constructs a name for the higher-order feature by taking the product of the resulting values: (attrib1)*(attrib2)...... where attrib1 and attrib2 are fully-qualified attribute names.</td>
</tr>
<tr>
<td>coefficient</td>
<td>The linear coefficient estimate.</td>
</tr>
<tr>
<td>std_error</td>
<td>Standard error of the coefficient estimate.</td>
</tr>
<tr>
<td>test_statistic</td>
<td>For linear regression, the t-value of the coefficient estimate. For logistic regression, the Wald chi-square value of the coefficient estimate.</td>
</tr>
<tr>
<td>p-value</td>
<td>Probability of the test_statistic. Used to analyze the significance of specific attributes in the model.</td>
</tr>
<tr>
<td>VIF</td>
<td>Variance Inflation Factor. The value is zero for the intercept. For logistic regression, VIF is null. VIF is not computed if the solver is Cholesky.</td>
</tr>
<tr>
<td>std_coefficient</td>
<td>Standardized estimate of the coefficient.</td>
</tr>
<tr>
<td>lower_coeff_limit</td>
<td>Lower confidence bound of the coefficient.</td>
</tr>
<tr>
<td>upper_coeff_limit</td>
<td>Upper confidence bound of the coefficient.</td>
</tr>
<tr>
<td>exp_coefficient</td>
<td>Exponentiated coefficient for logistic regression. For linear regression, exp_coefficient is null.</td>
</tr>
<tr>
<td>exp_lower_coeff_limit</td>
<td>Exponentiated coefficient for lower confidence bound of the coefficient for logistic regression. For linear regression, exp_lower_coeff_limit is null.</td>
</tr>
<tr>
<td>exp_upper_coeff_limit</td>
<td>Exponentiated coefficient for upper confidence bound of the coefficient for logistic regression. For linear regression, exp_upper_coeff_limit is null.</td>
</tr>
</tbody>
</table>

**Usage Notes**

Not all statistics are necessarily returned for each coefficient. Statistics will be null if:

- They do not apply to the machine learning function. For example, exp_coefficient does not apply to linear regression.
- They cannot be computed from a theoretical standpoint. For information on ridge regression, see Table 40-18.
- They cannot be computed because of limitations in system resources.
• Their values would be infinity.
• When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

Examples

The following example returns some of the model details for the GLM regression model GLMR_SH_Regr_sample.

```sql
SET line 120
SET pages 99
column attribute_name format a30
column attribute_subname format a20
column attribute_value format a20
col coefficient format 990.9999
col std_error format 990.9999
SQL> SELECT *
    FROM (SELECT attribute_name, attribute_value, coefficient, std_error
    FROM DM$VDGLMR_SH_REGR_SAMPLE order by 1,2)
WHERE rownum < 11;
```

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>ATTRIBUTE_VALUE</th>
<th>COEFFICIENT</th>
<th>STD_ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFINITY_CARD</td>
<td>-0.5797</td>
<td>0.5283</td>
<td></td>
</tr>
<tr>
<td>BOOKKEEPING_APPLICATION</td>
<td>-0.4689</td>
<td>3.8872</td>
<td></td>
</tr>
<tr>
<td>BULK_PACK_DISKETTES</td>
<td>-0.9819</td>
<td>2.5430</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: Argentina</td>
<td>-1.2020</td>
<td>1.1876</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: Australia</td>
<td>-0.0071</td>
<td>5.1146</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: Brazil</td>
<td>5.2931</td>
<td>1.9233</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: Canada</td>
<td>4.0191</td>
<td>2.4108</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: China</td>
<td>0.8706</td>
<td>3.5889</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: Denmark</td>
<td>-2.9822</td>
<td>3.1803</td>
<td></td>
</tr>
<tr>
<td>COUNTRY_NAME: France</td>
<td>-1.1044</td>
<td>7.1811</td>
<td></td>
</tr>
</tbody>
</table>

Related Topics

• Oracle Machine Learning for SQL User’s Guide

40.1.5.28 GET_MODELDETAILS_GLOBAL Function

The GET_MODELDETAILS_GLOBAL function returns statistics about the model as a whole. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Global details are available for Generalized Linear Models, Association Rules, Singular Value Decomposition, and Expectation Maximization. There are new Global model views which show global information for all algorithms. Oracle recommends that users leverage the views instead. Refer to Model Details View Global.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_global(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL
) RETURN DM_model_global_details PIPELINED;
```
Parameters

Table 40-95  GET_MODEL_DETAILS_GLOBAL Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Return Values

Table 40-96  GET_MODEL_DETAILS_GLOBAL Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_MODEL_GLOBAL_DETAILS</td>
<td>A collection of rows of type DM_MODEL_GLOBAL_DETAIL. The rows have the following columns: (global_detail_name VARCHAR2(30), global_detail_value NUMBER)</td>
</tr>
</tbody>
</table>

Examples

The following example returns the global model details for the GLM regression model GLMR_SH_Regr_sample.

```
SELECT *
FROM TABLE(dbms_data_mining.get_model_details_global('GLMR_SH_Regr_sample'))
ORDER BY global_detail_name;
```

<table>
<thead>
<tr>
<th>GLOBAL_DETAIL_NAME</th>
<th>GLOBAL_DETAIL_VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADJUSTED_R_SQUARE</td>
<td>.731412557</td>
</tr>
<tr>
<td>AIC</td>
<td>5931.814</td>
</tr>
<tr>
<td>COEFF_VAR</td>
<td>18.1711243</td>
</tr>
<tr>
<td>CORRECTED_TOTAL_DF</td>
<td>1499</td>
</tr>
<tr>
<td>CORRECTED_TOT_SS</td>
<td>278740.504</td>
</tr>
<tr>
<td>DEPENDENT_MEAN</td>
<td>38.892</td>
</tr>
<tr>
<td>ERROR_DF</td>
<td>1433</td>
</tr>
<tr>
<td>ERROR_MEAN_SQUARE</td>
<td>49.9440956</td>
</tr>
<tr>
<td>ERROR_SUM_SQUARES</td>
<td>71569.8891</td>
</tr>
<tr>
<td>F_VALUE</td>
<td>62.8492452</td>
</tr>
<tr>
<td>GMSEP</td>
<td>52.280819</td>
</tr>
<tr>
<td>HOCKING_SP</td>
<td>.034877162</td>
</tr>
<tr>
<td>J_P</td>
<td>52.1749319</td>
</tr>
<tr>
<td>MODEL_CONVERGED</td>
<td>1</td>
</tr>
<tr>
<td>MODEL_DF</td>
<td>66</td>
</tr>
<tr>
<td>MODEL_F_P_VALUE</td>
<td>0</td>
</tr>
<tr>
<td>MODEL_MEAN_SQUARE</td>
<td>3138.94871</td>
</tr>
<tr>
<td>MODEL_SUM_SQUARES</td>
<td>207170.615</td>
</tr>
<tr>
<td>NUM_Params</td>
<td>67</td>
</tr>
<tr>
<td>NUM_ROWS</td>
<td>1500</td>
</tr>
<tr>
<td>ROOT_MEAN_SQ</td>
<td>7.06711367</td>
</tr>
<tr>
<td>R_SQ</td>
<td>.743238288</td>
</tr>
<tr>
<td>SBIC</td>
<td>6287.79977</td>
</tr>
<tr>
<td>VALID_COVARIANCE_MATRIX</td>
<td>1</td>
</tr>
</tbody>
</table>
Related Topics
• Oracle Machine Learning for SQL User’s Guide

40.1.5.29 GET_MODEL_DETAILS_KM Function

The GET_MODEL_DETAILS_KM function returns a set of rows that provide the details of a k-means clustering model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

You can provide input to GET_MODEL_DETAILS_KM to request specific information about the model, thus improving the performance of the query. If you do not specify filtering parameters, then GET_MODEL_DETAILS_KM returns all the information about the model.

Syntax

```
DBMS_DATA_MINING.get_model_details_km(
    model_name VARCHAR2,
    cluster_id NUMBER DEFAULT NULL,
    attribute VARCHAR2 DEFAULT NULL,
    centroid NUMBER DEFAULT 1,
    histogram NUMBER DEFAULT 1,
    rules NUMBER DEFAULT 2,
    attribute_subname VARCHAR2 DEFAULT NULL,
    topn_attributes NUMBER DEFAULT NULL,
    partition_name VARCHAR2 DEFAULT NULL)
RETURN dm_clusters PIPELINED;
```

Parameters

Table 40-97  GET_MODEL_DETAILS_KM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>cluster_id</td>
<td>The ID of a cluster in the model. When a valid cluster ID is specified, only the details of this cluster are returned. Otherwise the details for all clusters are returned.</td>
</tr>
<tr>
<td>attribute</td>
<td>The name of an attribute. When a valid attribute name is specified, only the details of this attribute are returned. Otherwise, the details for all attributes are returned.</td>
</tr>
<tr>
<td>centroid</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 1: Details about centroids are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 0: Details about centroids are not returned</td>
</tr>
<tr>
<td>histogram</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 1: Details about histograms are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 0: Details about histograms are not returned</td>
</tr>
<tr>
<td>rules</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td></td>
<td>- 2: Details about rules are returned (default)</td>
</tr>
<tr>
<td></td>
<td>- 1: Rule summaries are returned</td>
</tr>
<tr>
<td></td>
<td>- 0: No information about rules is returned</td>
</tr>
</tbody>
</table>
Table 40-97  (Cont.) GET_MODEL_DETAILS_KM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| attribute_subname  | The name of a nested attribute. The full name of a nested attribute has the form:  
where attribute_subname is the name of the column and attribute_subname is the name of the nested attribute in that column.  
If the attribute is not nested, attribute_subname is null. |
| topn_attributes    | Restricts the number of attributes returned in the centroid, histogram, and rules objects. Only the $n$ attributes with the highest confidence values in the rules are returned.  
If the number of attributes included in the rules is less than $topn$, then up to $n$ additional attributes in alphabetical order are returned.  
If both the attribute and topn_attributes parameters are specified, then topn_attributes is ignored. |
| partition_name     | Specifies a partition in a partitioned model.                                                                                                                                                                |

Usage Notes

1. The table function pipes out rows of type DM_CLUSTERS. For information on machine learning data types and Return Value for Clustering Algorithms piped output from table functions, see "Data Types".

2. When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

Examples

The following example returns model details for the $k$-means clustering model KM_SH_Clus_sample.

```
SELECT T.id       clu_id,
       T.record_count rec_cnt,
       T.parent      parent,
       T.tree_level  tree_level,
       T.dispersion  dispersion
FROM (SELECT *
       FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_KM(  
                     'KM_SH_Clus_sample'))
       ORDER BY id) T
WHERE ROWNUM < 6;
```

<table>
<thead>
<tr>
<th>CLU_ID</th>
<th>REC_CNT</th>
<th>PARENT</th>
<th>TREE_LEVEL</th>
<th>DISPERSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1500</td>
<td>1</td>
<td>1</td>
<td>5.9152211</td>
</tr>
<tr>
<td>2</td>
<td>638</td>
<td>1</td>
<td>2</td>
<td>3.98458982</td>
</tr>
<tr>
<td>3</td>
<td>862</td>
<td>1</td>
<td>2</td>
<td>5.83732097</td>
</tr>
<tr>
<td>4</td>
<td>376</td>
<td>3</td>
<td>3</td>
<td>5.05192137</td>
</tr>
<tr>
<td>5</td>
<td>486</td>
<td>3</td>
<td>3</td>
<td>5.42901522</td>
</tr>
</tbody>
</table>

Related Topics

- Oracle Machine Learning for SQL User's Guide
40.1.5.30 GET_MODEL_DETAILS_NB Function

The GET_MODEL_DETAILS_NB function returns a set of rows that provide the details of a naive Bayes model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_nb(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN DM_NB_Details PIPELINED;
```

Parameters

Table 40-98 GET_MODEL_DETAILS_NB Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model</td>
</tr>
</tbody>
</table>

Return Values

Table 40-99 GET_MODEL_DETAILS_NB Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_NB_DETAILS</td>
<td>A set of rows of type DM_NB_Detail. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(target_attribute_name VARCHAR2(30), target_attribute_str_value VARCHAR2(4000), target_attribute_num_value NUMBER, prior_probability NUMBER, conditionals DM_CONDITIONALS)</td>
</tr>
</tbody>
</table>

The conditionals column of DM_NB_DETAIL returns a nested table of type DM_CONDITIONALS. The rows, of type DM_CONDITIONAL, have the following columns:

| (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), attribute_str_value VARCHAR2(4000), attribute_num_value NUMBER, conditional_probability NUMBER) |

Usage Notes

- The table function pipes out rows of type DM_NB_DETAILS. For information on machine learning data types and piped output from table functions, see "Data Types".
- When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.
Examples

The following query is from the sample program dmnbdemo.sql. It returns model details about the model NB_SH_Clas_sample. For information about the sample programs, see Oracle Machine Learning for SQL User's Guide.

The query creates labels from the bin boundary tables that were used to bin the training data. It replaces the attribute values with the labels. For numeric bins, the labels are $([lower\_boundary,upper\_boundary])$; for categorical bins, the label matches the value it represents. (This method of categorical label representation will only work for cases where one value corresponds to one bin.) The target was not binned.

WITH
  bin_label_view AS (
    SELECT col, bin, (DECODE(bin,'1','[','(') || lv || ',' || val || ']) label
    FROM (SELECT col,
      bin,
      LAST_VALUE(val) OVER (
        PARTITION BY col ORDER BY val
        ROWS BETWEEN UNBOUNDED PRECEDING AND 1 PRECEDING) lv,
      val
    FROM nb_sh_sample_num)
    UNION ALL
    SELECT col, bin, val label
    FROM nb_sh_sample_cat
  ),
  model_details AS (
    SELECT T.target_attribute_name tname,
    NVL(TO_CHAR(T.target_attribute_num_value,T.target_attribute_str_value)) tval,
    C.attribute_name pname, 
    NVL(L.label, NVL(C.attribute_str_value, C.attribute_num_value)) pval,
    T.prior_probability priorp, 
    C.conditional_probability condp 
    FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_NB('NB_SH_Clas_sample')) T, 
    TABLE(T.conditionals) C, 
    bin_label_view L
    WHERE C.attribute_name = L.col (+) AND 
    (NVL(C.attribute_str_value,C.attribute_num_value) = L.bin(+))
  )
SELECT tname, tval, pname, pval, priorp, condp 
FROM model_details
WHERE ROWNUM < 11;

<table>
<thead>
<tr>
<th>TNAME</th>
<th>TVAL</th>
<th>PNAME</th>
<th>PVAL</th>
<th>PRIORP</th>
<th>CONDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(24,30]</td>
<td>.6500</td>
<td>.1714</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(30,35]</td>
<td>.6500</td>
<td>.1509</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(35,40]</td>
<td>.6500</td>
<td>.1125</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(40,46]</td>
<td>.6500</td>
<td>.1134</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(46,53]</td>
<td>.6500</td>
<td>.1071</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>(53,90]</td>
<td>.6500</td>
<td>.1312</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>AGE</td>
<td>[17,24]</td>
<td>.6500</td>
<td>.2134</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>BOOKKEEPING_APPLICATION</td>
<td>0</td>
<td>.6500</td>
<td>.1500</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>BOOKKEEPING_APPLICATION</td>
<td>1</td>
<td>.6500</td>
<td>.3500</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td>BULK_PACK_DISKETTES</td>
<td>0</td>
<td>.6500</td>
<td>.3670</td>
</tr>
</tbody>
</table>
40.1.5.31 GET_MODELDETAILS_NMF Function

The GETMODELDETAILS_NMF function returns a set of rows that provide the details of a non-negative matrix factorization model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

Syntax

```
DBMS_DATA_MINING.get_model_details_nmf(
    model_name IN VARCHAR2,
    partition_name VARCHAR2 DEFAULT NULL)
RETURN DM_NMF_Feature_Set PIPELINED;
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model</td>
</tr>
</tbody>
</table>

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_NMF_FEATURE_SET</td>
<td>A set of rows of DM_NMF_FEATURE. The rows have the following columns: (feature_id NUMBER, mapped_feature_id VARCHAR2(4000), attribute_set DM_NMF_ATTRIBUTE_SET)</td>
</tr>
<tr>
<td></td>
<td>The attribute_set column of DM_NMF_FEATURE returns a nested table of type DM_NMF_ATTRIBUTE_SET. The rows, of type DM_NMF_ATTRIBUTE, have the following columns: (attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), attribute_value VARCHAR2(4000), coefficient NUMBER)</td>
</tr>
</tbody>
</table>

Usage Notes

- The table function pipes out rows of type DM_NMF_FEATURE_SET. For information on machine learning data types and piped output from table functions, see "Data Types".
- When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.
Examples

The following example returns model details for the feature extraction model NMF_SH_Sample.

```sql
SELECT * FROM ( 
SELECT F.feature_id, A.attribute_name, A.attribute_value, A.coefficient 
FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_NMF('NMF_SH_Sample')) F, 
    TABLE(F.attribute_set) A 
ORDER BY feature_id,attribute_name,attribute_value 
) WHERE ROWNUM < 11;

<table>
<thead>
<tr>
<th>FEATURE_ID</th>
<th>ATTRIBUTE_NAME</th>
<th>ATTRIBUTE_VALUE</th>
<th>COEFFICIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AFFINITY_CARD</td>
<td></td>
<td>.051208078859308</td>
</tr>
<tr>
<td>1</td>
<td>AGE</td>
<td></td>
<td>.0390513260041573</td>
</tr>
<tr>
<td>1</td>
<td>BOOKKEEPING APPLICATION</td>
<td></td>
<td>.0512734004239326</td>
</tr>
<tr>
<td>1</td>
<td>BULK_PACK_DISKETTES</td>
<td></td>
<td>.232471260895683</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>Argentina</td>
<td>.00766817464479959</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>Australia</td>
<td>.000157637881096675</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>Brazil</td>
<td>.0031409632415604</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>Canada</td>
<td>.00144213099311427</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>China</td>
<td>.000102279310968754</td>
</tr>
<tr>
<td>1</td>
<td>COUNTRY_NAME</td>
<td>Denmark</td>
<td>.000242424084307513</td>
</tr>
</tbody>
</table>
```

Related Topics

- [Oracle Machine Learning for SQL User’s Guide](#)

### 40.1.5.32 GET_MODEL_DETAILS_OC Function

The `GET_MODEL_DETAILS_GC` function returns a set of rows that provide the details of an O-cluster clustering model. The rows are an enumeration of the clustering patterns generated during the creation of the model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in [Oracle Machine Learning for SQL User’s Guide](#).

You can provide input to `GET_MODEL_DETAILS_GC` to request specific information about the model, thus improving the performance of the query. If you do not specify filtering parameters, then `GET_MODEL_DETAILS_OC` returns all the information about the model.

**Syntax**

```sql
DBMS_DATA_MINING.get_model_details_oc( 
    model_name VARCHAR2, 
    cluster_id NUMBER  DEFAULT NULL, 
    attribute VARCHAR2 DEFAULT NULL, 
    centroid NUMBER  DEFAULT 1, 
    histogram NUMBER  DEFAULT 1, 
    rules NUMBER  DEFAULT 2, 
    topn_attributes NUMBER  DEFAULT NULL, 
    partition_name VARCHAR2 DEFAULT NULL) 
RETURN dm_clusters PIPELINED;
```
Parameters

Table 40-102  GET_MODEL_DETAILS_OC Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>cluster_id</td>
<td>The ID of a cluster in the model. When a valid cluster ID is specified, only the details of this cluster are returned. Otherwise the details for all clusters are returned.</td>
</tr>
<tr>
<td>attribute</td>
<td>The name of an attribute. When a valid attribute name is specified, only the details of this attribute are returned. Otherwise, the details for all attributes are returned.</td>
</tr>
<tr>
<td>centroid</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td>histogram</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td>rules</td>
<td>This parameter accepts the following values:</td>
</tr>
<tr>
<td>topn_attributes</td>
<td>Restricts the number of attributes returned in the centroid, histogram, and rules objects. Only the n attributes with the highest confidence values in the rules are returned. If the number of attributes included in the rules is less than topn, then up to n additional attributes in alphabetical order are returned. If both the attribute and topn_attributes parameters are specified, then topn_attributes is ignored.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Usage Notes

1. For information about machine learning data types and return values for clustering algorithms piped output from table functions, see "Data Types".

2. When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

Examples

The following example returns model details for the clustering model OC_SH_Clus_sample.

For each cluster in this example, the split predicate indicates the attribute and the condition used to assign records to the cluster’s children during model build. It provides an important piece of information on how the population within a cluster can be divided up into two smaller clusters.

```sql
SELECT clu_id, attribute_name, op, s_value
FROM (SELECT a.id clu_id, sp.attribute_name, sp.conditional_operator op, sp.attribute_str_value s_value
      FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_OC(  
```
'OC_SH_Clus_sample')) a,
  TABLE(a.split_predicate) sp
ORDER BY a.id, op, s_value)
WHERE ROWNUM < 11;

<table>
<thead>
<tr>
<th>CLU_ID</th>
<th>ATTRIBUTE_NAME</th>
<th>OP</th>
<th>S_VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>?</td>
</tr>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Armed-F</td>
</tr>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Cleric.</td>
</tr>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Crafts</td>
</tr>
<tr>
<td>2</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Armed-F</td>
</tr>
<tr>
<td>2</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Cleric.</td>
</tr>
<tr>
<td>3</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Exec.</td>
</tr>
<tr>
<td>3</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Farming</td>
</tr>
<tr>
<td>3</td>
<td>OCCUPATION</td>
<td>IN</td>
<td>Handler</td>
</tr>
</tbody>
</table>

Related Topics
• Oracle Machine Learning for SQL User’s Guide

40.1.5.33 GET_MODEL_SETTINGS Function

The GET_MODEL_SETTINGS function returns the settings used to build the given model. Starting from Oracle Database 12c Release 2, this function is deprecated. See "Static Data Dictionary Views: ALL_ALL_TABLES to ALL_OUTLINES" in Oracle Database Reference.

Syntax

FUNCTION get_model_settings(model_name IN VARCHAR2)
  RETURN DM_Model_Settings PIPELINED;

Parameters

Table 40-103 GET_MODEL_SETTINGS Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
</tbody>
</table>

Return Values

Table 40-104 GET_MODEL_SETTINGS Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_MODEL_SETTINGS</td>
<td>A set of rows of type DM_MODEL_SETTINGS. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>DM_MODEL_SETTINGS TABLE OF SYS.DM_MODEL_SETTING Type</td>
</tr>
<tr>
<td></td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>SETTING_NAME</td>
</tr>
<tr>
<td></td>
<td>SETTING_VALUE</td>
</tr>
</tbody>
</table>
Usage Notes

1. This table function pipes out rows of type DM_MODEL_SETTINGS. For information on machine learning data types and piped output from table functions, see "DBMS_DATA_MINING Datatypes".

2. The setting names/values include both those specified by the user and any defaults assigned by the build process.

Examples

The following example returns model model settings for an example naive Bayes model.

<table>
<thead>
<tr>
<th>SETTING_NAME</th>
<th>SETTING_VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGO_NAME</td>
<td>ALGO_NAIVE_BAYES</td>
</tr>
<tr>
<td>PREP_AUTO</td>
<td>ON</td>
</tr>
<tr>
<td>ODMS_MAX_PARTITIONS</td>
<td>1000</td>
</tr>
<tr>
<td>NABS_SINGLETON_THRESHOLD</td>
<td>0</td>
</tr>
<tr>
<td>CLAS_WEIGHTS_BALANCED</td>
<td>OFF</td>
</tr>
<tr>
<td>NABS_PAIRWISE_THRESHOLD</td>
<td>0</td>
</tr>
<tr>
<td>ODMS_PARTITION_COLUMNS</td>
<td>GENDER,Y_BOX_GAMES</td>
</tr>
<tr>
<td>ODMS_MISSING_VALUE_TREATMENT</td>
<td>ODMS_MISSING_VALUE_AUTO</td>
</tr>
<tr>
<td>ODMS_SAMPLING</td>
<td>ODMS_SAMPLING_DISABLE</td>
</tr>
</tbody>
</table>

9 rows selected.

Related Topics

- Oracle Database Reference

40.1.5.34 GETMODEL_SIGNATURE Function

The GETMODEL_SIGNATURE function returns the list of columns from the build input table that were used by the build process to train the model. Starting from Oracle Database 12c Release 2, this function is deprecated. See "Static Data Dictionary Views: ALL_ALL_TABLES to ALL_OUTLINES" in Oracle Database Reference.

Syntax

FUNCTION get_model_signature (model_name IN VARCHAR2) 
RETURN DM_Model_Signature PIPELINED;

Parameters

Table 40-105 GETMODEL_SIGNATURE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
</tbody>
</table>
## Return Values

### Table 40-106 GET_MODEL_SIGNATURE Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_MODEL_SIGNATURE</td>
<td>A set of rows of type DM_MODEL_SIGNATURE. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>DM_MODEL_SIGNATURE TABLE OF SYSDM_MODEL_SIGNATURE_ATTRIBUTE</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>----------------------------</td>
</tr>
<tr>
<td></td>
<td>ATTRIBUTE_NAME</td>
</tr>
<tr>
<td></td>
<td>ATTRIBUTE_TYPE</td>
</tr>
</tbody>
</table>

#### Usage Notes

1. This table function pipes out rows of type DM_MODEL_SIGNATURE. For information on machine learning data types and piped output from table functions, see "DBMS_DATA_MINING Datatypes".

2. The signature names or types include only those attributes used by the build process.

#### Examples

The following example returns model settings for an example naive Bayes model.

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>ATTRIBUTE_TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ANNUAL_INCOME</td>
<td>NUMBER</td>
</tr>
<tr>
<td>AVERAGE_ITEMS_PURCHASED</td>
<td>NUMBER</td>
</tr>
<tr>
<td>BOOKKEEPING_APPLICATION</td>
<td>NUMBER</td>
</tr>
<tr>
<td>BULK_PACK_DISKETTES</td>
<td>NUMBER</td>
</tr>
<tr>
<td>BULK_PURCH_AVE_AMT</td>
<td>NUMBER</td>
</tr>
<tr>
<td>DISABLE_COOKIES</td>
<td>NUMBER</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>FLAT_PANEL_MONITOR</td>
<td>NUMBER</td>
</tr>
<tr>
<td>GENDER</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>HOME_THEATER_PACKAGE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>HOUSEHOLD_SIZE</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>MAILING_LIST</td>
<td>NUMBER</td>
</tr>
<tr>
<td>MARITAL_STATUS</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>NO_DIFFERENT_KIND_ITEMS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>OCCUPATION</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>OS_DOC_SET_KANJI</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PETS</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PRINTER_SUPPLIES</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PROMO_RESPOND</td>
<td>NUMBER</td>
</tr>
<tr>
<td>SHIPPING_ADDRESS_COUNTRY</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>SR_CITIZEN</td>
<td>NUMBER</td>
</tr>
<tr>
<td>TOP_REASON_FOR_SHOPPING</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>WKS_SINCE_LAST_PURCH</td>
<td>NUMBER</td>
</tr>
<tr>
<td>WORKCLASS</td>
<td>VARCHAR2</td>
</tr>
<tr>
<td>YRS_RESIDENCE</td>
<td>NUMBER</td>
</tr>
<tr>
<td>Y_BOX_GAMES</td>
<td>NUMBER</td>
</tr>
</tbody>
</table>
GET_MODEL_DETAILS_SVD Function

The GET_MODEL_DETAILS_SVD function returns a set of rows that provide the details of a singular value decomposition model. Oracle recommends to use model details view settings. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

Refer to Model Details View for Singular Value Decomposition.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_svd(
    model_name IN VARCHAR2,
    matrix_type IN VARCHAR2 DEFAULT NULL,
    partition_name VARCHAR2 DEFAULT NULL)
RETURN DM_SVD_MATRIX_Set PIPELINED;
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>matrix_type</td>
<td>Specifies which of the three SVD matrix types to return. Values are: U, S, V, and NULL. When matrix_type is null (default), all matrices are returned.</td>
</tr>
<tr>
<td></td>
<td>The U matrix is only computed when the SVDS_U_MATRIX_OUTPUT setting is enabled. It is not computed by default. If the model does not contain U matrices and you set matrix_type to U, an empty set of rows is returned. See Table 40-27.</td>
</tr>
<tr>
<td>partition_name</td>
<td>A partition in a partitioned model.</td>
</tr>
</tbody>
</table>
Return Values

Table 40-108  GET_MODELDETAILS_SVD Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_SVD_MATRIX_SET</td>
<td>A set of rows of type DM_SVD_MATRIX. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(matrix_type CHAR(1), feature_id NUMBER, mapped_feature_id VARCHAR2(4000), attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000),</td>
</tr>
<tr>
<td></td>
<td>case_id VARCHAR2(4000), value NUMBER, variance NUMBER, pct_cum_variance NUMBER)</td>
</tr>
</tbody>
</table>

See Usage Notes for details.

Usage Notes

1. This table function pipes out rows of type DM_SVD_MATRIX. For information on machine learning data types and piped output from table functions, see "Data Types".

The columns in each row returned by GET_MODELDETAILS_SVD are described as follows:

<table>
<thead>
<tr>
<th>Column in DM_SVD_MATRIX_SET</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>matrix_type</td>
<td>The type of matrix. Possible values are S, V, and U. This field is never null.</td>
</tr>
<tr>
<td>feature_id</td>
<td>The feature that the matrix entry refers to.</td>
</tr>
<tr>
<td>mapped_feature_id</td>
<td>A descriptive name for the feature.</td>
</tr>
<tr>
<td>attribute_name</td>
<td>Column name in the V matrix component bases. This field is null for the S and U matrices.</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>Subname in the V matrix component bases. This is relevant only in the case of a nested column. This field is null for the S and U matrices.</td>
</tr>
<tr>
<td>case_id</td>
<td>Unique identifier of the row in the build data described by the U matrix projection. This field is null for the S and V matrices.</td>
</tr>
<tr>
<td>value</td>
<td>The matrix entry value.</td>
</tr>
<tr>
<td>variance</td>
<td>The variance explained by a component. It is non-null only for S matrix entries. This column is non-null only for S matrix entries and for SVD models with setting dbms_data_mining.svds_scoring_mode set to dbms_data_mining.svds_scoring_pca and the build data is centered, either manually or because the setting dbms_data_mining.prep_auto is set to dbms_data_mining.prep_auto_on.</td>
</tr>
<tr>
<td>Column in DM_SVD_MATRIX_SET</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>pct_cum_variance</td>
<td>The percent cumulative variance explained by the components thus far. The components are ranked by the explained variance in descending order. This column is non-null only for S matrix entries and for SVD models with setting dbms_data_mining.svds_scoring_mode set to dbms_data_mining.svds_scoring_pca and the build data is centered, either manually or because the setting dbms_data_mining.prep_auto is set to dbms_data_mining.prep_auto_on.</td>
</tr>
</tbody>
</table>

2. The output of GET_MODEL_DETAILS is in sparse format. Zero values are not returned. Only the diagonal elements of the S matrix, the non-zero coefficients in the V matrix bases, and the non-zero U matrix projections are returned.

There is one exception: If the data row does not produce non-zero U Matrix projections, the case ID for that row is returned with NULL for the feature_id and value. This is done to avoid losing any records from the original data.

3. GET_MODEL_DETAILS functions preserve model transparency by automatically reversing the transformations applied during the build process. Thus the attributes returned in the model details are the original attributes (or a close approximation of the original attributes) used to build the model.

4. When the value is NULL for a partitioned model, an exception is thrown. When the value is not null, it must contain the preferred partition name.

Related Topics
• Oracle Machine Learning for SQL User’s Guide

40.1.5.36 GET_MODEL_DETAILS_SVM Function

The GET_MODEL_DETAILS_SVM function returns a set of rows that provide the details of a linear support vector machines (SVM) model. If invoked for nonlinear SVM, it returns ORA-40215. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views in Oracle Machine Learning for SQL User’s Guide.

In linear SVM models, only nonzero coefficients are stored. This reduces storage and speeds up model loading. As a result, if an attribute is missing in the coefficient list returned by GET_MODEL_DETAILS_SVM, then the coefficient of this attribute should be interpreted as zero.

Syntax

```sql
DBMS_DATA_MINING.get_model_details_svm(
    model_name   VARCHAR2,
    reverse_coef NUMBER DEFAULT 0,
    partition_name VARCHAR2 DEFAULT NULL)
RETURN DM_SVM_Linear_Coeff_Set PIPELINED;
```

```
Parameters

Table 40-109  GET_MODELDETAILS_SVM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>reverse_coef</td>
<td>Whether or not GET_MODELDETAILS_SVM should transform the attribute coefficients using the original attribute transformations.</td>
</tr>
<tr>
<td></td>
<td>When reverse_coef is set to 0 (default), GET_MODELDETAILS_SVM returns the coefficients directly from the model without applying transformations.</td>
</tr>
<tr>
<td></td>
<td>When reverse_coef is set to 1, GET_MODELDETAILS_SVM transforms the coefficients and bias by applying the normalization shifts and scales that were generated using automatic data preparation.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Return Values

Table 40-110  GET.MODELDETAILS.SVM Function Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_SVM_LINEAR_COEFF_SET</td>
<td>A set of rows of type DM_SVM_LINEAR_COEFF. The rows have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(class VARCHAR2(4000), attribute_set DM_SVM_ATTRIBUTE_SET)</td>
</tr>
<tr>
<td></td>
<td>The attribute_set column returns a nested table of type DM_SVM_ATTRIBUTE_SET. The rows, of type DM_SVM_ATTRIBUTE, have the following columns:</td>
</tr>
<tr>
<td></td>
<td>(attribute_name VARCHAR2(4000), attribute_subname VARCHAR2(4000), attribute_value VARCHAR2(4000), coefficient NUMBER)</td>
</tr>
</tbody>
</table>

Usage Notes

1. This table function pipes out rows of type DM_SVM_LINEAR_COEFF. For information on machine learning data types and piped output from table functions, see “Data Types”.

2. The class column of DM_SVM_LINEAR_COEFF contains classification target values. For SVM Regression models, class is null. For each classification target value, a set of coefficients is returned. For binary classification, one-class classification, and regression models, only a single set of coefficients is returned.

3. The attribute_value column in DM_SVM_ATTRIBUTE_SET is used for categorical attributes.
4. **GET_MODELDETAILS** functions preserve model transparency by automatically reversing the transformations applied during the build process. Thus the attributes returned in the model details are the original attributes (or a close approximation of the original attributes) used to build the model.

The coefficients are related to the transformed, not the original, attributes. When returned directly with the model details, the coefficients may not provide meaningful information. If you want **GET_MODELDETAILS_SVM** to transform the coefficients such that they relate to the original attributes, set the `reverse_coef` parameter to 1.

5. When the value is **NULL** for a partitioned model, an exception is thrown. When the value is not null, it must contain the desired partition name.

**Examples**

The following example returns model details for the SVM classification model `SVMC_Scal_Clas_sample`, which was created by the sample program `dmsvcdem.sql`. For information about the sample programs, see [Oracle Machine Learning for SQL User's Guide](#).

```sql
WITH mod_dtls AS (
    SELECT *
    FROM TABLE(DBMS_DATA_MINING.GET_MODELDETAILS_SVM('SVMC_Scal_Clas_sample'))
),
model_details AS (
    SELECT D.class, A.attribute_name, A.attribute_value, A.coefficient
    FROM mod_dtls D,
    TABLE(D.attribute_set) A
    ORDER BY D.class, ABS(A.coefficient) DESC
)
SELECT class, attribute_name aname, attribute_value aval, coefficient coeff
FROM model_details
WHERE ROWNUM < 11;
```

<table>
<thead>
<tr>
<th>CLASS</th>
<th>ANAME</th>
<th>AVAL</th>
<th>COEFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BOOKKEEPING_APPLICATION</td>
<td></td>
<td>-2.85</td>
</tr>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>Other</td>
<td>-.94</td>
</tr>
<tr>
<td>1</td>
<td>HOUSEHOLD_SIZE</td>
<td>4-5</td>
<td>.88</td>
</tr>
<tr>
<td>1</td>
<td>CUST_MARITAL_STATUS</td>
<td>Married</td>
<td>.82</td>
</tr>
<tr>
<td>1</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td>.76</td>
</tr>
<tr>
<td>1</td>
<td>HOUSEHOLD_SIZE</td>
<td>6-8</td>
<td>-.74</td>
</tr>
<tr>
<td>1</td>
<td>OCCUPATION</td>
<td>Exec.</td>
<td>.71</td>
</tr>
<tr>
<td>1</td>
<td>EDUCATION</td>
<td>11th</td>
<td>-.71</td>
</tr>
<tr>
<td>1</td>
<td>EDUCATION</td>
<td>Masters</td>
<td>.63</td>
</tr>
</tbody>
</table>

**Related Topics**

- [Oracle Machine Learning for SQL User's Guide](#)

### 40.1.5.37 GET_MODELDETAILS_XML Function

This function returns an XML object that provides the details of a decision tree model. Starting from Oracle Database 12c Release 2, this function is deprecated. Use model detail views instead.

See Model Detail Views for Decision Tree in [Oracle Machine Learning for SQL User's Guide](#).
Syntax

DBMS_DATA_MINING.get_model_details_xml(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL
) RETURN XMLType;

Parameters

Table 40-111 GET_MODEL_DETAILS_XML Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.].model_name. If you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model.</td>
</tr>
</tbody>
</table>

Return Values

Table 40-112 GET_MODEL_DETAILS_XML Function Return Value

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XMLTYPE</td>
<td>The XML definition for the decision tree model. See &quot;XMLTYPE&quot; for details.</td>
</tr>
<tr>
<td></td>
<td>The XML definition conforms to the Data Mining Group Predictive Model Markup Language (PMML) version 2.1 specification. The specification is available at <a href="https://www.dmg.org">https://www.dmg.org</a>.</td>
</tr>
<tr>
<td></td>
<td>If a nested attribute is used as a splitter, the attribute will appear in the XML document as field=&quot;&lt;column_name&gt;.&lt;subname&gt;&quot;, as opposed to the non-nested attributes which appear in the document as field=&quot;&lt;column_name&gt;&quot;.</td>
</tr>
</tbody>
</table>

Note:

The column names are surrounded by single quotes and a period separates the column_name from the subname.

The rest of the document style remains unchanged.

Usage Notes

Special characters that cannot be displayed by Oracle XML are converted to '#'.

Examples

The following statements in SQL*Plus return the details of the decision tree model dt_sh_clas_sample.

Note: The "&quot" characters you will see in the XML output are a result of SQL*Plus behavior. To display the XML in proper format, cut and past it into a file and open the file in a browser.
column dt_details format a320
SELECT
dbms_data_mining.get_model_details_xml('dt_sh_clas_sample')
AS DT_DETAILS
FROM dual;

DT_DETAILS
--------------------------------------------------------------------------------
<PMML version="2.1">
<Header copyright="Copyright (c) 2004, Oracle Corporation. All rights
reserved."/>
<DataDictionary numberOfFields="9">
<DataField name="AFFINITY_CARD" optype="categorical"/>
<DataField name="AGE" optype="continuous"/>
<DataField name="BOOKKEEPING_APPLICATION" optype="continuous"/>
<DataField name="CUST_MARITAL_STATUS" optype="categorical"/>
<DataField name="EDUCATION" optype="categorical"/>
<DataField name="HOUSEHOLD_SIZE" optype="categorical"/>
<DataField name="OCCUPATION" optype="categorical"/>
<DataField name="YRS_RESIDENCE" optype="continuous"/>
<DataField name="Y_BOX_GAMES" optype="continuous"/>
</DataDictionary>
<TreeModel modelName="DT_SH_CLAS_SAMPLE" functionName="classification"
splitCharacteristic="binarySplit">
<Extension name="buildSettings">
<Setting name="TREE_IMPURITY_METRIC" value="TREE_IMPURITY_GINI"/>
<Setting name="TREE_TERM_MAX_DEPTH" value="7"/>
<Setting name="TREE_TERM_MINPCT_NODE" value=".05"/>
<Setting name="TREE_TERM_MINPCT_SPLIT" value=".1"/>
<Setting name="TREE_TERM_MINREC_NODE" value="10"/>
<Setting name="TREE_TERM_MINREC_SPLIT" value="20"/>
<costMatrix>
<costElement>
<actualValue>0</actualValue>
<predictedValue>0</predictedValue>
<cost>0</cost>
</costElement>
<costElement>
<actualValue>0</actualValue>
<predictedValue>1</predictedValue>
<cost>1</cost>
</costElement>
<costElement>
<actualValue>1</actualValue>
<predictedValue>0</predictedValue>
<cost>8</cost>
</costElement>
<costElement>
<actualValue>1</actualValue>
<predictedValue>1</predictedValue>
<cost>0</cost>
</costElement>
</costMatrix>
</Extension>
</TreeModel>
</PMML>
40.1.5.38 GET_MODEL_TRANSFORMATIONS Function

This function returns the transformation expressions embedded in the specified model. Starting from Oracle Database 12c Release 2, this function is deprecated. See “Static Data Dictionary Views: ALL_ALL_TABLES to ALL_OUTLINES” in Oracle Database Reference.

All GET * interfaces are replaced by model views, and Oracle recommends that users reference the model views to retrieve the relevant information. The GET_MODEL_TRANSFORMATIONS function is replaced by the following:

- USER(/DBA/ALL)_MINING_MODEL_XFORMS: provides the user-embedded transformations
- DM$VX prefixed model view: provides text feature extraction information
- D$VN prefixed mode view: provides normalization and missing value information
- DM$VB: provides binning information

Syntax

```sql
DBMS_DATA_MINING.get_model_transformations(
    model_name IN VARCHAR2,
    partition_name IN VARCHAR2 DEFAULT NULL)
RETURN DM_Transforms PIPELINED;
```
Parameters

Table 40-113  GET_MODEL_TRANSFORMATIONS Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Indicates the name of the model in the form [schema_name.]model_name. If</td>
</tr>
<tr>
<td></td>
<td>you do not specify a schema, then your own schema is used.</td>
</tr>
<tr>
<td>partition_name</td>
<td>Specifies a partition in a partitioned model</td>
</tr>
</tbody>
</table>

Return Values

Table 40-114  GET_MODEL_TRANSFORMATIONS Function Return Value

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM_TRANSFORMS</td>
<td>The transformation expressions embedded in model_name.</td>
</tr>
<tr>
<td></td>
<td>The DM_TRANSFORMS type is a table of DM_TRANSFORM objects. Each</td>
</tr>
<tr>
<td></td>
<td>DM_TRANSFORM has these fields:</td>
</tr>
<tr>
<td>attribute_name</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>expression</td>
<td>CLOB</td>
</tr>
<tr>
<td>reverse_expression</td>
<td>CLOB</td>
</tr>
</tbody>
</table>

Usage Notes

When Automatic Data Preparation (ADP) is enabled, both automatic and user-defined transformations may be associated with an attribute. In this case, the user-defined transformations are evaluated before the automatic transformations.

When invoked for a partitioned model, the partition_name parameter must be specified.

