

boston-housing-regression

October 8, 2019

1 Students Do: Housing Price Prediction on SageMaker

- **Dataset:** [Boston house prices dataset - Harrison, D. and Rubinfeld, D.L.](#)
- **Goal:** Predict the price of a house using linear regression given certain input features.

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

```
[1]: # Initial imports
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

%matplotlib inline
```

1.1 Loading the Boston House Price Data from sklearn

```
[2]: # Loading the Boston house price data from sklearn
from sklearn.datasets import load_boston

boston_dataset = load_boston()
```

```
[3]: dir(boston_dataset)
```

```
[3]: ['DESCR', 'data', 'feature_names', 'filename', 'target']
```

```
[4]: print(boston_dataset.DESCR)
```

```
.. _boston_dataset:

Boston house prices dataset
-----

**Data Set Characteristics:**

: Number of Instances: 506

: Number of Attributes: 13 numeric/categorical predictive. Median Value
```

(attribute 14) is usually the target.

:Attribute Information (in order):

- CRIM	per capita crime rate by town
- ZN	proportion of residential land zoned for lots over 25,000 sq.ft.
- INDUS	proportion of non-retail business acres per town
- CHAS	Charles River dummy variable (= 1 if tract bounds river; 0 otherwise)
- NOX	nitric oxides concentration (parts per 10 million)
- RM	average number of rooms per dwelling
- AGE	proportion of owner-occupied units built prior to 1940
- DIS	weighted distances to five Boston employment centres
- RAD	index of accessibility to radial highways
- TAX	full-value property-tax rate per \$10,000
- PTRATIO	pupil-teacher ratio by town
- B	$1000(B_k - 0.63)^2$ where B_k is the proportion of blacks by town
- LSTAT	% lower status of the population
- MEDV	Median value of owner-occupied homes in \$1000's

:Missing Attribute Values: None

:Creator: Harrison, D. and Rubinfeld, D.L.

This is a copy of UCI ML housing dataset.

<https://archive.ics.uci.edu/ml/machine-learning-databases/housing/>

This dataset was taken from the StatLib library which is maintained at Carnegie Mellon University.

The Boston house-price data of Harrison, D. and Rubinfeld, D.L. 'Hedonic prices and the demand for clean air', J. Environ. Economics & Management, vol.5, 81-102, 1978. Used in Belsley, Kuh & Welsch, 'Regression diagnostics ...', Wiley, 1980. N.B. Various transformations are used in the table on pages 244-261 of the latter.

The Boston house-price data has been used in many machine learning papers that address regression problems.

.. topic:: References

- Belsley, Kuh & Welsch, 'Regression diagnostics: Identifying Influential Data and Sources of Collinearity', Wiley, 1980. 244-261.
- Quinlan, R. (1993). Combining Instance-Based and Model-Based Learning. In Proceedings on the Tenth International Conference of Machine Learning, 236-243,

University of Massachusetts, Amherst. Morgan Kaufmann.

```
[5]: # Creating a DataFrame with the Boston House Data features
features_df = pd.DataFrame(boston_dataset.data, columns=boston_dataset.
    ↪feature_names)
features_df.head()
```

```
[5]:
```

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	\
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	

	PTRATIO	B	LSTAT
0	15.3	396.90	4.98
1	17.8	396.90	9.14
2	17.8	392.83	4.03
3	18.7	394.63	2.94
4	18.7	396.90	5.33

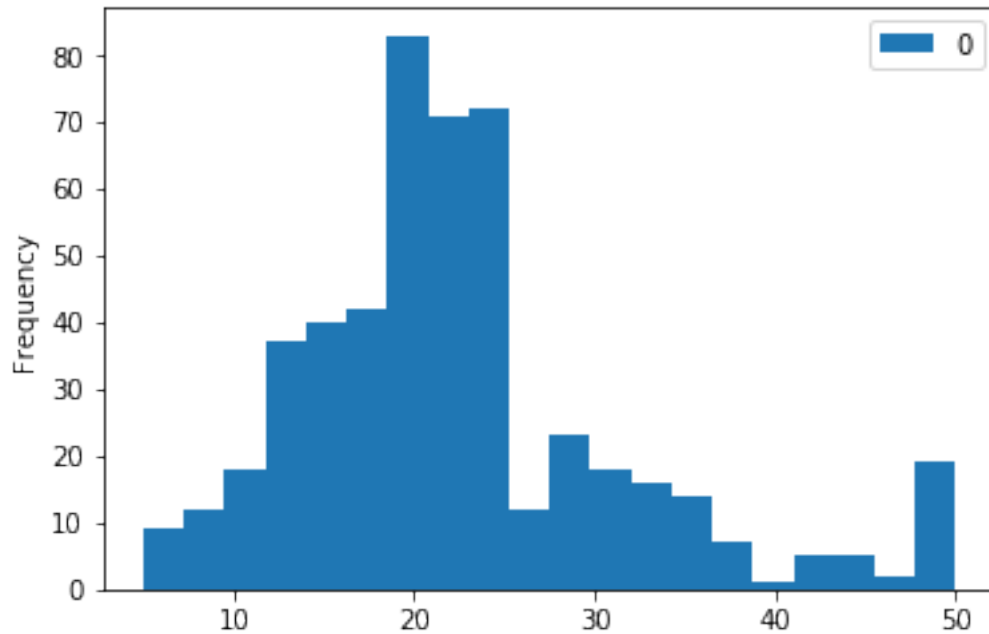
```
[6]: # Creating a DataFrame with the target data
target_df = pd.DataFrame(boston_dataset.target)
target_df.head()
```

```
[6]:
```

	0
0	24.0
1	21.6
2	34.7
3	33.4
4	36.2

```
[7]: # Plot target distribution
target_df.plot.hist(bins=20)
```

```
[7]: <matplotlib.axes._subplots.AxesSubplot at 0x7f1949cb0438>
```



1.2 Data Preparation

A linear regression model will be trained using the average number of rooms per dwelling (RM) to predict the house price.

