Students Do: Credit Risk Classification with Amazon SageMaker

- **Dataset:** German Credit Risk Dataset - Prof. Dr. Hans Hofmann (original source: ics.uci.edu (https://archive.ics.uci.edu/ml/datasets/statlog+ (german+credit+data)), download: Kaggle (https://www.kaggle.com/uciml/german-credit))
- **Goal:** Classify the credit risk of a person as described by a given set of input features.

Note: You should import and run this notebook into your notebook intance on Amazon SageMaker.

In [1]:

```python
# Initial imports
import numpy as np
import pandas as pd
from pathlib import Path
import matplotlib.pyplot as plt

%matplotlib inline
```

Loading the data

In [2]:

```python
# Upload the german_credit_data.csv file (located in ../Resources/) through through JupyterLab
file_path = Path("Data/german_credit_data.csv")
df = pd.read_csv(file_path, index_col=0)
df.head()
```

Out[2]:

	Age	Sex	Job	Housing	Saving accounts	Checking account	Credit amount	Duration	Purpose	Risk
0	67	male	2	own	NaN	little	1169	6	radio/TV	good
1	22	female	2	own	little	moderate	5951	48	radio/TV	bad
2	49	male	1	own	little	NaN	2096	12	education	good
3	45	male	2	free	little	little	7882	42	furniture/equipment	good
4	53	male	2	free	little	little	4870	24	car	bad

In [6]:

```python
# Creating a DataFrame with the features (include all columns except "Risk")
features_df = df.drop("Risk", axis=1)
features_df.head()
```

Out[6]:

	Age	Sex	Job	Housing	Saving accounts	Checking account	Credit amount	Duration	Purpose
0	67	male	2	own	NaN	little	1169	6	radio/TV
1	22	female	2	own	little	moderate	5951	48	radio/TV
2	49	male	1	own	little	NaN	2096	12	education
3	45	male	2	free	little	little	7882	42	furniture/equipment
4	53	male	2	free	little	little	4870	24	car

In [7]:

```python
# Creating a DataFrame with the target data (The "Risk" column)
target_df = pd.DataFrame(df["Risk"])
target_df.head()
```

Out[7]:

	Risk
0	good
1	bad
2	good
3	good
4	bad

Data Preparation

A logistic regression model will be trained using all the input features.

- `X` is the predictor variable vector with the values of all features.
- `Y` is the target variable vector with the risk result.

In [8]:

```python
# Encode the categorical features (One-hot encode)
features_enc = pd.get_dummies(features_df)
features_enc.head()
```

Out[8]:

	Age	Job	Credit amount	Duration	Sex_female	Sex_male	Housing_free	Housing_own	Housing_rent	Saving accounts_little	...	Checking account_moderate
0	67	2	1169	6	0	1	0	1	0	0	...	(
1	22	2	5951	48	1	0	0	1	0	1	...	1
2	49	1	2096	12	0	1	0	1	0	1	...	(
3	45	2	7882	42	0	1	1	0	0	1	...	(
4	53	2	4870	24	0	1	1	0	0	1	...	(

5 rows × 24 columns

In [9]:

```python
# ignore DataConversionWarning messages
import warnings
from sklearn.exceptions import DataConversionWarning

warnings.filterwarnings(action="ignore", category=DataConversionWarning)
```

In [10]:

```python
# Scale the features
from sklearn import preprocessing

scaler = preprocessing.StandardScaler().fit(features_enc)
scaler
print(scaler.mean_[:5])
print(scaler.scale_[:5])
```

```
[3.554600e+01 1.904000e+00 3.271258e+03 2.090300e+01 3.100000e-01]
[1.13697794e+01 6.53287073e-01 2.82132515e+03 1.20527835e+01
 4.62493243e-01]
```

In [13]:

```python
features_enc_scaled = scaler.transform(features_enc)
features_enc_scaled
```

Out[13]:

```
array([[ 2.76645648,  0.14694918, -0.74513141, ...,  1.60356745,
        -0.14998296, -0.11020775],
       [-1.19140394,  0.14694918,  0.94981679, ...,  1.60356745,
        -0.14998296, -0.11020775],
       [ 1.18331231, -1.38377145, -0.41656241, ..., -0.62360956,
        -0.14998296, -0.11020775],
       ...,
       [ 0.21583532,  0.14694918, -0.87450324, ...,  1.60356745,
        -0.14998296, -0.11020775],
       [-1.10345149,  0.14694918, -0.50552769, ...,  1.60356745,
        -0.14998296, -0.11020775],
       [-0.75164167,  0.14694918,  0.46245715, ..., -0.62360956,
        -0.14998296, -0.11020775]])
```

In [14]:

```
target_enc = pd.get_dummies(target_df)
target_enc.head()
```

Out[14]:

	Risk_bad	Risk_good
0	0	1
1	1	0
2	0	1
3	0	1
4	1	0

In [15]:

```
X = features_enc_scaled
Y = target_enc["Risk_bad"].values.reshape(-1)  # 0 = Good, 1 = Bad Risk
print(X[:5])
print(Y[:5])
```

```
[[ 2.76645648  0.14694918 -0.74513141 -1.23647786 -0.67028006  0.67028006
  -0.3479601   0.63444822 -0.4669334  -1.23243324 -0.33886163 -0.25929878
  -0.22454436  1.62776996 -0.60662102 -0.25929878 -0.32774947 -0.71294854
  -0.11020775 -0.2503982  -0.47010767  1.60356745 -0.14998296 -0.11020775]
 [-1.19140394  0.14694918  0.94981679  2.24819436  1.49191369 -1.49191369
  -0.3479601   0.63444822 -0.4669334   0.81140298 -0.33886163 -0.25929878
  -0.22454436 -0.61433742  1.6484757  -0.25929878 -0.32774947 -0.71294854
  -0.11020775 -0.2503982  -0.47010767  1.60356745 -0.14998296 -0.11020775]
 [ 1.18331231 -1.38377145 -0.41656241 -0.73866754 -0.67028006  0.67028006
  -0.3479601   0.63444822 -0.4669334   0.81140298 -0.33886163 -0.25929878
  -0.22454436 -0.61433742 -0.60662102 -0.25929878 -0.32774947 -0.71294854
  -0.11020775  3.99363901 -0.47010767 -0.62360956 -0.14998296 -0.11020775]
 [ 0.8315025   0.14694918  1.63424694  1.75038404 -0.67028006  0.67028006
   2.8738927  -1.57617276 -0.4669334   0.81140298 -0.33886163 -0.25929878
  -0.22454436  1.62776996 -0.60662102 -0.25929878 -0.32774947 -0.71294854
  -0.11020775 -0.2503982   2.12717227 -0.62360956 -0.14998296 -0.11020775]
 [ 1.53512213  0.14694918  0.5666635   0.25695309 -0.67028006  0.67028006
   2.8738927  -1.57617276 -0.4669334   0.81140298 -0.33886163 -0.25929878
  -0.22454436  1.62776996 -0.60662102 -0.25929878 -0.32774947  1.40262577
  -0.11020775 -0.2503982  -0.47010767 -0.62360956 -0.14998296 -0.11020775]]
[0 1 0 0 1]
```