Examples

In this example, several columns in the SH.CUSTOMERS table are used to create a naive Bayes model. A transformation expression is specified for one of the columns. The model does not use ADP.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_income_level,cust_credit_limit
    FROM sh.customers;

describe mining_data
Name  | Null? | Type |
-------|------|------|
CUST_ID | NOT NULL | NUMBER |
CUST_YEAR_OF_BIRTH | NOT NULL | NUMBER(4) |
CUST_INCOME_LEVEL | | VARCHAR2(30) |
CUST_CREDIT_LIMIT | | NUMBER |

CREATE TABLE settings_nb(
    setting_name  VARCHAR2(30),
    setting_value VARCHAR2(30));
BEGIN
    INSERT INTO settings_nb (setting_name, setting_value) VALUES
```
(dbms_data_mining.algo_name, dbms_data_mining.algo_naive_bayes);

INSERT INTO settings_nb (setting_name, setting_value) VALUES
  (dbms_data_mining.prep_auto, dbms_data_mining.prep_auto_off);

COMMIT;

END;
/

DECLARE
  mining_data_xforms dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.SET_TRANSFORM (
    xform_list => mining_data_xforms,
    attribute_name => 'cust_year_of_birth',
    attribute_subname => null,
    expression => 'cust_year_of_birth + 10',
    reverse_expression => 'cust_year_of_birth - 10');
  dbms_data_mining.CREATE_MODEL (
    model_name => 'new_model',
    mining_function => dbms_data_mining.classification,
    data_table_name => 'mining_data',
    case_id_column_name => 'cust_id',
    target_column_name => 'cust_income_level',
    settings_table_name => 'settings_nb',
    data_schema_name => null,
    settings_schema_name => null,
    xform_list => mining_data_xforms );
END;
/

SELECT attribute_name, TO_CHAR(expression), TO_CHAR(reverse_expression)
  FROM TABLE (dbms_data_mining.GET_MODEL_TRANSFORMATIONS('new_model'));

ATTRIBUTE_NAME      TO_CHAR(EXPRESSION)       TO_CHAR(REVERSE_EXPRESSION)
------------------  ------------------------  -----------------------------
CUST_YEAR_OF_BIRTH  cust_year_of_birth + 10   cust_year_of_birth - 10

Related Topics
• Oracle Database Reference

40.1.5.39 GET_TRANSFORM_LIST Procedure

This procedure converts transformation expressions specified as DM_TRANSFORMS to a
transformation list (TRANSFORM_LIST) that can be used in creating a model.
DM_TRANSFORMS is returned by the GET_MODEL_TRANSFORMATIONS function.

You can also use routines in the DBMS_DATA_MINING_TRANSFORM package to construct a
transformation list.

See Also:
  “About Transformation Lists” in DBMS_DATA_MINING_TRANSFORM
  "GET_MODEL_TRANSFORMATIONS Function"
  "CREATE_MODEL Procedure"
Syntax

```sql
DBMS_DATA_MINING.GET_TRANSFORM_LIST (
    xform_list           OUT NOCOPY TRANSFORM_LIST,
    model_xforms         IN  DM_TRANSFORMS);
```

Parameters

**Table 40-115  GET_TRANSFORM_LIST Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xform_list</td>
<td>A list of transformation specifications that can be embedded in a model. Accepted as a parameter to the <code>CREATE_MODEL</code> Procedure. The <code>TRANSFORM_LIST</code> type is a table of <code>TRANSFORM_REC</code> objects. Each <code>TRANSFORM_REC</code> has these fields:</td>
</tr>
<tr>
<td></td>
<td>attribute_name      VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>attribute_subname   VARCHAR2(4000)</td>
</tr>
<tr>
<td></td>
<td>expression          EXPRESSION_REC</td>
</tr>
<tr>
<td></td>
<td>reverse_expression  EXPRESSION_REC</td>
</tr>
<tr>
<td></td>
<td>attribute_spec      VARCHAR2(4000)</td>
</tr>
<tr>
<td>model_xforms</td>
<td>A list of embedded transformation expressions returned by the <code>GET_MODEL_TRANSFORMATIONS</code> Function for a specific model. The <code>DM_TRANSFORMS</code> type is a table of <code>DM_TRANSFORM</code> objects. Each <code>DM_TRANSFORM</code> has these fields:</td>
</tr>
<tr>
<td></td>
<td>attribute_name      VARCHAR2(4000)</td>
</tr>
<tr>
<td></td>
<td>attribute_subname   VARCHAR2(4000)</td>
</tr>
<tr>
<td></td>
<td>expression          CLOB</td>
</tr>
<tr>
<td></td>
<td>reverse_expression  CLOB</td>
</tr>
</tbody>
</table>

For details about the `TRANSFORM_LIST` collection type, see Table 40-122.

Examples

In this example, a model `mod1` is trained using several columns in the `SH.CUSTOMERS` table. The model uses ADP, which automatically bins one of the columns.

A second model `mod2` is trained on the same data without ADP, but it uses a transformation list that was obtained from `mod1`. As a result, both `mod1` and `mod2` have the same embedded transformation expression.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_income_level, cust_credit_limit
    FROM sh.customers;

describe mining_data
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
CUST_ID                                   NOT NULL NUMBER
CUST_YEAR_OF_BIRTH                        NOT NULL NUMBER(4)
CUST_INCOME_LEVEL                                  VARCHAR2(30)
CUST_CREDIT_LIMIT                                  NUMBER

CREATE TABLE setmod1(setting_name  VARCHAR2(30),setting_value VARCHAR2(30));
BEGIN
```
INSERT INTO setmod1 VALUES (dbms_data_mining.algo_name, dbms_data_mining.algo_naive_bayes);
INSERT INTO setmod1 VALUES (dbms_data_mining.prep_auto, dbms_data_mining.prep_auto_on);

dbms_data_mining.CREATE_MODEL (
    model_name            => 'mod1',
    mining_function       => dbms_data_mining.classification,
    data_table_name       => 'mining_data',
    case_id_column_name   => 'cust_id',
    target_column_name    => 'cust_income_level',
    settings_table_name   => 'setmod1');

COMMIT;
END;
/

CREATE TABLE setmod2(setting_name  VARCHAR2(30),setting_value VARCHAR2(30));
BEGIN
    INSERT INTO setmod2
    VALUES (dbms_data_mining.algo_name, dbms_data_mining.algo_naive_bayes);
    COMMIT;
END;
/

DECLARE
    v_xform_list       dbms_data_mining_transform.TRANSFORM_LIST;
    dmxf               DM_TRANSFORMS;
BEGIN
    EXECUTE IMMEDIATE
        'SELECT dm_transform(attribute_name, attribute_subname,expression, reverse_expression)
         FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS (''mod1''))'
        BULK COLLECT INTO dmxf;
    dbms_data_mining.GET_TRANSFORM_LIST (
        xform_list             =>  v_xform_list,
        model_xforms           =>  dmxf);
    dbms_data_mining.CREATE_MODEL(
        model_name            => 'mod2',
        mining_function       => dbms_data_mining.classification,
        data_table_name       => 'mining_data',
        case_id_column_name   => 'cust_id',
        target_column_name    => 'cust_income_level',
        settings_table_name   => 'setmod2',
        xform_list            =>  v_xform_list);
END;
/

-- Transformation expression embedded in mod1
SELECT TO_CHAR(expression) FROM TABLE (dbms_data_mining.GET_MODEL_TRANSFORMATIONS('mod1'));

TO_CHAR(EXPRESSION)
-------------------------------------------
CASE WHEN "CUST_YEAR_OF_BIRTH"<1915 THEN 0 WHEN "CUST_YEAR_OF_BIRTH"<=1915 THEN 0 WHEN "CUST_YEAR_OF_BIRTH"<=1920.5 THEN 1 WHEN "CUST_YEAR_OF_BIRTH"<=1924.5 THEN 2 . . 5 THEN 29 WHEN "CUST_YEAR_OF_BIRTH" IS NOT NULL THEN 30 END

-- Transformation expression embedded in mod2
SELECT TO_CHAR(expression) FROM TABLE (dbms_data_mining.GET_MODEL_TRANSFORMATIONS('mod2'));

TO_CHAR(EXPRESSION)
-------------------------------------------
CASE WHEN "CUST_YEAR_OF_BIRTH"<1915 THEN 0 WHEN "CUST_YEAR_OF_BIRTH"<=1915 THEN 0 WHEN "CUST_YEAR_OF_BIRTH"<=1920.5 THEN 1 WHEN "CUST_YEAR_OF_BIRTH"<=1924.5 THEN 2 .
.5 THEN 29 WHEN "CUST_YEAR_OF_BIRTH" IS NOT NULL THEN 30 END

-- Reverse transformation expression embedded in mod1
SELECT TO_CHAR(reverse_expression)FROM TABLE (dbms_data_mining.GET_MODEL_TRANSFORMATIONS('mod1'));

TO_CHAR(REVERSE_EXPRESSION)
--------------------------------------------------------------------------------
DECODE("CUST_YEAR_OF_BIRTH",0,'( ; 1915), [1915; 1915]',1,'(1915; 1920.5]',2,'(1920.5; 1924.5]',3,'(1924.5; 1928.5]',4,'(1928.5; 1932.5]',5,'(1932.5; 1936.5]',6
.
.
8,'(1987.5; 1988.5]',29,'(1988.5; 1989.5]',30,'(1989.5; )',NULL,'NULL')

-- Reverse transformation expression embedded in mod2

SELECT TO_CHAR(reverse_expression) FROM TABLE (dbms_data_mining.GET_MODEL_TRANSFORMATIONS('mod2'));

TO_CHAR(REVERSE_EXPRESSION)
--------------------------------------------------------------------------------
DECODE("CUST_YEAR_OF_BIRTH",0,'( ; 1915), [1915; 1915]',1,'(1915; 1920.5]',2,'(1920.5; 1924.5]',3,'(1924.5; 1928.5]',4,'(1928.5; 1932.5]',5,'(1932.5; 1936.5]',6
.
.
8,'(1987.5; 1988.5]',29,'(1988.5; 1989.5]',30,'(1989.5; )',NULL,'NULL')

40.1.5.40 IMPORT_MODEL Procedure

This procedure imports one or more machine learning models. The procedure is overloaded. You can call it to import machine learning models from a dump file set, or you can call it to import a single machine learning model from a PMML document.

Import from a dump file set

You can import machine learning models from a dump file set that was created by the EXPORT_MODEL Procedure. IMPORT_MODEL and EXPORT_MODEL use Oracle Data Pump technology to export to and import from a dump file set.

When Oracle Data Pump is used directly to export/import an entire schema or database, the machine learning models in the schema or database are included. EXPORT_MODEL and IMPORT_MODEL export/import machine learning models only.

Import from PMML

You can import a machine learning model represented in Predictive Model Markup Language (PMML). The model must be of type RegressionModel, either linear regression or binary logistic regression.

PMML is an XML-based standard specified by the Data Mining Group (https://www.dmg.org). Applications that are PMML-compliant can deploy PMML-compliant models that were created by any vendor. Oracle Machine Learning for SQL supports the core features of PMML 3.1 for regression models.
Syntax

Imports a machine learning model from a dump file set:

```
DBMS_DATA_MINING.IMPORT_MODEL (  
    filename   IN  VARCHAR2,  
    directory  IN  VARCHAR2,  
    model_filter IN  VARCHAR2 DEFAULT NULL,  
    operation   IN  VARCHAR2 DEFAULT NULL,  
    remote_link IN  VARCHAR2 DEFAULT NULL,  
    jobname     IN  VARCHAR2 DEFAULT NULL,  
    schema_remap IN  VARCHAR2 DEFAULT NULL,  
    tablespace_remap IN  VARCHAR2 DEFAULT NULL);
```

Imports a machine learning model from a PMML document:

```
DBMS_DATA_MINING.IMPORT_MODEL (  
    model_name IN  VARCHAR2,  
    pmmldoc    IN  XMLTYPE  
    strict_check IN  BOOLEAN DEFAULT FALSE);
```

Parameters

Table 40-116 IMPORT_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>Name of the dump file set from which the models should be imported. The dump file set must have been created by the \texttt{EXPORT_MODEL} procedure or the expdp export utility of Oracle Data Pump. The dump file set can contain one or more files. (Refer to &quot;\texttt{EXPORT_MODEL} Procedure&quot; for details.) If the dump file set contains multiple files, you can specify 'filename%U' instead of listing them. For example, if your dump file set contains 3 files, archive01.dmp, archive02.dmp, and archive03.dmp, you can import them by specifying 'archive%U'.</td>
</tr>
<tr>
<td>directory</td>
<td>Name of a pre-defined directory object that specifies where the dump file set is located. Both the exporting and the importing user must have read/write access to the directory object and to the file system directory that it identifies. Note: The target database must have also have read/write access to the file system directory.</td>
</tr>
</tbody>
</table>
### Table 40-116 (Cont.) IMPORT_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_filter</td>
<td>Optional parameter that specifies one or more models to import. If you do not specify a value for model_filter, all models in the dump file set are imported. You can also specify NULL (the default) or 'ALL' to import all models. The value of model_filter can be one or more model names. The following are valid filters:  'mymodel1'  'name IN ('mymodel2','mymodel3')'  The first causes IMPORT_MODEL to import a single model named mymodel1. The second causes IMPORT_MODEL to import two models, mymodel2 and mymodel3.</td>
</tr>
<tr>
<td>operation</td>
<td>Optional parameter that specifies whether to import the models or the SQL statements that create the models. By default, the models are imported. You can specify either of the following values for operation:  · 'IMPORT' — Import the models (Default)  · 'SQL_FILE'— Write the SQL DDL for creating the models to a text file. The text file is named job_name.sql and is located in the dump set directory.</td>
</tr>
<tr>
<td>remote_link</td>
<td>Optional parameter that specifies the name of a database link to a remote system. The default value is NULL. A database link is a schema object in a local database that enables access to objects in a remote database. When you specify a value for remote_link, you can import models into the local database from the remote database. The import is fileless; no dump file is involved. The IMP_FULL_DATABASE role is required for importing the remote models. The EXP_FULL_DATABASE privilege, the CREATE DATABASE LINK privilege, and other privileges may also be required. (See Example 2.)</td>
</tr>
<tr>
<td>jobname</td>
<td>Optional parameter that specifies the name of the import job. By default, the name has the form username_imp_nnnn, where nnnn is a number. For example, a job name in the SCOTT schema might be SCOTT_imp_134. If you specify a job name, it must be unique within the schema. The maximum length of the job name is 30 characters. A log file for the import job, named jobname.log, is created in the same directory as the dump file set.</td>
</tr>
<tr>
<td>schema_remap</td>
<td>Optional parameter for importing into a different schema. By default, models are exported and imported within the same schema. If the dump file set belongs to a different schema, you must specify a schema mapping in the form export_user:import_user. For example, you would specify 'SCOTT:MARY' to import a model exported by SCOTT into the MARY schema. Note: In some cases, you may need to have the IMP_FULL_DATABASE privilege or the SYS role to import a model from a different schema.</td>
</tr>
</tbody>
</table>
### Table 40-116  (Cont.) IMPORT_MODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablespace_remap</td>
<td>Optional parameter for importing into a different tablespace. By default, models are exported and imported within the same tablespace.</td>
</tr>
<tr>
<td></td>
<td>If the dump file set belongs to a different tablespace, you must specify a tablespace mapping in the form export_tablespace:import_tablespace. For example, you would specify 'TBLSPC01:TBLSPC02' to import a model that was exported from tablespace TBLSPC01 into tablespace TBLSPC02.</td>
</tr>
<tr>
<td></td>
<td>Note: In some cases, you may need to have the IMP_FULL_DATABASE privilege or the SYS role to import a model from a different tablespace.</td>
</tr>
<tr>
<td>model_name</td>
<td>Name for the new model that will be created in the database as a result of an import from PMML. The name must be unique within the user's schema.</td>
</tr>
<tr>
<td>pmmldoc</td>
<td>The PMML document representing the model to be imported. The PMML document has an XMLTYPE object type. See &quot;XML TYPE&quot; for details.</td>
</tr>
<tr>
<td>strict_check</td>
<td>Whether or not an error occurs when the PMML document contains sections that are not part of core PMML (for example, Output or Targets). OML4SQL supports only core PMML; any non-core features may affect the scoring representation.</td>
</tr>
<tr>
<td></td>
<td>If the PMML does not strictly conform to core PMML and strict_check is set to TRUE, then IMPORT_MODEL returns an error. If strict_check is FALSE (the default), then the error is suppressed. The model may be imported and scored.</td>
</tr>
</tbody>
</table>

### Examples

1. This example shows a model being exported and imported within the schema oml_user2. Then the same model is imported into the oml_user3 schema. The oml_user3 user has the IMP_FULL_DATABASE privilege. The oml_user2 user has been assigned the USER2 tablespace; oml_user3 has been assigned the USER3 tablespace.

   SQL> connect oml_user2
   Enter password: oml_user2_password
   Connected.

   SQL> select model_name from user_mining_models;

   MODEL_NAME
   ------------------------
   NMF_SH_SAMPLE
   SVMO_SH_CLAS_SAMPLE
   SVMR_SH_REGR_SAMPLE

   -- export the model called NMF_SH_SAMPLE to a dump file in same schema
   SQL> execute dbms_data_mining.export_model (  
   file_name => 'NMF_SH_SAMPLE_out',  
   directory => 'DATA_PUMP_DIR',  
   model_filter => 'name = 'NMF_SH_SAMPLE'');  

   -- import the model back into the same schema
   SQL> execute dbms_data_mining.import_model (  
   file_name => 'NMF_SH_SAMPLE_out01.dmp',  
   directory => 'DATA_PUMP_DIR',  

model_filter => 'name = 'NMF_SH_SAMPLE'');

-- connect as different user
-- import same model into that schema
SQL> connect oml_user3
Enter password: oml_user3_password
Connected.
SQL> EXECUTE DBMS_DATA_MINING.IMPORT_MODEL (  
  filename => 'NMF_SH_SAMPLE_out01.dmp',  
  directory => 'DATA_PUMP_DIR',  
  model_filter => 'name = 'NMF_SH_SAMPLE''',  
  operation =>'IMPORT',  
  remote_link => NULL,  
  jobname => 'nmf_imp_job',  
  schema_remap => 'oml_user2:oml_user3',  
  tablespace_remap => 'USER2:USER3');

The following example shows user MARY importing all models from a dump file, model_exp_001.dmp, which was created by user SCOTT. User MARY has been assigned a tablespace named USER2; user SCOTT was assigned the tablespace USERS when the models were exported into the dump file model_exp_001.dmp. The dump file is located in the file system directory mapped to a directory object called DM_DUMP. If user MARY does not have IMP_FULL_DATABASE privileges, IMPORT_MODEL will raise an error.

-- import all models
DECLARE
  file_name  VARCHAR2(40);
BEGIN
  file_name := 'model_exp_001.dmp';
  DBMS_DATA_MINING.IMPORT_MODEL(  
    filename=> 'file_name',  
    directory=>'DM_DUMP',  
    schema_remap=>'SCOTT:MARY',  
    tablespace_remap=>'USERS:USER2');
  DBMS_OUTPUT.PUT_LINE(  
    'DBMS_DATA_MINING.IMPORT_MODEL of all models from SCOTT done!');
END;
/

2. This example shows how the user xuser could import the model oml_user.r1mod from a remote database. The SQL*Net connection alias for the remote database is R1DB. The user xuser is assigned the SYSAUX tablespace; the user oml_user is assigned the TBS_1 tablespace.

CONNECT / AS SYSDBA;
GRANT CREATE DATABASE LINK TO xuser;
GRANT imp_full_database TO xuser;
CONNECT xuser/xuserpassword
CREATE DATABASE LINK oml_user_link
    CONNECT TO oml_user IDENTIFIED BY oml_userpassword USING 'R1DB';
EXEC dbms_data_mining.import_model (  
  NULL,  
  'oml_user_DIR',  
  'R1MOD',  
  remote_link => 'oml_user_LINK', schema_remap => 'oml_user:XUSER',  
  tablespace_remap => 'TBS_1:SYSAUX' );

SELECT name FROM dm_user_models;

NAME
3. This example shows how a PMML document called \texttt{SamplePMML1.xml} could be imported from a location referenced by directory object \texttt{PMMLDIR} into the schema of the current user. The imported model will be called \texttt{PMMLMODEL1}.

```sql
BEGIN
   dbms_data_mining.import_model ('PMMLMODEL1',
   XMLType (bfilename ('PMMLDIR', 'SamplePMML1.xml'),
   nls_charset_id ('AL32UTF8')));
END;
```

### Related Topics

- *Oracle Database PL/SQL Packages and Types Reference*

### 40.1.5.41 IMPORT_SERMODEL Procedure

This procedure imports the serialized format of the model back into a database.

The import routine takes the serialized content in the \texttt{BLOB} and the name of the model to be created with the content. This import does not create model views or tables that are needed for querying model details. The import procedure only provides the ability to score the model.

**Syntax**

```sql
DBMS_DATA_MINING.IMPORT_SERMODEL (  
   model_data     IN BLOB,
   model_name     IN VARCHAR2,);
```

**Parameters**

**Table 40-117**  IMPORT_SERMODEL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_data</td>
<td>Provides model data in \texttt{BLOB} format.</td>
</tr>
<tr>
<td>model_name</td>
<td>Name of the machine learning model in the form \texttt{[schema_name].model_name}. If you do not specify a schema, then your own schema is used.</td>
</tr>
</tbody>
</table>

**Examples**

The following statement imports the serialized format of the models.

```sql
declare
   v_blob blob;
BEGIN
   dbms_lob.createtemporary(v_blob, FALSE);
   -- fill in v_blob from somewhere (e.g., bfile, etc.)
   dbms_data_mining.import_sermodel(v_blob, 'MY_MODEL');
   dbms_lob.freetemporary(v_blob);
```
Related Topics

- **EXPORT_SERMODEL Procedure**
  This procedure exports the model in a serialized format so that they can be moved to another platform for scoring.

## 40.1.5.42 JSON Schema for R Extensible Algorithm

Provides some flexibility when creating a new JSON object following the JSON schema.

**Usage Note**

Some flexibility when creating a new JSON object is as follows:

- Partial registration is allowed. For example, the detail function can be missing.
- Different orders are allowed. For example, the detail function can be written before the build function or after it.

**Example 40-1 JSON Schema**

JSON schema 1.1 for R extensible algorithm:

```json
{
   "type": "object",
   "properties": {
      "algo_name_display": { "type": "object",
                               "properties": {
                                  "language": { "type": "string",
                                                "enum": ["English", "Spanish", "French"],
                                                "default": "English"},
                               "name": { "type": "string"}
                           },
      "function_language": { "type": "string" },
      "mining_function": { "type": "array",
                           "items": [ { "type": "object",
                                  "properties": { "mining_function_name": { "type": "string"},
                                                     "build_function": { ...
```
Example 40-2   JSON object example

The following is an JSON object example that must be passed to the registration procedure:

```json
{  "algo_name_display" : {"English", "t1"},
   "function_language" : "R",
   "mining_function" : {
      "mining_function_name" : "CLASSIFICATION",
      "build_function" : {"function_body": "function(dat, formula, family)\n{
set.seed(1234);                     mod <- glm(formula =
formula, data=dat,                 family=
eval(parse(text=family)));            mod"},
      "score_function" : { "function_body": "function(mod, dat) {
res <- predict(mod, newdata = dat,
type='"response"
                      '});
res2=data.frame(1-res, res); res2\n)"})
   },
   "algo_setting" : [{"name" : "dbms_data_mining.odms_missing_value_treatment",
      "name_display" : {"English",} }}
}
```


40.1.5.43 REGISTER_ALGORITHM Procedure

Use this function to register a new algorithm by providing the algorithm name, machine learning function, and all other algorithm metadata.

Syntax

```
DBMS_DATA_MINING.REGISTER_ALGORITHM (
    algorithm_name           IN VARCHAR2,
    algorithm_metadata       IN CLOB,
    algorithm_description    IN VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-118  REGISTER_ALGORITHM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>algorithm_name</td>
<td>Name of the algorithm.</td>
</tr>
<tr>
<td>algorithm_metadata</td>
<td>Metadata of the algorithm.</td>
</tr>
<tr>
<td>algorithm_description</td>
<td>Description of the algorithm.</td>
</tr>
</tbody>
</table>

Usage Notes

The registration procedure performs the following:
• Checks whether `algorithm_metadata` has correct JSON syntax.
• Checks whether the input JSON object follows the predefined JSON schema.
• Checks whether current user has `RQADMIN` privilege.
• Checks duplicate algorithms so that the same algorithm is not registered twice.
• Checks for missing entries. For example, algorithm name, algorithm type, metadata, and build function.

Register Algorithms After the JSON Object Is Created

SQL users can register new algorithms by creating a JSON object following the JSON schema and passing it to the `REGISTER_ALGORITHM` procedure.

```sql
BEGIN
    DBMS_DATA_MINING.register_algorithm(
        algorithm_name => 't1',
        algorithm_metadata =>
            '{
                "function_language" : "R",
                "mining_function"
                    : {
                        "mining_function_name" : "CLASSIFICATION",
                        "build_function" : {
                            "function_body": "function(dat, formula, family) { set.seed(1234);
                                        mod <- glm(formula =
                                        family=eval(parse(text=family)));
                                        mod)"},
                            "score_function" : {
                                "function_body": "function(mod, dat) {
                                                res <- predict(mod,
                                                newdata = dat, type='response');
                                                res2=data.frame(1-res,
                                                res); res2}"}
                        },
            
            algorithm_description  => 't1');
END;
/
```

40.1.5.44 RANK_APPLY Procedure

This procedure ranks the results of an `APPLY` operation based on a top-N specification for predictive and descriptive model results.

For classification models, you can provide a cost matrix as input, and obtain the ranked results with costs applied to the predictions.

**Syntax**

```sql
DBMS_DATA_MINING.RANK_APPLY ( 
    apply_result_table_name        IN VARCHAR2,
    case_id_column_name            IN VARCHAR2,
    score_column_name              IN VARCHAR2,
    score_criterion_column_name    IN VARCHAR2,
    ranked_apply_table_name        IN VARCHAR2,
    top_N                          IN NUMBER (38) DEFAULT 1,
    cost_matrix_table_name         IN VARCHAR2 DEFAULT NULL,
```
Parameters

Table 40-119  RANK_APPLY Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>apply_result_table_name</td>
<td>Name of the table or view containing the results of an APPLY operation on the test data set (see Usage Notes)</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Name of the case identifier column. This must be the same as the one used for generating APPLY results.</td>
</tr>
<tr>
<td>score_column_name</td>
<td>Name of the prediction column in the apply results table</td>
</tr>
<tr>
<td>score_criterion_column_name</td>
<td>Name of the probability column in the apply results table</td>
</tr>
<tr>
<td>ranked_apply_result_table_name</td>
<td>Name of the table containing the ranked apply results</td>
</tr>
<tr>
<td>top_N</td>
<td>Top N predictions to be considered from the APPLY results for precision recall computation</td>
</tr>
<tr>
<td>cost_matrix_table_name</td>
<td>Name of the cost matrix table</td>
</tr>
<tr>
<td>apply_result_schema_name</td>
<td>Name of the schema hosting the APPLY results table</td>
</tr>
<tr>
<td>cost_matrix_schema_name</td>
<td>Name of the schema hosting the cost matrix table</td>
</tr>
</tbody>
</table>

Usage Notes

You can use RANK_APPLY to generate ranked apply results, based on a top-N filter and also with application of cost for predictions, if the model was built with costs.

The behavior of RANK_APPLY is similar to that of APPLY with respect to other DDL-like operations such as CREATE_MODEL, DROP_MODEL, and RENAME_MODEL. The procedure does not depend on the model; the only input of relevance is the apply results generated in a fixed schema table from APPLY.

The main intended use of RANK_APPLY is for the generation of the final APPLY results against the scoring data in a production setting. You can apply the model against test data using APPLY, compute various test metrics against various cost matrix tables, and use the candidate cost matrix for RANK_APPLY.

The schema for the apply results from each of the supported algorithms is listed in subsequent sections. The case_id column will be the same case identifier column as that of the apply results.

Classification Models — NB and SVM

For numerical targets, the ranked results table will have the definition as shown:

```sql
(case_id VARCHAR2/NUMBER,
prediction NUMBER,
probability NUMBER,
cost NUMBER,
rank INTEGER)
```

For categorical targets, the ranked results table will have the following definition:
Clustering Using \textit{k}-Means or O-Cluster

Clustering is an unsupervised machine learning function, and hence there are no targets. The results of an \texttt{APPLY} operation contains simply the cluster identifier corresponding to a case, and the associated probability. Cost matrix is not considered here. The ranked results table will have the definition as shown, and contains the cluster ids ranked by top-N.

\begin{verbatim}
(case_id VARCHAR2/NUMBER,
cluster_id NUMBER,
probability NUMBER,
rank INTEGER)
\end{verbatim}

Feature Extraction using NMF

Feature extraction is also an unsupervised machine learning function, and hence there are no targets. The results of an \texttt{APPLY} operation contains simply the feature identifier corresponding to a case, and the associated match quality. Cost matrix is not considered here. The ranked results table will have the definition as shown, and contains the feature ids ranked by top-N.

\begin{verbatim}
(case_id VARCHAR2/NUMBER,
feature_id NUMBER,
match_quality NUMBER,
rank INTEGER)
\end{verbatim}

Examples

\begin{verbatim}
BEGIN
/* build a model with name census_model. * (See example under CREATE_MODEL) */
/* if training data was pre-processed in any manner, * perform the same pre-processing steps on apply * data also. * (See examples in the section on DBMS_DATA_MINING_TRANSFORM) */
/* apply the model to data to be scored */
DBMS_DATA_MINING.RANK_APPLY(
    apply_result_table_name       => 'census_apply_result',
    case_id_column_name           => 'person_id',
    score_column_name             => 'prediction',
    score_criterion_column_name   => 'probability',
    ranked_apply_result_tab_name  => 'census_ranked_apply_result',
    top_N                         => 3,
    cost_matrix_table_name        => 'census_cost_matrix');
END;
/
-- View Ranked Apply Results
SELECT *
FROM census_ranked_apply_result;
\end{verbatim}
40.1.5.45 REMOVE_COST_MATRIX Procedure

The REMOVE_COST_MATRIX procedure removes the default scoring matrix from a classification model.

See Also:

- "ADD_COST_MATRIX Procedure"
- "REMOVE_COST_MATRIX Procedure"

Syntax

```sql
DBMS_DATA_MINING.REMOVE_COST_MATRIX (  
    model_name   IN  VARCHAR2);
```

Parameters

Table 40-120  Remove_Cost_Matrix Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Name of the model in the form [schema_name.]model_name. If you do not specify a schema, your own schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

If the model is not in your schema, then REMOVE_COST_MATRIX requires the ALTER ANY MINING MODEL system privilege or the ALTER object privilege for the machine learning model.

Example

The naive Bayes model `NB_SH_CLAS_SAMPLE` has an associated cost matrix that can be used for scoring the model.

```sql
SELECT *  
FROM TABLE(dbms_data_mining.get_model_cost_matrix('nb_sh_clas_sample'))  
ORDER BY predicted, actual;
```

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>PREDICTED</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>.75</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>.25</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

You can remove the cost matrix with REMOVE_COST_MATRIX.

```sql
EXECUTE dbms_data_mining.remove_cost_matrix('nb_sh_clas_sample');
```

```sql
SELECT *  
FROM TABLE(dbms_data_mining.get_model_cost_matrix('nb_sh_clas_sample'))  
ORDER BY predicted, actual;
```

no rows selected
40.1.5.46 RENAME_MODEL Procedure

This procedure changes the name of the machine learning model indicated by `model_name` to the name that you specify as `new_model_name`.

If a model with `new_model_name` already exists, then the procedure optionally renames `new_model_name` to `versioned_model_name` before renaming `model_name` to `new_model_name`.

The model name is in the form `[schema_name.]model_name`. If you do not specify a schema, your own schema is used. For machine learning model naming restrictions, see the Usage Notes for "CREATE_MODEL Procedure".

Syntax

```sql
DBMS_DATA_MINING.RENAME_MODEL (  
  model_name            IN VARCHAR2,
  new_model_name        IN VARCHAR2,
  versioned_model_name  IN VARCHAR2 DEFAULT NULL);
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model_name</td>
<td>Model to be renamed.</td>
</tr>
<tr>
<td>new_model_name</td>
<td>New name for the model <code>model_name</code>.</td>
</tr>
<tr>
<td>versioned_model_name</td>
<td>New name for the model <code>new_model_name</code> if it already exists.</td>
</tr>
</tbody>
</table>

Usage Notes

If you attempt to rename a model while it is being applied, then the model will be renamed but the apply operation will return indeterminate results.

Examples

1. This example changes the name of model `census_model` to `census_model_2012`.

   ```sql
   BEGIN
   DBMS_DATA_MINING.RENAME_MODEL(
     model_name  => 'census_model',
     new_model_name => 'census_model_2012');
   END;
   /
   ```

2. In this example, there are two classification models in the user's schema: `clas_mod`, the working model, and `clas_mod_tst`, a test model. The RENAME_MODEL procedure preserves `clas_mod` as `clas_mod_old` and makes the test model the new working model.

   ```sql
   SELECT model_name FROM user_mining_models;
   MODEL_NAME
   --------------------------
   CLAS_MOD
   CLAS_MOD_TST
   ```
BEGIN
    DBMS_DATA_MINING.RENAME_MODEL(
        model_name => 'clas_mod_tst',
        new_model_name => 'clas_mod',
        versioned_model_name => 'clas_mod_old');
END;
/

SELECT model_name FROM user_mining_models;
MODEL_NAME
-----------------------------------------------
CLAS_MOD
CLAS_MOD_OLD

40.2 DBMS_DATA_MINING_TRANSFORM

DBMS_DATA_MINING_TRANSFORM implements a set of transformations that are commonly used in machine learning.

This chapter contains the following topics:

- Overview
- Operational Notes
- Security Model
- Datatypes
- Constants
- Summary of DBMS_DATA_MINING_TRANSFORM Subprograms

See Also:

- DBMS_DATA_MINING
- Oracle Machine Learning for SQL User’s Guide

40.2.1 Using DBMS_DATA_MINING_TRANSFORM

This section contains topics that relate to using the DBMS_DATA_MINING_TRANSFORM package.

- Overview
- Operational Notes
- Security Model
- Datatypes
- Constants
40.2.1.1 DBMS_DATA_MINING_TRANSFORM Overview

A transformation is a SQL expression that modifies the data in one or more columns.

Data must typically undergo certain transformations before it can be used to build a machine learning model. Many machine learning algorithms have specific transformation requirements.

Data that will be scored must be transformed in the same way as the data that was used to create (train) the model.

**External or Embedded Transformations**

DBMS_DATA_MINING_TRANSFORM offers two approaches to implementing transformations. For a given model, you can either:

- Create a list of transformation expressions and pass it to the CREATE_MODEL Procedure
- Create a view that implements the transformations and pass the name of the view to the CREATE_MODEL Procedure

If you create a transformation list and pass it to CREATE_MODEL, the transformation expressions are embedded in the model and automatically implemented whenever the model is applied.

If you create a view, the transformation expressions are external to the model. You will need to re-create the transformations whenever you apply the model.

**Note:**

- Embedded transformations significantly enhance the model's usability while simplifying the process of model management.

**Automatic Transformations**

Oracle Machine Learning for SQL supports an Automatic Data Preparation (ADP) mode. When ADP is enabled, most algorithm-specific transformations are automatically embedded. Any additional transformations must be explicitly provided in an embedded transformation list or in a view.

If ADP is enabled and you create a model with a transformation list, both sets of transformations are embedded. The model will execute the user-specified transformations from the transformation list before executing the automatic transformations specified by ADP.

Within a transformation list, you can selectively disable ADP for individual attributes.
Transformations in DBMS_DATA_MINING_TRANSFORM

The transformations supported by DBMS_DATA_MINING_TRANSFORM are summarized in this section.

**Binning**

Binning refers to the mapping of continuous or discrete values to discrete values of reduced cardinality.

- **Supervised Binning (Categorical and Numerical)**
  Binning is based on intrinsic relationships in the data as determined by a decision tree model.
  See "INSERT_BIN_SUPER Procedure".

- **Top-N Frequency Categorical Binning**
  Binning is based on the number of cases in each category.
  See "INSERT_BIN_CAT_FREQ Procedure".

- **Equi-Width Numerical Binning**
  Binning is based on equal-range partitions.
  See "INSERT_BIN_NUM_EQWIDTH Procedure".

- **Quantile Numerical Binning**
  Binning is based on quantiles computed using the SQL NTILE function.
  See "INSERT_BIN_NUM_QTILE Procedure".

**Linear Normalization**

Normalization is the process of scaling continuous values down to a specific range, often between zero and one. Normalization transforms each numerical value by subtracting a number (the shift) and dividing the result by another number (the scale).

\[ x_{new} = \frac{(x_{old} - \text{shift})}{\text{scale}} \]

- **Min-Max Normalization**
  Normalization is based on the minimum and maximum with the following shift and scale:

  \[
  \text{shift} = \text{min} \\
  \text{scale} = \text{max-min}
  \]

  See "INSERT_NORM_LIN_MINMAX Procedure".

- **Scale Normalization**
  Normalization is based on the minimum and maximum with the following shift and scale:
shift = 0
scale = max(abs(max), abs(min))

See "INSERT_NORM_LIN_SCALE Procedure".

• Z-Score Normalization

Normalization is based on the mean and standard deviation with the following shift and scale:

shift = mean
scale = standard_deviation

See "INSERT_NORM_LIN_ZSCORE Procedure".

Outlier Treatment

An outlier is a numerical value that is located far from the rest of the data. Outliers can artificially skew the results of machine learning.

• Winsorizing

Outliers are replaced with the nearest value that is not an outlier.

See "INSERT_CLIP_WINSOR_TAIL Procedure"

• Trimming

Outliers are set to NULL.

See "INSERT_CLIP_TRIM_TAIL Procedure".

Missing Value Treatment

Missing data may indicate sparsity or it may indicate that some values are missing at random. DBMS_DATA_MINING_TRANSFORM supports the following transformations for minimizing the effects of missing values:

• Missing numerical values are replaced with the mean.

See "INSERT_MISS_NUM_MEAN Procedure"

• Missing categorical values are replaced with the mode.

See "INSERT_MISS_CAT_MODE Procedure".

Note:

Oracle Machine Learning for SQL also has default mechanisms for handling missing data. See Oracle Machine Learning for SQL User’s Guide for details.

40.2.1.2 DBMS_DATA_MINING_TRANSFORM Security Model

The DBMS_DATA_MINING_TRANSFORM package is owned by user SYS and is installed as part of database installation. Execution privilege on the package is granted to public. The routines in the package are run with invokers’ rights (run with the privileges of the current user).

The DBMS_DATA_MINING_TRANSFORM.INSERT_* procedures have a data_table_name parameter that enables the user to provide the input data for transformation purposes.
The value of `data_table_name` can be the name of a physical table or a view. The `data_table_name` parameter can also accept an inline query.

**Note:**

Because an inline query can be used to specify the data for transformation, Oracle strongly recommends that the calling routine perform any necessary SQL injection checks on the input string.

**See Also:**

"Operational Notes" for a description of the `DBMS_DATA_MINING_TRANSFORM.INSERT_*` procedures

---

40.2.1.3 DBMS_DATA_MINING_TRANSFORM Datatypes

`DBMS_DATA_MINING_TRANSFORM` defines the datatypes described in the following table.

### Table 40-122  Datatypes in DBMS_DATA_MINING_TRANSFORM

<table>
<thead>
<tr>
<th>List Type</th>
<th>List Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLUMN_LIST</td>
<td>VARRAY(1000) OF varchar2(32)</td>
<td><code>COLUMN_LIST</code> stores quoted and non-quoted identifiers for column names. <code>COLUMN_LIST</code> is the datatype of the <code>exclude_list</code> parameter in the INSERT procedures. See &quot;INSERT_AUTOBIN_NUM_EQWIDTH Procedure&quot; for an example. See Oracle Database PL/SQL Language Reference for information about populating VARRAY structures.</td>
</tr>
</tbody>
</table>
### Table 40-122  (Cont.) Datatypes in DBMS_DATA_MINING_TRANSFORM

<table>
<thead>
<tr>
<th>List Type</th>
<th>List Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIBE_LIST</td>
<td>DBMS_SQL.DESC_TAB2</td>
<td>DESCRIBE_LIST describes the columns of the data table after the transformation list has been applied. A DESCRIBE_LIST is returned by the DESCRIBE_STACK Procedure.</td>
</tr>
<tr>
<td></td>
<td>TYPE desc_tab2 IS TABLE OF desc_rec2 INDEX BY BINARY_INTEGER</td>
<td>The DESC_TAB2 and DESC_REC2 types are defined in the DBMS_SQL package. See &quot;DESC_REC2 Record Type&quot;.</td>
</tr>
<tr>
<td></td>
<td>TYPE desc_rec2 IS RECORD ( col_type BINARY_INTEGER := 0, col_name VARCHAR2(32767) := '', ...)</td>
<td>The col_type field of DESC_REC2 identifies the datatype of the column. The datatype is expressed as a numeric constant that represents a built-in datatype. For example, a 1 indicates a variable length character string. The codes for Oracle built-in datatypes are listed in Oracle Database SQL Language Reference. The codes for the Oracle Machine Learning for SQL nested types are described in &quot;Constants&quot;.</td>
</tr>
<tr>
<td></td>
<td>col_name VARCHAR2(32) := '', col_schema_name VARCHAR2(32) := ''</td>
<td>The col_name field of DESC_REC2 identifies the column name. It may be populated with a column name, an alias, or an expression. If the column name is a SELECT expression, it may be very long. If the expression is longer than 30 bytes, it cannot be used in a view unless it is given an alias.</td>
</tr>
</tbody>
</table>
Table 40-122  (Cont.) Datatypes in DBMS_DATA_MINING_TRANSFORM

<table>
<thead>
<tr>
<th>List Type</th>
<th>List Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFORM LIST</td>
<td>TABLE OF transform_rec</td>
<td>TRANSFORM_LIST is a list of transformations that can be embedded in a model. A TRANSFORM_LIST is accepted as an argument by the CREATE_MODEL Procedure.</td>
</tr>
<tr>
<td></td>
<td>TYPE transform_rec IS RECORD (attribute_name VARCHAR2(30), attribute_subname VARCHAR2(4000), expression EXPRESSION_REC, reverse_expression EXPRESSION_REC, attribute_spec VARCHAR2(4000));</td>
<td>Each element in a TRANSFORM_LIST is a TRANSFORM_REC that specifies how to transform a single attribute. The attribute_name is a column name. The attribute_subname is the nested attribute name if the column is nested, otherwise attribute_subname is null. The expression field holds a SQL expression for transforming the attribute. See &quot;About Transformation Lists&quot; for an explanation of reverse expressions.</td>
</tr>
<tr>
<td></td>
<td>TYPE expression_rec IS RECORD (lstmt DBMS_SQL.VARCHAR2A, lb INTEGER DEFAULT 1, ub INTEGER DEFAULT 0);</td>
<td>The attribute_spec field can be used to cause the attribute to be handled in a specific way during the model build. See Table 40-154 for details.</td>
</tr>
<tr>
<td></td>
<td>TYPE varchar2a IS TABLE OF VARCHAR2(32767) INDEX BY BINARY_INTEGER;</td>
<td>The expressions in a TRANSFORM_REC have type EXPRESSION_REC. The lstmt field stores a VARCHAR2A, which is a table of VARCHAR2 (32767). The VARCHAR2A datatype allows transformation expressions to be very long, as they can be broken up across multiple rows of VARCHAR2. The VARCHAR2A type is defined in the DBMS_SQL package. See &quot;VARCHAR2A Table Type&quot;. The ub (upper bound) and lb (lower bound) fields indicate how many rows are in the VARCHAR2A table. If ub &lt; lb (default) the EXPRESSION_REC is empty; if lb=ub=1 there is one row; if lb=1 and ub=2 there are 2 rows, and so on.</td>
</tr>
</tbody>
</table>

Related Topics
- Oracle Database PL/SQL Packages and Types Reference

40.2.1.4 DBMS_DATA_MINING_TRANSFORM Constants

DBMS_DATA_MINING_TRANSFORM defines the constants described in the following table.
Table 40-123  Constants in DBMS_DATA_MINING_TRANSFORM

<table>
<thead>
<tr>
<th>Constant</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEST_NUM_COL_TYPE</td>
<td>100001</td>
<td>Indicates that an attribute in the transformation list comes from a row in a column of DM_NESTED_NUMERICALS. Nested numerical attributes are defined as follows:</td>
</tr>
</tbody>
</table>
|                       |         | attribute_name VARCHAR2(4000)  
|                       |         | value NUMBER                                                                                                                             |
| NEST_CAT_COL_TYPE     | 100002  | Indicates that an attribute in the transformation list comes from a row in a column of DM_NESTED_CATEGORICALS. Nested categorical attributes are defined as follows: |
|                       |         | attribute_name VARCHAR2(4000)  
|                       |         | value VARCHAR2(4000)                                                                                                                      |
| NEST_BD_COL_TYPE      | 100003  | Indicates that an attribute in the transformation list comes from a row in a column of DM_NESTED_BINARY_DOUBLES. Nested binary double attributes are defined as follows: |
|                       |         | attribute_name VARCHAR2(4000)  
|                       |         | value BINARY_DOUBLE                                                                                                                      |
| NEST_BF_COL_TYPE      | 100004  | Indicates that an attribute in the transformation list comes from a row in a column of DM_NESTED_BINARY_FLOATS. Nested binary float attributes are defined as follows: |
|                       |         | attribute_name VARCHAR2(4000)  
|                       |         | value BINARY_FLOAT                                                                                                                       |

See Also:


40.2.2 DBMS_DATA_MINING_TRANSFORM Operational Notes

The DBMS_DATA_MINING_TRANSFORM package offers a flexible framework for specifying data transformations. If you choose to embed transformations in the model (the preferred method), you create a transformation list object and pass it to the CREATE_MODEL Procedure. If you choose to transform the data without embedding, you create a view.

When specified in a transformation list, the transformation expressions are executed by the model. When specified in a view, the transformation expressions are executed by the view.

Transformation Definitions

Transformation definitions are used to generate the SQL expressions that transform the data. For example, the transformation definitions for normalizing a numeric column are the shift and scale values for that data.
With the `DBMS_DATA_MINING_TRANSFORM` package, you can call procedures to compute the transformation definitions, or you can compute them yourself, or you can do both.

**Transformation Definition Tables**

`DBMS_DATA_MINING_TRANSFORM` provides `INSERT` procedures that compute transformation definitions and insert them in transformation definition tables. You can modify the values in the transformation definition tables or populate them yourself.

