

# Data Analysis Project in BigQuery

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# Stages of the project

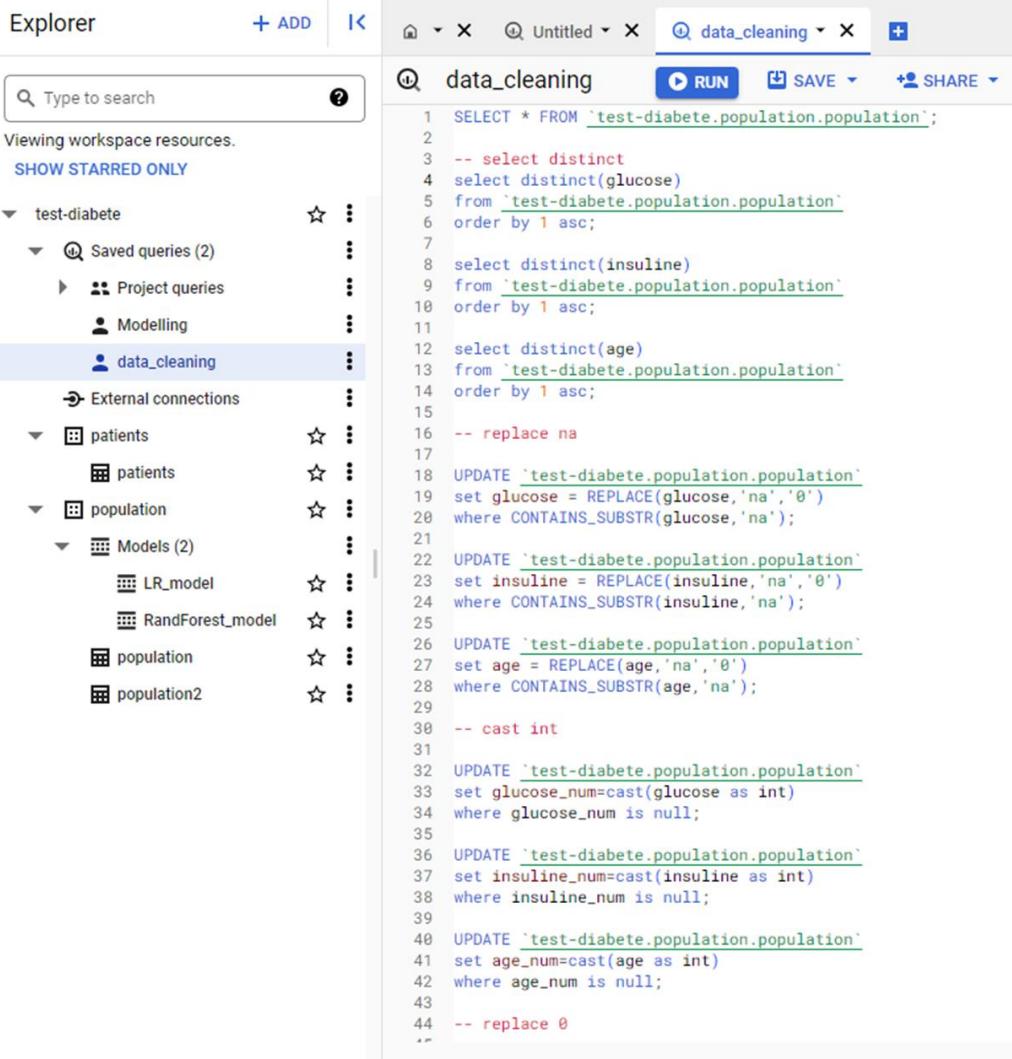
1. Brief / Debriefing
2. Load, Transform, Export data
3. EDA (Exploratory Data Analysis)
4. Modelling
  1. Logistic Regression
  2. Random Forrest Classifier
  3. Deep Neural Networks
  4. Boosted Trees
5. Hyperparameter Tuning
6. Summary / Key Learnings

# Data Cleaning

# Stages of data cleaning

1. Load data
2. Transform data
  1. Replace NaNs
  2. Check/change datatypes
  3. Replace Zeros with Medians
  4. Drop non-used columns
3. Ready to export data (e.g. for EDA)

# The code in SQL



The screenshot shows a SQL editor interface with the following details:

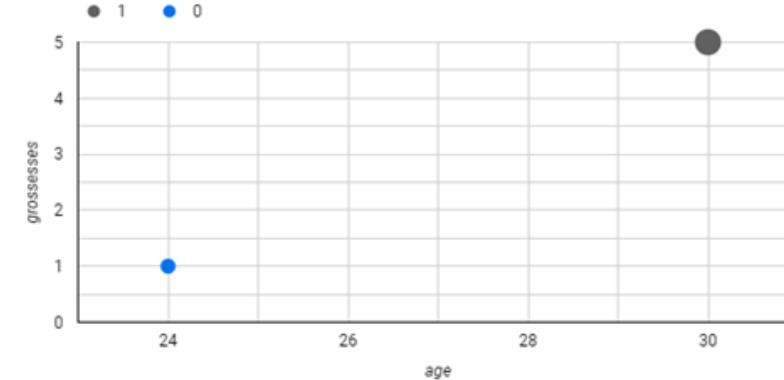
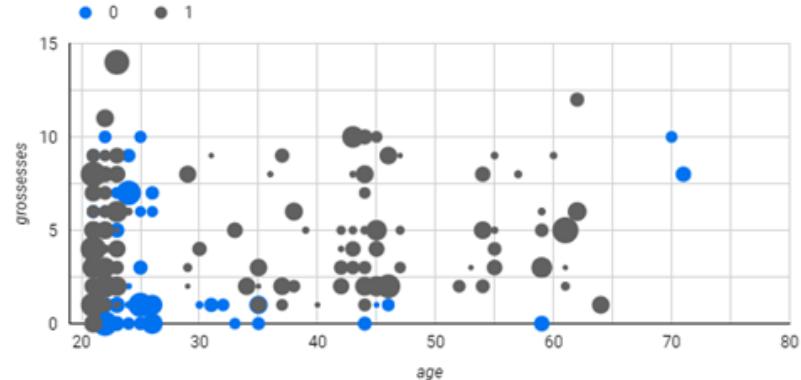
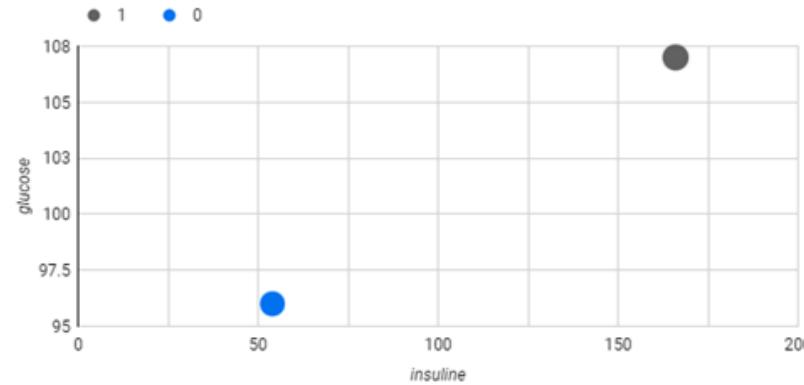
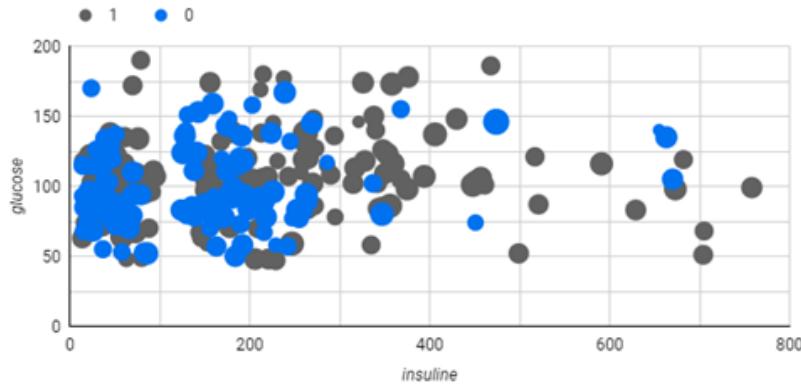
- Explorer:** On the left, it lists workspace resources under "test-diabete". The "data\_cleaning" query is selected.
- Query Tab:** The current tab is "data\_cleaning".
- Code Area:** The code is as follows:

```
1  SELECT * FROM `test-diabete.population.population`;
2
3  -- select distinct
4  select distinct(glucose)
5  from `test-diabete.population.population`
6  order by 1 asc;
7
8  select distinct(insuline)
9  from `test-diabete.population.population`
10 order by 1 asc;
11
12 select distinct(age)
13 from `test-diabete.population.population`
14 order by 1 asc;
15
16 -- replace na
17
18 UPDATE `test-diabete.population.population`
19 set glucose = REPLACE(glucose,'na','0')
20 where CONTAINS_SUBSTR(glucose,'na');
21
22 UPDATE `test-diabete.population.population`
23 set insuline = REPLACE(insuline,'na','0')
24 where CONTAINS_SUBSTR(insuline,'na');
25
26 UPDATE `test-diabete.population.population`
27 set age = REPLACE(age,'na','0')
28 where CONTAINS_SUBSTR(age,'na');
29
30 -- cast int
31
32 UPDATE `test-diabete.population.population`
33 set glucose_num=cast(glucose as int)
34 where glucose_num is null;
35
36 UPDATE `test-diabete.population.population`
37 set insuline_num=cast(insuline as int)
38 where insuline_num is null;
39
40 UPDATE `test-diabete.population.population`
41 set age_num=cast(age as int)
42 where age_num is null;
43
44 -- replace 0
45
46 UPDATE `test-diabete.population.population`
47 set glucose_num=105
48 where glucose_num=0;
49
50 (select PERCENTILE_CONT(glucose_num, 0.5) over()
51 from `test-diabete.population.population`
52 limit 1)
53
54 UPDATE `test-diabete.population.population`
55 set insuline_num=128
56 where insuline_num=0;
57
58 (select PERCENTILE_CONT(insuline_num, 0.5) over()
59 from `test-diabete.population.population`
60 limit 1)
61
62 UPDATE `test-diabete.population.population`
63 set age_num=24
64 where age_num=0;
65
66 (select PERCENTILE_CONT(age_num, 0.5) over()
67 from `test-diabete.population.population`
68 limit 1)
69
70 -- drop columns
71
72 alter table `test-diabete.population.population`
73 drop column glucose;
74
75 alter table `test-diabete.population.population`
76 drop column insuline;
77
78 alter table `test-diabete.population.population`
79 drop column age;
80
```

# EDA / Exploratory Data Analysis

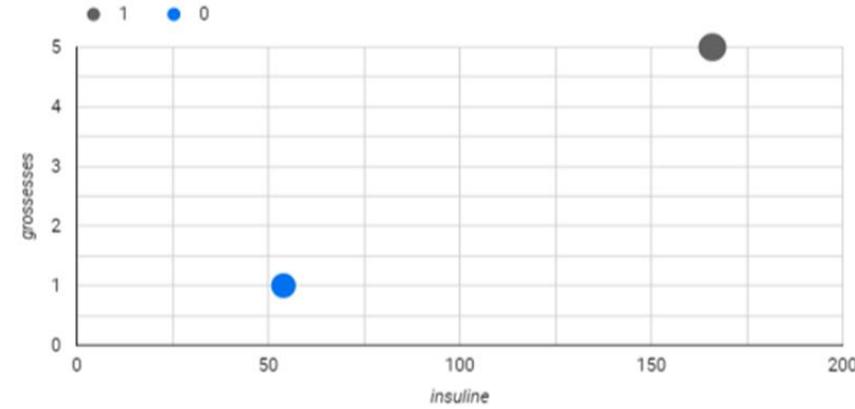
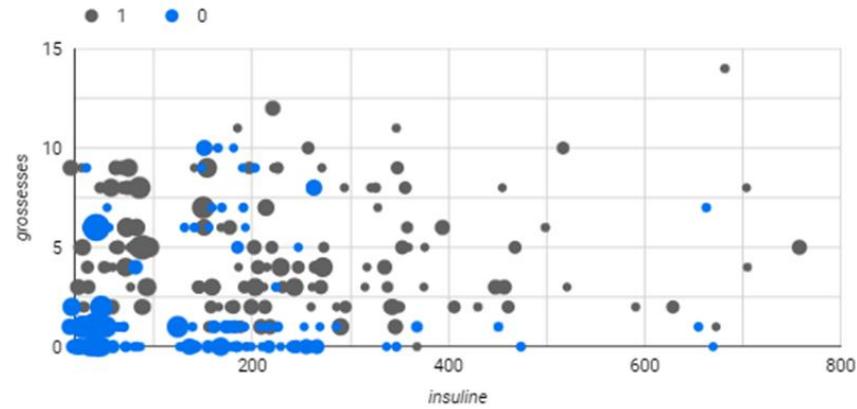
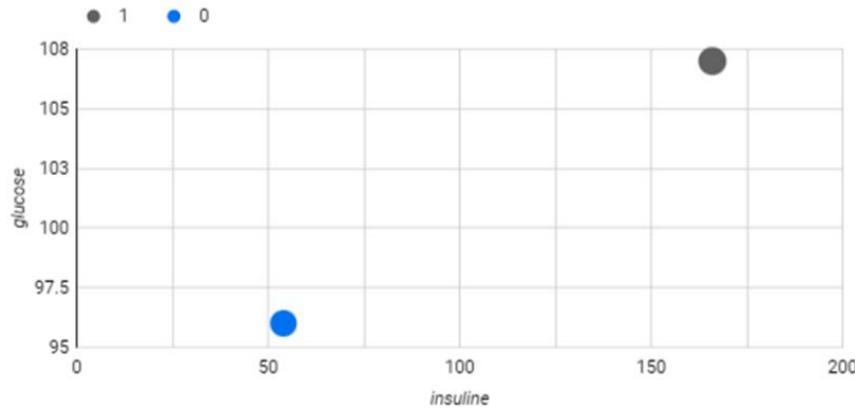
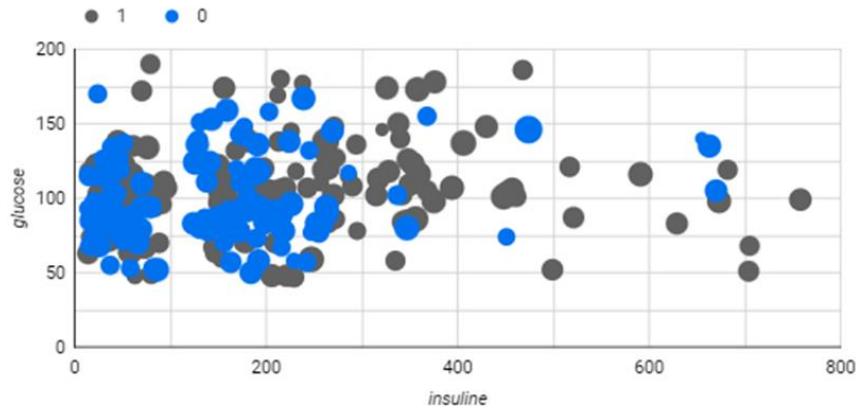
<https://lookerstudio.google.com/s/hutQa9uTOE4>

