Problem Statement

DESCRIPTION

Problem Statement: Facial recognition is a biometric alternative that measures unique characteristics of a human face. Applications available today include flight check in, tagging friends and family members in photos, and “tailored” advertising. You are a computer vision engineer who needs to develop a face recognition programme with deep convolutional neural networks. Objective: Use a deep convolutional neural network to perform facial recognition using Keras.

Dataset Details: ORL face database composed of 400 images of size 112 x 92. There are 40 people, 10 images per person. The images were taken at different times, lighting and facial expressions. The faces are in an upright position in frontal view, with a slight left-right rotation. Link to the Dataset: https://www.dropbox.com/s/i7uzp5yxk7wruva/ORL_faces.npz?dl=0 (https://www.dropbox.com/s/i7uzp5yxk7wruva/ORL_faces.npz?dl=0)

Prerequisites: Keras Scikit Learn Steps to be followed:

1. Input the required libraries
2. Load the dataset after loading the dataset, you have to normalize every image.
3. Split the dataset
4. Transform the images to equal sizes to feed in CNN
5. Build a CNN model that has 3 main layers:

   i. Convolutional Layer

   ii. Pooling Layer

   iii. Fully Connected Layer
6. Train the model
7. Plot the result
8. Iterate the model until the accuracy is above 90%

Task 1 - Import Libraries

In [ ]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import tensorflow as tf
import seaborn as sn
import cv2
from glob import glob
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: F
utureWarning: pandas.util.testing is deprecated. Use the functions in the
public API at pandas.testing instead.
  import pandas.util.testing as tm
```

Task 2(a) - Load File

Load file and view the list of files in the dataset

In [ ]:

```
# Mount drive to colab

from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, c
all drive.mount("/content/drive", force_remount=True).
```

In [ ]:

```
# Load the NPZ file to data
data = np.load("drive/My Drive/PG AI ML/ORL_faces.npz",allow_pickle=False)

# View files/folders present in data
lst = data.files
for item in lst:
    print(item)
```

```
testY
testX
trainX
trainY
```

```
In [ ]:
```

```
lst = data.files
for item in lst:
    print(item)
    print(data[item])
    print("\n")
```

```
testY
[ 0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  2  2  2  2  2  2  2  2
  3  3  3  3  3  3  3  3  4  4  4  4  4  4  4  4  5  5  5  5  5  5  5  5
  6  6  6  6  6  6  6  6  7  7  7  7  7  7  7  7  8  8  8  8  8  8  8  8
  9  9  9  9  9  9  9  9 10 10 10 10 10 10 10 10 11 11 11 11 11 11 11 11
 12 12 12 12 12 12 12 12 13 13 13 13 13 13 13 13 14 14 14 14 14 14 14 14
 15 15 15 15 15 15 15 15 16 16 16 16 16 16 16 16 17 17 17 17 17 17 17 17
 18 18 18 18 18 18 18 18 19 19 19 19 19 19 19 19]


testX
[[ 41.  47.  47. ...  35.  37.  38.]
 [ 44.  43.  32. ...  43.  43.  37.]
 [ 42.  41.  44. ...  42.  43.  41.]
 ...
 [101. 100. 103. ...  31.  40.  42.]
 [105. 108. 106. ...  44.  40.  47.]
 [113. 114. 111. ...  62.  81.  89.]]


trainX
[[ 48.  49.  45. ...  47.  46.  46.]
 [ 60.  60.  62. ...  32.  34.  34.]
 [ 39.  44.  53. ...  29.  26.  29.]
 ...
 [114. 117. 114. ...  98.  96.  98.]
 [105. 105. 107. ...  54.  47.  41.]
 [116. 114. 117. ...  95. 100. 101.]]