In [16]:

```
# Split the data in training and testing sets
from sklearn.model_selection import train_test_split

X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2)
```

Machine Learning Model Creation

In [19]:

```python
bucket = "fintech-bootcamp-activities-ss-20220516"   #'<your_s3_bucket_name_here>'
prefix = "german-credit-risk"

# Amazon SageMaker and related imports
import sagemaker
import sagemaker.amazon.common as smac
from sagemaker.predictor import csv_serializer, json_deserializer
from sagemaker import get_execution_role
import boto3   # AWS Python sdk

import os
import io
import json

# AWS IAM role
role = get_execution_role()
```

Uploading Training Data to Amazon S3

In order to train your machine learning model using Amazon SageMaker, the training data should passed through an Amazon S3 Bucket formatted as a [protobuf recordIO format (https://docs.aws.amazon.com/sagemaker/latest/dg/cdf-training.html#td-serialization)](https://docs.aws.amazon.com/sagemaker/latest/dg/cdf-training.html#td-serialization).

The profobuf recordIO format, is a method to serialize structured data (similar to `JSON`), to allow different applications to communicate with each other or for storing data.

Using the profobuf recordIO format, allows you to take advantage of *Pipe mode* when training the algorithms that support it. In *Pipe mode*, your training job streams data directly from Amazon S3. Streaming can provide faster start times for training jobs and better throughput.

The following code converts the training data as a Protocol Buffer, next the data is uploaded to the Amazon S3 bucket.

In [20]:

```python
# Encode the training data as Protocol Buffer
buf = io.BytesIO()
smac.write_numpy_to_dense_tensor(
    buf, np.array(X_train).astype("float32"), np.array(Y_train).astype("float32")
)
buf.seek(0)

# Upload encoded training data to Amazon S3
key = "train.data"
boto3.resource("s3").Bucket(bucket).Object(
    os.path.join(prefix, "train", key)
).upload_fileobj(buf)
s3_train_data = "s3://{}/{}/train/{}".format(bucket, prefix, key)
print("Training data uploaded to: {}".format(s3_train_data))
```

Training data uploaded to: s3://fintech-bootcamp-activities-ss-20220516/german-credit-risk/train/train.data

Upload Test Data to Amazon S3

If you provide test data, the algorithm logs include the test score for the final model.

In [21]:

```python
# Encode the testing data as Protocol Buffer
buf = io.BytesIO()
smac.write_numpy_to_dense_tensor(
    buf, np.array(X_test).astype("float32"), np.array(Y_test).astype("float32")
)
buf.seek(0)

# Upload encoded testing data to Amazon S3
key = "test.data"
boto3.resource("s3").Bucket(bucket).Object(
    os.path.join(prefix, "test", key)
).upload_fileobj(buf)
s3_test_data = "s3://{}/{}/test/{}".format(bucket, prefix, key)
print("Testing data uploaded to: {}".format(s3_test_data))
```

Testing data uploaded to: s3://fintech-bootcamp-activities-ss-20220516/german-credit-risk/test/test.
data

Training the Machine Learning Model

Once you have uploaded your data to Amazon S3, it's time to train the machine learning model. In this activity, you will use the Amazon SageMaker's _linear learner algorithm_ (https://docs.aws.amazon.com/sagemaker/latest/dg/linear-learner.html) to run a linear regression prediction model.

You can learn more about the diferent Amazon SageMaker built-in algorithms in this page (https://docs.aws.amazon.com/sagemaker/latest/dg/algos.html).

First, an intance of the linear learner algorithm is created.

In [22]:

```python
# Create an instance of the linear learner algorithm
from sagemaker.amazon.amazon_estimator import get_image_uri

container = get_image_uri(boto3.Session().region_name, "linear-learner")
```

The method get_image_uri has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
Defaulting to the only supported framework/algorithm version: 1. Ignoring framework/algorithm versio
n: 1.

Next, the estimator container is created in an AWS EC2 instance using a `ml.m4.xlarge` .

Note: This step might take a few minutes.

