Common Task 2 - Quark-Gluon Classification M1

March 26, 2024

0.1 Importing Libraries

[1]:
```
import os
import h5py
import numpy as np
import pandas as pd
import pyarrow as pa
import tensorflow as tf
import pyarrow.parquet as pq
import matplotlib.pyplot as plt
from tensorflow.keras.optimizers import Adam
from sklearn.model_selection import train_test_split
from tensorflow.keras.models import Sequential, Model
from sklearn.metrics import roc_curve, auc, roc_auc_score
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Dense, Flatten,␣
↪Dropout, BatchNormalization, Add, Input
```

```
2024-03-25 06:16:08.198379: E
external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:9261] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
2024-03-25 06:16:08.198541: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:607] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
2024-03-25 06:16:08.351352: E
external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1515] Unable to
register cuBLAS factory: Attempting to register factory for plugin cuBLAS when
one has already been registered
```

0.2 Disable Warnings

[2]:
```
import warnings
warnings.simplefilter("ignore")
warnings.filterwarnings("ignore")
```

0.3 Load the Dataset

[3]:
```
def read_file(path):
  chunk_size = 25

# Create a Parquet file reader object
  parquet_file = pq.ParquetFile(path)

# Determine the total number of rows in the file
  total_rows = parquet_file.metadata.num_rows

# Loop over the file in chunks
  data = []
  for i in range(0, total_rows, chunk_size):
    # Read a chunk of rows from the file
      chunk = (parquet_file.read_row_group(i))
      dm = (chunk.to_pandas())
      data.append(dm)

# Concatenate all the DataFrames into a single DataFrame
  df = pd.concat(data, ignore_index=True)
  print(parquet_file.read_row_group(0).to_pandas())
  return df
```

[4]:
```
df1 = read_file('/kaggle/input/common-task-2-dataset/Task - 2 Data (Parquet)/
 ↪jet0_run0.test.snappy.parquet')
df2 = read_file('/kaggle/input/common-task-2-dataset/Task - 2 Data (Parquet)/
 ↪jet0_run1.test.snappy.parquet')
df3 = read_file('/kaggle/input/common-task-2-dataset/Task - 2 Data (Parquet)/
 ↪jet0_run2.test.snappy.parquet')
```

```
                                              X_jets          pt         m0  \
0  [[[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0…  112.411095  21.098248

     y
0  0.0
                                              X_jets          pt         m0  \
0  [[[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0…  147.686737  32.114449

     y
0  0.0
                                              X_jets          pt         m0  \
0  [[[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0…  107.854118  18.723455

     y
0  0.0
```

0.4 Constructing X and y

[5]:
```
def construct_X_y(df):
    # Get the total number of samples
    num_samples = len(df)

    # Initialize empty arrays for X and y
    X = np.empty((num_samples, 3, 125, 125), dtype=np.float32)
    y = np.empty(num_samples, dtype=int)

    # Iterate through the DataFrame and fill X and y
    for i, row in df.iterrows():
        # Stack the three channels of X_jets and transpose them to match the␣
 ↪desired shape
        X[i] = np.transpose(np.dstack((np.stack(row['X_jets'][0]), np.
 ↪stack(row['X_jets'][1]), np.stack(row['X_jets'][2]))), (2, 0, 1))
        # Assign the label to y
        y[i] = row['y']

    # Rearrange the dimensions of X to match the TensorFlow format (samples,␣
 ↪height, width, channels)
    X = np.transpose(X, (0, 2, 3, 1))

    return X, y
```

[6]:
```
# Assuming 'df' is the pandas DataFrame
X1, y1 = construct_X_y(df1)
X2, y2 = construct_X_y(df2)
X3, y3 = construct_X_y(df3)
```

[7]:
```
# Save X1 array to binary file 'X1.npy'
with open('X1.npy', 'wb') as f:
    np.save(f, X1)

# Save y1 array to binary file 'y1.npy'
with open('y1.npy', 'wb') as f:
    np.save(f, y1)

# Save X2 array to binary file 'X2.npy'
with open('X2.npy', 'wb') as f:
    np.save(f, X2)

# Save y2 array to binary file 'y2.npy'
with open('y2.npy', 'wb') as f:
    np.save(f, y2)

# Save X3 array to binary file 'X3.npy'
```

```
with open('X3.npy', 'wb') as f:
    np.save(f, X3)

# Save y3 array to binary file 'y3.npy'
with open('y3.npy', 'wb') as f:
    np.save(f, y3)
```