trainY
[ 0  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1
  2  2  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  3  3
  4  4  4  4  4  4  4  4  4  4  4  4  5  5  5  5  5  5  5  5  5  5  5  5
  6  6  6  6  6  6  6  6  6  6  6  6  7  7  7  7  7  7  7  7  7  7  7  7
  8  8  8  8  8  8  8  8  8  8  8  8  9  9  9  9  9  9  9  9  9  9  9  9
 10 10 10 10 10 10 10 10 10 10 10 10 11 11 11 11 11 11 11 11 11 11 11 11
 12 12 12 12 12 12 12 12 12 12 12 12 13 13 13 13 13 13 13 13 13 13 13 13
 14 14 14 14 14 14 14 14 14 14 14 14 15 15 15 15 15 15 15 15 15 15 15 15
 16 16 16 16 16 16 16 16 16 16 16 17 17 17 17 17 17 17 17 17 17 17 17 17
 18 18 18 18 18 18 18 18 18 18 18 18 19 19 19 19 19 19 19 19 19 19 19 19]
```

Observation:

We can see that there are **4 folders** present in the given data set. **trainX, trainY, testX and testY**

Train data set contains **12 images** of each person (20 persons total)

Test data set contains **8 images** of each person (20 person total)

Task 3 - Seperate the Train and Test Data

Analysis:

Train X contains the **images** and **Train Y** contains the **Label** for those images

Test X contains **images** to test and **Test Y** contains the **Label** for those images

In [ ]:

```
x_train,x_test,y_train,y_test=data['trainX'],data['testX'], data['trainY'],data['testY'
]
x_train.shape, x_test.shape, y_train.shape, y_test.shape
```

Out[ ]:

```
((240, 10304), (160, 10304), (240,), (160,))
```

Reshape the Train & Test Data to the shape required to display an image

In [ ]:

```
x_train_img=np.reshape(x_train,(x_train.shape[0],112,-1))
print ("Reshaped Image of X_Train_img is: ", x_train_img.shape, "\n")
#plt.imshow(x_train[30])
```

```
Reshaped Image of X_Train_img is:  (240, 112, 92)
```

In [ ]:

```
x_test_img=np.reshape(x_test,(x_test.shape[0],112,92))
print ("Reshaped Image of X_Test_img is: ", x_test_img.shape, "\n")
```

```
Reshaped Image of X_Test_img is:  (160, 112, 92)
```

View Unique Faces that is present in Train Data set

In [ ]:

```
print("unique target number:",np.unique(data['trainY']))
```

```
unique target number: [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
17 18 19]
```

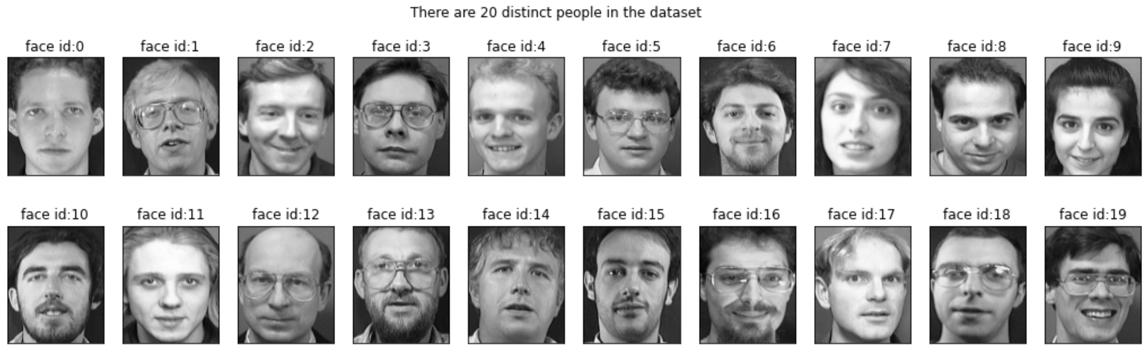
In [ ]:

```
def show_20_distinct_people(images, unique_ids):
  #Creating 2*10 subplots in  18x5 figure size
  fig, axarr=plt.subplots(nrows=2, ncols=10, figsize=(18, 5))

  #For easy iteration flattened 2X10 subplots matrix to 20 array
  axarr=axarr.flatten()