## population



<https://lookerstudio.google.com/s/hutQa9uTOE4>

## population



# Logistic regression model

Classification Problem

Supervised Learning

# Summary metrics (1)

Type to search

Viewing workspace resources. SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
  - population
    - Models (2)
      - LR\_model
      - RandForest\_model
    - population
    - population2

LR\_model

DETAILS TRAINING EVALUATION INTERPRETABILITY SCHEMA

QUERY MODEL DELETE MODEL EXPORT MODEL REFRESH

### Aggregate metrics

Threshold	0.5000
Precision	0.7868
Recall	0.7750
Accuracy	0.7825
F1 score	0.7809
Log loss	0.4588
ROC AUC	0.8721

### Score threshold

Positive class threshold	0.0187
Positive class	true
Negative class	false
Precision	0.5000
Recall	1.0000
Accuracy	0.5000
F1 score	0.6667

### Precision-recall by threshold

This plot shows precision (blue line) and recall (red line) as a function of the confidence threshold. The x-axis ranges from 0.0 to 1.0, and the y-axis ranges from 0% to 100%. The blue line starts at (0, 100%) and decreases to (1, 0). The red line starts at (0, 0) and increases to (1, 100%). A point on the red line is highlighted with a red circle.

Precision

Confidence threshold

Area under curve: 0.843

### Precision-recall curve

This plot shows precision (blue line) as a function of recall. The x-axis ranges from 0% to 100%, and the y-axis ranges from 0% to 100%. The blue line starts at (0, 100%) and decreases to (100, 0). A point on the blue line is highlighted with a blue circle.

Precision

Recall

### ROC curve

This plot shows the true positive rate (blue line) as a function of the false positive rate. The x-axis ranges from 0% to 100%, and the y-axis ranges from 0% to 100%. The blue line starts at (0, 0) and increases to (100, 100%). A point on the blue line is highlighted with a blue circle.

True positive rate

False positive rate

Area under curve: 0.872

# Summary metrics (2)

Explorer    + ADD    K

Type to search

Viewing workspace resources.  
SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
  - population
    - Models (5)
      - Boosted\_Trees\_mo...
      - DNN\_model
      - LR\_HPT\_model
      - LR\_model
      - RandForest\_model
    - population

Modelling    LR\_model

LR\_model

EVALUATION

Precision-recall by threshold

Precision-recall curve

ROC curve

Confusion matrix

This table shows how often the model classified each label correctly (in blue), and which labels were most often confused for that label (in grey).

True label	Predicted label	
	true	false
true	78%	23%
false	21%	79%

# Summary metrics for Test data

Explorer    + ADD    K

Type to search

Viewing workspace resources.  
SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
  - population
    - Models (2)
      - LR\_model
      - RandForest\_model
- population
- population2

Modelling    RUN    SAVE    SHARE    SCHEDULE    MORE    Query completed.

```
31 FROM
32 ML_EVALUATE (MODEL `test-diabete.population.LR_model`);
33
34 -- evaluate the model on test data
35
36 SELECT
37 ...*
38 FROM
39 ML_EVALUATE (MODEL `test-diabete.population.LR_model`,
40 ...(
41 ...  SELECT
42 ...    grossesses,pressure,imc,K,glucose,insuline,age,label
43 ...  FROM
44 ...    `test-diabete.patients.patients`
45 ...
46 ...);
47
48 -- globally explain the model
49
50 SELECT
```

Press Alt+F1 for accessibility options.

Query results    SAVE RESULTS    EXPLORE DATA

Row	precision	recall	accuracy	f1_score	log_loss	roc_auc
1	0.711538461538...	0.74	0.72	0.725490196078...	0.561732922173...	0.803197802197...

# Features Importance

The screenshot shows a data modeling interface with the following details:

- Explorer View:** On the left, under the workspace "test-diabete", there are sections for "Saved queries (2)", "External connections", "patients", "population", and "Models (2)". The "LR\_model" entry is selected, highlighted with a blue background.
- Model Overview:** The main area shows the model "LR\_model" with tabs for DETAILS, TRAINING, EVALUATION, INTERPRETABILITY (which is currently selected), and SCHEMA.
- Explainable AI Section:** This section is titled "Explainable AI" and provides an overview of the model's features and their importance scores.
- Table of Feature Importance:** A table lists the features and their attribution scores:

Feature name	Attribution
grossesses	0,986
insuline	0,56
age	0,544
imc	0,475
K	0,44
pression	0,204
glucose	0,091

# SQL code

The screenshot shows a data modeling interface with the following components:

- Explorer Sidebar:** On the left, it displays workspace resources under the project "test-diabete". The "Modelling" folder is selected. Other visible items include "Saved queries (2)", "Project queries", "data\_cleaning", "External connections", "patients", "population", and "Models (2)" which contain "LR\_model" and "RandForest\_model".
- Central Query Editor:** The main area shows an SQL script titled "Modelling". The script performs the following steps:
  - Creates or replaces a logistic regression model named "test-diabete.population.LR\_model".
  - Selects columns from the "test-diabete.population.population" table.
  - Evaluates the model on train data using the ML.EVALUATE function.
  - Selects columns from the "test-diabete.patients.patients" table.
  - Evaluates the model on test data using the ML.EVALUATE function.
  - Globally explains the model using the ML.GLOBAL\_EXPLAIN function.
- Status Bar:** At the bottom right, it says "Press Alt+F1 for accessibility options".
- Bottom Navigation:** It includes links for "PERSONAL HISTORY" and "PROJECT HISTORY", a "REFRESH" button, and a back/forward navigation icon.

```
-- LOGISTIC MODEL
CREATE OR REPLACE MODEL `test-diabete.population.LR_model`
OPTIONS
(
  model_type='LOGISTIC_REG',
  auto_class_weights=TRUE,
  enable_global_explain=TRUE,
  data_split_method='NO_SPLIT',
  input_label_cols=['label'],
  max_iterations=15) AS
SELECT
  grossesses,pressure,imc,K,glucose,insuline,age,label
FROM
  `test-diabete.population.population`;
-- evaluate the model on train data
SELECT
  *
FROM
  ML.EVALUATE (MODEL `test-diabete.population.LR_model`);
-- evaluate the model on test data
SELECT
  *
FROM
  ML.EVALUATE (MODEL `test-diabete.population.LR_model`,
  (
    SELECT
      grossesses,pressure,imc,K,glucose,insuline,age,label
    FROM
      `test-diabete.patients.patients`
  )
);
-- globally explain the model
SELECT
  *
FROM
  ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.LR_model`);
```

# Random Forest Classifier

Classification Problem

Supervised Learning

# Summary metrics (1)

Type to search

Viewing workspace resources.

SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
  - population
    - Models (2)
      - LR\_model
      - RandForest\_model
- population
- population2

SHOW MORE

## RandForest\_model

DETAILS TRAINING EVALUATION INTERPRETABILITY SCHEMA

QUERY MODEL DELETE MODEL EXPORT MODEL REFRESH

### Aggregate metrics

Threshold	0.5000
Precision	0.9701
Recall	0.9750
Accuracy	0.9725
F1 score	0.9726
Log loss	0.2167
ROC AUC	0.9972

### Score threshold

Positive class threshold	0.1326
Positive class	true
Negative class	false
Precision	0.5000
Recall	1.0000
Accuracy	0.5000
F1 score	0.6667

### Precision-recall by threshold

A line graph showing precision on the y-axis (0.0 to 1.0) against confidence threshold on the x-axis (0.0 to 1.0). Two curves are shown: a blue curve starting at (0, 1) and a red curve starting at approximately (0.1, 0.1). The blue curve drops sharply to 0 at a threshold of about 0.75. The red curve rises to 1 at a threshold of about 0.25. A vertical grey line marks the threshold at 0.5000.

Area under curve: 0.996

### Precision-recall curve

A line graph showing precision on the y-axis (0% to 100%) against recall on the x-axis (0% to 100%). A single blue curve starts at (0%, 100%) and drops to (100%, 0%). A vertical grey line marks the threshold at 0.5000.

Area under curve: 0.996

### ROC curve

A line graph showing true positive rate on the y-axis (0% to 100%) against false positive rate on the x-axis (0% to 100%). A single blue curve starts at (0%, 0%) and rises to (100%, 100%). A vertical grey line marks the threshold at 0.5000.

Area under curve: 0.997

# Summary metrics (2)

Type to search ?

Viewing workspace resources. [SHOW STARRED ONLY](#)

- test-diabete
- Saved queries (2)
  - Project queries
  - Modelling
  - data\_cleaning
- External connections
- patients
- population
- Models (5)
  - Boosted\_Trees\_mo...
  - DNN\_model
  - LR\_HPT\_model
  - LR\_model
  - RandForest\_model
- population

## RandForest\_model

QUERY MODEL DELETE MODEL EXPORT MODEL CREFR

DETAILS TRAINING EVALUATION INTERPRETABILITY SCHEMA

Precision-recall by threshold ?

Precision-recall curve ?

Precision

Recall

Area under curve: 0.996

Precision-recall by threshold

Confidence threshold

ROC curve ?

True positive rate

False positive rate

Area under curve: 0.997

ROC curve

True positive rate

False positive rate

### Confusion matrix

This table shows how often the model classified each label correctly (in blue), and which labels were most often confused for that label (in grey).

True label	Predicted label	
	true	false
true	98%	3%
false	3%	97%

Item counts

# Summary metrics for Test data

The screenshot shows a data modeling workspace interface. The left sidebar is titled "Explorer" and lists workspace resources under "test-diabete". The main area is titled "Modelling" and contains a query editor with the following code:

```
74 FROM
75 ML.EVALUATE (MODEL `test-diabete.population.RandForest_model`);
76
77 -- evaluate the model on test data
78
79 SELECT
80 ...
81 FROM
82 ML.EVALUATE (MODEL `test-diabete.population.RandForest_model`,
83 ...
84 (
85 ...
86 ...
87 ...
88 );
89 );
90
91 -- globally explain the model
92
93 SELECT
94 *
```

The "Query results" section below the code displays the following table:

Row	precision	recall	accuracy	f1_score	log_loss	roc_auc
1	0.933333333333...	0.84	0.89	0.884210526315	0.322185200369...	0.959001998001...