In [23]:

```python
# Start the Amazon SageMaker session
sess = sagemaker.Session()

# Create an instance of the linear learner estimator
linear = sagemaker.estimator.Estimator(
    container,
    role,
    train_instance_count=1,
    train_instance_type="ml.m4.xlarge",
    output_path="s3://{}/{}/output".format(bucket, prefix),
    sagemaker_session=sess,
)

# Get the dimension of the feature-input vector
feature_dim = len(X[:1][0])


# Define linear learner hyperparameters
# Note how in this case we use: predictor_type='binary_classifier' # (credit risk: good or bad)
linear.set_hyperparameters(
    feature_dim=feature_dim, mini_batch_size=200, predictor_type="binary_classifier"
)

# Fitting the linear learner model with the training data
linear.fit({"train": s3_train_data, "test": s3_test_data})
```

```
train_instance_count has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
train_instance_type has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
```

```
2022-05-17 01:45:30 Starting - Starting the training job...
2022-05-17 01:45:57 Starting - Preparing the instances for trainingProfilerReport-1652751930: InProg
ress
.........
2022-05-17 01:47:15 Downloading - Downloading input data...
2022-05-17 01:47:55 Training - Downloading the training image...
2022-05-17 01:48:24 Training - Training image download completed. Training in progress..Docker entry
point called with argument(s): train
Running default environment configuration script
[05/17/2022 01:48:31 INFO 140479342323520] Reading default configuration from /opt/amazon/lib/python
3.7/site-packages/algorithm/resources/default-input.json: {'mini_batch_size': '1000', 'epochs': '1
5', 'feature_dim': 'auto', 'use_bias': 'true', 'binary_classifier_model_selection_criteria': 'accura
cy', 'f_beta': '1.0', 'target_recall': '0.8', 'target_precision': '0.8', 'num_models': 'auto', 'num_
calibration_samples': '10000000', 'init_method': 'uniform', 'init_scale': '0.07', 'init_sigma': '0.0
1', 'init_bias': '0.0', 'optimizer': 'auto', 'loss': 'auto', 'margin': '1.0', 'quantile': '0.5', 'lo
ss_insensitivity': '0.01', 'huber_delta': '1.0', 'num_classes': '1', 'accuracy_top_k': '3', 'wd': 'a
uto', 'l1': 'auto', 'momentum': 'auto', 'learning_rate': 'auto', 'beta_1': 'auto', 'beta_2': 'auto',
'bias_lr_mult': 'auto', 'bias_wd_mult': 'auto', 'use_lr_scheduler': 'true', 'lr_scheduler_step': 'au
to', 'lr_scheduler_factor': 'auto', 'lr_scheduler_minimum_lr': 'auto', 'positive_example_weight_mul
t': '1.0', 'balance_multiclass_weights': 'false', 'normalize_data': 'true', 'normalize_label': 'aut
o', 'unbias_data': 'auto', 'unbias_label': 'auto', 'num_point_for_scaler': '10000', '_kvstore': 'aut
o', '_num_gpus': 'auto', '_num_kv_servers': 'auto', '_log_level': 'info', '_tuning_objective_metri
c': '', 'early_stopping_patience': '3', 'early_stopping_tolerance': '0.001', '_enable_profiler': 'fa
lse'}
[05/17/2022 01:48:31 INFO 140479342323520] Merging with provided configuration from /opt/ml/input/co
nfig/hyperparameters.json: {'feature_dim': '24', 'mini_batch_size': '200', 'predictor_type': 'binary
_classifier'}
[05/17/2022 01:48:31 INFO 140479342323520] Final configuration: {'mini_batch_size': '200', 'epochs':
'15', 'feature_dim': '24', 'use_bias': 'true', 'binary_classifier_model_selection_criteria': 'accura
cy', 'f_beta': '1.0', 'target_recall': '0.8', 'target_precision': '0.8', 'num_models': 'auto', 'num_
calibration_samples': '10000000', 'init_method': 'uniform', 'init_scale': '0.07', 'init_sigma': '0.0
1', 'init_bias': '0.0', 'optimizer': 'auto', 'loss': 'auto', 'margin': '1.0', 'quantile': '0.5', 'lo
ss_insensitivity': '0.01', 'huber_delta': '1.0', 'num_classes': '1', 'accuracy_top_k': '3', 'wd': 'a
uto', 'l1': 'auto', 'momentum': 'auto', 'learning_rate': 'auto', 'beta_1': 'auto', 'beta_2': 'auto',
'bias_lr_mult': 'auto', 'bias_wd_mult': 'auto', 'use_lr_scheduler': 'true', 'lr_scheduler_step': 'au
to', 'lr_scheduler_factor': 'auto', 'lr_scheduler_minimum_lr': 'auto', 'positive_example_weight_mul
t': '1.0', 'balance_multiclass_weights': 'false', 'normalize_data': 'true', 'normalize_label': 'aut
o', 'unbias_data': 'auto', 'unbias_label': 'auto', 'num_point_for_scaler': '10000', '_kvstore': 'aut
o', '_num_gpus': 'auto', '_num_kv_servers': 'auto', '_log_level': 'info', '_tuning_objective_metri
c': '', 'early_stopping_patience': '3', 'early_stopping_tolerance': '0.001', '_enable_profiler': 'fa
lse', 'predictor_type': 'binary_classifier'}
[05/17/2022 01:48:31 WARNING 140479342323520] Loggers have already been setup.
```

```
Process 1 is a worker.
[05/17/2022 01:48:31 INFO 140479342323520] Using default worker.
[05/17/2022 01:48:32 INFO 140479342323520] Checkpoint loading and saving are disabled.
[2022-05-17 01:48:32.163] [tensorio] [warning] TensorIO is already initialized; ignoring the initial
ization routine.
[2022-05-17 01:48:32.183] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 0, "duration": 21, "num_examples": 1, "num_bytes": 28000}
[05/17/2022 01:48:32 INFO 140479342323520] Create Store: local
[2022-05-17 01:48:32.220] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 1, "duration": 36, "num_examples": 4, "num_bytes": 112000}
[05/17/2022 01:48:32 INFO 140479342323520] Scaler algorithm parameters
 <algorithm.scaler.ScalerAlgorithmStable object at 0x7fc385579b50>
[05/17/2022 01:48:32 INFO 140479342323520] Scaling model computed with parameters:
 {'stdev_label': None, 'stdev_weight':
[1.0006372  0.9960791  0.9916559  0.9918492  1.0043733  1.0043733
 1.0229621  1.0056351  0.9994534  1.0002146  1.0138124  0.97746116
 0.96977025 1.0134498  0.99069977 0.9774612  0.93598664 1.0082291
 1.0203624  1.0176705  1.0058751  0.9930586  1.0380819  1.0203624 ]
<NDArray 24 @cpu(0)>, 'mean_label': None, 'mean_weight':
[-0.00151717 -0.01760327 -0.00940976 -0.00543443  0.01081099 -0.01081099
  0.01852565 -0.01215841 -0.00065213 -0.00102192  0.01069222 -0.01234754
 -0.01403403  0.02746578 -0.01747702 -0.01234754 -0.0447699   0.024858
  0.00459199  0.0095491   0.00714253 -0.01391985  0.01193046  0.00459199]
<NDArray 24 @cpu(0)>}
[05/17/2022 01:48:32 INFO 140479342323520] nvidia-smi: took 0.032 seconds to run.
[05/17/2022 01:48:32 INFO 140479342323520] nvidia-smi identified 0 GPUs.
[05/17/2022 01:48:32 INFO 140479342323520] Number of GPUs being used: 0
#metrics {"StartTime": 1652752112.3601613, "EndTime": 1652752112.3602023, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "Meta": "init_train_data_iter"}, "M
etrics": {"Total Records Seen": {"sum": 1000.0, "count": 1, "min": 1000, "max": 1000}, "Total Batche
s Seen": {"sum": 5.0, "count": 1, "min": 5, "max": 5}, "Max Records Seen Between Resets": {"sum": 80
0.0, "count": 1, "min": 800, "max": 800}, "Max Batches Seen Between Resets": {"sum": 4.0, "count":
 1, "min": 4, "max": 4}, "Reset Count": {"sum": 2.0, "count": 1, "min": 2, "max": 2}, "Number of Rec
ords Since Last Reset": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Number of Batches Since Last
 Reset": {"sum": 0.0, "count": 1, "min": 0, "max": 0}}}
[2022-05-17 01:48:32.538] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 4, "duration": 177, "num_examples": 4, "num_bytes": 112000}
#metrics {"StartTime": 1652752112.5386455, "EndTime": 1652752112.538751, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 0}, "Metrics": {"t
rain_binary_classification_cross_entropy_objective": {"sum": 0.6708366203308106, "count": 1, "min":
 0.6708366203308106, "max": 0.6708366203308106}}}
#metrics {"StartTime": 1652752112.5388515, "EndTime": 1652752112.5388737, "Dimensions": {"Algorith
```