  #iterating over user ids
  for unique_id in unique_ids:
    image_index=unique_id*12
    axarr[unique_id].imshow(images[image_index], cmap='gray')
    axarr[unique_id].set_xticks([])
    axarr[unique_id].set_yticks([])
    axarr[unique_id].set_title("face id:{}".format(unique_id))
    plt.suptitle("There are 20 distinct people in the dataset")

show_20_distinct_people(x_train_img, np.unique(data['trainY']))
```



View Unique Faces that is present in Test Data set

In [ ]:

```
print("unique target number:",np.unique(data['testY']))
```

```
unique target number: [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
 17 18 19]
```

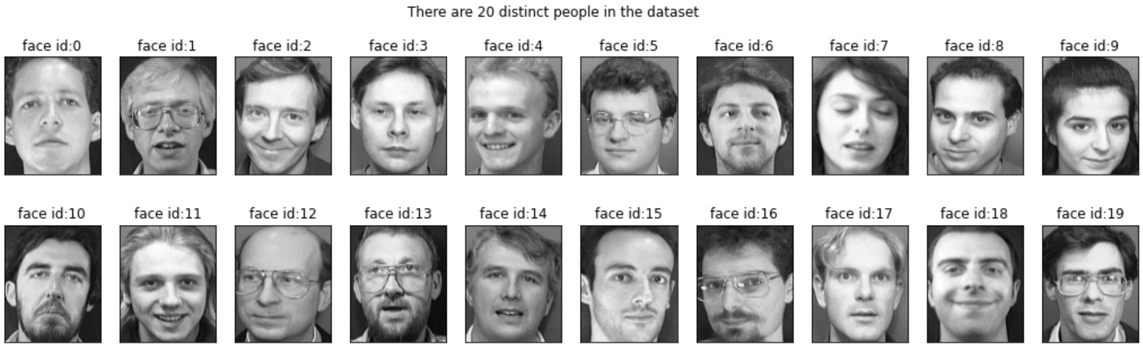
In [ ]:

```
def show_16_distinct_people(images, unique_ids):
  #Creating 2*10 subplots in  18x5 figure size
  fig, axarr=plt.subplots(nrows=2, ncols=10, figsize=(18, 5))

  #For easy iteration flattened 2X10 subplots matrix to 20 array
  axarr=axarr.flatten()

  #iterating over user ids
  for unique_id in unique_ids:
    image_index=unique_id*8
    axarr[unique_id].imshow(images[image_index], cmap='gray')
    axarr[unique_id].set_xticks([])
    axarr[unique_id].set_yticks([])
    axarr[unique_id].set_title("face id:{}".format(unique_id))
    plt.suptitle("There are 20 distinct people in the dataset")

