oncloud_v2

November 3, 2024

1 Machine Learning on AWS Cloud

1.1 Combined Data version 1

[1]:
```
# import libraries
import warnings, requests, zipfile, io

warnings.simplefilter("ignore")
import pandas as pd
from scipy.io import arff

import os
import boto3
import sagemaker
from sagemaker.image_uris import retrieve
from sklearn.model_selection import train_test_split
```

```
sagemaker.config INFO - Not applying SDK defaults from location:
/etc/xdg/sagemaker/config.yaml
sagemaker.config INFO - Not applying SDK defaults from location:
/home/ec2-user/.config/sagemaker/config.yaml
```

1.1.1 Setting up S3 bucket

[2]:
```
import logging


# import boto3


from botocore.exceptions import ClientError


def create_bucket(bucket_name, region=None):
    # Create an S3 bucket in a specified region
    # If a region is not specified, the bucket is created in the S3 default
    # region (us-east-1).
    # :param bucket_name: Bucket to create
```

```
    # :param region: String region to create bucket in, e.g., 'us-west-2'
    # :return: True if bucket created, else False

    # Create bucket

    try:

        if region is None:

            s3_client = boto3.client("s3")

            s3_client.create_bucket(Bucket=bucket_name)
        else:

            s3_client = boto3.client("s3", region_name=region)

            location = {"LocationConstraint": region}

            s3_client.create_bucket(
                Bucket=bucket_name, CreateBucketConfiguration=location
            )

    except ClientError as e:

        logging.error(e)

        return False

    print(f"S3 Bucket: {bucket_name} created successfully")

    return True
```

[3]:
```
# Function to check if the bucket exists
def check_bucket_exists(bucket_name):
    s3 = boto3.client("s3")
    try:
        s3.head_bucket(Bucket=bucket_name)
        print(f"Bucket '{bucket_name}' already exists.")
        return True
    except ClientError as e:
        # If a 404 error is raised, the bucket does not exist
        if e.response["Error"]["Code"] == "404":
            print(f"Bucket '{bucket_name}' does not exist.")
            return False
        else:
            # If there's any other error, raise it
            raise
```

[4]:
```
# set the s3 bucket name
bucket = "u3253992-ajulthomas-oncloud"

# fetch the s3 resource
s3_resource = boto3.Session().resource("s3")


# check if bucket exists
bucket_exists = check_bucket_exists(bucket)

# Create the bucket if it doesn't exist
if not bucket_exists:
    create_bucket(bucket)
```

```
Bucket 'u3253992-ajulthomas-oncloud' already exists.
```

[5]:
```
# setting the prefix
prefix = "oncloud2"


# uploading data to aws s3
def upload_s3_csv(filename, folder, dataframe):
    csv_buffer = io.StringIO()
    dataframe.to_csv(csv_buffer, header=False, index=False)
    print(s3_resource.Bucket(bucket))
    s3_resource.Bucket(bucket).Object(os.path.join(prefix, folder, filename)).
 ↪put(
        Body=csv_buffer.getvalue()
    )
```

1.1.2 Generic Functions

[6]:
```
from sklearn.metrics import confusion_matrix
import matplotlib.pyplot as plt
import seaborn as sns


# function to plot confusion matrix
def plot_confusion_matrix(test_labels, target_predicted):
    # complete the code here
    cm = confusion_matrix(test_labels, target_predicted)
    # Create a heatmap
    sns.heatmap(
        cm,
        annot=True,
        fmt="d",
        cmap="Blues",
        xticklabels=["On-Time", "Delayed"],
```

```
        yticklabels=["On-Time", "Delayed"],
    )
    plt.xlabel("Predicted")
    plt.ylabel("Actual")
    plt.title("Confusion Matrix")
    plt.show()
```

```
Matplotlib is building the font cache; this may take a moment.
```

1.1.3 Loading Data

[7]:
```
import pandas as pd

# load the data


data_v2 = pd.read_csv("./combined_csv_v2.csv")


data_v2.head()
```

[7]:

	target	Distance	DepHourofDay	AWND_O	PRCP_O	TAVG_O	AWND_D	PRCP_D	\
0	0.0	689.0	21	33	0	54.0	30	0	
1	0.0	731.0	9	39	0	136.0	33	0	
2	0.0	1199.0	18	33	0	54.0	77	0	
3	0.0	1587.0	16	33	0	54.0	20	0	
4	0.0	1587.0	7	20	0	165.0	33	0	

	TAVG_D	SNOW_O	…	Origin_SFO	Dest_CLT	Dest_DEN	Dest_DFW	Dest_IAH	\
0	130.0	0.0	…	0	0	0	0	1	
1	54.0	0.0	…	0	0	0	0	0	
2	68.0	0.0	…	0	0	1	0	0	
3	165.0	0.0	…	0	0	0	0	0	
4	54.0	0.0	…	0	0	0	0	0	

	Dest_LAX	Dest_ORD	Dest_PHX	Dest_SFO	is_holiday_True
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	1	0	0
4	0	0	0	0	0

[5 rows x 86 columns]

[8]:
```
# shape of the data
data_v2.shape
```

[8]:
```
(1635590, 86)
```

1.2 Model 1 - Linear Learner

---

[9]:
```
# create a copt of the version 1 data

df = data_v2.copy()

df.shape
```

[9]:
```
(1635590, 86)
```

[ ]:
```
# df_cleaned = df.replace({True: 1, False: 0})

# df_cleaned.head(5)
```

[ ]:
```
# df_cleaned.isnull().sum().sum()
```

[ ]:
```
# df_cleaned.shape
```

[10]:
```
# split the data

train, test_and_validate = train_test_split(
    df, test_size=0.3, random_state=42, stratify=df["target"]
)
test, validate = train_test_split(
    test_and_validate,
    test_size=0.5,
    random_state=42,
    stratify=test_and_validate["target"],
)
```

[11]:
```
# shape of train data
train.shape
```

[11]:
```
(1144913, 86)
```

[12]:
```
# shape of test
test.shape
```

[12]:
```
(245338, 86)
```

[13]:
```
# shape of validate
validate.shape
```

[13]:
```
(245339, 86)
```

[14]:
```
# set the names of the csv files
train_file = "data_v2_train.csv"
```

```
test_file = "data_v2_test.csv"
validate_file = "data_v2_validate.csv"
```

1.2.1 Upload data to S3 Bucket

[15]:
```
import io
import numpy as np
import sagemaker.amazon.common as smac


# prepare data for sagemaker training


def prepare_data(dataframe):
    vectors = dataframe.drop(columns=["target"]).values.astype("float32")
    labels = dataframe["target"].values.astype("float32")
    buf = io.BytesIO()
    smac.write_numpy_to_dense_tensor(buf, vectors, labels)
    buf.seek(0)

    return buf
```

[16]:
```
import boto3
import os


# upload training data to s3
def upload_s3_buf(buf, bucket, prefix, type):
    key = "recordio-pb-data"
    boto3.resource("s3").Bucket(bucket).Object(
        os.path.join(prefix, type, key)
    ).upload_fileobj(buf)
    s3_data_path = "s3://{}/{}/{}/{}".format(bucket, prefix, type, key)
    print("uploaded {} data to location: {}".format(type, s3_data_path))
    return s3_data_path
```

