Detection of COVID-19

Importing Libraries

```
from imutils import paths
import matplotlib.pyplot as plt
import numpy as np
import argparse
import cv2
import os
import time
import tensorflow as tf
import seaborn as sns

import keras
from sklearn.model_selection import train_test_split
from keras.applications import VGG16
from keras.layers import  Flatten, Dense, Activation
from keras.models import Sequential, load_model
from keras.optimizers import Adam
from keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau
from keras.utils import np_utils, to_categorical
from sklearn.datasets import load_files
from sklearn.preprocessing import LabelBinarizer
from sklearn.metrics import classification_report, confusion_matrix


import os
import cv2

folder1 = "COVID-19_Radiography_Dataset\\COVID\\images"
folder2 = "COVID-19_Radiography_Dataset\\Normal\\images"
folder3 = "COVID-19_Radiography_Dataset\\Viral Pneumonia\\images"

def load_images_from_folder(folder, num):
    images = []
    y = []
    for filename in os.listdir(folder):
        img = cv2.imread(os.path.join(folder,filename));
        img = tf.keras.preprocessing.image.img_to_array(img)
        img = cv2.resize(img,(128,128))
        if img is not None:
            images.append(img)
            y.append(num)
    return images , y

OriginalCovidImages, class1 = load_images_from_folder(folder1,0)
OriginalNormalImages, class3 = load_images_from_folder(folder2,2)
OriginalViralPneumoniaImages, class2 = load_images_from_folder(folder3,1)



def reshapeimages(images, y):
    images = np.array(images)
    y = np.array(y).reshape(-1,1)
    return images, y
```

Reshaping the images into numpy array

```
OriginalCovidImages, class1 = reshapeimages(OriginalCovidImages,class1)
OriginalViralPneumoniaImages, class2 = reshapeimages(OriginalViralPneumoniaImages,class2)
OriginalNormalImages, class3 = reshapeimages(OriginalNormalImages,class3)

print(len(OriginalCovidImages))
print(OriginalCovidImages.shape)
print(class1.shape)
```

```
3616
(3616, 128, 128, 3)
(3616, 1)
```

Splitting the covid test data into train/validation/test

```
Covid_train, Covid_test, class1_train, class1_test = train_test_split(OriginalCovidImages,class1, test_size=0.1, random_state=42)
Covid_test, Covid_val, class1_test, class1_val = train_test_split(Covid_test, class1_test, test_size=0.2, random_state=42)
print(Covid_train.shape)
print(Covid_val.shape)
print(Covid_test.shape)
```

```
(3254, 128, 128, 3)
(73, 128, 128, 3)
(289, 128, 128, 3)
```

Splitting the Viral Pneumonia Data into Train/Validation/Test

```
ViralP_train, ViralP_test, class2_train, class2_test = train_test_split(OriginalViralPneumoniaImages,class2, test_size=0.1, random_state=42)
ViralP_test, ViralP_val, class2_test, class2_val = train_test_split(ViralP_test, class2_test, test_size=0.2, random_state=42)
print(ViralP_train.shape)
print(ViralP_val.shape)
print(ViralP_test.shape)
```

```
(1210, 128, 128, 3)
(27, 128, 128, 3)
(108, 128, 128, 3)
```

Splitting the Normal Data into Train/Validation/Test

```
Normal_train, Normal_test, class3_train, class3_test = train_test_split(OriginalNormalImages,class3, test_size=0.1, random_state=42)
Normal_test, Normal_val, class3_test, class3_val = train_test_split(Normal_test, class3_test, test_size=0.2, random_state=42)
print(Normal_train.shape)
print(Normal_val.shape)
print(Normal_test.shape)
```

```
(9172, 128, 128, 3)
(204, 128, 128, 3)
(816, 128, 128, 3)
```