- X is the predictor variable vector with the values of RM.
- Y is the target variable vector with the house prices value.

```
[8]: # Define the X and Y vectors
X = features_df["RM"].values.reshape(-1, 1)
Y = boston_dataset.target

# 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)
```

1.3 Machine Learning Model Creation

```
[9]: bucket = "sagemaker-20191007-2307" #'<your_s3_bucket_name_here>'
prefix = "boston-housing-regression"

# 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 time
import json
import re

# AWS IAM role
role = get_execution_role()

```

1.3.1 Uploading Training Data to Amazon S3

In order to train your machine learning model using Amazon SageMaker, the training data should be passed through an Amazon S3 Bucket formatted as a [protobuf recordIO format](#).

The protobuf 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 protobuf 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.

```

[10]: # Encode the training data as Protocol Buffer
buf = io.BytesIO()
vectors = np.array(X_train).astype("float32")
labels = np.array(Y_train).astype("float32")
smac.write_numpy_to_dense_tensor(buf, vectors, labels)
buf.seek(0)

# Upload encoded training data to Amazon S3
key = "linear_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://sagemaker-20191007-2307/boston-housing-regression/train/linear_train.data

Upload Test Data to Amazon S3 If you provide test data, the algorithm logs include the test score for the final model.

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

# Upload encoded testing data to Amazon S3
key = "linear_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://sagemaker-20191007-2307/boston-housing-regression/test/linear_test.data

1.3.2 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* to run a linear regression prediction model.

You can learn more about the different Amazon SageMaker built-in algorithms [in this page](#).

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

```
[12]: # 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")
```

Next, the estimator container is created in an AWS EC2 instance (@ train_instance_type) using a ml.m4.xlarge.

Note: This step might take a few minutes.

```
[13]: # 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,
)
```

```
# Define lineal learner hyperparameters
linear.set_hyperparameters(
    feature_dim=1,
    mini_batch_size=100,
    predictor_type="regressor",
    epochs=10,
    num_models=32,
    loss="absolute_loss",
)

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

```
2019-10-09 03:31:18 Starting - Starting the training job...
2019-10-09 03:31:20 Starting - Launching requested ML instances...
2019-10-09 03:32:19 Starting - Preparing the instances for training..
2019-10-09 03:33:26 Downloading - Downloading input data...
2019-10-09 03:34:05 Training - Downloading the training image..Docker
entrypoint called with argument(s): train
```

```
[10/09/2019 03:34:26 INFO 140533026703168] Reading default configuration
from /opt/amazon/lib/python2.7/site-packages/algorithm/resources/default-
input.json: {u'loss_insensitivity': u'0.01', u'epochs': u'15', u'init_bias':
u'0.0', u'lr_scheduler_factor': u'auto', u'num_calibration_samples':
u'10000000', u'accuracy_top_k': u'3', u'_num_kv_servers': u'auto', u'use_bias':
u'true', u'num_point_for_scaler': u'10000', u'_log_level': u'info', u'quantile':
u'0.5', u'bias_lr_mult': u'auto', u'lr_scheduler_step': u'auto', u'init_method':
u'uniform', u'init_sigma': u'0.01', u'lr_scheduler_minimum_lr': u'auto',
u'target_recall': u'0.8', u'num_models': u'auto', u'early_stopping_patience':
u'3', u'momentum': u'auto', u'unbias_label': u'auto', u'wd': u'auto',
u'optimizer': u'auto', u'_tuning_objective_metric': u'',
u'early_stopping_tolerance': u'0.001', u'learning_rate': u'auto', u'_kvstore':
u'auto', u'normalize_data': u'true',
u'binary_classifier_model_selection_criteria': u'accuracy', u'use_lr_scheduler':
u'true', u'target_precision': u'0.8', u'unbias_data': u'auto', u'init_scale':
u'0.07', u'bias_wd_mult': u'auto', u'f_beta': u'1.0', u'mini_batch_size':
u'1000', u'huber_delta': u'1.0', u'num_classes': u'1', u'beta_1': u'auto',
u'loss': u'auto', u'beta_2': u'auto', u'_enable_profiler': u'false',
u'normalize_label': u'auto', u'_num_gpus': u'auto',
u'balance_multiclass_weights': u'false', u'positive_example_weight_mult':
u'1.0', u'l1': u'auto', u'margin': u'1.0'}
[10/09/2019 03:34:26 INFO 140533026703168] Reading provided configuration
from /opt/ml/input/config/hyperparameters.json: {u'loss': u'absolute_loss',
u'mini_batch_size': u'100', u'predictor_type': u'regressor', u'epochs': u'10',
u'feature_dim': u'1', u'num_models': u'32'}
```



```

[10/09/2019 03:34:26 INFO 140533026703168] Final configuration:
{u'loss_insensitivity': u'0.01', u'epochs': u'10', u'feature_dim': u'1',
u'init_bias': u'0.0', u'lr_scheduler_factor': u'auto',
u'num_calibration_samples': u'10000000', u'accuracy_top_k': u'3',
u'_num_kv_servers': u'auto', u'use_bias': u'true', u'num_point_for_scaler':
u'10000', u'_log_level': u'info', u'quantile': u'0.5', u'bias_lr_mult': u'auto',
u'lr_scheduler_step': u'auto', u'init_method': u'uniform', u'init_sigma':
u'0.01', u'lr_scheduler_minimum_lr': u'auto', u'target_recall': u'0.8',
u'num_models': u'32', u'early_stopping_patience': u'3', u'momentum': u'auto',
u'unbias_label': u'auto', u'wd': u'auto', u'optimizer': u'auto',
u'_tuning_objective_metric': u'', u'early_stopping_tolerance': u'0.001',
u'learning_rate': u'auto', u'_kvstore': u'auto', u'normalize_data': u'true',
u'binary_classifier_model_selection_criteria': u'accuracy', u'use_lr_scheduler':
u'true', u'target_precision': u'0.8', u'unbias_data': u'auto', u'init_scale':
u'0.07', u'bias_wd_mult': u'auto', u'f_beta': u'1.0', u'mini_batch_size':
u'100', u'huber_delta': u'1.0', u'num_classes': u'1', u'predictor_type':
u'regressor', u'beta_1': u'auto', u'loss': u'absolute_loss', u'beta_2': u'auto',
u'_enable_profiler': u'false', u'normalize_label': u'auto', u'_num_gpus':
u'auto', u'balance_multiclass_weights': u'false',
u'positive_example_weight_mult': u'1.0', u'l1': u'auto', u'margin': u'1.0'}
[10/09/2019 03:34:26 WARNING 140533026703168] Loggers have already been
setup.
Process 1 is a worker.
[10/09/2019 03:34:26 INFO 140533026703168] Using default worker.
[2019-10-09 03:34:26.667] [tensorio] [warning] TensorIO is already
initialized; ignoring the initialization routine.
[2019-10-09 03:34:26.684] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 0, "duration": 17, "num_examples": 1,
"num_bytes": 4800}
[10/09/2019 03:34:26 INFO 140533026703168] Create Store: local
[2019-10-09 03:34:26.709] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 1, "duration": 23, "num_examples": 5,
"num_bytes": 19392}