[17]:
```
# prepare train data
train_buf = prepare_data(train)

# upload train data
s3_train_data = upload_s3_buf(train_buf, bucket, prefix, "train")
```

```
uploaded train data to location: s3://u3253992-ajulthomas-
oncloud/oncloud2/train/recordio-pb-data
```

[18]:
```
# prepare validation data
validate_buf = prepare_data(validate)
```

```
# upload validation data
s3_validate_data = upload_s3_buf(validate_buf, bucket, prefix, "validate")
```

```
uploaded validate data to location: s3://u3253992-ajulthomas-
oncloud/oncloud2/validate/recordio-pb-data
```

[19]:
```
output_location = "s3://{}/{}/output".format(bucket, prefix)
print("training artifacts will be uploaded to: {}".format(output_location))
```

```
training artifacts will be uploaded to: s3://u3253992-ajulthomas-
oncloud/oncloud2/output
```

[20]:
```
from sagemaker.image_uris import retrieve

# container = retrieve("linear-learner", boto3.Session().region_name)
container = retrieve("linear-learner", "us-east-1")
```

1.2.2 Training the model

[21]:
```
import boto3

# sess = sagemaker.Session()

# Ensure your session is set to the same region as the bucket
session = sagemaker.Session(boto3.session.Session(region_name="us-east-1"))

# Get the execution role
role = sagemaker.get_execution_role()

linear = sagemaker.estimator.Estimator(
    container,
    role,
    train_instance_count=1,
    train_instance_type="ml.c5.2xlarge",
    output_path=output_location,
    sagemaker_session=session,
)
linear.set_hyperparameters(feature_dim=85, predictor_type="binary_classifier")

linear.fit({"train": s3_train_data, "validation": s3_validate_data}, logs=False)
```

```
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.
INFO:sagemaker:Creating training-job with name: linear-
learner-2024-11-03-03-45-21-975
```

```
2024-11-03 03:45:24 Starting - Starting the training job..
2024-11-03 03:45:40 Starting - Preparing the instances for training…
2024-11-03 03:46:01 Downloading - Downloading input data…
2024-11-03 03:46:26 Downloading - Downloading the training image…
2024-11-03 03:47:17 Training - Training image download completed. Training in
progress…
2024-11-03 03:53:28 Uploading - Uploading generated training model
2024-11-03 03:53:36 Completed - Training job completed
```

1.2.3 Deploying the model

[ ]:
```
# from sagemaker.serializers import CSVSerializer
# from sagemaker.deserializers import JSONDeserializer

# linear_predictor = linear.deploy(
#     initial_instance_count=1,
#     instance_type="ml.c5.2xlarge",
#     serializer=CSVSerializer(),
#     deserializer=JSONDeserializer(),
# )
```

1.2.4 Using the Model to predict on the test dataset

[ ]:
```
# predictions = []
# for i in range(0, 10000):
#     result = linear_predictor.predict(test.iloc[i, 1:].to_numpy(dtype=np.
 ↪float32))
#     predictions += [r["predicted_label"] for r in result["predictions"]]

# predictions = np.array(predictions)
```

[ ]:
```
# predictions
```

[22]:
```
import boto3
import pandas as pd
import io

# Prepare the input data for batch prediction
batch_X_linear = test.iloc[:, 1:]
batch_X_file_linear = 'batch-in-linear.csv'

# Upload the CSV to S3
upload_s3_csv(batch_X_file_linear, 'batch-in-linear', batch_X_linear)

# Define the S3 paths
batch_output = "s3://{}/{}/batch-out-linear/".format(bucket, prefix)
```

```
batch_input = "s3://{}/{}/batch-in-linear/{}".format(bucket, prefix,␣
 ↪batch_X_file_linear)
```

```
s3.Bucket(name='u3253992-ajulthomas-oncloud')
```