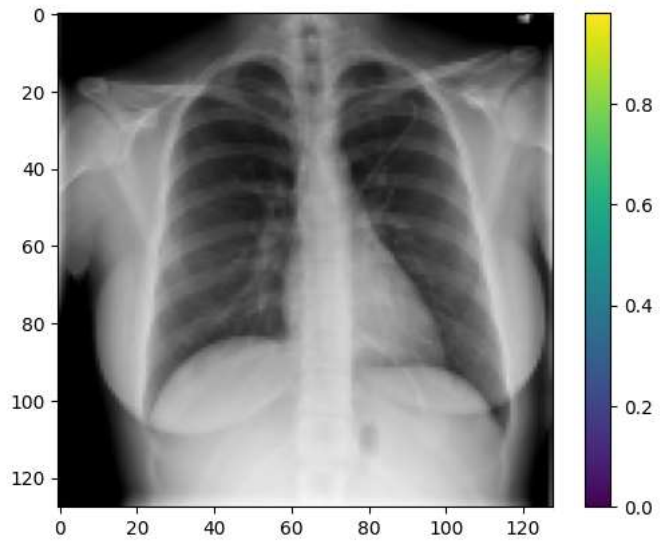
Final Train Test Validation set

```
X_train = np.concatenate((Covid_train, ViralP_train, Normal_train), axis=0)
y_train = np.concatenate((class1_train, class2_train, class3_train), axis=0)
X_test = np.concatenate((Covid_test, ViralP_test, Normal_test), axis=0)
y_test = np.concatenate((class1_test, class2_test, class3_test), axis=0)
X_val = np.concatenate((Covid_val, ViralP_val, Normal_val), axis=0)
y_val = np.concatenate((class1_val, class2_val, class3_val), axis=0)
```

```
print(X_train.shape)
print()
plt.figure()
plt.imshow(X_train[12300])
plt.colorbar()
plt.grid(False)
plt.show
print(y_train[12300])
```

```
(13636, 128, 128, 3)
```

[2]




```
X_train = X_train /255
X_test_scaled = X_test / 255
X_val = X_val/255


print(X_train.shape)
print(X_train)
```

```
          ...
          [0.00000000e+00 0.00000000e+00 0.00000000e+00]
          [0.00000000e+00 0.00000000e+00 0.00000000e+00]
          [9.52410549e-02 9.52410549e-02 9.52410549e-02]]

         [[7.50723362e-01 7.50723362e-01 7.50723362e-01]
          [7.55565822e-01 7.55565822e-01 7.55565822e-01]
          [7.86948502e-01 7.86948502e-01 7.86948502e-01]
          ...
          [1.30208337e-03 1.30208337e-03 1.30208337e-03]
          [0.00000000e+00 0.00000000e+00 0.00000000e+00]
          [1.04828775e-01 1.04828775e-01 1.04828775e-01]]]
```

```
from keras.utils import np_utils
y_train = np_utils.to_categorical(y_train)
y_test= np_utils.to_categorical(y_test)
y_val = np_utils.to_categorical(y_val)
```

```
print(y_test)
```

```
[[1. 0. 0.]
 [1. 0. 0.]
 [1. 0. 0.]
 ...
 [0. 0. 1.]
 [0. 0. 1.]
 [0. 0. 1.]]
```

```
# base_model = VGG16(weights='imagenet', include_top=False, input_shape=(128,128,3))

# for layer in base_model.layers:
#     layer.trainable=False

# model = Sequential()
# model.add(Conv2D)
# model.add(Flatten())
# model.add(Dense(1024))
# model.add(Activation('relu'))
# model.add(Dense(512))
# model.add(Activation('relu'))
# model.add(Dense(3))
# model.add(Activation('sigmoid'))

from numpy import concatenate
import keras.backend as K

input_shape = (128,128,3)

input_img = tf.keras.Input(shape=input_shape)
# Define the input layer
input_img = tf.keras.Input(shape=input_shape)

# First convolutional layer
Z1 = tf.keras.layers.Conv2D(8, (4, 4), strides=(1, 1), padding="same")(input_img)
A1 = tf.keras.layers.ReLU()(Z1)
P1 = tf.keras.layers.MaxPooling2D(pool_size=(8, 8), strides=(4, 4), padding="same")(A1)

# Second convolutional layer
Z2 = tf.keras.layers.Conv2D(filters=16,kernel_size=(2, 2), strides=(1, 1), padding="same")(P1)
A2 = tf.keras.layers.ReLU()(Z2)
P2 = tf.keras.layers.MaxPooling2D(pool_size=(4, 4), strides=(4, 4), padding="same")(A2)

# Third convolutional layer
Z3 = tf.keras.layers.Conv2D(32, (4, 4), strides=(1, 1), padding="same")(P2)
A3 = tf.keras.layers.ReLU()(Z3)
P3 = tf.keras.layers.MaxPooling2D(pool_size=(4, 4), strides=(4, 4), padding="valid")(A3)

# Skip Connection Z1
S1 = tf.keras.layers.Conv2D(16,kernel_size=(1,1),strides=(1,1),padding="same")(Z1)
S1_pooled = tf.keras.layers.MaxPool2D(pool_size=(56,56), strides=(8,8),padding = "same")

# Fourth convolutional layer
Z4 = tf.keras.layers.Conv2D(filters=16,kernel_size=(2, 2), strides=(1, 1), padding="same")(P3)
# merge = tf.keras.layers.Concatenate(axis=3)([Z4, S1_pooled])
A4 = tf.keras.layers.ReLU()(Z4)
P4 = tf.keras.layers.MaxPooling2D(pool_size=(4, 4), strides=(4, 4), padding="same")(A4)
```

```
F = tf.keras.layers.Flatten()(P4)

D1 = tf.keras.layers.Dense(units = 16, activation="tanh")(F)

outputs = tf.keras.layers.Dense(units=3,activation="softmax")(D1)

model = tf.keras.Model(inputs=input_img, outputs = outputs)
model.summary()
```

