Explore ecommerce data

Scenario: Your data analyst team exported the Google Analytics logs for an ecommerce website into BigQuery and created a new table of all the raw ecommerce visitor session data for you to explore. Using this data, you'll try to answer a few questions.

Question: Out of the total visitors who visited our website, what % made a purchase?

Click the **Compose Query** button and add the following to the New Query field:

```
#standardSQL
WITH visitors AS(
SELECT
COUNT(DISTINCT fullVisitorId) AS total_visitors
FROM `data-to-insights.ecommerce.web_analytics`
),

purchasers AS(
SELECT
COUNT(DISTINCT fullVisitorId) AS total_purchasers
FROM `data-to-insights.ecommerce.web_analytics`
WHERE totals.transactions IS NOT NULL
)

SELECT
  total_visitors,
  total_purchasers,
  total_purchasers / total_visitors AS conversion_rate
FROM visitors, purchasers
```

Then click **Run Query**.

The result: 2.69%

Question: What are the top 5 selling products?

Replace the previous query with the following, and then **Run Query**:

```
#standardSQL
SELECT
  p.v2ProductName,
  p.v2ProductCategory,
  SUM(p.productQuantity) AS units_sold,
  ROUND(SUM(p.localProductRevenue/1000000),2) AS revenue
FROM `data-to-insights.ecommerce.web_analytics`,
UNNEST(hits) AS h,
UNNEST(h.product) AS p
GROUP BY 1, 2
ORDER BY revenue DESC
LIMIT 5;
```

The result:

Row	v2ProductName	v2ProductCategory	units_sold	revenue

1	Nest® Learning Thermostat 3rd Gen-USA - Stainless Steel	Nest-USA	17651	870976.95
2	Nest® Cam Outdoor Security Camera - USA	Nest-USA	16930	684034.55
3	Nest® Cam Indoor Security Camera - USA	Nest-USA	14155	548104.47
4	Nest® Protect Smoke + CO White Wired Alarm-USA	Nest-USA	6394	178937.6
5	Nest® Protect Smoke + CO White Battery Alarm-USA	Nest-USA	6340	178572.4

Question: How many visitors bought on subsequent visits to our website? Run the following query to find out:

```
#standardSQL

# visitors who bought on a return visit (could have bought on first as well
WITH all_visitor_stats AS (
SELECT
  fullvisitorid, # 741,721 unique visitors
  IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid
)

SELECT
  COUNT(DISTINCT fullvisitorid) AS total_visitors,
  will_buy_on_return_visit
FROM all_visitor_stats
GROUP BY will_buy_on_return_visit
```

The results:

Row	total_visitors	will_buy_on_return_visit
1	729848	0
2	11873	1

Analyzing the results, you can see that (11873 / 729848) = 1.6% of total visitors will return and purchase from the website. This includes the subset of visitors who bought on their very first session and then came back and bought again.

Question: What are some of the reasons a typical ecommerce customer will browse but not buy until a later visit?
Answer: Although there is no one right answer, one popular reason is comparison shopping between different ecommerce sites before ultimately making a purchase decision. This is very common for luxury goods where significant upfront research and comparison is required by the customer before deciding (think car purchases) but also true to a lesser extent for the merchandise on our site (t-shirts, accessories etc).
In the world of online marketing, identifying and marketing to these future customers based on the characteristics of their first visit will increase conversion rates and reduce the outflow to competitor sites.

Identify an objective

We will now create a Machine Learning model in BigQuery to predict whether or not a new user is likely to purchase in the future. Identifying these high-value users can help your marketing team target them with special promotions and ad campaigns to ensure a conversion while they comparison shop between visits to our ecommerce site.

Select features and create your training dataset

Google Analytics captures a wide variety of dimensions and measures about a user's visit on our ecommerce website. Browse the complete list of fields here and then preview the demo dataset to find useful features that will

help a machine learning model understand the relationship between data about a visitor's first time on our website and whether they will return and make a purchase.
Your team decides to test whether these two fields are good inputs for your classification model:

- Totals.bounces (whether the visitor left the website immediately)
- totals.timeOnSite (how long the visitor was on our website)