[23]:
```
# Create the transformer for the Linear Learner model
linear_transformer = linear.transformer(
    instance_count=1,
    instance_type='ml.c5.4xlarge',
    strategy='MultiRecord',
    assemble_with='Line',
    output_path=batch_output
)

# Start the batch transform job
linear_transformer.transform(
    data=batch_input,
    data_type='S3Prefix',
    content_type='text/csv',
    split_type='Line',
    logs=False
)

linear_transformer.wait()
```

```
INFO:sagemaker:Creating model with name: linear-learner-2024-11-03-03-55-16-209
INFO:sagemaker:Creating transform job with name: linear-
learner-2024-11-03-03-55-17-793
```

```
…!
Docker entrypoint called with argument(s): serve
Running default environment configuration script
[11/03/2024 04:01:32 INFO 139856703743808] Memory profiler is not enabled

by the environment variable ENABLE_PROFILER.
/opt/amazon/lib/python3.8/site-packages/mxnet/model.py:97: SyntaxWarning:

"is" with a literal. Did you mean "=="?

  if num_device is 1 and 'dist' not in kvstore:
Docker entrypoint called with argument(s): serve
Running default environment configuration script
[11/03/2024 04:01:32 INFO 139856703743808] Memory profiler is not enabled

by the environment variable ENABLE_PROFILER.
/opt/amazon/lib/python3.8/site-packages/mxnet/model.py:97: SyntaxWarning:

"is" with a literal. Did you mean "=="?

  if num_device is 1 and 'dist' not in kvstore:
```

```
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:495:
SyntaxWarning: "is" with a literal. Did you mean "=="?
  if cons['type'] is 'ineq':
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:743:
SyntaxWarning: "is not" with a literal. Did you mean "!="?
  if len(self.X_min) is not 0:
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:495:
SyntaxWarning: "is" with a literal. Did you mean "=="?
  if cons['type'] is 'ineq':
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:743:
SyntaxWarning: "is not" with a literal. Did you mean "!="?
  if len(self.X_min) is not 0:
[11/03/2024 04:01:34 WARNING 139856703743808] Loggers have already been
setup.
[11/03/2024 04:01:35 INFO 139856703743808] loaded entry point class
algorithm.serve.server_config:config_api
[11/03/2024 04:01:35 INFO 139856703743808] loading entry points
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/json
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/jsonlines
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/x-recordio-protobuf
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
text/csv
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/json
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/jsonlines
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/x-recordio-protobuf
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
text/csv
[11/03/2024 04:01:35 INFO 139856703743808] loaded entry point class
algorithm:model
[11/03/2024 04:01:35 INFO 139856703743808] Number of server workers: 16
[11/03/2024 04:01:35 INFO 139856703743808] loading model…
```

```
[11/03/2024 04:01:35 INFO 139856703743808] …model loaded.
[2024-11-03 04:01:35 +0000] [1] [INFO] Starting gunicorn 20.1.0
[2024-11-03 04:01:35 +0000] [1] [INFO] Listening at: http://0.0.0.0:8080
(1)
[2024-11-03 04:01:35 +0000] [1] [INFO] Using worker: sync
[2024-11-03 04:01:35 +0000] [61] [INFO] Booting worker with pid: 61
[2024-11-03 04:01:35 +0000] [70] [INFO] Booting worker with pid: 70
[2024-11-03 04:01:35 +0000] [79] [INFO] Booting worker with pid: 79
[2024-11-03 04:01:35 +0000] [88] [INFO] Booting worker with pid: 88
[2024-11-03 04:01:35 +0000] [97] [INFO] Booting worker with pid: 97
[2024-11-03 04:01:35 +0000] [106] [INFO] Booting worker with pid: 106
[2024-11-03 04:01:35 +0000] [115] [INFO] Booting worker with pid: 115
[2024-11-03 04:01:35 +0000] [124] [INFO] Booting worker with pid: 124
[11/03/2024 04:01:34 WARNING 139856703743808] Loggers have already been
setup.
[11/03/2024 04:01:35 INFO 139856703743808] loaded entry point class
algorithm.serve.server_config:config_api
[11/03/2024 04:01:35 INFO 139856703743808] loading entry points
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/json
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/jsonlines
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
application/x-recordio-protobuf
[11/03/2024 04:01:35 INFO 139856703743808] loaded request iterator
text/csv
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/json
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/jsonlines
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
application/x-recordio-protobuf
[11/03/2024 04:01:35 INFO 139856703743808] loaded response encoder
text/csv
[11/03/2024 04:01:35 INFO 139856703743808] loaded entry point class
algorithm:model
[11/03/2024 04:01:35 INFO 139856703743808] Number of server workers: 16
[11/03/2024 04:01:35 INFO 139856703743808] loading model…
[11/03/2024 04:01:35 INFO 139856703743808] …model loaded.
[2024-11-03 04:01:35 +0000] [1] [INFO] Starting gunicorn 20.1.0
```

```
[2024-11-03 04:01:35 +0000] [1] [INFO] Listening at: http://0.0.0.0:8080
(1)
[2024-11-03 04:01:35 +0000] [1] [INFO] Using worker: sync
[2024-11-03 04:01:35 +0000] [61] [INFO] Booting worker with pid: 61
[2024-11-03 04:01:35 +0000] [70] [INFO] Booting worker with pid: 70
[2024-11-03 04:01:35 +0000] [79] [INFO] Booting worker with pid: 79
[2024-11-03 04:01:35 +0000] [88] [INFO] Booting worker with pid: 88
[2024-11-03 04:01:35 +0000] [97] [INFO] Booting worker with pid: 97
[2024-11-03 04:01:35 +0000] [106] [INFO] Booting worker with pid: 106
[2024-11-03 04:01:35 +0000] [115] [INFO] Booting worker with pid: 115
[2024-11-03 04:01:35 +0000] [124] [INFO] Booting worker with pid: 124
[2024-11-03 04:01:35 +0000] [133] [INFO] Booting worker with pid: 133
[2024-11-03 04:01:35 +0000] [142] [INFO] Booting worker with pid: 142
[2024-11-03 04:01:35 +0000] [133] [INFO] Booting worker with pid: 133
[2024-11-03 04:01:35 +0000] [142] [INFO] Booting worker with pid: 142
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606495.5306318,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"execution_parameters.count": {"sum": 1.0,
"count": 1, "min": 1, "max": 1}}}
[2024-11-03 04:01:35 +0000] [151] [INFO] Booting worker with pid: 151
[2024-11-03 04:01:35 +0000] [160] [INFO] Booting worker with pid: 160
[2024-11-03 04:01:35 +0000] [169] [INFO] Booting worker with pid: 169
[2024-11-03 04:01:35 +0000] [178] [INFO] Booting worker with pid: 178
[2024-11-03 04:01:35 +0000] [187] [INFO] Booting worker with pid: 187
[2024-11-03 04:01:35 +0000] [196] [INFO] Booting worker with pid: 196
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606495.5306318,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"execution_parameters.count": {"sum": 1.0,
"count": 1, "min": 1, "max": 1}}}
[2024-11-03 04:01:35 +0000] [151] [INFO] Booting worker with pid: 151
[2024-11-03 04:01:35 +0000] [160] [INFO] Booting worker with pid: 160
[2024-11-03 04:01:35 +0000] [169] [INFO] Booting worker with pid: 169
[2024-11-03 04:01:35 +0000] [178] [INFO] Booting worker with pid: 178
[2024-11-03 04:01:35 +0000] [187] [INFO] Booting worker with pid: 187
[2024-11-03 04:01:35 +0000] [196] [INFO] Booting worker with pid: 196
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.6314416,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
28.60260009765625, "count": 1, "min": 28.60260009765625, "max":
28.60260009765625}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
```

#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.9465346,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
61.081647872924805, "count": 1, "min": 61.081647872924805, "max":
61.081647872924805}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.9622269,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
63.292503356933594, "count": 1, "min": 63.292503356933594, "max":
63.292503356933594}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0392454,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
52.09636688232422, "count": 1, "min": 52.09636688232422, "max":
52.09636688232422}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.042428,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
82.15761184692383, "count": 1, "min": 82.15761184692383, "max":
82.15761184692383}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.6314416,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
28.60260009765625, "count": 1, "min": 28.60260009765625, "max":
28.60260009765625}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}

#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.9465346,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
61.081647872924805, "count": 1, "min": 61.081647872924805, "max":
61.081647872924805}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606496.9622269,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
63.292503356933594, "count": 1, "min": 63.292503356933594, "max":
63.292503356933594}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0392454,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
52.09636688232422, "count": 1, "min": 52.09636688232422, "max":
52.09636688232422}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.042428,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
82.15761184692383, "count": 1, "min": 82.15761184692383, "max":
82.15761184692383}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0733724,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.611900329589844, "count": 1, "min": 51.611900329589844, "max":
51.611900329589844}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}

#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0864477,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.891326904296875, "count": 1, "min": 51.891326904296875, "max":
51.891326904296875}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.5307395, "EndTime": 1730606497.11261,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.70798301696777, "count": 1, "min": 51.70798301696777, "max":
51.70798301696777}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0733724,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.611900329589844, "count": 1, "min": 51.611900329589844, "max":
51.611900329589844}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.1043053, "EndTime": 1730606497.0864477,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.891326904296875, "count": 1, "min": 51.891326904296875, "max":
51.891326904296875}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
#metrics {"StartTime": 1730606495.5307395, "EndTime": 1730606497.11261,
"Dimensions": {"Algorithm": "LinearLearnerModel", "Host": "UNKNOWN",
"Operation": "scoring"}, "Metrics": {"json.encoder.time": {"sum":
51.70798301696777, "count": 1, "min": 51.70798301696777, "max":
51.70798301696777}, "invocations.count": {"sum": 1.0, "count": 1, "min": 1,
"max": 1}}}
2024-11-03T04:01:35.534:[sagemaker logs]: MaxConcurrentTransforms=16,
MaxPayloadInMB=6, BatchStrategy=MULTI_RECORD

[24]:
```
# Fetch and read the output from S3
s3 = boto3.client('s3')
obj = s3.get_object(Bucket=bucket, Key="{}/batch-out-linear/{}".format(prefix,␣
 ↪'batch-in-linear.csv.out'))
target_predicted = pd.read_csv(io.BytesIO(obj['Body'].read()), header = None,␣
 ↪names=['class'])

# Print or further process the predictions
target_predicted.head(5)
```