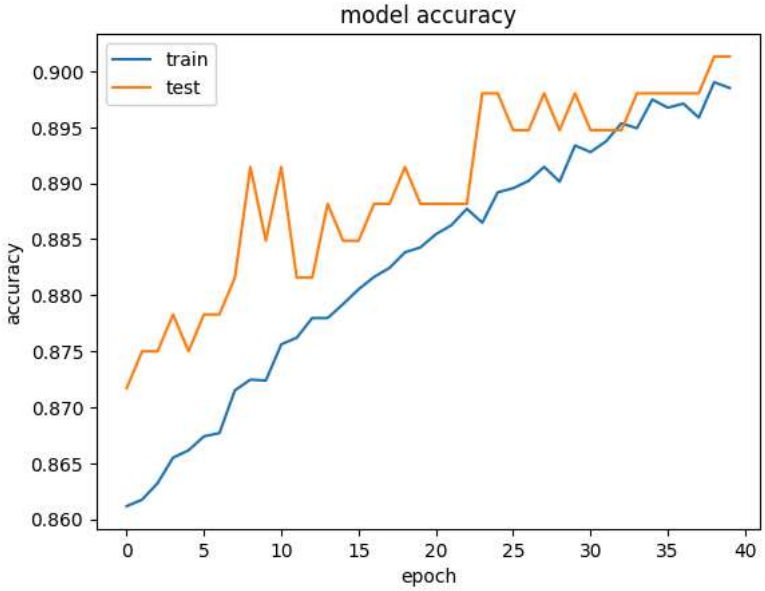
```
Model: "model_13"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_77 (InputLayer)       [(None, 128, 128, 3)]     0

 conv2d_176 (Conv2D)         (None, 128, 128, 8)       392

 re_lu_121 (ReLU)            (None, 128, 128, 8)       0

 max_pooling2d_153 (MaxPooli  (None, 32, 32, 8)        0
 ng2D)

 conv2d_177 (Conv2D)         (None, 32, 32, 16)        528

 re_lu_122 (ReLU)            (None, 32, 32, 16)        0

 max_pooling2d_154 (MaxPooli  (None, 8, 8, 16)         0
 ng2D)

 conv2d_178 (Conv2D)         (None, 8, 8, 32)          8224

 re_lu_123 (ReLU)            (None, 8, 8, 32)          0

 max_pooling2d_155 (MaxPooli  (None, 2, 2, 32)         0
 ng2D)

 conv2d_180 (Conv2D)         (None, 2, 2, 16)          2064

 re_lu_124 (ReLU)            (None, 2, 2, 16)          0

 max_pooling2d_157 (MaxPooli  (None, 1, 1, 16)         0
 ng2D)

 flatten_17 (Flatten)        (None, 16)                0

 dense_27 (Dense)            (None, 16)                272

 dense_28 (Dense)            (None, 3)                 51

=================================================================
Total params: 11,531
Trainable params: 11,531
Non-trainable params: 0
_________________________________________________________________
```