m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 1}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6958411026000977, "count": 1, "min": 0.6958411026000977, "max": 0.6958411026000977}}}
#metrics {"StartTime": 1652752112.5389378, "EndTime": 1652752112.5389578, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 2}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6656685256958008, "count": 1, "min": 0.6656685256958008, "max": 0.6656685256958008}}}
#metrics {"StartTime": 1652752112.5390174, "EndTime": 1652752112.5390844, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 3}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.688514232635498, "count": 1, "min": 0.688514232635498, "max": 0.688514232635498}}}
#metrics {"StartTime": 1652752112.539156, "EndTime": 1652752112.5391767, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 4}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6193310546875, "count": 1, "min": 0.6193310546875, "max": 0.6193310546875}}}
#metrics {"StartTime": 1652752112.5392354, "EndTime": 1652752112.539253, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 5}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6180638694763183, "count": 1, "min": 0.6180638694763183, "max": 0.6180638694763183}}}
#metrics {"StartTime": 1652752112.5393097, "EndTime": 1652752112.5393271, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 6}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6198533535003662, "count": 1, "min": 0.6198533535003662, "max": 0.6198533535003662}}}
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#metrics {"StartTime": 1652752112.5399206, "EndTime": 1652752112.539938, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 0, "model": 8}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6687181091308594, "count": 1, "min": 0.6687181091308594, "max": 0.6687181091308594}}}
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[05/17/2022 01:48:32 INFO 140479342323520] #quality_metric: host=algo-1, epoch=0, train binary_class
ification_cross_entropy_objective <loss>=0.6708366203308106
[05/17/2022 01:48:32 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=0, cr

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iteria=binary_classification_cross_entropy_objective, value=0.6178207015991211
[05/17/2022 01:48:32 INFO 140479342323520] Epoch 0: Loss improved. Updating best model
[05/17/2022 01:48:32 INFO 140479342323520] Saving model for epoch: 0
[05/17/2022 01:48:32 INFO 140479342323520] Saved checkpoint to "/tmp/tmpofw_zcf_/mx-mod-0000.params"
[05/17/2022 01:48:32 INFO 140479342323520] #progress_metric: host=algo-1, completed 6.66666666666666
7 % of epochs
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[05/17/2022 01:48:32 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=4124.39
0426778078 records/second
[2022-05-17 01:48:32.720] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:32 INFO 140479342323520] #quality_metric: host=algo-1, epoch=1, train binary_classification_cross_entropy_objective <loss>=0.6274016952514648
[05/17/2022 01:48:32 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=1, criteria=binary_classification_cross_entropy_objective, value=0.5433438682556152
[05/17/2022 01:48:32 INFO 140479342323520] Epoch 1: Loss improved. Updating best model
[05/17/2022 01:48:32 INFO 140479342323520] Saving model for epoch: 1
[05/17/2022 01:48:32 INFO 140479342323520] Saved checkpoint to "/tmp/tmpnqx51q3e/mx-mod-0000.params"
[05/17/2022 01:48:32 INFO 140479342323520] #progress_metric: host=algo-1, completed 13.333333333333334 % of epochs
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[05/17/2022 01:48:32 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=4492.336858001998 records/second
[2022-05-17 01:48:32.923] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/train", "epoch": 8, "duration": 190, "num_examples": 4, "num_bytes": 112000}
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[05/17/2022 01:48:32 INFO 140479342323520] #quality_metric: host=algo-1, epoch=2, train binary_class
ification_cross_entropy_objective <loss>=0.5971791172027587
[05/17/2022 01:48:32 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=2, cr
iteria=binary_classification_cross_entropy_objective, value=0.5225193500518799
[05/17/2022 01:48:32 INFO 140479342323520] Epoch 2: Loss improved. Updating best model
[05/17/2022 01:48:32 INFO 140479342323520] Saving model for epoch: 2
[05/17/2022 01:48:32 INFO 140479342323520] Saved checkpoint to "/tmp/tmpi24zr98r/mx-mod-0000.params"
[05/17/2022 01:48:32 INFO 140479342323520] #progress_metric: host=algo-1, completed 20.0 % of epochs
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[05/17/2022 01:48:32 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3766.08
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[2022-05-17 01:48:33.194] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:33 INFO 140479342323520] #quality_metric: host=algo-1, epoch=3, train binary_class
ification_cross_entropy_objective <loss>=0.5781174659729004
[05/17/2022 01:48:33 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=3, cr
iteria=binary_classification_cross_entropy_objective, value=0.5244575500488281
[05/17/2022 01:48:33 INFO 140479342323520] Saving model for epoch: 3
[05/17/2022 01:48:33 INFO 140479342323520] Saved checkpoint to "/tmp/tmpux7m5dif/mx-mod-0000.params"
[05/17/2022 01:48:33 INFO 140479342323520] #progress_metric: host=algo-1, completed 26.6666666666666
68 % of epochs
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[05/17/2022 01:48:33 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3015.34
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[2022-05-17 01:48:33.453] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai

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[05/17/2022 01:48:33 INFO 140479342323520] #quality_metric: host=algo-1, epoch=4, train binary_class
ification_cross_entropy_objective <loss>=0.5671360397338867
[05/17/2022 01:48:33 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=4, cr
iteria=binary_classification_cross_entropy_objective, value=0.518602409362793
[05/17/2022 01:48:33 INFO 140479342323520] Epoch 4: Loss improved. Updating best model
[05/17/2022 01:48:33 INFO 140479342323520] Saving model for epoch: 4
[05/17/2022 01:48:33 INFO 140479342323520] Saved checkpoint to "/tmp/tmpet0_gv3m/mx-mod-0000.params"
[05/17/2022 01:48:33 INFO 140479342323520] #progress_metric: host=algo-1, completed 33.3333333333333
36 % of epochs
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s": {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Max Batches Seen Between Resets": {"sum":
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 "Number of Records Since Last Reset": {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Number o
f Batches Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:33 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3060.40
2077332667 records/second
[2022-05-17 01:48:33.704] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 14, "duration": 231, "num_examples": 4, "num_bytes": 112000}
#metrics {"StartTime": 1652752113.7043028, "EndTime": 1652752113.70444, "Dimensions": {"Algorithm":
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{"train_binary_classification_cross_entropy_objective": {"sum": 0.57133620262146, "count": 1, "min":
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#metrics {"StartTime": 1652752113.7049582, "EndTime": 1652752113.7049801, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7050402, "EndTime": 1652752113.7050588, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 5}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5170059871673583, "count": 1, "min": 0.5170059871673583, "max": 0.5170059871673583}}}
#metrics {"StartTime": 1652752113.70516, "EndTime": 1652752113.7051806, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 6}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5168664741516114, "count": 1, "min": 0.5168664741516114, "max": 0.5168664741516114}}}
#metrics {"StartTime": 1652752113.7052643, "EndTime": 1652752113.7052872, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 7}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5166750717163086, "count": 1, "min": 0.5166750717163086, "max": 0.5166750717163086}}}
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#metrics {"StartTime": 1652752113.705471, "EndTime": 1652752113.7054918, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 9}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5636484050750732, "count": 1, "min": 0.5636484050750732, "max": 0.5636484050750732}}}
#metrics {"StartTime": 1652752113.7055514, "EndTime": 1652752113.7055817, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 10}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5659074974060059, "count": 1, "min": 0.5659074974060059, "max": 0.5659074974060059}}}
#metrics {"StartTime": 1652752113.7056665, "EndTime": 1652752113.7056851, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 11}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5658791732788085, "count": 1, "min": 0.5658791732788085, "max": 0.5658791732788085}}}
#metrics {"StartTime": 1652752113.7058153, "EndTime": 1652752113.7058384, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 12}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5149854469299316, "count": 1, "min": 0.5149854469299316, "max": 0.5149854469299316}}}
#metrics {"StartTime": 1652752113.7058995, "EndTime": 1652752113.705951, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "model": 13}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5143668556213379, "count": 1, "min": 0.5143668556213379, "max": 0.5143668556213379}}}
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#metrics {"StartTime": 1652752113.706209, "EndTime": 1652752113.7062278, "Dimensions": {"Algorithm":
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#metrics {"StartTime": 1652752113.7063215, "EndTime": 1652752113.7063425, "Dimensions": {"Algorith
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5858054733276368, "count": 1,
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#metrics {"StartTime": 1652752113.7065172, "EndTime": 1652752113.7065372, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7067275, "EndTime": 1652752113.7067473, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7068036, "EndTime": 1652752113.7068536, "Dimensions": {"Algorith
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5907255268096924, "count": 1,
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n": 0.5838248920440674, "max": 0.5838248920440674}}}
#metrics {"StartTime": 1652752113.7070217, "EndTime": 1652752113.7070417, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7071016, "EndTime": 1652752113.7071197, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7074034, "EndTime": 1652752113.7074237, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7074792, "EndTime": 1652752113.7075324, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752113.7075977, "EndTime": 1652752113.7076168, "Dimensions": {"Algorith
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6084424495697022, "count": 1,
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#metrics {"StartTime": 1652752113.707722, "EndTime": 1652752113.7077427, "Dimensions": {"Algorithm":
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  {"train_binary_classification_cross_entropy_objective": {"sum": 0.6188495349884033, "count": 1, "mi
n": 0.6188495349884033, "max": 0.6188495349884033}}}
[05/17/2022 01:48:33 INFO 140479342323520] #quality_metric: host=algo-1, epoch=5, train binary_class
ification_cross_entropy_objective <loss>=0.5610561847686768
[05/17/2022 01:48:33 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=5, cr
iteria=binary_classification_cross_entropy_objective, value=0.5143668556213379
[05/17/2022 01:48:33 INFO 140479342323520] Epoch 5: Loss improved. Updating best model
[05/17/2022 01:48:33 INFO 140479342323520] Saving model for epoch: 5
[05/17/2022 01:48:33 INFO 140479342323520] Saved checkpoint to "/tmp/tmpz8jsfzg4/mx-mod-0000.params"
[05/17/2022 01:48:33 INFO 140479342323520] #progress_metric: host=algo-1, completed 40.0 % of epochs
#metrics {"StartTime": 1652752113.472907, "EndTime": 1652752113.7219837, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 5, "Meta": "training_data_ite
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Batches Seen": {"sum": 29.0, "count": 1, "min": 29, "max": 29}, "Max Records Seen Between Resets":
  {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Max Batches Seen Between Resets": {"sum": 4.0,
"count": 1, "min": 4, "max": 4}, "Reset Count": {"sum": 8.0, "count": 1, "min": 8, "max": 8}, "Numbe
r of Records Since Last Reset": {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Number of Batch
es Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}