```

```

[10/09/2019 03:34:26 INFO 140533026703168] Scaler algorithm parameters
<algorithm.scaler.ScalerAlgorithmStable object at 0x7fd007d20390>
[10/09/2019 03:34:26 INFO 140533026703168] Scaling model computed with
parameters:
    {'stdev_weight':
[0.71143115]
<NDArray 1 @cpu(0)>, 'stdev_label':
[9.142572]
<NDArray 1 @cpu(0)>, 'mean_label':
[22.454502]
<NDArray 1 @cpu(0)>, 'mean_weight':
[6.29612]
<NDArray 1 @cpu(0)>}
[10/09/2019 03:34:26 INFO 140533026703168] nvidia-smi took: 0.0252139568329
secs to identify 0 gpus
[10/09/2019 03:34:26 INFO 140533026703168] Number of GPUs being used: 0
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,
"max": 5, "sum": 5.0, "min": 5}, "Number of Batches Since Last Reset": {"count":
1, "max": 0, "sum": 0.0, "min": 0}, "Number of Records Since Last Reset":
{"count": 1, "max": 0, "sum": 0.0, "min": 0}, "Total Batches Seen": {"count": 1,
"max": 6, "sum": 6.0, "min": 6}, "Total Records Seen": {"count": 1, "max": 504,
"sum": 504.0, "min": 504}, "Max Records Seen Between Resets": {"count": 1,
"max": 404, "sum": 404.0, "min": 404}, "Reset Count": {"count": 1, "max": 2,
"sum": 2.0, "min": 2}}, "EndTime": 1570592066.81586, "Dimensions": {"Host":
"algo-1", "Meta": "init_train_data_iter", "Operation": "training", "Algorithm":
"Linear Learner"}, "StartTime": 1570592066.815786}

[2019-10-09 03:34:26.903] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 4, "duration": 86, "num_examples": 5,
"num_bytes": 19392}
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
0.7167009735107421, "sum": 0.7167009735107421, "min": 0.7167009735107421}},
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},
"StartTime": 1570592066.903228}