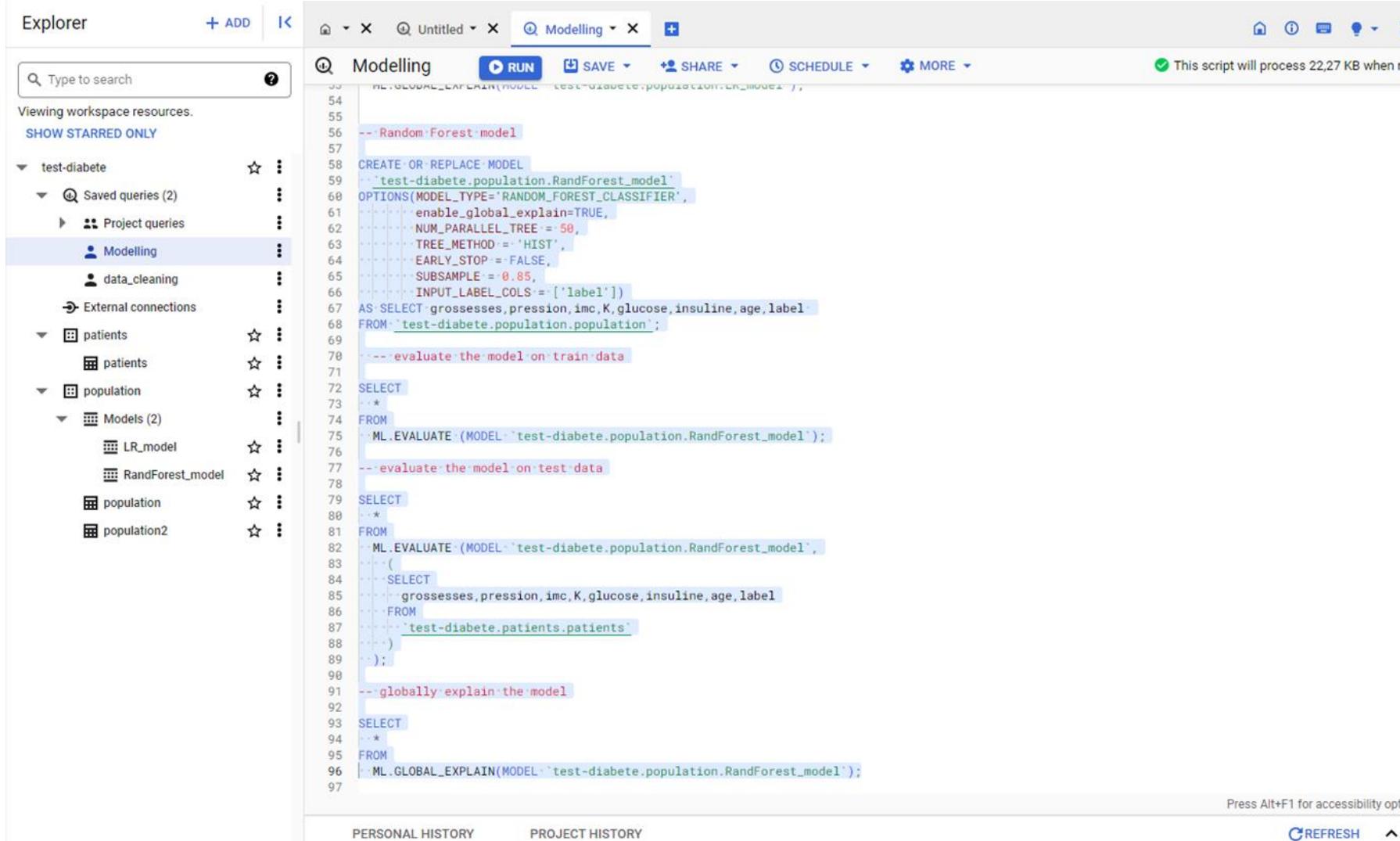
# Features Importance

The screenshot shows a workspace interface with the following details:

- Explorer:** On the left, a tree view of workspace resources. Key items include "test-diabete", "Saved queries (2)", "patients", "population", "Models (2)" containing "LR\_model" and "RandForest\_model" (which is selected).
- Top Bar:** Includes tabs for "data\_cleaning", "Modelling", "LR\_model", and "RandForest\_model".
- Model Details Page:** The "RandForest\_model" page is displayed. It has tabs for "DETAILS", "TRAINING", "EVALUATION", "INTERPRETABILITY" (which is selected), and "SCHEMA".
- Interpretability Section:** Titled "Explainable AI", it provides an overview of the model's features and their importance scores.
- Table:** A table showing feature names and their attribution scores:

Feature name	Attribution
grossesses	0,533
imc	0,183
insuline	0,139
age	0,13
glucose	0,044
pression	0,021
K	0,019

# SQL code



The screenshot shows a SQL development environment with the following interface elements:

- Explorer** pane on the left, displaying workspace resources under "test-diabete".
- Modelling** tab selected in the top bar.
- Code Editor** pane containing the following SQL script:

```
RE_GLOBALLY_EXPLAIN(MODEL `test-diabete.population.RandForest_model`);  
-- Random Forest model  
CREATE OR REPLACE MODEL `test-diabete.population.RandForest_model`  
OPTIONS(MODEL_TYPE='RANDOM_FOREST_CLASSIFIER',  
       enable_global_explain=TRUE,  
       NUM_PARALLEL_TREE = 50,  
       TREE_METHOD = 'HIST',  
       EARLY_STOP = FALSE,  
       SUBSAMPLE = 0.85,  
       INPUT_LABEL_COLS = ['label'])  
AS SELECT grossesses,pressure,imc,K,glucose,insuline,age,label  
FROM `test-diabete.population.population`;  
-- evaluate the model on train data  
SELECT *  
FROM  
ML.EVALUATE(MODEL `test-diabete.population.RandForest_model`);  
-- evaluate the model on test data  
SELECT *  
FROM  
ML.EVALUATE(MODEL `test-diabete.population.RandForest_model`,  
            (SELECT  
             grossesses,pressure,imc,K,glucose,insuline,age,label  
             FROM  
             `test-diabete.patients.patients`  
            ));  
-- globally explain the model  
SELECT *  
FROM  
ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.RandForest_model`);
```

The code is numbered from 53 to 97. A note at the top right says "This script will process 22,27 KB when run".

# Deep Neural Networks

Classification Problem

Supervised Learning

# Summary metrics (1)

Type to search

Viewing workspace resources. SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
- patients
  - patients
- population
  - Models (4)
    - Boosted\_Trees\_mo...
    - DNN\_model
    - LR\_model
    - RandForest\_model
  - population
  - population2

## DNN\_model

QUERY MODEL DELETE MODEL EXPORT MODEL REFRESH

EVALUATION

### Aggregate metrics

Threshold	0.5000
Precision	0.8916
Recall	0.9050
Accuracy	0.8975
F1 score	0.8983
Log loss	0.2339
ROC AUC	0.9678

### Score threshold

Positive class threshold	0.0003
Positive class	true
Negative class	false
Precision	0.5000
Recall	1.0000
Accuracy	0.5000
F1 score	0.6667

### Precision-recall by threshold

Precision

Confidence threshold

Area under curve: 0.965

### Precision-recall curve

Precision

Recall

### ROC curve

True positive rate

False positive rate

Area under curve: 0.968

# Summary metrics (2)

Type to search

Viewing workspace resources.  
SHOW STARRED ONLY

- test-diabete
- Saved queries (2)
  - Project queries
  - Modelling
  - data\_cleaning
- External connections
- patients
- population
- Models (5)
  - Boosted\_Trees\_mo...
  - DNN\_model
  - LR\_HPT\_model
  - LR\_model
  - RandForest\_model
- population

DNN\_model

DETAILS TRAINING EVALUATION SCHEMA

QUERY MODEL DELETE MODEL EXPORT MODEL REFRES

Precision-recall by threshold

Precision-recall curve

ROC curve

Confusion matrix

This table shows how often the model classified each label correctly (in blue), and which labels were most often confused for that label (in grey).

True label	Predicted label	
	true	false
true	90%	10%
false	11%	90%

# Summary metrics for Test data

Explorer    + ADD | ↵

Type to search ?

Viewing workspace resources.