[05/17/2022 01:48:33 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3208.49
109916705 records/second
[2022-05-17 01:48:34.064] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 16, "duration": 342, "num_examples": 4, "num_bytes": 112000}
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n": 0.5572343826293945, "max": 0.5572343826293945}}}
#metrics {"StartTime": 1652752114.0658417, "EndTime": 1652752114.0658722, "Dimensions": {"Algorith
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 {"train_binary_classification_cross_entropy_objective": {"sum": 0.5682960605621338, "count": 1, "mi
n": 0.5682960605621338, "max": 0.5682960605621338}}}
#metrics {"StartTime": 1652752114.066261, "EndTime": 1652752114.066287, "Dimensions": {"Algorithm":
 "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 2}, "Metrics":
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#metrics {"StartTime": 1652752114.0666249, "EndTime": 1652752114.066652, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 3}, "Metrics": {"t
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#metrics {"StartTime": 1652752114.067056, "EndTime": 1652752114.0670824, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 4}, "Metrics": {"t
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#metrics {"StartTime": 1652752114.0674937, "EndTime": 1652752114.067521, "Dimensions": {"Algorithm":
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#metrics {"StartTime": 1652752114.0680215, "EndTime": 1652752114.068049, "Dimensions": {"Algorithm":
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#metrics {"StartTime": 1652752114.0684144, "EndTime": 1652752114.0684419, "Dimensions": {"Algorith
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#metrics {"StartTime": 1652752114.0688553, "EndTime": 1652752114.068882, "Dimensions": {"Algorithm":
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#metrics {"StartTime": 1652752114.0693467, "EndTime": 1652752114.0693932, "Dimensions": {"Algorith
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n": 0.5591536808013916, "max": 0.5591536808013916}}}
#metrics {"StartTime": 1652752114.0698056, "EndTime": 1652752114.0698342, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 10}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5614498615264892, "count": 1,
 "min": 0.5614498615264892, "max": 0.5614498615264892}}}
#metrics {"StartTime": 1652752114.0702512, "EndTime": 1652752114.0702806, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 11}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5617300033569336, "count": 1,
 "min": 0.5617300033569336, "max": 0.5617300033569336}}}
#metrics {"StartTime": 1652752114.0707111, "EndTime": 1652752114.070741, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 12}, "Metrics":
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n": 0.5146118450164795, "max": 0.5146118450164795}}}
#metrics {"StartTime": 1652752114.071219, "EndTime": 1652752114.0712473, "Dimensions": {"Algorithm":
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#metrics {"StartTime": 1652752114.0717094, "EndTime": 1652752114.0717378, "Dimensions": {"Algorith
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5135185432434082, "count": 1,
 "min": 0.5135185432434082, "max": 0.5135185432434082}}}
#metrics {"StartTime": 1652752114.0721276, "EndTime": 1652752114.0721538, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 15}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5148161697387695, "count": 1,
 "min": 0.5148161697387695, "max": 0.5148161697387695}}}
#metrics {"StartTime": 1652752114.072389, "EndTime": 1652752114.0724647, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 16}, "Metrics":
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#metrics {"StartTime": 1652752114.0725281, "EndTime": 1652752114.0725486, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 17}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5836073112487793, "count": 1,
 "min": 0.5836073112487793, "max": 0.5836073112487793}}}
#metrics {"StartTime": 1652752114.072639, "EndTime": 1652752114.0726597, "Dimensions": {"Algorithm":
"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 6, "model": 18}, "Metrics":
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[05/17/2022 01:48:34 INFO 140479342323520] #quality_metric: host=algo-1, epoch=6, train binary_class
ification_cross_entropy_objective <loss>=0.5572343826293945
[05/17/2022 01:48:34 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=6, cr
iteria=binary_classification_cross_entropy_objective, value=0.5135185432434082
[05/17/2022 01:48:34 INFO 140479342323520] Epoch 6: Loss improved. Updating best model
[05/17/2022 01:48:34 INFO 140479342323520] Saving model for epoch: 6
[05/17/2022 01:48:34 INFO 140479342323520] Saved checkpoint to "/tmp/tmp0o3kjdvl/mx-mod-0000.params"
[05/17/2022 01:48:34 INFO 140479342323520] #progress_metric: host=algo-1, completed 46.6666666666666
64 % of epochs
#metrics {"StartTime": 1652752113.7225146, "EndTime": 1652752114.092372, "Dimensions": {"Algorithm":
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es Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:34 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=2160.46
30184667826 records/second
[2022-05-17 01:48:34.338] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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#metrics {"StartTime": 1652752114.350123, "EndTime": 1652752114.3501503, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 7, "model": 27}, "Metrics": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6172583293914795, "count": 1, "min": 0.6172583293914795, "max": 0.6172583293914795}}}
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[05/17/2022 01:48:34 INFO 140479342323520] #quality_metric: host=algo-1, epoch=7, train binary_classification_cross_entropy_objective <loss>=0.554042797088623
[05/17/2022 01:48:34 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=7, criteria=binary_classification_cross_entropy_objective, value=0.5117400074005127
[05/17/2022 01:48:34 INFO 140479342323520] Epoch 7: Loss improved. Updating best model
[05/17/2022 01:48:34 INFO 140479342323520] Saving model for epoch: 7
[05/17/2022 01:48:34 INFO 140479342323520] Saved checkpoint to "/tmp/tmpk_jz2p4p/mx-mod-0000.params"
[05/17/2022 01:48:34 INFO 140479342323520] #progress_metric: host=algo-1, completed 53.33333333333336 % of epochs
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[05/17/2022 01:48:34 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=2912.597337777604 records/second
[2022-05-17 01:48:34.613] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/train", "epoch": 20, "duration": 244, "num_examples": 4, "num_bytes": 112000}
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[05/17/2022 01:48:34 INFO 140479342323520] #quality_metric: host=algo-1, epoch=8, train binary_class
ification_cross_entropy_objective <loss>=0.5508936309814453
[05/17/2022 01:48:34 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=8, cr
iteria=binary_classification_cross_entropy_objective, value=0.5122397708892822
[05/17/2022 01:48:34 INFO 140479342323520] Saving model for epoch: 8
[05/17/2022 01:48:34 INFO 140479342323520] Saved checkpoint to "/tmp/tmpowvzz1au/mx-mod-0000.params"
[05/17/2022 01:48:34 INFO 140479342323520] #progress_metric: host=algo-1, completed 60.0 % of epochs
#metrics {"StartTime": 1652752114.3683438, "EndTime": 1652752114.6314392, "Dimensions": {"Algorith
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[05/17/2022 01:48:34 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3038.46
4505823483 records/second
[2022-05-17 01:48:34.856] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:34 INFO 140479342323520] #quality_metric: host=algo-1, epoch=9, train binary_class
ification_cross_entropy_objective <loss>=0.5477657890319825
[05/17/2022 01:48:34 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=9, cr
iteria=binary_classification_cross_entropy_objective, value=0.5120306396484375
[05/17/2022 01:48:34 INFO 140479342323520] Saving model for epoch: 9
[05/17/2022 01:48:34 INFO 140479342323520] Saved checkpoint to "/tmp/tmplo14xhwk/mx-mod-0000.params"
[05/17/2022 01:48:34 INFO 140479342323520] #progress_metric: host=algo-1, completed 66.6666666666666
7 % of epochs
#metrics {"StartTime": 1652752114.631819, "EndTime": 1652752114.871054, "Dimensions": {"Algorithm":
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tches Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:34 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3341.91
84560085337 records/second
[2022-05-17 01:48:35.089] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:35 INFO 140479342323520] #quality_metric: host=algo-1, epoch=10, train binary_clas
sification_cross_entropy_objective <loss>=0.5448601818084717
[05/17/2022 01:48:35 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=10, c
riteria=binary_classification_cross_entropy_objective, value=0.5107568740844727
[05/17/2022 01:48:35 INFO 140479342323520] Epoch 10: Loss improved. Updating best model
[05/17/2022 01:48:35 INFO 140479342323520] Saving model for epoch: 10
[05/17/2022 01:48:35 INFO 140479342323520] Saved checkpoint to "/tmp/tmpfqd4t67v/mx-mod-0000.params"
[05/17/2022 01:48:35 INFO 140479342323520] #progress_metric: host=algo-1, completed 73.3333333333333
3 % of epochs
#metrics {"StartTime": 1652752114.8714814, "EndTime": 1652752115.1382132, "Dimensions": {"Algorith
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[05/17/2022 01:48:35 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=2992.96
78559355066 records/second
[2022-05-17 01:48:35.338] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:35 INFO 140479342323520] #quality_metric: host=algo-1, epoch=11, train binary_clas
sification_cross_entropy_objective <loss>=0.5423219394683838
[05/17/2022 01:48:35 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=11, c
riteria=binary_classification_cross_entropy_objective, value=0.5116070079803466
[05/17/2022 01:48:35 INFO 140479342323520] Saving model for epoch: 11
[05/17/2022 01:48:35 INFO 140479342323520] Saved checkpoint to "/tmp/tmpt80x7run/mx-mod-0000.params"
[05/17/2022 01:48:35 INFO 140479342323520] #progress_metric: host=algo-1, completed 80.0 % of epochs
#metrics {"StartTime": 1652752115.139291, "EndTime": 1652752115.3501058, "Dimensions": {"Algorithm":

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r of Batches Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:35 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=3791.54
2643288387 records/second
[2022-05-17 01:48:35.530] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:35 INFO 140479342323520] #quality_metric: host=algo-1, epoch=12, train binary_clas
sification_cross_entropy_objective <loss>=0.5401366233825684
[05/17/2022 01:48:35 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=12, c
riteria=binary_classification_cross_entropy_objective, value=0.5107496929168701
[05/17/2022 01:48:35 INFO 140479342323520] Saving model for epoch: 12
[05/17/2022 01:48:35 INFO 140479342323520] Saved checkpoint to "/tmp/tmp9ifdpkty/mx-mod-0000.params"
[05/17/2022 01:48:35 INFO 140479342323520] #progress_metric: host=algo-1, completed 86.6666666666666
7 % of epochs
#metrics {"StartTime": 1652752115.350478, "EndTime": 1652752115.543795, "Dimensions": {"Algorithm":
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[05/17/2022 01:48:35 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=4135.23
2207910006 records/second
[2022-05-17 01:48:35.718] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
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[05/17/2022 01:48:35 INFO 140479342323520] #quality_metric: host=algo-1, epoch=13, train binary_clas
sification_cross_entropy_objective <loss>=0.5382320022583008
[05/17/2022 01:48:35 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=13, c
riteria=binary_classification_cross_entropy_objective, value=0.5105856800079346
[05/17/2022 01:48:35 INFO 140479342323520] Saving model for epoch: 13
[05/17/2022 01:48:35 INFO 140479342323520] Saved checkpoint to "/tmp/tmp9rwc5kin/mx-mod-0000.params"
[05/17/2022 01:48:35 INFO 140479342323520] #progress_metric: host=algo-1, completed 93.3333333333333