[8]:
```
x1 = np.load('X1.npy')
x2 = np.load('X2.npy')
x3 = np.load('X3.npy')

y1 = np.load('y1.npy')
y2 = np.load('y2.npy')
y3 = np.load('y3.npy')
```

[9]:
```
# Combine x arrays along the first axis (axis=0)
x = np.concatenate((x1, x2, x3), axis=0)

# Combine y arrays along the first axis (axis=0)
y = np.concatenate((y1, y2, y3), axis=0)

# Save the combined X array to a binary file named 'X.npy'
with open('x.npy', 'wb') as f:
    np.save(f, x)

# Save the combined y array to a binary file named 'y.npy'
with open('y.npy', 'wb') as f:
    np.save(f, y)
```

[10]:
```
# Loading the content of x.npy into the variable x
x = np.load('x.npy')

# Loading the content of y.npy into the variable y
y = np.load('y.npy')
```

0.5 Similar to VGG with 12 layers Model Creation

[11]:
```
# Create a Sequential model
model = Sequential()

# First convolutional block
model.add(Conv2D(64, (3, 3), activation="relu", padding="same",␣
 ↪input_shape=(125, 125, 3)))
model.add(Conv2D(64, (3, 3), activation="relu", padding="same"))
model.add(MaxPooling2D((2, 2), strides=(2, 2)))
```

```
# Four more convolutional blocks with increasing filter numbers
for filters in [128, 256, 256, 256]:
    model.add(Conv2D(filters, (3, 3), activation="relu", padding="same"))
    model.add(Conv2D(filters, (3, 3), activation="relu", padding="same"))
    model.add(MaxPooling2D((2, 2), strides=(2, 2)))

# Flatten the output for fully connected layers
model.add(Flatten())

# Fully connected layers
model.add(Dense(4096, activation="relu"))
model.add(Dense(4096, activation="relu"))
model.add(Dense(1, activation='sigmoid'))

# Define the optimizer (Adam) with a learning rate of 1e-4
optimizer = Adam(learning_rate=1e-4)

# Compile the model with binary crossentropy loss and accuracy metric
model.compile(optimizer=optimizer, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
```

[12]:
```
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 125, 125, 64)	1,792
conv2d_1 (Conv2D)	(None, 125, 125, 64)	36,928
max_pooling2d (MaxPooling2D)	(None, 62, 62, 64)	0
conv2d_2 (Conv2D)	(None, 62, 62, 128)	73,856
conv2d_3 (Conv2D)	(None, 62, 62, 128)	147,584
max_pooling2d_1 (MaxPooling2D)	(None, 31, 31, 128)	0
conv2d_4 (Conv2D)	(None, 31, 31, 256)	295,168
conv2d_5 (Conv2D)	(None, 31, 31, 256)	590,080
max_pooling2d_2 (MaxPooling2D)	(None, 15, 15, 256)	0

conv2d_6 (Conv2D)	(None, 15, 15, 256)	590,080
conv2d_7 (Conv2D)	(None, 15, 15, 256)	590,080
max_pooling2d_3 (MaxPooling2D)	(None, 7, 7, 256)	0
conv2d_8 (Conv2D)	(None, 7, 7, 256)	590,080
conv2d_9 (Conv2D)	(None, 7, 7, 256)	590,080
max_pooling2d_4 (MaxPooling2D)	(None, 3, 3, 256)	0
flatten (Flatten)	(None, 2304)	0
dense (Dense)	(None, 4096)	9,441,280
dense_1 (Dense)	(None, 4096)	16,781,312
dense_2 (Dense)	(None, 1)	4,097

Total params: 29,732,417 (113.42 MB)

Trainable params: 29,732,417 (113.42 MB)

Non-trainable params: 0 (0.00 B)

0.6 Data Splitting

[13]:
```
xtrain, xtest, ytrain, ytest = train_test_split(x,
                                                y,
                                                test_size = 0.2,
                                                random_state = 42)
```

0.7 Model Training

[14]:
```
history = model.fit(xtrain,
                    ytrain,
                    epochs=2,
                    batch_size=8,
                    validation_split=0.1,
                    verbose=1)
```

Epoch 1/2