Question: What are the risks of only using the above two fields?
Answer: Machine learning is only as good as the training data that is fed into it. If there isn't enough information for the model to determine and learn the relationship between your input features and your label (in our case, whether the visitor bought in the future) then you will not have an accurate model. While training a model on just these two fields is a start, we will see if they're good enough to produce an accurate model.
Click **Compose Query** and add the following:

```
#standardSQL
SELECT
  * EXCEPT(fullVisitorId)
FROM

  # features
  (SELECT
    fullVisitorId,
    IFNULL(totals.bounces, 0) AS bounces,
    IFNULL(totals.timeOnSite, 0) AS time_on_site
  FROM
    `data-to-insights.ecommerce.web_analytics`
  WHERE
    totals.newVisits = 1)
  JOIN
  (SELECT
    fullvisitorid,
    IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM
      `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid)
  USING (fullVisitorId)
ORDER BY time_on_site DESC
LIMIT 10;
```

Then **Run Query**.
Results:

Row	bounces	time_on_site	will_buy_on_return_visit
1	0	15047	0

2	0	12136	0
3	0	11201	0
4	0	10046	0
5	0	9974	0
6	0	9564	0
7	0	9520	0
8	0	9275	1
9	0	9138	0
10	0	8872	0

Which fields are the model features (inputs)? What is the label (correct answer)?

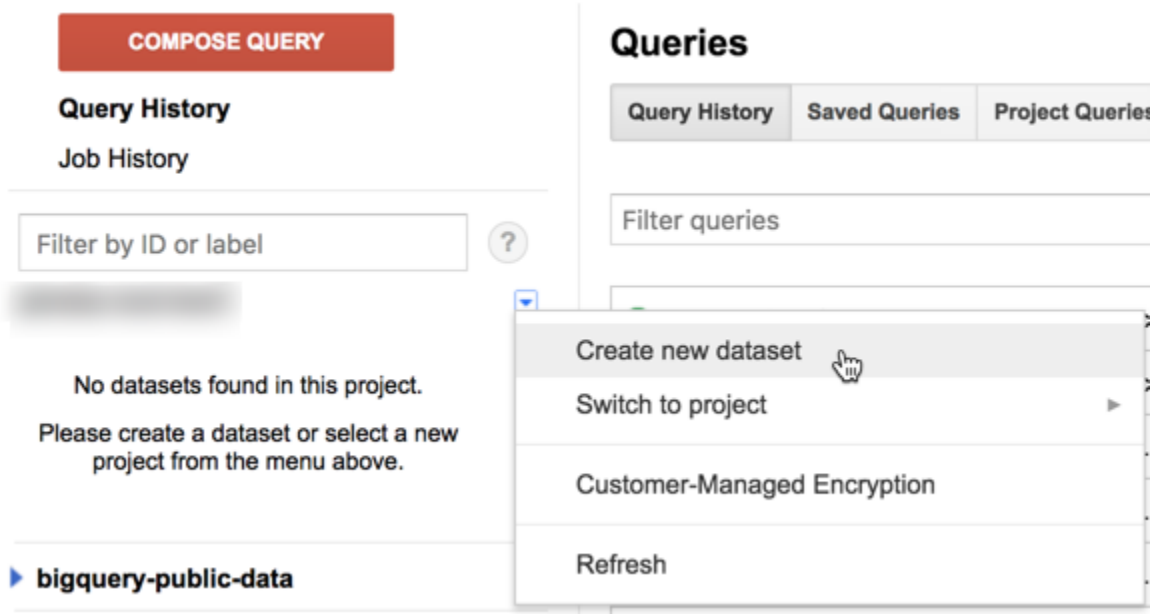
The inputs are bounces and time_on_site. The label is will_buy_on_return_visit

Question: Which two fields are known after a visitor's first session?
Answer: bounces and **time_on_site** are known after a visitor's first session.
Question: Which field isn't known until later in the future?
Answer: will_buy_on_return_visit is not known after the first visit. Again, you're predicting for a subset of users who returned to your website and purchased. Since you don't know the future at prediction time, you cannot say with certainty whether a new visitor come back and purchase. The value of building a ML model is to get the probability of future purchase based on the data gleaned about their first session.
Question: Looking at the initial data results, do you think **time_on_site** and **bounces** will be a good indicator of whether the user will return and purchase or not?
Answer: It's often too early to tell before training and evaluating the model, but at first glance out of the top 10 time_on_site only 1 customer returned to buy which isn't very promising. Let's see how well the model does.