[24]:
```
                                          class
{"predicted_label":0  score:0.092295482754707}
{"predicted_label":0  score:0.150472730398178}
{"predicted_label":0   score:0.09202516824007}
{"predicted_label":0  score:0.127865061163902}
{"predicted_label":0  score:0.150395348668098}
```

[33]:
```
predictions = target_predicted.index
predictions[0][-1]
```

[33]:
```
'0'
```

[34]:
```
target_predicted.iloc[0, 0][6:-1]
```

[34]:
```
'0.092295482754707'
```

[35]:
```
predictions = target_predicted.index
prediction_labels = [prediction[-1] for prediction in predictions]
# prediction_label
```

[36]:
```
prediction_scores = [row[0][6:-1] for row in target_predicted.
 ↪itertuples(index=False)]
# prediction_scores
```

[37]:
```
import pandas as pd

# Convert prediction_scores and prediction_labels to numeric
prediction_scores = pd.to_numeric(prediction_scores)
prediction_labels = pd.to_numeric(prediction_labels)
```

[38]:
```
len(prediction_scores)
```

[38]:
```
245338
```

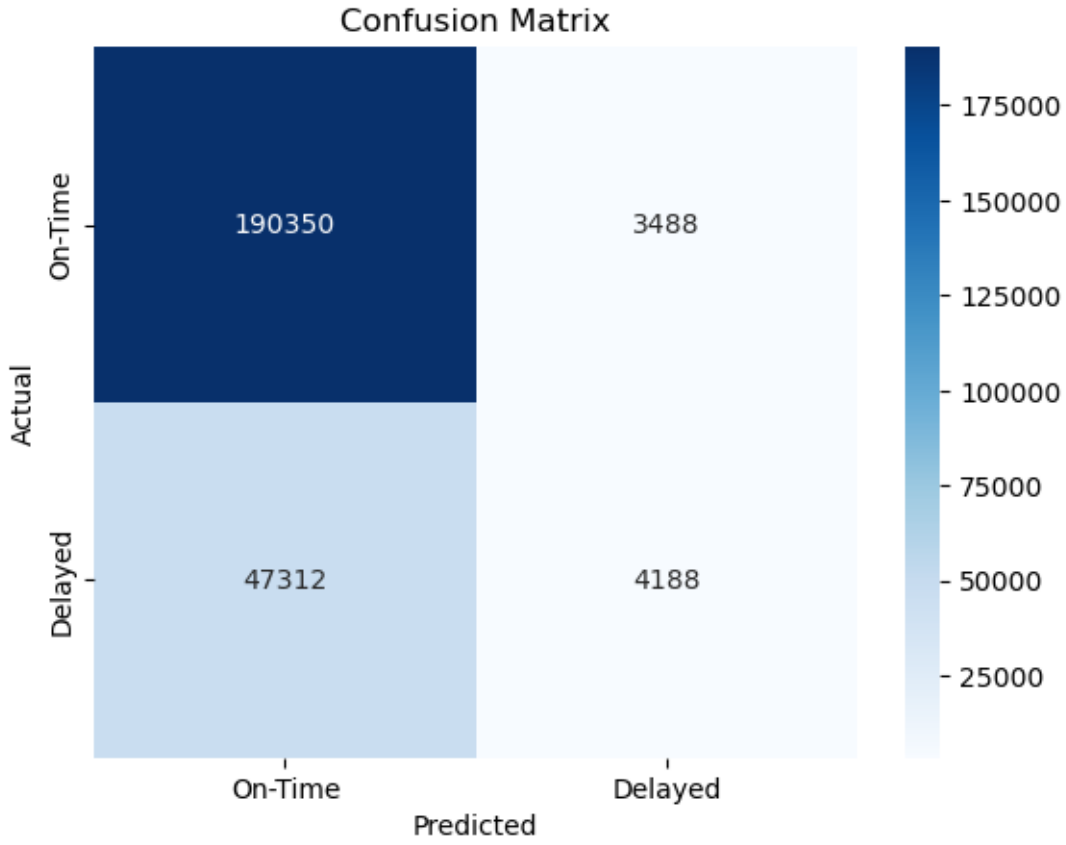
[39]:
```
len(prediction_labels)
```

[39]:
```
245338
```

[ ]:

1.2.5 Results

[40]:
```
# Confusion matrix for test data
plot_confusion_matrix(test.iloc[:, 0], prediction_labels)
```



[41]:
```
# classification report
from sklearn.metrics import classification_report

# Classification report for test data
print("Classification Report on Test Data")
print(classification_report(test.iloc[:, 0], prediction_labels))
```

```
Classification Report on Test Data
              precision    recall  f1-score   support

         0.0       0.80      0.98      0.88    193838
         1.0       0.55      0.08      0.14     51500
```

```
    accuracy                           0.79    245338
   macro avg       0.67      0.53      0.51    245338
weighted avg       0.75      0.79      0.73    245338
```

1.2.6 Observations and Insights

1.3 Model 2 - Ensemble Model

1.3.1 Loading Data

[42]:
```
df_ensemble = data_v2.copy()

df_ensemble.shape
```

[42]:
```
(1635590, 86)
```

[43]:
```
df_ensemble.head()
```

[43]:

	target	Distance	DepHourofDay	AWND_O	PRCP_O	TAVG_O	AWND_D	PRCP_D	\
0	0.0	689.0	21	33	0	54.0	30	0	
1	0.0	731.0	9	39	0	136.0	33	0	
2	0.0	1199.0	18	33	0	54.0	77	0	
3	0.0	1587.0	16	33	0	54.0	20	0	
4	0.0	1587.0	7	20	0	165.0	33	0	

	TAVG_D	SNOW_O	…	Origin_SFO	Dest_CLT	Dest_DEN	Dest_DFW	Dest_IAH	\
0	130.0	0.0	…	0	0	0	0	1	
1	54.0	0.0	…	0	0	0	0	0	
2	68.0	0.0	…	0	0	1	0	0	
3	165.0	0.0	…	0	0	0	0	0	
4	54.0	0.0	…	0	0	0	0	0	

	Dest_LAX	Dest_ORD	Dest_PHX	Dest_SFO	is_holiday_True
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	1	0	0
4	0	0	0	0	0

[5 rows x 86 columns]

[44]:
```
df_ensemble_cleaned = df_ensemble.replace({True: 1, False: 0})

df_ensemble_cleaned.head(5)
```

[44]:

	target	Distance	DepHourofDay	AWND_O	PRCP_O	TAVG_O	AWND_D	PRCP_D	\
0	0.0	689.0	21	33	0	54.0	30	0	
1	0.0	731.0	9	39	0	136.0	33	0	
2	0.0	1199.0	18	33	0	54.0	77	0	
3	0.0	1587.0	16	33	0	54.0	20	0	
4	0.0	1587.0	7	20	0	165.0	33	0	

	TAVG_D	SNOW_O	…	Origin_SFO	Dest_CLT	Dest_DEN	Dest_DFW	Dest_IAH	\
0	130.0	0.0	…	0	0	0	0	1	
1	54.0	0.0	…	0	0	0	0	0	
2	68.0	0.0	…	0	0	1	0	0	
3	165.0	0.0	…	0	0	0	0	0	
4	54.0	0.0	…	0	0	0	0	0	