```
2024-03-25 06:17:15.976982: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15625: 3.14988, expected 2.35139
2024-03-25 06:17:15.977054: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15626: 4.78672, expected 3.98824
2024-03-25 06:17:15.977065: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15627: 6.03375, expected 5.23526
2024-03-25 06:17:15.977074: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15628: 6.17867, expected 5.38018
2024-03-25 06:17:15.977083: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15630: 6.82997, expected 6.03149
2024-03-25 06:17:15.977092: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15631: 6.72692, expected 5.92843
2024-03-25 06:17:15.977101: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15633: 6.1838, expected 5.38532
2024-03-25 06:17:15.977110: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15634: 6.46883, expected 5.67035
2024-03-25 06:17:15.977119: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15635: 6.90205, expected 6.10357
2024-03-25 06:17:15.977128: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15636: 6.83442, expected 6.03594
2024-03-25 06:17:15.981147: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[8,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[8,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:15.981203: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:15.981212: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:15.981220: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
```

```
(535.129.3)
2024-03-25 06:17:15.981227: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:15.981244: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
2024-03-25 06:17:16.212502: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15625: 3.14988, expected 2.35139
2024-03-25 06:17:16.212574: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15626: 4.78672, expected 3.98824
2024-03-25 06:17:16.212585: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15627: 6.03375, expected 5.23526
2024-03-25 06:17:16.212594: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15628: 6.17867, expected 5.38018
2024-03-25 06:17:16.212602: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15630: 6.82997, expected 6.03149
2024-03-25 06:17:16.212611: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15631: 6.72692, expected 5.92843
2024-03-25 06:17:16.212620: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15633: 6.1838, expected 5.38532
2024-03-25 06:17:16.212629: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15634: 6.46883, expected 5.67035
2024-03-25 06:17:16.212638: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15635: 6.90205, expected 6.10357
2024-03-25 06:17:16.212647: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15636: 6.83442, expected 6.03594
2024-03-25 06:17:16.216855: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[8,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[8,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:16.216912: E
```

```
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:16.216923: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:16.216931: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:16.216939: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:16.216957: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
```

```
  7/502            10s 22ms/step - accuracy:
0.4998 - loss: 0.7293
```

```
WARNING: All log messages before absl::InitializeLog() is called are written to
STDERR
I0000 00:00:1711347442.413253     110 device_compiler.h:186] Compiled cluster
using XLA!  This line is logged at most once for the lifetime of the process.
W0000 00:00:1711347442.440764     110 graph_launch.cc:671] Fallback to op-by-op
mode because memset node breaks graph update
```

```
499/502            0s 21ms/step -
accuracy: 0.5899 - loss: 0.6920
```

```
2024-03-25 06:17:33.420833: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.56937, expected 2.92516
2024-03-25 06:17:33.420903: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
3.02387, expected 2.37967
2024-03-25 06:17:33.420914: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 2:
4.54004, expected 3.89583
2024-03-25 06:17:33.420923: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 3:
5.09986, expected 4.45565
2024-03-25 06:17:33.420931: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 4:
4.45816, expected 3.81396
2024-03-25 06:17:33.420940: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 6:
5.17383, expected 4.52963
2024-03-25 06:17:33.420949: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 7:
5.35262, expected 4.70841
2024-03-25 06:17:33.420957: E
```

```
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 8:
4.21949, expected 3.57529
2024-03-25 06:17:33.420966: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 9:
5.01183, expected 4.36763
2024-03-25 06:17:33.420975: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 10:
5.08633, expected 4.44212
2024-03-25 06:17:33.421000: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[4,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[4,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:33.421010: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:33.421024: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:33.421032: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:33.421040: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:33.421056: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
2024-03-25 06:17:33.475326: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.56937, expected 2.92516
2024-03-25 06:17:33.475401: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
3.02387, expected 2.37967
2024-03-25 06:17:33.475412: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 2:
4.54004, expected 3.89583
2024-03-25 06:17:33.475421: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 3:
5.09986, expected 4.45565
2024-03-25 06:17:33.475430: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 4:
4.45816, expected 3.81396
```

```
2024-03-25 06:17:33.475439: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 6:
5.17383, expected 4.52963
2024-03-25 06:17:33.475447: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 7:
5.35262, expected 4.70841
2024-03-25 06:17:33.475456: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 8:
4.21949, expected 3.57529
2024-03-25 06:17:33.475465: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 9:
5.01183, expected 4.36763
2024-03-25 06:17:33.475473: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 10:
5.08633, expected 4.44212
2024-03-25 06:17:33.475495: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[4,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[4,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:33.475505: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:33.475513: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:33.475521: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:33.475529: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:33.475547: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0