Create a BigQuery dataset to store models

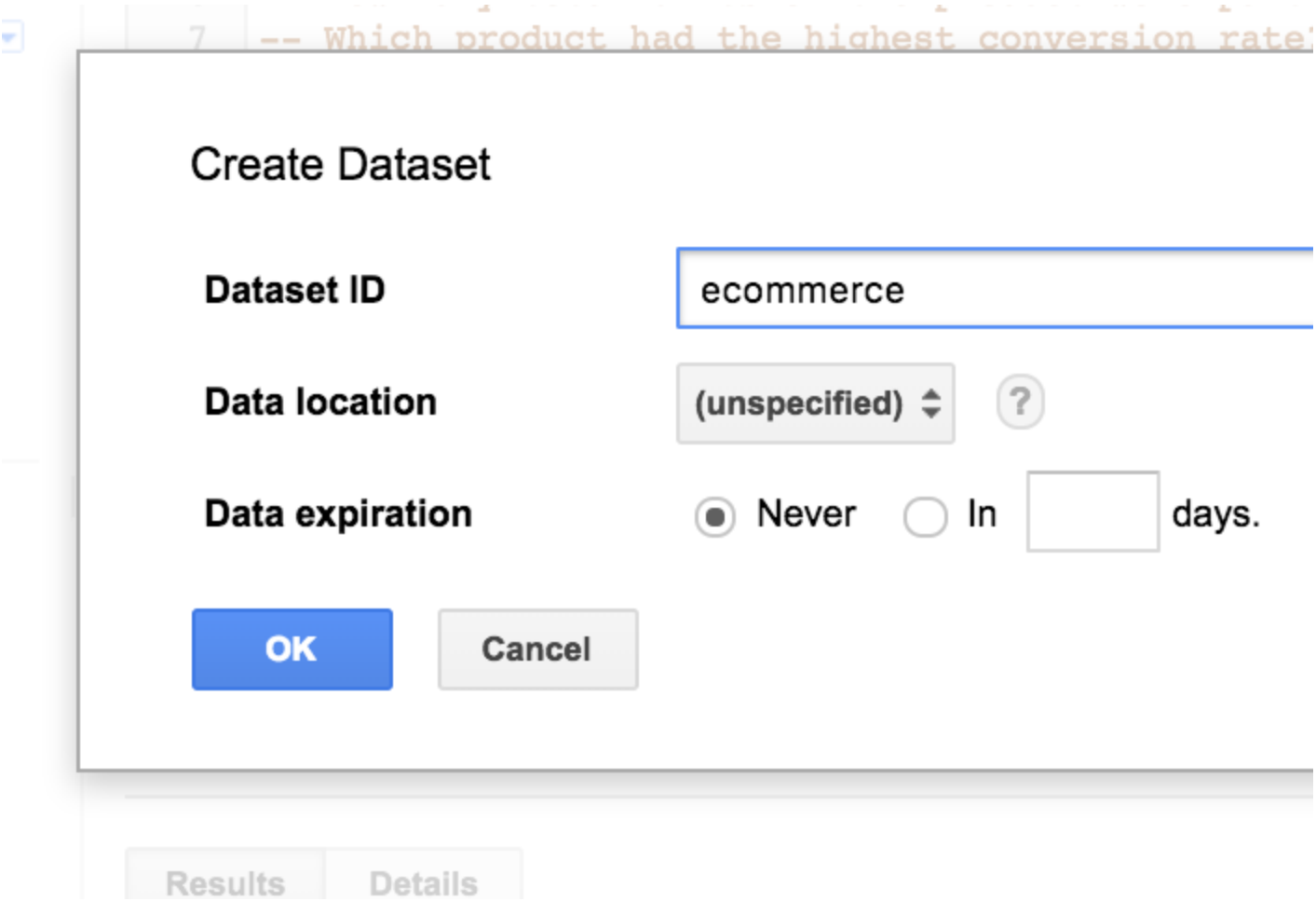
Next, create a new BigQuery dataset which will also store your ML models.

1. In the left pane, click the down arrow icon ( ) next to your project name, and then click **Create new dataset**.



2. In the **Create Dataset** dialog:

- For **Dataset ID**, type **ecommerce**.
- Leave the other values at their defaults.



3. Click **OK**.

Select a BQML model type and specify options

Now that you have your initial features selected, you are now ready to create your first ML model in BigQuery.