	Dest_LAX	Dest_ORD	Dest_PHX	Dest_SFO	is_holiday_True
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	1	0	0
4	0	0	0	0	0

[5 rows x 86 columns]

[45]:
```
df_ensemble_cleaned.isnull().sum().sum()
```

[45]: 0

[46]:
```
df_ensemble_cleaned.shape
```

[46]: (1635590, 86)

1.3.2 Train, Test and Validate Splits

[47]:
```
# split the data

train, test_and_validate = train_test_split(
    df_ensemble_cleaned,
    test_size=0.3,
    random_state=42,
    stratify=df_ensemble_cleaned["target"],
)
test, validate = train_test_split(
    test_and_validate,
    test_size=0.5,
    random_state=42,
    stratify=test_and_validate["target"],
)
```

[48]:
```
# shape of train data
train.shape
```

[48]:
```
(1144913, 86)
```

[49]:
```
# shape of test
test.shape
```

[49]:
```
(245338, 86)
```

[50]:
```
# shape of validate
validate.shape
```

[50]:
```
(245339, 86)
```

1.3.3 Uploading Data to AWS S3 Buckets

[51]:
```
# set the names of the csv files
train_file = "data_v2E_train.csv"
test_file = "data_v2E_test.csv"
validate_file = "data_v2E_validate.csv"
```

[52]:
```
# uploading data to aws s3

upload_s3_csv(train_file, "train", train)
upload_s3_csv(test_file, "test", test)
upload_s3_csv(validate_file, "validate", validate)
```

```
s3.Bucket(name='u3253992-ajulthomas-oncloud')
s3.Bucket(name='u3253992-ajulthomas-oncloud')
s3.Bucket(name='u3253992-ajulthomas-oncloud')
```

1.3.4 Retrieving the ML model - xgboost

[53]:
```
import boto3
from sagemaker.image_uris import retrieve

container = retrieve("xgboost", "us-east-1", version="1.0-1")
```

```
INFO:sagemaker.image_uris:Defaulting to only available Python version: py3
INFO:sagemaker.image_uris:Defaulting to only supported image scope: cpu.
```

[54]:
```
hyperparams = {"num_round": "42", "eval_metric": "auc", "objective": "binary:
 ↪logistic"}
```

[55]:
```
import sagemaker

# Ensure your session is set to the same region as the bucket
session = sagemaker.Session(boto3.session.Session(region_name="us-east-1"))
```

```
s3_output_location = "s3://{}/{}/output/".format(bucket, prefix)
xgb_model = sagemaker.estimator.Estimator(
    container,
    sagemaker.get_execution_role(),
    instance_count=1,
    instance_type="ml.c5.2xlarge",
    output_path=s3_output_location,
    hyperparameters=hyperparams,
    sagemaker_session=session,
)
```

```
INFO:botocore.credentials:Found credentials from IAM Role:
BaseNotebookInstanceEc2InstanceRole
```

[56]:
```
train_channel = sagemaker.inputs.TrainingInput(
    "s3://{}/{}/train/{}".format(bucket, prefix, train_file),␣
 ↪content_type="text/csv"
)

validate_channel = sagemaker.inputs.TrainingInput(
    "s3://{}/{}/validate/{}".format(bucket, prefix, validate_file),
    content_type="text/csv",
)

print(f"channels {validate_channel} \n {train_channel}")

data_channels = {"train": train_channel, "validation": validate_channel}
```

```
channels <sagemaker.inputs.TrainingInput object at 0x7f901b2a5900>
 <sagemaker.inputs.TrainingInput object at 0x7f901b2a6980>
```

1.3.5 Training the model

[57]:
```
xgb_model.fit(inputs=data_channels, logs=False)
```

```
INFO:sagemaker:Creating training-job with name: sagemaker-
xgboost-2024-11-03-04-04-31-407


2024-11-03 04:04:33 Starting - Starting the training job.
2024-11-03 04:04:47 Starting - Preparing the instances for training…
2024-11-03 04:05:11 Downloading - Downloading input data…
2024-11-03 04:05:36 Downloading - Downloading the training image…
2024-11-03 04:05:57 Training - Training image download completed. Training in
progress…
2024-11-03 04:07:00 Uploading - Uploading generated training model
2024-11-03 04:07:08 Completed - Training job completed
```

1.3.6 Deploying the model

[ ]:
```
# xgb_predictor = xgb_model.deploy(
#     initial_instance_count=1,
#     serializer=sagemaker.serializers.CSVSerializer(),
#     instance_type="ml.c5.2xlarge",
# )
```

1.3.7 Creating batch input for predictions

[58]:
```
# extracts the features from the test data
batch_X = test.iloc[:, 1:]

# replace all True, False Values with 1 and 0
# batch_X = batch_X.replace({True: 1, False: 0})

# filename of the batch input file while uploading to s3
batch_X_file = "batch-in.csv"

# save the batch input file
upload_s3_csv(batch_X_file, "batch-in", batch_X)
```

```
s3.Bucket(name='u3253992-ajulthomas-oncloud')
```

[59]:
```
batch_X.isnull().sum().sum()

batch_X.shape
```

[59]:
```
(245338, 85)
```

[60]:
```
batch_X.head()
```

[60]:

	Distance	DepHourofDay	AWND_O	PRCP_O	TAVG_O	AWND_D	PRCP_D	\
470151	1947.0	13	30	0	158.0	22	0	
985696	925.0	14	50	0	212.0	33	0	
394886	862.0	9	31	0	24.0	45	0	
924542	1744.0	10	41	0	229.0	34	0	
1533313	936.0	7	20	43	257.0	52	0	

	TAVG_D	SNOW_O	SNOW_D	…	Origin_SFO	Dest_CLT	Dest_DEN	\
470151	244.0	0.0	0.0	…	0	0	0	
985696	109.0	0.0	0.0	…	0	0	0	
394886	-58.0	0.0	0.0	…	0	0	1	
924542	194.0	0.0	0.0	…	0	0	0	
1533313	301.0	0.0	0.0	…	0	0	0	

	Dest_DFW	Dest_IAH	Dest_LAX	Dest_ORD	Dest_PHX	Dest_SFO	\
470151	0	0	0	0	0	0	

```
985696          0         0         0         1         0         0
394886          0         0         0         0         0         0
924542          0         0         1         0         0         0
1533313         1         0         0         0         0         0

         is_holiday_True
470151                 0
985696                 0
394886                 0
924542                 1
1533313                0

[5 rows x 85 columns]
```

1.3.8 Setting up batch transformation job

[61]:
```
# set the output location for the batch output
batch_output = "s3://{}/{}/batch-out/".format(bucket, prefix)

# set the batch input location
batch_input = "s3://{}/{}/batch-in/{}".format(bucket, prefix, batch_X_file)

# create the transformer object from the xgb model
xgb_transformer = xgb_model.transformer(
    instance_count=1,
    instance_type="ml.c5.2xlarge",
    strategy="MultiRecord",
    assemble_with="Line",
    output_path=batch_output,
)
```

```
INFO:sagemaker:Creating model with name: sagemaker-
xgboost-2024-11-03-04-08-21-409
```