```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.904924}
```

```
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"EndTime": 1570592066.905024, "Dimensions": {"model": 18, "Host": "algo-1",  
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"StartTime": 1570592066.905004}
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"EndTime": 1570592066.905109, "Dimensions": {"model": 19, "Host": "algo-1",  
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"StartTime": 1570592066.90509}
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"EndTime": 1570592066.905179, "Dimensions": {"model": 20, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.905256, "Dimensions": {"model": 21, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.905244}
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"EndTime": 1570592066.90532, "Dimensions": {"model": 22, "Host": "algo-1",  
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"StartTime": 1570592066.905303}
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"EndTime": 1570592066.905398, "Dimensions": {"model": 23, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.905379}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.90548, "Dimensions": {"model": 24, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.905561, "Dimensions": {"model": 25, "Host": "algo-1",  
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"StartTime": 1570592066.905543}
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"EndTime": 1570592066.905632, "Dimensions": {"model": 26, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.905614}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.90571, "Dimensions": {"model": 27, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.905692}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.905787, "Dimensions": {"model": 28, "Host": "algo-1",  
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"StartTime": 1570592066.905769}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.905863, "Dimensions": {"model": 29, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},  
"StartTime": 1570592066.905844}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"training", "Algorithm": "Linear Learner", "epoch": 0}, "StartTime":  
1570592066.905926}
```



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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592066.906018, "Dimensions": {"model": 31, "Host": "algo-1",
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 0},
"StartTime": 1570592066.905999}

[10/09/2019 03:34:26 INFO 140533026703168] #quality_metric: host=algo-1,
epoch=0, train absolute_loss_objective <loss>=0.716700973511
[10/09/2019 03:34:26 INFO 140533026703168] #early_stopping_criteria_metric:
host=algo-1, epoch=0, criteria=absolute_loss_objective, value=0.695264968872
[10/09/2019 03:34:26 INFO 140533026703168] Epoch 0: Loss improved. Updating
best model
[10/09/2019 03:34:26 INFO 140533026703168] #progress_metric: host=algo-1,
completed 10 % of epochs
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,
"max": 5, "sum": 5.0, "min": 5}, "Number of Batches Since Last Reset": {"count":
1, "max": 5, "sum": 5.0, "min": 5}, "Number of Records Since Last Reset":
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1, "max": 908, "sum": 908.0, "min": 908}, "Max Records Seen Between Resets":
{"count": 1, "max": 404, "sum": 404.0, "min": 404}, "Reset Count": {"count": 1,
"max": 3, "sum": 3.0, "min": 3}}, "EndTime": 1570592066.910108, "Dimensions":
{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",
"Algorithm": "Linear Learner", "epoch": 0}, "StartTime": 1570592066.816135}

[10/09/2019 03:34:26 INFO 140533026703168] #throughput_metric: host=algo-1,
train throughput=4292.97875424 records/second
[2019-10-09 03:34:26.996] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 6, "duration": 86, "num_examples": 5,
"num_bytes": 19392}

```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997081, "Dimensions": {"model": 0, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.996983}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997178, "Dimensions": {"model": 1, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997248, "Dimensions": {"model": 2, "Host": "algo-1",  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997309, "Dimensions": {"model": 3, "Host": "algo-1",  
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"EndTime": 1570592066.997372, "Dimensions": {"model": 4, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997354}
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"EndTime": 1570592066.997436, "Dimensions": {"model": 5, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997508, "Dimensions": {"model": 6, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997488}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997572, "Dimensions": {"model": 7, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997554}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997633, "Dimensions": {"model": 8, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997616}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997696, "Dimensions": {"model": 9, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997678}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997759, "Dimensions": {"model": 10, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997742}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997821, "Dimensions": {"model": 11, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997804}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997884, "Dimensions": {"model": 12, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997866}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.997946, "Dimensions": {"model": 13, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.997929}
```

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"EndTime": 1570592066.998008, "Dimensions": {"model": 14, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.99807, "Dimensions": {"model": 15, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998053}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998142, "Dimensions": {"model": 16, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998265, "Dimensions": {"model": 18, "Host": "algo-1",  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998328, "Dimensions": {"model": 19, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998389, "Dimensions": {"model": 20, "Host": "algo-1",  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998451, "Dimensions": {"model": 21, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998515, "Dimensions": {"model": 22, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998497}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998577, "Dimensions": {"model": 23, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.99856}
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998641, "Dimensions": {"model": 24, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
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```

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"EndTime": 1570592066.998702, "Dimensions": {"model": 25, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998755, "Dimensions": {"model": 26, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.99874}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.998815, "Dimensions": {"model": 27, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998798}
```

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"EndTime": 1570592066.998875, "Dimensions": {"model": 28, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998858}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
0.7999888038635254, "sum": 0.7999888038635254, "min": 0.7999888038635254}},  
"EndTime": 1570592066.998945, "Dimensions": {"model": 29, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998927}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592066.999004, "Dimensions": {"model": 30, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.998988}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
0.796055736541748, "sum": 0.796055736541748, "min": 0.796055736541748}},  
"EndTime": 1570592066.999068, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 1},  
"StartTime": 1570592066.99905}
```

```
[10/09/2019 03:34:26 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=1, train absolute_loss_objective <loss>=0.70601020813  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=1, criteria=absolute_loss_objective, value=0.655196676254  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 1: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 20 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
"max": 5, "sum": 5.0, "min": 5}, "Number of Batches Since Last Reset": {"count":  
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{"count": 1, "max": 404, "sum": 404.0, "min": 404}, "Reset Count": {"count": 1,  
"max": 4, "sum": 4.0, "min": 4}}, "EndTime": 1570592067.002386, "Dimensions":  
{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 1}, "StartTime": 1570592066.910414}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=4386.10943409 records/second
```



```

[2019-10-09 03:34:27.087] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 8, "duration": 85, "num_examples": 5,
"num_bytes": 19392}
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.08806, "Dimensions": {"model": 0, "Host": "algo-1",
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 2},
"StartTime": 1570592067.08796}

#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.088168, "Dimensions": {"model": 1, "Host": "algo-1",
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"StartTime": 1570592067.088146}

#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.088239, "Dimensions": {"model": 2, "Host": "algo-1",
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 2},
"StartTime": 1570592067.088219}