show_16_distinct_people(x_test_img, np.unique(data['testY']))
```



View different images of single person, present in Train Data

Images of Single person in different posture, orientation, etc etc

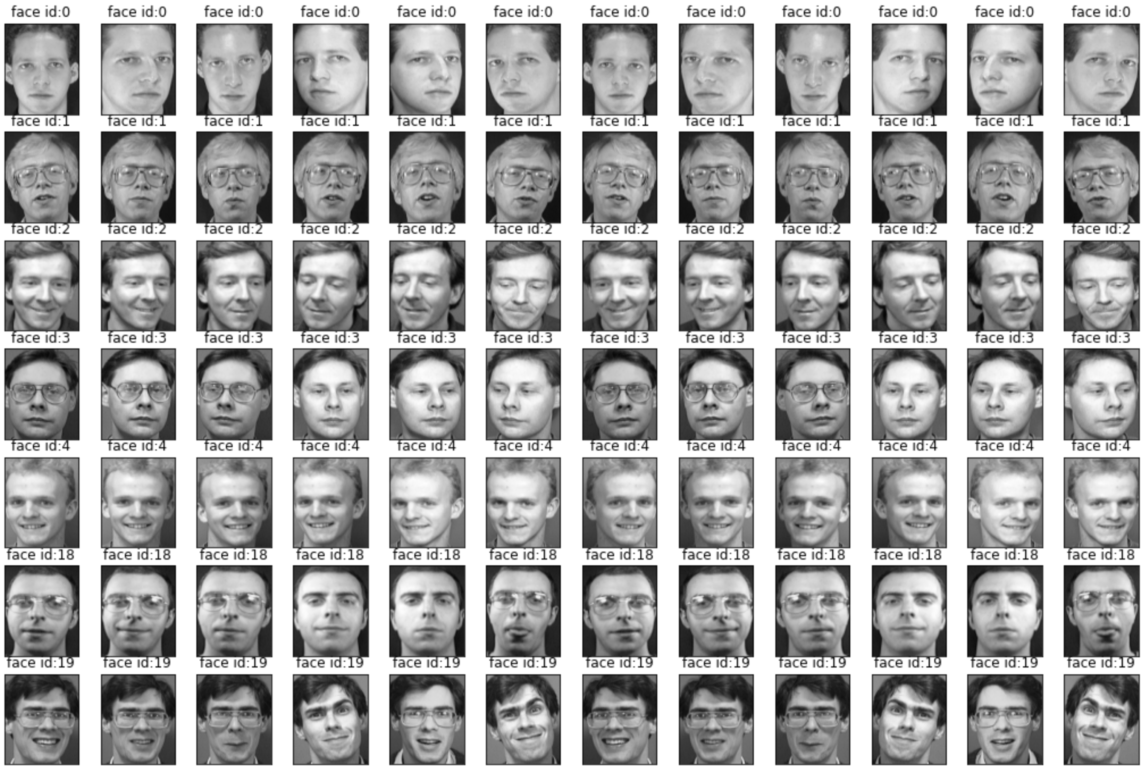
In [ ]:

```
def show_12_faces_of_n_subject(images, subject_ids):
    cols=12
    rows=(len(subject_ids)*12)/cols
    rows=int(rows)

    fig, axarr=plt.subplots(nrows=rows, ncols=cols, figsize=(18,12))
    #axarr=axarr.flatten()

    for i, subject_id in enumerate(subject_ids):
        for j in range(cols):
            image_index=subject_id*12 + j
            axarr[i,j].imshow(images[image_index], cmap="gray")
            axarr[i,j].set_xticks([])
            axarr[i,j].set_yticks([])
            axarr[i,j].set_title("face id:{}".format(subject_id))

show_12_faces_of_n_subject(images=x_train_img, subject_ids=[0, 1, 2 , 3, 4, 18, 19])
```



Different Images of single person, in Test Data set

In [ ]:

```
def show_8_faces_of_n_subject(images, subject_ids):
    cols=8
    rows=(len(subject_ids)*8)/cols
    rows=int(rows)

    fig, axarr=plt.subplots(nrows=rows, ncols=cols, figsize=(12,10))
    #axarr=axarr.flatten()

    for i, subject_id in enumerate(subject_ids):
        for j in range(cols):
            image_index=subject_id*8 + j
            axarr[i,j].imshow(images[image_index], cmap="gray")
            axarr[i,j].set_xticks([])
            axarr[i,j].set_yticks([])
            axarr[i,j].set_title("face id:{}".format(subject_id))