1.3.9 Batch Transform

[62]:
```
# starts the batch transform job
xgb_transformer.transform(
    data=batch_input, data_type="S3Prefix", content_type="text/csv",␣
 ↪split_type="Line"
)

# waits for the batch transform job to finish
xgb_transformer.wait()
```

```
INFO:sagemaker:Creating transform job with name: sagemaker-
xgboost-2024-11-03-04-08-54-513
```

```
…[2024-11-03:04:14:22:INFO] No GPUs detected
(normal if no gpus installed)
[2024-11-03:04:14:22:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:22:INFO] nginx config:
worker_processes auto;
daemon off;
pid /tmp/nginx.pid;
error_log  /dev/stderr;
worker_rlimit_nofile 4096;
events {
  worker_connections 2048;
}
http {
  include /etc/nginx/mime.types;
  default_type application/octet-stream;
  access_log /dev/stdout combined;
  upstream gunicorn {
    server unix:/tmp/gunicorn.sock;
  }
  server {
    listen 8080 deferred;
    client_max_body_size 0;
    keepalive_timeout 3;
    location ~ ^/(ping|invocations|execution-parameters) {
      proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
      proxy_set_header Host $http_host;
      proxy_redirect off;
      proxy_read_timeout 60s;
      proxy_pass http://gunicorn;
    }
    location / {
      return 404 "{}";
    }
  }
```

```
}
[2024-11-03 04:14:22 +0000] [27] [INFO] Starting gunicorn 19.10.0
[2024-11-03 04:14:22 +0000] [27] [INFO] Listening at:
unix:/tmp/gunicorn.sock (27)
[2024-11-03 04:14:22 +0000] [27] [INFO] Using worker: gevent
[2024-11-03 04:14:22 +0000] [38] [INFO] Booting worker with pid: 38
[2024-11-03 04:14:22 +0000] [39] [INFO] Booting worker with pid: 39
[2024-11-03 04:14:22 +0000] [47] [INFO] Booting worker with pid: 47
[2024-11-03 04:14:22 +0000] [48] [INFO] Booting worker with pid: 48
[2024-11-03 04:14:22 +0000] [56] [INFO] Booting worker with pid: 56
[2024-11-03 04:14:22 +0000] [57] [INFO] Booting worker with pid: 57
[2024-11-03 04:14:22 +0000] [65] [INFO] Booting worker with pid: 65
[2024-11-03 04:14:22 +0000] [66] [INFO] Booting worker with pid: 66
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /ping HTTP/1.1" 200 0
"-" "Go-http-client/1.1"
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /execution-parameters
HTTP/1.1" 200 84 "-" "Go-http-client/1.1"
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:28 +0000] "POST /invocations
HTTP/1.1" 200 251045 "-" "Go-http-client/1.1"
```

```
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652539 "-" "Go-http-client/1.1"
[2024-11-03:04:14:29:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652678 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652521 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652564 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652425 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652416 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652539 "-" "Go-http-client/1.1"
[2024-11-03:04:14:29:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652678 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652521 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652564 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652425 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652416 "-" "Go-http-client/1.1"
2024-11-03T04:14:26.752:[sagemaker logs]: MaxConcurrentTransforms=8,
MaxPayloadInMB=6, BatchStrategy=MULTI_RECORD
169.254.255.130 - - [03/Nov/2024:04:14:31 +0000] "POST /invocations
HTTP/1.1" 200 652335 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:31 +0000] "POST /invocations
HTTP/1.1" 200 652335 "-" "Go-http-client/1.1"

[2024-11-03:04:14:22:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:22:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:22:INFO] nginx config:
```

```
worker_processes auto;
daemon off;
pid /tmp/nginx.pid;
error_log  /dev/stderr;
worker_rlimit_nofile 4096;
events {
  worker_connections 2048;
}
[2024-11-03:04:14:22:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:22:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:22:INFO] nginx config:
worker_processes auto;
daemon off;
pid /tmp/nginx.pid;
error_log  /dev/stderr;
worker_rlimit_nofile 4096;
events {
  worker_connections 2048;
}
```

```
http {
  include /etc/nginx/mime.types;
  default_type application/octet-stream;
  access_log /dev/stdout combined;
  upstream gunicorn {
    server unix:/tmp/gunicorn.sock;
  }
  server {
    listen 8080 deferred;
    client_max_body_size 0;
    keepalive_timeout 3;
    location ~ ^/(ping|invocations|execution-parameters) {
      proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
      proxy_set_header Host $http_host;
      proxy_redirect off;
      proxy_read_timeout 60s;
      proxy_pass http://gunicorn;
    }
    location / {
      return 404 "{}";
    }
  }
}
[2024-11-03 04:14:22 +0000] [27] [INFO] Starting gunicorn 19.10.0
[2024-11-03 04:14:22 +0000] [27] [INFO] Listening at:
unix:/tmp/gunicorn.sock (27)
[2024-11-03 04:14:22 +0000] [27] [INFO] Using worker: gevent
[2024-11-03 04:14:22 +0000] [38] [INFO] Booting worker with pid: 38
[2024-11-03 04:14:22 +0000] [39] [INFO] Booting worker with pid: 39
[2024-11-03 04:14:22 +0000] [47] [INFO] Booting worker with pid: 47
[2024-11-03 04:14:22 +0000] [48] [INFO] Booting worker with pid: 48
[2024-11-03 04:14:22 +0000] [56] [INFO] Booting worker with pid: 56
[2024-11-03 04:14:22 +0000] [57] [INFO] Booting worker with pid: 57
[2024-11-03 04:14:22 +0000] [65] [INFO] Booting worker with pid: 65
[2024-11-03 04:14:22 +0000] [66] [INFO] Booting worker with pid: 66
```

```
http {
  include /etc/nginx/mime.types;
  default_type application/octet-stream;
  access_log /dev/stdout combined;
  upstream gunicorn {
    server unix:/tmp/gunicorn.sock;
  }
  server {
    listen 8080 deferred;
    client_max_body_size 0;
    keepalive_timeout 3;
    location ~ ^/(ping|invocations|execution-parameters) {
      proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
      proxy_set_header Host $http_host;
      proxy_redirect off;
      proxy_read_timeout 60s;
      proxy_pass http://gunicorn;
    }
    location / {
      return 404 "{}";
    }
  }
}
[2024-11-03 04:14:22 +0000] [27] [INFO] Starting gunicorn 19.10.0
[2024-11-03 04:14:22 +0000] [27] [INFO] Listening at:
unix:/tmp/gunicorn.sock (27)
[2024-11-03 04:14:22 +0000] [27] [INFO] Using worker: gevent
[2024-11-03 04:14:22 +0000] [38] [INFO] Booting worker with pid: 38
[2024-11-03 04:14:22 +0000] [39] [INFO] Booting worker with pid: 39
[2024-11-03 04:14:22 +0000] [47] [INFO] Booting worker with pid: 47
[2024-11-03 04:14:22 +0000] [48] [INFO] Booting worker with pid: 48
[2024-11-03 04:14:22 +0000] [56] [INFO] Booting worker with pid: 56
[2024-11-03 04:14:22 +0000] [57] [INFO] Booting worker with pid: 57
[2024-11-03 04:14:22 +0000] [65] [INFO] Booting worker with pid: 65
[2024-11-03 04:14:22 +0000] [66] [INFO] Booting worker with pid: 66
```

```
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /ping HTTP/1.1" 200 0
"-" "Go-http-client/1.1"
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /execution-parameters
HTTP/1.1" 200 84 "-" "Go-http-client/1.1"
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /ping HTTP/1.1" 200 0
"-" "Go-http-client/1.1"
[2024-11-03:04:14:26:INFO] No GPUs detected (normal if no gpus
installed)
169.254.255.130 - - [03/Nov/2024:04:14:26 +0000] "GET /execution-parameters
HTTP/1.1" 200 84 "-" "Go-http-client/1.1"
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
```

```
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] No GPUs detected (normal if no gpus
installed)
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
[2024-11-03:04:14:27:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:28 +0000] "POST /invocations
HTTP/1.1" 200 251045 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:28 +0000] "POST /invocations
HTTP/1.1" 200 251045 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652539 "-" "Go-http-client/1.1"
[2024-11-03:04:14:29:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652678 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652521 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652564 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652425 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652416 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652539 "-" "Go-http-client/1.1"
[2024-11-03:04:14:29:INFO] Determined delimiter of CSV input is ','
169.254.255.130 - - [03/Nov/2024:04:14:29 +0000] "POST /invocations
HTTP/1.1" 200 652678 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652521 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652564 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652425 "-" "Go-http-client/1.1"
```

```
169.254.255.130 - - [03/Nov/2024:04:14:30 +0000] "POST /invocations
HTTP/1.1" 200 652416 "-" "Go-http-client/1.1"
2024-11-03T04:14:26.752:[sagemaker logs]: MaxConcurrentTransforms=8,
MaxPayloadInMB=6, BatchStrategy=MULTI_RECORD
169.254.255.130 - - [03/Nov/2024:04:14:31 +0000] "POST /invocations
HTTP/1.1" 200 652335 "-" "Go-http-client/1.1"
169.254.255.130 - - [03/Nov/2024:04:14:31 +0000] "POST /invocations
HTTP/1.1" 200 652335 "-" "Go-http-client/1.1"
```