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[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1, epoch=2, train absolute_loss_objective <loss>=0.695652580261  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric: host=algo-1, epoch=2, criteria=absolute_loss_objective, value=0.573432283401  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 2: Loss improved. Updating best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1, completed 30 % of epochs  
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[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1, train throughput=4443.42157074 records/second
```

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[2019-10-09 03:34:27.189] [tensorio] [info] epoch_stats={"data_pipeline":  
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 3},  
"StartTime": 1570592067.190617}
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"EndTime": 1570592067.190683, "Dimensions": {"model": 26, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 3},  
"StartTime": 1570592067.190669}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.190735, "Dimensions": {"model": 27, "Host": "algo-1",  
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"StartTime": 1570592067.190721}
```

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"StartTime": 1570592067.190774}
```

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"EndTime": 1570592067.190841, "Dimensions": {"model": 29, "Host": "algo-1",  
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"StartTime": 1570592067.190827}
```

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"EndTime": 1570592067.190892, "Dimensions": {"model": 30, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 3},  
"StartTime": 1570592067.190878}
```

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"EndTime": 1570592067.190943, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 3},  
"StartTime": 1570592067.19093}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=3, train absolute_loss_objective <loss>=0.685416517258  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=3, criteria=absolute_loss_objective, value=0.572938394547  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 40 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
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{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 3}, "StartTime": 1570592067.093766}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=3997.43054563 records/second  
[2019-10-09 03:34:27.265] [tensorio] [info] epoch_stats={"data_pipeline":  
"/opt/ml/input/data/train", "epoch": 12, "duration": 70, "num_examples": 5,  
"num_bytes": 19392}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.266129, "Dimensions": {"model": 0, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.266034}
```

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"EndTime": 1570592067.266229, "Dimensions": {"model": 1, "Host": "algo-1",  
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"StartTime": 1570592067.266205}
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"EndTime": 1570592067.266522, "Dimensions": {"model": 2, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.266496}
```

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"EndTime": 1570592067.266592, "Dimensions": {"model": 3, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.266573}
```

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"EndTime": 1570592067.266839, "Dimensions": {"model": 4, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.266813}
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"EndTime": 1570592067.266989, "Dimensions": {"model": 5, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.267165, "Dimensions": {"model": 6, "Host": "algo-1",  
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"StartTime": 1570592067.267141}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.267231, "Dimensions": {"model": 7, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.267213}
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"EndTime": 1570592067.267358, "Dimensions": {"model": 8, "Host": "algo-1",  
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"StartTime": 1570592067.267337}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.267497, "Dimensions": {"model": 9, "Host": "algo-1",  
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"StartTime": 1570592067.267473}
```



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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"StartTime": 1570592067.267549}
```

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"EndTime": 1570592067.267691, "Dimensions": {"model": 11, "Host": "algo-1",  
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"StartTime": 1570592067.26767}
```

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"EndTime": 1570592067.267819, "Dimensions": {"model": 12, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
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```

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"EndTime": 1570592067.26789, "Dimensions": {"model": 13, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.267963, "Dimensions": {"model": 14, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.267944}
```

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"EndTime": 1570592067.268026, "Dimensions": {"model": 15, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.268009}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268086, "Dimensions": {"model": 16, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268153, "Dimensions": {"model": 17, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268281, "Dimensions": {"model": 19, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
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```

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"EndTime": 1570592067.268408, "Dimensions": {"model": 21, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268471, "Dimensions": {"model": 22, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
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"EndTime": 1570592067.268561, "Dimensions": {"model": 23, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.268542}
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"EndTime": 1570592067.268751, "Dimensions": {"model": 26, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268818, "Dimensions": {"model": 27, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.268801}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268877, "Dimensions": {"model": 28, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.268942, "Dimensions": {"model": 29, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.268923}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.269005, "Dimensions": {"model": 30, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.268988}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.269067, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 4},  
"StartTime": 1570592067.26905}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=4, train absolute_loss_objective <loss>=0.677116861343  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=4, criteria=absolute_loss_objective, value=0.534236974716  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 4: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 50 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
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{"count": 1, "max": 404, "sum": 404.0, "min": 404}, "Reset Count": {"count": 1,  
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{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 4}, "StartTime": 1570592067.194976}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=5213.04050454 records/second
```

```
[2019-10-09 03:34:27.341] [tensorio] [info] epoch_stats={"data_pipeline":
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"num_bytes": 19392}
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 5},
"StartTime": 1570592067.341245}

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"EndTime": 1570592067.341439, "Dimensions": {"model": 1, "Host": "algo-1",
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 5},
"StartTime": 1570592067.341419}

#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.341509, "Dimensions": {"model": 2, "Host": "algo-1",
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 5},
"StartTime": 1570592067.341491}

#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.341575, "Dimensions": {"model": 3, "Host": "algo-1",
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"StartTime": 1570592067.341556}

#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":
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"EndTime": 1570592067.34164, "Dimensions": {"model": 4, "Host": "algo-1",
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"StartTime": 1570592067.341622}
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"EndTime": 1570592067.3417, "Dimensions": {"model": 5, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.341766, "Dimensions": {"model": 6, "Host": "algo-1",  
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"StartTime": 1570592067.341747}
```

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"EndTime": 1570592067.341837, "Dimensions": {"model": 7, "Host": "algo-1",  
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[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=5, train absolute_loss_objective <loss>=0.667941417694  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=5, criteria=absolute_loss_objective, value=0.509839515686  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 5: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 60 % of epochs  
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[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=5465.59628423 records/second
```