3 % of epochs

#metrics {"StartTime": 1652752115.5440962, "EndTime": 1652752115.7372637, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 13, "Meta": "training_data_iter"}, "Metrics": {"Total Records Seen": {"sum": 12200.0, "count": 1, "min": 12200, "max": 12200}, "Total Batches Seen": {"sum": 61.0, "count": 1, "min": 61, "max": 61}, "Max Records Seen Between Resets": {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Max Batches Seen Between Resets": {"sum": 4.0, "count": 1, "min": 4, "max": 4}, "Reset Count": {"sum": 16.0, "count": 1, "min": 16, "max": 16}, "Number of Records Since Last Reset": {"sum": 800.0, "count": 1, "min": 800, "max": 800}, "Number of Batches Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:35 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=4138.149313811577 records/second
[2022-05-17 01:48:35.899] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/train", "epoch": 32, "duration": 161, "num_examples": 4, "num_bytes": 112000}
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#metrics {"StartTime": 1652752115.9001312, "EndTime": 1652752115.9001496, "Dimensions": {"Algorith

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 "min": 0.5822758865356445, "max": 0.5822758865356445}}}
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 "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 21}, "Metrics":
  {"train_binary_classification_cross_entropy_objective": {"sum": 0.5818934535980225, "count": 1, "mi
n": 0.5818934535980225, "max": 0.5818934535980225}}}
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.5827976131439209, "count": 1,
 "min": 0.5827976131439209, "max": 0.5827976131439209}}}
 #metrics {"StartTime": 1652752115.901307, "EndTime": 1652752115.9013243, "Dimensions": {"Algorithm":
 "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 23}, "Metrics":
  {"train_binary_classification_cross_entropy_objective": {"sum": 0.581735372543335, "count": 1, "mi
n": 0.581735372543335, "max": 0.581735372543335}}}
 #metrics {"StartTime": 1652752115.9014363, "EndTime": 1652752115.901455, "Dimensions": {"Algorithm":
 "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 24}, "Metrics":
  {"train_binary_classification_cross_entropy_objective": {"sum": 0.6169385242462159, "count": 1, "mi
n": 0.6169385242462159, "max": 0.6169385242462159}}}
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m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 25}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6165551567077636, "count": 1,
 "min": 0.6165551567077636, "max": 0.6165551567077636}}}
 #metrics {"StartTime": 1652752115.9015863, "EndTime": 1652752115.9016032, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 26}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6169178295135498, "count": 1,
 "min": 0.6169178295135498, "max": 0.6169178295135498}}}
 #metrics {"StartTime": 1652752115.9016573, "EndTime": 1652752115.9016743, "Dimensions": {"Algorith
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s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6168086814880371, "count": 1,
 "min": 0.6168086814880371, "max": 0.6168086814880371}}}
 #metrics {"StartTime": 1652752115.90173, "EndTime": 1652752115.9017484, "Dimensions": {"Algorithm":