1.3.10 Retrieving Prediction Results

[63]:
```python
# initialize the s3 client
s3 = boto3.client("s3")

# get the batch output file generated by the batch transform job
obj = s3.get_object(
    Bucket=bucket, Key="{}/batch-out/{}".format(prefix, "batch-in.csv.out")
)

# read the batch output file
target_predicted = pd.read_csv(io.BytesIO(obj["Body"].read()), names=["class"])
```

1.3.11 Exploring results

[117]:
```python
# functoin to convert the predicted values to binary
def binary_convert(x):
    threshold = 0.28
    if x > threshold:
        return 1
    else:
        return 0


# convert the predicted values to binary
target_predicted_binary = target_predicted["class"].apply(binary_convert)

print(target_predicted_binary.head(5))
test.head(5)
```

```
0    0
1    0
2    0
3    0
4    0
Name: class, dtype: int64
```

[117]:
```
         target  Distance  DepHourofDay  AWND_O  PRCP_O  TAVG_O  AWND_D  \
470151      0.0    1947.0            13      30       0   158.0      22
985696      0.0     925.0            14      50       0   212.0      33
394886      0.0     862.0             9      31       0    24.0      45
924542      0.0    1744.0            10      41       0   229.0      34
1533313     0.0     936.0             7      20      43   257.0      52

         PRCP_D  TAVG_D  SNOW_O  …  Origin_SFO  Dest_CLT  Dest_DEN  \
470151        0   244.0     0.0  …           0         0         0
985696        0   109.0     0.0  …           0         0         0
394886        0   -58.0     0.0  …           0         0         1
924542        0   194.0     0.0  …           0         0         0
1533313       0   301.0     0.0  …           0         0         0

         Dest_DFW  Dest_IAH  Dest_LAX  Dest_ORD  Dest_PHX  Dest_SFO  \
470151          0         0         0         0         0         0
985696          0         0         0         1         0         0
394886          0         0         0         0         0         0
924542          0         0         1         0         0         0
1533313         1         0         0         0         0         0

         is_holiday_True
470151                 0
985696                 0
394886                 0
924542                 1
1533313                0

[5 rows x 86 columns]
```

[118]:
```
# extract the test labels
test_labels = test.iloc[:, 0]

test_labels.head(5)
```

[118]:
```
470151     0.0
985696     0.0
394886     0.0
924542     0.0
1533313    0.0
Name: target, dtype: float64
```

1.3.12 Results

Classification Report

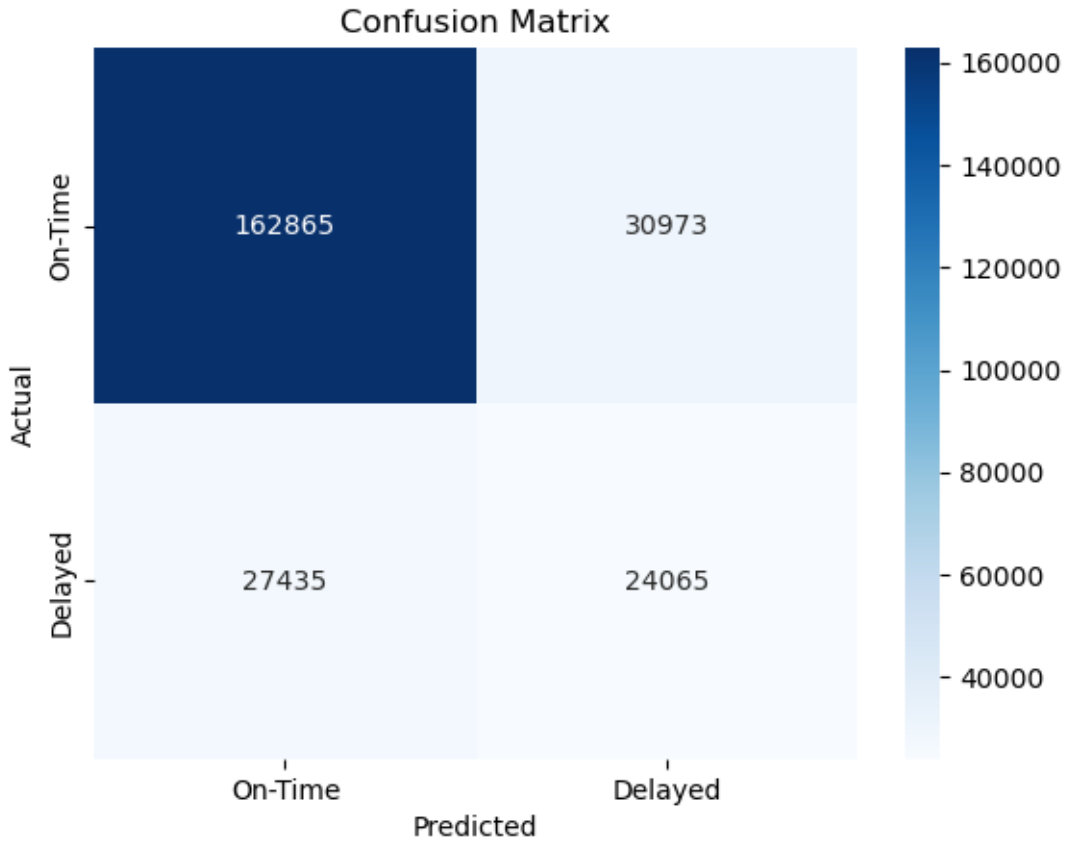
[119]:
```
# classification report
from sklearn.metrics import classification_report
```

```
# Classification report for test data
print("Classification Report on Test Data")
print(classification_report(test_labels, target_predicted_binary))
```

```
Classification Report on Test Data
              precision    recall  f1-score   support

         0.0       0.86      0.84      0.85    193838
         1.0       0.44      0.47      0.45     51500

    accuracy                           0.76    245338
   macro avg       0.65      0.65      0.65    245338
weighted avg       0.77      0.76      0.76    245338
```