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[2019-10-09 03:34:27.459] [tensorio] [info] epoch_stats={"data_pipeline":
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"EndTime": 1570592067.461224, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 6},  
"StartTime": 1570592067.461207}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=6, train absolute_loss_objective <loss>=0.659129457474  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=6, criteria=absolute_loss_objective, value=0.50122756958  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 6: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 70 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
"max": 5, "sum": 5.0, "min": 5}, "Number of Batches Since Last Reset": {"count":  
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{"count": 1, "max": 404, "sum": 404.0, "min": 404}, "Reset Count": {"count": 1,  
"max": 9, "sum": 9.0, "min": 9}}, "EndTime": 1570592067.465999, "Dimensions":  
{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 6}, "StartTime": 1570592067.346715}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=3382.56399528 records/second
```

```
[2019-10-09 03:34:27.535] [tensorio] [info] epoch_stats={"data_pipeline":  
"/opt/ml/input/data/train", "epoch": 18, "duration": 69, "num_examples": 5,  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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```

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```

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```

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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 7},  
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```

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```

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```

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```

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```

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```

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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 7},  
"StartTime": 1570592067.5369}
```

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"EndTime": 1570592067.536981, "Dimensions": {"model": 14, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 7},  
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```

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```

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```

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```

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```

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```

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```

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```

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```

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```



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```

```
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```

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```

```
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```

```
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 7},  
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```

```
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```

```
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.538082, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 7},  
"StartTime": 1570592067.538064}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=7, train absolute_loss_objective <loss>=0.649830093384  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=7, criteria=absolute_loss_objective, value=0.498902845383  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 7: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 80 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
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{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 7}, "StartTime": 1570592067.466295}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=5367.28067936 records/second
```

```
[2019-10-09 03:34:27.627] [tensorio] [info] epoch_stats={"data_pipeline":  
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```

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```

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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 8},  
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```

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```

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```

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```

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```

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```

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```

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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.628099, "Dimensions": {"model": 11, "Host": "algo-1",  
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```

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```

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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.628281, "Dimensions": {"model": 14, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 8},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.628406, "Dimensions": {"model": 16, "Host": "algo-1",  
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"StartTime": 1570592067.628389}
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"EndTime": 1570592067.628473, "Dimensions": {"model": 17, "Host": "algo-1",  
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"StartTime": 1570592067.628454}
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"EndTime": 1570592067.628564, "Dimensions": {"model": 18, "Host": "algo-1",  
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```

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"EndTime": 1570592067.62869, "Dimensions": {"model": 20, "Host": "algo-1",  
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"StartTime": 1570592067.628881}
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"EndTime": 1570592067.628959, "Dimensions": {"model": 24, "Host": "algo-1",  
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"StartTime": 1570592067.628941}
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"EndTime": 1570592067.629022, "Dimensions": {"model": 25, "Host": "algo-1",  
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```

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"StartTime": 1570592067.629193}
```

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"EndTime": 1570592067.629273, "Dimensions": {"model": 29, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 8},  
"StartTime": 1570592067.629255}
```



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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.629343, "Dimensions": {"model": 30, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 8},  
"StartTime": 1570592067.629325}
```

```
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.629406, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 8},  
"StartTime": 1570592067.629388}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=8, train absolute_loss_objective <loss>=0.64202337265  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=8, criteria=absolute_loss_objective, value=0.49220826149  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 8: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 90 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
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{"Host": "algo-1", "Meta": "training_data_iter", "Operation": "training",  
"Algorithm": "Linear Learner", "epoch": 8}, "StartTime": 1570592067.541738}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=4432.93642937 records/second
```

```
[2019-10-09 03:34:27.733] [tensorio] [info] epoch_stats={"data_pipeline":  
"/opt/ml/input/data/train", "epoch": 22, "duration": 100, "num_examples": 5,  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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```

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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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```

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```

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```

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```

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```

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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.734584, "Dimensions": {"model": 14, "Host": "algo-1",  
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"EndTime": 1570592067.734642, "Dimensions": {"model": 15, "Host": "algo-1",  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.734703, "Dimensions": {"model": 16, "Host": "algo-1",  
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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.734763, "Dimensions": {"model": 17, "Host": "algo-1",  
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"EndTime": 1570592067.734822, "Dimensions": {"model": 18, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"Operation": "training", "Algorithm": "Linear Learner", "epoch": 9},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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```

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```

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"EndTime": 1570592067.735062, "Dimensions": {"model": 22, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735122, "Dimensions": {"model": 23, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.73518, "Dimensions": {"model": 24, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735244, "Dimensions": {"model": 25, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735305, "Dimensions": {"model": 26, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735366, "Dimensions": {"model": 27, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 9},  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735424, "Dimensions": {"model": 28, "Host": "algo-1",  
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```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735481, "Dimensions": {"model": 29, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 9},  
"StartTime": 1570592067.735466}
```

```
#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735541, "Dimensions": {"model": 30, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 9},  
"StartTime": 1570592067.735525}
```

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#metrics {"Metrics": {"train_absolute_loss_objective": {"count": 1, "max":  
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"EndTime": 1570592067.735601, "Dimensions": {"model": 31, "Host": "algo-1",  
"Operation": "training", "Algorithm": "Linear Learner", "epoch": 9},  
"StartTime": 1570592067.735585}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,  
epoch=9, train absolute_loss_objective <loss>=0.633839712143  
[10/09/2019 03:34:27 INFO 140533026703168] #early_stopping_criteria_metric:  
host=algo-1, epoch=9, criteria=absolute_loss_objective, value=0.491617898941  
[10/09/2019 03:34:27 INFO 140533026703168] Epoch 9: Loss improved. Updating  
best model  
[10/09/2019 03:34:27 INFO 140533026703168] #progress_metric: host=algo-1,  
completed 100 % of epochs  
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,  
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"Algorithm": "Linear Learner", "epoch": 9}, "StartTime": 1570592067.633024}  
  
[10/09/2019 03:34:27 INFO 140533026703168] #throughput_metric: host=algo-1,  
train throughput=3759.39586943 records/second
```



```

[10/09/2019 03:34:27 WARNING 140533026703168] wait_for_all_workers will not
sync workers since the kv store is not running distributed
[10/09/2019 03:34:27 WARNING 140533026703168] wait_for_all_workers will not
sync workers since the kv store is not running distributed
[2019-10-09 03:34:27.742] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 24, "duration": 1, "num_examples": 1,
"num_bytes": 4800}
[2019-10-09 03:34:27.757] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/train", "epoch": 26, "duration": 7, "num_examples": 5,
"num_bytes": 19392}
[10/09/2019 03:34:27 INFO 140533026703168] #train_score (algo-1) :
('absolute_loss_objective', 4.498295375616244)
[10/09/2019 03:34:27 INFO 140533026703168] #train_score (algo-1) : ('mse',
44.41557731250725)
[10/09/2019 03:34:27 INFO 140533026703168] #train_score (algo-1) :
('absolute_loss', 4.498295375616244)
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
train absolute_loss_objective <loss>=4.49829537562
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
train mse <loss>=44.4155773125
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
train absolute_loss <loss>=4.49829537562
[10/09/2019 03:34:27 INFO 140533026703168] Best model found for
hyperparameters: {"lr_scheduler_step": 10, "wd": 0.0001, "optimizer": "adam",
"lr_scheduler_factor": 0.99, "l1": 0.0, "learning_rate": 0.1,
"lr_scheduler_minimum_lr": 0.0001}
[10/09/2019 03:34:27 INFO 140533026703168] Saved checkpoint to
"/tmp/tmpd2WC27/mx-mod-0000.params"
[2019-10-09 03:34:27.762] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/test", "epoch": 0, "duration": 1094, "num_examples": 1,
"num_bytes": 4800}
[2019-10-09 03:34:27.767] [tensorio] [info] epoch_stats={"data_pipeline":
"/opt/ml/input/data/test", "epoch": 1, "duration": 4, "num_examples": 2,
"num_bytes": 4896}

```

```
#metrics {"Metrics": {"Max Batches Seen Between Resets": {"count": 1,
"max": 2, "sum": 2.0, "min": 2}, "Number of Batches Since Last Reset": {"count":
1, "max": 2, "sum": 2.0, "min": 2}, "Number of Records Since Last Reset":
{"count": 1, "max": 102, "sum": 102.0, "min": 102}, "Total Batches Seen":
{"count": 1, "max": 2, "sum": 2.0, "min": 2}, "Total Records Seen": {"count": 1,
"max": 102, "sum": 102.0, "min": 102}, "Max Records Seen Between Resets":
{"count": 1, "max": 102, "sum": 102.0, "min": 102}, "Reset Count": {"count": 1,
"max": 1, "sum": 1.0, "min": 1}}, "EndTime": 1570592067.767257, "Dimensions":
{"Host": "algo-1", "Meta": "test_data_iter", "Operation": "training",
"Algorithm": "Linear Learner"}}, "StartTime": 1570592067.762176}
```

```
[10/09/2019 03:34:27 INFO 140533026703168] #test_score (algo-1) :
('absolute_loss_objective', 4.287738706551346)
[10/09/2019 03:34:27 INFO 140533026703168] #test_score (algo-1) : ('mse',
44.92679406147377)
[10/09/2019 03:34:27 INFO 140533026703168] #test_score (algo-1) :
('absolute_loss', 4.287738706551346)
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
test absolute_loss_objective <loss>=4.28773870655
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
test mse <loss>=44.9267940615
[10/09/2019 03:34:27 INFO 140533026703168] #quality_metric: host=algo-1,
test absolute_loss <loss>=4.28773870655
```

```
#metrics {"Metrics": {"totaltime": {"count": 1, "max": 1188.443899154663,
"sum": 1188.443899154663, "min": 1188.443899154663}, "finalize.time": {"count":
1, "max": 17.27604866027832, "sum": 17.27604866027832, "min":
17.27604866027832}, "initialize.time": {"count": 1, "max": 147.51720428466797,
"sum": 147.51720428466797, "min": 147.51720428466797},
"check_early_stopping.time": {"count": 10, "max": 1.3880729675292969, "sum":
10.936260223388672, "min": 0.26297569274902344}, "setuptime": {"count": 1,
"max": 27.67491340637207, "sum": 27.67491340637207, "min": 27.67491340637207},
"update.time": {"count": 10, "max": 119.07315254211426, "sum":
919.6221828460693, "min": 73.59790802001953}, "epochs": {"count": 1, "max": 10,
"sum": 10.0, "min": 10}}, "EndTime": 1570592067.771476, "Dimensions": {"Host":
"algo-1", "Operation": "training", "Algorithm": "Linear Learner"}, "StartTime":
1570592066.666025}
```

2019-10-09 03:34:36 Uploading - Uploading generated training model

2019-10-09 03:34:36 Completed - Training job completed

Training seconds: 70

Billable seconds: 70

1.3.3 Deploying the Model to Make Predictions

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

Note: This step might take a few minutes.

```
[14]: # An instance of the lineal-learner predictor is created
linear_predictor = linear.deploy(initial_instance_count=1, instance_type="ml.t2.
↪medium")
```

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

```
[15]: # Linear predictor configurations
linear_predictor.content_type = "text/csv"
linear_predictor.serializer = csv_serializer
linear_predictor.deserializer = json_deserializer
```

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

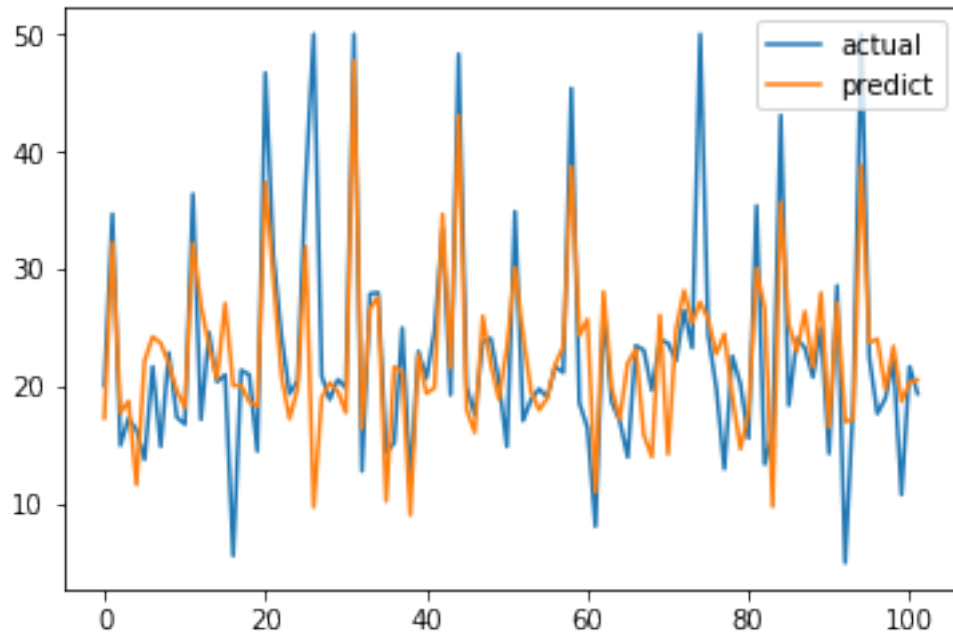
```
y_predictions
```

```
[16]: array([17.31322479, 32.28639221, 17.76079559, 18.76782227, 11.63726044,  
          22.19577789, 24.2505188 , 23.70123291, 21.93130875, 19.64261246,  
          18.22870636, 32.21518707, 26.91558075, 23.43676758, 20.64963913,  
          27.08850098, 20.10035324, 20.09017944, 18.70678711, 18.33042908,  
          37.3825531 , 29.12290192, 20.90393829, 17.27254105, 19.83588028,  
          31.91002655,  9.75543976, 19.06281281, 20.32413483, 19.58158112,  
          17.78113556, 47.73764801, 16.4384346 , 26.64093781, 27.62762451,  
          10.2538681 , 21.6770134 , 21.25995636,  9.07391739, 22.69421005,  
          19.41883087, 19.88674164, 34.67681122, 21.62615204, 43.08904266,  
          18.0557785 , 16.09259033, 26.00010681, 21.8804512 , 18.93057632,  
          23.2943573 , 30.15027618, 24.36241913, 19.55106735, 18.01509476,  
          19.01195145, 21.90079498, 23.40624237, 38.74560547, 24.35224152,  
          25.72546387, 11.00659561, 28.0650177 , 19.90708542, 17.24202347,  
          22.00251007, 23.1824646 , 15.87897873, 14.02767563, 26.08148193,  
          14.25146103, 24.87100983, 28.1769104 , 25.42030334, 27.18005371,  
          25.70511627, 22.78575516, 24.4743042 , 19.12384033, 14.6990242 ,  
          17.76079559, 30.07907104, 26.63076782,  9.78595734, 35.69400787,  
          25.26772308, 23.00953674, 26.39681244, 21.6566658 , 27.98364258,  
          16.54015732, 27.12919617, 17.00806808, 17.26237106, 38.85749054,  
          23.74192047, 24.05725098, 19.74433517, 23.43676758, 18.74747849,  
          20.32413483, 20.54792023])
```

1.3.4 Model Evaluation

To evaluate the model, a plot to contrast the predicted housing prices values versus the real values is created. Additionally, the RMSE and R2 scores are calculated.

```
[17]: # Plotting predicted Vs. actual values  
plt.plot(np.array(Y_test), label="actual")  
plt.plot(y_predictions, label="predict")  
plt.legend()  
plt.show()
```



```
[18]: # Calculating the RMSE and R2 scores
from sklearn.metrics import mean_squared_error, r2_score

rmse = np.sqrt(mean_squared_error(Y_test, y_predictions))
r2 = r2_score(Y_test, y_predictions)

print("RMSE: {}".format(rmse))
print("R2 score: {}".format(r2))
```

RMSE: 6.702745271896026

R2 score: 0.48852922866417436

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

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