`XFORM` routines use populated definition tables to transform data in external views. `STACK` routines use populated definition tables to build transformation lists.

To specify transformations based on definition tables, follow these steps:

1. Use `CREATE` routines to create transformation definition tables.
   The tables have columns to hold the transformation definitions for a given type of transformation. For example, the `CREATE_BIN_NUM Procedure` creates a definition table that has a column for storing data values and another column for storing the associated bin identifiers.

2. Use `INSERT` routines to compute and insert transformation definitions in the tables.
   Each `INSERT` routine uses a specific technique for computing the transformation definitions. For example, the `INSERT_BIN_NUM_EQWIDTH Procedure` computes bin boundaries by identifying the minimum and maximum values then setting the bin boundaries at equal intervals.

3. Use `STACK` or `XFORM` routines to generate transformation expressions based on the information in the definition tables:
   - Use `STACK` routines to add the transformation expressions to a transformation list. Pass the transformation list to the `CREATE_MODEL Procedure`. The transformation expressions will be assembled into one long SQL query and embedded in the model.
   - Use `XFORM` routines to execute the transformation expressions within a view. The transformations will be external to the model and will need to be re-created whenever the model is applied to new data.

**Transformations Without Definition Tables**

`STACK` routines are not the only method for adding transformation expressions to a transformation list. You can also build a transformation list without using definition tables.

To specify transformations without using definition tables, follow these steps:

1. Write a SQL expression for transforming an attribute.

2. Write a SQL expression for reversing the transformation. (See "Reverse Transformations and Model Transparency" in "DBMS_DATA_MINING_TRANSFORM-About Transformation Lists".)

3. Determine whether or not to disable ADP for the attribute. By default ADP is enabled for the attribute if it is specified for the model. (See "Disabling Automatic Data Preparation" in "DBMS_DATA_MINING_TRANSFORM - About Transformation Lists".)

4. Specify the SQL expressions and ADP instructions in a call to the `SET_TRANSFORM Procedure`, which adds the information to a transformation list.

5. Repeat steps 1 through 4 for each attribute that you wish to transform.
6. Pass the transformation list to the `CREATE_MODEL Procedure`. The transformation expressions will be assembled into one long SQL query and embedded in the model.

Note:

SQL expressions that you specify with `SET_TRANSFORM` must fit within a `VARCHAR2`. To specify a longer expression, you can use the `SET_EXPRESSION Procedure`. With `SET_EXPRESSION`, you can build an expression by appending rows to a `VARCHAR2` array.

About Stacking

Transformation lists are built by stacking transformation records. Transformation lists are evaluated from bottom to top. Each transformation expression depends on the result of the transformation expression below it in the stack.

Related Topics

- `CREATE_MODEL Procedure`
  This procedure creates an Oracle Machine Learning for SQL model with a given machine learning function.

- `DBMS_DATA_MINING_TRANSFORM — About Transformation Lists`
  The elements of a transformation list are `transformation records`. Each transformation record provides all the information needed by the model for managing the transformation of a single attribute.

- `DBMS_DATA_MINING_TRANSFORM — About Stacking and Stack Procedures`
  Transformation lists are built by stacking transformation records. Transformation lists are evaluated from bottom to top. Each transformation expression depends on the result of the transformation expression below it in the stack.

- `DBMS_DATA_MINING_TRANSFORM — Nested Data Transformations`
  The `CREATE` routines create transformation definition tables that include two columns, `col` and `att`, for identifying attributes.

40.2.2.1 DBMS_DATA_MINING_TRANSFORM — About Transformation Lists

The elements of a transformation list are `transformation records`. Each transformation record provides all the information needed by the model for managing the transformation of a single attribute.

Each transformation record includes the following fields:

- `attribute_name` — Name of the column of data to be transformed
- `attribute_subname` — Name of the nested attribute if `attribute_name` is a nested column, otherwise NULL
- `expression` — SQL expression for transforming the attribute
- `reverse_expression` — SQL expression for reversing the transformation
- `attribute_spec` — Identifies special treatment for the attribute during the model build. See Table 40-154 for details.
Reverse Transformations and Model Transparency

An algorithm manipulates transformed attributes to train and score a model. The transformed attributes, however, may not be meaningful to an end user. For example, if attribute $x$ has been transformed into bins 1 — 4, the bin names 1, 2, 3, and 4 are manipulated by the algorithm, but a user is probably not interested in the model details about bins 1 — 4 or in predicting the numbers 1 — 4.

To return original attribute values in model details and predictions, you can provide a reverse expression in the transformation record for the attribute. For example, if you specify the transformation expression $'\log(10, y)'$ for attribute $y$, you could specify the reverse transformation expression $'\text{power}(10, y)'$.

Reverse transformations enable model transparency. They make internal processing transparent to the user.

**Note:**

STACK procedures automatically reverse normalization transformations, but they do not provide a mechanism for reversing binning, clipping, or missing value transformations.

You can use the `DBMS_DATA_MINING.ALTER_REVERSE_EXPRESSION` procedure to specify or update reverse transformations expressions for an existing model.

Disabling Automatic Data Preparation

ADP is controlled by a model-specific setting (`PREP_AUTO`). The `PREP_AUTO` setting affects all model attributes unless you disable it for individual attributes.
If ADP is enabled and you set `attribute_spec` to `NOPREP`, only the transformations that you specify for that attribute will be evaluated. If ADP is enabled and you do not set `attribute_spec` to `NOPREP`, the automatic transformations will be evaluated after the transformations that you specify for the attribute.

If ADP is not enabled for the model, the `attribute_spec` field of the transformation record is ignored.

**See Also:**

"Automatic Data Preparation" for information about the `PREP_AUTO` setting

---

**Adding Transformation Records to a Transformation List**

A transformation list is a stack of transformation records. When a new transformation record is added, it is appended to the top of the stack. (See "About Stacking" for details.)

When you use `SET_TRANSFORM` to add a transformation record to a transformation list, you can specify values for all the fields in the transformation record.

When you use `STACK` procedures to add transformation records to a transformation list, only the transformation expression field is populated. For normalization transformations, the reverse transformation expression field is also populated.

You can use both `STACK` procedures and `SET_TRANSFORM` to build one transformation list. Each `STACK` procedure call adds transformation records for all the attributes in a specified transformation definition table. Each `SET_TRANSFORM` call adds a transformation record for a single attribute.

---

**40.2.2.2 DBMS_DATA_MINING_TRANSFORM — About Stacking and Stack Procedures**

Transformation lists are built by stacking transformation records. Transformation lists are evaluated from bottom to top. Each transformation expression depends on the result of the transformation expression below it in the stack.

**Stack Procedures**

`STACK` procedures create transformation records from the information in transformation definition tables. For example `STACK_BIN_NUM` builds a transformation record for each attribute specified in a definition table for numeric binning. `STACK` procedures stack the transformation records as follows:

- If an attribute is specified in the definition table but not in the transformation list, the `STACK` procedure creates a transformation record, computes the reverse transformation (if possible), inserts the transformation and reverse transformation in the transformation record, and appends the transformation record to the top of the transformation list.
- If an attribute is specified in the transformation list but not in the definition table, the `STACK` procedure takes no action.
• If an attribute is specified in the definition table and in the transformation list, the \texttt{STACK} procedure stacks the transformation expression from the definition table on top of the transformation expression in the transformation record and updates the reverse transformation. See Table 40-122 and Example 40-6.

**Example 40-3  Stacking a Clipping Transformation**

This example shows how \texttt{STACK_CLIP Procedure} would add transformation records to a transformation list. Note that the clipping transformations are not reversed in \texttt{COL1} and \texttt{COL2} after stacking (as described in "Reverse Transformations and Model Transparency" in "DBMS_DATA_MINING_TRANSFORM-About Transformation Lists").

Refer to:

• \texttt{CREATE_CLIP Procedure} — Creates the definition table
• \texttt{INSERT_CLIP_TRIM_TAIL Procedure} — Inserts definitions in the table
• \texttt{INSERT_CLIP_WINSOR_TAIL Procedure} — Inserts definitions in the table
• Table 40-122 — Describes the structure of the transformation list (\texttt{TRANSFORM_LIST} object)

Assume a clipping definition table populated as follows.

<table>
<thead>
<tr>
<th>col</th>
<th>att</th>
<th>lcut</th>
<th>lval</th>
<th>rcut</th>
<th>rval</th>
</tr>
</thead>
<tbody>
<tr>
<td>COL1</td>
<td>null</td>
<td>-1.5</td>
<td>-1.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>COL2</td>
<td>null</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Assume the following transformation list before stacking.

```plaintext
-------------------------
transformation record #1:
-------------------------
attribute_name       = \texttt{COL1}
attribute_subname    = null
expression           = \log(10, \texttt{COL1})
reverse_expression   = \texttt{power(10, COL1)}
-------------------------
transformation record #2:
-------------------------
attribute_name       = \texttt{COL3}
attribute_subname    = null
expression           = \ln(\texttt{COL3})
reverse_expression   = \texttt{exp(\texttt{COL3})}
```

After stacking, the transformation list is as follows.

```plaintext
-------------------------
transformation record #1:
-------------------------
attribute_name       = \texttt{COL1}
attribute_subname    = null
expression           = \begin{cases} 
  \texttt{-1.5} & \text{if } \log(10, \texttt{COL1}) < -1.5 \\
  \texttt{4.5} & \text{if } \log(10, \texttt{COL1}) > 4.5 \\
  \log(10, \texttt{COL1}) & \text{otherwise}
\end{cases}
reverse_expression   = \texttt{power(10, COL1)}
-------------------------
transformation record #2:
-------------------------
```
attribute_name       = COL3
attribute_subname    = null
expression           = ln(COL3)
reverse_expression   = exp(COL3)

-------------------------
transformation record #3:
-------------------------
attribute_name       = COL2
attribute_subname    = null
expression           = CASE WHEN COL2 < 0 THEN 0
                         WHEN COL2 > 1 THEN 1
                         ELSE COL2
                         END;
reverse_expression   = null

40.2.2.3 DBMS_DATA_MINING_TRANSFORM — Nested Data Transformations

The CREATE routines create transformation definition tables that include two columns, col and att, for identifying attributes.

The column col holds the name of a column in the data table. If the data column is not nested, then att is null, and the name of the attribute is col. If the data column is nested, then att holds the name of the nested attribute, and the name of the attribute is col.att. The INSERT and XFORM routines ignore the att column in the definition tables. Neither the INSERT nor the XFORM routines support nested data.

Only the STACK procedures and SET_TRANSFORM support nested data. Nested data transformations are always embedded in the model.

Nested columns in Oracle Machine Learning for SQL can have the following types:

DM_NESTED_NUMERICALS
DM_NESTED_CATEGORICALS
DM_NESTED_BINARY_DOUBLES
DM_NESTED_BINARY_FLOATS

See Also:

"Constants"

Oracle Machine Learning for SQL User’s Guide for details about nested attributes in Oracle Machine Learning for SQL

Specifying Nested Attributes in a Transformation Record

A transformation record (TRANSFORM_REC) includes two fields, attribute_name and attribute_subname, for identifying the attribute. The field attribute_name holds the name of a column in the data table. If the data column is not nested, then attribute_subname is null, and the name of the attribute is attribute_name. If the data column is nested, then attribute_subname holds the name of the nested attribute, and the name of the attribute is attribute_name.attribute_subname.
Transforming Individual Nested Attributes

You can specify different transformations for different attributes in a nested column, and you can specify a default transformation for all the remaining attributes in the column. To specify a default nested transformation, specify null in the attribute_name field and the name of the nested column in the attribute_subname field as shown in Example 40-4. Note that the keyword VALUE is used to represent the value of a nested attribute in a transformation expression.

Example 40-4  Transforming a Nested Column

The following statement transforms two of the nested attributes in COL_N1. Attribute ATTR1 is transformed with normalization; Attribute ATTR2 is set to null, which causes attribute removal transformation (ATTR2 is not used in training the model). All the remaining attributes in COL_N1 are divided by 10.

```sql
DECLARE
  stk dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.SET_TRANSFORM(
    stk,'COL_N1', 'ATTR1', '(VALUE - (-1.5))/20', 'VALUE *20 + (-1.5)');
  dbms_data_mining_transform.SET_TRANSFORM(
    stk,'COL_N1', 'ATTR2', NULL, NULL);
  dbms_data_mining_transform.SET_TRANSFORM(
    stk, NULL, 'COL_N1', 'VALUE/10', 'VALUE*10');
END;
/
```

The following SQL is generated from this statement.

```sql
CAST(MULTISET(SELECT DM_NESTED_NUMERICAL(
  "ATTRIBUTE_NAME",
  DECODE("ATTRIBUTE_NAME",
    'ATTR1', ('VALUE' - (-1.5))/20,
    'VALUE'/10))
FROM TABLE("COL_N1")
WHERE "ATTRIBUTE_NAME" IS NOT IN ('ATTR2'))
AS DM_NESTED_NUMERICALS)
```

If transformations are not specified for COL_N1.ATTR1 and COL_N1.ATTR2, then the default transformation is used for all the attributes in COL_N1, and the resulting SQL does not include a DECODE.

```sql
CAST(MULTISET(SELECT DM_NESTED_NUMERICAL(
  "ATTRIBUTE_NAME",
  "VALUE"/10)
FROM TABLE("COL_N1")
AS DM_NESTED_NUMERICALS)
```

Since DECODE is limited to 256 arguments, multiple DECODE functions are nested to support an arbitrary number of individual nested attribute specifications.

Adding a Nested Column

You can specify a transformation that adds a nested column to the data, as shown in Example 40-5.
Example 40-5  Adding a Nested Column to a Transformation List

```sql
DECLARE
    v_xlst dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.SET_TRANSFORM(v_xlst, 'YOB_CREDLIM', NULL,
        'dm_nested_numericals(' dm_nested_numerical(
            ''CUST_YEAR_OF_BIRTH'', cust_year_of_birth),
            dm_nested_numerical(
                ''CUST_CREDIT_LIMIT'', cust_credit_limit))',
        NULL);
    dbms_data_mining_transform.SET_TRANSFORM(v_xlst, 'CUST_YEAR_OF_BIRTH', NULL, NULL, NULL);
    dbms_data_mining_transform.SET_TRANSFORM(v_xlst, 'CUST_CREDIT_LIMIT', NULL, NULL, NULL);
    dbms_data_mining_transform.XFORM_STACK(v_xlst, 'mining_data', 'mining_data_v');
END;
/
```

```sql
set long 2000
SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_V';
```

TEXT

```
---------------------------------------------------------------------------------
SELECT "CUST_ID","CUST_POSTAL_CODE",dm_nested_numericals(dm_nested_numerical(
    'CUST_YEAR_OF_BIRTH', cust_year_of_birth),
    dm_nested_numerical('CUST_CREDIT_LIMIT', cust_credit_limit)) "YOB_CREDLIM" FROM mining_data

SELECT * FROM mining_data_v WHERE cust_id = 104500;
```

```
CUST_ID CUST_POSTAL_CODE YOB_CREDLIM(ATTRIBUTE_NAME, VALUE)
------- ---------------- ----------------------------------------
104500 68524            DM_NESTED_NUMERICALS(DM_NESTED_NUMERICAL('CUST_YEAR_OF_BIRTH', 1962),
    DM_NESTED_NUMERICAL('CUST_CREDIT_LIMIT', 15000))
```

Stacking Nested Transformations

Example 40-6 shows how the STACK_NORM_LIN Procedure would add transformation records for nested column COL_N to a transformation list.

Refer to:

- CREATE_NORM_LIN Procedure — Creates the definition table
- INSERT_NORM_LIN_MINMAX Procedure — Inserts definitions in the table
- INSERT_NORM_LIN_SCALE Procedure — Inserts definitions in the table
- INSERT_NORM_LIN_ZSCORE Procedure — Inserts definitions in the table
- Table 40-122 — Describes the structure of the transformation list

Example 40-6  Stacking a Nested Normalization Transformation

Assume a linear normalization definition table populated as follows.
Assume the following transformation list before stacking.

-------------------------
transformation record #1:
-------------------------
attribute_name       = COL_N
attribute_subname    = ATT1
expression           = log(10, VALUE)
reverse_expression   = power(10, VALUE)

-------------------------
transformation record #2:
-------------------------
attribute_name       = null
attribute_subname    = COL_N
expression           = ln(VALUE)
reverse_expression   = exp(VALUE)

After stacking, the transformation list is as follows.

-------------------------
transformation record #1:
-------------------------
attribute_name       = COL_N
attribute_subname    = ATT1
expression           = (log(10, VALUE) - 0)/10
reverse_expression   = power(10, VALUE*10 + 0)

-------------------------
transformation record #2:
-------------------------
attribute_name       = NULL
attribute_subname    = COL_N
expression           = (ln(VALUE) - 0)/10
reverse_expression   = exp(VALUE *10 + 0)

-------------------------
transformation record #3:
-------------------------
attribute_name       = COL_N
attribute_subname    = ATT2
expression           = (ln(VALUE) - 0)/20
reverse_expression   = exp(VALUE * 20 + 0)

40.2.3 Summary of DBMS_DATA_MINING_TRANSFORM Subprograms

This table lists the DBMS_DATA_MINING_TRANSFORM subprograms in alphabetical order and briefly describes them.

Table 40-124  DBMS_DATA_MINING_TRANSFORM Package Subprograms

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE_BIN_CAT Procedure</td>
<td>Creates a transformation definition table for categorical binning</td>
</tr>
</tbody>
</table>
Table 40-124  (Cont.) DBMS_DATA_MINING_TRANSFORM Package Subprograms

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE_BIN_NUM Procedure</td>
<td>Creates a transformation definition table for numerical binning</td>
</tr>
<tr>
<td>CREATE_CLIP Procedure</td>
<td>Creates a transformation definition table for clipping</td>
</tr>
<tr>
<td>CREATE_COL_REM Procedure</td>
<td>Creates a transformation definition table for column removal</td>
</tr>
<tr>
<td>CREATE_MISS_CAT Procedure</td>
<td>Creates a transformation definition table for categorical missing value treatment</td>
</tr>
<tr>
<td>CREATE_MISS_NUM Procedure</td>
<td>Creates a transformation definition table for numerical missing values treatment</td>
</tr>
<tr>
<td>CREATE_NORM_LIN Procedure</td>
<td>Creates a transformation definition table for linear normalization</td>
</tr>
<tr>
<td>DESCRIBE_STACK Procedure</td>
<td>Describes the transformation list</td>
</tr>
<tr>
<td>GET_EXPRESSION Function</td>
<td>Returns a VARCHAR2 chunk from a transformation expression</td>
</tr>
<tr>
<td>INSERT_AUTOBIN_NUM_EQWIDT</td>
<td>Inserts numeric automatic equi-width binning definitions in a transformation definition table</td>
</tr>
<tr>
<td>H Procedure</td>
<td></td>
</tr>
<tr>
<td>INSERT_BIN_CAT_FREQ Procedure</td>
<td>Inserts categorical frequency-based binning definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_BIN_NUM_EQWIDTH Procedure</td>
<td>Inserts numeric equi-width binning definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_BIN_NUM_QTILE Procedure</td>
<td>Inserts numeric quantile binning expressions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_BIN_SUPER Procedure</td>
<td>Inserts supervised binning definitions in numerical and categorical transformation definition tables</td>
</tr>
<tr>
<td>INSERT_CLIP_TRIM_TAIL Procedure</td>
<td>Inserts numerical trimming definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_CLIP_WINSOR_TAIL Procedure</td>
<td>Inserts numerical winsorizing definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_MISS_CAT_MODE Procedure</td>
<td>Inserts categorical missing value treatment definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_MISS_NUM_MEAN Procedure</td>
<td>Inserts numerical missing value treatment definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_NORM_LIN_MINMAX Procedure</td>
<td>Inserts linear min-max normalization definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_NORM_LIN_SCALE Procedure</td>
<td>Inserts linear scale normalization definitions in a transformation definition table</td>
</tr>
<tr>
<td>INSERT_NORM_LIN_ZSCORE Procedure</td>
<td>Inserts linear zscore normalization definitions in a transformation definition table</td>
</tr>
<tr>
<td>SET_EXPRESSION Procedure</td>
<td>Adds a VARCHAR2 chunk to an expression</td>
</tr>
<tr>
<td>SET_TRANSFORM Procedure</td>
<td>Adds a transformation record to a transformation list</td>
</tr>
<tr>
<td>STACK_BIN_CAT Procedure</td>
<td>Adds a categorical binning expression to a transformation list</td>
</tr>
<tr>
<td>STACK_BIN_NUM Procedure</td>
<td>Adds a numerical binning expression to a transformation list</td>
</tr>
<tr>
<td>STACK_CLIP Procedure</td>
<td>Adds a clipping expression to a transformation list</td>
</tr>
<tr>
<td>STACK_COL_REM Procedure</td>
<td>Adds a column removal expression to a transformation list</td>
</tr>
<tr>
<td>STACK_MISS_CAT Procedure</td>
<td>Adds a categorical missing value treatment expression to a transformation list</td>
</tr>
</tbody>
</table>
Table 40-124  (Cont.) DBMS_DATA_MINING_TRANSFORM Package Subprograms

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>STACK_MISS_NUM Procedure</td>
<td>Adds a numerical missing value treatment expression to a transformation list</td>
</tr>
<tr>
<td>STACK_NORM_LIN Procedure</td>
<td>Adds a linear normalization expression to a transformation list</td>
</tr>
<tr>
<td>XFORM_BIN_CAT Procedure</td>
<td>Creates a view of the data table with categorical binning transformations</td>
</tr>
<tr>
<td>XFORM_BIN_NUM Procedure</td>
<td>Creates a view of the data table with numerical binning transformations</td>
</tr>
<tr>
<td>XFORM_CLIP Procedure</td>
<td>Creates a view of the data table with clipping transformations</td>
</tr>
<tr>
<td>XFORM_COL_REM Procedure</td>
<td>Creates a view of the data table with column removal transformations</td>
</tr>
<tr>
<td>XFORM_EXPR_NUM Procedure</td>
<td>Creates a view of the data table with the specified numeric transformations</td>
</tr>
<tr>
<td>XFORM_EXPR_STR Procedure</td>
<td>Creates a view of the data table with the specified categorical transformations</td>
</tr>
<tr>
<td>XFORM_MISS_CAT Procedure</td>
<td>Creates a view of the data table with categorical missing value treatment</td>
</tr>
<tr>
<td>XFORM_MISS_NUM Procedure</td>
<td>Creates a view of the data table with numerical missing value treatment</td>
</tr>
<tr>
<td>XFORM_NORM_LIN Procedure</td>
<td>Creates a view of the data table with linear normalization transformations</td>
</tr>
<tr>
<td>XFORM_STACK Procedure</td>
<td>Creates a view of the transformation list</td>
</tr>
</tbody>
</table>

40.2.3.1 CREATE_BIN_CAT Procedure

This procedure creates a transformation definition table for categorical binning.

The columns are described in the following table.

Table 40-125  Columns in a Transformation Definition Table for Categorical Binning

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of categorical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see Oracle Machine Learning for SQL User's Guide.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if col is a nested column. If col is nested, the attribute name is col.att. If col is not nested, att is null.</td>
</tr>
<tr>
<td>val</td>
<td>VARCHAR2(4000)</td>
<td>Values of the attribute</td>
</tr>
<tr>
<td>bin</td>
<td>VARCHAR2(4000)</td>
<td>Bin assignments for the values</td>
</tr>
</tbody>
</table>
Syntax

```
DBMS_DATA_MINING_TRANSFORM.CREATE_BIN_CAT (  
    bin_table_name IN VARCHAR2,  
    bin_schema_name IN VARCHAR2 DEFAULT NULL );
```

Parameters

**Table 40-126   CREATE_BIN_CAT Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of <code>bin_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

1. See *Oracle Machine Learning for SQL User’s Guide* for details about categorical data.
2. See "Nested Data Transformations" for information about transformation definition tables and nested data.
3. You can use the following procedures to populate the transformation definition table:
   - `INSERT_BIN_CAT_FREQ Procedure` — frequency-based binning
   - `INSERT_BIN_SUPER Procedure` — supervised binning

See Also:

- "Bininning" in `DBMS_DATA_MINING_TRANSFORM Overview`
- "Operational Notes"

Examples

The following statement creates a table called `bin_cat_xtbl` in the current schema. The table has columns that can be populated with bin assignments for categorical attributes.

```
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_BIN_CAT('bin_cat_xtbl');
END;
/
```

```
DESCRIBE bin_cat_xtbl
```

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>COL</td>
<td></td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>ATT</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>VAL</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>BIN</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>
40.2.3.2 CREATE_BIN_NUM Procedure

This procedure creates a transformation definition table for numerical binning.

The columns are described in the following table.

**Table 40-127  Columns in a Transformation Definition Table for Numerical Binning**

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of numerical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see <em>Oracle Machine Learning for SQL User’s Guide</em>.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if col is a nested column. If col is nested, the attribute name is col.att. If col is not nested, att is null.</td>
</tr>
<tr>
<td>val</td>
<td>NUMBER</td>
<td>Values of the attribute</td>
</tr>
<tr>
<td>bin</td>
<td>VARCHAR2(4000)</td>
<td>Bin assignments for the values</td>
</tr>
</tbody>
</table>

**Syntax**

```sql
DBMS_DATA_MINING_TRANSFORM.CREATE_BIN_NUM (  
    bin_table_name IN VARCHAR2,  
    bin_schema_name IN VARCHAR2 DEFAULT NULL );
```

**Parameters**

**Table 40-128  CREATE_BIN_NUM Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

2. See "Nested Data Transformations" for information about transformation definition tables and nested data.
3. You can use the following procedures to populate the transformation definition table:
   - `INSERT_AUTOBIN_NUM_EQWIDTH Procedure` — automatic equi-width binning
   - `INSERT_BIN_NUM_EQWIDTH Procedure` — user-specified equi-width binning
   - `INSERT_BIN_NUM_QTILE Procedure` — quantile binning
   - `INSERT_BIN_SUPER Procedure` — supervised binning
Examples

The following statement creates a table called `bin_num_xtbl` in the current schema. The table has columns that can be populated with bin assignments for numerical attributes.

```sql
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_BIN_NUM('bin_num_xtbl');
END;
/
```

**DESCRIBE bin_num_xtbl**

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>COL</td>
<td></td>
<td>VARCHAR2(30)</td>
</tr>
<tr>
<td>ATT</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
<tr>
<td>VAL</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>BIN</td>
<td></td>
<td>VARCHAR2(4000)</td>
</tr>
</tbody>
</table>

### 40.2.3.3 CREATE_CLIP Procedure

This procedure creates a transformation definition table for clipping or winsorizing to minimize the effect of outliers.

The columns are described in the following table.

**Table 40-129 Columns in a Transformation Definition Table for Clipping or Winsorizing**

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of numerical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see <em>Oracle Machine Learning for SQL User's Guide</em>.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute <code>att</code> name if <code>col</code> is a nested column of <code>DM_NESTED_NUMERICALS</code>. If <code>col</code> is nested, the attribute name is <code>col.att</code>.</td>
</tr>
<tr>
<td>lcut</td>
<td>NUMBER</td>
<td>The lowest typical value for the attribute. If the attribute values were plotted on an <code>xy</code> axis, <code>lcut</code> would be the left-most boundary of the range of values considered typical for this attribute. Any values to the left of <code>lcut</code> are outliers.</td>
</tr>
<tr>
<td>lval</td>
<td>NUMBER</td>
<td>Value assigned to an outlier to the left of <code>lcut</code>.</td>
</tr>
</tbody>
</table>
Table 40-129  (Cont.) Columns in a Transformation Definition Table for Clipping or Winsorizing

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rcut</td>
<td>NUMBER</td>
<td>The highest typical value for the attribute. If the attribute values were plotted on an xy axis, rcut would be the right-most boundary of the range of values considered typical for this attribute. Any values to the right of rcut are outliers.</td>
</tr>
<tr>
<td>rval</td>
<td>NUMBER</td>
<td>Value assigned to an outlier to the right of rcut</td>
</tr>
</tbody>
</table>

Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.CREATE_CLIP (    
    clip_table_name    IN VARCHAR2,
    clip_schema_name   IN VARCHAR2 DEFAULT NULL );
```

Parameters

Table 40-130  CREATE_CLIP Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clip_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>clip_schema_name</td>
<td>Schema of clip_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

2. See "Nested Data Transformations" for information about transformation definition tables and nested data.
3. You can use the following procedures to populate the transformation definition table:
   - INSERT_CLIP_TRIM_TAIL Procedure — replaces outliers with nulls
   - INSERT_CLIP_WINSOR_TAIL Procedure — replaces outliers with an average value

See Also:

- "Outlier Treatment" in DBMS_DATA_MINING_TRANSFORM Overview
- "Operational Notes"

Examples

The following statement creates a table called clip_xtbl in the current schema. The table has columns that can be populated with clipping instructions for numerical attributes.

```sql
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_CLIP('clip_xtbl');
END;
```
40.2.3.4 CREATE_COL_REM Procedure

This procedure creates a transformation definition table for removing columns from the data table.

The columns are described in the following table.

**Table 40-131 Columns in a Transformation Definition Table for Column Removal**

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the column is not nested, the column name is also the attribute name.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For information about attribute names, see <em>Oracle Machine Learning for SQL User’s Guide</em>.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if <em>col</em> is nested (DM_NESTED_NUMERICALS or DM_NESTED_CATEGORICALS).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If <em>col</em> is nested, the attribute name is <em>col</em>.att.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If <em>col</em> is not nested, <em>att</em> is null.</td>
</tr>
</tbody>
</table>

**Syntax**

```sql
DBMS_DATA_MINING_TRANSFORM.CREATE_COL_REM (
    rem_table_name   VARCHAR2,
    rem_schema_name  VARCHAR2 DEFAULT NULL );
```

**Parameters**

**Table 40-132 CREATE_COL_REM Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rem_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>rem_schema_name</td>
<td>Schema of <em>rem_table_name</em>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

1. See "Nested Data Transformations" for information about transformation definition tables and nested data.
2. See "Operational Notes".
Examples

The following statement creates a table called `rem_att_xtbl` in the current schema. The table has columns that can be populated with the names of attributes to exclude from the data to be mined.

```
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_COL_REM ('rem_att_xtbl');
END;
/
```

```
DESCRIBE rem_att_xtbl
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
COL                                                VARCHAR2(30)
ATT                                                VARCHAR2(4000)
```

40.2.3.5 CREATE_MISS_CAT Procedure

This procedure creates a transformation definition table for replacing categorical missing values.

The columns are described in the following table.

Table 40-133 Columns in a Transformation Definition Table for Categorical Missing Value Treatment

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of categorical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see Oracle Machine Learning for SQL User’s Guide.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if <code>col</code> is a nested column of <code>DM_NESTED_CATEGORICALS</code>. If <code>col</code> is nested, the attribute name is <code>col.att</code>. If <code>col</code> is not nested, <code>att</code> is null.</td>
</tr>
<tr>
<td>val</td>
<td>VARCHAR2(4000)</td>
<td>Replacement for missing values in the attribute</td>
</tr>
</tbody>
</table>

Syntax

```
DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_CAT (
    miss_table_name IN VARCHAR2,
    miss_schema_name IN VARCHAR2 DEFAULT NULL );
```

Parameters

Table 40-134 CREATE_MISS_CAT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of <code>miss_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>
Usage Notes


2. See “Nested Data Transformations” for information about transformation definition tables and nested data.

3. You can use the INSERT_MISS_CAT_MODE Procedure to populate the transformation definition table.

See Also:

“Missing Value Treatment” in DBMS_DATA_MINING_TRANSFORM Overview
“Operational Notes”

Examples

The following statement creates a table called miss_cat_xtbl in the current schema. The table has columns that can be populated with values for missing data in categorical attributes.

```
BEGIN
  DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_CAT('miss_cat_xtbl');
END;
/
```

```
DESCRIBE miss_cat_xtbl
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
col                                                VARCHAR2(30)
ATT                                                VARCHAR2(4000)
VAL                                                VARCHAR2(4000)
```

40.2.3.6 CREATE_MISS_NUM Procedure

This procedure creates a transformation definition table for replacing numerical missing values.

The columns are described in Table 40-135.

Table 40-135  Columns in a Transformation Definition Table for Numerical Missing Value Treatment

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of numerical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see Oracle Machine Learning for SQL User’s Guide.</td>
</tr>
</tbody>
</table>
Table 40-135 (Cont.) Columns in a Transformation Definition Table for Numerical Missing Value Treatment

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if col is a nested column of DM_NESTED_NUMERICALS. If col is nested, the attribute name is col.att. If col is not nested, att is null.</td>
</tr>
<tr>
<td>val</td>
<td>NUMBER</td>
<td>Replacement for missing values in the attribute</td>
</tr>
</tbody>
</table>

Syntax

```
DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_NUM (
    miss_table_name       IN VARCHAR2,
    miss_schema_name      IN VARCHAR2 DEFAULT NULL );
```

Parameters

Table 40-136 CREATE_MISS_NUM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

2. See "Nested Data Transformations" for information about transformation definition tables and nested data.
3. You can use the INSERT_MISS_NUM_MEAN Procedure to populate the transformation definition table.

See Also:

"Missing Value Treatment" in DBMS_DATA_MINING_TRANSFORM Overview
"Operational Notes"

Example

The following statement creates a table called miss_num_xtbl in the current schema. The table has columns that can be populated with values for missing data in numerical attributes.

```
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_NUM('miss_num_xtbl');
END;
/
```
40.2.3.7 CREATE_NORM_LIN Procedure

This procedure creates a transformation definition table for linear normalization.

The columns are described in Table 40-137.

Table 40-137 Columns in a Transformation Definition Table for Linear Normalization

<table>
<thead>
<tr>
<th>Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>VARCHAR2(30)</td>
<td>Name of a column of numerical data. If the column is not nested, the column name is also the attribute name. For information about attribute names, see Oracle Machine Learning for SQL User's Guide.</td>
</tr>
<tr>
<td>att</td>
<td>VARCHAR2(4000)</td>
<td>The attribute subname if col is a nested column of DM_NESTED_NUMERICALS. If col is nested, the attribute name is col.att. If col is not nested, att is null.</td>
</tr>
<tr>
<td>shift</td>
<td>NUMBER</td>
<td>A constant to subtract from the attribute values</td>
</tr>
<tr>
<td>scale</td>
<td>NUMBER</td>
<td>A constant by which to divide the shifted values</td>
</tr>
</tbody>
</table>

Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.CREATE_NORM_LIN (
    norm_table_name       IN VARCHAR2,
    norm_schema_name      IN VARCHAR2 DEFAULT NULL );
```

Parameters

Table 40-138 CREATE_NORM_LIN Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>norm_table_name</td>
<td>Name of the transformation definition table to be created</td>
</tr>
<tr>
<td>norm_schema_name</td>
<td>Schema of norm_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes


2. See "Nested Data Transformations" for information about transformation definition tables and nested data.

3. You can use the following procedures to populate the transformation definition table:
- **INSERT_NORM_LIN_MINMAX Procedure** — Uses linear min-max normalization
- **INSERT_NORM_LIN_SCALE Procedure** — Uses linear scale normalization
- **INSERT_NORM_LIN_ZSCORE Procedure** — Uses linear zscore normalization

**See Also:**

“Linear Normalization” in [DBMS_DATA_MINING_TRANSFORM Overview](#)

“Operational Notes”

### Examples

The following statement creates a table called `norm_xtbl` in the current schema. The table has columns that can be populated with shift and scale values for normalizing numerical attributes.

```sql
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_NORM_LIN('norm_xtbl');
END;
/
```

```
DESCRIBE norm_xtbl
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
COL                                                VARCHAR2(30)
ATT                                                VARCHAR2(4000)
SHIFT                                              NUMBER
SCALE                                              NUMBER
```

#### 40.2.3.8 DESCRIBE_STACK Procedure

This procedure describes the columns of the data table after a list of transformations has been applied.

Only the columns that are specified in the transformation list are transformed. The remaining columns in the data table are included in the output without changes.

To create a view of the data table after the transformations have been applied, use the **XFORM_STACK Procedure**.

#### Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.DESCRIBE_STACK (
    xform_list           IN  TRANSFORM_LIST,
    data_table_name      IN  VARCHAR2,
    describe_list        OUT DESCRIBE_LIST,
    data_schema_name     IN  VARCHAR2 DEFAULT NULL);
```
Parameters

Table 40-139  DESCRIBE_STACK Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xform_list</td>
<td>A list of transformations. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>describe_list</td>
<td>Descriptions of the columns in the data table after the transformations specified in xform_list have been applied. See Table 40-122 for a description of the DESCRIBE_LIST object type.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes" for information about transformation lists and embedded transformations.

Examples

This example shows the column name and datatype, the column name length, and the column maximum length for the view omi_user.cust_info after the transformation list has been applied. All the transformations are user-specified. The results of DESCRIBE_STACK do not include one of the columns in the original table, because the SET_TRANSFORM procedure sets that column to NULL.

```sql
CREATE OR REPLACE VIEW cust_info AS
    SELECT a.cust_id, c.country_id, c.cust_year_of_birth,
           CAST(COLLECT(DM_Nested_Numerical(
                       b.prod_name, 1))
           AS DM_Nested_Numericals) custprods
    FROM sh.sales a, sh.products b, sh.customers c
    WHERE a.prod_id = b.prod_id AND
          a.cust_id = c.cust_id AND
          a.cust_id between 100001 AND 105000
    GROUP BY a.cust_id, country_id, cust_year_of_birth;
```

describe cust_info

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST ID</td>
<td>NOT NULL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>COUNTRY ID</td>
<td>NOT NULL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CUST YEAR OF BIRTH</td>
<td>NOT NULL</td>
<td>NUMBER(4)</td>
</tr>
<tr>
<td>CUSTPRODS</td>
<td></td>
<td>SYS.DM_NESTED_NUMERICALS</td>
</tr>
</tbody>
</table>

declare cust_stack cust_cols
dbms_data_mining_transform.TRANSFORM_LIST;
dbms_data_mining_transform.DESCRIBE_LIST;
BEGIN
    dbms_data_mining_transform.SET_TRANSFORM (cust_stack,
      'country_id', NULL, 'country_id/10', 'country_id*10');
    dbms_data_mining_transform.SET_TRANSFORM (cust_stack,
      'cust_year_of_birth', NULL, NULL, NULL);
    dbms_data_mining_transform.SET_TRANSFORM (cust_stack,
      'custprods', 'Mouse Pad', 'value*100', 'value/100');
dbms_data_mining_transform.DESCRIBE_STACK(
    xform_list => cust_stack,
    data_table_name => 'cust_info',
    describe_list => cust_cols);

dbms_output.put_line('====');
for i in 1..cust_cols.COUNT loop
    dbms_output.put_line('COLUMN_NAME:     '||cust_cols(i).col_name);
    dbms_output.put_line('COLUMN_TYPE:     '||cust_cols(i).col_type);
    dbms_output.put_line('COLUMN_NAME_LEN: '||cust_cols(i).col_name_len);
    dbms_output.put_line('COLUMN_MAX_LEN:  '||cust_cols(i).col_max_len);
    dbms_output.put_line('====');
END loop;
END;
/
====
COLUMN_NAME:     CUST_ID
COLUMN_TYPE:     2
COLUMN_NAME_LEN: 7
COLUMN_MAX_LEN:  22
====
COLUMN_NAME:     COUNTRY_ID
COLUMN_TYPE:     2
COLUMN_NAME_LEN: 10
COLUMN_MAX_LEN:  22
====
COLUMN_NAME:     CUSTPRODS
COLUMN_TYPE:     100001
COLUMN_NAME_LEN: 9
COLUMN_MAX_LEN:  40
====

40.2.3.9 GET_EXPRESSION Function

This function returns a row from a VARCHAR2 array that stores a transformation expression. The array is built by calls to the SET_EXPRESSION Procedure. The array can be used for specifying SQL expressions that are too long to be used with the SET_TRANSFORM Procedure.

Syntax

DBMS_DATA_MINING_TRANSFORM.GET_EXPRESSION (
    expression           IN EXPRESSION_REC,
    chunk_num            IN PLS_INTEGER DEFAULT NULL);
RETURN VARCHAR2;
Parameters

Table 40-140  GET_EXPRESSION Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expression</td>
<td>An expression record (EXPRESSION_REC) that specifies a transformation expression or a reverse transformation expression for an attribute. Each expression record includes a VARCHAR2 array and index fields for specifying upper and lower boundaries within the array. There are two EXPRESSION_REC fields within a transformation record (TRANSFORM_REC): one for the transformation expression; the other for the reverse transformation expression. See Table 40-122 for a description of the EXPRESSION_REC type.</td>
</tr>
<tr>
<td>chunk</td>
<td>A VARCHAR2 chunk (row) to be appended to expression.</td>
</tr>
</tbody>
</table>

Usage Notes

1. Chunk numbering starts with one. For chunks outside of the range, the return value is null. When a chunk number is null the whole expression is returned as a string. If the expression is too big, a VALUE_ERROR is raised.
2. See "About Transformation Lists".
3. See "Operational Notes".

Examples

See the example for the SET_EXPRESSION Procedure.

Related Topics

- SET_EXPRESSION Procedure
  This procedure appends a row to a VARCHAR2 array that stores a SQL expression.
- SET_TRANSFORM Procedure
  This procedure appends the transformation instructions for an attribute to a transformation list.

40.2.3.10 INSERT_AUTOBIN_NUM_EQWIDTH Procedure

This procedure performs numerical binning and inserts the transformation definitions in a transformation definition table. The procedure identifies the minimum and maximum values and computes the bin boundaries at equal intervals.

INSERT_AUTOBIN_NUM_EQWIDTH computes the number of bins separately for each column. If you want to use equi-width binning with the same number of bins for each column, use the INSERT_BIN_NUM_EQWIDTH Procedure.

INSERT_AUTOBIN_NUM_EQWIDTH bins all the NUMBER and FLOAT columns in the data source unless you specify a list of columns to ignore.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.INSERT_AUTOBIN_NUM_EQWIDTH (  
  bin_table_name        IN VARCHAR2,  
  data_table_name       IN VARCHAR2,  
)  
```
Parameters

Table 40-141 INSERT_AUTOBIN_NUM_EQWIDTH Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table for numerical binning. You can use the CREATE_BIN_NUM Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>VAL NUMBER</td>
</tr>
<tr>
<td></td>
<td>BIN VARCHAR2(4000)</td>
</tr>
<tr>
<td></td>
<td>CREATE_BIN_NUM creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_AUTOBIN_NUM_EQWIDTH.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>bin_num</td>
<td>Minimum number of bins. If bin_num is 0 or NULL, it is ignored. The default value of bin_num is 3.</td>
</tr>
<tr>
<td>max_bin_num</td>
<td>Maximum number of bins. If max_bin_num is 0 or NULL, it is ignored. The default value of max_bin_num is 100.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to be excluded from the binning process. If you do not specify exclude_list, all numerical columns in the data source are binned.</td>
</tr>
<tr>
<td></td>
<td>The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2',...'coln')</td>
</tr>
<tr>
<td>round_num</td>
<td>Specifies how to round the number in the VAL column of the transformation definition table.</td>
</tr>
<tr>
<td></td>
<td>When round_num is positive, it specifies the most significant digits to retain.</td>
</tr>
<tr>
<td></td>
<td>When round_num is negative, it specifies the least significant digits to remove. In both cases, the result is rounded to the specified number of digits.</td>
</tr>
<tr>
<td></td>
<td>See the Usage Notes for an example.</td>
</tr>
<tr>
<td></td>
<td>The default value of round_num is 6.</td>
</tr>
<tr>
<td>sample_size</td>
<td>Size of the data sample. If sample_size is less than the total number of non-NULL values in the column, then sample_size is used instead of SQL COUNT function in computing the number of bins. If sample_size is 0 or NULL, it is ignored. See the Usage Notes.</td>
</tr>
<tr>
<td></td>
<td>The default value of sample_size is 50,000.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>
Table 40-141  (Cont.) INSERT_AUTOBIN_NUM_EQWIDTH Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>rem_table_name</td>
<td>Name of a transformation definition table for column removal. The table must have the columns described in &quot;CREATE_COL_REM Procedure&quot;. INSERT_AUTOBIN_NUM_EQWIDTH ignores columns with all nulls or only one unique value. If you specify a value for rem_table_name, these columns are removed from the mining data. If you do not specify a value for rem_table_name, these unbinned columns remain in the data.</td>
</tr>
<tr>
<td>rem_schema_name</td>
<td>Schema of rem_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes


2. INSERT_AUTOBIN_NUM_EQWIDTH computes the number of bins for a column based on the number of non-null values (COUNT), the maximum (MAX), the minimum (MIN), the standard deviation (STDDEV), and the constant C=3.49/0.9:

\[ N = \text{floor}(\text{power}(\text{COUNT}, 1/3) \cdot (\text{max}-\text{min})/(c \cdot \text{dev})) \]

If the sample_size parameter is specified, it is used instead of COUNT.