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n": 0.6174078750610351, "max": 0.6174078750610351}}}
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"Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 29}, "Metrics":
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n": 0.6172642803192139, "max": 0.6172642803192139}}}
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n": 0.6164234352111816, "max": 0.6164234352111816}}}
#metrics {"StartTime": 1652752115.9019465, "EndTime": 1652752115.9019635, "Dimensions": {"Algorith
m": "Linear Learner", "Host": "algo-1", "Operation": "training", "epoch": 14, "model": 31}, "Metric
s": {"train_binary_classification_cross_entropy_objective": {"sum": 0.6178598403930664, "count": 1,
 "min": 0.6178598403930664, "max": 0.6178598403930664}}}
[05/17/2022 01:48:35 INFO 140479342323520] #quality_metric: host=algo-1, epoch=14, train binary_clas
sification_cross_entropy_objective <loss>=0.5365001106262207
[05/17/2022 01:48:35 INFO 140479342323520] #early_stopping_criteria_metric: host=algo-1, epoch=14, c
riteria=binary_classification_cross_entropy_objective, value=0.5102970123291015
[05/17/2022 01:48:35 INFO 140479342323520] Saving model for epoch: 14
[05/17/2022 01:48:35 INFO 140479342323520] Saved checkpoint to "/tmp/tmp7q46e6zp/mx-mod-0000.params"
[05/17/2022 01:48:35 INFO 140479342323520] Early stop condition met. Stopping training.
[05/17/2022 01:48:35 INFO 140479342323520] #progress_metric: host=algo-1, completed 100 % epochs
#metrics {"StartTime": 1652752115.7376165, "EndTime": 1652752115.9116127, "Dimensions": {"Algorith
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_iter"}, "Metrics": {"Total Records Seen": {"sum": 13000.0, "count": 1, "min": 13000, "max": 13000},
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r of Batches Since Last Reset": {"sum": 4.0, "count": 1, "min": 4, "max": 4}}}
[05/17/2022 01:48:35 INFO 140479342323520] #throughput_metric: host=algo-1, train throughput=4593.34
5115201759 records/second
[05/17/2022 01:48:35 WARNING 140479342323520] wait_for_all_workers will not sync workers since the k
v store is not running distributed
[05/17/2022 01:48:35 WARNING 140479342323520] wait_for_all_workers will not sync workers since the k
v store is not running distributed
[2022-05-17 01:48:35.913] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 34, "duration": 1, "num_examples": 1, "num_bytes": 28000}
[2022-05-17 01:48:36.057] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai
n", "epoch": 37, "duration": 141, "num_examples": 4, "num_bytes": 112000}
[2022-05-17 01:48:36.097] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/trai

```
n", "epoch": 39, "duration": 17, "num_examples": 4, "num_bytes": 112000}
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('binary_classification_cross_ent
ropy_objective', 0.5094737243652344)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('binary_classification_accurac
y', 0.74875)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('binary_f_1.000', 0.567741935483
871)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('precision', 0.6027397260273972)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('recall', 0.5365853658536586)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('roc_auc_score', 0.7755716004813
479)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('binary_balanced_accuracy', 0.5)
[05/17/2022 01:48:36 INFO 140479342323520] #train_score (algo-1) : ('binary_log_loss', 0.72379722423
06673)
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train binary_classification
_cross_entropy_objective <loss>=0.5094737243652344
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train binary_classification
_accuracy <score>=0.74875
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train binary_f_1.000 <score
>=0.567741935483871
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train precision <score>=0.6
027397260273972
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train recall <score>=0.5365
853658536586
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train roc_auc_score <score>
=0.7755716004813479
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train binary_balanced_accur
acy <score>=0.5
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, train binary_log_loss <scor
e>=0.7237972242306673
[05/17/2022 01:48:36 INFO 140479342323520] Best model found for hyperparameters: {"optimizer": "ada
m", "learning_rate": 0.1, "wd": 0.0001, "l1": 0.0, "lr_scheduler_step": 10, "lr_scheduler_factor":
 0.99, "lr_scheduler_minimum_lr": 1e-05}
[05/17/2022 01:48:36 INFO 140479342323520] Saved checkpoint to "/tmp/tmp_7gb5t1s/mx-mod-0000.params"
[2022-05-17 01:48:36.112] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/test",
"epoch": 0, "duration": 3949, "num_examples": 1, "num_bytes": 28000}
[2022-05-17 01:48:36.116] [tensorio] [info] epoch_stats={"data_pipeline": "/opt/ml/input/data/test",
"epoch": 1, "duration": 4, "num_examples": 1, "num_bytes": 28000}
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```

unt": 1, "min": 200, "max": 200}, "Max Batches Seen Between Resets": {"sum": 1.0, "count": 1, "min": 1, "max": 1}, "Reset Count": {"sum": 1.0, "count": 1, "min": 1, "max": 1}, "Number of Records Since Last Reset": {"sum": 200.0, "count": 1, "min": 200, "max": 200}, "Number of Batches Since Last Reset": {"sum": 1.0, "count": 1, "min": 1, "max": 1}}}
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('binary_classification_cross_entropy_objective', 0.5093637466430664)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('binary_classification_accuracy', 0.765)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('binary_f_1.000', 0.5436893203883495)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('precision', 0.5714285714285714)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('recall', 0.5185185185185185)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('roc_auc_score', 0.745433789954338)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('binary_balanced_accuracy', 0.5)
[05/17/2022 01:48:36 INFO 140479342323520] #test_score (algo-1) : ('binary_log_loss', 0.7396719781625611)
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test binary_classification_cross_entropy_objective <loss>=0.5093637466430664
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test binary_classification_accuracy <score>=0.765
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test binary_f_1.000 <score>=0.5436893203883495
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test precision <score>=0.5714285714285714
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test recall <score>=0.5185185185185185
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test roc_auc_score <score>=0.745433789954338
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test binary_balanced_accuracy <score>=0.5
[05/17/2022 01:48:36 INFO 140479342323520] #quality_metric: host=algo-1, test binary_log_loss <score>=0.7396719781625611
#metrics {"StartTime": 1652752112.1615698, "EndTime": 1652752116.126296, "Dimensions": {"Algorithm": "Linear Learner", "Host": "algo-1", "Operation": "training"}, "Metrics": {"initialize.time": {"sum": 195.8446502685547, "count": 1, "min": 195.8446502685547, "max": 195.8446502685547}, "epochs": {"sum": 15.0, "count": 1, "min": 15, "max": 15}, "check_early_stopping.time": {"sum": 15.007495880126953, "count": 15, "min": 0.23794174194335938, "max": 2.295255661010742}, "update.time": {"sum": 3456.831455230713, "count": 15, "min": 170.06945610046387, "max": 364.80164527893066}, "finalize.time": {"sum": 196.7167854309082, "count": 1, "min": 196.7167854309082, "max": 196.7167854309082}, "setuptime": {"sum": 35.841941833496094, "count": 1, "min": 35.841941833496094, "max": 35.841941833496094}, "totaltime": {"sum": 4253.671884536743, "count": 1, "min": 4253.671884536743, "max": 4253.6718845367

```
43}}}
```

```
2022-05-17 01:48:55 Uploading - Uploading generated training model
2022-05-17 01:48:55 Completed - Training job completed
Training seconds: 102
Billable seconds: 102
```

Deploying the Model to Make Predictions

In this section, the `linear-learner` model that was trained will be used to make predictions of credit risk. Deploy the model using a `ml.t2.medium` instance type.

Note: This step might take a few minutes.

In [24]:

```python
# An instance of the linear-learner predictor is created
linear_predictor = linear.deploy(initial_instance_count=1, instance_type="ml.t2.medium")
```

```
-------!
```

In [25]:

```python
# Linear predictor configurations
linear_predictor.serializer = csv_serializer
linear_predictor.deserializer = json_deserializer
```

In [26]:

```python
# Making some predictions using the test data.
result = linear_predictor.predict(X_test)
y_predictions = np.array(
    [np.uint8(r["predicted_label"]) for r in result["predictions"]]
)
y_predictions
```

The csv_serializer has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
The json_deserializer has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.

Out[26]:

```
array([0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0,
       0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, 0, 1,
       0, 0, 1, 1, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0,
       0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1], dtype=uint8)
```

Model Evaluation

To evaluate the model, we create a confusion matrix to compare the cases where each predicted value matches the expected test-value and when not.

In [27]:

```python
import pandas as pd

# Encode the predictios results as 0 = Good, 1 = Bad Risk
cat_test = np.array(["Good" if x == 0 else "Bad" for x in Y_test])
cat_pred = np.array(["Good" if x == 0 else "Bad" for x in y_predictions])

# Create the confusion matrix
pd.crosstab(cat_test, cat_pred, rownames=["actuals"], colnames=["predictions"])
```

Out[27]:

predictions	Bad	Good
actuals		
Bad	28	26
Good	21	125

The model is also evaluated using the `sklearn` metrics module. The following metrics are calculated:

- `accuracy_score` (https://scikit-learn.org/stable/modules/generated/sklearn.metrics.accuracy_score.html)
- `confusion_matrix` (https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html)
- `classification_report` (https://scikit-learn.org/stable/modules/generated/sklearn.metrics.classification_report.html)

In [28]:

```python
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report

print(f"accuracy_score: {accuracy_score(Y_test,y_predictions)}\n\n")
print(
    f"sklearn's confusion_matrix: \n\n{confusion_matrix(Y_test, y_predictions, labels=[0, 1])}\n\n"
)
print(
    f"classification_report: \n\n{classification_report(Y_test, y_predictions, target_names=['Good', 'Bad'])}\n
\n"
)
```

```
accuracy_score: 0.765


sklearn's confusion_matrix:

[[125  21]
 [ 26  28]]


classification_report:

              precision    recall  f1-score   support

        Good       0.83      0.86      0.84       146
         Bad       0.57      0.52      0.54        54

    accuracy                           0.77       200
   macro avg       0.70      0.69      0.69       200
weighted avg       0.76      0.77      0.76       200
```

Finally the end point is deleted to avoid additional AWS resources usage.

In [29]:

```
# Delete Amazon SageMaker end-point
sagemaker.Session().delete_endpoint(linear_predictor.endpoint)
```

The endpoint attribute has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.

In [ ]: