Class Challenge: Image Classification of COVID-19 X-rays

Task 2 [Total points: 30]

Setup

- This assignment involves the following packages: 'matplotlib', 'numpy', and 'sklearn'.
- If you are using conda, use the following commands to install the above packages:

```
conda install matplotlib
conda install numpy
conda install –c anaconda scikit–learn
```

- If you are using pip, use use the following commands to install the above packages:

```
pip install matplotlib
pip install numpy
pip install sklearn
```

Data

Please download the data using the following link: COVID-19.

- After downloading 'Covid_Data_GradientCrescent.zip', unzip the file and you should see the following data structure:

|--all
|-------train
|-------test
|--two
|-------train
|-------test

- Put the 'all' folder, the 'two' folder and this python notebook in the **same directory** so that the following code can correctly locate the data.

[20 points] Multi-class Classification

```
import os

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.image import ImageDataGenerator

os.environ['OMP_NUM_THREADS'] = '1'
os.environ['CUDA_VISIBLE_DEVICES'] = '-1'
tf.__version__
```

```
'2.8.0'
```

Load Image Data

```
from google.colab import drive

drive.mount('/content/drive')

DATA_LIST = os.listdir('/content/drive/My Drive/CC/Covid_Data_GradientCrescent/'
DATASET_PATH  = '/content/drive/My Drive/CC/Covid_Data_GradientCrescent/all/trai
TEST_DIR =  '/content/drive/My Drive/CC/Covid_Data_GradientCrescent/all/test'

IMAGE_SIZE    = (224, 224)
NUM_CLASSES   = len(DATA_LIST)
BATCH_SIZE    = 10  # try reducing batch size or freeze more layers if your GPU
NUM_EPOCHS    = 100
LEARNING_RATE = 0.0001 # start off with high rate first 0.001 and experiment wit
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, ca
```

Generate Training and Validation Batches

```
train_datagen = ImageDataGenerator(rescale=1./255,rotation_range=50,featurewise_
                                   featurewise_std_normalization = True,width_sh
                                   height_shift_range=0.2,shear_range=0.25,zoom_
                                   zca_whitening = True,channel_shift_range = 20
                                   horizontal_flip = True,vertical_flip = True,
                                   validation_split = 0.2,fill_mode='constant')


train_batches = train_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE
                                                  shuffle=True,batch_size=BATCH_
                                                  subset = "training",seed=42,
                                                  class_mode="categorical")

valid_batches = train_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE
                                                  shuffle=True,batch_size=BATCH_
                                                  subset = "validation",
                                                  seed=42,class_mode="categorica
```

```
Found 216 images belonging to 4 classes.
Found 54 images belonging to 4 classes.
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data
  warnings.warn('This ImageDataGenerator specifies '
```

[10 points] Build Model

Hint: Starting from a pre-trained model typically helps performance on a new task, e.g. starting with weights obtained by training on ImageNet.

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications import DenseNet121
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import BatchNormalization
from tensorflow.keras.layers import Dense
from tensorflow.keras.layers import Input
from tensorflow.keras.layers import AveragePooling2D
from tensorflow.keras.optimizers import Adam
import numpy as np
import argparse
```

```
# model 2
model = tf.keras.models.Sequential()
model.add (DenseNet121 (weights= 'imagenet', include_top=False, input_shape =(22
model.add (BatchNormalization())
model.add (AveragePooling2D(pool_size=(2,2)))
model.add (Flatten())
#model.add (Dropout(0.3))
model.add(Dense(units=128,activation="relu"))
#model.add (Dropout(0.3))
model.add(Dense(units=4,activation="softmax"))
model.layers[0].trainable = False
model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 densenet121 (Functional)    (None, 7, 7, 1024)        7037504

 batch_normalization_3 (Batc  (None, 7, 7, 1024)       4096
 hNormalization)

 average_pooling2d_3 (Averag  (None, 3, 3, 1024)       0
 ePooling2D)

 flatten_3 (Flatten)         (None, 9216)              0

 dense_6 (Dense)             (None, 128)               1179776

 dense_7 (Dense)             (None, 4)                 516

=================================================================
Total params: 8,221,892
Trainable params: 1,182,340
Non-trainable params: 7,039,552
_________________________________________________________________
```

[5 points] Train Model

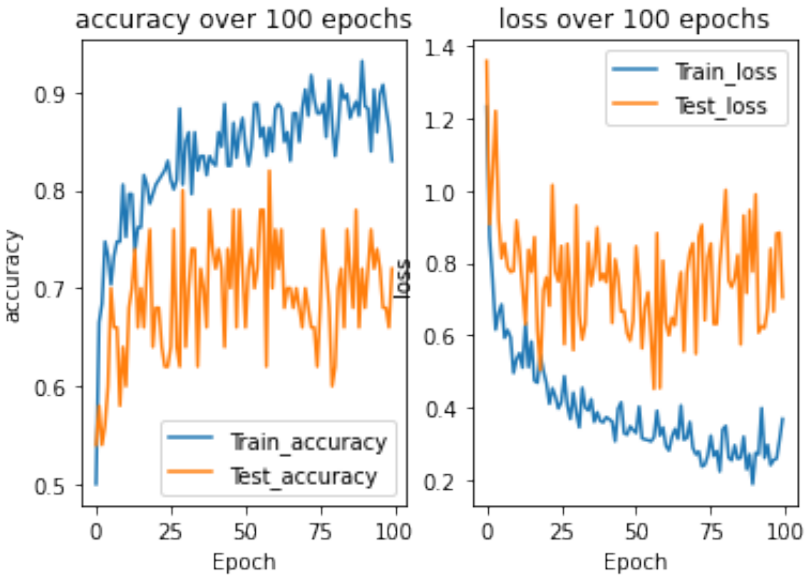
```
#FIT MODEL
print(len(train_batches))
print(len(valid_batches))

STEP_SIZE_TRAIN=train_batches.n//train_batches.batch_size
STEP_SIZE_VALID=valid_batches.n//valid_batches.batch_size

model.compile(optimizer='SGD', loss='categorical_crossentropy', metrics=['accura
history = model.fit(x=train_batches,epochs=NUM_EPOCHS,batch_size=BATCH_SIZE, ste
```

```
      validation_batch_size=BATCH_SIZE, validation_steps=STEP_SIZE_VALID)
Epoch 68/100
21/21 [==============================] - 42s 2s/step - loss: 0.3175 - accur
Epoch 69/100
21/21 [==============================] - 43s 2s/step - loss: 0.3610 - accur
Epoch 70/100
21/21 [==============================] - 41s 2s/step - loss: 0.2897 - accur
Epoch 71/100
21/21 [==============================] - 41s 2s/step - loss: 0.2717 - accur
Epoch 72/100
21/21 [==============================] - 41s 2s/step - loss: 0.2798 - accur
Epoch 73/100
21/21 [==============================] - 41s 2s/step - loss: 0.2384 - accur
Epoch 74/100
21/21 [==============================] - 41s 2s/step - loss: 0.2431 - accur
Epoch 75/100
21/21 [==============================] - 41s 2s/step - loss: 0.2684 - accur
Epoch 76/100
21/21 [==============================] - 41s 2s/step - loss: 0.3231 - accur
Epoch 77/100
21/21 [==============================] - 41s 2s/step - loss: 0.2673 - accur
Epoch 78/100
21/21 [==============================] - 41s 2s/step - loss: 0.2807 - accur
Epoch 79/100
21/21 [==============================] - 41s 2s/step - loss: 0.2246 - accur
Epoch 80/100
21/21 [==============================] - 41s 2s/step - loss: 0.3408 - accur
Epoch 81/100
21/21 [==============================] - 41s 2s/step - loss: 0.3500 - accur
Epoch 82/100
21/21 [==============================] - 41s 2s/step - loss: 0.2623 - accur
Epoch 83/100
21/21 [==============================] - 41s 2s/step - loss: 0.2553 - accur
Epoch 84/100
21/21 [==============================] - 41s 2s/step - loss: 0.2968 - accur
Epoch 85/100
21/21 [==============================] - 41s 2s/step - loss: 0.2595 - accur
Epoch 86/100
21/21 [==============================] - 41s 2s/step - loss: 0.2625 - accur
Epoch 87/100
21/21 [==============================] - 41s 2s/step - loss: 0.3205 - accur
Epoch 88/100
21/21 [==============================] - 41s 2s/step - loss: 0.2305 - accur
Epoch 89/100
21/21 [==============================] - 42s 2s/step - loss: 0.2716 - accur
Epoch 90/100
21/21 [==============================] - 43s 2s/step - loss: 0.1897 - accur
Epoch 91/100
21/21 [==============================] - 44s 2s/step - loss: 0.2763 - accur
Epoch 92/100
21/21 [==============================] - 43s 2s/step - loss: 0.2719 - accur
Epoch 93/100
21/21 [==============================] - 43s 2s/step - loss: 0.3995 - accur
```

```
Epoch 94/100
21/21 [==============================] - 43s 2s/step - loss: 0.2620 - accur
Epoch 95/100
21/21 [==============================] - 43s 2s/step - loss: 0.2982 - accur
Epoch 96/100
21/21 [==============================] - 43s 2s/step - loss: 0.2423 - accur
Epoch 97/100
21/21 [==============================] - 43s 2s/step - loss: 0.2562 - accur
```

[5 points] Plot Accuracy and Loss During Training