SHOW STARRED ONLY

test-diabete

- Saved queries (2)
  - Project queries
  - Modelling
- External connections
- patients
- population
- Models (4)
  - Boosted\_Trees\_mo...
  - DNN\_model
  - LR\_model
  - RandForest\_model
- population
- population2

Modelling

RUN SAVE SHARE SCHEDULE MORE

Query completed

```
117 SELECT
118 *
119 FROM
120 ML.EVALUATE (MODEL `test-diabete.population.DNN_model`);
121
-- evaluate the model on test data
123
124 SELECT
125 *
126 FROM
127 ML.EVALUATE (MODEL `test-diabete.population.DNN_model`,
128 (
129   SELECT
130     grossesses,pressure,imc,K,glucose,insuline,age,label
131   FROM
132     `test-diabete.patients.patients`
133   );
134 );
135
-- globally explain the model
136
137 SELECT
138 *
139 FROM
140 ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.DNN_model`);
141
-- Boosted Trees model
142
143 CREATE MODEL `test-diabete.population.Boosted_Trees_model`
```

Press Alt+F1 for accessibility options

Query results

SAVE RESULTS EXPLORE DATA

JOB INFORMATION RESULTS JSON EXECUTION DETAILS EXECUTION GRAPH

Row	precision	recall	accuracy	f1_score	log_loss	roc_auc
1	0.775510204081...	0.76	0.77	0.767676767676...	0.557753980810...	0.846214785214...

# SQL code

Type to search ?

Modelling RUN SAVE SHARE SCHEDULE MORE This script will process 54 KB when run

Viewing workspace resources.

SHOW STARRED ONLY

test-diabete

- Saved queries (2)
  - Project queries
  - Modelling
- External connections
- patients
- population
- Models (4)
  - Boosted\_Trees\_mo...
  - DNN\_model
  - LR\_model
  - RandForest\_model
- population
- population2

```
97 -- Deep Neural Network (DNN) model
98
99
100 CREATE OR REPLACE MODEL `test-diabete.population.DNN_model`
101 OPTIONS(MODEL_TYPE='DNN_CLASSIFIER',
102         enable_global_explain=TRUE,
103         ACTIVATION_FN = 'RELU',
104         BATCH_SIZE = 16,
105         DROPOUT = 0.1,
106         EARLY_STOP = TRUE,
107         HIDDEN_UNITS = [128, 128, 128],
108         INPUT_LABEL_COLS = ['label'],
109         LEARN_RATE=0.001,
110         MAX_ITERATIONS = 25,
111         OPTIMIZER = 'ADAM')
112 AS SELECT grossesses.pression,imc,K,glucose,insuline,age,label
113 FROM `test-diabete.population.population`;
114
115 -- evaluate the model on train data
116 SELECT
117   *
118 FROM
119   ML.EVALUATE (MODEL `test-diabete.population.DNN_model`);
120
121 -- evaluate the model on test data
122 SELECT
123   *
124 FROM
125   ML.EVALUATE (MODEL `test-diabete.population.DNN_model`,
126   (
127     (
128       SELECT
129       | grossesses,pression,imc,K,glucose,insuline,age,label
130       FROM
131       | `test-diabete.patients.patients`
132     )
133   );
134
135 -- globally explain the model
136 SELECT
137   *
138 FROM
139   ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.DNN_model`);
```

# Boosted Trees Classifier

Classification Problem

Supervised Learning

# Summary metrics (1)

Type to search

Viewing workspace resources.  
SHOW STARRED ONLY

Boosted\_Trees\_model

DETAILS TRAINING EVALUATION INTERPRETABILITY SCHEMA

Aggregate metrics

Threshold	0.5000
Precision	1.0000
Recall	1.0000
Accuracy	1.0000
F1 score	1.0000
Log loss	0.0117
ROC AUC	1.0000

Score threshold

Positive class threshold	0.0001
Positive class	true
Negative class	false
Precision	0.5000
Recall	1.0000
Accuracy	0.5000
F1 score	0.6667

Precision-recall by threshold

Precision-recall curve

ROC curve

Area under curve: 0.997

Area under curve: 1

# Summary metrics (2)

Explorer    + ADD    🔍

Type to search

Viewing workspace resources. SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
    - patients
  - population
  - Models (4)
    - Boosted\_Trees\_mo... (selected)
    - DNN\_model
    - LR\_model
    - RandForest\_model
  - population
  - population2

Boosted\_Trees\_model

EVALUATION

Precision-recall by threshold

Precision-recall curve Area under curve: 0.997

Precision-recall curve

ROC curve

True positive rate Area under curve: 1

Confusion matrix

This table shows how often the model classified each label correctly (in blue), and which labels were most often confused for that label (in grey).

True label	Predicted label	
	true	false
true	100%	0%
false	100%	0%

PERSONAL HISTORY PROJECT HISTORY REFRESH

# Summary metrics for Test data

The screenshot shows a data modeling interface with the following details:

- Header:** Search bar with placeholder "Search (/) for resources, docs, products and more" and a "Search" button.
- Toolbar:** Includes icons for Home, Help, and More.
- Left Sidebar (Explorer):** Shows a workspace structure:
  - test-diabete (selected)
  - Viewing workspace resources.
  - SHOW STARRED ONLY
  - test-diabete
    - Saved queries (2)
      - Project queries
      - Modelling (selected)
      - data\_cleaning
    - External connections
    - patients
      - patients
    - population
      - Models (4)
        - Boosted\_Trees\_mo...
        - DNN\_model
        - LR\_model
        - RandForest\_model
      - population
      - population2
- Central Area:** Modelling tab selected.
  - SQL code:

```
159
160 SELECT
161 *
162 FROM
163 ML.EVALUATE (MODEL `test-diabete.population.Boosted_Trees_model`);
164
165 -- evaluate the model on test data
166
167 SELECT
168 ...
169 FROM
170 ML.EVALUATE (MODEL `test-diabete.population.Boosted_Trees_model` ,
171 ...
172 ...
173 ...
174 ...
175 ...
176 ...
177 ...
178 ...
179 -- globally explain the model
```
  - Buttons: RUN, SAVE, SHARE, SCHEDULE, MORE.
  - Checkmark: Query cor.
- Bottom Area:** Query results table.

Row	precision	recall	accuracy	f1_score	log_loss	roc_auc
1	0.96	0.96	0.96	0.96	0.119129015752...	0.992408591408...

  - Buttons: SAVE RESULTS, EXPLORE DATA.

# Features Importance

Type to search ?

Viewing workspace resources. SHOW STARRED ONLY

- test-diabete
  - Saved queries (2)
    - Project queries
    - Modelling
    - data\_cleaning
  - External connections
  - patients
    - patients
  - population
    - Models (4)
      - Boosted\_Trees\_mo... ☆ ::
      - DNN\_model ☆ ::
      - LR\_model ☆ ::
      - RandForest\_model ☆ ::
    - population ☆ ::
    - population2 ☆ ::

## Boosted\_Trees\_model

QUERY MODEL DELETE MODEL EXPORT MODEL REFRESH

DETAILS TRAINING EVALUATION INTERPRETABILITY SCHEMA

### Explainable AI

Explainable AI provides a way of explaining the model and the predictions it produces. The following contains the features with the largest importance scores for your model overall. For explanationable prediction on a per example basis, please run ML.EXPLAIN\_PREDICT or ML.EXPLAIN\_FORECAST.