show_8_faces_of_n_subject(images=x_test_img, subject_ids=[0, 1, 2 , 3, 4, 18, 19])
```

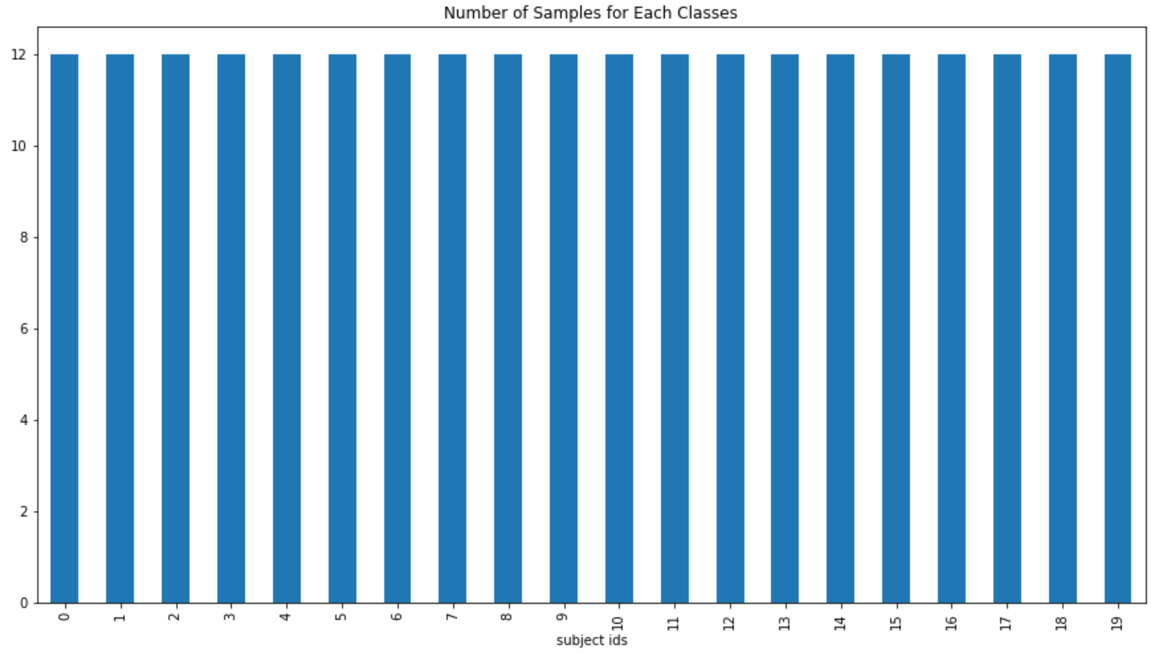
No of Sample for each Image

In [ ]:

```
y_frame=pd.DataFrame()
y_frame['subject ids']=y_train
y_frame.groupby(['subject ids']).size().plot.bar(figsize=(15,8),title="Number of Sample
s for Each Classes")
```

Out[ ]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff21d28df98>
```



Task 2(b) - Normalize the Data

In [ ]:

```
print("-------------------------")
print("X train pixels:")
print("-------------------------")
print("Minimum Pixels: ", x_train.min(), "\t", "Maximum Pixels: ", x_train.max(), "\n")
x_train = np.array(x_train,dtype='float64')/255
print("Post Normalization")
print("Minimum Pixels: ", x_train.min(), "\t", "Maximum Pixels: ", x_train.max(), "\n")

print("--------------------------")
print("X test pixels:")
print("--------------------------")
print("Minimum Pixels: ", x_test.min(), "\t", "Maximum Pixels: ", x_test.max(), "\n")
x_test = np.array(x_test,dtype='float64')/255
print("Post Normalization")
print("Minimum Pixels: ", x_test.min(), "\t", "Maximum Pixels: ", x_test.max())
```

```
-------------------------
X train pixels:
-------------------------
Minimum Pixels:  0.0     Maximum Pixels:  244.0

Post Normalization
Minimum Pixels:  0.0     Maximum Pixels:  0.9568627450980393

--------------------------
X test pixels:
--------------------------
Minimum Pixels:  0.0     Maximum Pixels:  244.0

Post Normalization
Minimum Pixels:  0.0     Maximum Pixels:  0.9568627450980393
```

Task 4 - Transform the images to equal sizes

In [ ]:

```
#imageGrayScale = np.array([cv2.cvtColor(i, cv2.COLOR_BGR2GRAY) for i in x_train)
```

In [ ]:

```
x_train_final = np.array([cv2.resize(i,(112,92), interpolation=cv2.INTER_CUBIC) for i i
n x_train])
print("Shape of X Train: ", x_train_final.shape)
```

```
Shape of X Train:  (240, 92, 112)
```