Confusion Matrix

[120]:
```
# plot the confusion matrix
plot_confusion_matrix(test_labels, target_predicted_binary)
```



[121]:
```
TN, FP, FN, TP = confusion_matrix(test_labels, target_predicted_binary).ravel()

print(f"True Negative (TN) : {TN}")
print(f"False Positive (FP): {FP}")
print(f"False Negative (FN): {FN}")
print(f"True Positive (TP) : {TP}")
```

```
True Negative (TN) : 162865
False Positive (FP): 30973
False Negative (FN): 27435
True Positive (TP) : 24065
```

Sensitivity *Sensitivity* is also known as *hit rate*, *recall*, or *true positive rate (TPR)*. It measures the proportion of the actual positives that are correctly identified.

[122]:
```
# Sensitivity, hit rate, recall, or true positive rate
Sensitivity = float(TP) / (TP + FN) * 100
print(f"Sensitivity or TPR: {Sensitivity}%")
print(
    f"There is a {Sensitivity}% chance of detecting detecting flights delayed␣
 ↪are actually delayed."
)
```

```
Sensitivity or TPR: 46.728155339805824%
There is a 46.728155339805824% chance of detecting detecting flights delayed are
actually delayed.
```

Specificity

[123]:
```
# Specificity or true negative rate
Specificity = float(TN) / (TN + FP) * 100
print(f"Specificity or TNR: {Specificity}%")
print(f"There is a {Specificity}% chance of flights on-time are actually␣
 ↪on-time")
```

```
Specificity or TNR: 84.02119295494175%
There is a 84.02119295494175% chance of flights on-time are actually on-time
```

Overall Accuracy

[124]:
```
# Overall accuracy
ACC = float(TP + TN) / (TP + FP + FN + TN) * 100
print(f"Accuracy: {ACC}%")
```

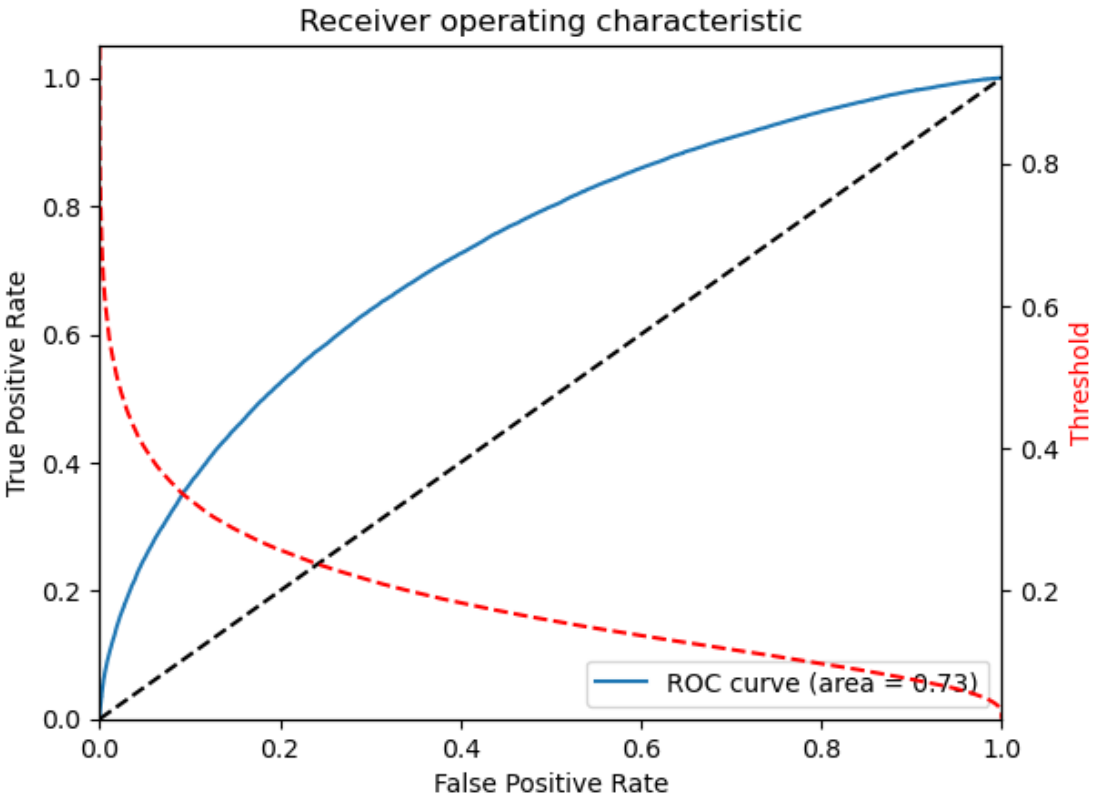
```
Accuracy: 76.19284415785569%
```

AUC-ROC Curve

[125]:
```
from sklearn.metrics import roc_auc_score, roc_curve, auc

print("Validation AUC", roc_auc_score(test_labels, target_predicted))
```

```
Validation AUC 0.7314451676041759
```

[126]:
```python
import numpy as np

fpr, tpr, thresholds = roc_curve(test_labels, target_predicted)

finite_indices = np.isfinite(thresholds)
fpr_finite = fpr[finite_indices]
tpr_finite = tpr[finite_indices]
thresholds_finite = thresholds[finite_indices]

plt.figure()
plt.plot(
    fpr_finite,
    tpr_finite,
    label="ROC curve (area = %0.2f)" % auc(fpr_finite, tpr_finite),
)
plt.plot([0, 1], [0, 1], "k--")  # Dashed diagonal
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("Receiver operating characteristic")
plt.legend(loc="lower right")

roc_auc = auc(fpr, tpr)

if thresholds_finite.size > 0:
    ax2 = plt.gca().twinx()
    ax2.plot(
        fpr_finite,
        thresholds_finite,
        markeredgecolor="r",
        linestyle="dashed",
        color="r",
    )
    ax2.set_ylabel("Threshold", color="r")
    ax2.set_ylim([thresholds_finite[-1], thresholds_finite[0]])
    ax2.set_xlim([fpr_finite[0], fpr_finite[-1]])

plt.show()
```


Receiver operating characteristic
True Positive Rate
False Positive Rate
Threshold
ROC curve (area = 0.73)
0.0
0.2
0.4
0.6
0.8
1.0