3. INSERT_AUTOBIN_NUM_EQWIDTH uses absolute values to compute the number of bins. The sign of the parameters bin_num, max_bin_num, and sample_size has no effect on the result.

4. In computing the number of bins, INSERT_AUTOBIN_NUM_EQWIDTH evaluates the following criteria in the following order:

   a. The minimum number of bins (bin_num)
   b. The maximum number of bins (max_bin_num)
   c. The maximum number of bins for integer columns, calculated as the number of distinct values in the range max-min+1.

5. The round_num parameter controls the rounding of column values in the transformation definition table, as follows:

   For a value of 308.162:

<table>
<thead>
<tr>
<th>round_num</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>310</td>
</tr>
<tr>
<td>3</td>
<td>308</td>
</tr>
<tr>
<td>0</td>
<td>308.162</td>
</tr>
<tr>
<td>-1</td>
<td>308.16</td>
</tr>
<tr>
<td>-2</td>
<td>308.2</td>
</tr>
</tbody>
</table>
Examples

In this example, \texttt{INSERT\_AUTOBIN\_NUM\_EQWIDTH} computes the bin boundaries for the \texttt{cust\_year\_of\_birth} column in \texttt{sh.customers} and inserts the transformations in a transformation definition table. The \texttt{STACK\_BIN\_NUM Procedure} creates a transformation list from the contents of the definition table. The \texttt{CREATE\_MODEL Procedure} embeds the transformation list in a new model called \texttt{nb\_model}.

The transformation and reverse transformation expressions embedded in \texttt{nb\_model} are returned by the \texttt{GET\_MODEL\_TRANSFORMATIONS Function}.

```sql
CREATE OR REPLACE VIEW mining_data AS
SELECT cust_id, cust_year_of_birth, cust_postal_code
FROM sh.customers;

DESCRIBE mining_data
<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_ID</td>
<td>NOT NULL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>NOT NULL</td>
<td>NUMBER(4)</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>NOT NULL</td>
<td>VARCHAR2(10)</td>
</tr>
</tbody>
</table>

BEGIN
  dbms_data_mining_transform.CREATE\_BIN\_NUM(
    bin_table_name   => 'bin\_tbl');
  dbms_data_mining_transform.INSERT\_AUTOBIN\_NUM\_EQWIDTH {
    bin_table_name   => 'bin\_tbl',
    data_table_name  => 'mining\_data',
    bin_num          => 3,
    max_bin_num      => 5,
    exclude_list     => dbms_data_mining_transform.COLUMN\_LIST('cust\_id'));
END;
/

set numwidth 4
column val off
SELECT col, val, bin FROM bin\_tbl
  ORDER BY val ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1913</td>
<td></td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1928</td>
<td>1</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1944</td>
<td>2</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1959</td>
<td>3</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1975</td>
<td>4</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1990</td>
<td>5</td>
</tr>
</tbody>
</table>

DECLARE
  year\_birth\_xform dbms_data_mining_transform.TRANSFORM\_LIST;
BEGIN
  dbms_data_mining_transform.STACK\_BIN\_NUM {
    bin_table_name   => 'bin\_tbl',
    xform\_list      => year\_birth\_xform};
  dbms_data_mining_transform.CREATE\_MODEL(
    model_name       => 'nb\_model',
    mining\_function => dbms_data_mining.classification,
    data_table_name  => 'mining\_data',
    case_id\_column_name => 'cust\_id',
    target\_column_name => 'cust\_postal\_code',
  );
END;
/
40.2.3.11 INSERT_BIN_CAT_FREQ Procedure

This procedure performs categorical binning and inserts the transformation definitions in a transformation definition table. The procedure computes the bin boundaries based on frequency.

INSERT_BIN_CAT_FREQ bins all the CHAR and VARCHAR2 columns in the data source unless you specify a list of columns to ignore.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.INSERT_BIN_CAT_FREQ (
    bin_table_name IN VARCHAR2,
    data_table_name IN VARCHAR2,
    bin_num IN PLS_INTEGER DEFAULT 9,
    exclude_list IN COLUMN_LIST DEFAULT NULL,
    default_num IN PLS_INTEGER DEFAULT 2,
    bin_support IN NUMBER DEFAULT NULL,
    bin_schema_name IN VARCHAR2 DEFAULT NULL,
    data_schema_name IN VARCHAR2 DEFAULT NULL);
```
Parameters

Table 40-142  INSERT_BIN_CAT_FREQ Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| bin_table_name    | Name of the transformation definition table for categorical binning. You can use the CREATE_BIN_CAT Procedure to create the definition table. The following columns are required:  
                  | COL       VARCHAR2(30) 
                  | VAL       VARCHAR2(4000) 
                  | BIN       VARCHAR2(4000)  
                  | CREATE_BIN_CAT creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_BIN_CAT_FREQ. |
| data_table_name   | Name of the table containing the data to be transformed                                                                                                                                                       |
| bin_num           | The number of bins to fill using frequency-based binning. The total number of bins will be bin_num+1. The additional bin is the default bin. Classes that are not assigned to a frequency-based bin will be assigned to the default bin.  
                  | The default binning order is from highest to lowest: the most frequently occurring class is assigned to the first bin, the second most frequently occurring class is assigned to the second bin, and so on. You can reverse the binning order by specifying a negative number for bin_num. The negative sign causes the binning order to be from lowest to highest.  
                  | If the total number of distinct values (classes) in the column is less than bin_num, then a separate bin will be created for each value and the default bin will be empty.  
                  | If you specify NULL or 0 for bin_num, no binning is performed. The default value of bin_num is 9.                                                                                                             |
| exclude_list      | List of categorical columns to be excluded from the binning process. If you do not specify exclude_list, all categorical columns in the data source are binned.  
                  | The format of exclude_list is:  
                  | dbms_data_mining_transform.COLUMN_LIST('col1','col2','...','coln') |
| default_num       | The number of class occurrences (rows of the same class) required for assignment to the default bin  
                  | By default, default_num is the minimum number of occurrences required for assignment to the default bin. For example, if default_num is 3 and a given class occurs only once, it will not be assigned to the default bin. You can change the occurrence requirement from minimum to maximum by specifying a negative number for default_num. For example, if default_num is -3 and a given class occurs only once, it will be assigned to the default bin, but a class that occurs four or more times will not be included.  
                  | If you specify NULL or 0 for default_bin, there are no requirements for assignment to the default bin. The default value of default_num is 2.                                                                 |
Table 40-142 (Cont.) INSERT_BIN_CAT_FREQ Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_support</td>
<td>The number of class occurrences (rows of the same class) required for assignment to a frequency-based bin. <em>bin_support</em> is expressed as a fraction of the total number of rows.</td>
</tr>
<tr>
<td></td>
<td>By default, <em>bin_support</em> is the minimum percentage required for assignment to a frequency-based bin. For example, if there are twenty rows of data and you specify .2 for <em>bin_support</em>, then there must be four or more occurrences of a class (.2*20) in order for it to be assigned to a frequency-based bin. You can change <em>bin_support</em> from a minimum percentage to a maximum percentage by specifying a negative number for <em>bin_support</em>. For example, if there are twenty rows of data and you specify -.2 for <em>bin_support</em>, then there must be four or less occurrences of a class in order for it to be assigned to a frequency-based bin. Classes that occur less than a positive <em>bin_support</em> or more than a negative <em>bin_support</em> will be assigned to the default bin.</td>
</tr>
<tr>
<td></td>
<td>If you specify NULL or 0 for <em>bin_support</em>, then there is no support requirement for frequency-based binning. The default value of <em>bin_support</em> is NULL.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of <em>bin_table_name</em>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of <em>data_table_name</em>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

1. See *Oracle Machine Learning for SQL User’s Guide* for details about categorical data.

2. If values occur with the same frequency, *INSERT_BIN_CAT_FREQ* assigns them in descending order when binning is from most to least frequent, or in ascending order when binning is from least to most frequent.

Examples

1. In this example, *INSERT_BIN_CAT_FREQ* computes the bin boundaries for the cust_postal_code and cust_city columns in sh.customers and inserts the transformations in a transformation definition table. The *STACK_BIN_CAT Procedure* creates a transformation list from the contents of the definition table, and the *CREATE_MODEL Procedure* embeds the transformation list in a new model called nb_model.

   The transformation and reverse transformation expressions embedded in nb_model are returned by the *GET_MODEL_TRANSFORMATIONS Function*.

   ```sql
   CREATE OR REPLACE VIEW mining_data AS
   SELECT cust_id, cust_year_of_birth, cust_postal_code, cust_city
   FROM sh.customers;
   
   DESCRIBE mining_data
   Name                      Null?    Type
   --------------------------------------- -------------------------
   CUST_ID                   NOT NULL NUMBER
   CUST_YEAR_OF_BIRTH        NOT NULL NUMBER(4)
   ```
CUST_POSTAL_CODE NOT NULL VARCHAR2(10)
CUST_CITY NOT NULL VARCHAR2(30)

BEGIN
    dbms_data_mining_transform.CREATE_BIN_CAT(
        bin_table_name   => 'bin_tbl_1',
    );
    dbms_data_mining_transform.INSERT_BIN_CAT_FREQ(
        bin_table_name   => 'bin_tbl_1',
        data_table_name  => 'mining_data',
        bin_num          => 4,
    );
END;
/

column col format a18
column val format a15
column bin format a10

SELECT col, val, bin
FROM bin_tbl_1
ORDER BY col ASC, bin ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_CITY</td>
<td>Los Angeles</td>
<td>1</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Greenwich</td>
<td>2</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Killarney</td>
<td>3</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Montara</td>
<td>4</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>38082</td>
<td>1</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>63736</td>
<td>2</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>55787</td>
<td>3</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>78558</td>
<td>4</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

DECLARE
    city_xform dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_BIN_CAT(
        bin_table_name           => 'bin_tbl_1',
        xform_list               => city_xform,
    );
    dbms_data_mining.CREATE_MODEL(
        model_name              => 'nb_model',
        mining_function         => dbms_data_mining.classification,
        data_table_name         => 'mining_data',
        case_id_column_name     => 'cust_id',
        target_column_name      => 'cust_city',
        settings_table_name     => null,
        data_schema_name        => null,
        settings_schema_name    => null,
        xform_list              => city_xform,
    );
END;
/

SELECT attribute_name
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('nb_model'));

ATTRIBUTE_NAME
-----------------------------
CUST_CITY
CUST_POSTAL_CODE

SELECT expression
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('nb_model'));

EXPRESSION
-----------------------------------------------------------------------------
DECODE("CUST_CITY" , 'Greenwich', '2', 'Killarney', '3', 'Los Angeles', '1',
'Montara', '4', NULL, NULL, '5')
DECODE("CUST_POSTAL_CODE" , '38082', '1', '55787', '3', '63736', '2', '78558', '4', NULL, NULL, '5')

SELECT reverse_expression
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('nb_model'));

REVERSE_EXPRESSION
-----------------------------------------------------------------------------
DECODE("CUST_CITY" , '2', '"Greenwich"', '3', '"Killarney"', '1',
'"Los Angeles", "4", "Montara", NULL, "DEFAULT")
DECODE("CUST_POSTAL_CODE" , '1', '"38082"', '3', '"55787"', '2', '"63736"',
'"78558", NULL, "DEFAULT")

2. The binning order in example 1 is from most frequent to least frequent. The
following example shows reverse order binning (least frequent to most frequent).
The binning order is reversed by setting bin_num to -4 instead of 4.

BEGIN
  dbms_data_mining_transform.CREATE_BIN_CAT(
    bin_table_name => 'bin_tbl_reverse',
  );
  dbms_data_mining_transform.INSERT_BIN_CAT_FREQ ( 
    bin_table_name => 'bin_tbl_reverse',
    data_table_name => 'mining_data',
    bin_num => -4); 
END;
/

column col format a20
SELECT col, val, bin
FROM bin_tbl_reverse
ORDER BY col ASC, bin ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_CITY</td>
<td>Tokyo</td>
<td>1</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Sliedrecht</td>
<td>2</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Haarlem</td>
<td>3</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>Diemen</td>
<td>4</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>49358</td>
<td>1</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>80563</td>
<td>2</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>74903</td>
<td>3</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td>71349</td>
<td>4</td>
</tr>
<tr>
<td>CUST_POSTAL_CODE</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

40.2.3.12 INSERT_BIN_NUM_EQWIDTH Procedure

This procedure performs numerical binning and inserts the transformation definitions in
a transformation definition table. The procedure identifies the minimum and maximum
values and computes the bin boundaries at equal intervals.

INSERT_BIN_NUM_EQWIDTH computes a specified number of bins (n) and assigns (max-
min)/n values to each bin. The number of bins is the same for each column. If you
want to use equi-width binning, but you want the number of bins to be calculated on a
per-column basis, use the INSERT_AUTOBIN_NUM_EQWIDTH Procedure.
INSERT_BIN_NUM_EQWIDTH bins all the NUMBER and FLOAT columns in the data source unless you specify a list of columns to ignore.

Syntax

DBMS_DATA_MINING_TRANSFORM.INSERT_BIN_NUM_EQWIDTH (  
  bin_table_name        IN VARCHAR2,  
  data_table_name       IN VARCHAR2,  
  bin_num               IN PLS_INTEGER DEFAULT 10,  
  exclude_list          IN COLUMN_LIST DEFAULT NULL,  
  round_num             IN PLS_INTEGER DEFAULT 6,  
  bin_schema_name       IN VARCHAR2 DEFAULT NULL,  
  data_schema_name      IN VARCHAR2 DEFAULT NULL);  

Parameters

Table 40-143  INSERT_BIN_NUM_EQWIDTH Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| bin_table_name     | Name of the transformation definition table for numerical binning. You can use the CREATE_BIN_NUM Procedure to create the definition table. The following columns are required:  
  COL   VARCHAR2(30)  
  VAL   NUMBER  
  BIN   VARCHAR2(4000)  

CREATE_BIN_NUM creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_BIN_NUM_EQWIDTH. |
| data_table_name    | Name of the table containing the data to be transformed                                                                                       |
| bin_num            | Number of bins. No binning occurs if bin_num is 0 or NULL. The default number of bins is 10.                                                  |
| exclude_list       | List of numerical columns to be excluded from the binning process. If you do not specify exclude_list, all numerical columns in the data source are binned.  
  The format of exclude_list is:  
  dbms_data_mining_transform.COLUMN_LIST('col1','col2',  
  ...'coln')  
| round_num          | Specifies how to round the number in the VAL column of the transformation definition table.  
  When round_num is positive, it specifies the most significant digits to retain.  
  When round_num is negative, it specifies the least significant digits to remove. In both cases, the result is rounded to the specified number of digits. See the Usage Notes for an example.  
  The default value of round_num is 6. |
| bin_schema_name    | Schema of bin_table_name. If no schema is specified, the current schema is used.                                                              |
| data_schema_name   | Schema of data_table_name. If no schema is specified, the current schema is used.                                                             |
Usage Notes


2. The round_num parameter controls the rounding of column values in the transformation definition table, as follows:

   For a value of 308.162:
   
   - when round_num = 1       result is 300
   - when round_num = 2       result is 310
   - when round_num = 3       result is 308
   - when round_num = 0       result is 308.162
   - when round_num = -1      result is 308.16
   - when round_num = -2      result is 308.2

3. INSERT_BIN_NUM_EQWIDTH ignores columns with all NULL values or only one unique value.

Examples

In this example, INSERT_BIN_NUM_EQWIDTH computes the bin boundaries for the affinity_card column in mining_data_build and inserts the transformations in a transformation definition table. The STACK_BIN_NUM Procedure creates a transformation list from the contents of the definition table. The CREATE_MODEL Procedure embeds the transformation list in a new model called glm_model.

The transformation and reverse transformation expressions embedded in glm_model are returned by the GET_MODEL_TRANSFORMATIONS Function.

```sql
CREATE OR REPLACE VIEW mining_data AS
SELECT cust_id, cust_income_level, cust_gender, affinity_card
FROM mining_data_build;

DESCRIBE mining_data
Name                      Null?    Type
------------------------- -------- -----------------
CUST_ID                   NOT NULL NUMBER
CUST_INCOME_LEVEL                  VARCHAR2(30)
CUST_GENDER                        VARCHAR2(1)
AFFINITY_CARD                      NUMBER(10)

BEGIN
    dbms_data_mining_transform.CREATE_BIN_NUM(
        bin_table_name => 'bin_tbl');
    dbms_data_mining_transform.INSERT_BIN_NUM_EQWIDTH (
        bin_table_name => 'bin_tbl',
        data_table_name => 'mining_data',
        bin_num => 4,
        exclude_list => dbms_data_mining_transform.COLUMN_LIST('cust_id'));
END;
/

set numwidth 10
column val off
column col format a20
column bin format a10
SELECT col, val, bin FROM bin_tbl
ORDER BY val ASC;
```
<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFINITY_CARD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>.25</td>
<td>1</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>.5</td>
<td>2</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>.75</td>
<td>3</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

CREATE TABLE glmsettings(
    setting_name VARCHAR2(30),
    setting_value VARCHAR2(30));

BEGIN
    INSERT INTO glmsettings (setting_name, setting_value) VALUES (
        dbms_data_mining.algo_name, dbms_data_mining.algo_generalized_linear_model);
    COMMIT;
END;
/

DECLARE
    xforms dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_BIN_NUM (
        bin_table_name => 'bin_tbl',
        xform_list => xforms,
        literal_flag => TRUE);
    dbms_data_mining.CREATE_MODEL(
        model_name => 'glm_model',
        mining_function => dbms_data_mining.regression,
        data_table_name => 'mining_data',
        case_id_column_name => 'cust_id',
        target_column_name => 'affinity_card',
        settings_table_name => 'glmsettings',
        data_schema_name => null,
        settings_schema_name => null,
        xform_list => xforms);
END;
/

SELECT attribute_name
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('glm_model'));

ATTRIBUTE_NAME
------------------------
AFFINITY_CARD

SELECT expression
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('glm_model'));

EXPRESSION
--------------------------------------------------------------------------------
CASE WHEN "AFFINITY_CARD"<0 THEN NULL WHEN "AFFINITY_CARD"<.25 THEN 1 WHEN "AFFINITY_CARD"<.5 THEN 2 WHEN "AFFINITY_CARD"<.75 THEN 3 WHEN "AFFINITY_CARD"<1 THEN 4 END

SELECT reverse_expression
FROM TABLE(dbms_data_mining.GET_MODEL_TRANSFORMATIONS('glm_model'));

REVERSE_EXPRESSION
--------------------------------------------------------------------------------
40.2.3.13 INSERT_BIN_NUM_QTILE Procedure

This procedure performs numerical binning and inserts the transformation definitions in a transformation definition table. The procedure calls the SQL \texttt{NTILE} function to order the data and divide it equally into the specified number of bins (quantiles).

\texttt{INSERT_BIN_NUM_QTILE} bins all the \texttt{NUMBER} and \texttt{FLOAT} columns in the data source unless you specify a list of columns to ignore.

Syntax

\begin{verbatim}
DBMS_DATA_MINING_TRANSFORM.INSERT_BIN_NUM_QTILE (
    bin_table_name       IN VARCHAR2,
    data_table_name      IN VARCHAR2,
    bin_num              IN PLS_INTEGER DEFAULT 10,
    exclude_list         IN COLUMN_LIST DEFAULT NULL,
    bin_schema_name      IN VARCHAR2 DEFAULT NULL,
    data_schema_name     IN VARCHAR2 DEFAULT NULL);
\end{verbatim}

Parameters

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
Parameter & Description \\
\hline
\texttt{bin_table_name} & Name of the transformation definition table for numerical binning. You can use the \texttt{CREATE_BIN_NUM Procedure} to create the definition table. The following columns are required: \\
& \begin{align*}
   \text{COL} & \quad \text{VARCHAR2(30)} \\
   \text{VAL} & \quad \text{NUMBER} \\
   \text{BIN} & \quad \text{VARCHAR2(4000)}
\end{align*} \\
& \texttt{CREATE BIN NUM} creates an additional column, \texttt{ATT}, which may be used for specifying nested attributes. This column is not used by \texttt{INSERT_BIN_NUM_QTILE}. \\
\texttt{data_table_name} & Name of the table containing the data to be transformed \\
\texttt{bin_num} & Number of bins. No binning occurs if \texttt{bin_num} is 0 or NULL. The default number of bins is 10. \\
\texttt{exclude_list} & List of numerical columns to be excluded from the binning process. If you do not specify \texttt{exclude_list}, all numerical columns in the data source are binned. The format of \texttt{exclude_list} is: \\
& \texttt{dbms_data_mining_transform.COLUMN_LIST('col1','col2',...,'coln')} \\
\texttt{bin_schema_name} & Schema of \texttt{bin_table_name}. If no schema is specified, the current schema is used. \\
\texttt{data_schema_name} & Schema of \texttt{data_table_name}. If no schema is specified, the current schema is used. \\
\hline
\end{tabular}
\end{table}
Usage Notes


2. After dividing the data into quantiles, the NTILE function distributes any remainder values one for each quantile, starting with the first. See Oracle Database SQL Language Reference for details.

3. Columns with all NULL values are ignored by INSERT_BIN_NUM_QTILE.

Examples

In this example, INSERT_BIN_NUM_QTILE computes the bin boundaries for the cust_year_of_birth and cust_credit_limit columns in sh.customers and inserts the transformations in a transformation definition table. The STACK_BIN_NUM Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in STACK_VIEW. The view is for display purposes only; it cannot be used to embed the transformations in a model.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_credit_limit, cust_city
    FROM sh.customers;

DESCRIBE mining_data
Name                                    Null?    Type
--------------------------------------- -------- -----------------------------
CUST_ID                                 NOT NULL NUMBER
CUST_YEAR_OF_BIRTH                      NOT NULL NUMBER(4)
CUST_CREDIT_LIMIT                       NUMBER
CUST_CITY                               NOT NULL VARCHAR2(30)

BEGIN
    dbms_data_mining_transform.CREATE_BIN_NUM(
        bin_table_name   => 'bin_tbl');
    dbms_data_mining_transform.INSERT_BIN_NUM_QTILE ( 
        bin_table_name   => 'bin_tbl',
        data_table_name  => 'mining_data',
        bin_num          => 3,
        exclude_list     => dbms_data_mining_transform.COLUMN_LIST('cust_id'));
END;
/
```

```
set numwidth 8
column val off
column col format a20
column bin format a10
SELECT col, val, bin
    FROM bin_tbl
    ORDER BY col ASC, val ASC;

COL               VAL  BIN
----------------------- -------
CUST_CREDIT_LIMIT   1500  
CUST_CREDIT_LIMIT   3000  1
CUST_CREDIT_LIMIT   9000  2
CUST_CREDIT_LIMIT  15000  3
CUST_YEAR_OF_BIRTH  1913  
CUST_YEAR_OF_BIRTH  1949  1
CUST_YEAR_OF_BIRTH  1965  2
```
CUST_YEAR_OF_BIRTH  1990 3

DECLARE 
  xforms   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN 
  dbms_data_mining_transform.STACK_BIN_NUM ( 
    bin_table_name        => 'bin_tbl', 
    xform_list            => xforms);
  dbms_data_mining_transform.XFORM_STACK ( 
    xform_list            => xforms, 
    data_table_name       => 'mining_data', 
    xform_view_name       => 'stack_view');
END;
/

set long 3000
SELECT text FROM user_views WHERE view_name in 'STACK_VIEW';

TEXT

SELECT "CUST_ID",CASE WHEN "CUST_YEAR_OF_BIRTH"<1913 THEN NULL WHEN "CUST_YEAR_OF_BIRTH"<=1949 THEN '1' WHEN "CUST_YEAR_OF_BIRTH"<=1965 THEN '2' WHEN "CUST_YEAR_OF_BIRTH"<=1990 THEN '3' END "CUST_YEAR_OF_BIRTH",CASE WHEN "CUST_CREDIT_LIMIT"<1500 THEN NULL WHEN "CUST_CREDIT_LIMIT"<=3000 THEN '1' WHEN "CUST_CREDIT_LIMIT"<=9000 THEN '2' WHEN "CUST_CREDIT_LIMIT"<=15000 THEN '3' END "CUST_CREDIT_LIMIT","CUST_CITY" FROM mining_data

40.2.3.14 INSERT_BIN_SUPER Procedure

This procedure performs numerical and categorical binning and inserts the transformation definitions in transformation definition tables. The procedure computes bin boundaries based on intrinsic relationships between predictors and a target.

INSERT_BIN_SUPER uses an intelligent binning technique known as supervised binning. It builds a single-predictor decision tree and derives the bin boundaries from splits within the tree.

INSERT_BIN_SUPER bins all the VARCHAR2, CHAR, NUMBER, and FLOAT columns in the data source unless you specify a list of columns to ignore.

Syntax

DBMS_DATA_MINING_TRANSFORM.INSERT_BIN_SUPER ( 
  num_table_name        IN VARCHAR2, 
  cat_table_name        IN VARCHAR2, 
  data_table_name       IN VARCHAR2, 
  target_column_name    IN VARCHAR2, 
  max_bin_num           IN PLS_INTEGER  DEFAULT 1000, 
  exclude_list          IN COLUMN_LIST  DEFAULT NULL, 
  num_schema_name       IN VARCHAR2 DEFAULT NULL, 
  cat_schema_name       IN VARCHAR2 DEFAULT NULL, 
  data_schema_name      IN VARCHAR2 DEFAULT NULL, 
  rem_table_name        IN VARCHAR2 DEFAULT NULL, 
  rem_schema_name       IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-145  INSERT_BIN_SUPER Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>num_table_name</td>
<td>Name of the transformation definition table for numerical binning. You can use the CREATE_BIN_NUM Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL</td>
</tr>
<tr>
<td></td>
<td>VAL</td>
</tr>
<tr>
<td></td>
<td>BIN</td>
</tr>
<tr>
<td></td>
<td>CREATE_BIN_NUM creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_BIN_SUPER.</td>
</tr>
<tr>
<td>cat_table_name</td>
<td>Name of the transformation definition table for categorical binning. You can use the CREATE_BIN_CAT Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL</td>
</tr>
<tr>
<td></td>
<td>VAL</td>
</tr>
<tr>
<td></td>
<td>BIN</td>
</tr>
<tr>
<td></td>
<td>CREATE_BIN_CAT creates an additional column, ATT, which is used for specifying nested attributes. This column is not used by INSERT_BIN_SUPER.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Name of a column to be used as the target for the decision tree models</td>
</tr>
<tr>
<td>max_bin_num</td>
<td>The maximum number of bins. The default is 1000.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of columns to be excluded from the binning process. If you do not specify exclude_list, all numerical and categorical columns in the data source are binned.</td>
</tr>
<tr>
<td></td>
<td>The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2',...'coln')</td>
</tr>
<tr>
<td>num_schema_name</td>
<td>Schema of num_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>cat_schema_name</td>
<td>Schema of cat_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>rem_table_name</td>
<td>Name of a column removal definition table. The table must have the columns described in &quot;CREATE_COL_REM Procedure&quot;. You can use CREATE_COL_REM to create the table. See Usage Notes.</td>
</tr>
<tr>
<td>rem_schema_name</td>
<td>Schema of rem_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>
Usage Notes


2. Columns that have no significant splits are not binned. You can remove the unbinned columns from the mining data by specifying a column removal definition table. If you do not specify a column removal definition table, the unbinned columns remain in the mining data.

3. See Oracle Machine Learning for SQL Concepts to learn more about decision trees in Oracle Machine Learning for SQL

Examples

In this example, INSERT_BIN_SUPER computes the bin boundaries for predictors of cust_credit_limit and inserts the transformations in transformation definition tables. One predictor is numerical, the other is categorical. (INSERT_BIN_SUPER determines that the cust_postal_code column is not a significant predictor.) STACK procedures create transformation lists from the contents of the definition tables.

The SQL expressions that compute the transformations are shown in the views MINING_DATA_STACK_NUM and MINING_DATA_STACK_CAT. The views are for display purposes only; they cannot be used to embed the transformations in a model.

```sql
CREATE OR REPLACE VIEW mining_data AS
SELECT cust_id, cust_year_of_birth, cust_marital_status,
cust_postal_code, cust_credit_limit
FROM sh.customers;
DESCRIBE mining_data
Name                              Null?    Type
-------------------------------- -------- ------------------------------------
CUST_ID                          NOT NULL NUMBER
CUST_YEAR_OF_BIRTH               NOT NULL NUMBER(4)
CUST_MARITAL_STATUS                       VARCHAR2(20)
CUST_POSTAL_CODE                 NOT NULL VARCHAR2(10)
CUST_CREDIT_LIMIT                         NUMBER
BEGIN
  dbms_data_mining_transform.CREATE_BIN_NUM(
    bin_table_name      => 'bin_num_tbl');
  dbms_data_mining_transform.CREATE_BIN_CAT(
    bin_table_name      => 'bin_cat_tbl');
  dbms_data_mining_transform.CREATE_COL_REM(
    rem_table_name      => 'rem_tbl');
END;
/
BEGIN
  COMMIT;
  dbms_data_mining_transform.INSERT_BIN_SUPER {
    num_table_name   => 'bin_num_tbl',
    cat_table_name   => 'bin_cat_tbl',
    data_table_name  => 'mining_data',
    target_column_name => 'cust_credit_limit',
    max_bin_num       => 4,
    exclude_list      => dbms_data_mining_transform.COLUMN_LIST('cust_id'),
    num_schema_name   => 'oml_user',
    cat_schema_name   => 'oml_user',
```
data_schema_name    => 'oml_user',
rem_table_name      => 'rem_tbl',
rem_schema_name     => 'oml_user');
COMMIT;
END;
/

set numwidth 8
column val off
SELECT col, val, bin FROM bin_num_tbl
   ORDER BY bin ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1923.5</td>
<td>1</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1923.5</td>
<td>1</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1945.5</td>
<td>2</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1980.5</td>
<td>3</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

column val on
column val format a20
SELECT col, val, bin FROM bin_cat_tbl
   ORDER BY bin ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
<th>BIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>married</td>
<td>1</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>single</td>
<td>2</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Mar-AF</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Mabsent</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Divorc.</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Married</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Widowed</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>NeverM</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>Separ.</td>
<td>3</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>divorced</td>
<td>4</td>
</tr>
<tr>
<td>CUST_MARITAL_STATUS</td>
<td>widow</td>
<td>4</td>
</tr>
</tbody>
</table>

SELECT col from rem_tbl;

<table>
<thead>
<tr>
<th>COL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_POSTAL_CODE</td>
</tr>
</tbody>
</table>

DECLARE
xforms_num      dbms_data_mining_transform.TRANSFORM_LIST;
xforms_cat      dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
   dbms_data_mining_transform.STACK_BIN_NUM {
      bin_table_name    => 'bin_num_tbl',
      xform_list        => xforms_num);
   dbms_data_mining_transform.XFORM_STACK {
      xform_list        => xforms_num,
      data_table_name   => 'mining_data',
      xform_view_name   => 'mining_data_stack_num');
   dbms_data_mining_transform.STACK_BIN_CAT {
      bin_table_name    => 'bin_cat_tbl',
      xform_list        => xforms_cat);
   dbms_data_mining_transform.XFORM_STACK {
      xform_list        => xforms_cat,
40.2.3.15 INSERT_CLIP_TRIM_TAIL Procedure

This procedure replaces numeric outliers with nulls and inserts the transformation definitions in a transformation definition table.

**INSERT_CLIP_TRIM_TAIL** computes the boundaries of the data based on a specified percentage. It removes the values that fall outside the boundaries (tail values) from the data. If you wish to replace the tail values instead of removing them, use the **INSERT_CLIP_WINSOR_TAIL** Procedure.

**INSERT_CLIP_TRIM_TAIL** clips all the NUMBER and FLOAT columns in the data source unless you specify a list of columns to ignore.

**Syntax**

```sql
DBMS_DATA_MINING_TRANSFORM.INSERT_CLIP_TRIM_TAIL (
    clip_table_name IN VARCHAR2,
    data_table_name IN VARCHAR2,
    tail_frac IN NUMBER DEFAULT 0.025,
    exclude_list IN COLUMN_LIST DEFAULT NULL,
    clip_schema_name IN VARCHAR2 DEFAULT NULL,
    data_schema_name IN VARCHAR2 DEFAULT NULL);
```

---

```sql
SELECT "CUST_ID",CASE WHEN "CUST_YEAR_OF_BIRTH"<1923.5 THEN '1' WHEN "CUST_YEAR_OF_BIRTH"<=1923.5 THEN '1' WHEN "CUST_YEAR_OF_BIRTH"<=1945.5 THEN '2' WHEN "CUST_YEAR_OF_BIRTH"<=1980.5 THEN '3' WHEN "CUST_YEAR_OF_BIRTH" IS NOT NULL THEN '4' END "CUST_YEAR_OF_BIRTH","CUST_MARITAL_STATUS","CUST_POSTAL_CODE","CUST_CREDIT_LIMIT" FROM mining_data
```

```sql
SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_STACK_NUM';
```

```sql
SELECT "CUST_ID","CUST_YEAR_OF_BIRTH",DECODE("CUST_MARITAL_STATUS","Divorc.'','3'
 ,'.Mabsent','3','.Mar-AF','3','Married','3','NeverM','3','Separ.','3','Widowed','3
 ','divorced','4','married','1','single','2','widow','4') "CUST_MARITAL_STATUS","CUST_POSTAL_CODE","CUST_CREDIT_LIMIT" FROM mining_data
```
Parameters

Table 40-146  INSERT_CLIP_TRIM_TAIL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clip_table_name</td>
<td>Name of the transformation definition table for numerical clipping. You can use the CREATE_CLIP Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>LCUT NUMBER</td>
</tr>
<tr>
<td></td>
<td>LVAL NUMBER</td>
</tr>
<tr>
<td></td>
<td>RCUT NUMBER</td>
</tr>
<tr>
<td></td>
<td>RVAL NUMBER</td>
</tr>
<tr>
<td></td>
<td>CREATE_CLIP creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_CLIP_TRIM_TAIL.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>tail_frac</td>
<td>The percentage of non-null values to be designated as outliers at each end of the data. For example, if tail_frac is .01, then 1% of the data at the low end and 1% of the data at the high end will be treated as outliers. If tail_frac is greater than or equal to .5, no clipping occurs. The default value of tail_frac is 0.025.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to be excluded from the clipping process. If you do not specify exclude_list, all numerical columns in the data are clipped. The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2','...','coln')</td>
</tr>
<tr>
<td>clip_schema_name</td>
<td>Schema of clip_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes


2. The DBMS_DATA_MINING_TRANSFORM package provides two clipping procedures: INSERT_CLIP_TRIM_TAIL and INSERT_CLIP_WINSOR_TAIL. Both procedures compute the boundaries as follows:
   - Count the number of non-null values, n, and sort them in ascending order
   - Calculate the number of outliers, t, as n*tail_frac
   - Define the lower boundary lcut as the value at position 1+floor(t)
   - Define the upper boundary rcut as the value at position n-floor(t)
   (The SQL FLOOR function returns the largest integer less than or equal to t.)
   - All values that are <= lcut or => rcut are designated as outliers.
**INSERT_CLIP_TRIM_TAIL** replaces the outliers with nulls, effectively removing them from the data.

**INSERT_CLIP_WINSOR_TAIL** assigns \( l_{cut} \) to the low outliers and \( r_{cut} \) to the high outliers.

**Examples**

In this example, **INSERT_CLIP_TRIM_TAIL** trims 10% of the data in two columns (5% from the high end and 5% from the low end) and inserts the transformations in a transformation definition table. The **STACK_CLIP** Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the trimming is shown in the view **MINING_DATA_STACK**. The view is for display purposes only; it cannot be used to embed the transformations in a model.

```sql
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_credit_limit, cust_city
    FROM sh.customers;

DESCRIBE mining_data
Name         Null?    Type
------------------------- -------- -------------------
CUST_ID       NOT NULL NUMBER
CUST_YEAR_OF_BIRTH NOT NULL NUMBER(4)
CUST_CREDIT_LIMIT NUMBER
CUST_CITY       NOT NULL VARCHAR2(30)

BEGIN
    dbms_data_mining_transform.CREATE_CLIP(
        clip_table_name => 'clip_tbl');
    dbms_data_mining_transform.INSERT_CLIP_TRIM_TAIL(
        clip_table_name => 'clip_tbl',
        data_table_name => 'mining_data',
        tail_frac        => 0.05,
        exclude_list     => DBMS_DATA_MINING_TRANSFORM.COLUMN_LIST('cust_id'));
END;
/

SELECT col, icut, lval, rcut, rval
FROM clip_tbl
ORDER BY col ASC;

COL                      LCUT     LVAL     RCUT     RVAL
-------------------- -------- -------- -------- --------
CUST_CREDIT_LIMIT        1500             11000
CUST_YEAR_OF_BIRTH       1934              1982

DECLARE
    xforms      dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_CLIP (
        clip_table_name => 'clip_tbl',
        xform_list => xforms);
    dbms_data_mining_transform.XFORM_STACK (
        xform_list => xforms,
        data_table_name => 'mining_data',
        xform_view_name => 'mining_data_stack');
END;
/
set long 3000
SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_STACK';

TEXT
-------------------------------------------------------------------------------------------------
SELECT "CUST_ID",CASE WHEN "CUST_YEAR_OF_BIRTH" < 1934 THEN NULL WHEN "CUST_YEAR_OF_BIRTH" > 1982 THEN NULL ELSE "CUST_YEAR_OF_BIRTH" END "CUST_YEAR_OF_BIRTH",CASE WHEN "CUST_CREDIT_LIMIT" < 1500 THEN NULL WHEN "CUST_CREDIT_LIMIT" > 11000 THEN NULL ELSE "CUST_CREDIT_LIMIT" END "CUST_CREDIT_LIMIT","CUST_CITY" FROM mining_data

40.2.3.16 INSERT_CLIP_WINSOR_TAIL Procedure

This procedure replaces numeric outliers with the upper or lower boundary values. It inserts the transformation definitions in a transformation definition table.

INSERT_CLIP_WINSOR_TAIL computes the boundaries of the data based on a specified percentage. It replaces the values that fall outside the boundaries (tail values) with the related boundary value. If you wish to set tail values to null, use the INSERT_CLIP_TRIM_TAIL Procedure.

INSERT_CLIP_WINSOR_TAIL clips all the NUMBER and FLOAT columns in the data source unless you specify a list of columns to ignore.

Syntax

DBMS_DATA_MINING_TRANSFORM.INSERT_CLIP_WINSOR_TAIL (clip_table_name    IN VARCHAR2,
data_table_name    IN VARCHAR2,
tail_frac          IN NUMBER DEFAULT 0.025,
exclude_list       IN COLUMN_LIST DEFAULT NULL,
clip_schema_name   IN VARCHAR2 DEFAULT NULL,
data_schema_name   IN VARCHAR2 DEFAULT NULL);

Parameters

Table 40-147  INSERT_CLIP_WINSOR_TAIL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clip_table_name</td>
<td>Name of the transformation definition table for numerical clipping. You can use the CREATE_CLIP Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>LCUT NUMBER</td>
</tr>
<tr>
<td></td>
<td>LVAL NUMBER</td>
</tr>
<tr>
<td></td>
<td>RCUT NUMBER</td>
</tr>
<tr>
<td></td>
<td>RVAL NUMBER</td>
</tr>
<tr>
<td>CREATE_CLIP creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_CLIP_WINSOR_TAIL.</td>
<td></td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
</tbody>
</table>
Table 40-147 (Cont.) INSERT_CLIP_WINSOR_TAIL Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tail_frac</td>
<td>The percentage of non-null values to be designated as outliers at each end</td>
</tr>
<tr>
<td></td>
<td>of the data. For example, if tail_frac is .01, then 1% of the data at the</td>
</tr>
<tr>
<td></td>
<td>low end and 1% of the data at the high end will be treated as outliers.</td>
</tr>
<tr>
<td></td>
<td>If tail_frac is greater than or equal to .5, no clipping occurs.</td>
</tr>
<tr>
<td></td>
<td>The default value of tail_frac is 0.025.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to be excluded from the clipping process. If you</td>
</tr>
<tr>
<td></td>
<td>do not specify exclude_list, all numerical columns in the data are clipped.</td>
</tr>
<tr>
<td></td>
<td>The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2','...','coln')</td>
</tr>
<tr>
<td>clip_schema_name</td>
<td>Schema of clip_table_name. If no schema is specified, the current</td>
</tr>
<tr>
<td></td>
<td>schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current</td>
</tr>
<tr>
<td></td>
<td>schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes


2. The DBMS_DATA_MINING_TRANSFORM package provides two clipping procedures: INSERT_CLIP_WINSOR_TAIL and INSERT_CLIP_TRIM_TAIL. Both procedures compute the boundaries as follows:
   - Count the number of non-null values, n, and sort them in ascending order
   - Calculate the number of outliers, t, as n*tail_frac
   - Define the lower boundary lcut as the value at position 1+floor(t)
   - Define the upper boundary rcut as the value at position n-floor(t)
     (The SQL FLOOR function returns the largest integer less than or equal to t.)
   - All values that are <= lcut or => rcut are designated as outliers.
     INSERT_CLIP_WINSOR_TAIL assigns lcut to the low outliers and rcut to the high outliers.
     INSERT_CLIP_TRIM_TAIL replaces the outliers with nulls, effectively removing them from the data.

Examples

In this example, INSERT_CLIP_WINSOR_TAIL winsorizes 10% of the data in two columns (5% from the high end, and 5% from the low end) and inserts the transformations in a transformation definition table. The STACK_CLIP Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view MINING_DATA_STACK. The view is for display purposes only; it cannot be used to embed the transformations in a model.
CREATE OR REPLACE VIEW mining_data AS
  SELECT cust_id, cust_year_of_birth, cust_credit_limit, cust_city
  FROM sh.customers;

describe mining_data

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_ID</td>
<td>NOT NULL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>NOT NULL</td>
<td>NUMBER(4)</td>
</tr>
<tr>
<td>CUST_CREDIT_LIMIT</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>CUST_CITY</td>
<td>NOT NULL</td>
<td>VARCHAR2(30)</td>
</tr>
</tbody>
</table>

BEGIN
  dbms_data_mining_transform.CREATE_CLIP(
    clip_table_name   => 'clip_tbl');
  dbms_data_mining_transform.INSERT_CLIP_WINSOR_TAIL(
    clip_table_name   => 'clip_tbl',
    data_table_name   => 'mining_data',
    tail_frac         => 0.05,
    exclude_list      => DBMS_DATA_MINING_TRANSFORM.COLUMN_LIST('cust_id'));
END;
/

SELECT col, lcut, lval, rcut, rval FROM clip_tbl
ORDER BY col ASC;

<table>
<thead>
<tr>
<th>COL</th>
<th>LCUT</th>
<th>LVAL</th>
<th>RCUT</th>
<th>RVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_CREDIT_LIMIT</td>
<td>1500</td>
<td>1500</td>
<td>11000</td>
<td>11000</td>
</tr>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1934</td>
<td>1934</td>
<td>1982</td>
<td>1982</td>
</tr>
</tbody>
</table>

DECLARE
  xforms      dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.STACK_CLIP(
    clip_table_name    => 'clip_tbl',
    xform_list        => xforms);
  dbms_data_mining_transform.XFORM_STACK(
    xform_list         => xforms,
    data_table_name    => 'mining_data',
    xform_view_name    => 'mining_data_stack');
END;
/

set long 3000
SQL> SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_STACK';

TEXT
--------------------------------------------------------------------------------
SELECT "CUST_ID",CASE WHEN "CUST_YEAR_OF_BIRTH" < 1934 THEN 1934 WHEN "CUST_YEAR_OF_BIRTH" > 1982 THEN 1982 ELSE "CUST_YEAR_OF_BIRTH" END "CUST_YEAR_OF_BIRTH",CASE WHEN "CUST_CREDIT_LIMIT" < 1500 THEN 1500 WHEN "CUST_CREDIT_LIMIT" > 11000 THEN 11000 ELSE "CUST_CREDIT_LIMIT" END "CUST_CREDIT_LIMIT","CUST_CITY" FROM mining_data
40.2.3.17 INSERT_MISS_CAT_MODE Procedure

This procedure replaces missing categorical values with the value that occurs most frequently in the column (the mode). It inserts the transformation definitions in a transformation definition table.

**INSERT_MISS_CAT_MODE** replaces missing values in all **VARCHAR2** and **CHAR** columns in the data source unless you specify a list of columns to ignore.