In [ ]:

```
x_test_final = np.array([cv2.resize(i,(112,92), interpolation=cv2.INTER_CUBIC) for i in
x_test])
print("Shape of X Test: ", x_test_final.shape)
```

```
Shape of X Test:  (160, 92, 112)
```

Changing classes count for Label

In [ ]:

```
y_train_final = tf.keras.utils.to_categorical(y_train, num_classes=20, dtype='float32')
y_test_final = tf.keras.utils.to_categorical(y_test, num_classes=20, dtype='float32')
```

Task 5 - Creating CNN Model

i. Convolutional Layer

ii. Pooling Layer

iii. Fully Connected Layer

In [ ]:

```
x_train_edited = np.array([np.reshape(i, (112, 92, 1)) for i in x_train])
x_test_edited = np.array([np.reshape(i, (112, 92, 1)) for i in x_test])
print(x_train_edited.shape,",",x_test_edited.shape)
```

```
(240, 112, 92, 1) , (160, 112, 92, 1)
```

In [ ]:

```
# Set Parameters
batchSize = 12
epochs = 200
tf.random.set_seed(2507)
np.random.seed(2507)

# Initialising the CNN
classifier = tf.keras.models.Sequential()

# Step 1 - Convolution  #No of Feature Maps, Filter, color image with channel,
classifier.add(tf.keras.layers.Conv2D(32, (3, 3), input_shape = (112, 92, 1), activatio
n = 'relu'))

# Step 2 - Pooling
classifier.add(tf.keras.layers.MaxPooling2D(pool_size = (2, 2)))

# Adding a second convolutional layer
classifier.add(tf.keras.layers.Conv2D(64, (3, 3), activation = 'relu'))
classifier.add(tf.keras.layers.MaxPooling2D(pool_size = (2, 2)))

# Adding a second convolutional layer
classifier.add(tf.keras.layers.Conv2D(128, (3, 3), activation = 'relu'))
classifier.add(tf.keras.layers.MaxPooling2D(pool_size = (2, 2)))

# Step 3 - Flattening
classifier.add(tf.keras.layers.Flatten())
#classifier.add(tf.keras.layers.GlobalAveragePooling2D())

# Step 4 - Full connection
classifier.add(tf.keras.layers.Dense(units = 512, activation = 'relu'))
classifier.add(tf.keras.layers.Dropout(0.25))
classifier.add(tf.keras.layers.Dense(units = 256, activation = 'relu'))
classifier.add(tf.keras.layers.Dropout(0.25))
classifier.add(tf.keras.layers.Dense(units = 128, activation = 'relu'))
classifier.add(tf.keras.layers.Dropout(0.25))
classifier.add(tf.keras.layers.Dense(units = 64, activation = 'relu'))
classifier.add(tf.keras.layers.Dense(units = 20, activation = 'softmax'))

# Compiling the CNN
classifier.compile(optimizer = "Adam" , loss = 'categorical_crossentropy', metrics = [
'accuracy'])
```

In [ ]:

```
classifier.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d (Conv2D)              (None, 110, 90, 32)       320       
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 55, 45, 32)        0         
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 53, 43, 64)        18496     
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 26, 21, 64)        0         
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 24, 19, 128)       73856     
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 12, 9, 128)        0         
_________________________________________________________________
flatten (Flatten)            (None, 13824)             0         
_________________________________________________________________
dense (Dense)                (None, 512)               7078400   
_________________________________________________________________
dropout (Dropout)            (None, 512)               0         
_________________________________________________________________
dense_1 (Dense)              (None, 256)               131328    
_________________________________________________________________
dropout_1 (Dropout)          (None, 256)               0         
_________________________________________________________________
dense_2 (Dense)              (None, 128)               32896     
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0         
_________________________________________________________________
dense_3 (Dense)              (None, 64)                8256      
_________________________________________________________________
dense_4 (Dense)              (None, 20)                1300      
=================================================================
Total params: 7,344,852
Trainable params: 7,344,852
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:

```
#Custom Callback

class MyThresholdCallBack(tf.keras.callbacks.Callback):
    def __init__(self,cl):
        super(MyThresholdCallBack, self).__init__()
        self.cl = cl

    def on_epoch_end(self, epoch, logs=None):
        test_score = logs["val_accuracy"]
        train_score = logs["accuracy"]

        if test_score > train_score and test_score > self.cl:
        #if test_score > self.cl:
            self.model.stop_training = True
```

Task 6 - Train the Model

In [ ]:

```
myR2ScoreMonitor = MyThresholdCallBack(cl=0.90)

history = classifier.fit(x = x_train_edited, y = y_train_final,
                              validation_data = (x_test_edited, y_test_final),
                              steps_per_epoch= (x_train_final.shape[0])/batchSize,
                              epochs = epochs,
                              callbacks = [myR2ScoreMonitor],
                              validation_steps= (x_test_final.shape[0])/batchSize,
                              verbose=2
                              )
```

```
Epoch 1/200
20/20 - 0s - loss: 3.0082 - accuracy: 0.0292 - val_loss: 2.9955 - val_accu
racy: 0.0500
Epoch 2/200
20/20 - 0s - loss: 2.9979 - accuracy: 0.0458 - val_loss: 2.9955 - val_accu
racy: 0.0500
Epoch 3/200
20/20 - 0s - loss: 2.9962 - accuracy: 0.0625 - val_loss: 2.9939 - val_accu
racy: 0.0938
Epoch 4/200
20/20 - 0s - loss: 2.9992 - accuracy: 0.0458 - val_loss: 2.9915 - val_accu
racy: 0.0625
Epoch 5/200
20/20 - 0s - loss: 2.9628 - accuracy: 0.0583 - val_loss: 2.8499 - val_accu
racy: 0.1000
Epoch 6/200
20/20 - 0s - loss: 2.6820 - accuracy: 0.1458 - val_loss: 2.7778 - val_accu
racy: 0.1750
Epoch 7/200
20/20 - 0s - loss: 2.2670 - accuracy: 0.2917 - val_loss: 1.7695 - val_accu
racy: 0.3562
Epoch 8/200
20/20 - 0s - loss: 1.6622 - accuracy: 0.4750 - val_loss: 1.1813 - val_accu
racy: 0.6000
Epoch 9/200
20/20 - 0s - loss: 1.0720 - accuracy: 0.6417 - val_loss: 0.8300 - val_accu
racy: 0.7063
Epoch 10/200
20/20 - 0s - loss: 0.8808 - accuracy: 0.7042 - val_loss: 0.7005 - val_accu
racy: 0.7375
Epoch 11/200
20/20 - 0s - loss: 0.8016 - accuracy: 0.7250 - val_loss: 0.6564 - val_accu