Feature name	Attribution
grossesses	1,231
imc	0,611
age	0,602
insuline	0,493
glucose	0,418
pression	0,296
K	0,233

# SQL code

Modelling    RUN    SAVE    SHARE    SCHEDULE    MORE    This script will process 54 KB when run.

```
142 -- Boosted Trees model
143
144 CREATE MODEL `test-diabete.population.Boosted_Trees_model`
145 OPTIONS(MODEL_TYPE='BOOSTED_TREE_CLASSIFIER',
146           enable_global_explain=TRUE,
147           BOOSTER_TYPE = 'GBTREE',
148           NUM_PARALLEL_TREE = 1,
149           MAX_ITERATIONS = 50,
150           TREE_METHOD = 'HIST',
151           EARLY_STOP = FALSE,
152           SUBSAMPLE = 0.85,
153           INPUT_LABEL_COLS = ['label'])
154 AS SELECT grossesses,pressure,imc,K,glucose,insuline,age,label
155 FROM `test-diabete.population.population`;
156
157 -- evaluate the model on train data
158
159 SELECT
160   *
161 FROM
162   ML.EVALUATE (MODEL `test-diabete.population.Boosted_Trees_model`);
163
164 -- evaluate the model on test data
165
166 SELECT
167   *
168 FROM
169   ML.EVALUATE (MODEL `test-diabete.population.Boosted_Trees_model`,
170   (
171     SELECT
172       grossesses,pressure,imc,K,glucose,insuline,age,label
173     FROM
174       `test-diabete.patients.patients`
175   )
176 );
177
178 -- globally explain the model
179
180 SELECT
181   *
182 FROM
183   ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.Boosted_Trees_model`);
```

Press Alt+F1 for accessibility options.

Query results    SAVE RESULTS    EXPLORE DATA

# Prediction for test / SQL code

Explorer    + ADD       \*Modelling    population    +

Type to search

Viewing workspace resources.

SHOW STARRED ONLY

test-diabete

- Saved queries (2)
  - Project queries
  - Modelling
- External connections
- patients
- population
- Models (4)
  - Boosted\_Trees\_mo...
  - DNN\_model
  - LR\_model
  - RandForest\_model
- population

Modelling

RUN    SAVE    SHARE    SCHEDULE    MORE    Query completed

```
181 -- the model prediction for test data
182 SELECT
183 *
184 FROM
185 ML.PREDICT (MODEL `test-diabete.population.Boosted_Trees_model`,
186 (
187   SELECT
188     | grossesses,pressure,imc,K,glucose,insuline,age,label
189   FROM
190     | `test-diabete.patients.patients`
191   )
192 )
193
194
195 -- explain the model prediction for test data
196 SELECT
197 *
198 FROM
199 ML.EXPLAIN_PREDICT(MODEL `test-diabete.population.Boosted_Trees_model`,
200 (
201   SELECT
202     | grossesses,pressure,imc,K,glucose,insuline,age,label
203   FROM
204     | `test-diabete.patients.patients`
205   ),
206   STRUCT(3 as top_k_features)
207 )
```

Press Alt+F1 for accessibility options

Query results

SAVE RESULTS    EXPLORE DATA

JOB INFORMATION		RESULTS	JSON	EXECUTION DETAILS		EXECUTION GRAPH			
Row	predicted	probability	top_feature_attribu...	feature	t... attribution	baseline_prediction	prediction_value	approximation_error	grossesses
1	false	0.989577753469...		grossesses	2.851242065429...	0.545232415199...	3.034668743610...	0.0	0
				imc	-0.21151876449...				
				K	0.211415126919...				
2	false	0.999275551002...		grossesses	2.057404756546...	0.545232415199...	4.263222649693...	0.0	0
				age	1.032763004302...				

Results per page: 50 ▾ 1 – 50 of 100

# Hyperparameter Tuning

Example for a Logistic Regression model

# Evaluation Summary

?

Viewing workspace resources. [SHOW STARRED ONLY](#)

- test-diabete ☆ ⋮
  - Saved queries (2) ⋮
    - Project queries ⋮
    - Modelling ⋮
    - data\_cleaning ⋮
  - External connections ⋮
- patients ☆ ⋮
  - patients ☆ ⋮
- population ☆ ⋮
  - Models (5) ⋮
    - Boosted\_Trees\_mo... ☆ ⋮
    - DNN\_model ☆ ⋮
    - LR\_HPT\_model ☆ ⋮ (Optimal)
    - LR\_model ☆ ⋮
    - RandForest\_model ☆ ⋮
  - population ☆ ⋮

### LR\_HPT\_model

🔍 QUERY MODEL trash DELETE MODEL export EXPORT MODEL

DETAILS	TRAINING	EVALUATION	INTERPRETABILITY	SCHEMA			
Trial ID <span>↑</span>	L1 regularisation	L2 regularisation	Precision	Recall	Accuracy	F1 score	Log loss
1	0.0000	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
2	0.0000	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
3	0.0000	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
4	0.0000	0.0006	0.7868	0.7750	0.7825	0.7809	0.4588
5	0.0000	7.6178	0.7868	0.7750	0.7825	0.7809	0.4625
6	0.0073	0.0002	0.7868	0.7750	0.7825	0.7809	0.4588
7	10.0000	0.0000	0.7755	0.7600	0.7700	0.7677	0.4746
8	10.0000	0.0000	0.7755	0.7600	0.7700	0.7677	0.4746
9 (Optimal)	0.0000	10.0000	0.7979	0.7700	0.7875	0.7837	0.4635
10	0.0002	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
11 (Optimal)	0.0000	10.0000	0.7979	0.7700	0.7875	0.7837	0.4635
12	0.0000	0.1571	0.7868	0.7750	0.7825	0.7809	0.4588
13 (Optimal)	0.0000	10.0000	0.7979	0.7700	0.7875	0.7837	0.4635
14	0.0000	9.5086	0.7979	0.7700	0.7875	0.7837	0.4632
15	10.0000	0.0209	0.7755	0.7600	0.7700	0.7677	0.4746
16	0.0000	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
17	0.0000	0.0130	0.7868	0.7750	0.7825	0.7809	0.4588
18	10.0000	0.0000	0.7755	0.7600	0.7700	0.7677	0.4746
19	0.0000	0.0000	0.7868	0.7750	0.7825	0.7809	0.4588
20	10.0000	0.0000	0.7755	0.7600	0.7700	0.7677	0.4746

# SQL code

Explorer    + ADD    🔍    \*Modelling    X    LR\_HPT\_model    X    +

Type to search    ?

Viewing workspace resources.