502/502            0s 31ms/step -
accuracy: 0.5902 - loss: 0.6919

W0000 00:00:1711347459.249347     110 graph_launch.cc:671] Fallback to op-by-op
mode because memset node breaks graph update
2024-03-25 06:17:39.749690: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.11701, expected 2.35351
```

```
2024-03-25 06:17:39.749747: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
3.74674, expected 2.98324
2024-03-25 06:17:39.749757: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 2:
5.51069, expected 4.74718
2024-03-25 06:17:39.749766: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 3:
4.987, expected 4.2235
2024-03-25 06:17:39.749774: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 4:
6.19833, expected 5.43482
2024-03-25 06:17:39.749783: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 5:
6.08456, expected 5.32105
2024-03-25 06:17:39.749791: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 6:
6.00823, expected 5.24473
2024-03-25 06:17:39.749799: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 7:
5.88386, expected 5.12036
2024-03-25 06:17:39.749807: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 8:
4.82103, expected 4.05752
2024-03-25 06:17:39.749815: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 9:
5.6066, expected 4.84309
2024-03-25 06:17:39.749838: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[6,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[6,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:39.749848: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:39.749856: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:39.749863: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:39.749870: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
```

```
<undefined>
2024-03-25 06:17:39.749886: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
2024-03-25 06:17:39.808739: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.11701, expected 2.35351
2024-03-25 06:17:39.808815: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
3.74674, expected 2.98324
2024-03-25 06:17:39.808825: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 2:
5.51069, expected 4.74718
2024-03-25 06:17:39.808833: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 3:
4.987, expected 4.2235
2024-03-25 06:17:39.808842: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 4:
6.19833, expected 5.43482
2024-03-25 06:17:39.808850: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 5:
6.08456, expected 5.32105
2024-03-25 06:17:39.808878: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 6:
6.00823, expected 5.24473
2024-03-25 06:17:39.808887: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 7:
5.88386, expected 5.12036
2024-03-25 06:17:39.808895: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 8:
4.82103, expected 4.05752
2024-03-25 06:17:39.808904: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 9:
5.6066, expected 4.84309
2024-03-25 06:17:39.808929: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[6,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[6,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:39.808940: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:39.808948: E
```

```
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:39.808957: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:39.808968: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:39.808988: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
```

```
502/502            31s 38ms/step -
accuracy: 0.5902 - loss: 0.6918 - val_accuracy: 0.6637 - val_loss: 0.6261
Epoch 2/2
502/502            11s 21ms/step -
accuracy: 0.6875 - loss: 0.6303 - val_accuracy: 0.6794 - val_loss: 0.6054
```

0.7.1 Prediction Probability

[15]:
```
y_pred_probs = model.predict(xtest)
```

```
2024-03-25 06:17:53.697767: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
2.43505, expected 2.04048
2024-03-25 06:17:53.697911: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15624: 2.7146, expected 2.32004
2024-03-25 06:17:53.697991: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
31181: 2.35534, expected 2.0195
2024-03-25 06:17:53.698000: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
31249: 1.93263, expected 1.59678
2024-03-25 06:17:53.698019: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
33499: 2.10129, expected 1.76903
2024-03-25 06:17:53.698494: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93750: 3.83611, expected 2.97959
2024-03-25 06:17:53.698528: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93751: 5.87899, expected 5.02247
2024-03-25 06:17:53.698538: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93752: 7.04584, expected 6.18933
2024-03-25 06:17:53.698546: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
```

```
93753: 6.05786, expected 5.20134
2024-03-25 06:17:53.698555: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93755: 7.15218, expected 6.29566
2024-03-25 06:17:53.714193: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[32,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[32,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:53.714256: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:53.714266: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:53.714274: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:53.714282: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:53.714300: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
2024-03-25 06:17:54.095636: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
2.43505, expected 2.04048
2024-03-25 06:17:54.095780: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
15624: 2.7146, expected 2.32004
2024-03-25 06:17:54.095860: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
31181: 2.35534, expected 2.0195
2024-03-25 06:17:54.095870: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
31249: 1.93263, expected 1.59678
2024-03-25 06:17:54.095890: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
33499: 2.10129, expected 1.76903
2024-03-25 06:17:54.096408: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93750: 3.83611, expected 2.97959
2024-03-25 06:17:54.096460: E
```