racy: 0.7500
Epoch 12/200
20/20 - 0s - loss: 0.5518 - accuracy: 0.8167 - val_loss: 0.5155 - val_accu
racy: 0.8375
Epoch 13/200
20/20 - 0s - loss: 0.3760 - accuracy: 0.8458 - val_loss: 0.4656 - val_accu
racy: 0.8813
Epoch 14/200
20/20 - 0s - loss: 0.3938 - accuracy: 0.8667 - val_loss: 0.3926 - val_accu
racy: 0.8625
Epoch 15/200
20/20 - 0s - loss: 0.2316 - accuracy: 0.9208 - val_loss: 0.3373 - val_accu
racy: 0.9000
Epoch 16/200
20/20 - 0s - loss: 0.1991 - accuracy: 0.9292 - val_loss: 0.1886 - val_accu
racy: 0.9688
```

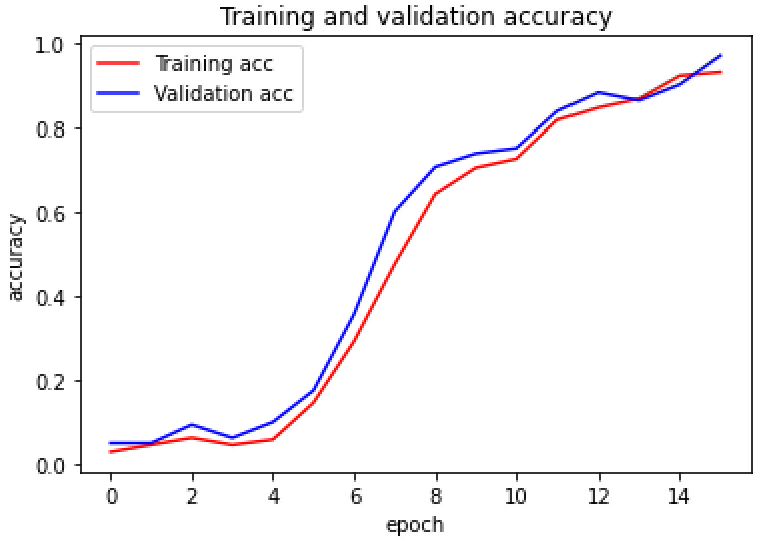
Task 7 - Train Results (Graph Visualization)

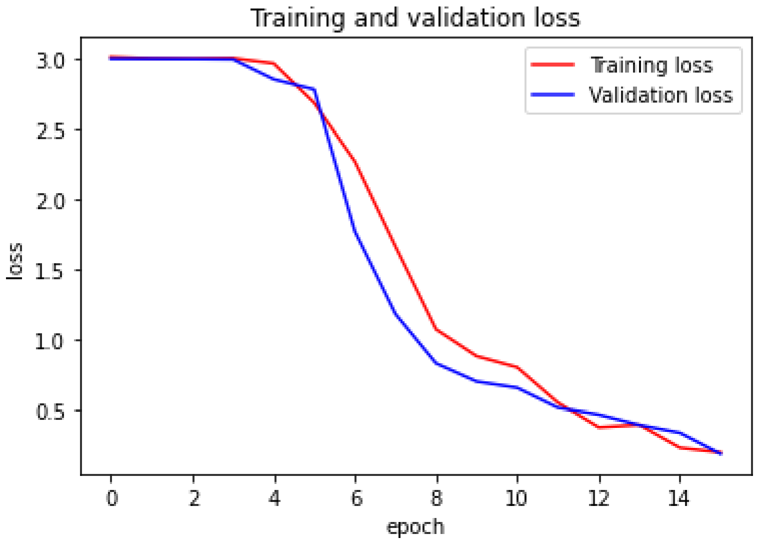
In [ ]:

```
#Graphing our training and validation
import matplotlib.pyplot as plt
%matplotlib inline
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(len(acc))
plt.plot(epochs, acc, 'r', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend()
plt.figure()

plt.plot(epochs, loss, 'r', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend()
plt.show()
```


Training and validation accuracy


Training and validation loss

Task 8 - Model trained above 90% and generalized successfully

In [ ]:

```
# training accuracy after final epoch
history.history['accuracy'][-1]
```

Out[ ]:

```
0.9291666746139526
```

In [ ]:

```
# test accuracy after final epoch
history.history['val_accuracy'][-1]
```

Out[ ]:

```
0.96875
```

Save The Model

In [ ]:

```
#classifier.save("FaceDetection.tf")
#classifier.save("FaceRecognition.h5")
classifier.save('FaceRecognition.tf2')
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/
python/training/tracking/tracking.py:111: Model.state_updates (from tensor
flow.python.keras.engine.training) is deprecated and will be removed in a
future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/
python/training/tracking/tracking.py:111: Layer.updates (from tensorflow.p
ython.keras.engine.base_layer) is deprecated and will be removed in a futu
re version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied
automatically.
INFO:tensorflow:Assets written to: FaceRecognition.tf2/assets
```