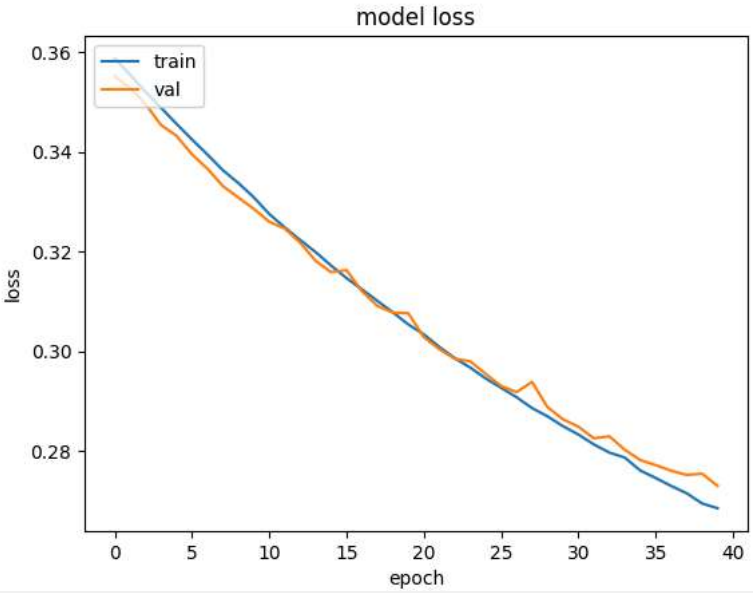
```
from keras.callbacks import EarlyStopping

learning_rate = 0.00001
decay_steps = 10
decay_rate = 1


lr_schedular = tf.keras.optimizers.schedules.ExponentialDecay(learning_rate, decay_steps, decay_rate)
optimizer1 = tf.keras.optimizers.Adam(learning_rate=lr_schedular)
early_stop = EarlyStopping(monitor='val_loss', patience=5, restore_best_weights=True)

model.compile(optimizer = optimizer1, loss='categorical_crossentropy', metrics=['accuracy'])

history = model.fit(X_train,y_train, batch_size=32,epochs=40, validation_data=(X_val, y_val), callbacks=[early_stop])
```

```
427/427 [==============================] - 50s 117ms/step - loss: 0.3124 - accuracy: 0.8816 - val_loss: 0.3120 - val_accuracy: 0.8882
Epoch 18/40
427/427 [==============================] - 49s 114ms/step - loss: 0.3101 - accuracy: 0.8824 - val_loss: 0.3091 - val_accuracy: 0.8882
Epoch 19/40
427/427 [==============================] - 45s 106ms/step - loss: 0.3078 - accuracy: 0.8838 - val_loss: 0.3078 - val_accuracy: 0.8914
Epoch 20/40
427/427 [==============================] - 47s 110ms/step - loss: 0.3054 - accuracy: 0.8843 - val_loss: 0.3076 - val_accuracy: 0.8882
Epoch 21/40
427/427 [==============================] - 47s 110ms/step - loss: 0.3034 - accuracy: 0.8855 - val_loss: 0.3028 - val_accuracy: 0.8882
Epoch 22/40
427/427 [==============================] - 47s 109ms/step - loss: 0.3009 - accuracy: 0.8863 - val_loss: 0.3004 - val_accuracy: 0.8882
Epoch 23/40
427/427 [==============================] - 46s 109ms/step - loss: 0.2986 - accuracy: 0.8877 - val_loss: 0.2985 - val_accuracy: 0.8882
Epoch 24/40
427/427 [==============================] - 46s 107ms/step - loss: 0.2967 - accuracy: 0.8865 - val_loss: 0.2980 - val_accuracy: 0.8980
Epoch 25/40
427/427 [==============================] - 46s 108ms/step - loss: 0.2945 - accuracy: 0.8892 - val_loss: 0.2954 - val_accuracy: 0.8980
Epoch 26/40
427/427 [==============================] - 47s 109ms/step - loss: 0.2927 - accuracy: 0.8896 - val_loss: 0.2930 - val_accuracy: 0.8947
Epoch 27/40
427/427 [==============================] - 48s 113ms/step - loss: 0.2908 - accuracy: 0.8902 - val_loss: 0.2918 - val_accuracy: 0.8947
Epoch 28/40
427/427 [==============================] - 46s 108ms/step - loss: 0.2886 - accuracy: 0.8915 - val_loss: 0.2938 - val_accuracy: 0.8980
Epoch 29/40
427/427 [==============================] - 49s 115ms/step - loss: 0.2869 - accuracy: 0.8901 - val_loss: 0.2888 - val_accuracy: 0.8947
Epoch 30/40
427/427 [==============================] - 51s 120ms/step - loss: 0.2850 - accuracy: 0.8934 - val_loss: 0.2863 - val_accuracy: 0.8980
Epoch 31/40
427/427 [==============================] - 48s 113ms/step - loss: 0.2833 - accuracy: 0.8928 - val_loss: 0.2849 - val_accuracy: 0.8947
Epoch 32/40
427/427 [==============================] - 45s 105ms/step - loss: 0.2813 - accuracy: 0.8937 - val_loss: 0.2825 - val_accuracy: 0.8947
Epoch 33/40
427/427 [==============================] - 50s 116ms/step - loss: 0.2797 - accuracy: 0.8954 - val_loss: 0.2829 - val_accuracy: 0.8947
Epoch 34/40
427/427 [==============================] - 48s 113ms/step - loss: 0.2787 - accuracy: 0.8949 - val_loss: 0.2802 - val_accuracy: 0.8980
Epoch 35/40
427/427 [==============================] - 48s 113ms/step - loss: 0.2761 - accuracy: 0.8975 - val_loss: 0.2782 - val_accuracy: 0.8980