SHOW STARRED ONLY

test-diabete    ★ :

- Saved queries (2)    ::
- Project queries    ::
- Modelling    ::
- data\_cleaning    ::
- External connections    ::

patients    ★ :

- patients    ★ ::

population    ★ :

- Models (5)    ::
- Boosted\_Trees\_mo...    ★ ::
- DNN\_model    ★ ::
- LR\_HPT\_model    ★ ::
- LR\_model    ★ ::
- RandForest\_model    ★ ::
- population    ★ ::

Modelling    RUN    SAVE    SHARE    SCHEDULE    MORE    ✓ Query completed

```
43   FROM
44   | `test-diabete.patients.patients`
45   )
46 );
47
48 -- globally explain the model
49
50 SELECT
51   *
52 FROM
53   ML.GLOBAL_EXPLAIN(MODEL `test-diabete.population.LR_model`);
54
55 -- Hyper Parameter Tuning
56
57 CREATE OR REPLACE MODEL
58   | `test-diabete.population.LR_HPT_model`
59   OPTIONS
60   | ('model_type='LOGISTIC_REG',
61   | 'enable_global_explain=TRUE,
62   | 'input_label_cols=['label'],
63   | 'num_trials=20,
64   | 'max_parallel_trials=2') AS
65   SELECT
66     | 'grossesses,pressure,imc,K,glucose,insuline,age,label'
67   FROM
68   | `test-diabete.population.population`;
```

Press Alt+F1 for accessibility options

Query results    SAVE RESULTS    EXPLORE DATA

JOB INFORMATION	RESULTS	EXECUTION DETAILS	EXECUTION GRAPH										
Elapsed time 10 min 6 sec	Slot time consumed ? 55 min 29 sec	Stages ? <table border="1"><tr><td>Preprocess</td><td>0</td></tr><tr><td>trial_1:Train</td><td>0</td></tr><tr><td>trial_2:Train</td><td>0</td></tr><tr><td>trial_1:Evaluate</td><td>0</td></tr><tr><td>trial_2:Evaluate</td><td>0</td></tr></table>	Preprocess	0	trial_1:Train	0	trial_2:Train	0	trial_1:Evaluate	0	trial_2:Evaluate	0	Training iterations Completed: 0 Planned: 0
Preprocess	0												
trial_1:Train	0												
trial_2:Train	0												
trial_1:Evaluate	0												
trial_2:Evaluate	0												

# Model deployment

Example for the Boosted Trees model

# Export the model to the Bucket

Cloud Storage    [Bucket details](#)    [REFRESH](#)    [HELP ASSISTANT](#)    [LEARN](#)

**Buckets**    **230712-test-diabete**

Location	Storage class	Public access	Protection
us (multiple regions in United States)	Standard	Not public	None

[OBJECTS](#)    [CONFIGURATION](#)    [PERMISSIONS](#)    [PROTECTION](#)    [LIFECYCLE](#)    [OBSERVABILITY](#)    [INVENTORY REPORTS](#)

Buckets > 230712-test-diabete > BT\_model

[UPLOAD FILES](#)    [UPLOAD FOLDER](#)    [CREATE FOLDER](#)    [TRANSFER DATA](#) ▾    [MANAGE HOLDS](#)    [DOWNLOAD](#)    [DELETE](#)

Filter by name prefix only ▾    [Filter](#) Filter objects and folders     Show deleted data    [☰](#)

Name	Size	Type	Created	Storage class	Last modified	Public	⋮
<a href="#">assets/</a>	–	Folder	–	–	–	–	⋮
<a href="#">explanation_metadata.json</a>	216 B	application/octet-stream	Jul 18, 2023, 10:24:03 AM	Standard	Jul 18, 2023, 10:24:03 AM	Not p	⬇️ ⋮
<a href="#">main.py</a>	883 B	application/octet-stream	Jul 18, 2023, 10:24:03 AM	Standard	Jul 18, 2023, 10:24:03 AM	Not p	⬇️ ⋮
<a href="#">model.bst</a>	94 KB	application/octet-stream	Jul 18, 2023, 10:24:02 AM	Standard	Jul 18, 2023, 10:24:02 AM	Not p	⬇️ ⋮
<a href="#">xgboost_predictor-0.1.tar.gz</a>	4,2 KB	application/octet-stream	Jul 18, 2023, 10:24:03 AM	Standard	Jul 18, 2023, 10:24:03 AM	Not p	⬇️ ⋮

# Register and Deploy the model

Vertex AI

BT\_model

EDIT DETAILS

Model description: diabete

Region: us-west2 (Los Angeles)

Model labels: -

Versions

Filter: Enter a property name

Version ID	Alias	Status	Description	Endpoints	Created	Labels
1	default	Deployed on Vertex AI	-	BT_ep1	Jul 18, 2023, 12:32:21	

⋮

Edit alias

Edit description

Edit labels

Copy to another region

Delete model version

Deploy to endpoint

Resume training

Vertex AI

BT\_ep1

EDIT SETTINGS

SAMPLE REQUEST

Region: us-west2

Logs: View Logs

Model Monitoring: Disabled

Model	Status	Deployment resource pool	Most recent alerts	Monitoring	Traffic split	Compute nodes	Type	Created
BT_model (Version 1)	Ready	-	-	Disabled	100 %	Auto (1 minimum, 1 maximum)	Custom trained	Jul 18, 2023, 2:21:53 PM

# Workbench request

The screenshot shows the Google Cloud Workbench interface with a Jupyter notebook titled "diabete\_model.ipynb". The notebook contains Python code for interacting with Google's AI Platform API to make predictions on diabetes dataset instances.

```
[16]: from typing import Dict, List, Union
       from google.cloud import aiplatform
       from google.protobuf import json_format
       from google.protobuf.struct_pb2 import Value

[18]: project="689275957566"
       endpoint_id="4892536472533467136"
       location="us-west2"

[19]: endpoint_name=f"projects/{project}/locations/{location}/endpoints/{endpoint_id}"

[29]: # projects/689275957566/locations/us-west2/endpoints/4892536472533467136

[20]: endpoint=aiplatform.Endpoint(endpoint_name=endpoint_name)

[25]: instances0=[[0,80,37.22895209,0.28373613,138,71,22]]
       instances1=[[1,63,33.15925172,0.608796752,98,62,57]]

[30]: endpoint.predict(instances=instances0).predictions, endpoint.predict(instances=instances1).predictions

[30]: ([[0.01042224653065205, 0.9895777702331543]],
      [[0.7208105325698853, 0.2791894674301147]])
```

# Summary / Key Learnings

# Summary of models performance

Model	Accuracy / Train	Accuracy / Test
Logistic Regression / HPT	0,78 / 0,80	0,72 / 0,71
Random Forrest Trees	0,97	0,89
Deep Neural Network	0,90	0,77
Boosted Trees	1,00	0,96

# Major points / technical

1. Data cleaning:
  1. Manual cleaning for modelling is not necessary
  2. BigQuery (BQ) ML automatically preprocesses data cleaning (imputation of missing values & data transformation (standardisation, encoding))
  3. But the type of the missing value is to be NULL
2. BQ Looker gives a lot of possibilities to visualize data & make data stories
3. ML models make data transformation automatically, though it may be done manually
4. There is a possibility for Hyper Parameters Tuning to improve the models' performance