There are the two model types to choose from:

Model	Model Type	Label Data type	Example
Forecasting	linear_reg	Numeric value (typically an integer or floating point)	Forecast sales figures for next year given historical sales data.
Classification	logistic_reg	0 or 1 for binary classification	Classify an email as spam or not spam given the context.

Note: There are many additional model types used in Machine Learning (like Neural Networks and decision trees) and available using libraries like TensorFlow. At time of writing, BQML supports the two listed above.
Which model type should we choose?

Since we are bucketing visitors into "will buy in future" or "wont buy in future" we will use logistic_reg in a classification model.

Enter the following query to create a model and specify model options:

```
#standardSQL

CREATE OR REPLACE MODEL `ecommerce.classification_model`
OPTIONS
(
model_type='logistic_reg',
labels = ['will_buy_on_return_visit']
)
AS

#standardSQL
SELECT
  * EXCEPT(fullVisitorId)
FROM

  # features
  (SELECT
    fullVisitorId,
    IFNULL(totals.bounces, 0) AS bounces,
    IFNULL(totals.timeOnSite, 0) AS time_on_site
  FROM
    `data-to-insights.ecommerce.web_analytics`
  WHERE
    totals.newVisits = 1
    AND date BETWEEN '20160801' AND '20170430') # train on first 9 months
  JOIN
  (SELECT
    fullvisitorid,
    IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
```

```
 FROM
    `data-to-insights.ecommerce.web_analytics`
 GROUP BY fullvisitorid)
 USING (fullVisitorId)
;
```

Note that we cannot feed all of our available data to the model during training since we need to save some unseen data points for model evaluation and testing. To accomplish this, we simply add a WHERE clause condition to filter and train on only the first 9 months of session data in our 12 month dataset.

Next, click **Run Query** to train your model
Wait for the model to train (5 - 10 minutes).

After your model is trained, you will see the message "This was a CREATE operation. Results will not be shown" which indicates that your model has been successfully trained.

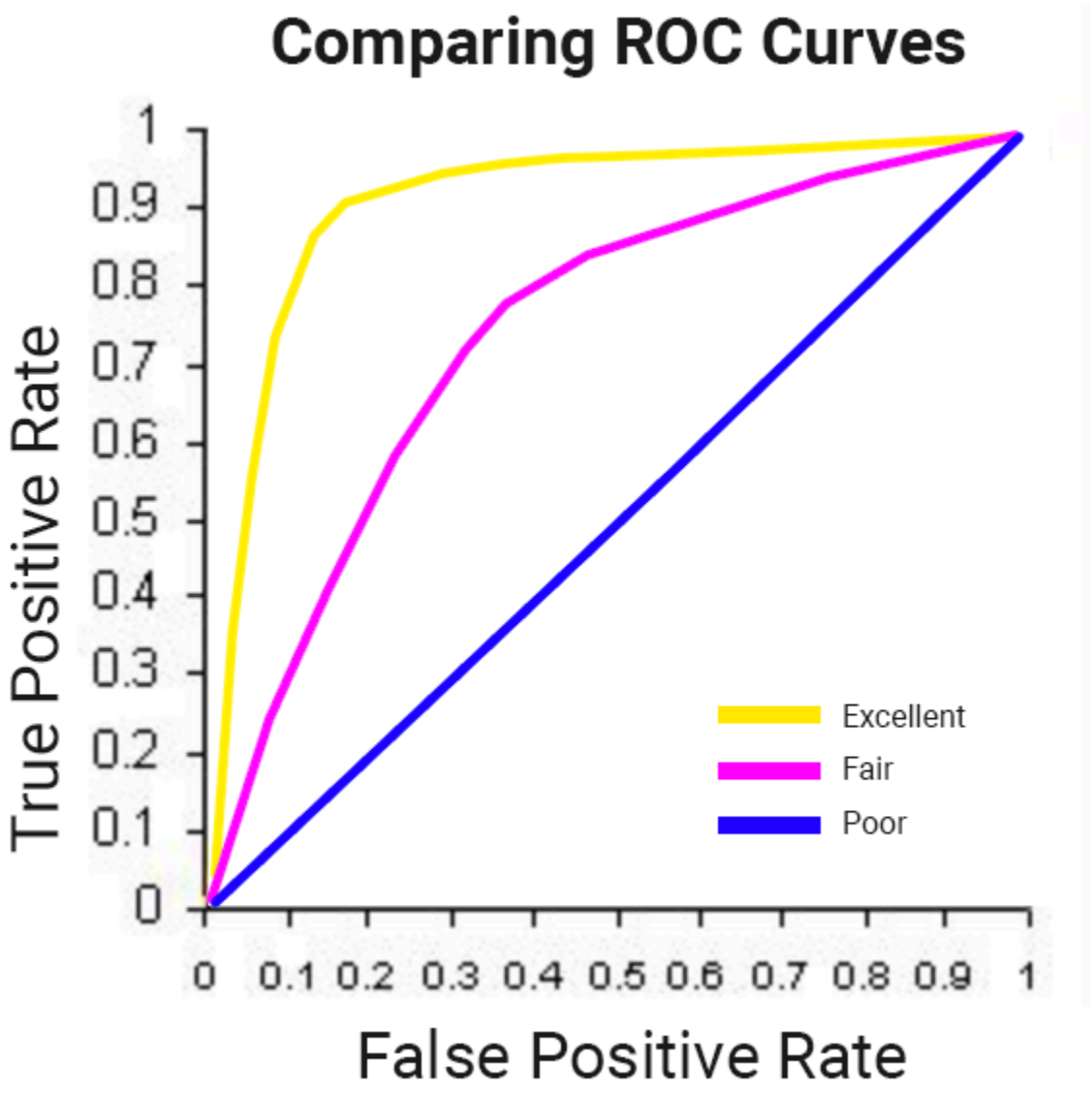
Look inside your project dataset and confirm **classification_model** now appears.
Next, we will evaluate the performance of the model against new unseen evaluation data.