Epoch 36/40
427/427 [==============================] - 50s 116ms/step - loss: 0.2746 - accuracy: 0.8967 - val_loss: 0.2772 - val_accuracy: 0.8980
Epoch 37/40
427/427 [==============================] - 50s 116ms/step - loss: 0.2730 - accuracy: 0.8971 - val_loss: 0.2760 - val_accuracy: 0.8980
Epoch 38/40
427/427 [==============================] - 49s 115ms/step - loss: 0.2715 - accuracy: 0.8959 - val_loss: 0.2752 - val_accuracy: 0.8980
Epoch 39/40
427/427 [==============================] - 50s 117ms/step - loss: 0.2695 - accuracy: 0.8990 - val_loss: 0.2754 - val_accuracy: 0.9013
Epoch 40/40
427/427 [==============================] - 53s 124ms/step - loss: 0.2685 - accuracy: 0.8985 - val_loss: 0.2730 - val_accuracy: 0.9013
```

```
from matplotlib import pyplot as plt
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train','test'], loc='upper left')
plt.show()
```

```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train','val'],loc='upper left')
plt.show()
```






```
model.save('model3.h5')
```

```
model1 = load_model('model3.h5')
```

```
y_hat = model.predict(X_test_scaled)
```

```
38/38 [==============================] - 2s 31ms/step
```

```
print(y_hat)
```

```
[[5.4535764e-01 4.9512004e-03 4.4969115e-01]
 [6.6805887e-01 5.3332742e-02 2.7860838e-01]
 [7.5268650e-01 2.0961214e-02 2.2635239e-01]
 ...
 [1.5964955e-02 2.2508282e-02 9.6152681e-01]
 [4.0431865e-02 2.9818751e-04 9.5926988e-01]
 [4.2345547e-03 1.2909606e-04 9.9563640e-01]]
```

```
y_pred = y_hat.round()
print(y_pred)
```

```
[[1. 0. 0.]
 [1. 0. 0.]
 [1. 0. 0.]
 ...
 [0. 0. 1.]
```

```
       [0. 0. 1.]
       [0. 0. 1.]]
```

```
print(y_test)
```

```
[[1. 0. 0.]
 [1. 0. 0.]
 [1. 0. 0.]
 ...
 [0. 0. 1.]
 [0. 0. 1.]
 [0. 0. 1.]]
```

```
from sklearn.metrics import accuracy_score
accuracy = accuracy_score(y_test,y_pred)
print(accuracy)
```

```
0.8854080791426217
```

```
labels = ['Covid', 'Viral Pneumonia', 'Normal']
report = classification_report(y_test, y_pred, target_names=labels)
print(report)
print(f"Accuracy: {accuracy}")
```

```
                precision    recall  f1-score   support

         Covid       0.81      0.78      0.79       289
Viral Pneumonia       0.94      0.82      0.88       108
        Normal       0.92      0.93      0.93       816

     micro avg       0.90      0.89      0.89      1213
     macro avg       0.89      0.84      0.87      1213
  weighted avg       0.90      0.89      0.89      1213
   samples avg       0.89      0.89      0.89      1213

Accuracy: 0.8854080791426217
c:\Users\Naziya Mahimkar\AppData\Local\Programs\Python\Python39\lib\site-packages\sklearn\metrics\_classification.py:1344: UndefinedMetr
  _warn_prf(average, modifier, msg_start, len(result))
```

```
cm = confusion_matrix(np.asarray(y_test).argmax(axis=1), np.asarray(y_pred).argmax(axis=1))
print(cm)
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')

tick_labels = ['Covid', 'Viral Pneumonia', 'Normal']
plt.xticks(np.arange(len(tick_labels)) + 0.5, tick_labels)
```

```
[[230   1  58]
 [ 10  89   9]
 [ 50   5 761]]
([<matplotlib.axis.XTick at 0x1c2e7ca10a0>,
  <matplotlib.axis.XTick at 0x1c2e7ca1070>,
  <matplotlib.axis.XTick at 0x1c2e88de250>],
 [Text(0.5, 0, 'Covid'),
  Text(1.5, 0, 'Viral Pneumonia'),
  Text(2.5, 0, 'Normal')])
```