```
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93751: 5.87899, expected 5.02247
2024-03-25 06:17:54.096478: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93752: 7.04584, expected 6.18933
2024-03-25 06:17:54.096502: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93753: 6.05786, expected 5.20134
2024-03-25 06:17:54.096515: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at
93755: 7.15218, expected 6.29566
2024-03-25 06:17:54.112742: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[32,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[32,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:54.112805: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:54.112816: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:54.112824: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:54.112832: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:54.112852: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
```

```
33/35            0s 14ms/step
```

```
2024-03-25 06:17:59.423865: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.04372, expected 2.47797
2024-03-25 06:17:59.423938: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
4.27935, expected 3.7136
2024-03-25 06:17:59.423951: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 23:
4.38252, expected 3.81677
2024-03-25 06:17:59.423962: E
```

```
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 24:
3.82394, expected 3.25819
2024-03-25 06:17:59.423976: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 28:
3.93545, expected 3.36971
2024-03-25 06:17:59.423994: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 30:
4.59424, expected 4.02849
2024-03-25 06:17:59.424007: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 51:
4.56387, expected 3.99813
2024-03-25 06:17:59.424018: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 56:
3.96228, expected 3.39653
2024-03-25 06:17:59.424029: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 58:
4.37348, expected 3.80774
2024-03-25 06:17:59.424040: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 65:
4.63631, expected 4.07056
2024-03-25 06:17:59.437540: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[27,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[27,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:59.437608: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:59.437626: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:59.437638: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:59.437656: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
<undefined>
2024-03-25 06:17:59.437681: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
2024-03-25 06:17:59.731561: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 0:
3.04372, expected 2.47797
```

```
2024-03-25 06:17:59.731639: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 1:
4.27935, expected 3.7136
2024-03-25 06:17:59.731654: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 23:
4.38252, expected 3.81677
2024-03-25 06:17:59.731666: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 24:
3.82394, expected 3.25819
2024-03-25 06:17:59.731678: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 28:
3.93545, expected 3.36971
2024-03-25 06:17:59.731689: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 30:
4.59424, expected 4.02849
2024-03-25 06:17:59.731701: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 51:
4.56387, expected 3.99813
2024-03-25 06:17:59.731713: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 56:
3.96228, expected 3.39653
2024-03-25 06:17:59.731725: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 58:
4.37348, expected 3.80774
2024-03-25 06:17:59.731737: E
external/local_xla/xla/service/gpu/buffer_comparator.cc:1137] Difference at 65:
4.63631, expected 4.07056
2024-03-25 06:17:59.745138: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:705] Results
mismatch between different convolution algorithms. This is likely a
bug/unexpected loss of precision in cudnn.
(f32[27,64,125,125]{3,2,1,0}, u8[0]{0}) custom-call(f32[27,3,125,125]{3,2,1,0},
f32[64,3,3,3]{3,2,1,0}, f32[64]{0}), window={size=3x3 pad=1_1x1_1},
dim_labels=bf01_oi01->bf01,
custom_call_target="__cudnn$convBiasActivationForward", backend_config={"conv_re
sult_scale":1,"activation_mode":"kRelu","side_input_scale":0,"leakyrelu_alpha":0
} for eng20{k2=1,k4=1,k5=1,k6=0,k7=0} vs eng15{k5=1,k6=0,k7=1,k10=1}
2024-03-25 06:17:59.745226: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:270] Device: Tesla
P100-PCIE-16GB
2024-03-25 06:17:59.745244: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:271] Platform:
Compute Capability 6.0
2024-03-25 06:17:59.745256: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:272] Driver: 12020
(535.129.3)
2024-03-25 06:17:59.745267: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:273] Runtime:
```

```
<undefined>
2024-03-25 06:17:59.745301: E
external/local_xla/xla/service/gpu/conv_algorithm_picker.cc:280] cudnn version:
8.9.0
```

```
35/35              10s 141ms/step
```

0.7.2 ROC-AUC Score

[16]:
```
roc_auc = roc_auc_score(ytest, y_pred_probs)
print(f'ROC AUC score: {roc_auc}')
```