**Syntax**

```
DBMS_DATA_MINING_TRANSFORM.INSERT_MISS_CAT_MODE (  
  miss_table_name    IN VARCHAR2,  
  data_table_name    IN VARCHAR2,  
  exclude_list       IN COLUMN_LIST DEFAULT NULL,  
  miss_schema_name   IN VARCHAR2 DEFAULT NULL,  
  data_schema_name   IN VARCHAR2 DEFAULT NULL);
```

**Parameters**

**Table 40-148  INSERT_MISS_CAT_MODE Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for categorical missing value treatment. You can use the CREATE_MISS_CAT Procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COL VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>VAL VARCHAR2(4000)</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of categorical columns to be excluded from missing value treatment. If you do not specify exclude_list, all categorical columns are transformed. The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1', 'col2', ...'coln')</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

1. See *Oracle Machine Learning for SQL User’s Guide* for details about categorical data.
2. If you wish to replace categorical missing values with a value other than the mode, you can edit the transformation definition table.
Example

In this example, `INSERT_MISS_CAT_MODE` computes missing value treatment for `cust_city` and inserts the transformation in a transformation definition table. The `STACK_MISS_CAT` Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view `MINING_DATA_STACK`. The view is for display purposes only; it cannot be used to embed the transformations in a model.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_city
    FROM sh.customers;

describe mining_data

Name          Null?    Type
--------------- -------- ----------------
CUST_ID       NOT NULL NUMBER
CUST_YEAR_OF_BIRTH  NOT NULL NUMBER(4)
CUST_CITY     NOT NULL VARCHAR2(30)

BEGIN
    dbms_data_mining_transform.create_miss_cat(
        miss_table_name   => 'missc_tbl');
    dbms_data_mining_transform.insert_miss_cat_mode(
        miss_table_name   => 'missc_tbl',
        data_table_name   => 'mining_data');
END;
/

SELECT stats_mode(cust_city) FROM mining_data;

STATS_MODE(CUST_CITY)
----------------------
Los Angeles

SELECT col, val
    FROM missc_tbl;

COL          VAL
------------- ---------------------
CUST_CITY    Los Angeles

DECLARE
    xforms dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_MISS_CAT (
        miss_table_name => 'missc_tbl',
        xform_list      => xforms);
    dbms_data_mining_transform.XFORM_STACK (
        xform_list      => xforms,
        data_table_name => 'mining_data',
        xform_view_name => 'mining_data_stack');
```
40.2.3.18 INSERT_MISS_NUM_MEAN Procedure

This procedure replaces missing numerical values with the average (the mean) and inserts the transformation definitions in a transformation definition table.

INSERT_MISS_NUM_MEAN replaces missing values in all NUMBER and FLOAT columns in the data source unless you specify a list of columns to ignore.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.INSERT_MISS_NUM_MEAN (  
    miss_table_name    IN VARCHAR2,  
    data_table_name    IN VARCHAR2,  
    exclude_list       IN COLUMN_LIST DEFAULT NULL,  
    round_num          IN PLS_INTEGER DEFAULT 6,  
    miss_schema_name   IN VARCHAR2 DEFAULT NULL,  
    data_schema_name   IN VARCHAR2 DEFAULT NULL);
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for numerical missing value treatment. You can use the <code>CREATE_MISS_NUM</code> Procedure to create the definition table.</td>
</tr>
<tr>
<td></td>
<td>The following columns are required by INSERT_MISS_NUM_MEAN:</td>
</tr>
<tr>
<td></td>
<td>COL          VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>VAL          NUMBER</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to be excluded from missing value treatment. If you do not specify exclude_list, all numerical columns are transformed.</td>
</tr>
<tr>
<td></td>
<td>The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_minining_transform.COLUMN_LIST('col1','col2',...,'coln')</td>
</tr>
<tr>
<td>round_num</td>
<td>The number of significant digits to use for the mean. The default number is 6.</td>
</tr>
</tbody>
</table>
Table 40-149  (Cont.) INSERT_MISS_NUM_MEAN Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

2. If you wish to replace numerical missing values with a value other than the mean, you can edit the transformation definition table.

Example

In this example, INSERT_MISS_NUM_MEAN computes missing value treatment for cust_year_of_birth and inserts the transformation in a transformation definition table. The STACK_MISS_NUM Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view MINING_DATA_STACK. The view is for display purposes only; it cannot be used to embed the transformations in a model.

```sql
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_year_of_birth, cust_city
    FROM sh.customers;

DESCRIBE mining_data
Name                                      Null?    Type
------------------------------------------ -------- -------------------
cust_id                                   NOT NULL NUMBER
cust_year_of_birth                        NOT NULL NUMBER(4)
cust_city                                 NOT NULL VARCHAR2(30)

BEGIN
    dbms_data_mining_transform.create_miss_num(
        miss_table_name => 'missn_tbl');
    dbms_data_mining_transform.insert_miss_num_mean(
        miss_table_name => 'missn_tbl',
        data_table_name => 'mining_data',
        exclude_list => DBMS_DATA_MINING_TRANSFORM.COLUMN_LIST('cust_id'));
END;
/
```

set numwidth 4
column val off
SELECT col, val
40.2.3.19 INSERT_NORM_LIN_MINMAX Procedure

This procedure performs linear normalization and inserts the transformation definitions in a transformation definition table.

INSERT_NORM_LIN_MINMAX computes the minimum and maximum values from the data and sets the value of \texttt{shift} and \texttt{scale} as follows:

\begin{align*}
\texttt{shift} &= \text{min} \\
\texttt{scale} &= \max - \text{min}
\end{align*}

Normalization is computed as:

\begin{align*}
\texttt{x\_new} &= (\texttt{x\_old} - \texttt{shift})/\texttt{scale}
\end{align*}

INSERT_NORM_LIN_MINMAX rounds the value of \texttt{scale} to a specified number of significant digits before storing it in the transformation definition table.

INSERT_NORM_LIN_MINMAX normalizes all the \texttt{NUMBER} and \texttt{FLOAT} columns in the data source unless you specify a list of columns to ignore.

Syntax

\begin{verbatim}
DBMS_DATA_MINING_TRANSFORM.INSERT_NORM_LIN_MINMAX (  
    norm_table_name IN VARCHAR2,  
    data_table_name IN VARCHAR2,  
    exclude_list IN COLUMN_LIST DEFAULT NULL,

) 
\end{verbatim}
Parameters

Table 40-150  INSERT_NORM_LIN_MINMAX Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| norm_table_name | Name of the transformation definition table for linear normalization. You can use the CREATE_NORM_LIN Procedure to create the definition table. The following columns are required:  
COL: VARCHAR2(30)  
SHIFT: NUMBER  
SCALE: NUMBER  
CREATE_NORM_LIN creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_NORM_LIN_MINMAX. |
| data_table_name | Name of the table containing the data to be transformed                     |
| exclude_list    | List of numerical columns to be excluded from normalization. If you do not specify exclude_list, all numerical columns are transformed.  
The format of exclude_list is:  
dbms_data_mining_transform.COLUMN_LIST('col1','col2', '...','coln') |
| round_num       | The number of significant digits to use for the minimum and maximum. The default number is 6. |
| norm_schema_name| Schema of norm_table_name. If no schema is specified, the current schema is used. |
| data_schema_name| Schema of data_table_name. If no schema is specified, the current schema is used. |

Usage Notes


Examples

In this example, INSERT_NORM_LIN_MINMAX normalizes the cust_year_of_birth column and inserts the transformation in a transformation definition table. The STACK_NORM_LIN Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view MINING_DATA_STACK. The view is for display purposes only; it cannot be used to embed the transformations in a model.

CREATE OR REPLACE VIEW mining_data AS  
SELECT cust_id, cust_gender, cust_year_of_birth  
FROM sh.customers;

describe mining_data
Name                         Null?  Type
------------------------------  ------ ------------
CUST_ID                      NOT NULL NUMBER
### 40.2.3.20 INSERT_NORM_LIN_SCALE Procedure

This procedure performs linear normalization and inserts the transformation definitions in a transformation definition table.

**INSERT_NORM_LIN_SCALE** computes the minimum and maximum values from the data and sets the value of **shift** and **scale** as follows:

\[
\begin{align*}
\text{shift} & = 0 \\
\text{scale} & = \max(\abs{\max}, \abs{\min})
\end{align*}
\]

Normalization is computed as:

\[
x_{\text{new}} = \frac{x_{\text{old}}}{\text{scale}}
\]

**INSERT_NORM_LIN_SCALE** rounds the value of **scale** to a specified number of significant digits before storing it in the transformation definition table.
**Insert Norm Lin Scale** normalizes all the *number* and *float* columns in the data source unless you specify a list of columns to ignore.

**Syntax**

```sql
DBMS_DATA_MINING_TRANSFORM.INSERT_NORM_LIN_SCALE (  
    norm_table_name     IN VARCHAR2,  
    data_table_name     IN VARCHAR2,  
    exclude_list        IN COLUMN_LIST DEFAULT NULL,  
    round_num           IN PLS_INTEGER DEFAULT 6,  
    norm_schema_name    IN VARCHAR2 DEFAULT NULL,  
    data_schema_name    IN VARCHAR2 DEFAULT NULL);
```

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>norm_table_name</td>
<td>Name of the transformation definition table for linear normalization. You can use the <code>CREATE_NORM_LIN</code> procedure to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td><code>COL</code> VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td><code>SHIFT</code> NUMBER</td>
</tr>
<tr>
<td></td>
<td><code>SCALE</code> NUMBER</td>
</tr>
<tr>
<td></td>
<td><code>CREATE_NORM_LIN</code> creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by <code>INSERT_NORM_LIN_SCALE</code>.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to be excluded from normalization. If you do not specify <code>exclude_list</code>, all numerical columns are transformed. The format of <code>exclude_list</code> is:</td>
</tr>
<tr>
<td></td>
<td><code>dbms_data_mining_transform.COLUMN_LIST('col1','col2',...,'coln')</code></td>
</tr>
<tr>
<td>round_num</td>
<td>The number of significant digits to use for <code>scale</code>. The default number is 6.</td>
</tr>
<tr>
<td>norm_schema_name</td>
<td>Schema of <code>norm_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of <code>data_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

See *Oracle Machine Learning for SQL User's Guide* for details about numerical data.

**Examples**

In this example, `INSERT_NORM_LIN_SCALE` normalizes the `cust_year_of_birth` column and inserts the transformation in a transformation definition table. The `STACK_NORM_LIN` procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view `MINING_DATA_STACK`. The view is for display purposes only; it cannot be used to embed the transformations in a model.
CREATE OR REPLACE VIEW mining_data AS
SELECT cust_id, cust_gender, cust_year_of_birth
FROM sh.customers;

DESCRIBE mining_data
Name                      Null? Type
------------------------- -------- ------------------
CUST_ID                   NOT NULL NUMBER
CUST_GENDER               NOT NULL CHAR(1)
CUST_YEAR_OF_BIRTH        NOT NULL NUMBER(4)

BEGIN
  dbms_data_mining_transform.CREATE_NORM_LIN(
    norm_table_name  => 'norm_tbl');
  dbms_data_mining_transform.INSERT_NORM_LIN_SCALE(
    norm_table_name  => 'norm_tbl',
    data_table_name  => 'mining_data',
    exclude_list     => dbms_data_mining_transform.COLUMN_LIST( 'cust_id'),
    round_num        => 3);
END;
/

SELECT col, shift, scale FROM norm_tbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>SHIFT</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>0</td>
<td>1990</td>
</tr>
</tbody>
</table>

DECLARE
  xforms      dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.STACK_NORM_LIN (
    norm_table_name    => 'norm_tbl',
    xform_list        => xforms);
  dbms_data_mining_transform.XFORM_STACK (
    xform_list         => xforms,
    data_table_name    => 'mining_data',
    xform_view_name    => 'mining_data_stack');
END;
/

set long 3000
SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_STACK';

------------------------------------------------------------------------------------------------------------
SELECT "CUST_ID","CUST_GENDER",("CUST_YEAR_OF_BIRTH"-0)/1990 "CUST_YEAR_OF_BIRTH" FROM mining_data

### 40.2.3.21 INSERT_NORM_LIN_ZSCORE Procedure

This procedure performs linear normalization and inserts the transformation definitions in a transformation definition table.

INSERT_NORM_LIN_ZSCORE computes the mean and the standard deviation from the data and sets the value of shift and scale as follows:

\[
\text{shift} = \text{mean} \\
\text{scale} = \text{stddev}
\]
Normalization is computed as:
\[ x_{\text{new}} = \frac{x_{\text{old}} - \text{shift}}{\text{scale}} \]

`INSERT_NORM_LIN_ZSCORE` rounds the value of `scale` to a specified number of significant digits before storing it in the transformation definition table.

`INSERT_NORM_LIN_ZSCORE` normalizes all the `NUMBER` and `FLOAT` columns in the data unless you specify a list of columns to ignore.

**Syntax**

```sql
DBMS_DATA_MINING_TRANSFORM.INSERT_NORM_LIN_ZSCORE (
    norm_table_name     IN VARCHAR2,
    data_table_name     IN VARCHAR2,
    exclude_list        IN COLUMN_LIST DEFAULT NULL,
    round_num           IN PLS_INTEGER DEFAULT 6,
    norm_schema_name    IN VARCHAR2 DEFAULT NULL,
    data_schema_name    IN VARCHAR2 DEFAULT NULL);
```

**Parameters**

**Table 40-152  INSERT_NORM_LIN_ZSCORE Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>norm_table_name</code></td>
<td>Name of the transformation definition table for linear normalization. You can use the <code>CREATE_NORM_LIN Procedure</code> to create the definition table. The following columns are required:</td>
</tr>
<tr>
<td></td>
<td>COL      VARCHAR2(30)</td>
</tr>
<tr>
<td></td>
<td>SHIFT     NUMBER</td>
</tr>
<tr>
<td></td>
<td>SCALE     NUMBER</td>
</tr>
<tr>
<td></td>
<td>CREATE_NORM_LIN creates an additional column, ATT, which may be used for specifying nested attributes. This column is not used by INSERT_NORM_LIN_ZSCORE.</td>
</tr>
<tr>
<td><code>data_table_name</code></td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td><code>exclude_list</code></td>
<td>List of numerical columns to be excluded from normalization. If you do not specify <code>exclude_list</code>, all numerical columns are transformed. The format of <code>exclude_list</code> is:</td>
</tr>
<tr>
<td></td>
<td><code>dbms_data_mining_transform.COLUMN_LIST('col1', 'col2', '...coln')</code></td>
</tr>
<tr>
<td><code>round_num</code></td>
<td>The number of significant digits to use for <code>scale</code>. The default number is 6.</td>
</tr>
<tr>
<td><code>norm_schema_name</code></td>
<td>Schema of <code>norm_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td><code>data_schema_name</code></td>
<td>Schema of <code>data_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

See *Oracle Machine Learning for SQL User’s Guide* for details about numerical data.
Examples

In this example, INSERT_NORM_LIN_ZSCORE normalizes the cust_year_of_birth column and inserts the transformation in a transformation definition table. The STACK_NORM_LIN Procedure creates a transformation list from the contents of the definition table.

The SQL expression that computes the transformation is shown in the view MINING_DATA_STACK. The view is for display purposes only; it cannot be used to embed the transformations in a model.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_gender, cust_year_of_birth
    FROM sh.customers;
DESCRIBE mining_data
```
```
Name                                Null?    Type
----------------------------------- -------- --------------------
CUST_ID                             NOT NULL NUMBER
CUST_GENDER                         NOT NULL CHAR(1)
CUST_YEAR_OF_BIRTH                  NOT NULL NUMBER(4)
```
```
BEGIN
    dbms_data_mining_transform.CREATE_NORM_LIN(
        norm_table_name  => 'norm_tbl');
    dbms_data_mining_transform.INSERT_NORM_LIN_ZSCORE(
        norm_table_name  => 'norm_tbl',
        data_table_name  => 'mining_data',
        exclude_list     => dbms_data_mining_transform.COLUMN_LIST( 'cust_id'),
        round_num        => 3);
END;
/
SELECT col, shift, scale FROM norm_tbl;
```
```
COL                  SHIFT SCALE
-------------------- ----- ----- 
CUST_YEAR_OF_BIRTH    1960    15
```
```
DECLARE
    xforms      dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_NORM_LIN (
        norm_table_name    => 'norm_tbl',
        xform_list        => xforms);
    dbms_data_mining_transform.XFORM_STACK (
        xform_list         => xforms,
        data_table_name    => 'mining_data',
        xform_view_name    => 'mining_data_stack');
END;
/
```
```
set long 3000
SQL> SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_STACK';
```
```
TEXT
--------------------------------------------------------------------------------
SELECT "CUST_ID","CUST_GENDER",("CUST_YEAR_OF_BIRTH"-1960)/15 "CUST_YEAR_OF_BIRTH" FROM mining_data
```
40.2.3.22 SET_EXPRESSION Procedure

This procedure appends a row to a VARCHAR2 array that stores a SQL expression.

The array can be used for specifying a transformation expression that is too long to be used with the SET_TRANSFORM Procedure.

The GET_EXPRESSION Function returns a row in the array.

When you use SET_EXPRESSION to build a transformation expression, you must build a corresponding reverse transformation expression, create a transformation record, and add the transformation record to a transformation list.

Syntax

DBMS_DATA_MINING_TRANSFORM.SET_EXPRESSION (  
    expression    IN OUT NOCOPY EXPRESSION_REC,  
    chunk                       VARCHAR2 DEFAULT NULL);  

Parameters

Table 40-153  SET_EXPRESSION Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| expression | An expression record (EXPRESSION_REC) that specifies a transformation expression or a reverse transformation expression for an attribute. Each expression record includes a VARCHAR2 array and index fields for specifying upper and lower boundaries within the array.  

There are two EXPRESSION_REC fields within a transformation record (TRANSFORM_REC): one for the transformation expression; the other for the reverse transformation expression.  

See Table 40-122 for a description of the EXPRESSION_REC type. |
| chunk    | A VARCHAR2 chunk (row) to be appended to expression. |

Notes

1. You can pass NULL in the chunk argument to SET_EXPRESSION to clear the previous chunk. The default value of chunk is NULL.

2. See "About Transformation Lists".

3. See "Operational Notes".

Examples

In this example, two calls to SET_EXPRESSION construct a transformation expression and two calls construct the reverse transformation.
Note:

This example is for illustration purposes only. It shows how `SET_EXPRESSION` appends the text provided in `chunk` to the text that already exists in `expression`. The `SET_EXPRESSION` procedure is meant for constructing very long transformation expressions that cannot be specified in a `VARCHAR2` argument to `SET_TRANSFORM`.

Similarly while transformation lists are intended for embedding in a model, the transformation list `v_xlst` is shown in an external view for illustration purposes.

```sql
CREATE OR REPLACE VIEW mining_data AS
SELECT cust_id, cust_year_of_birth, cust_postal_code, cust_credit_limit
FROM sh.customers;

DECLARE
  v_expr dbms_data_mining_transform.EXPRESSION_REC;
  v_rexp dbms_data_mining_transform.EXPRESSION_REC;
  v_xrec dbms_data_mining_transform.TRANSFORM_REC;
  v_xlst dbms_data_mining_transform.TRANSFORM_LIST :=
    dbms_data_mining_transform.TRANSFORM_LIST(NULL);
BEGIN
  dbms_data_mining_transform.SET_EXPRESSION(
    EXPRESSION  => v_expr,
    CHUNK       => '("CUST_YEAR_OF_BIRTH"-1910)');
  dbms_data_mining_transform.SET_EXPRESSION(
    EXPRESSION  => v_expr,
    CHUNK       => '/77');
  dbms_data_mining_transform.SET_EXPRESSION(
    EXPRESSION  => v_rexp,
    CHUNK       => '"CUST_YEAR_OF_BIRTH"*77');
  dbms_data_mining_transform.SET_EXPRESSION(
    EXPRESSION  => v_rexp,
    CHUNK       => '+1910');
  v_xrec := null;
  v_xrec.attribute_name := 'CUST_YEAR_OF_BIRTH';
  v_xrec.expression := v_expr;
  v_xrec.reverse_expression := v_rexp;
  v_xlst.TRIM;
  v_xlst.extend(1);
  v_xlst(1) := v_xrec;
  dbms_data_mining_transform.XFORM_STACK (
    xform_list => v_xlst,
    data_table_name => 'mining_data',
    xform_view_name => 'v_xlst_view');
  dbms_output.put_line('====');
  FOR i IN 1..v_xlst.count LOOP
    dbms_output.put_line('ATTR: '||v_xlst(i).attribute_name);
    dbms_output.put_line('SUBN: '||v_xlst(i).attribute_subname);
    FOR j IN v_xlst(i).expression.lb..v_xlst(i).expression.ub LOOP
      dbms_output.put_line('EXPR: '||v_xlst(i).expression.lstmt(j));
    END LOOP;
  END LOOP;
END;
```
v_xlst(i).reverse_expression.ub LOOP
   dbms_output.put_line('REXP: '||v_xlst(i).reverse_expression.lstmt(j));
   END LOOP;
   dbms_output.put_line('====');
   END LOOP;
/  
====
ATTR: CUST_YEAR_OF_BIRTH
SUBN:
EXPR: ("CUST_YEAR_OF_BIRTH"-1910)
EXPR: /77
REXP: "CUST_YEAR_OF_BIRTH"*77
REXP: +1910
====

40.2.3.23 SET_TRANSFORM Procedure

This procedure appends the transformation instructions for an attribute to a transformation list.

Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.SET_TRANSFORM (  
   xform_list               IN OUT NOCOPY TRANSFORM_LIST,  
   attribute_name           VARCHAR2,  
   attribute_subname        VARCHAR2,  
   expression               VARCHAR2,  
   reverse_expression       VARCHAR2,  
   attribute_spec           VARCHAR2 DEFAULT NULL);
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>attribute_name</td>
<td>Name of the attribute to be transformed</td>
</tr>
<tr>
<td>attribute_subname</td>
<td>Name of the nested attribute if attribute_name is a nested column, otherwise NULL.</td>
</tr>
<tr>
<td>expression</td>
<td>A SQL expression that specifies the transformation of the attribute.</td>
</tr>
<tr>
<td>reverse_expression</td>
<td>A SQL expression that reverses the transformation for readability in model details and in the target of a supervised model (if the attribute is a target)</td>
</tr>
</tbody>
</table>
Table 40-154  (Cont.) SET_TRANSFORM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>attribute_spec</td>
<td>One or more keywords that identify special treatment for the attribute during model build. Values are:</td>
</tr>
<tr>
<td></td>
<td>• NOPREP — When ADP is on, prevents automatic transformation of the attribute. If ADP is not on, this value has no effect.</td>
</tr>
<tr>
<td></td>
<td>• TEXT — Causes the attribute to be treated as unstructured text data</td>
</tr>
<tr>
<td></td>
<td>• FORCE_IN — Forces the inclusion of the attribute in the model build. Applies only to GLM models with feature selection enabled (ftr_selection_enable = yes). Feature selection is disabled by default. If the model is not using GLM with feature selection, this value has no effect.</td>
</tr>
</tbody>
</table>

Usage Notes

1. See the following relevant sections in "Operational Notes":
   • About Transformation Lists
   • Nested Data Transformations

2. As shown in the following example, you can eliminate an attribute by specifying a null transformation expression and reverse expression. You can also use the STACK interface to remove a column (CREATE_COL_REM Procedure and STACK_COL_REM Procedure).

40.2.3.24 STACK_BIN_CAT Procedure

This procedure adds categorical binning transformations to a transformation list.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.STACK_BIN_CAT (  
    bin_table_name     IN            VARCHAR2,   
    xform_list         IN OUT NOCOPY TRANSFORM_LIST,   
    literal_flag       IN            BOOLEAN  DEFAULT FALSE,   
    bin_schema_name    IN            VARCHAR2 DEFAULT NULL);   
```
Parameters

Table 40-155  STACK_BIN_CAT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table for categorical binning. You can use the CREATE_BIN_CAT Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_BIN_CAT. To populate the table, you can use one of the INSERT procedures for categorical binning or you can write your own SQL. See Table 40-125</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>literal_flag</td>
<td>Indicates whether the values in the bin column in the transformation definition table are valid SQL literals. When literal_flag is FALSE (the default), the bin identifiers will be transformed to SQL literals by surrounding them with single quotes. Set literal_flag to TRUE if the bin identifiers are numbers that should have a numeric datatype, as is the case for an O-Cluster model. See &quot;INSERT_BIN_NUM_EQWIDTH Procedure&quot; for an example.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
- "About Stacking"
- "Nested Data Transformations"

Examples

This example shows how a binning transformation for the categorical column cust_postal_code could be added to a stack called mining_data_stack.

```
CREATE or REPLACE VIEW mining_data AS
SELECT cust_id, cust_postal_code, cust_credit_limit
FROM sh.customers
WHERE cust_id BETWEEN 100050 AND 100100;
```

Note:

This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.
dbms_data_mining_transform.CREATE_BIN_CAT ('bin_cat_tbl');

dbms_data_mining_transform.INSERT_BIN_CAT_FREQ {
    _bin_table_name => 'bin_cat_tbl',
    data_table_name => 'mining_data',
    bin_num => 3,
}

END;
/

DECLARE
    MINING_DATA_STACK   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.STACK_BIN_CAT (
        bin_table_name       => 'bin_cat_tbl',
        xform_list           =>  mining_data_stack);
    dbms_data_mining_transform.XFORM_STACK (
        xform_list           =>  mining_data_stack,
        data_table_name      => 'mining_data',
        xform_view_name      => 'mining_data_stack_view');
END;
/

-- Before transformation

COLUMN cust_postal_code FORMAT A16

SELECT * FROM mining_data
WHERE cust_id BETWEEN 100050 AND 100053
ORDER BY cust_id;

CUST_ID  CUST_POSTAL_CODE  CUST_CREDIT_LIMIT
---------- ------------------ -----------------
100050 76486               1500
100051 73216               9000
100052 69499               5000
100053 45704               7000

-- After transformation

SELECT * FROM mining_data_stack_view
WHERE cust_id BETWEEN 100050 AND 100053
ORDER BY cust_id;

CUST_ID  CUST_POSTAL_CODE  CUST_CREDIT_LIMIT
---------- ------------------ -----------------
100050 4       1500
100051 1       9000
100052 4       5000
100053 4       7000

40.2.3.25 STACK_BIN_NUM Procedure

This procedure adds numerical binning transformations to a transformation list.

Syntax

DBMS_DATA_MINING_TRANSFORM.STACK_BIN_NUM (
    bin_table_name    IN VARCHAR2,
    xform_list        IN OUT NOCOPY TRANSFORM_LIST,
    literal_flag      IN BOOLEAN DEFAULT FALSE,
    bin_schema_name   IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-156  STACK_BIN_NUM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table for numerical binning. You can use the CREATE_BIN_NUM Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_BIN_NUM. To populate the table, you can use one of the INSERT procedures for numerical binning or you can write your own SQL. See Table 40-127.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>literal_flag</td>
<td>Indicates whether the values in the bin column in the transformation definition table are valid SQL literals. When literal_flag is FALSE (the default), the bin identifiers will be transformed to SQL literals by surrounding them with single quotes. Set literal_flag to TRUE if the bin identifiers are numbers that should have a numeric datatype, as is the case for an O-Cluster model. See &quot;INSERT_BIN_NUM_EQWIDTH Procedure&quot; for an example.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
- "About Stacking"
- "Nested Data Transformations"

Examples

This example shows how a binning transformation for the numerical column cust_credit_limit could be added to a stack called mining_data_stack.

```
CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_postal_code, cust_credit_limit
    FROM sh.customers
    WHERE cust_id BETWEEN 100050 and 100100;
BEGIN
```

Note:

This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.
dbms_data_mining_transform.create_bin_num ('bin_num_tbl');
dbms_data_mining_transform.insert_bin_num_qtile {
  bin_table_name => 'bin_num_tbl',
  data_table_name => 'mining_data',
  bin_num => 5,
  exclude_list => dbms_data_mining_transform.COLUMN_LIST('cust_id'));
END;
/
DECLARE
MINING_DATA_STACK dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
dbms_data_mining_transform.STACK_BIN_CAT {
  bin_table_name => 'bin_num_tbl',
  xform_list => mining_data_stack);
}dbms_data_mining_transform.XFORM_STACK {
  xform_list => mining_data_stack,
  data_table_name => 'mining_data',
  xform_view_name => 'mining_data_stack_view'};
END;
/
-- Before transformation
SELECT cust_id, cust_postal_code, ROUND(cust_credit_limit) FROM mining_data
WHERE cust_id BETWEEN 100050 AND 100055
ORDER BY cust_id;
CUST_ID    CUST_POSTAL_CODE    ROUND(CUST_CREDIT_LIMIT)
-------    ----------------    -------------------------
100050    76486                   1500
100051    73216                   9000
100052    69499                   5000
100053    45704                   7000
100055    74673                  11000
100055    74673                  11000

-- After transformation
SELECT cust_id, cust_postal_code, ROUND(cust_credit_limit)
FROM mining_data_stack_view
WHERE cust_id BETWEEN 100050 AND 100055
ORDER BY cust_id;
CUST_ID    CUST_POSTAL_CODE    ROUND(CUST_CREDIT_LIMIT)
-------    ----------------    -------------------------
100050    76486
100051    73216                     2
100052    69499                     1
100053    45704
100054    88021                     3
100055    74673                     3

40.2.3.26 STACK_CLIP Procedure

This procedure adds clipping transformations to a transformation list.

Syntax

DBMS_DATA_MINING_TRANSFORM.STACK_CLIP {
  clip_table_name    IN    VARCHAR2,
  xform_list    IN OUT NOCOPY TRANSFORM_LIST,
  clip_schema_name    IN    VARCHAR2 DEFAULT NULL);}
Parameters

Table 40-157  STACK_CLIP Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clip_table_name</td>
<td>Name of the transformation definition table for clipping. You can use the CREATE_CLIP Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_CLIP. To populate the table, you can use one of the INSERT procedures for clipping or you can write your own SQL. See Table 40-129</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>clip_schema_name</td>
<td>Schema of clip_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See DBMS_DATA_MINING_TRANSFORM Operational Notes. The following sections are especially relevant:

- “About Transformation Lists”
- “About Stacking”
- “Nested Data Transformations”

Examples

This example shows how a clipping transformation for the numerical column cust_credit_limit could be added to a stack called mining_data_stack.

Note:

This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.

CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, cust_postal_code, cust_credit_limit
    FROM sh.customers
    WHERE cust_id BETWEEN 100050 AND 100100;
BEGIN
    DBMS_DATA_MINING_TRANSFORM.CREATE_CLIP ('clip_tbl');
    DBMS_DATA_MINING_TRANSFORM.INSERT_CLIP_WINSOR_TAIL (clip_table_name => 'clip_tbl',
                                                        data_table_name => 'mining_data',
                                                        tail_frac => 0.25,
                                                        exclude_list => DBMS_DATA_MINING_TRANSFORM.COLUMN_LIST('cust_id'));
END;
DECLARE
MINING_DATA_STACK dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.STACK_CLIP (clip_table_name => 'clip_tbl', xform_list => mining_data_stack);
  dbms_data_mining_transform.XFORM_STACK (xform_list => mining_data_stack, data_table_name => 'mining_data', xform_view_name => 'mining_data_stack_view');
END;
/
-- Before transformation
SELECT cust_id, cust_postal_code, round(cust_credit_limit)
FROM mining_data
  WHERE cust_id BETWEEN 100050 AND 100054
ORDER BY cust_id;
CUST_ID   CUST_POSTAL_CODE   ROUND(CUST_CREDIT_LIMIT)
-------   ----------------   ------------------------
100050    76486                                 1500
100051    73216                                 9000
100052    69499                                 5000
100053    45704                                 7000
100054    88021                                11000

-- After transformation
SELECT cust_id, cust_postal_code, round(cust_credit_limit)
FROM mining_data_stack_view
  WHERE cust_id BETWEEN 100050 AND 100054
ORDER BY cust_id;
CUST_ID   CUST_POSTAL_CODE   ROUND(CUST_CREDIT_LIMIT)
-------   ----------------   ------------------------
100050    76486                                 5000
100051    73216                                 9000
100052    69499                                 5000
100053    45704                                 7000
100054    88021                                11000

40.2.3.27 STACK_COL_REM Procedure

This procedure adds column removal transformations to a transformation list.

Syntax

DBMS_DATA_MINING_TRANSFORM.STACK_COL_REM (rem_table_name IN VARCHAR2, xform_list IN OUT NOCOPY TRANSFORM_LIST, rem_schema_name IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-158  STACK_COL_REM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rem_table_name</td>
<td>Name of the transformation definition table for column removal. You can use the CREATE_COL_REM Procedure to create the definition table. See Table 40-131. The table must be populated with column names before you call STACK_COL_REM. The INSERT_BIN_SUPER Procedure and the INSERT_AUTOBIN_NUM_EQWIDTH Procedure can optionally be used to populate the table. You can also use SQL INSERT statements.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>rem_schema_name</td>
<td>Schema of rem_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
- "About Stacking"
- "Nested Data Transformations"

Examples

This example shows how the column cust_credit_limit could be removed in a transformation list called mining_data_stack.

```
Note:
This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.

CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, country_id, cust_postal_code, cust_credit_limit
    FROM sh.customers;
BEGIN
    dbms_data_mining_transform.create_col_rem ('rem_tbl');
END;
/

INSERT into rem_tbl VALUES (upper('cust_postal_code'), null);
DECLARE
MINING_DATA_STACK dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.stack_col_rem (rem_table_name => 'rem_tbl',
                                           xform_list => mining_data_stack);
  dbms_data_mining_transform.XFORM_STACK (xform_list => mining_data_stack,
                                          data_table_name => 'mining_data',
                                          xform_view_name => 'mining_data_stack_view');
END;
/
SELECT * FROM mining_data
  WHERE cust_id BETWEEN 100050 AND 100051
  ORDER BY cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>COUNTRY_ID</th>
<th>CUST_POSTAL_CODE</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100050</td>
<td>52773</td>
<td>76486</td>
<td>1500</td>
</tr>
<tr>
<td>100051</td>
<td>52790</td>
<td>73216</td>
<td>9000</td>
</tr>
</tbody>
</table>

SELECT * FROM mining_data_stack_view
  WHERE cust_id BETWEEN 100050 AND 100051
  ORDER BY cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>COUNTRY_ID</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100050</td>
<td>52773</td>
<td>1500</td>
</tr>
<tr>
<td>100051</td>
<td>52790</td>
<td>9000</td>
</tr>
</tbody>
</table>

40.2.3.28 STACK_MISS_CAT Procedure

This procedure adds categorical missing value transformations to a transformation list.

Syntax

DBMS_DATA_MINING_TRANSFORM.STACK_MISS_CAT (miss_table_name IN VARCHAR2,
                                            xform_list IN OUT NOCOPY TRANSFORM_LIST,
                                            miss_schema_name IN VARCHAR2 DEFAULT NULL);

Parameters

Table 40-159  STACK_MISS_CAT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for categorical missing value treatment. You can use the CREATE_MISS_CAT Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_MISS_CAT. To populate the table, you can use the INSERT_MISS_CAT_MODE Procedure or you can write your own SQL. See Table 40-133.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>
Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
- "About Stacking"
- "Nested Data Transformations"

Examples

This example shows how the missing values in the column cust_marital_status could be replaced with the mode in a transformation list called mining_data_stack.

Note:

This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.

CREATE OR REPLACE VIEW mining_data AS
  SELECT cust_id, country_id, cust_marital_status
  FROM sh.customers
  where cust_id BETWEEN 1 AND 10;
BEGIN
  dbms_data_mining_transform.create_miss_cat ('miss_cat_tbl');
  dbms_data_mining_transform.insert_miss_cat_mode ('miss_cat_tbl', 'mining_data');
END;
/
DECLARE
  MINING_DATA_STACK   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.stack_miss_cat (
    miss_table_name   => 'miss_cat_tbl',
    xform_list        => mining_data_stack);
  dbms_data_mining_transform.XFORM_STACK (
    xform_list        =>  mining_data_stack,
    data_table_name   => 'mining_data',
    xform_view_name   => 'mining_data_stack_view');
END;
/
SELECT * FROM mining_data
ORDER BY cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>COUNTRY_ID</th>
<th>CUST_MARITAL_STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52789</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>52778</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>52770</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>52770</td>
<td></td>
</tr>
</tbody>
</table>
40.2.3.29 STACK_MISS_NUM Procedure

This procedure adds numeric missing value transformations to a transformation list.

Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.STACK_MISS_NUM (  
    miss_table_name     IN       VARCHAR2,  
    xform_list          IN OUT   NOCOPY TRANSFORM_LIST,  
    miss_schema_name    IN       VARCHAR2 DEFAULT NULL);  
```

Parameters

Table 40-160  STACK_MISS_NUM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for numerical missing value treatment. You can use the CREATE_MISS_NUM Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_MISS_NUM. To populate the table, you can use the INSERT_MISS_NUM_MEAN Procedure or you can write your own SQL. See Table 40-135.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
Examples

This example shows how the missing values in the column `cust_credit_limit` could be replaced with the mean in a transformation list called `mining_data_stack`.

Note:

This example invokes the `XFORM_STACK Procedure` to show how the data is transformed by the stack. `XFORM_STACK` simply generates an external view of the transformed data. The actual purpose of the `STACK` procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to `CREATE_MODEL` in the `xform_list` parameter. See `INSERT_BIN_NUM_EQWIDTH Procedure` for an example.

describe mining_data
Name Null? Type
---------------------------------------- -------- -----  
CUST_ID NOT NULL NUMBER
CUST_CREDIT_LIMIT NUMBER

BEGIN
  dbms_data_mining_transform.create_miss_num ('miss_num_tbl');
  dbms_data_mining_transform.insert_miss_num_mean ('miss_num_tbl','mining_data');
END;
/
SELECT * FROM miss_num_tbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>ATT</th>
<th>VAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUST_ID</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>CUST_CREDIT_LIMIT</td>
<td>185.71</td>
<td></td>
</tr>
</tbody>
</table>

DECLARE
MINING_DATA_STACK   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
  dbms_data_mining_transform.STACK_MISS_NUM (
    miss_table_name => 'miss_num_tbl',
    xform_list => mining_data_stack);
  dbms_data_mining_transform.XFORM_STACK (
    xform_list => mining_data_stack,
    data_table_name => 'mining_data',
    xform_view_name => 'mining_data_stack_view');
END;
/
-- Before transformation
SELECT * FROM mining_data
ORDER BY cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
40.2.3.30 STACK_NORM_LIN Procedure

This procedure adds linear normalization transformations to a transformation list.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.STACK_NORM_LIN (
    norm_table_name     IN       VARCHAR2,
    xform_list          IN OUT   NOCOPY TRANSFORM_LIST,
    norm_schema_name    IN       VARCHAR2 DEFAULT NULL);
```

Parameters

Table 40-161  STACK_NORM_LIN Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>norm_table_name</td>
<td>Name of the transformation definition table for linear normalization. You can use the CREATE_NORM_LIN Procedure to create the definition table. The table must be populated with transformation definitions before you call STACK_NORM_LIN. To populate the table, you can use one of the INSERT procedures for normalization or you can write your own SQL. See Table 40-137.</td>
</tr>
<tr>
<td>xform_list</td>
<td>A transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>norm_schema_name</td>
<td>Schema of norm_table_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
About Stacking

Nested Data Transformations

Examples

This example shows how the column cust_credit_limit could be normalized in a transformation list called mining_data_stack.

Note:

This example invokes the XFORM_STACK Procedure to show how the data is transformed by the stack. XFORM_STACK simply generates an external view of the transformed data. The actual purpose of the STACK procedures is to assemble a list of transformations for embedding in a model. The transformations are passed to CREATE_MODEL in the xform_list parameter. See INSERT_BIN_NUM_EQWIDTH Procedure for an example.

CREATE OR REPLACE VIEW mining_data AS
    SELECT cust_id, country_id, cust_postal_code, cust_credit_limit
    FROM sh.customers;
BEGIN
    dbms_data_mining_transform.create_norm_lin ('norm_lin_tbl');
    dbms_data_mining_transform.insert_norm_lin_minmax (
        norm_table_name   => 'norm_lin_tbl',
        data_table_name   => 'mining_data',
        exclude_list      =>  dbms_data_mining_transform.COLUMN_LIST('cust_id',
                                                                    'country_id'));
END;
/
SELECT * FROM norm_lin_tbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>ATT</th>
<th>SHIFT</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_CREDIT_LIMIT</td>
<td>1500</td>
<td>13500</td>
<td></td>
</tr>
</tbody>
</table>

DECLARE
    MINING_DATA_STACK   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.stack_norm_lin (
        norm_table_name   => 'norm_lin_tbl',
        xform_list        => mining_data_stack);
    dbms_data_mining_transform.XFORM_STACK (
        xform_list        =>  mining_data_stack,
        data_table_name   => 'mining_data',
        xform_view_name   => 'mining_data_stack_view');
END;
/
SELECT * FROM mining_data
WHERE cust_id between 1 and 10
ORDER BY cust_id;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>COUNTRY_ID</th>
<th>CUST_POSTAL_CODE</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52789</td>
<td>30828</td>
<td>9000</td>
</tr>
<tr>
<td>2</td>
<td>52778</td>
<td>86319</td>
<td>10000</td>
</tr>
<tr>
<td>3</td>
<td>52770</td>
<td>88666</td>
<td>1500</td>
</tr>
<tr>
<td>4</td>
<td>52770</td>
<td>87551</td>
<td>1500</td>
</tr>
<tr>
<td>5</td>
<td>52789</td>
<td>59200</td>
<td>1500</td>
</tr>
</tbody>
</table>
### 40.2.3.31 XFORM_BIN_CAT Procedure

This procedure creates a view that implements the categorical binning transformations specified in a definition table. Only the columns that are specified in the definition table are transformed; the remaining columns from the data table are present in the view, but they are not changed.

#### Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.XFORM_BIN_CAT (
  bin_table_name       IN VARCHAR2,
  data_table_name      IN VARCHAR2,
  xform_view_name      IN VARCHAR2,
  literal_flag         IN BOOLEAN DEFAULT FALSE,
  bin_schema_name      IN VARCHAR2 DEFAULT NULL,
  data_schema_name     IN VARCHAR2 DEFAULT NULL,
  xform_schema_name    IN VARCHAR2 DEFAULT NULL);
```

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table for categorical binning. You can use the CREATE_BIN_CAT Procedure to create the definition table. The table must be populated with transformation definitions before you call XFORM_BIN_CAT. To populate the table, you can use one of the INSERT procedures for categorical binning or you can write your own SQL. See Table 40-125.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed.</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in <code>data_table_name</code> with the transformations specified in <code>bin_table_name</code>.</td>
</tr>
</tbody>
</table>

```sql
SELECT * FROM mining_data_stack_view
WHERE cust_id between 1 and 10
ORDER BY cust_id;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>COUNTRY_ID</th>
<th>CUST_POSTAL_CODE</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52789</td>
<td>30828</td>
<td>.55556</td>
</tr>
<tr>
<td>2</td>
<td>52778</td>
<td>86319</td>
<td>.62963</td>
</tr>
<tr>
<td>3</td>
<td>52770</td>
<td>88666</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>52770</td>
<td>87551</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>52789</td>
<td>59200</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>52769</td>
<td>77287</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>52790</td>
<td>38763</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>52790</td>
<td>58488</td>
<td>.11111</td>
</tr>
<tr>
<td>9</td>
<td>52770</td>
<td>63033</td>
<td>.11111</td>
</tr>
<tr>
<td>10</td>
<td>52790</td>
<td>52602</td>
<td>.11111</td>
</tr>
</tbody>
</table>
Table 40-162  (Cont.) XFORM_BIN_CAT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>literal_flag</td>
<td>Indicates whether the values in the bin column in the transformation definition table are valid SQL literals. When literal_flag is FALSE (the default), the bin identifiers will be transformed to SQL literals by surrounding them with single quotes. Set literal_flag to TRUE if the bin identifiers are numbers that should have a numeric datatype, as is the case for an O-Cluster model. See &quot;INSERT_BIN_NUM_EQWIDTH Procedure&quot; for an example.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes".