Evaluate classification model performance

Select your performance criteria

For classification problems in ML, you want to minimize the False Positive Rate (i.e. predict that the user will return and purchase and they don't) and maximize the True Positive Rate (predict that the user will return and purchase and they do).

This relationship is visualized with a ROC curve (Receiver Operating Characteristic) like the one shown here, where you try to maximize the area under the curve or AUC:



In BQML, **roc_auc** is simply a queryable field when evaluating your trained ML model.

Now that training is complete, you can evaluate how well the model performs with this query using ML.EVALUATE:

```
#standardSQL
SELECT
  roc_auc,
```

```
  CASE
    WHEN roc_auc > .9 THEN 'good'
    WHEN roc_auc > .8 THEN 'fair'
    WHEN roc_auc > .7 THEN 'decent'
    WHEN roc_auc > .6 THEN 'not great'
  ELSE 'poor' END AS model_quality
FROM
  ML.EVALUATE(MODEL ecommerce.classification_model,  (

SELECT
  * EXCEPT(fullVisitorId)
FROM

  # features
  (SELECT
    fullVisitorId,
    IFNULL(totals.bounces, 0) AS bounces,
    IFNULL(totals.timeOnSite, 0) AS time_on_site
  FROM
    `data-to-insights.ecommerce.web_analytics`
  WHERE
    totals.newVisits = 1
    AND date BETWEEN '20170501' AND '20170630') # eval on 2 months
  JOIN
  (SELECT
    fullvisitorid,
    IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM
      `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid)
  USING (fullVisitorId)

));
```

Row	roc_auc	model_quality
1	0.724588	decent

After evaluating our model we get a **roc_auc** of 0.72, which shows the model has decent, but not great, predictive power. Since the goal is to get the area under the curve as close to 1.0 as possible there is room for improvement.

Improve model performance with Feature Engineering

As we hinted at earlier, there are many more features in the dataset that may help the model better understand the relationship between a visitor's first session and the likelihood that they will purchase on a subsequent visit.

Let's add these new features and create your second machine learning model which we will call **classification_model_2**:

- How far the visitor got in the checkout process on their first visit
- Where the visitor came from (traffic source: organic search, referring site etc..)
- Device category (mobile, tablet, desktop)
- Geographic information (country)