```
ROC AUC score: 0.7627503673343129
```

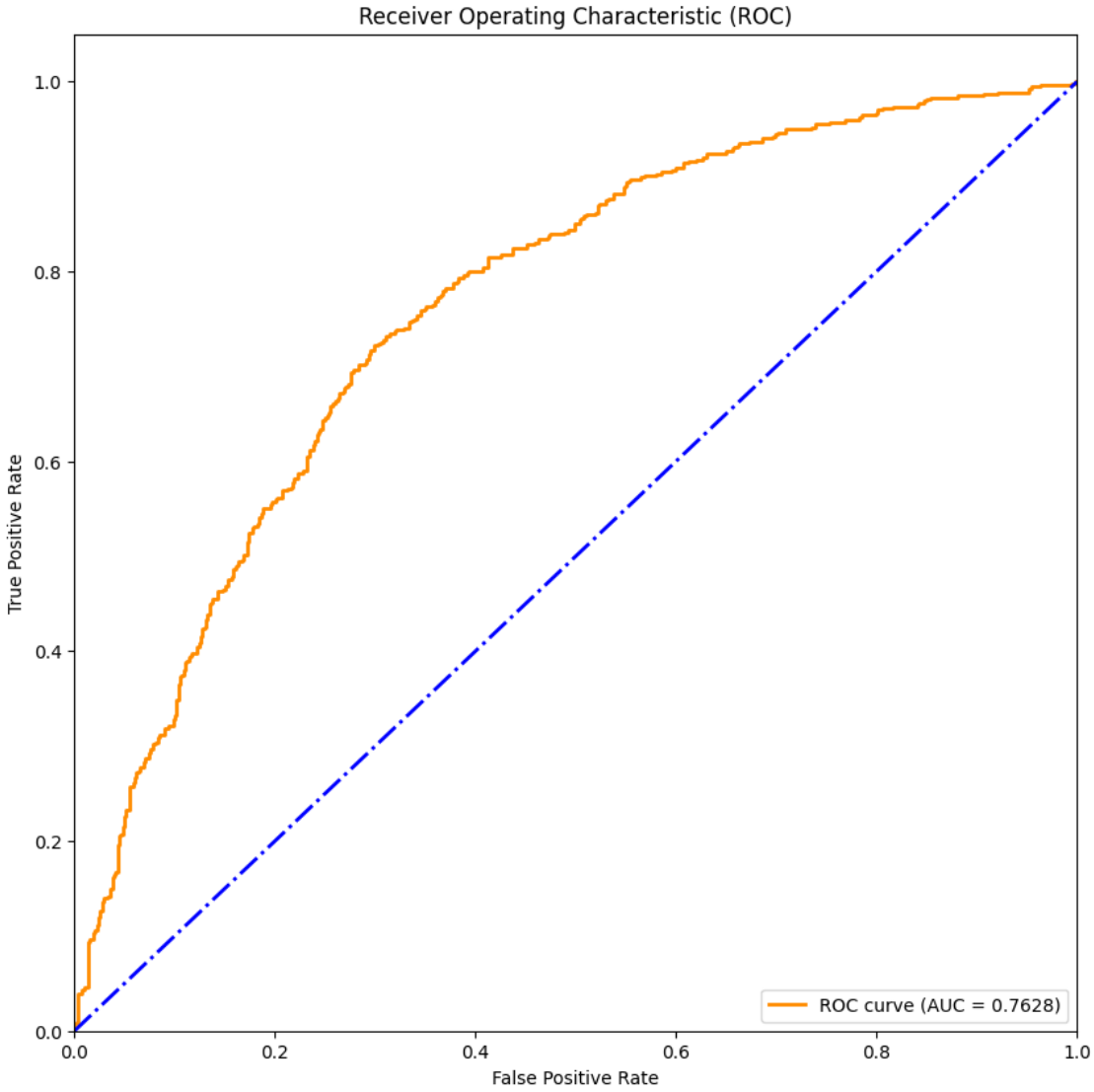
[17]:
```
# Calculate the false positive rate (false_pr), true positive rate (true_pr),␣
 ↪and thresholds
false_pr, true_pr, thresholds = roc_curve(ytest, y_pred_probs)
```

0.7.3 Calculate the ROC-AUC Scores

[18]:
```
roc_auc = auc(false_pr, true_pr)
```

0.8 Plotting ROC-AUC Curve

[19]:
```
plt.figure(figsize = (10, 10))
lw = 2
plt.plot(false_pr, true_pr, color='darkorange', lw=lw, label='ROC curve (AUC =␣
 ↪%0.4f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='blue', lw=lw, linestyle='-.')
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 (ROC)')
plt.legend(loc="lower right")
plt.show()
```


Receiver Operating Characteristic (ROC)
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (AUC = 0.7628)