```
import matplotlib.pyplot as plt
fig, (ax) = plt.subplots(1, 2)

c=0

for i in ['accuracy', 'loss']:
  ax[c].plot(history.history[i], label='Train_'+i)
  ax[c].plot(history.history['val_'+i], label='Test_'+i)
  ax[c].set_xlabel('Epoch')
  ax[c].set_ylabel(i)
  if i=='accuracy':
    ax[c].legend(loc='lower right')
  else:
    ax[c].legend(loc='upper right')

  ax[c].set_title(str(i)+' over '+str(NUM_EPOCHS)+' epochs')
  c+=1

plt.show()
```



Testing Model

```
test_datagen = ImageDataGenerator(rescale=1. / 255)

eval_generator = test_datagen.flow_from_directory(TEST_DIR,target_size=IMAGE_SIZ
                                                  batch_size=1,shuffle=True,seed
eval_generator.reset()
print(len(eval_generator))
x = model.evaluate_generator(eval_generator,steps = np.ceil(len(eval_generator))
                             use_multiprocessing = False,verbose = 1,workers=1)
print('Test loss:' , x[0])
print('Test accuracy:',x[1])
```

```
Found 36 images belonging to 4 classes.
36
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:8: UserWarning

36/36 [==============================] - 13s 361ms/step - loss: 0.4509 - ac
Test loss: 0.4508759081363678
Test accuracy: 0.8333333134651184
```

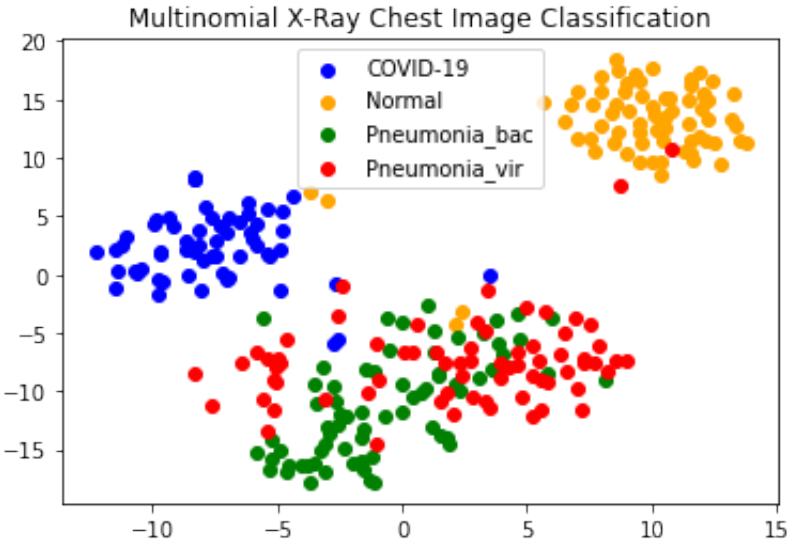
[10 points] TSNE Plot

t-Distributed Stochastic Neighbor Embedding (t-SNE) is a widely used technique for dimensionality reduction that is particularly well suited for the visualization of high-dimensional datasets. After training is complete, extract features from a specific deep layer of your choice, use t-SNE to reduce the dimensionality of your extracted features to 2 dimensions and plot the resulting 2D features.

```
from sklearn.manifold import TSNE
from tensorflow.keras import models

intermediate_layer_model = models.Model(inputs=model.input,
                                        outputs=model.get_layer('dense_6').outpu

tsne_eval_generator = test_datagen.flow_from_directory(DATASET_PATH,target_size=
                                                  batch_size=1,shuffle=False,see

activations2 = intermediate_layer_model.predict(tsne_eval_generator, 1, verbose=
tsne2 = TSNE(n_components=2,init='random',random_state= 55)
print(activations2.shape)
tsne_obj2 = tsne2.fit_transform(activations2)
print(tsne_obj2.shape)
colors = ['blue', 'orange', 'green', 'red']
```

```
c=[colors[i] for i in tsne_eval_generator.labels]
labels = ['COVID-19','Normal', 'Pneumonia_bac', 'Pneumonia_vir']
l=[labels[i] for i in tsne_eval_generator.labels]

x1 = []
y1 = []

for i in range(len(labels)):
  x2 = []
  y2 = []
  for j in range(tsne_obj2.shape[0]):
    if(tsne_eval_generator.labels[j]==i):
      x2.append(tsne_obj2[j,0])
      y2.append(tsne_obj2[j,1])
  x1.append(x2)
  y1.append(y2)

for i in range(len(labels)):
  plt.scatter(x1[i][:], y1[i],c = colors[i],label = labels[i])

plt.title("Multinomial X-Ray Chest Image Classification")
plt.legend()
```

```
Found 270 images belonging to 4 classes.
270/270 [==============================] - 53s 186ms/step
(270, 128)
/usr/local/lib/python3.7/dist-packages/sklearn/manifold/_t_sne.py:793: Futu
  FutureWarning,
(270, 2)
<matplotlib.legend.Legend at 0x7f7b21b0af90>
```



✓ 1m 26s completed at 1:33 PM