Examples

This example creates a view that bins the cust_postal_code column. The data source consists of three columns from sh.customer.

```
describe mining_data
Name                                   Null?    Type
-------------------------------------- -------- ------------------------
CUST_ID                                NOT NULL NUMBER
CUST_POSTAL_CODE                       NOT NULL VARCHAR2(10)
CUST_CREDIT_LIMIT                               NUMBER

SELECT * FROM mining_data WHERE cust_id between 104066 and 104069;

    CUST_ID CUST_POSTAL_CODE   CUST_CREDIT_LIMIT
        --------- ------------- --------------
          104066 69776         7000
          104067 52602         9000
          104068 55787        11000
          104069 55977          5000

BEGIN
    dbms_data_mining_transform.create_bin_cat(
        bin_table_name => 'bin_cat_tbl');
    dbms_data_mining_transform.insert_bin_cat_freq(
        bin_table_name => 'bin_cat_tbl',
        data_table_name => 'mining_data',
        bin_num => 10);
```
dbms_data_mining_transform.xform_bin_cat(
    bin_table_name => 'bin_cat_tbl',
    data_table_name => 'mining_data',
    xform_view_name => 'bin_cat_view');
END;
/

SELECT * FROM bin_cat_view WHERE cust_id between 104066 and 104069;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CUST_POSTAL_CODE</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>104066</td>
<td>6</td>
<td>7000</td>
</tr>
<tr>
<td>104067</td>
<td>11</td>
<td>9000</td>
</tr>
<tr>
<td>104068</td>
<td>3</td>
<td>11000</td>
</tr>
<tr>
<td>104069</td>
<td>11</td>
<td>5000</td>
</tr>
</tbody>
</table>

SELECT text FROM user_views WHERE view_name IN 'BIN_CAT_VIEW';

TEXT

--------------------------------------------------------------------------------
SELECT "CUST_ID",DECODE("CUST_POSTAL_CODE","38082",'1','45704',"9","48346","5",
55787,"3","63736","2","67843","7","69776","6","72860","10","78558","4","80841",
8,NULL,NULL,"11") "CUST_POSTAL_CODE","CUST_CREDIT_LIMIT" FROM mining_data

40.2.3.32 XFORM_BIN_NUM Procedure

This procedure creates a view that implements the numerical binning transformations specified in a definition table. Only the columns that are specified in the definition table are transformed; the remaining columns from the data table are present in the view, but they are not changed.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_BIN_NUM (
    bin_table_name IN VARCHAR2,
    data_table_name IN VARCHAR2,
    xform_view_name IN VARCHAR2,
    literal_flag IN BOOLEAN DEFAULT FALSE,
    bin_schema_name IN VARCHAR2 DEFAULT NULL,
    data_schema_name IN VARCHAR2 DEFAULT NULL,
    xform_schema_name IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-163  XFORM_BIN_NUM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_table_name</td>
<td>Name of the transformation definition table for numerical binning. You can use the CREATE_BIN_NUM Procedure to create the definition table. The table must be populated with transformation definitions before you call XFORM_BIN_NUM. To populate the table, you can use one of the INSERT procedures for numerical binning or you can write your own SQL. See &quot;Table 40-127&quot;.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in data_table_name with the transformations specified in bin_table_name.</td>
</tr>
<tr>
<td>literal_flag</td>
<td>Indicates whether the values in the bin column in the transformation definition table are valid SQL literals. When literal_flag is FALSE (the default), the bin identifiers will be transformed to SQL literals by surrounding them with single quotes. Set literal_flag to TRUE if the bin identifiers are numbers that should have a numeric datatype, as is the case for an O-Cluster model. See &quot;INSERT_BIN_NUM_EQWIDTH Procedure&quot; for an example.</td>
</tr>
<tr>
<td>bin_schema_name</td>
<td>Schema of bin_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes".

Examples

This example creates a view that bins the cust_credit_limit column. The data source consists of three columns from sh.customer.

describe mining_data
Name                                   Null?    Type
-------------------------------------- -------- ------------------------
CUST_ID                                NOT NULL NUMBER
CUST_POSTAL_CODE                       NOT NULL VARCHAR2(10)
CUST_CREDIT_LIMIT                               NUMBER

column cust_credit_limit off
SELECT * FROM mining_data WHERE cust_id between 104066 and 104069;

    CUST_ID CUST_POSTAL_CODE CUST_CREDIT_LIMIT
    --------- ------------------ ---------------------
    104066   69776             7000
    104067   52602             7000
BEGIN
    dbms_data_mining_transform.create_bin_num(
        bin_table_name => 'bin_num_tbl');
    dbms_data_mining_transform.insert_autobin_num_eqwidth(
        bin_table_name => 'bin_num_tbl',
        data_table_name => 'mining_data',
        bin_num => 5,
        max_bin_num => 10,
        exclude_list =>
            dbms_data_mining_transform.COLUMN_LIST('cust_id'));
    dbms_data_mining_transform.xform_bin_num(
        bin_table_name => 'bin_num_tbl',
        data_table_name => 'mining_data',
        xform_view_name => 'mining_data_view');
END;
/
describe mining_data_view
Name                                 Null?    Type
------------------------------------ -------- ------------------------
CUST_ID                              NOT NULL NUMBER
CUST_POSTAL_CODE                     NOT NULL VARCHAR2(10)
CUST_CREDIT_LIMIT                             VARCHAR2(2)

col cust_credit_limit on
col cust_credit_limit format a25
SELECT * FROM mining_data_view WHERE cust_id between 104066 and 104069;

    CUST_ID  CUST_POSTAL_CODE  CUST_CREDIT_LIMIT
----------  -----------------  -------------------------
   104066    69776             
             5
   104067    52602             
             6
   104068    55787             
             8
   104069    55977             
             3

set long 2000
SELECT text FROM user_views WHERE view_name IN 'MINING_DATA_VIEW';
TEXT
--------------------------------------------------------------------------------
SELECT "CUST_ID","CUST_POSTAL_CODE",CASE WHEN "CUST_CREDIT_LIMIT"<1500 THEN NULL
  WHEN "CUST_CREDIT_LIMIT"<=2850 THEN '1'
  WHEN "CUST_CREDIT_LIMIT"<=4200 THEN '2'
  WHEN "CUST_CREDIT_LIMIT"<=5550 THEN '3'
  WHEN "CUST_CREDIT_LIMIT"<=6900 THEN '4'
  WHEN "CUST_CREDIT_LIMIT"<=8250 THEN '5'
  WHEN "CUST_CREDIT_LIMIT"<=9600 THEN '6'
  ELSE '7'
END FROM mining_data_view;
WHEN "CUST_CREDIT_LIMIT"<=10950 THEN '7' WHEN "CUST_CREDIT_LIMIT"<=12300 THEN
'8' WHEN "CUST_CREDIT_LIMIT"<=13650 THEN '9' WHEN "CUST_CREDIT_LIMIT"<=15000 THEN
'10' END "CUST_CREDIT_LIMIT" FROM mining_data

40.2.3.33 XFORM_CLIP Procedure

This procedure creates a view that implements the clipping transformations specified in a
definition table. Only the columns that are specified in the definition table are transformed; the
remaining columns from the data table are present in the view, but they are not changed.

Syntax

```
DBMS_DATA_MINING_TRANSFORM.XFORM_CLIP (  
    clip_table_name       IN VARCHAR2,  
    data_table_name       IN VARCHAR2,  
    xform_view_name       IN VARCHAR2,  
    clip_schema_name      IN VARCHAR2 DEFAULT NULL,  
    data_schema_name      IN VARCHAR2, DEFAULT NULL,  
    xform_schema_name     IN VARCHAR2,DEFAULT NULL);  
```

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clip_table_name</td>
<td>Name of the transformation definition table for clipping. You can use the</td>
</tr>
<tr>
<td></td>
<td>CREATE_CLIP Procedure to create the definition table. The table must be</td>
</tr>
<tr>
<td></td>
<td>populated with transformation definitions before you call XFORM_CLIP. To</td>
</tr>
<tr>
<td></td>
<td>populate the table, you can use one of the INSERT procedures for clipping</td>
</tr>
<tr>
<td></td>
<td>you can write your own SQL. See Table 40-129.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in data_table_name</td>
</tr>
<tr>
<td></td>
<td>with the transformations specified in clip_table_name.</td>
</tr>
<tr>
<td>clip_schema_name</td>
<td>Schema of clip_table_name. If no schema is specified, the current schema</td>
</tr>
<tr>
<td></td>
<td>is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema</td>
</tr>
<tr>
<td></td>
<td>is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema</td>
</tr>
<tr>
<td></td>
<td>is used.</td>
</tr>
</tbody>
</table>

Examples

This example creates a view that clips the cust_credit_limit column. The data source
consists of three columns from sh.customer.

```
describe mining_data
Name                           Null?    Type
------------------------------ -------- -------------------------
CUST_ID                        NOT NULL NUMBER
CUST_POSTAL_CODE               NOT NULL VARCHAR2 (10)
```
CUST_CREDIT_LIMIT                        NUMBER

BEGIN
  dbms_data_mining_transform.create_clip(
    clip_table_name    => 'clip_tbl');
  dbms_data_mining_transform.insert_clip_trim_tail(
    clip_table_name    => 'clip_tbl',
    data_table_name    => 'mining_data',
    tail_frac          => 0.05,
    exclude_list       => dbms_data_mining_transform.COLUMN_LIST('cust_id'));
  dbms_data_mining_transform.xform_clip(
    clip_table_name    => 'clip_tbl',
    data_table_name    => 'mining_data',
    xform_view_name    => 'clip_view');
END;
/

describe clip_view
Name                          Null?    Type
----------------------------- -------- --------------------------
CUST_ID                       NOT NULL NUMBER
CUST_POSTAL_CODE              NOT NULL VARCHAR2(10)
CUST_CREDIT_LIMIT                      NUMBER

SELECT MIN(cust_credit_limit), MAX(cust_credit_limit) FROM mining_data;

MIN(CUST_CREDIT_LIMIT) MAX(CUST_CREDIT_LIMIT)
------------------------------- ----------------------
1500                  15000

SELECT MIN(cust_credit_limit), MAX(cust_credit_limit) FROM clip_view;

MIN(CUST_CREDIT_LIMIT) MAX(CUST_CREDIT_LIMIT)
------------------------------- ----------------------
1500                  11000

set long 2000
SELECT text FROM user_views WHERE view_name IN 'CLIP_VIEW';

TEXT
--------------------------------------------------------------------------------
SELECT "CUST_ID","CUST_POSTAL_CODE",CASE WHEN "CUST_CREDIT_LIMIT" < 1500 THEN NULL WHEN "CUST_CREDIT_LIMIT" > 11000 THEN NULL ELSE "CUST_CREDIT_LIMIT" END "CUST_CREDIT_LIMIT" FROM mining_data

40.2.3.34 XFORM_COL_REM Procedure

This procedure creates a view that implements the column removal transformations specified in a definition table. Only the columns that are specified in the definition table are removed; the remaining columns from the data table are present in the view.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_COL_REM (
  rem_table_name IN VARCHAR2,
  data_table_name IN VARCHAR2,
  xform_view_name IN VARCHAR2,
  rem_schema_name IN VARCHAR2 DEFAULT NULL,
  data_schema_name IN VARCHAR2 DEFAULT NULL,
  xform_schema_name IN VARCHAR2 DEFAULT NULL);
Parameters

Table 40-165  XFORM_COL_REM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rem_table_name</td>
<td>Name of the transformation definition table for column removal. You can use the CREATE_COL_REM Procedure to create the definition table. See Table 40-131. The table must be populated with column names before you call XFORM_COL_REM. The INSERT_BIN_SUPER Procedure and the INSERT_AUTOBIN_NUM_EQWIDTH Procedure can optionally be used to populate the table. You can also use SQL INSERT statements.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents the columns in data_table_name that are not specified in rem_table_name.</td>
</tr>
<tr>
<td>rem_schema_name</td>
<td>Schema of rem_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See “Operational Notes”.

Examples

This example creates a view that includes all but one column from the table customers in the current schema.

describe customers
Name                                      Null?    Type
----------------------------------------- -------- ----------------------------
CUST_ID                                   NOT NULL NUMBER
CUST_MARITAL_STATUS                                VARCHAR2(20)
OCCUPATION                                         VARCHAR2(21)
AGE                                                NUMBER
YRS_RESIDENCE                                      NUMBER

BEGIN
   DBMS_DATA_MINING_TRANSFORM.CREATE_COL_REM ('colrem_xtbl');
END;
/
INSERT INTO colrem_xtbl VALUES('CUST_MARITAL_STATUS', null);

NOTE: This currently doesn't work. See bug 9310319

BEGIN
   DBMS_DATA_MINING_TRANSFORM.XFORM_COL_REM (rem_table_name => 'colrem_xtbl',
                                           data_table_name => 'customers',
                                           xform_view_name => 'colrem_view');
END;
/
describe colrem_view

<table>
<thead>
<tr>
<th>Name</th>
<th>Null?</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_ID</td>
<td>NOT NULL</td>
<td>NUMBER</td>
</tr>
<tr>
<td>OCCUPATION</td>
<td></td>
<td>VARCHAR2 (21)</td>
</tr>
<tr>
<td>AGE</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td>YRS_RESIDENCE</td>
<td></td>
<td>NUMBER</td>
</tr>
</tbody>
</table>

40.2.3.35 XFORM_EXPR_NUM Procedure

This procedure creates a view that implements the specified numeric transformations. Only the columns that you specify are transformed; the remaining columns from the data table are present in the view, but they are not changed.

Syntax

```sql
DBMS_DATA_MINING_TRANSFORM.XFORM_EXPR_NUM ( expr_pattern IN VARCHAR2,
    data_table_name IN VARCHAR2,
    xform_view_name IN VARCHAR2,
    exclude_list IN COLUMN_LIST DEFAULT NULL,
    include_list IN COLUMN_LIST DEFAULT NULL,
    col_pattern IN VARCHAR2 DEFAULT ':col',
    data_schema_name IN VARCHAR2 DEFAULT NULL,
    xform_schema_name IN VARCHAR2 DEFAULT NULL);
```

Parameters

**Table 40-166  XFORM_EXPR_NUM Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr_pattern</td>
<td>A numeric transformation expression</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in</td>
</tr>
<tr>
<td></td>
<td><code>data_table_name</code> with the transformations specified in <code>expr_pattern</code> and <code>col_pattern</code>.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of numerical columns to exclude. If NULL, no numerical columns are excluded.</td>
</tr>
<tr>
<td></td>
<td>The format of <code>exclude_list</code> is:</td>
</tr>
<tr>
<td></td>
<td><code>dbms_data_mining_transform.COLUMN_LIST('col1','col2', ...'coln')</code></td>
</tr>
<tr>
<td>include_list</td>
<td>List of numeric columns to include. If NULL, all numeric columns are included.</td>
</tr>
<tr>
<td></td>
<td>The format of <code>include_list</code> is:</td>
</tr>
<tr>
<td></td>
<td><code>dbms_data_mining_transform.COLUMN_LIST('col1','col2', ...'coln')</code></td>
</tr>
<tr>
<td>col_pattern</td>
<td>The value within <code>expr_pattern</code> that will be replaced with a column name. The value of <code>col_pattern</code> is case-sensitive.</td>
</tr>
<tr>
<td></td>
<td>The default value of <code>col_pattern</code> is ':col'</td>
</tr>
</tbody>
</table>
**Table 40-166  (Cont.) XFORM_EXPR_NUM Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_schema_name</td>
<td>Schema of <code>data_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of <code>xform_view_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

**Usage Notes**

1. The `XFORM_EXPR_NUM` procedure constructs numeric transformation expressions from the specified expression pattern (`expr_pattern`) by replacing every occurrence of the specified column pattern (`col_pattern`) with an actual column name.

   `XFORM_EXPR_NUM` uses the SQL `REPLACE` function to construct the transformation expressions.

   ```sql
   REPLACE (expr_pattern, col_pattern, '"column_name"') || '"column_name"'
   ```

   If there is a column match, then the replacement is made in the transformation expression; if there is not a match, then the column is used without transformation.

   **See:**

   Oracle Database SQL Language Reference for information about the `REPLACE` function

2. Because of the include and exclude list parameters, the `XFORM_EXPR_NUM` and `XFORM_EXPR_STR` procedures allow you to easily specify individual columns for transformation within large data sets. The other `XFORM_*` procedures support an exclude list only. In these procedures, you must enumerate every column that you do not want to transform.

3. See "Operational Notes"

**Examples**

This example creates a view that transforms the datatype of numeric columns.

```sql
describe customers
Name                                Null?    Type
----------------------------------- -------- ------------------------
CUST_ID                             NOT NULL NUMBER
CUST_MARITAL_STATUS                          VARCHAR2(20)
OCCUPATION                                   VARCHAR2(21)
AGE                                          NUMBER
YRS_RESIDENCE                                NUMBER

BEGIN
DBMS_DATA_MINING_TRANSFORM.XFORM_EXPR_NUM(
    expr_pattern => 'to_char(:col)',
    data_table_name => 'customers',
    xform_view_name => 'cust_nonum_view',
    exclude_list => dbms_data_mining_transform.COLUMN_LIST( 'cust_id'),

    ...
)`
describe cust_nonum_view
Name                                Null?    Type
----------------------------------- -------- ------------------------
CUST_ID                             NOT NULL NUMBER
CUST_MARITAL_STATUS                          VARCHAR2(20)
OCCUPATION                                   VARCHAR2(21)
AGE                                          VARCHAR2(40)
YRS_RESIDENCE                                VARCHAR2(40)

40.2.3.36 XFORM_EXPR_STR Procedure

This procedure creates a view that implements the specified categorical
transformations. Only the columns that you specify are transformed; the remaining
columns from the data table are present in the view, but they are not changed.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_EXPR_STR (
  expr_pattern       IN       VARCHAR2,
  data_table_name    IN       VARCHAR2,
  xform_view_name    IN       VARCHAR2,
  exclude_list       IN       COLUMN_LIST DEFAULT NULL,
  include_list       IN       COLUMN_LIST DEFAULT NULL,
  col_pattern        IN       VARCHAR2 DEFAULT ':col',
  data_schema_name   IN       VARCHAR2 DEFAULT NULL,
  xform_schema_name  IN       VARCHAR2 DEFAULT NULL);

Parameters

Table 40-167  XFORM_EXPR_STR Procedure Parameters
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr_pattern</td>
<td>A character transformation expression</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in data_table_name with the transformations specified in expr_pattern and col_pattern.</td>
</tr>
<tr>
<td>exclude_list</td>
<td>List of categorical columns to exclude. If NULL, no categorical columns are excluded. The format of exclude_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2', ...'coln')</td>
</tr>
<tr>
<td>include_list</td>
<td>List of character columns to include. If NULL, all character columns are included. The format of include_list is:</td>
</tr>
<tr>
<td></td>
<td>dbms_data_mining_transform.COLUMN_LIST('col1','col2', ...'coln')</td>
</tr>
</tbody>
</table>
Table 40-167  (Cont.) XFORM_EXPR_STR Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>col_pattern</td>
<td>The value within expr_pattern that will be replaced with a column name. The value of col_pattern is case-sensitive. The default value of col_pattern is ':col'</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

1. The XFORM_EXPR_STR procedure constructs character transformation expressions from the specified expression pattern (expr_pattern) by replacing every occurrence of the specified column pattern (col_pattern) with an actual column name.

   XFORM_EXPR_STR uses the SQL REPLACE function to construct the transformation expressions.

   REPLACE (expr_pattern, col_pattern,'"column_name"') || '"column_name"'

   If there is a column match, then the replacement is made in the transformation expression; if there is not a match, then the column is used without transformation.

   See: Oracle Database SQL Language Reference for information about the REPLACE function

2. Because of the include and exclude list parameters, the XFORM_EXPR_STR and XFORM_EXPR_NUM procedures allow you to easily specify individual columns for transformation within large data sets. The other XFORM_* procedures support an exclude list only. In these procedures, you must enumerate every column that you do not want to transform.

3. See "Operational Notes"

Examples

This example creates a view that transforms character columns to upper case.

describe customers
Name                                Null?    Type
----------------------------------- -------- ------------------------
CUST_ID                             NOT NULL NUMBER
CUST_MARITAL_STATUS                          VARCHAR2(20)
OCCUPATION                                   VARCHAR2(21)
AGE                                          NUMBER
YRS_RESIDENCE                                NUMBER
SELECT cust_id, cust_marital_status, occupation FROM customers
WHERE cust_id > 102995
ORDER BY cust_id desc;

CUST_ID CUST_MARITAL_STATUS  OCCUPATION
------- -------------------- ---------------------
103000 Divorc.              Cleric.
102999 Married              Cleric.
102998 Married              Exec.
102997 Married              Exec.
102996 NeverM               Other

BEGIN
DBMS_DATA_MINING_TRANSFORM.XFORM_EXPR_STR(
   expr_pattern => 'upper(:col)',
   data_table_name => 'customers',
   xform_view_name => 'cust_upcase_view');
END;
/
describe cust_upcase_view
Name     Null?    Type
----------------------------- -------- -------------------
CUST_ID                       NOT NULL NUMBER
CUST_MARITAL_STATUS                    VARCHAR2(20)
OCCUPATION                             VARCHAR2(21)
AGE                                    NUMBER
YRS_RESIDENCE                          NUMBER

SELECT cust_id, cust_marital_status, occupation FROM cust_upcase_view
WHERE cust_id > 102995
ORDER BY cust_id desc;

CUST_ID CUST_MARITAL_STATUS  OCCUPATION
------- -------------------- ---------------------
103000 DIVORC.              CLERIC.
102999 MARRIED              CLERIC.
102998 MARRIED              EXEC.
102997 MARRIED              EXEC.
102996 NEVERM               OTHER

40.2.3.37 XFORM_MISS_CAT Procedure

This procedure creates a view that implements the categorical missing value treatment transformations specified in a definition table. Only the columns that are specified in the definition table are transformed; the remaining columns from the data table are present in the view, but they are not changed.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_MISS_CAT (
    miss_table_name IN VARCHAR2,
    data_table_name IN VARCHAR2,
    xform_view_name IN VARCHAR2,
    miss_schema_name IN VARCHAR2 DEFAULT NULL,
    data_schema_name IN VARCHAR2 DEFAULT NULL,
    xform_schema_name IN VARCHAR2 DEFAULT NULL;
Parameters

Table 40-168  XFORM_MISS_CAT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for categorical missing value treatment. You can use the CREATE_MISS_CAT Procedure to create the definition table. The table must be populated with transformation definitions before you call XFORM_MISS_CAT. To populate the table, you can use the INSERT_MISS_CAT_MODE Procedure or you can write your own SQL. See Table 40-133.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in data_table_name with the transformations specified in miss_table_name.</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See “Operational Notes”.

Examples

This example creates a view that replaces missing categorical values with the mode.

```sql
SELECT * FROM geog;

REG_ID REGION
------ ------------------------------
 1   NE
 2   SW
 3   SE
 4   SW
 5
 6   NE
 7   NW
 8   NW
 9
10
11   SE
12   SE
13   NW
14   SE
15   SE

SELECT STATS_MODE(region) FROM geog;

STATS_MODE(REGION)
-------------------------------
 SE
```
BEGIN
  DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_CAT('misscat_xtbl');
  DBMS_DATA_MINING_TRANSFORM.INSERT_MISS_CAT_MODE (misstable_name => 'misscat_xtbl', data_table_name => 'geog');
END;
/

SELECT col, val FROM misscat_xtbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>REGION</td>
<td>SE</td>
</tr>
</tbody>
</table>

BEGIN
  DBMS_DATA_MINING_TRANSFORM.XFORM_MISS_CAT (misstable_name => 'misscat_xtbl', data_table_name => 'geog', xform_view_name => 'geogxf_view');
END;
/

SELECT * FROM geogxf_view;

<table>
<thead>
<tr>
<th>REG_ID</th>
<th>REGION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NE</td>
</tr>
<tr>
<td>2</td>
<td>SW</td>
</tr>
<tr>
<td>3</td>
<td>SE</td>
</tr>
<tr>
<td>4</td>
<td>SW</td>
</tr>
<tr>
<td>5</td>
<td>SE</td>
</tr>
<tr>
<td>6</td>
<td>NE</td>
</tr>
<tr>
<td>7</td>
<td>NW</td>
</tr>
<tr>
<td>8</td>
<td>NW</td>
</tr>
<tr>
<td>9</td>
<td>SE</td>
</tr>
<tr>
<td>10</td>
<td>SE</td>
</tr>
<tr>
<td>11</td>
<td>SE</td>
</tr>
<tr>
<td>12</td>
<td>SE</td>
</tr>
<tr>
<td>13</td>
<td>NW</td>
</tr>
<tr>
<td>14</td>
<td>SE</td>
</tr>
<tr>
<td>15</td>
<td>SE</td>
</tr>
</tbody>
</table>

40.2.3.38 XFORM_MISS_NUM Procedure

This procedure creates a view that implements the numerical missing value treatment transformations specified in a definition table. Only the columns that are specified in the definition table are transformed; the remaining columns from the data table are present in the view, but they are not changed.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_MISS_NUM (miss_table_name IN VARCHAR2, data_table_name IN VARCHAR2, xform_view_name IN VARCHAR2, miss_schema_name IN VARCHAR2 DEFAULT NULL, data_schema_name IN VARCHAR2 DEFAULT NULL, xform_schema_name IN VARCHAR2 DEFAULT NULL;
Parameters

Table 40-169  XFORM_MISS_NUM Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>miss_table_name</td>
<td>Name of the transformation definition table for numerical missing value treatment. You can use the CREATE_MISS_NUM Procedure to create the definition table. The table must be populated with transformation definitions before you call XFORM_MISS_NUM. To populate the table, you can use the INSERT_MISS_NUM_MEAN Procedure or you can write your own SQL. See Table 40-135.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view presents columns in data_table_name with the transformations specified in miss_table_name.</td>
</tr>
<tr>
<td>miss_schema_name</td>
<td>Schema of miss_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes".

Examples

This example creates a view that replaces missing numerical values with the mean.

```
SELECT * FROM items;

ITEM_ID       QTY
---------- -----
aa            200
bb            200
c
cc            250
d
dd            100
e
ff            250
g
hh            200
ii            200
jj

SELECT AVG(qty) FROM items;

AVG(QTY)
-------
  200

BEGIN
  DBMS_DATA_MINING_TRANSFORM.CREATE_MISS_NUM('missnum_xtbl');
  DBMS_DATA_MINING_TRANSFORM.INSERT_MISS_NUM_MEAN (  
```
miss_table_name          => 'missnum_xtbl',
data_table_name         => 'items' );
END;
/

SELECT col, val FROM missnum_xtbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>VAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTY</td>
<td>200</td>
</tr>
</tbody>
</table>

BEGIN
  DBMS_DATA_MINING_TRANSFORM.XFORM_MISS_NUM ( 
    miss_table_name => 'missnum_xtbl',
    data_table_name => 'items',
    xform_view_name => 'items_view');
END;
/

SELECT * FROM items_view;

<table>
<thead>
<tr>
<th>ITEM_ID</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>aa</td>
<td>200</td>
</tr>
<tr>
<td>bb</td>
<td>200</td>
</tr>
<tr>
<td>cc</td>
<td>250</td>
</tr>
<tr>
<td>dd</td>
<td>200</td>
</tr>
<tr>
<td>ee</td>
<td>200</td>
</tr>
<tr>
<td>ff</td>
<td>100</td>
</tr>
<tr>
<td>gg</td>
<td>250</td>
</tr>
<tr>
<td>hh</td>
<td>200</td>
</tr>
<tr>
<td>ii</td>
<td>200</td>
</tr>
<tr>
<td>jj</td>
<td>200</td>
</tr>
</tbody>
</table>

40.2.3.39 XFORM_NORM_LIN Procedure

This procedure creates a view that implements the linear normalization transformations specified in a definition table. Only the columns that are specified in the definition table are transformed; the remaining columns from the data table are present in the view, but they are not changed.

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_NORM_LIN ( 
  norm_table_name IN VARCHAR2,
  data_table_name IN VARCHAR2,
  xform_view_name IN VARCHAR2,
  norm_schema_name IN VARCHAR2 DEFAULT NULL,
  data_schema_name IN VARCHAR2 DEFAULT NULL,
  xform_schema_name IN VARCHAR2 DEFAULT NULL);
### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>norm_table_name</code></td>
<td>Name of the transformation definition table for linear normalization. You can use the <code>CREATE_NORM_LIN Procedure</code> to create the definition table. The table must be populated with transformation definitions before you call <code>XFORM_NORM_LIN</code>. To populate the table, you can use one of the <code>INSERT</code> procedures for normalization or you can write your own SQL. See Table 40-133.</td>
</tr>
<tr>
<td><code>data_table_name</code></td>
<td>Name of the table containing the data to be transformed</td>
</tr>
<tr>
<td><code>xform_view_name</code></td>
<td>Name of the view to be created. The view presents columns in <code>data_table_name</code> with the transformations specified in <code>miss_table_name</code>.</td>
</tr>
<tr>
<td><code>norm_schema_name</code></td>
<td>Schema of <code>miss_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td><code>data_schema_name</code></td>
<td>Schema of <code>data_table_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td><code>xform_schema_name</code></td>
<td>Schema of <code>xform_view_name</code>. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

### Usage Notes

See "Operational Notes".

### Examples

This example creates a view that normalizes the `cust_year_of_birth` and `cust_credit_limit` columns. The data source consists of three columns from `sh.customer`.

```sql
CREATE OR REPLACE VIEW mining_data AS
  SELECT cust_id, cust_year_of_birth, cust_credit_limit
  FROM sh.customers;

describe mining_data
Name                  Null?    Type
------------------------------ --------------------------
CUST_ID               NOT NULL NUMBER
CUST_YEAR_OF_BIRTH    NOT NULL NUMBER(4)
CUST_CREDIT_LIMIT     NUMBER

SELECT * FROM mining_data WHERE cust_id > 104495
ORDER BY cust_year_of_birth;

CUST_ID CUST_YEAR_OF_BIRTH CUST_CREDIT_LIMIT
----------- ------------------ -------------------
104496 1947 3000
104498 1954 10000
104500 1962 15000
104499 1970 3000
104497 1976 3000

BEGIN
  dbms_data_mining_transform.CREATE_NORM_LIN(
```
norm_table_name => 'normx_tbl');
dbms_data_mining_transform.INSERT_NORM_LIN_MINMAX(
  norm_table_name => 'normx_tbl',
  data_table_name => 'mining_data',
  exclude_list => dbms_data_mining_transform.COLUMN_LIST( 'cust_id'),
  round_num => 3);
END;
/
SELECT col, shift, scale FROM normx_tbl;

<table>
<thead>
<tr>
<th>COL</th>
<th>SHIFT</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUST_YEAR_OF_BIRTH</td>
<td>1910</td>
<td>77</td>
</tr>
<tr>
<td>CUST_CREDIT_LIMIT</td>
<td>1500</td>
<td>13500</td>
</tr>
</tbody>
</table>

BEGIN
  DBMS_DATA_MINING_TRANSFORM.XFORM_NORM_LIN (
    norm_table_name => 'normx_tbl',
    data_table_name => 'mining_data',
    xform_view_name => 'norm_view');
END;
/
SELECT * FROM norm_view WHERE cust_id > 104495
  ORDER BY cust_year_of_birth;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CUST_YEAR_OF_BIRTH</th>
<th>CUST_CREDIT_LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>104496</td>
<td>.4805195</td>
<td>.1111111</td>
</tr>
<tr>
<td>104498</td>
<td>.5714286</td>
<td>.6296296</td>
</tr>
<tr>
<td>104500</td>
<td>.6753247</td>
<td>1</td>
</tr>
<tr>
<td>104499</td>
<td>.7792208</td>
<td>.1111111</td>
</tr>
<tr>
<td>104497</td>
<td>.8571429</td>
<td>.1111111</td>
</tr>
</tbody>
</table>

set long 2000
SQL> SELECT text FROM user_views WHERE view_name IN 'NORM_VIEW';

TEXT

40.2.3.40 XFORM_STACK Procedure

This procedure creates a view that implements the transformations specified by the stack. Only the columns and nested attributes that are specified in the stack are transformed. Any remaining columns and nested attributes from the data table appear in the view without changes.

To create a list of objects that describe the transformed columns, use the DESCRIBE_STACK Procedure.
See Also:

"Overview"

Oracle Machine Learning for SQL User’s Guide for more information about machine learning attributes

Syntax

DBMS_DATA_MINING_TRANSFORM.XFORM_STACK (
    xform_list         IN     TRANSFORM_list,
    data_table_name    IN     VARCHAR2,
    xform_view_name    IN     VARCHAR2,
    data_schema_name   IN     VARCHAR2 DEFAULT NULL,
    xform_schema_name  IN     VARCHAR2 DEFAULT NULL);

Parameters

Table 40-171  XFORM_STACK Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xform_list</td>
<td>The transformation list. See Table 40-122 for a description of the TRANSFORM_LIST object type.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be transformed.</td>
</tr>
<tr>
<td>xform_view_name</td>
<td>Name of the view to be created. The view applies the transformations in xform_list to data_table_name.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Schema of data_table_name. If no schema is specified, the current schema is used.</td>
</tr>
<tr>
<td>xform_schema_name</td>
<td>Schema of xform_view_name. If no schema is specified, the current schema is used.</td>
</tr>
</tbody>
</table>

Usage Notes

See "Operational Notes". The following sections are especially relevant:

- "About Transformation Lists"
- "About Stacking"
- "Nested Data Transformations"

Examples

This example applies a transformation list to the view oml_user.cust_info and shows how the data is transformed. The CREATE statement for cust_info is shown in "DESCRIBE_STACK Procedure".

BEGIN
    dbms_data_mining_transform.CREATE_BIN_NUM ('birth_yr_bins');
    dbms_data_mining_transform.INSERT_BIN_NUM_QTILE (  
        bin_table_name => 'birth_yr_bins',  
        data_table_name => 'cust_info',  
        bin_num => 6,  
        exclude_list => dbms_data_mining_transform.column_list");
DECLARE
    cust_stack   dbms_data_mining_transform.TRANSFORM_LIST;
BEGIN
    dbms_data_mining_transform.SET_TRANSFORM (cust_stack,
        'country_id', NULL, 'country_id/10', 'country_id*10');
    dbms_data_mining_transform.STACK_BIN_NUM ('birth_yr_bins',
        cust_stack);
    dbms_data_mining_transform.SET_TRANSFORM (cust_stack,
        'custprods', 'Mouse Pad', 'value*100', 'value/100');
    dbms_data_mining_transform.XFORM_STACK(
        xform_list        => cust_stack,
        data_table_name   => 'cust_info',
        xform_view_name   =>  'cust_xform_view');
END;
/

-- Two rows of data without transformations
SELECT * from cust_info WHERE cust_id BETWEEN 100010 AND 100011;

CUST_ID COUNTRY_ID CUST_YEAR_OF_BIRTH CUSTPRODS(ATTRIBUTE_NAME, VALUE)
------- ---------- ------------------ -----------------------------------------
100010      52790       1975 DM_NESTED_NUMERICALS(
                               DM_NESTED_NUMERICAL(
                                   '18" Flat Panel Graphics Monitor', 1),
                               DM_NESTED_NUMERICAL(
                                   'SIMM- 16MB PCMCIAII card', 1))

100011      52775       1972 DM_NESTED_NUMERICALS(
                               DM_NESTED_NUMERICAL(
                                   'External 8X CD-ROM', 1),
                               DM_NESTED_NUMERICAL(
                                   'Mouse Pad', 1),
                               DM_NESTED_NUMERICAL(
                                   'SIMM- 16MB PCMCIAII card', 1),
                               DM_NESTED_NUMERICAL(
                                   'Keyboard Wrist Rest', 1),
                               DM_NESTED_NUMERICAL(
                                   '18" Flat Panel Graphics Monitor', 1),
                               DM_NESTED_NUMERICAL(
                                   'O/S Documentation Set - English', 1))

-- Same two rows of data with transformations
SELECT * FROM cust_xform_view WHERE cust_id BETWEEN 100010 AND 100011;

CUST_ID COUNTRY_ID  C CUSTPRODS(ATTRIBUTE_NAME, VALUE)
------- -------- -- -----------------------------------------
100010      5279  5 DM_NESTED_NUMERICALS(
40.3 DBMS_PREDICTIVE_ANALYTICS

Machine learning can discover useful information buried in vast amounts of data. However, both the programming interfaces and the machine learning expertise required to obtain these results are too complex for use by the wide audiences that can obtain benefits from using Oracle Machine Learning for SQL.

The DBMS_PREDICTIVE_ANALYTICS package addresses both of these complexities by automating the entire machine learning process from data preprocessing through model building to scoring new data. This package provides an important tool that makes machine learning possible for a broad audience of users, in particular, business analysts.

This chapter contains the following topics:

- Overview
- Security Model
- Summary of DBMS_PREDICTIVE_ANALYTICS Subprograms

40.3.1 Using DBMS_PREDICTIVE_ANALYTICS

This section contains topics that relate to using the DBMS_PREDICTIVE_ANALYTICS package.

- Overview
- Security Model

40.3.1.1 DBMS_PREDICTIVE_ANALYTICS Overview

DBMS_PREDICTIVE_ANALYTICS automates parts of the machine learning process.

Machine learning, according to a commonly used process model, requires the following steps:

1. Understand the business problem.
2. Understand the data.
3. Prepare the data for mining.
4. Create models using the prepared data.
5. Evaluate the models.
6. Deploy and use the model to score new data.

**DBMS_PREDICTIVE_ANALYTICS** automates parts of step 3 — 5 of this process.

Predictive analytics procedures analyze and prepare the input data, create and test machine learning models using the input data, and then use the input data for scoring. The results of scoring are returned to the user. The models and supporting objects are not preserved after the operation completes.

### 40.3.1.2 DBMS_PREDICTIVE_ANALYTICS Security Model

The **DBMS_PREDICTIVE_ANALYTICS** package is owned by user **SYS** and is installed as part of database installation. Execution privilege on the package is granted to public. The routines in the package are run with invokers' rights (run with the privileges of the current user).

The **DBMS_PREDICTIVE_ANALYTICS** package exposes APIs which are leveraged by the Oracle Machine Learning for SQL option. Users who wish to invoke procedures in this package require the **CREATE_MINING_MODEL** system privilege (as well as the **CREATE TABLE** and **CREATE VIEW** system privilege).

### 40.3.2 Summary of DBMS_PREDICTIVE_ANALYTICS Subprograms

This table lists and briefly describes the **DBMS_PREDICTIVE_ANALYTICS** package subprograms.

<table>
<thead>
<tr>
<th>Subprogram</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPLAIN Procedure</td>
<td>Ranks attributes in order of influence in explaining a target column.</td>
</tr>
<tr>
<td>PREDICT Procedure</td>
<td>Predicts the value of a target column based on values in the input data.</td>
</tr>
<tr>
<td>PROFILE Procedure</td>
<td>Generates rules that identify the records that have the same target value.</td>
</tr>
</tbody>
</table>

#### 40.3.2.1 EXPLAIN Procedure

The **EXPLAIN** procedure identifies the attributes that are important in explaining the variation in values of a target column.

The input data must contain some records where the target value is known (not **NULL**). These records are used by the procedure to train a model that calculates the attribute importance.
**Note:**

EXPLAIN supports **DATE** and **TIMESTAMP** datatypes in addition to the numeric, character, and nested datatypes supported by Oracle Machine Learning for SQL models.

Data requirements for Oracle Machine Learning for SQL are described in *Oracle Machine Learning for SQL User's Guide*.

The EXPLAIN procedure creates a result table that lists the attributes in order of their explanatory power. The result table is described in the Usage Notes.

**Syntax**

```sql
DBMS_PREDICTIVE_ANALYTICS.EXPLAIN (
    data_table_name  IN VARCHAR2,
    explain_column_name IN VARCHAR2,
    result_table_name   IN VARCHAR2,
    data_schema_name    IN VARCHAR2 DEFAULT NULL);
```

**Parameters**

**Table 40-173  EXPLAIN Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_table_name</td>
<td>Name of input table or view</td>
</tr>
<tr>
<td>explain_column_name</td>
<td>Name of the column to be explained</td>
</tr>
<tr>
<td>result_table_name</td>
<td>Name of the table where results are saved</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Name of the schema where the input table or view resides and where the result table is created. Default: the current schema.</td>
</tr>
</tbody>
</table>

**Usage Notes**

The EXPLAIN procedure creates a result table with the columns described in **Table 40-174**.

**Table 40-174  EXPLAIN Procedure Result Table**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(30)</td>
<td>Name of a column in the input data; all columns except the explained column are listed in the result table.</td>
</tr>
</tbody>
</table>
Table 40-174  (Cont.) EXPLAIN Procedure Result Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPLANATORY_VALUE</td>
<td>NUMBER</td>
<td>Value indicating how useful the column is for determining the value of the explained column. Higher values indicate greater explanatory power. Value can range from 0 to 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An individual column's explanatory value is independent of other columns in the input table. The values are based on how strong each individual column correlates with the explained column. The value is affected by the number of records in the input table, and the relations of the values of the column to the values of the explain column.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An explanatory power value of 0 implies there is no useful correlation between the column's values and the explain column's values. An explanatory power of 1 implies perfect correlation; such columns should be eliminated from consideration for PREDICT. In practice, an explanatory power equal to 1 is rarely returned.</td>
</tr>
<tr>
<td>RANK</td>
<td>NUMBER</td>
<td>Ranking of explanatory power. Rows with equal values for explanatory_value have the same rank. Rank values are not skipped in the event of ties.</td>
</tr>
</tbody>
</table>

Example

The following example performs an EXPLAIN operation on the SUPPLEMENTARY_DEMOGRAPHICS table of Sales History.

```sql
--Perform EXPLAIN operation
BEGIN
    DBMS_PREDICTIVE_ANALYTICS.EXPLAIN(
        data_table_name => 'supplementary_demographics',
        explain_column_name => 'home_theater_package',
        result_table_name => 'demographics_explain_result');
END;
/
--Display results
SELECT * FROM demographics_explain_result;
```

<table>
<thead>
<tr>
<th>ATTRIBUTE_NAME</th>
<th>EXPLANATORY_VALUE</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_BOX_GAMES</td>
<td>.524311073</td>
<td>1</td>
</tr>
<tr>
<td>YRS_RESIDENCE</td>
<td>.495987246</td>
<td>2</td>
</tr>
<tr>
<td>HOUSEHOLD_SIZE</td>
<td>.146208506</td>
<td>3</td>
</tr>
<tr>
<td>AFFINITY_CARD</td>
<td>.0598227</td>
<td>4</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>.018462703</td>
<td>5</td>
</tr>
<tr>
<td>OCCUPATION</td>
<td>.009721543</td>
<td>6</td>
</tr>
<tr>
<td>FLAT_PANEL_MONITOR</td>
<td>.00013733</td>
<td>7</td>
</tr>
<tr>
<td>PRINTER_SUPPLIES</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>OS_DOC_SET_KANJI</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>BULK_PACK_DISKETTES</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>BOOKKEEPING_APPLICATION</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>CUST_ID</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

The results show that **Y_BOX_GAMES, YRS_RESIDENCE, and HOUSEHOLD_SIZE** are the best predictors of **HOME_THEATER_PACKAGE**.
40.3.2.2 PREDICT Procedure

The PREDICT procedure predicts the values of a target column.

The input data must contain some records where the target value is known (not NULL). These records are used by the procedure to train and test a model that makes the predictions.

Note:

PREDICT supports DATE and TIMESTAMP datatypes in addition to the numeric, character, and nested datatypes supported by Oracle Machine Learning for SQL models.

Data requirements for OML4SQL are described in Oracle Machine Learning for SQL User’s Guide.

The PREDICT procedure creates a result table that contains a predicted target value for every record. The result table is described in the Usage Notes.

Syntax

```sql
DBMS_PREDICTIVE_ANALYTICS.PREDICT (    accuracy                  OUT NUMBER,    data_table_name           IN VARCHAR2,    case_id_column_name       IN VARCHAR2,    target_column_name        IN VARCHAR2,    result_table_name         IN VARCHAR2,    data_schema_name          IN VARCHAR2 DEFAULT NULL);```

Parameters

Table 40-175  PREDICT Procedure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>accuracy</td>
<td>Output parameter that returns the predictive confidence, a measure of the accuracy of the predicted values. The predictive confidence for a categorical target is the most common target value; the predictive confidence for a numerical target is the mean.</td>
</tr>
<tr>
<td>data_table_name</td>
<td>Name of the input table or view.</td>
</tr>
<tr>
<td>case_id_column_name</td>
<td>Name of the column that uniquely identifies each case (record) in the input data.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Name of the column to predict.</td>
</tr>
<tr>
<td>result_table_name</td>
<td>Name of the table where results will be saved.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Name of the schema where the input table or view resides and where the result table is created. Default: the current schema.</td>
</tr>
</tbody>
</table>

Usage Notes

The PREDICT procedure creates a result table with the columns described in Table 40-176.
### Table 40-176  PREDICT Procedure Result Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case ID column name</td>
<td>VARCHAR2 or NUMBER</td>
<td>The name of the case ID column in the input data.</td>
</tr>
<tr>
<td>PREDICTION</td>
<td>VARCHAR2 or NUMBER</td>
<td>The predicted value of the target column for the given case.</td>
</tr>
<tr>
<td>PROBABILITY</td>
<td>NUMBER</td>
<td>For classification (categorical target), the probability of the prediction. For regression problems (numerical target), this column contains NULL.</td>
</tr>
</tbody>
</table>

**Note:**
Make sure that the name of the case ID column is not 'PREDICTION' or 'PROBABILITY'.

Predictions are returned for all cases whether or not they contained target values in the input.

Predicted values for known cases may be interesting in some situations. For example, you could perform deviation analysis to compare predicted values and actual values.

**Example**

The following example performs a PREDICT operation and displays the first 10 predictions. The results show an accuracy of 79% in predicting whether each customer has an affinity card.

```sql
--Perform PREDICT operation
DECLARE
  v_accuracy NUMBER(10,9);
BEGIN
  DBMS_PREDICTIVE_ANALYTICS.PREDICT(
    accuracy             => v_accuracy,
    data_table_name      => 'supplementary_demographics',
    case_id_column_name  => 'cust_id',
    target_column_name   => 'affinity_card',
    result_table_name    => 'pa_demographics_predict_result');
  DBMS_OUTPUT.PUT_LINE('Accuracy = ' || v_accuracy);
END;
/
```

Accuracy = .788696903

```sql
--Display results
SELECT * FROM pa_demographics_predict_result WHERE rownum < 10;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PREDICTION</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>101501</td>
<td>1</td>
<td>.834069848</td>
</tr>
<tr>
<td>101502</td>
<td>0</td>
<td>.991269965</td>
</tr>
<tr>
<td>101503</td>
<td>0</td>
<td>.99978311</td>
</tr>
<tr>
<td>101504</td>
<td>1</td>
<td>.971643388</td>
</tr>
<tr>
<td>101505</td>
<td>1</td>
<td>.541754127</td>
</tr>
</tbody>
</table>
40.3.2.3 PROFILE Procedure

The PROFILE procedure generates rules that describe the cases (records) from the input data. For example, if a target column CHURN has values 'Yes' and 'No', PROFILE generates a set of rules describing the expected outcomes. Each profile includes a rule, record count, and a score distribution.

The input data must contain some cases where the target value is known (not NULL). These cases are used by the procedure to build a model that calculates the rules.

**Note:**

PROFILE does not support nested types or dates.

Data requirements for Oracle Machine Learning for SQL are described in Oracle Machine Learning for SQL User's Guide.

The PROFILE procedure creates a result table that specifies rules (profiles) and their corresponding target values. The result table is described in the Usage Notes.

**Syntax**

```sql
DBMS_PREDICTIVE_ANALYTICS.PROFILE (  
data_table_name IN VARCHAR2,  
target_column_name IN VARCHAR2,  
result_table_name IN VARCHAR2,  
data_schema_name IN VARCHAR2 DEFAULT NULL);
```

**Parameters**

**Table 40-177   PROFILE Procedure Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_table_name</td>
<td>Name of the table containing the data to be analyzed.</td>
</tr>
<tr>
<td>target_column_name</td>
<td>Name of the target column.</td>
</tr>
<tr>
<td>result_table_name</td>
<td>Name of the table where the results will be saved.</td>
</tr>
<tr>
<td>data_schema_name</td>
<td>Name of the schema where the input table or view resides and where the result table is created. Default: the current schema.</td>
</tr>
</tbody>
</table>

**Usage Notes**

The PROFILE procedure creates a result table with the columns described in Table 40-178.
### Table 40-178  PROFILE Procedure Result Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Datatype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>NUMBER</td>
<td>A unique identifier for this profile (rule).</td>
</tr>
<tr>
<td>RECORD_COUNT</td>
<td>NUMBER</td>
<td>The number of records described by the profile.</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>SYS.XMLTYPE</td>
<td>The profile rule. See &quot;XML Schema for Profile Rules&quot;.</td>
</tr>
</tbody>
</table>

**XML Schema for Profile Rules**

The `DESCRIPTION` column of the result table contains XML that conforms to the following XSD:

```xml
<xs:element name="SimpleRule">
  <xs:complexType>
    <xs:sequence>
      <xs:group ref="PREDICATE"/>
      <xs:element ref="ScoreDistribution" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="id" type="xs:string" use="optional"/>
    <xs:attribute name="score" type="xs:string" use="required"/>
    <xs:attribute name="recordCount" type="NUMBER" use="optional"/>
  </xs:complexType>
</xs:element>
```

**Example**

This example generates a rule describing customers who are likely to use an affinity card (target value is 1) and a set of rules describing customers who are not likely to use an affinity card (target value is 0). The rules are based on only two predictors: education and occupation.

```sql
SET serveroutput ON
SET trimspool ON
SET pages 10000
SET long 10000
SET pagesize 10000
SET linesize 150
CREATE VIEW cust_edu_occ_view AS
  SELECT cust_id, education, occupation, affinity_card
  FROM sh.supplementary_demographics;
BEGIN
  DBMS_PREDICTIVE_ANALYTICS.PROFILE(
    DATA_TABLE_NAME    => 'cust_edu_occ_view',
    TARGET_COLUMN_NAME => 'affinity_card',
    RESULT_TABLE_NAME  => 'profile_result');
END;
/
```

This example generates eight rules in the result table `profile_result`. Seven of the rules suggest a target value of 0; one rule suggests a target value of 1. The `score` attribute on a rule identifies the target value.

This `SELECT` statement returns all the rules in the result table.

```sql
SELECT a.profile_id, a.record_count, a.description.getstringval()
FROM profile_result a;
```
This `SELECT` statement returns the rules for a target value of 0.

```sql
SELECT *
FROM profile_result t
WHERE extractvalue(t.description, '/SimpleRule/@score') = 0;
```

The eight rules generated by this example are displayed as follows.

```xml
<SimpleRule id="1" score="0" recordCount="443">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"Armed-F" "Exec." "Prof." "Protec."
    </Array>
  </SimpleSetPredicate>
  <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
    <Array type="string">"< Bach." "Assoc-V" "HS-grad"
  </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="297" />
  <ScoreDistribution value="1" recordCount="146" />
</SimpleRule>

<SimpleRule id="2" score="0" recordCount="18">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"Armed-F" "Exec." "Prof." "Protec."
    </Array>
  </SimpleSetPredicate>
  <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
    <Array type="string">"10th" "11th" "12th" "1st-4th" "5th-6th" "7th-8th" "9th" "Presch."
  </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="18" />
</SimpleRule>

<SimpleRule id="3" score="0" recordCount="458">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"Armed-F" "Exec." "Prof." "Protec."
    </Array>
  </SimpleSetPredicate>
  <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
    <Array type="string">"Assoc-A" "Bach."
  </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="248" />
  <ScoreDistribution value="1" recordCount="210" />
</SimpleRule>

<SimpleRule id="4" score="1" recordCount="276">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"Armed-F" "Exec." "Prof." "Protec."
    </Array>
  </SimpleSetPredicate>
  <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
    <Array type="string">"Masters" "PhD" "Profsc"
  </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="276" />
</SimpleRule>

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DBMS_PREDICTIVE_ANALYTICS

40-285
<SimpleRule id="5" score="0" recordCount="307">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
      <Array type="string">"Assoc-A" "Bach." "Masters" "PhD" "Profsc"</Array>
    </SimpleSetPredicate>
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"Crafts" "Sales" "TechSup" "Transp."
    </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="184" />  
  <ScoreDistribution value="1" recordCount="123" />
</SimpleRule>

<SimpleRule id="6" score="0" recordCount="243">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
      <Array type="string">"Assoc-A" "Bach." "Masters" "PhD" "Profsc"
    </SimpleSetPredicate>
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"?” "Cleric." "Crafts" "Farming" "Handler" "House-s" "Machine" "Other"
    </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="197" />
  <ScoreDistribution value="1" recordCount="46" />
</SimpleRule>

<SimpleRule id="7" score="0" recordCount="2158">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
      <Array type="string">"10th" "11th" "12th" "1st-4th" "5th-6th" "7th-8th" "9th" ">Bach." "Assoc-V" "HS-grad" "Presch."
    </SimpleSetPredicate>
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"?” "Cleric." "Crafts" "Farming" "Machine" "Sales" "TechSup" "Transp."
    </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="1819" />
  <ScoreDistribution value="1" recordCount="339" />
</SimpleRule>

<SimpleRule id="8" score="0" recordCount="597">
  <CompoundPredicate booleanOperator="and">
    <SimpleSetPredicate field="EDUCATION" booleanOperator="isIn">
      <Array type="string">"10th" "11th" "12th" "1st-4th" "5th-6th" "7th-8th" "9th" ">Bach." "Assoc-V" "HS-grad" "Presch."
    </SimpleSetPredicate>
    <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
      <Array type="string">"?” "Cleric." "Crafts" "Farming" "Handler" "House-s" "Machine" "Other"
    </SimpleSetPredicate>
  </CompoundPredicate>
  <ScoreDistribution value="0" recordCount="560" />
  <ScoreDistribution value="1" recordCount="37" />
</SimpleRule>
<SimpleSetPredicate>
  <SimpleSetPredicate field="OCCUPATION" booleanOperator="isIn">
    <Array type="string">"Handler" "House-s" "Other"
  </Array>
</SimpleSetPredicate>
</CompoundPredicate>
<ScoreDistribution value="0" recordCount="572"/>
<ScoreDistribution value="1" recordCount="25"/>
</SimpleRule>
Data Dictionary Views

The information in the data dictionary tables can be viewed through data dictionary views. The Oracle Machine Learning for SQL related dictionary views are listed in this chapter.

- **ALL_MINING_MODELS**
- **ALL_MINING_MODEL_ATTRIBUTES**
- **ALL_MINING_MODEL_PARTITIONs**
- **ALL_MINING_MODEL_SETTINGS**
- **ALL_MINING_MODEL_VIEWS**
- **ALL_MINING_MODEL_XFORMS**

### 41.1 ALL_MINING_MODELS

**ALL_MINING_MODELS** describes the machine learning models accessible to the current user.

Mining models are schema objects created by Oracle Machine Learning for SQL.

#### Related Views

- **DBA_MINING_MODELS** describes all machine learning models in the database.
- **USER_MINING_MODELS** describes the machine learning models owned by the current user. This view does not display the **OWNER** column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Owner of the machine learning model</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the machine learning model</td>
</tr>
</tbody>
</table>
| MINING_FUNCTION   | VARCHAR2(30)    | NOT NULL| Function of the mining model. The function identifies the class of problems that can be solved by this model. The machine learning function is specified when the model is built:  
  - CLASSIFICATION  
  - REGRESSION  
  - CLUSTERING  
  - FEATURE_EXTRACTION  
  - ASSOCIATION_RULES  
  - ATTRIBUTE_IMPORTANCE  
  - TIME_SERIES       |
<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGORITHM</td>
<td>VARCHAR2(30)</td>
<td>NOT NULL</td>
<td>Algorithm used by the model. Each machine learning function has a default algorithm. The default can be overridden with a model setting (see <code>*_MINING_MODEL_SETTINGS</code>):</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- APRIORI_ASSOCIATION_RULES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- CUR_DECOMPOSITION</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- DECISION_TREE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- EXPECTATION_MAXIMIZATION</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- EXPLICIT_SEMANTIC_ANALYSIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- EXPONENTIAL_SMOOTHING</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- EXTENSIBLE_LANG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- GENERALIZED_LINEAR_MODEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- KMEANS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- MINIMUM_DESCRIPTION_LENGTH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- MSET_SPRT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- NAIVE_BAYES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- NEURAL_NETWORK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- NONNEGATIVE_MATRIX_FACTOR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- O_CLUSTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- RANDOM_FOREST</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- SUPPORT_VECTOR_MACHINE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- SINGULAR_VALUE_DECOMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- XGBOOST</td>
</tr>
<tr>
<td>ALGORITHM_TYPE</td>
<td>VARCHAR2(10)</td>
<td>NOT NULL</td>
<td>Algorithm type of the model</td>
</tr>
<tr>
<td>CREATION_DATE</td>
<td>DATE</td>
<td>NOT NULL</td>
<td>Date that the model was created</td>
</tr>
<tr>
<td>BUILD_DURATON</td>
<td>NUMBER</td>
<td>NOT NULL</td>
<td>Time (in seconds) of the model build process</td>
</tr>
<tr>
<td>MODEL_SIZE</td>
<td>NUMBER</td>
<td>NOT NULL</td>
<td>Size of the model (in megabytes)</td>
</tr>
<tr>
<td>PARTITIONED</td>
<td>VARCHAR2(3)</td>
<td>NOT NULL</td>
<td>Indicates whether the model is partitioned or not. Possible values:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- YES: The model is partitioned.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- NO: The model is not partitioned</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>VARCHAR2(4000)</td>
<td>NOT NULL</td>
<td>Comment applied to the model with a SQL COMMENT statement</td>
</tr>
</tbody>
</table>

Related Topics

- `DBA_MINING_MODEL`
- `USER_MINING_MODELS`

See Also:

- *Oracle Machine Learning for SQL API Guide* for information about machine learning model schema objects
- *Oracle Machine Learning for SQL Concepts* for an introduction to Oracle Machine Learning for SQL
41.2 ALL_MINING_MODEL_ATTRIBUTES

ALL_MINING_MODEL_ATTRIBUTES describes the attributes of the machine learning models accessible to the current user.

Only the attributes in the model signature are included in this view. The attributes in the model signature correspond to the columns in the training data that were used to build the model.

Machine learning models are schema objects created by Oracle Machine Learning for SQL.

Related Views

- DBA_MINING_MODEL_ATTRIBUTES describes the attributes of all machine learning models in the database.
- USER_MINING_MODEL_ATTRIBUTES describes the attributes of the machine learning models owned by the current user. This view does not display the OWNER column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Owner of the machine learning model</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the machine learning model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td>ATTRIBUTE_TYPE</td>
<td>VARCHAR2(11)</td>
<td>–</td>
<td>Logical type of the attribute. The type is identified during the model build or apply process:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- NUMERICAL: Numeric data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- CATEGORICAL: Character data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- TEXT: Unstructured text data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- PARTITION: The input signature column is used for the partitioning key</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- MIXED: The input signature column takes on more than one attribute type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>This is due to user-defined embedded transformations that allow an input column to be transformed into multiple independent mining attributes, including mining attributes of different types.</td>
</tr>
<tr>
<td>DATA_TYPE</td>
<td>VARCHAR2(106)</td>
<td>–</td>
<td>Data type of the attribute</td>
</tr>
<tr>
<td>DATA_LENGTH</td>
<td>NUMBER</td>
<td>–</td>
<td>Length of the data type</td>
</tr>
<tr>
<td>DATA_PRECISION</td>
<td>NUMBER</td>
<td>–</td>
<td>Precision of a fixed point number. Precision, which is the total number of significant decimal digits, is represented as ( p ) in the data type ( \text{NUMBER}(p,s) ).</td>
</tr>
<tr>
<td>DATA_SCALE</td>
<td>NUMBER</td>
<td>–</td>
<td>Scale of a fixed point number. Scale, which is the number of digits from the decimal to the least significant digit, is represented as ( s ) in the data type ( \text{NUMBER}(p,s) ).</td>
</tr>
<tr>
<td>Column</td>
<td>Datatype</td>
<td>NULL</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| USAGE_TYPE     | VARCHAR2 (8)   | ☐    | Indicates whether the attribute was used to construct the model (ACTIVE) or not (INACTIVE). Some attributes may be eliminated by transformations or algorithmic processing. The 

  "MINING_MODEL_ATTRIBUTES" view only lists the attributes used by the model, therefore the value of this column is always ACTIVE. |
| TARGET         | VARCHAR2 (3)   | ☐    | Indicates whether the attribute is the target of a predictive model (YES) or not (NO). The target describes the result that is produced when the model is applied. |
| ATTRIBUTE_SPEC | VARCHAR2 (4000)| ☐    | One or more keywords that identify special treatment for the attribute during model build. Values are:                                             |
|                |                |      | - **FORCE IN**: (GLM only) When feature selection is enabled, forces the inclusion of the attribute in the model build. Feature selection is disabled by default. If the model is not using GLM with feature selection enabled, this value is ignored. |
|                |                |      | - **NOPREP**: When ADP is on, prevents automatic transformation of the attribute. If ADP is OFF, this value is ignored.                          |
|                |                |      | - **TEXT**: Causes the attribute to be treated as unstructured text data. The **TEXT** value supports three subsettings: **POLICY_NAME**, **MAX_FEATURES**, **TOKEN_TYPE**, and **MIN_DOCUMENTS**. Subsettings are specified as name:value pairs within parentheses. For example: (**POLICY_NAME**:mypolicy) (**MAX_FEATURES**:2000) (**TOKEN_TYPE**:THEME). See Oracle Machine Learning for SQL API Guide for details. |
|                |                |      | - **NULL**: The **ATTRIBUTE_SPEC** for this attribute is NULL. **ATTRIBUTE_SPEC** is a parameter to the PL/SQL procedure DBMS_DATA_MINING_TRANSFORM.SET_TRANSFORM. See Oracle Database PL/SQL Packages and Types Reference for details. |

### Related Topics

- **DBA_MINING_MODEL_ATTRIBUTES**
- **USER_MINING_MODEL_ATTRIBUTES**

### See Also:

*Oracle Machine Learning for SQL API Guide* for more information about the attributes of machine learning models.
41.3 ALL_MINING_MODEL_PARTITIONS

ALL_MINING_MODEL_PARTITIONS describes all the model partitions accessible to the user.

Related Views

- **DBA_MINING_MODEL_PARTITIONS** describes all the model partitions accessible to the system.
- **USER_MINING_MODEL_PARTITIONS** describes the user’s own model partitions. This view does not display the OWNER column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model owner</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model</td>
</tr>
<tr>
<td>PARTITION_NAME</td>
<td>VARCHAR2(128)</td>
<td>–</td>
<td>Name of the model partition</td>
</tr>
<tr>
<td>POSITION</td>
<td>NUMBER</td>
<td>–</td>
<td>Column position number for partitioning column.</td>
</tr>
<tr>
<td>COLUMN_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the column used for partitioning</td>
</tr>
<tr>
<td>COLUMN_VALUE</td>
<td>VARCHAR2(4000)</td>
<td>–</td>
<td>Value of the column for this partition</td>
</tr>
</tbody>
</table>

Related Topics

- **DBA_MINING_MODEL_PARTITIONS**
- **USER_MINING_MODEL_PARTITIONS**

41.4 ALL_MINING_MODEL_SETTINGS

ALL_MINING_MODEL_SETTINGS describes the settings of the machine learning models accessible to the current user.

Machine learning models are schema objects created by Oracle Machine Learning for SQL.

Related Views

- **DBA_MINING_MODEL_SETTINGS** describes the settings of all machine learning models in the database.
- **USER_MINING_MODEL_SETTINGS** describes the settings of the machine learning models owned by the current user. This view does not display the OWNER column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Owner of the machine learning model</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the machine learning model</td>
</tr>
<tr>
<td>SETTING_NAME</td>
<td>VARCHAR2(30)</td>
<td>NOT NULL</td>
<td>Name of the setting</td>
</tr>
<tr>
<td>SETTING_VALUE</td>
<td>VARCHAR2(4000)</td>
<td>–</td>
<td>Value of the setting</td>
</tr>
<tr>
<td>Column</td>
<td>Datatype</td>
<td>NULL</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SETTING_TYPE</td>
<td>VARCHAR2(?)</td>
<td>–</td>
<td>Indicates whether the default value (DEFAULT) or a user-specified value (INPUT) is used by the model</td>
</tr>
</tbody>
</table>

**Related Topics**

- `DBA_MINING_MODEL_SETTINGS`
- `USER_MINING_MODEL_SETTINGS`

**See Also:**

*Oracle Database PL/SQL Packages and Types Reference* for descriptions of model settings

### 41.5 ALL_MINING_MODEL_VIEWS

`ALL_MINING_MODEL_VIEWS` provides a description of all the model views accessible to the user.

**Related Views**

- `DBA_MINING_MODEL_VIEWS` provides a description of all the model views in the database.
- `USER_MINING_MODEL_VIEWS` provides a description of the user's own model views. This view does not display the `OWNER` column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Owner of the model view</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model to which model views belongs</td>
</tr>
<tr>
<td>VIEW_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model view</td>
</tr>
<tr>
<td>VIEW_TYPE</td>
<td>VARCHAR2(128)</td>
<td>–</td>
<td>Type of the model view</td>
</tr>
</tbody>
</table>

**Related Topics**

- `DBA_MINING_MODEL_VIEWS`
- `USER_MINING_MODEL_VIEWS`

**See Also:**

"ALL_MINING_MODEL_VIEWS" in *Oracle Machine Learning for SQL User’s Guide*
41.6 ALL_MINING_MODEL_XFORMS

ALL_MINING_MODEL_XFORMS describes the user-specified transformations embedded in all models accessible to the user.

**Related Views**

- **DBA_MINING_MODEL_XFORMS** describes the user-specified transformations embedded in all models accessible in the system.
- **USER_MINING_MODEL_XFORMS** describes the user-specified transformations embedded with the user's own models. This view does not display the **OWNER** column.

<table>
<thead>
<tr>
<th>Column</th>
<th>Datatype</th>
<th>NULL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWNER</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model owner</td>
</tr>
<tr>
<td>MODEL_NAME</td>
<td>VARCHAR2(128)</td>
<td>NOT NULL</td>
<td>Name of the model</td>
</tr>
<tr>
<td>ATTRIBUTE_NAME</td>
<td>VARCHAR2(128)</td>
<td></td>
<td>Name of the attribute used in the transformation</td>
</tr>
<tr>
<td>ATTRIBUTE_SUBNAME</td>
<td>VARCHAR2(4000)</td>
<td></td>
<td>Subname of the attribute used in the transformation</td>
</tr>
<tr>
<td>ATTRIBUTE_SPEC</td>
<td>VARCHAR2(4000)</td>
<td></td>
<td>Attribute specification provided to model training</td>
</tr>
<tr>
<td>EXPRESSION</td>
<td>CLOB</td>
<td></td>
<td>Transformation expression provided to model training</td>
</tr>
<tr>
<td>REVERSE</td>
<td>VARCHAR2(3)</td>
<td></td>
<td>Indicates whether the specified transformation is a reverse transformation (YES) or a forward expression (NO)</td>
</tr>
</tbody>
</table>

**Related Topics**

- **DBA_MINING_MODEL_XFORMS**
- **USER_MINING_MODEL_XFORMS**
Oracle Machine Learning for SQL functions are single-row functions that use OML4SQL to score data. The functions can apply a mining model schema object to the data, or they can dynamically mine the data by executing an analytic clause.

Note:
For a description of the syntax diagrams for these functions, see How to Read Syntax Diagrams in Oracle Database SQL Language Reference

- CLUSTER_DETAILS
- CLUSTER_DISTANCE
- CLUSTER_ID
- CLUSTER_PROBABILITY
- CLUSTER_SET
- FEATURE_COMPARE
- FEATUREDETAILS
- FEATURE_ID
- FEATURE_SET
- FEATURE_VALUE
- ORA_DM_PARTITION_NAME
- PREDICTION
- PREDICTION_BOUNDS
- PREDICTION_COST
- PREDICTION_DETAILS
- PREDICTION_PROBABILITY
- PREDICTION_SET
42.1 CLUSTER_DETAILS

Syntax

\[
\text{cluster_details} ::= \\
\text{CLUSTER_DETAILS} \left( \text{schema} . \text{model} , \text{cluster_id} , \text{topN} \right)
\]

Analytic Syntax

\[
\text{cluster_details_analytic} ::= \\
\text{CLUSTER_DETAILS} \left( \text{INTO n} , \text{cluster_id} , \text{topN} \right) \left( \text{OVER \text{mining_analytic_clause}} \right)
\]

\[
\text{mining_attribute_clause} ::= \\
\text{USING} \left( \ast \text{schema} . \text{table} . \ast \text{expr} \text{AS alias} \right)
\]

\[
\text{mining_analytic_clause} ::= \\
\text{query_partition_clause \text{order_by_clause}}
\]
Purpose

CLUSTER_DETAILS returns cluster details for each row in the selection. The return value is an XML string that describes the attributes of the highest probability cluster or the specified cluster_id.

topN

If you specify a value for topN, the function returns the N attributes that most influence the cluster assignment (the score). If you do not specify topN, the function returns the 5 most influential attributes.

DESC, ASC, or ABS

The returned attributes are ordered by weight. The weight of an attribute expresses its positive or negative impact on cluster assignment. A positive weight indicates an increased likelihood of assignment. A negative weight indicates a decreased likelihood of assignment.

By default, CLUSTER_DETAILS returns the attributes with the highest positive weights (DESC). If you specify ASC, the attributes with the highest negative weights are returned. If you specify ABS, the attributes with the greatest weights, whether negative or positive, are returned. The results are ordered by absolute value from highest to lowest. Attributes with a zero weight are not included in the output.

Syntax Choice

CLUSTER_DETAILS can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a clustering model.

- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include INTO n, where n is the number of clusters to compute, and mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=").

The syntax of the CLUSTER_DETAILS function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

mining_attribute_clause

mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause".)
Example

This example lists the attributes that have the greatest impact (more than 20% probability) on cluster assignment for customer ID 100955. The query invokes the `CLUSTER_DETAILS` and `CLUSTER_SET` functions, which apply the clustering model `em_sh_clus_sample`.

```sql
SELECT S.cluster_id, probability prob,
       CLUSTER_DETAILS(em_sh_clus_sample, S.cluster_id, 5 USING T.*) det
FROM
  (SELECT v.*, CLUSTER_SET(em_sh_clus_sample, NULL, 0.2 USING *) pset
   FROM mining_data_apply_v v
   WHERE cust_id = 100955) T,
  TABLE(T.pset) S
ORDER BY 2 DESC;
```

<table>
<thead>
<tr>
<th>CLUSTER_ID</th>
<th>PROB</th>
<th>DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------</td>
<td>------</td>
<td>-----</td>
</tr>
</tbody>
</table>
| 14 .6761   | <Details algorithm="Expectation Maximization" cluster="14">
|            | <Attribute name="AGE" actualValue="51" weight=".676" rank="1"/>
|            | <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".557" rank="2"/>
|            | <Attribute name="FLAT_PANEL_MONITOR" actualValue="0" weight=".412" rank="3"/>
|            | <Attribute name="Y_BOX_GAMES" actualValue="0" weight=".171" rank="4"/>
|            | <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight="-.003" rank="5"/>
|            | </Details> |
| 3 .3227    | <Details algorithm="Expectation Maximization" cluster="3">
|            | <Attribute name="YRS_RESIDENCE" actualValue="3" weight=".323" rank="1"/>
|            | <Attribute name="BULK_PACK_DISKETTES" actualValue="1" weight=".265" rank="2"/>
|            | <Attribute name="EDUCATION" actualValue="HS-grad" weight=".172" rank="3"/>
|            | <Attribute name="AFFINITY_CARD" actualValue="0" weight=".125" rank="4"/>
|            | <Attribute name="OCCUPATION" actualValue="Crafts" weight=".055" rank="5"/>
|            | </Details> |
Analytic Example

This example divides the customer database into four segments based on common characteristics. The clustering functions compute the clusters and return the score without a predefined clustering model.

```sql
SELECT * FROM (
    SELECT cust_id,
    CLUSTER_ID(INTO 4 USING *) OVER () cls,
    CLUSTER_DETAILS(INTO 4 USING *) OVER () cls_details
    FROM mining_data_apply_v)
WHERE cust_id <= 100003
ORDER BY 1;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CLS</th>
<th>CLS_DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100001</td>
<td>5</td>
<td>&lt;Details algorithm=&quot;K-Means Clustering&quot; cluster=&quot;5&quot;&gt; &lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;0&quot; weight=&quot;.349&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;BULK_PACK_DISKETTES&quot; actualValue=&quot;0&quot; weight=&quot;.33&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;CUST_INCOME_LEVEL&quot; actualValue=&quot;G: 130,000 - 149,999&quot; weight=&quot;.291&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.268&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.179&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
<tr>
<td>100002</td>
<td>6</td>
<td>&lt;Details algorithm=&quot;K-Means Clustering&quot; cluster=&quot;6&quot;&gt; &lt;Attribute name=&quot;CUST_GENDER&quot; actualValue=&quot;F&quot; weight=&quot;.945&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;CUST_MARITAL_STATUS&quot; actualValue=&quot;NeverM&quot; weight=&quot;.856&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;HOUSEHOLD_SIZE&quot; actualValue=&quot;2&quot; weight=&quot;.468&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.012&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;CUST_INCOME_LEVEL&quot; actualValue=&quot;L: 300,000 and above&quot; weight=&quot;.009&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
<tr>
<td>100003</td>
<td>7</td>
<td>&lt;Details algorithm=&quot;K-Means Clustering&quot; cluster=&quot;7&quot;&gt; &lt;Attribute name=&quot;CUST_MARITAL_STATUS&quot; actualValue=&quot;NeverM&quot; weight=&quot;.862&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;HOUSEHOLD_SIZE&quot; actualValue=&quot;2&quot; weight=&quot;.423&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;0&quot; weight=&quot;.113&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.007&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;CUST_ID&quot; actualValue=&quot;100003&quot; weight=&quot;.006&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
</tbody>
</table>

42.2 CLUSTER_DISTANCE

Syntax

```
cluster_distance::=
```

[Diagram of CLUSTER_DISTANCE]
Analytic Syntax

\[ \text{cluster_distance_analytic}::= \]

\[
\text{CLUSTER\_DISTANCE} \leftarrow \text{INTO } n \rightarrow \text{cluster\_id} \rightarrow \text{mining\_attribute\_clause} \rightarrow \text{OVER} \leftarrow \text{mining\_analytic\_clause} \rightarrow \]

\[ \text{mining\_attribute\_clause}::= \]

\[
\text{USING} \leftarrow \text{schema} \rightarrow \text{table} \rightarrow \text{expr} \rightarrow \text{AS } \text{alias} \rightarrow \]

\[ \text{mining\_analytic\_clause}::= \]

\[
\text{query\_partition\_clause} \rightarrow \text{order\_by\_clause} \rightarrow \]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \text{mining\_analytic\_clause}

Purpose

\text{CLUSTER\_DISTANCE} returns a cluster distance for each row in the selection. The cluster distance is the distance between the row and the centroid of the highest probability cluster or the specified \text{cluster\_id}. The distance is returned as \text{BINARY\_DOUBLE}.

Syntax Choice

\text{CLUSTER\_DISTANCE} can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose \text{Syntax} or \text{Analytic Syntax}:

- \text{Syntax} — Use the first syntax to score the data with a pre-defined model. Supply the name of a clustering model.
• **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include INTO n, where n is the number of clusters to compute, and mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=".)

The syntax of the CLUSTER_DISTANCE function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, this data is also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause".)

**See Also:**

- *Oracle Machine Learning for SQL Concepts* for information about clustering.

**Note:**

The following example is excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in *Oracle Machine Learning for SQL User’s Guide*.

**Example**

This example finds the 10 rows that are most anomalous as measured by their distance from their nearest cluster centroid.

```sql
SELECT cust_id
FROM (SELECT cust_id,
    rank() over
    (order by CLUSTER_DISTANCE(km_sh_clus_sample USING *) desc) rnk
     FROM mining_data_apply_v)
WHERE rnk <= 11
ORDER BY rnk;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100579</td>
</tr>
<tr>
<td>100050</td>
</tr>
<tr>
<td>100329</td>
</tr>
<tr>
<td>100962</td>
</tr>
<tr>
<td>101251</td>
</tr>
<tr>
<td>100179</td>
</tr>
<tr>
<td>100382</td>
</tr>
<tr>
<td>100713</td>
</tr>
<tr>
<td>100629</td>
</tr>
</tbody>
</table>
42.3 CLUSTER_ID

Syntax

\[
\text{cluster_id} ::= \\
\text{CLUSTER_ID (schema . model . mining_attribute_clause )}
\]

Analytic Syntax

\[
\text{cluster_id_analytic} ::= \\
\text{CLUSTER_ID INTO n mining_attribute_clause OVER mining_analytic_clause)
\]

\[
\text{mining_attribute_clause} ::= \\
\text{USING * schema . table . * expr AS alias ,}
\]

\[
\text{mining_analytic_clause} ::= \\
\text{query_partition_clause order_by_clause}
\]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \text{mining_analytic_clause}

Purpose

\text{CLUSTER_ID} returns the identifier of the highest probability cluster for each row in the selection. The cluster identifier is returned as an Oracle \text{NUMBER}.
Syntax Choice

CLUSTER_ID can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a clustering model.
- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include INTO \( n \), where \( n \) is the number of clusters to compute, and `mining_analytic_clause`, which specifies if the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`. (See "analytic_clause::=".)

The syntax of the CLUSTER_ID function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

### mining_attribute_clause

`mining_attribute_clause` identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The `mining_attribute_clause` behaves as described for the PREDICTION function. (See "mining_attribute_clause".)

#### See Also:

- Oracle Machine Learning for SQL Concepts for information about clustering.

#### Note:

The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.

#### Example

The following example lists the clusters into which the customers in `mining_data_apply_v` have been grouped.

```sql
SELECT CLUSTER_ID(km_sh_clus_sample USING *) AS clus, COUNT(*) AS cnt
FROM mining_data_apply_v
GROUP BY CLUSTER_ID(km_sh_clus_sample USING *)
ORDER BY cnt DESC;
```

<table>
<thead>
<tr>
<th>CLUS</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>580</td>
</tr>
<tr>
<td>10</td>
<td>216</td>
</tr>
<tr>
<td>6</td>
<td>186</td>
</tr>
</tbody>
</table>
Analytic Example

This example divides the customer database into four segments based on common characteristics. The clustering functions compute the clusters and return the score without a predefined clustering model.

```
SELECT * FROM (  
SELECT cust_id,  
    CLUSTER_ID(INTO 4 USING *) OVER () cls,  
    CLUSTER_DETAILS(INTO 4 USING *) OVER () cls_details  
FROM mining_data_apply_v)  
WHERE cust_id <= 100003  
ORDER BY 1;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CLS</th>
<th>CLS_DETAILS</th>
</tr>
</thead>
</table>
| 100001  | 5   | <Details algorithm="K-Means Clustering" cluster="5">  
          <Attribute name="FLAT_PANEL_MONITOR" actualValue="0" weight=".349" rank="1"/>  
          <Attribute name="BULK_PACK_DISKETTES" actualValue="0" weight=".33" rank="2"/>  
          <Attribute name="CUST_INCOME_LEVEL" actualValue="G: 130,000 - 149,999" weight=".291" rank="3"/>  
          <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".268" rank="4"/>  
          <Attribute name="Y_BOX_GAMES" actualValue="0" weight=".179" rank="5"/>  
      </Details> |
| 100002  | 6   | <Details algorithm="K-Means Clustering" cluster="6">  
          <Attribute name="CUST_GENDER" actualValue="F" weight=".945" rank="1"/>  
          <Attribute name="CUST_MARITAL_STATUS" actualValue="NeverM" weight=".856" rank="2"/>  
          <Attribute name="HOUSEHOLD_SIZE" actualValue="2" weight=".468" rank="3"/>  
          <Attribute name="AFFINITY_CARD" actualValue="0" weight=".012" rank="4"/>  
          <Attribute name="CUST_INCOME_LEVEL" actualValue="L: 300,000 and above" weight=".009" rank="5"/>  
      </Details> |
| 100003  | 7   | <Details algorithm="K-Means Clustering" cluster="7">  
          <Attribute name="CUST_MARITAL_STATUS" actualValue="NeverM" weight=".862" rank="1"/>  
          <Attribute name="HOUSEHOLD_SIZE" actualValue="2" weight=".423" rank="2"/>  
          <Attribute name="HOME_THEATER_PACKAGE" actualValue="0" weight=".113" rank="3"/>  
          <Attribute name="AFFINITY_CARD" actualValue="0" weight=".007" rank="4"/>  
          <Attribute name="CUST_ID" actualValue="100003" weight=".006" rank="5"/>  
      </Details> |

### 42.4 CLUSTER_PROBABILITY

**Syntax**

```
cluster_probability ::=  
```

![Diagram](image-url)
Analytic Syntax

\[ \text{cluster_prob_analytic} ::= \]

\[
\text{CLUSTER_PROBABILITY} \leftarrow \text{INTO} \quad \text{cluster_id} \quad \text{mining_attribute_clause} \]

\[
\text{OVER} \quad \text{mining_analytic_clause} \]

\[ \text{mining_attribute_clause} ::= \]

\[
\text{USING} \quad \text{schema} \quad \text{table} \quad \text{expr} \quad \text{AS} \quad \text{alias}, \]

\[ \text{mining_analytic_clause} ::= \]

\[
\text{query_partition_clause} \quad \text{order_by_clause} \]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \text{mining_analytic_clause}

Purpose

\text{CLUSTER_PROBABILITY} returns a probability for each row in the selection. The probability refers to the highest probability cluster or to the specified \text{cluster_id}. The cluster probability is returned as \text{BINARY_DOUBLE}.

Syntax Choice

\text{CLUSTER_PROBABILITY} can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- Syntax — Use the first syntax to score the data with a pre-defined model. Supply the name of a clustering model.
Analytic Syntax — Use the analytic syntax to score the data without a pre-defined model. Include INTO n, where n is the number of clusters to compute, and mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=".)

The syntax of the CLUSTER_PROBABILITY function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

mining_attribute_clause

mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause".)

See Also:

- Oracle Machine Learning for SQL Concepts for information about clustering.

Note:

The following example is excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.

Example

The following example lists the ten most representative customers, based on likelihood, of cluster 2.

```
SELECT cust_id
FROM (SELECT cust_id, rank() OVER (ORDER BY prob DESC, cust_id) rnk_clus2
     FROM (SELECT cust_id, CLUSTER_PROBABILITY(km_sh_clus_sample, 2 USING *) prob
          FROM mining_data_apply_v))
WHERE rnk_clus2 <= 10
ORDER BY rnk_clus2;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100256</td>
</tr>
<tr>
<td>100988</td>
</tr>
<tr>
<td>100889</td>
</tr>
<tr>
<td>101086</td>
</tr>
<tr>
<td>101215</td>
</tr>
<tr>
<td>100390</td>
</tr>
<tr>
<td>100985</td>
</tr>
<tr>
<td>101026</td>
</tr>
</tbody>
</table>
42.5 CLUSTER_SET

Syntax

\[ \text{cluster\_set::=} \]

Analytic Syntax

\[ \text{cluster\_set\_analytic::=} \]

\[ \text{mining\_attribute\_clause::=} \]

\[ \text{mining\_analytic\_clause::=} \]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \textit{mining\_analytic\_clause}
Purpose

CLUSTER_SET returns a set of cluster ID and probability pairs for each row in the selection. The return value is a varray of objects with field names CLUSTER_ID and PROBABILITY. The cluster identifier is an Oracle NUMBER; the probability is BINARY_DOUBLE.

topN and cutoff

You can specify topN and cutoff to limit the number of clusters returned by the function. By default, both topN and cutoff are null and all clusters are returned.

- topN is the N most probable clusters. If multiple clusters share the Nth probability, then the function chooses one of them.
- cutoff is a probability threshold. Only clusters with probability greater than or equal to cutoff are returned. To filter by cutoff only, specify NULL for topN.

To return up to the N most probable clusters that are greater than or equal to cutoff, specify both topN and cutoff.

Syntax Choice

CLUSTER_SET can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a clustering model.
- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include INTO n, where n is the number of clusters to compute, and mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=".)

The syntax of the CLUSTER_SET function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**See Also:**

- Oracle Machine Learning for SQL Concepts for information about clustering.
Example

This example lists the attributes that have the greatest impact (more than 20% probability) on cluster assignment for customer ID 100955. The query invokes the CLUSTER_DETAILS and CLUSTER_SET functions, which apply the clustering model em_sh_clus_sample.

```
SELECT S.cluster_id, probability prob,
       CLUSTER_DETAILS(em_sh_clus_sample, S.cluster_id, 5 USING T.*) det
FROM
       (SELECT v.*, CLUSTER_SET(em_sh_clus_sample, NULL, 0.2 USING *) pset
        FROM mining_data_apply_v v
        WHERE cust_id = 100955) T,
       TABLE(T.pset) S
ORDER BY 2 DESC;
```

CLUSTER_ID  PROB  DET
---------- ----- --------------------------------------------------
   14 .6761 <Details algorithm="Expectation Maximization" cluster="14">
               <Attribute name="AGE" actualValue="51" weight=".676" rank="1"/>
               <Attribute name="HOME_THEATER_PACKAGE" actualValue="1" weight=".557" rank="2"/>
               <Attribute name="FLAT_PANEL_MONITOR" actualValue="0" weight=".412" rank="3"/>
               <Attribute name="Y_BOX_GAMES" actualValue="0" weight=".171" rank="4"/>
               <Attribute name="BOOKKEEPING_APPLICATION" actualValue="1" weight="-.003" rank="5"/>
             </Details>
   3 .3227 <Details algorithm="Expectation Maximization" cluster="3">
               <Attribute name="YRS_RESIDENCE" actualValue="3" weight=".323" rank="1"/>
               <Attribute name="BULK_PACK_DISKETTES" actualValue="1" weight=".265" rank="2"/>
               <Attribute name="EDUCATION" actualValue="HS-grad" weight=".172" rank="3"/>
               <Attribute name="AFFINITY_CARD" actualValue="0" weight=".125" rank="4"/>
               <Attribute name="OCCUPATION" actualValue="Crafts" weight=".055" rank="5"/>
             </Details>

42.6 FEATURE_COMPARE

Syntax

```
feature_compare ::= 
```

Diagram
**mining_attribute_clause::=**

```
USING
  schema
  table
  expr
AS alias,
```

**Purpose**

The `FEATURE_COMPARE` function uses a feature extraction model to compare two different documents, including short ones such as keyword phrases or two attribute lists, for similarity or dissimilarity. The `FEATURE_COMPARE` function can be used with Feature Extraction algorithms such as Singular Value Decomposition (SVD), Principal Component Analysis (PCA), Non-negative Matrix Factorization (NMF), and Explicit Semantic Analysis (ESA). This function is applicable not only to documents, but also to numeric and categorical data.

The input to the `FEATURE_COMPARE` function is a single feature model built using the Feature Extraction algorithms of Oracle Machine Learning for SQL, such as NMF, SVD, and ESA. The double `USING` clause provides a mechanism to compare two different documents or constant keyword phrases, or any combination of the two, for similarity or dissimilarity using the extracted features in the model.

The syntax of the `FEATURE_COMPARE` function can use an optional `GROUPING` hint when scoring a partitioned model. See `GROUPING Hint`.

**mining_attribute_clause**

The `mining_attribute_clause` identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The `mining_attribute_clause` behaves as described for the `PREDICTION` function. See `mining_attribute_clause`.

---

### See Also:

- *Oracle Machine Learning for SQL User’s Guide* for information about scoring
- *Oracle Machine Learning for SQL Concepts* for information about clustering
Examples

An ESA model is built against a 2005 Wiki data set rendering over 200,000 features. The documents are mined as text and the document titles are considered as the Feature IDs.

The examples show the `FEATURE_Compare` function with the ESA algorithm, which compares a similar set of texts and then a dissimilar set of texts.

**Similar texts**

```sql
SELECT 1-FEATURE_COMPARE(esa_wiki_mod USING 'There are several PGA tour golfers from South Africa' text AND USING 'Nick Price won the 2002 Mastercard Colonial Open' text) similarity
FROM DUAL;
```

```
SIMILARITY
----------
.258
```

The output metric shows the results of a distance calculation. Therefore, a smaller number represents more similar texts. So 1 minus the distance in the queries represents a document similarity metric.

**Dissimilar texts**

```sql
SELECT 1-FEATURE_COMPARE(esa_wiki_mod USING 'There are several PGA tour golfers from South Africa' text AND USING 'John Elway played quarterback for the Denver Broncos' text) similarity
FROM DUAL;
```

```
SIMILARITY
----------
.007
```
42.7 FEATURE_DETAILS

Syntax

\[ \text{feature_details} ::= \]

\[ \text{FEATURE_DETAILS ( schema . model , feature_id , topN DESC ASC ABS mining_attribute_clause )} \]

Analytic Syntax

\[ \text{feature_details_analytic} ::= \]

\[ \text{FEATURE_DETAILS ( INTO n , feature_id , topN DESC ASC ABS mining_attribute_clause ) OVER ( mining_analytic_clause )} \]

\[ \text{mining_attribute_clause} ::= \]

\[ \text{USING * schema . table . * expr AS alias , mining_analytic_clause} \]

\[ \text{mining_analytic_clause} ::= \]

\[ \text{query_partition_clause order_by_clause} \]
Purpose

FEATURE_DETAILS returns feature details for each row in the selection. The return value is an XML string that describes the attributes of the highest value feature or the specified feature_id.

topN

If you specify a value for `topN`, the function returns the `N` attributes that most influence the feature value. If you do not specify `topN`, the function returns the 5 most influential attributes.

DESC, ASC, or ABS

The returned attributes are ordered by weight. The weight of an attribute expresses its positive or negative impact on the value of the feature. A positive weight indicates a higher feature value. A negative weight indicates a lower feature value.

By default, FEATURE_DETAILS returns the attributes with the highest positive weight (DESC). If you specify `ASC`, the attributes with the highest negative weight are returned. If you specify `ABS`, the attributes with the greatest weight, whether negative or positive, are returned. The results are ordered by absolute value from highest to lowest. Attributes with a zero weight are not included in the output.

Syntax Choice

FEATURE_DETAILS can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a feature extraction model.

- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include INTO `n`, where `n` is the number of features to extract, and mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=.")

The syntax of the FEATURE_DETAILS function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

mining_attribute_clause

mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause").
See Also:

- Oracle Machine Learning for SQL Concepts for information about feature extraction.

Note:
The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.

Example
This example uses the feature extraction model nmf_sh_sample to score the data. The query returns the three features that best represent customer 100002 and the attributes that most affect those features.

```
SELECT S.feature_id fid, value val,
       FEATURE_DETAILS(nmf_sh_sample, S.feature_id, 5 using T.*) det
FROM
       (SELECT v.*, FEATURE_SET(nmf_sh_sample, 3 USING *) fset
            FROM mining_data_apply_v v
            WHERE cust_id = 100002) T,
       TABLE(T.fset) S
ORDER BY 2 DESC;
```

<table>
<thead>
<tr>
<th>FID</th>
<th>VAL</th>
<th>DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3.492</td>
<td>&lt;Details algorithm=&quot;Non-Negative Matrix Factorization&quot; feature=&quot;5&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;BULK_PACK_DISKETTES&quot; actualValue=&quot;1&quot; weight=&quot;.077&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;OCCUPATION&quot; actualValue=&quot;Prof.&quot; weight=&quot;.062&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;BOOKKEEPING_APPLICATION&quot; actualValue=&quot;1&quot; weight=&quot;.001&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;OS_DOC_SET_KANJI&quot; actualValue=&quot;0&quot; weight=&quot;0&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;4&quot; weight=&quot;0&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;/Details&gt;</td>
</tr>
<tr>
<td>3</td>
<td>1.928</td>
<td>&lt;Details algorithm=&quot;Non-Negative Matrix Factorization&quot; feature=&quot;3&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOUSEHOLD_SIZE&quot; actualValue=&quot;2&quot; weight=&quot;.239&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;CUST_INCOME_LEVEL&quot; actualValue=&quot;L: 300,000 and above&quot; weight=&quot;.051&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;1&quot; weight=&quot;.02&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.006&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AGE&quot; actualValue=&quot;41&quot; weight=&quot;.004&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;/Details&gt;</td>
</tr>
<tr>
<td>8</td>
<td>.816</td>
<td>&lt;Details algorithm=&quot;Non-Negative Matrix Factorization&quot; feature=&quot;8&quot;&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;EDUCATION&quot; actualValue=&quot;Bach.&quot; weight=&quot;.211&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;CUST_MARITAL_STATUS&quot; actualValue=&quot;NeverM&quot; weight=&quot;.143&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;1&quot; weight=&quot;.137&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;CUST_GENDER&quot; actualValue=&quot;F&quot; weight=&quot;.044&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;BULK_PACK_DISKETTES&quot; actualValue=&quot;1&quot; weight=&quot;.032&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;/Details&gt;</td>
</tr>
</tbody>
</table>
**Analytic Example**

This example dynamically maps customer attributes into six features and returns the feature mapping for customer 100001.

```
SELECT feature_id, value
FROM (SELECT cust_id, feature_set(INTO 6 USING *) OVER () fset
    FROM mining_data_apply_v),
    TABLE (fset)
WHERE cust_id = 100001
ORDER BY feature_id;
```

<table>
<thead>
<tr>
<th>FEATURE_ID</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.670</td>
</tr>
<tr>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>3</td>
<td>1.792</td>
</tr>
<tr>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>5</td>
<td>.000</td>
</tr>
<tr>
<td>6</td>
<td>3.379</td>
</tr>
</tbody>
</table>

**42.8 FEATURE_ID**

**Syntax**

```
feature_id ::= 
```

**Analytic Syntax**

```
feature_id_analytic ::= 
```

**mining_attribute_clause ::=**
**Purpose**

`FEATURE_ID` returns the identifier of the highest value feature for each row in the selection. The feature identifier is returned as an Oracle `NUMBER`.

**Syntax Choice**

`FEATURE_ID` can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose **Syntax** or **Analytic Syntax**:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a feature extraction model.
- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include `INTO n`, where `n` is the number of features to extract, and `mining_analytic_clause`, which specifies if the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`. (See "analytic_clause::=".)

The syntax of the `FEATURE_ID` function can use an optional `GROUPING` hint when scoring a partitioned model. See `GROUPING` Hint.

**See Also:**

- Oracle Machine Learning for SQL Concepts for information about feature extraction.
Example

This example lists the features and corresponding count of customers in a data set.

```sql
SELECT FEATURE_ID(nmf_sh_sample USING *) AS feat, COUNT(*) AS cnt
FROM nmf_sh_sample_apply_prepared
GROUP BY FEATURE_ID(nmf_sh_sample USING *)
ORDER BY cnt DESC, feat DESC;
```

<table>
<thead>
<tr>
<th>FEAT</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1443</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

42.9 FEATURE_SET

Syntax

```sql
feature_set ::= *
```

Analytic Syntax

```sql
feature_set_analytic ::= *
```

Note:

The following example is excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.
**Purpose**

`FEATURE_SET` returns a set of feature ID and feature value pairs for each row in the selection. The return value is a varray of objects with field names `FEATURE_ID` and `VALUE`. The data type of both fields is `NUMBER`.

**topN and cutoff**

You can specify `topN` and `cutoff` to limit the number of features returned by the function. By default, both `topN` and `cutoff` are null and all features are returned.

- `topN` is the $N$ highest value features. If multiple features have the $N$th value, then the function chooses one of them.
- `cutoff` is a value threshold. Only features that are greater than or equal to `cutoff` are returned. To filter by `cutoff` only, specify `NULL` for `topN`.

To return up to $N$ features that are greater than or equal to `cutoff`, specify both `topN` and `cutoff`.

**Syntax Choice**

`FEATURE_SET` can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose **Syntax** or **Analytic Syntax**:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a feature extraction model.

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of `mining_analytic_clause`
• **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include `INTO n`, where `n` is the number of features to extract, and `mining_analytic_clause`, which specifies if the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`. (See "analytic_clause::=".)

The syntax of the `FEATURE_SET` function can use an optional `GROUPING` hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

`mining_attribute_clause` identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The `mining_attribute_clause` behaves as described for the `PREDICTION` function. (See "mining_attribute_clause".)

---

**See Also:**

- *Oracle Machine Learning for SQL Concepts* for information about feature extraction.

---

**Note:**

The following example is excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in *Oracle Machine Learning for SQL User’s Guide*.

---

**Example**

This example lists the top features corresponding to a given customer record and determines the top attributes for each feature (based on coefficient > 0.25).

```sql
WITH feat_tab AS (
    SELECT F.feature_id fid,
           A.attribute_name attr,
           TO_CHAR(A.attribute_value) val,
           A.coefficient coeff
    FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_NMF('nmf_sh_sample')) F,
         TABLE(F.attribute_set) A
    WHERE A.coefficient > 0.25
  ),
feat AS (
    SELECT fid,
           CAST(COLLECT(Featattr(attr, val, coeff)) AS Featattrs) f_attr 
    FROM feat_tab
    GROUP BY fid
  ),
cust_10_features AS (
    SELECT T.cust_id, S.feature_id, S.value
    FROM TABLE(DBMS_DATA_MINING.GET_MODEL_DETAILS_NMF('nmf_sh_sample')) T,
         TABLE(T.attribute_set) S
    WHERE T.cust_id = cust_10_features.fid
  )
SELECT T.cust_id, S.feature_id, S.value
FROM cust_10_features AS fc,
     feat AS ft
WHERE fc.fid = ft.fid
```
FROM (SELECT cust_id, FEATURE_SET(nmf_sh_sample, 10 USING *) pset
FROM nmf_sh_sample_apply_prepared
WHERE cust_id = 100002) T,
TABLE(T.pset) S
)
SELECT A.value, A.feature_id fid,
B.attr, B.val, B.coeff
FROM cust_10_features A,
(SELECT T.fid, F.*
FROM feat T,
TABLE(T.f_attrs) F) B
WHERE A.feature_id = B.fid
ORDER BY A.value DESC, A.feature_id ASC, coeff DESC, attr ASC, val ASC;

<table>
<thead>
<tr>
<th>VALUE</th>
<th>FID</th>
<th>ATTR</th>
<th>VAL</th>
<th>COEFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.8409</td>
<td>7</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.8409</td>
<td>7</td>
<td>BOOKKEEPING_APPLICATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4975</td>
<td>3</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4975</td>
<td>3</td>
<td>BOOKKEEPING_APPLICATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4975</td>
<td>3</td>
<td>COUNTRY_NAME</td>
<td>United States of America</td>
<td></td>
</tr>
<tr>
<td>6.4886</td>
<td>2</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4886</td>
<td>2</td>
<td>CUST_GENDER</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>6.4886</td>
<td>2</td>
<td>PRINTER_SUPPLIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3953</td>
<td>4</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.9640</td>
<td>6</td>
<td>HOME_THEATER_PACKAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2424</td>
<td>5</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4714</td>
<td>8</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3559</td>
<td>1</td>
<td>YRS_RESIDENCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3559</td>
<td>1</td>
<td>FLAT_PANEL_MONITOR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

42.10 FEATURE_VALUE

Syntax

feature_value::=

```
FEATURE_VALUE ( schema . model, feature_id mining_attribute_clause )
```

Analytic Syntax

feature_value_analytic::=

```
FEATURE_VALUE INTO n ( feature_id mining_attribute_clause )
OVER ( mining_analytic_clause )
```

Chapter 42
FEATURE_VALUE
**Purpose**

`FEATURE_VALUE` returns a feature value for each row in the selection. The value refers to the highest value feature or to the specified `feature_id`. The feature value is returned as `BINARY_DOUBLE`.

**Syntax Choice**

`FEATURE_VALUE` can score the data in one of two ways: It can apply a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose **Syntax** or **Analytic Syntax**:

- **Syntax** — Use the first syntax to score the data with a pre-defined model. Supply the name of a feature extraction model.
- **Analytic Syntax** — Use the analytic syntax to score the data without a pre-defined model. Include `INTO n`, where `n` is the number of features to extract, and `mining_analytic_clause`, which specifies if the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`. (See "analytic_clause::=".)

The syntax of the `FEATURE_VALUE` function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

`mining_attribute_clause` identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, this data is also used for building the...
transient models. The `mining_attribute_clause` behaves as described for the `PREDICTION` function. (See "mining_attribute_clause").

**See Also:**

- *Oracle Machine Learning for SQL Concepts* for information about feature extraction.

**Note:**

The following example is excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in *Oracle Machine Learning for SQL User’s Guide*.

**Example**

The following example lists the customers that correspond to feature 3, ordered by match quality.

```sql
SELECT *
FROM (SELECT cust_id, FEATURE_VALUE(nmf_sh_sample, 3 USING *) match_quality
      FROM nmf_sh_sample_apply_prepared
      ORDER BY match_quality DESC)
WHERE ROWNUM < 11;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>MATCH_QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>100210</td>
<td>19.4101627</td>
</tr>
<tr>
<td>100962</td>
<td>15.2482251</td>
</tr>
<tr>
<td>101151</td>
<td>14.5685197</td>
</tr>
<tr>
<td>101499</td>
<td>14.4186292</td>
</tr>
<tr>
<td>100363</td>
<td>14.4037396</td>
</tr>
<tr>
<td>100372</td>
<td>14.3335148</td>
</tr>
<tr>
<td>100982</td>
<td>14.1716545</td>
</tr>
<tr>
<td>101039</td>
<td>14.1079914</td>
</tr>
<tr>
<td>100759</td>
<td>14.0913761</td>
</tr>
<tr>
<td>100953</td>
<td>14.0799737</td>
</tr>
</tbody>
</table>

### 42.11 ORA_DM_PARTITION_NAME

**Syntax**

![Syntax Diagram](image-url)
**mining_attribute_clause::=**

```
USING

schema .
table . *
expr
AS alias
,
```

**Purpose**

ORA_DM_PARTITION_NAME is a single row function that works along with other existing functions. This function returns the name of the partition associated with the input row. When ORA_DM_PARTITION_NAME is used on a non-partitioned model, the result is NULL.

The syntax of the ORA_DM_PARTITION_NAME function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

The mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. See mining_attribute_clause.

**See Also:**

- Oracle Machine Learning for SQL User’s Guide for information about scoring
- Oracle Machine Learning for SQL Concepts for information about clustering

**Note:**

The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.

**Example**

```
SELECT prediction(mymodel using *) pred, ora_dm_partition_name(mymodel USING *) pname FROM customers;
```
42.12 PREDICTION

Syntax

\[ \text{prediction} ::= \]

\[ \text{prediction}_\text{ordered} ::= \]

Analytic Syntax

\[ \text{prediction}_\text{analytic} ::= \]

\[ \text{cost_matrix_clause} ::= \]
**mining_attribute_clause::=**

```
USING 
* 

schema . 

* table . *

expr 

AS 

alias 

,```

**mining_analytic_clause::=**

```
query_partition_clause order_by_clause
```

---

**See Also:**

“Analytic Functions” in Oracle Database SQL Language Reference for information on the syntax, semantics, and restrictions of `query_partition_clause` and `order_by_clause`

---

**Purpose**

`PREDICTION` returns a prediction for each row in the selection. The data type of the returned prediction depends on whether the function performs Regression, Classification, or Anomaly Detection.

- **Regression**: Returns the expected target value for each row. The data type of the return value is the data type of the target.
- **Classification**: Returns the most probable target class (or lowest cost target class, if costs are specified) for each row. The data type of the return value is the data type of the target.
- **Anomaly Detection**: Returns 1 or 0 for each row. Typical rows are classified as 1. Rows that differ significantly from the rest of the data are classified as 0.

**cost_matrix_clause**

Costs are a biasing factor for minimizing the most harmful kinds of misclassifications. You can specify a `cost_matrix_clause` for classification or anomaly detection. Costs are not relevant for regression. The `cost_matrix_clause` behaves as described for "PREDICTION_COST".

**Syntax Choice**

`PREDICTION` can score data by applying a mining model object to the data, or it can dynamically score the data by executing an analytic clause that builds and applies one or more transient mining models. Choose **Syntax** or **Analytic Syntax**.
• **Syntax**: Use the `prediction` syntax to score the data with a pre-defined model. Supply the name of a model that performs Classification, Regression, or Anomaly Detection.

Use the `prediction_ordered` syntax for a model that requires ordered data, such as an MSET-SPRT model. The `prediction_ordered` syntax requires an `order_by_clause` clause.

Restrictions on the `prediction_ordered` syntax are that you cannot use it in the `WHERE` clause of a query. Also, you cannot use a `query_partition_clause` or a `windowing_clause` with the `prediction_ordered` syntax.

For details about the `order_by_clause`, see “Analytic Functions” in Oracle Database SQL Language Reference.

• **Analytic Syntax**: Use the `prediction_analytic` syntax to score the data without a pre-defined model. The analytic syntax uses the `mining_analytic_clause`, which specifies whether the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`. (See the `analytic_clause` in “Analytic Functions” in Oracle Database SQL Language Reference.)

  - For Regression, specify `FOR expr`, where `expr` is an expression that identifies a target column that has a numeric data type.
  - For Classification, specify `FOR expr`, where `expr` is an expression that identifies a target column that has a character data type.
  - For Anomaly Detection, specify the keywords `OF ANOMALY`.

The syntax of the `PREDICTION` function can use an optional `GROUPING` hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

The `mining_attribute_clause` identifies the column attributes to use as predictors for scoring.

• If you specify `USING *`, then all the relevant attributes present in the input row are used.

• If you invoke the function with the analytic syntax, then the `mining_attribute_clause` is used both for building the transient models and for scoring.

• If you invoke the function with a pre-defined model, then the `mining_attribute_clause` should include all or some of the attributes that were used to create the model. The following conditions apply:
  
  - If the `mining_attribute_clause` includes an attribute with the same name but a different data type from the one that was used to create the model, then the data type is converted to the type expected by the model.
  
  - If you specify more attributes for scoring than were used to create the model, then the extra attributes are silently ignored.

  - If you specify fewer attributes for scoring than were used to create the model, then scoring is performed on a best-effort basis.
See Also:

- *Oracle Machine Learning for SQL Concepts* for information about predictive Oracle Machine Learning for SQL.
- Appendix C in *Oracle Database Globalization Support Guide* for the collation derivation rules, which define the collation assigned to the return value of `PREDICTION` when it is a character value.

Note:

The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in *Oracle Machine Learning for SQL User’s Guide*.

Example

In this example, the model `dt_sh_clas_sample` predicts the gender and age of customers who are most likely to use an affinity card (`target = 1`). The `PREDICTION` function takes into account the cost matrix associated with the model and uses marital status, education, and household size as predictors.

```sql
SELECT cust_gender, COUNT(*) AS cnt, ROUND(AVG(age)) AS avg_age
FROM mining_data_apply_v
WHERE PREDICTION(dt_sh_clas_sample COST MODEL
    USING cust_marital_status, education, household_size) = 1
GROUP BY cust_gender
ORDER BY cust_gender;
```

<table>
<thead>
<tr>
<th>CUST_GENDER</th>
<th>CNT</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>170</td>
<td>38</td>
</tr>
<tr>
<td>M</td>
<td>685</td>
<td>42</td>
</tr>
</tbody>
</table>

The cost matrix associated with the model `dt_sh_clas_sample` is stored in the table `dt_sh_sample_costs`. The cost matrix specifies that the misclassification of 1 is 8 times more costly than the misclassification of 0.

```sql
SQL> select * from dt_sh_sample_cost;
```

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>.0000000000</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1.0000000000</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>8.0000000000</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>.0000000000</td>
</tr>
</tbody>
</table>

Analytic Example

In this example, dynamic regression is used to predict the age of customers who are likely to use an affinity card. The query returns the 3 customers whose predicted age is most different
from the actual. The query includes information about the predictors that have the greatest influence on the prediction.

SELECT cust_id, age, pred_age, age-pred_age age_diff, pred_det FROM
(SELECT cust_id, age, pred_age, pred_det,  
  RANK() OVER (ORDER BY ABS(age-pred_age) desc) rnk FROM
  (SELECT cust_id, age,  
   PREDICTION(FOR age USING *) OVER () pred_age, 
   PREDICTION_DETAILS(FOR age ABS USING *) OVER () pred_det 
  FROM mining_data_apply_v))
WHERE rnk <= 3;

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>AGE</th>
<th>PRED_AGE</th>
<th>AGE_DIFF</th>
<th>PRED_DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>100910</td>
<td>80</td>
<td>40.67</td>
<td>39.33</td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt; &lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;4&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
<tr>
<td>101285</td>
<td>79</td>
<td>42.18</td>
<td>36.82</td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt; &lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;HOUSEHOLD_SIZE&quot; actualValue=&quot;2&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;CUST_MARITAL_STATUS&quot; actualValue=&quot;Mabsent&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;OCCUPATION&quot; actualValue=&quot;Prof.&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
<tr>
<td>100694</td>
<td>77</td>
<td>41.04</td>
<td>35.96</td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt; &lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt; &lt;Attribute name=&quot;EDUCATION&quot; actualValue=&quot;&amp;lt; Bach.&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt; &lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt; &lt;Attribute name=&quot;CUST_ID&quot; actualValue=&quot;100694&quot; weight=&quot;.059&quot; rank=&quot;4&quot;/&gt; &lt;Attribute name=&quot;COUNTRY_NAME&quot; actualValue=&quot;United States of America&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt; &lt;/Details&gt;</td>
</tr>
</tbody>
</table>
42.13 PREDICTION_BOUNDS

Syntax

```
PREDICTION_BOUNDS
```

```
 mining_attribute_clause ::= USING *
```

Purpose

PREDICTION_BOUNDS applies a Generalized Linear Model (GLM) to predict a class or a value for each row in the selection. The function returns the upper and lower bounds of each prediction in a varray of objects with fields UPPER and LOWER.

GLM can perform either regression or binary classification:

- The bounds for regression refer to the predicted target value. The data type of UPPER and LOWER is the data type of the target.
- The bounds for binary classification refer to the probability of either the predicted target class or the specified class_value. The data type of UPPER and LOWER is BINARY_DOUBLE.

If the model was built using ridge regression, or if the covariance matrix is found to be singular during the build, then PREDICTION_BOUNDS returns NULL for both bounds.

confidence_level is a number in the range (0,1). The default value is 0.95. You can specify class_value while leaving confidence_level at its default by specifying NULL for confidence_level.

The syntax of the PREDICTION_BOUNDS function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

mining_attribute_clause

mining_attribute_clause identifies the column attributes to use as predictors for scoring. This clause behaves as described for the PREDICTION function. (Note that the reference to analytic syntax does not apply.) See "mining_attribute_clause".
Example

The following example returns the distribution of customers whose ages are predicted with 98% confidence to be greater than 24 and less than 46.

```sql
SELECT count(cust_id) cust_count, cust_marital_status
FROM (SELECT cust_id, cust_marital_status
      FROM mining_data_apply_v
      WHERE PREDICTION_BOUNDS(glmr_sh_regr_sample,0.98 USING *) . LOWER > 24 AND
           PREDICTION_BOUNDS(glmr_sh_regr_sample,0.98 USING *) . UPPER < 46)
GROUP BY cust_marital_status;
```

<table>
<thead>
<tr>
<th>CUST_COUNT</th>
<th>CUST_MARITAL_STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>NeverM</td>
</tr>
<tr>
<td>7</td>
<td>Mabsent</td>
</tr>
<tr>
<td>5</td>
<td>Separ.</td>
</tr>
<tr>
<td>35</td>
<td>Divorc.</td>
</tr>
<tr>
<td>72</td>
<td>Married</td>
</tr>
</tbody>
</table>

42.14 PREDICTION_COST

Syntax

```
prediction_cost ::= PREDICTION_COST ( schema . model , class | cost_matrix_clause mining_attribute_clause )
```
\textit{prediction\_cost\_ordered} ::= \\
\hspace{1em} \text{PREDICTION\_COST} \leftarrow \text{schema} \rightarrow \text{model} \rightarrow \text{class} \rightarrow \text{cost\_matrix\_clause} \rightarrow \text{order\_by\_clause} \rightarrow \text{mining\_attribute\_clause} \rightarrow \text{PREDICTION\_COST} (\text{schema . model . class . cost\_matrix\_clause . mining\_attribute\_clause}) \text{ OVER ( order\_by\_clause , )} \rightarrow \\

\text{Analytic Syntax} \\
\textit{prediction\_cost\_analytic} ::= \\
\hspace{1em} \text{PREDICTION\_COST} \leftarrow \text{OF ANOMALY FOR expr . class . cost\_matrix\_clause . mining\_attribute\_clause} \rightarrow \text{PREDICTION\_COST ( OF ANOMALY FOR expr . class . cost\_matrix\_clause . mining\_attribute\_clause . ) OVER ( mining\_analytic\_clause )} \rightarrow \\

\textit{cost\_matrix\_clause} ::= \\
\hspace{1em} \text{COST MODEL AUTO ( class_value . ) VALUES ( ( cost_value . ) , ) \rightarrow } \\

\textit{mining\_attribute\_clause} ::= \\
\hspace{1em} \text{USING * schema . table . * expr AS alias \rightarrow } \\

\textit{mining\_analytic\_clause} ::= \\
\hspace{1em} \text{query\_partition\_clause order\_by\_clause \rightarrow } \\

Chapter 42 \\
PREDICTION\_COST
Purpose

PREDICTION_COST returns a cost for each row in the selection. The cost refers to the lowest cost class or to the specified class. The cost is returned as a BINARY_DOUBLE.

PREDICTION_COST can perform classification or anomaly detection. For classification, the returned cost refers to a predicted target class. For anomaly detection, the returned cost refers to a classification of 1 (for typical rows) or 0 (for anomalous rows).

You can use PREDICTION_COST in conjunction with the PREDICTION function to obtain the prediction and the cost of the prediction.

cost_matrix_clause

Costs are a biasing factor for minimizing the most harmful kinds of misclassifications. For example, false positives might be considered more costly than false negatives. Costs are specified in a cost matrix that can be associated with the model or defined inline in a VALUES clause. All classification algorithms can use costs to influence scoring.

Decision Tree is the only algorithm that can use costs to influence the model build. The cost matrix used to build a Decision Tree model is also the default scoring cost matrix for the model.

The following cost matrix table specifies that the misclassification of 1 is five times more costly than the misclassification of 0.

<table>
<thead>
<tr>
<th>ACTUAL_TARGET_VALUE</th>
<th>PREDICTED_TARGET_VALUE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

In cost_matrix_clause:

- COST MODEL indicates that scoring should be performed by taking into account the scoring cost matrix associated with the model. If the cost matrix does not exist, then the function returns an error.

- COST MODEL AUTO indicates that the existence of a cost matrix is unknown. If a cost matrix exists, then the function uses it to return the lowest cost prediction. Otherwise the function returns the highest probability prediction.

- The VALUES clause specifies an inline cost matrix for class_value. For example, you could specify that the misclassification of 1 is five times more costly than the misclassification of 0 as follows:

  PREDICTION (nb_model COST (0,1) VALUES ((0, 1),(1, 5)) USING *)

If a model that has a scoring cost matrix is invoked with an inline cost matrix, then the inline costs are used.
Syntax Choice

PREDICTION_COST can score data by applying a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax**: Use the `prediction_cost` syntax to score the data with a pre-defined model. Supply the name of a model that performs classification or anomaly detection.

  Use the `prediction_cost_ordered` syntax for a model that requires ordered data, such as an MSET-SPRT model. The `prediction_cost_ordered` syntax requires an `order_by_clause`.

  Restrictions on the `prediction_cost_ordered` syntax are that you cannot use it in the `WHERE` clause of a query. Also, you cannot use a `query_partition_clause` or a `windowing_clause` with the `prediction_cost_ordered` syntax.

  For details about the `order_by_clause`, see "Analytic Functions" in Oracle Database SQL Language Reference.

- **Analytic Syntax**: Use the `prediction_cost_analytic` syntax to score the data without a pre-defined model. The analytic syntax uses the `mining_analytic_clause`, which specifies whether the data should be partitioned for multiple model builds. The `mining_analytic_clause` supports a `query_partition_clause` and an `order_by_clause`.

  (See the `analytic_clause` in "Analytic Functions" in Oracle Database SQL Language Reference.)

  – For classification, specify `FOR expr`, where `expr` is an expression that identifies a target column that has a character data type.

  – For anomaly detection, specify the keywords `OF ANOMALY`.

The syntax of the PREDICTION_COST function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

mining_attribute_clause

The `mining_attribute_clause` identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The `mining_attribute_clause` behaves as described for the PREDICTION function. (See "mining_attribute_clause").

See Also:

- Oracle Machine Learning for SQL Concepts for information about classification with costs
**Example**

This example predicts the ten customers in Italy who would respond to the least expensive sales campaign (offering an affinity card).

```sql
SELECT cust_id
FROM (SELECT cust_id, rank()
      OVER (ORDER BY PREDICTION_COST(DT_SH_Clas_sample, 1 COST MODEL USING *)
             ASC, cust_id) rnk
      FROM mining_data_apply_v
      WHERE country_name = 'Italy')
WHERE rnk <= 10
ORDER BY rnk;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100081</td>
</tr>
<tr>
<td>100179</td>
</tr>
<tr>
<td>100185</td>
</tr>
<tr>
<td>100324</td>
</tr>
<tr>
<td>100344</td>
</tr>
<tr>
<td>100554</td>
</tr>
<tr>
<td>100662</td>
</tr>
<tr>
<td>100733</td>
</tr>
<tr>
<td>101250</td>
</tr>
<tr>
<td>101306</td>
</tr>
</tbody>
</table>

### 42.15 PREDICTION_DETAILS

**Syntax**

`prediction_details ::=`
prediction_details_ordered ::=  

\[
\text{PREDICTION\_DETAILS} (\text{schema} . \text{model}, \text{class\_value}, \text{topN}\ 	ext{DESC}\ 	ext{ASC}\ 	ext{ABS}\ \text{mining\_attribute\_clause}) \over \text{order\_by\_clause}
\]

Analytic Syntax

prediction_details_analytic ::=  

\[
\text{PREDICTION\_DETAILS} (\text{OF ANOMALY FOR expr}, \text{class\_value}, \text{topN}\ 	ext{DESC}\ 	ext{ASC}\ 	ext{ABS}\ \text{mining\_attribute\_clause}) \over \text{mining\_analytic\_clause}
\]

mining_attribute_clause ::=  

\[
\text{USING} *\text{schema} . \text{table} . * \text{expr} \text{AS alias}
\]

mining_analytic_clause ::=  

\[
\text{query\_partition\_clause} \text{order\_by\_clause}
\]
See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of mining_analytic_clause

Purpose

PREDICTION_DETAILS returns prediction details for each row in the selection. The return value is an XML string that describes the attributes of the prediction.

For regression, the returned details refer to the predicted target value. For classification and anomaly detection, the returned details refer to the highest probability class or the specified class_value.

topN

If you specify a value for topN, the function returns the N attributes that have the most influence on the prediction (the score). If you do not specify topN, the function returns the 5 most influential attributes.

DESC, ASC, or ABS

The returned attributes are ordered by weight. The weight of an attribute expresses its positive or negative impact on the prediction. For regression, a positive weight indicates a higher value prediction; a negative weight indicates a lower value prediction. For classification and anomaly detection, a positive weight indicates a higher probability prediction; a negative weight indicates a lower probability prediction.

By default, PREDICTION_DETAILS returns the attributes with the highest positive weight (DESC). If you specify ASC, the attributes with the highest negative weight are returned. If you specify ABS, the attributes with the greatest weight, whether negative or positive, are returned. The results are ordered by absolute value from highest to lowest. Attributes with a zero weight are not included in the output.

Syntax Choice

PREDICTION_DETAILS can score the data by applying a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- Syntax: Use the prediction_details syntax to score the data with a pre-defined model. Supply the name of a model that performs classification, regression, or anomaly detection.

  Use the prediction_details_ordered syntax for a model that requires ordered data, such as an MSET-SPRT model. The prediction_details_ordered syntax requires an order_by_clause clause.

  Restrictions on the prediction_details_ordered syntax are that you cannot use it in the WHERE clause of a query. Also, you cannot use a query_partition_clause or a windowing_clause with the prediction_details_ordered syntax.
When random projections are engaged for an MSET-SPRT model, only the overall PREDICTION and PREDICTION_PROBABILITY are computed and PREDICTION_DETAILS are not reported.

For details about the order_by_clause, see "Analytic Functions" in Oracle Database SQL Language Reference.

- **Analytic Syntax**: Use the prediction_details_analytic syntax to score the data without a pre-defined model. The analytic syntax uses mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause. (See "analytic_clause::=".)
  - For classification, specify FOR expr, where expr is an expression that identifies a target column that has a character data type.
  - For regression, specify FOR expr, where expr is an expression that identifies a target column that has a numeric data type.
  - For anomaly detection, specify the keywords OF ANOMALY.

The syntax of the PREDICTION_DETAILS function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

The mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause".)

**See Also:**

- Oracle Machine Learning for SQL Concepts for information about predictive Oracle Machine Learning for SQL.

**Note:**

The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.

**Example**

This example uses the model svmr_sh_regr_sample to score the data. The query returns the three attributes that have the greatest influence on predicting a higher value for customer age.
Analytic Syntax

This example dynamically identifies customers whose age is not typical for the data. The query returns the attributes that predict or detract from a typical age.

```
SELECT cust_id, age, pred_age, age-pred_age age_diff, pred_det
FROM (SELECT cust_id, age, pred_age, pred_det,
       RANK() OVER (ORDER BY ABS(age-pred_age) DESC) rnk
       FROM (SELECT cust_id, age,
              PREDICTION(FOR age USING *) OVER () pred_age,
              PREDICTION_DETAILS(FOR age ABS USING *) OVER () pred_det
       FROM mining_data_apply_v))
WHERE rnk <= 5;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>AGE</th>
<th>PRED_AGE</th>
<th>AGE_DIFF</th>
<th>PRED_DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>100910</td>
<td>80</td>
<td>40.67</td>
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<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt;</td>
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<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt;</td>
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<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt;</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;4&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt;</td>
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<tr>
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<td>79</td>
<td>42.18</td>
<td>36.82</td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt;</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;HOUSEHOLD_SIZE&quot; actualValue=&quot;2&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt;</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;CUST_MARITAL_STATUS&quot; actualValue=&quot;Mabsent&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td></td>
<td>&lt;Attribute name=&quot;OCCUPATION&quot; actualValue=&quot;Prof.&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt;</td>
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<td>35.96</td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot;&gt;</td>
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<td>&lt;Attribute name=&quot;HOME_THEATER_PACKAGE&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;1&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;Y_BOX_GAMES&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;2&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AFFINITY_CARD&quot; actualValue=&quot;0&quot; weight=&quot;.059&quot; rank=&quot;3&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;FLAT_PANEL_MONITOR&quot; actualValue=&quot;1&quot; weight=&quot;.059&quot; rank=&quot;4&quot;/&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;4&quot; weight=&quot;.059&quot; rank=&quot;5&quot;/&gt;</td>
</tr>
</tbody>
</table>
42.16 PREDICTION_PROBABILITY

Syntax

\[\text{prediction\_probability::=}\]

\[\text{prediction\_probability\_ordered::=}\]

Chapter 42

PREDICTION_PROBABILITY
Analytic Syntax

\[ \text{prediction_prob_analytic} ::= \]

\[ \text{PREDICTION_PROBABILITY (OF ANOMALY FOR expr, class mining_attribute_clause) OVER (mining_analytic_clause)} \]

\[ \text{mining_attribute_clause} ::= \]

\[ \text{USING * schema . table . *} \text{expr AS alias}, \]

\[ \text{mining_analytic_clause} ::= \]

\[ \text{query_partition_clause order_by_clause} \]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \text{mining_analytic_clause}

Purpose

\text{PREDICTION_PROBABILITY} returns a probability for each row in the selection. The probability refers to the highest probability class or to the specified \text{class}. The data type of the returned probability is \text{BINARY_DOUBLE}.

\text{PREDICTION_PROBABILITY} can perform classification or anomaly detection. For classification, the returned probability refers to a predicted target class. For anomaly detection, the returned probability refers to a classification of 1 (for typical rows) or 0 (for anomalous rows).

You can use \text{PREDICTION_PROBABILITY} in conjunction with the \text{PREDICTION} function to obtain the prediction and the probability of the prediction.
Syntax Choice

PREDICTION_PROBABILITY can score the data by applying a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- **Syntax:** Use the prediction_probability syntax to score the data with a pre-defined model. Supply the name of a model that performs classification or anomaly detection.

  Use the prediction_probability_ordered syntax for a model that requires ordered data, such as an MSET-SPRT model. The prediction_probability_ordered syntax requires an order_by_clause clause.

  Restrictions on the prediction_probability_ordered syntax are that you cannot use it in the WHERE clause of a query. Also, you cannot use a query_partition_clause or a windowing_clause with the prediction_probability_ordered syntax.

  For details about the order_by_clause, see "Analytic Functions" in Oracle Database SQL Language Reference.

- **Analytic Syntax:** Use the analytic syntax to score the data without a pre-defined model. The analytic syntax uses mining_analytic_clause, which specifies if the data should be partitioned for multiple model builds. The mining_analytic_clause supports a query_partition_clause and an order_by_clause clause. (See "analytic_clause::=.

  - For classification, specify FOR expr, where expr is an expression that identifies a target column that has a character data type.

  - For anomaly detection, specify the keywords OF ANOMALY.

The syntax of the PREDICTION_PROBABILITY function can use an optional GROUPING hint when scoring a partitioned model. See GROUPING Hint.

**mining_attribute_clause**

mining_attribute_clause identifies the column attributes to use as predictors for scoring. When the function is invoked with the analytic syntax, these predictors are also used for building the transient models. The mining_attribute_clause behaves as described for the PREDICTION function. (See "mining_attribute_clause").

**See Also:**


- Oracle Machine Learning for SQL Concepts for information about predictive Oracle Machine Learning for SQL.

**Note:**

The following examples are excerpted from the Oracle Machine Learning for SQL examples. For more information about the examples, see Appendix A in Oracle Machine Learning for SQL User’s Guide.
Example

The following example returns the 10 customers living in Italy who are most likely to use an affinity card.

```
SELECT cust_id FROM (  
    SELECT cust_id  
    FROM mining_data_apply_v  
    WHERE country_name = 'Italy'  
    ORDER BY PREDICTION_PROBABILITY(DT_SH_Clas_sample, 1 USING *) DESC, cust_id)  
WHERE rownum < 11;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>100081</td>
</tr>
<tr>
<td>100179</td>
</tr>
<tr>
<td>100185</td>
</tr>
<tr>
<td>100324</td>
</tr>
<tr>
<td>100344</td>
</tr>
<tr>
<td>100554</td>
</tr>
<tr>
<td>100662</td>
</tr>
<tr>
<td>100733</td>
</tr>
<tr>
<td>101250</td>
</tr>
<tr>
<td>101306</td>
</tr>
</tbody>
</table>

Analytic Example

This example identifies rows that are most atypical in the data in mining_data_one_class_v. Each type of marital status is considered separately so that the most anomalous rows per marital status group are returned.

The query returns three attributes that have the most influence on the determination of anomalous rows. The `PARTITION BY` clause causes separate models to be built and applied for each marital status. Because there is only one record with status Mabsent, no model is created for that partition (and no details are provided).

```
SELECT cust_id, cust_marital_status, rank_anom, anom_det FROM  
(SELECT cust_id, cust_marital_status, anom_det,  
    rank() OVER (PARTITION BY CUST_MARITAL_STATUS  
    ORDER BY ANOM_PROB DESC,cust_id) rank_anom FROM  
(SELECT cust_id, cust_marital_status,  
    PREDICTION_PROBABILITY(OF ANOMALY, 0 USING *) anom_prob,  
    PREDICTION_DETAILS(OF ANOMALY, 0, 3 USING *) anom_det  
FROM mining_data_one_class_v  
))  
WHERE rank_anom < 3 order by 2, 3;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>CUST_MARITAL_STATUS</th>
<th>RANK_ANOM</th>
<th>ANOM_DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>102366</td>
<td>Divorc.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Details algorithm=&quot;Support Vector Machines&quot; class=&quot;0&quot;&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;COUNTRY_NAME&quot; actualValue=&quot;United Kingdom&quot; weight=&quot;.069&quot; rank=&quot;1&quot;/&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;AGE&quot; actualValue=&quot;28&quot; weight=&quot;.013&quot; rank=&quot;2&quot;/&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;Attribute name=&quot;YRS_RESIDENCE&quot; actualValue=&quot;4&quot;/&gt;</td>
<td></td>
</tr>
</tbody>
</table>
42.17 PREDICTION_SET

Syntax

\[
prediction\_set::=  
\]

\[
\text{PREDICTION\_SET} \rightarrow \text{schema}\rightarrow \text{model}\rightarrow \text{bestN}\rightarrow \text{cutoff}\rightarrow \text{cost\_matrix\_clause}\rightarrow \text{mining\_attribute\_clause}\rightarrow 
\]

\[
prediction\_set\_ordered::=  
\]

\[
\text{PREDICTION\_SET} \rightarrow \text{schema}\rightarrow \text{model}\rightarrow \text{bestN}\rightarrow \text{cutoff}\rightarrow \text{cost\_matrix\_clause}\rightarrow \text{mining\_attribute\_clause}\rightarrow \text{OVER}\rightarrow \text{order\_by\_clause}\rightarrow 
\]
Analytic Syntax

\[ \text{prediction_set_analytic}::= \]

\[
\begin{align*}
\text{PREDICTION_SET} & \quad \text{OF} \quad \text{ANOMALY} \\
& \quad \text{FOR} \quad \text{expr} \\
& \quad \text{bestN} \\
& \quad \text{cutoff} \\
& \quad \text{cost_matrix_clause} \\
& \quad \text{mining_attribute_clause} \\
& \quad \text{OVER} \quad \text{mining_analytic_clause} 
\end{align*}
\]

\[ \text{cost_matrix_clause}::= \]

\[
\begin{align*}
\text{MODEL} & \quad \text{AUTO} \\
\text{COST} & \quad \text{class_value} \\
& \quad \text{VALUES} \quad \text{cost_value} 
\end{align*}
\]

\[ \text{mining_attribute_clause}::= \]

\[
\begin{align*}
\text{USING} & \quad \text{schema} \cdot \text{table} \cdot \text{expr} \\
& \quad \text{expr} \quad \text{AS} \quad \text{alias} 
\end{align*}
\]

\[ \text{mining_analytic_clause}::=- \]

\[
\begin{align*}
\text{query_partition_clause} & \quad \text{order_by_clause} 
\end{align*}
\]

See Also:

"Analytic Functions" for information on the syntax, semantics, and restrictions of \text{mining_analytic_clause}
Purpose

PREDICTION_SET returns a set of predictions with either probabilities or costs for each row in the selection. The return value is a varray of objects with field names PREDICTION_ID and PROBABILITY or COST. The prediction identifier is an Oracle NUMBER; the probability and cost fields are BINARY_DOUBLE.

PREDICTION_SET can perform classification or anomaly detection. For classification, the return value refers to a predicted target class. For anomaly detection, the return value refers to a classification of 1 (for typical rows) or 0 (for anomalous rows).

bestN and cutoff

You can specify bestN and cutoff to limit the number of predictions returned by the function. By default, both bestN and cutoff are null and all predictions are returned.

- bestN is the N predictions that are either the most probable or the least costly. If multiple predictions share the Nth probability or cost, then the function chooses one of them.
- cutoff is a value threshold. Only predictions with probability greater than or equal to cutoff, or with cost less than or equal to cutoff, are returned. To filter by cutoff only, specify NULL for bestN. If the function uses a cost_matrix_clause with COST MODEL AUTO, then cutoff is ignored.

You can specify bestN with cutoff to return up to the N most probable predictions that are greater than or equal to cutoff. If costs are used, specify bestN with cutoff to return up to the N least costly predictions that are less than or equal to cutoff.

cost_matrix_clause

You can specify cost_matrix_clause as a biasing factor for minimizing the most harmful kinds of misclassifications. cost_matrix_clause behaves as described for "PREDICTION_COST".

Syntax Choice

PREDICTION_SET can score the data by applying a mining model object to the data, or it can dynamically mine the data by executing an analytic clause that builds and applies one or more transient mining models. Choose Syntax or Analytic Syntax:

- Syntax: Use the prediction_set syntax to score the data with a pre-defined model. Supply the name of a model that performs classification or anomaly detection.
  
  Use the prediction_set ordered syntax for a model that requires ordered data, such as an MSET-SPRT model. The prediction_set ordered syntax requires an order_by_clause clause.
  
  Restrictions on the prediction_set ordered syntax are that you cannot use it in the WHERE clause of a query. Also, you cannot use a query_partition_clause or a windowing_clause with the prediction_set ordered syntax.
  
  For details about the order_by_clause, see "Analytic Functions" in Oracle Database SQL Language Reference.

- Analytic Syntax: Use the analytic syntax to score the data without a pre-defined model. The analytic syntax uses mining_analytic_clause, which specifies if the data should be
partitioned for multiple model builds. The `mining_analytic_clause` supports a
`query_partition_clause` and an `order_by_clause`. (See "analytic_clause::=".)

- For classification, specify `FOR expr`, where `expr` is an expression that identifies
  a target column that has a character data type.
- For anomaly detection, specify the keywords `OF ANOMALY`.

The syntax of the `PREDICTION_SET` function can use an optional `GROUPING` hint when
scoring a partitioned model. See `GROUPING Hint`.

**mining_attribute_clause**

`mining_attribute_clause` identifies the column attributes to use as predictors for
scoring. When the function is invoked with the analytic syntax, these predictors are
also used for building the transient models. The `mining_attribute_clause` behaves
as described for the `PREDICTION` function. (See "mining_attribute_clause".)

---

**See Also:**

- Oracle Machine Learning for SQL User’s Guide for information about
  scoring.
- Oracle Machine Learning for SQL Concepts for information about
  predictive Oracle Machine Learning for SQL.

---

**Note:**

The following example is excerpted from the Oracle Machine Learning for
SQL examples. For more information about the examples, see Appendix A in

---

**Example**

This example lists the probability and cost that customers with ID less than 100006 will
use an affinity card. This example has a binary target, but such a query is also useful
for multiclass classification such as low, medium, and high.

```sql
SELECT T.cust_id, S.prediction, S.probability, S.cost
FROM (SELECT cust_id,
       PREDICTION_SET(dt_sh_clas_sample COST MODEL USING *) pset
       FROM mining_data_apply_v
       WHERE cust_id < 100006) T,
   TABLE(T.pset) S
ORDER BY cust_id, S.prediction;
```

<table>
<thead>
<tr>
<th>CUST_ID</th>
<th>PREDICTION</th>
<th>PROBABILITY</th>
<th>COST</th>
</tr>
</thead>
<tbody>
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<td>.270531401</td>
</tr>
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</tr>
<tr>
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<td>.740384615</td>
<td>2.076923077</td>
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</tr>
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</tr>
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<td>0.727642276</td>
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</tr>
</tbody>
</table>