Create this second model by running the below query:

```
#standardSQL
CREATE OR REPLACE MODEL `ecommerce.classification_model_2`
OPTIONS
  (model_type='logistic_reg', labels = ['will_buy_on_return_visit']) AS

WITH all_visitor_stats AS (
SELECT
  fullvisitorid,
  IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid
)

# add in new features
SELECT * EXCEPT(unique_session_id) FROM (

  SELECT
      CONCAT(fullvisitorid, CAST(visitId AS STRING)) AS unique_session_id,

      # labels
      will_buy_on_return_visit,

      MAX(CAST(h.eCommerceAction.action_type AS INT64)) AS latest_ecommerce_progress,

      # behavior on the site
      IFNULL(totals.bounces, 0) AS bounces,
      IFNULL(totals.timeOnSite, 0) AS time_on_site,
      totals.pageviews,

      # where the visitor came from
      trafficSource.source,
      trafficSource.medium,
      channelGrouping,
```

```
    # mobile or desktop
    device.deviceCategory,

    # geographic
    IFNULL(geoNetwork.country, "") AS country

  FROM `data-to-insights.ecommerce.web_analytics`,
    UNNEST(hits) AS h

   JOIN all_visitor_stats USING(fullvisitorid)

  WHERE 1=1
    # only predict for new visits
    AND totals.newVisits = 1
    AND date BETWEEN '20160801' AND '20170430' # train 9 months

  GROUP BY
  unique_session_id,
  will_buy_on_return_visit,
  bounces,
  time_on_site,
  totals.pageviews,
  trafficSource.source,
  trafficSource.medium,
  channelGrouping,
  device.deviceCategory,
  country
);
```

Note that we are still training on the same first 9 months of data even with this new model. It's important to have the same training dataset so we can be certain a better model output is attributable to better input features and not new or different training data.

A key new feature that has been added is the maximum checkout progress each visitor reached in their session which is recorded in the field **hits.eCommerceAction.action_type**. If you search for that field in the field definitions you will see the field mapping of 6 = Completed Purchase. As an aside, the web analytics dataset has nested and repeated fields like ARRAYS which we need to break apart into separate rows in our dataset. This is accomplished by using the UNNEST() function as you see in the above query.

Wait for the new model to finish training (5-10 minutes).

Evaluate this new model to see if there is better predictive power:

```
#standardSQL
SELECT
  roc_auc,
  CASE
    WHEN roc_auc > .9 THEN 'good'
```

```
    WHEN roc_auc > .8 THEN 'fair'
    WHEN roc_auc > .7 THEN 'decent'
    WHEN roc_auc > .6 THEN 'not great'
  ELSE 'poor' END AS model_quality
FROM
  ML.EVALUATE(MODEL ecommerce.classification_model_2,  (

WITH all_visitor_stats AS (
SELECT
  fullvisitorid,
  IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid
)

# add in new features
SELECT * EXCEPT(unique_session_id) FROM (

  SELECT
      CONCAT(fullvisitorid, CAST(visitId AS STRING)) AS unique_session_id,

      # labels
      will_buy_on_return_visit,

      MAX(CAST(h.eCommerceAction.action_type AS INT64)) AS latest_ecommerce_progress,

      # behavior on the site
      IFNULL(totals.bounces, 0) AS bounces,
      IFNULL(totals.timeOnSite, 0) AS time_on_site,
      totals.pageviews,

      # where the visitor came from
      trafficSource.source,
      trafficSource.medium,
      channelGrouping,

      # mobile or desktop
      device.deviceCategory,

      # geographic
      IFNULL(geoNetwork.country, "") AS country

  FROM `data-to-insights.ecommerce.web_analytics`,
     UNNEST(hits) AS h

    JOIN all_visitor_stats USING(fullvisitorid)

  WHERE 1=1
    # only predict for new visits
    AND totals.newVisits = 1
    AND date BETWEEN '20170501' AND '20170630' # eval 2 months

  GROUP BY
  unique_session_id,
  will_buy_on_return_visit,
  bounces,
```

```
  time_on_site,
  totals.pageviews,
  trafficSource.source,
  trafficSource.medium,
  channelGrouping,
  device.deviceCategory,
  country
)
));
```

Row	roc_auc	model_quality
1	0.910382	good

With the new model you now get a **roc_auc** of 0.91 which is significantly better than the first model.
Now that you have a trained model, time to make some predictions.

Predict which new visitors will come back and purchase

Next you will write a query to predict which new visitors will come back and make a purchase.The prediction query below uses the improved classification model we trained above to predict the probability that a first-time visitor to the Google Merchandise Store will make a purchase in a later visit. The predictions are made on the last 1 month (out of 12 months) of the dataset.

```
#standardSQL
SELECT
*
FROM
  ml.PREDICT(MODEL `ecommerce.classification_model_2`,
   (

WITH all_visitor_stats AS (
SELECT
  fullvisitorid,
  IF(COUNTIF(totals.transactions > 0 AND totals.newVisits IS NULL) > 0, 1, 0) AS will_buy_on_return_visit
  FROM `data-to-insights.ecommerce.web_analytics`
  GROUP BY fullvisitorid
```

```
)


 SELECT
    CONCAT(fullvisitorid, '-',CAST(visitId AS STRING)) AS unique_session_id,

    # labels
    will_buy_on_return_visit,

    MAX(CAST(h.eCommerceAction.action_type AS INT64)) AS latest_ecommerce_progress,

    # behavior on the site
    IFNULL(totals.bounces, 0) AS bounces,
    IFNULL(totals.timeOnSite, 0) AS time_on_site,
    totals.pageviews,

    # where the visitor came from
    trafficSource.source,
    trafficSource.medium,
    channelGrouping,

    # mobile or desktop
    device.deviceCategory,

    # geographic
    IFNULL(geoNetwork.country, "") AS country

 FROM `data-to-insights.ecommerce.web_analytics`,
   UNNEST(hits) AS h

  JOIN all_visitor_stats USING(fullvisitorid)

 WHERE
   # only predict for new visits
   totals.newVisits = 1
   AND date BETWEEN '20170701' AND '20170801' # test 1 month

 GROUP BY
 unique_session_id,
 will_buy_on_return_visit,
 bounces,
 time_on_site,
 totals.pageviews,
 trafficSource.source,
 trafficSource.medium,
 channelGrouping,
 device.deviceCategory,
 country
)

)


ORDER BY
  predicted_will_buy_on_return_visit DESC;
```

Your model will now output the predictions it has for those July 2017 ecommerce sessions. You can see three newly added fields:

- predicted_will_buy_on_return_visit: whether the model thinks the visitor will buy later (1 = yes)
- predicted_will_buy_on_return_visit_probs.label: the binary classifier for yes / no
- predicted_will_buy_on_return_visit.prob: the confidence the model has in it's prediction (1 = 100%)

Row	predicted_will_buy_later	predicted_will_buy_later_probs.label	predicted_will_buy_later_probs.prob	
1	1	1	0.5228795988998747	9
		0	0.4771204011001253	
2	1	1	0.6695093583569673	8
		0	0.33049064164303266	
3	1	1	0.6427874591746943	6
		0	0.35721254082530574	
4	1	1	0.5219786155291798	8
		0	0.4780213844708202	
5	1	1	0.5276646197922243	9
		0	0.47233538020777566	
6	1	1	0.5565841572260497	4
		0	0.4434158427739503	
7	1	1	0.5280541312946764	7
		0	0.4719458687053236	

Results

- Of the top 6% of first-time visitors (sorted in decreasing order of predicted probability), more than 6% make a purchase in a later visit.

- These users represent nearly 50% of all first-time visitors who make a purchase in a later visit.
- Overall, only 0.7% of first-time visitors make a purchase in a later visit.
- Targeting the top 6% of first-time increases marketing ROI by 9x vs targeting them all!

Additional information

Tip: add `warm_start = true` to your model options if you are retraining new data on an existing model for faster training times. Note that you cannot change the feature columns (this would necessitate a new model).
roc_auc is just one of the performance metrics available during model evaluation. Also available are accuracy, precision, and recall. Knowing which performance metric to rely on is highly dependent on what your overall objective or goal is.

Other datasets to explore

You can use this below link to bring in the **bigquery-public-data** project if you want to explore modeling on other datasets like forecasting fares for taxi trips:

- https://bigquery.cloud.google.com/table/bigquery-public-data:chicago_taxi_trips.taxi_trips

Congratulations!

You've successfully built a ML model in BigQuery to classify ecommerce visitors.

Next Steps / Learn More

Here are links

- Already have a Google Analytics account and want to query your own datasets in BigQuery? Follow this export guide.
- The complete BigQuery SQL reference guide is here as an additional resource: https://cloud.google.com/bigquery/docs/reference/standard-sql/query-syntax

Google Cloud Training & Certification

...helps you make the most of Google Cloud technologies. Our classesinclude technical skills and best practices to help you get up to speed quickly and continue your learning journey. We offer fundamental to advanced level training, with on-demand, live, and virtual options to suit your busy schedule. Certifications help you validate and prove your skill and expertise in Google Cloud technologies.
Manual Last Updated July 22, 2018
Lab Last Tested July 20, 2018