

faceMobileNet_TransferLearning

May 28, 2021

```
[ ]: # Mounting Google Drive
from google.colab import drive
from os.path import join
ROOT = '/content/drive'
print(ROOT)
drive.mount(ROOT)
```

```
/content/drive
Mounted at /content/drive
```

```
[ ]: %cd /content
```

```
/content
```

```
[1]: holly_face_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/archive.zip'

face_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
↳FaceRecognition/dataset2/'

VM_path = '/content'
drive_path = '/content/drive/MyDrive/Colab Notebooks/ProjectData/
↳FaceRecognition/'
VM_face_path = '/content/dataset2'
VM_face_aug_path = '/content/dataset'
face_detection_path= "/content/drive/MyDrive/Colab Notebooks/ProjectData/
↳FaceRecognition/face_detection_model/res10_300x300_ssd_iter_140000.
↳caffemodel"
proto_path = "/content/drive/MyDrive/Colab Notebooks/ProjectData/
↳FaceRecognition/face_detection_model/deploy.prototxt"
```

```
[2]: !cp '{holly_face_path}' '/content'
```

```
[3]: !unzip -q /content/archive.zip -d /content
```

```
[4]: #!cp -r '{face_path}' '{VM_path}'
```

```
[5]: #run this if you want to save augmented images
```

```
!mkdir /content/dataset
```

```
[ ]: # run this to clear all in dataset folder
```

```
!rm -r /content/dataset/*
```

rm: cannot remove '/content/dataset/*': No such file or directory

```
[ ]: # run this if you want to save face roi
```

```
!mkdir /content/dataset2
```

```
[ ]: #run this to clear all in dataset2 folder
```

```
!rm -r /content/dataset2/*
```

rm: cannot remove '/content/dataset2/*': No such file or directory

```
[ ]: %ls /content/dataset/
```

```
[6]: # Always run this
```

```
from keras.layers import Input, Lambda, Dense, Flatten,   
    ↳GlobalAveragePooling2D, Dropout
```

```
from keras.models import Model
```

```
from keras.applications.inception_v3 import InceptionV3
```

```
from keras.applications.mobilenet_v2 import MobileNetV2
```

```
from keras.applications.vgg16 import VGG16
```

```
from keras.applications.vgg16 import preprocess_input
```

```
from keras.preprocessing import image
```

```
from keras.preprocessing.image import ImageDataGenerator
```

```
from keras.callbacks import ModelCheckpoint
```

```
from keras.models import Sequential , load_model
```

```
import keras
```

```
import numpy as np
```

```
from glob import glob
```

```
import matplotlib.pyplot as plt
```

```
import os
```

```
import cv2
```

```
from google.colab.patches import cv2_imshow
```

```
import pickle
```

```
import random
```

```
import tensorflow as tf
```

```
from sklearn.model_selection import train_test_split
```

```
[ ]: #@title run this if do not have the face roi. What this code does is it
```

```
    ↳produces 5 augmentaions for each image in the dataset and saves it in the VM  
    ↳disk
```

```
# run this if do not have the face roi. What this code does is it produces 5
```

```
    ↳augmentaions for each image in the dataset
```

```
datagen = ImageDataGenerator(
```

```

rotation_range = 10,
width_shift_range = 0.2,
height_shift_range = 0.2,
zoom_range = 0.2,
horizontal_flip = True,
fill_mode='nearest')

image_size = 224
NUMBER_TO_AUGMENT = 5
c = 0
labelConverter = {}
dirpath = face_path
paths = os.listdir(dirpath)
#known_face = []

for directory in paths:
    !mkdir '/content/dataset/{directory}'
    labelConverter[directory] = c
    c+=1
print(labelConverter)
for p in paths:
    label = labelConverter[p]
    aug_save_path = VM_face_aug_path+'/' +p
    for p1 in os.listdir(dirpath+'/' +p):
        num_aug = 0
        try:
            path = dirpath+'/' +p+'/' +p1
            img = cv2.imread(path)
            #img = cv2.resize(img,(image_size, image_size))
            img_np = np.asarray(img)
            img_np = np.expand_dims(img_np,0)
            print("Image size = ",img_np.shape)
            it = datagen.flow(img_np, batch_size=1, save_to_dir=aug_save_path,
→save_prefix='celeb', save_format='png')
            while num_aug < NUMBER_TO_AUGMENT:
                it.next()
                print(num_aug+1,'th augmenatation of',path)
                num_aug += 1
        except Exception as e:
            print("Error",e)

```

```

[:]: #@title this uploads the augmented dataset from VM to drive
# this uploads the augmented dataset from VM to drive
!cp -r '{VM_face_aug_path}' '/content/drive/MyDrive/'

```

```

[:]: #@title Run This if you need Face detector model
# Run This if you need Face detector

```

```
print("Loading face detector.....")
detector = cv2.dnn.readNetFromCaffe(proto_path, face_detection_path)
```

```
[ ]: #@title run this if you need Haar Face detector model
```

```
# run this if you need Haar Face detector
```

```
face_dec = cv2.CascadeClassifier(cv2.data.
→haarcascades+'haarcascade_frontalface_default.xml')
```

```
[ ]: #@title run this if you need DNN Face detector fucntion
```

```
# run this if you need DNN Face detector
```

```
def getFace_CV2DNN(image):
    (h,w) = image.shape[:2]
    blob = cv2.dnn.blobFromImage(cv2.resize(image, (300,300)),1.0, (300,300),(104.
→0, 177.0, 123.0), swapRB= False, crop = False)
    detector.setInput(blob)
    detections = detector.forward()
    max = -1
    fHM = 0
    fWM = 0
    x1 = 0
    x2=0
    y1=0
    y2 = 0
    for i in range(0,detections.shape[2]):
        confidence = detections[0,0,i,2];

        if confidence < 0.7:
            continue

        box = detections[0, 0, i, 3:7] * np.array([w, h, w, h])
        (startX, startY, endX, endY) = box.astype("int")
        cv2.rectangle(image, (startX, startY), (endX, endY), (0,0,255), 2)

        fH = endX - startX
        fW = endY - startY
        #print("ggg-",fW,fH)
        if fH < 20 or fW < 20:
            continue
        area = fH*fW
        if max < area:
            max = area
            x1 = startX
            x2 = endX
            y1 = startY
            y2 = endY
    return x1,x2,y1,y2
```

```
[ ]: #@title run this if you need Haar Face detector function
```

```
# run this if you need Haar Face detector
def getFace_haar(image):
    max = -1
    x1 = 0
    x2=0
    y1=0
    y2 = 0
    faces = face_dec.detectMultiScale(image, 1.3,5)
    for (x,y,w,h) in faces:
        #print(w,h)
        if w < 20 or h <20:
            continue
        area = h*w
        if max < area:
            max = area
            x1 = x
            y1 = y
            x2 = x+w
            y2 = y+h

    return x1, x2, y1, y2
```

```
[ ]: #@title Run this if you want to get face_roi from augmented images
# Run this if you want to get face_roi from augmented images
#knownface = []
count = 0
k = 1
facelabels = os.listdir(VM_face_aug_path)
for f in facelabels:
    sorc = VM_face_aug_path+'/'+f
    dest = VM_face_path+'/'+f
    os.mkdir(dest)
    img_list = os.listdir(sorc)
    print('Processing ',f, str(k), 'out of ', str(len(facelabels)), 'classes')
    k += 1
    for img in img_list:
        imgPath = sorc+'/'+img
        image = cv2.imread(imgPath)
        #faces = face_dec.detectMultiScale(image)
        print(image.shape)
        cord = getFace_CV2DNN(image)
        if cord == None:
            continue
        x1,x2, y1, y2 = cord
        try:
```

```

image = cv2.cvtColor(image,cv2.COLOR_BGR2GRAY)
face = image[y1:y2, x1:x2]

savepath = dest+'/'+str(count)+'.png'
count += 1

cv2.imwrite(savepath, face)
except Exception as e:
    print('Error: ',e)

```

```

[:]: #@title run this if ypou want to upload the face_roi from VM to google drive
# run this if ypou want to upload the face_roi from VM to google drive
%cp -r '/content/dataset2' '/content/drive/MyDrive'

```

```

[:]: #@title run this if you want to download the face_roi from google drive to VM
# run this if you want to download the face_roi from google drive to VM
!cp -r '/content/drive/MyDrive/dataset2' '/content'

```

```

[7]: !ls -la /content/105_classes_pins_dataset/

```

```

total 1176
drwxr-xr-x 107 root root 4096 May 28 16:56 .
drwxr-xr-x  1 root root 4096 May 28 16:56 ..
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Adriana Lima'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_Alexandra Daddario'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Alex Lawther'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Alvaro Morte'
drwxr-xr-x  2 root root 16384 May 28 16:55 'pins_alycia dabnem carey'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_Amanda Crew'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_amber heard'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Andy Samberg'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Anne Hathaway'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Anthony Mackie'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Avril Lavigne'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_barack obama'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_barbara palvin'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_Ben Affleck'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_Bill Gates'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Bobby Morley'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Brenton Thwaites'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_Brian J. Smith'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Brie Larson'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_camila mendes'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Evans'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Hemsworth'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Chris Pratt'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Christian Bale'
drwxr-xr-x  2 root root 4096 May 28 16:55 'pins_Cristiano Ronaldo'
drwxr-xr-x  2 root root 12288 May 28 16:55 'pins_Danielle Panabaker'

```

drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Dominic Purcell'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Dwayne Johnson'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Elizabeth Lail'
drwxr-xr-x	2	root	root	16384	May	28	16:55	'pins_elizabeth olsen'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Eliza Taylor'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_ellen page'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_elon musk'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Emilια Clarke'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Emma Stone'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Emma Watson'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_gal gadot'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_grant gustin'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Gwyneth Paltrow'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Henry Cavil'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Hugh Jackman'
drwxr-xr-x	2	root	root	4096	May	28	16:55	'pins_Inbar Lavi'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Irina Shayk'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Jake Mcdorman'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Jason Momoa'
drwxr-xr-x	2	root	root	4096	May	28	16:56	'pins_jeff bezos'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Jennifer Lawrence'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Jeremy Renner'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Jessica Barden'
drwxr-xr-x	2	root	root	4096	May	28	16:55	'pins_Jimmy Fallon'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Johnny Depp'
drwxr-xr-x	2	root	root	4096	May	28	16:55	'pins_Josh Radnor'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Katharine Mcphee'
drwxr-xr-x	2	root	root	20480	May	28	16:55	'pins_Katherine Langford'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Keanu Reeves'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_kiernan shipka'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Krysten Ritter'
drwxr-xr-x	2	root	root	16384	May	28	16:55	'pins_Leonardo DiCaprio'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Lili Reinhart'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Lindsey Morgan'
drwxr-xr-x	2	root	root	4096	May	28	16:55	'pins_Lionel Messi'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Logan Lerman'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Madelaine Petsch'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Maisie Williams'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_margot robbie'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Maria Pedraza'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Marie Avgeropoulos'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Mark Ruffalo'
drwxr-xr-x	2	root	root	4096	May	28	16:55	'pins_Mark Zuckerberg'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Megan Fox'
drwxr-xr-x	2	root	root	12288	May	28	16:56	'pins_melissa fumero'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Miley Cyrus'
drwxr-xr-x	2	root	root	16384	May	28	16:55	'pins_Millie Bobby Brown'
drwxr-xr-x	2	root	root	12288	May	28	16:55	'pins_Morena Baccarin'

```

drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Morgan Freeman'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Nadia Hilker'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Natalie Dormer'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Natalie Portman'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Neil Patrick Harris'
drwxr-xr-x 2 root root 4096 May 28 16:55 'pins_Pedro Alonso'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Penn Badgley'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Rami Malek'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Rebecca Ferguson'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Richard Harmon'
drwxr-xr-x 2 root root 4096 May 28 16:55 pins_Rihanna
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Robert De Niro'
drwxr-xr-x 2 root root 16384 May 28 16:55 'pins_Robert Downey Jr'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Sarah Wayne Callies'
drwxr-xr-x 2 root root 16384 May 28 16:56 'pins_scarlett johansson'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Selena Gomez'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Shakira Isabel Mebarak'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Sophie Turner'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Stephen Amell'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Taylor Swift'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Tom Cruise'
drwxr-xr-x 2 root root 12288 May 28 16:56 'pins_tom ellis'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Tom Hardy'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Tom Hiddleston'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Tom Holland'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Tuppence Middleton'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Ursula Corbero'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Wentworth Miller'
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Zac Efron'
drwxr-xr-x 2 root root 4096 May 28 16:55 pins_Zendaya
drwxr-xr-x 2 root root 12288 May 28 16:55 'pins_Zoe Saldana'

```

[8]: *# set the dataset on which you want to train*

```

train_path1 = '/content/105_classes_pins_dataset/'
train_path = '/content/dataset'

```

[9]: *#title Takes 20 classes from 105_classes_pins_dataset and saves it a new
→ folder /content/dataset*

```

count = 0
NB_CLASS = 20
l = os.listdir(train_path1)
for li in l:
    count += 1
    sor = '"105_classes_pins_dataset/'+li+'"'
    dest = 'dataset'
    cmd = 'cp -r ' + sor + ' ' + dest
    cmd1 = 'rm -r ' + sor
    os.system(cmd)

```



```

os.system(cmd1)
if count >= NB_CLASS:
    break

```

[10]: *#@title Contains Image Data generator to generate augmented images and save it
→ in variable. Also contains code to take all the images and make a list out
→ of it*

```

datagen = ImageDataGenerator(
    rotation_range = 10,
    width_shift_range = 0.2,
    height_shift_range = 0.2,
    zoom_range = 0.2,
    horizontal_flip = True,
    fill_mode='nearest')
NUM_AUG = 1
knownface = []
labels = []
labelEncoder = {}
count = 0
c = 0
dir = '/content/dataset/'
'''
for d in os.listdir(dir):
    labelEncoder[count] = d
    print('Processig for ....',d)
    for k in os.listdir(dir+d):
        image = cv2.imread(dir+d+'/'+k)
        img_np = np.asarray(image)
        img_np = img_np[np.newaxis,:,:,:]

        for im in datagen.flow(img_np, batch_size=1):
            imnp = cv2.resize(im[0], (224,224))

            knownface.append(imnp)
            labels.append(count)
            c+=1
            if c >= NUM_AUG:
                break
        c = 0
    count += 1
'''
for d in os.listdir(dir):
    labelEncoder[count] = d
    print('Processig for ....',d)
    for k in os.listdir(dir+d):
        image = cv2.imread(dir+d+'/'+k)
        #img_np = np.asarray(image)

```

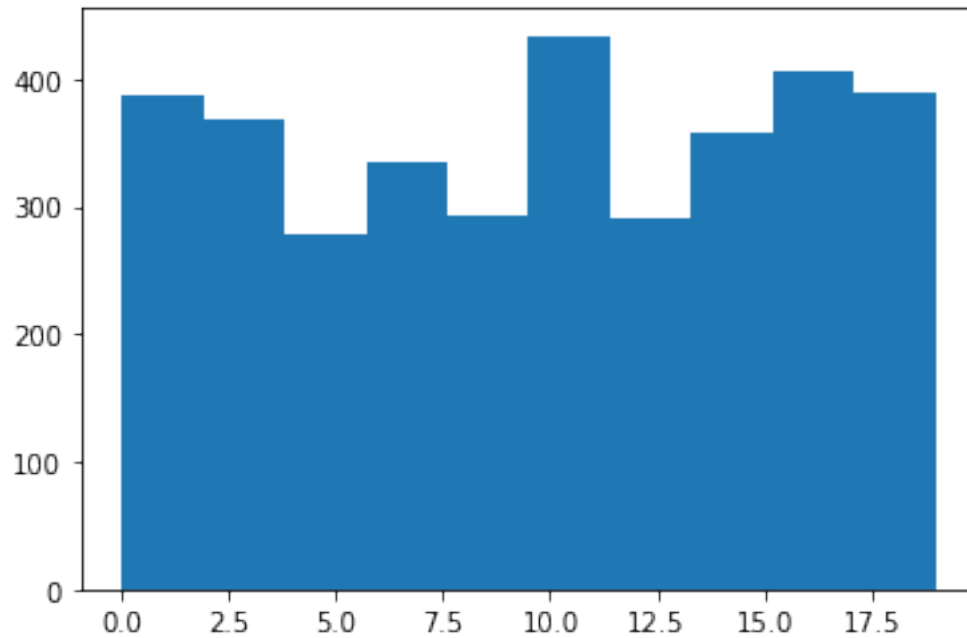
```
imnp = cv2.resize(image, (224,224))
knownface.append(imnp)
labels.append(count)
count += 1
```

```
Processig for ... pins_Miley Cyrus
Processig for ... pins_Emilia Clarke
Processig for ... pins_Rebecca Ferguson
Processig for ... pins_Millie Bobby Brown
Processig for ... pins_grant gustin
Processig for ... pins_Mark Zuckerberg
Processig for ... pins_amber heard
Processig for ... pins_Neil Patrick Harris
Processig for ... pins_Bill Gates
Processig for ... pins_Krysten Ritter
Processig for ... pins_Brenton Thwaites
Processig for ... pins_Alexandra Daddario
Processig for ... pins_Taylor Swift
Processig for ... pins_Stephen Amell
Processig for ... pins_Madelaine Petsch
Processig for ... pins_Jeremy Renner
Processig for ... pins_Katherine Langford
Processig for ... pins_Jennifer Lawrence
Processig for ... pins_Anne Hathaway
Processig for ... pins_Zoe Saldana
```

```
[11]: X = np.array(knownface)
      y = np.array(labels)
      num_classes = len(labelEncoder)
```

```
[12]: plt.hist(y)
```

```
[12]: (array([388., 369., 278., 334., 293., 434., 290., 359., 406., 389.]),
      array([ 0. ,  1.9,  3.8,  5.7,  7.6,  9.5, 11.4, 13.3, 15.2, 17.1, 19. ]),
      <a list of 10 Patch objects>)
```



```
[13]: labelEncoder
```

```
[13]: {0: 'pins_Miley Cyrus',  
      1: 'pins_Emilia Clarke',  
      2: 'pins_Rebecca Ferguson',  
      3: 'pins_Millie Bobby Brown',  
      4: 'pins_grant gustin',  
      5: 'pins_Mark Zuckerberg',  
      6: 'pins_amber heard',  
      7: 'pins_Neil Patrick Harris',  
      8: 'pins_Bill Gates',  
      9: 'pins_Krysten Ritter',  
      10: 'pins_Brenton Thwaites',  
      11: 'pins_Alexandra Daddario',  
      12: 'pins_Taylor Swift',  
      13: 'pins_Stephen Amell',  
      14: 'pins_Madelaine Petsch',  
      15: 'pins_Jeremy Renner',  
      16: 'pins_Katherine Langford',  
      17: 'pins_Jennifer Lawrence',  
      18: 'pins_Anne Hathaway',  
      19: 'pins_Zoe Saldana'}
```

```
[14]: print(len(knownface))
```

3540

```
[15]: X_1, X_test, y_1, y_test = train_test_split( X, y, shuffle=True, random_state = 100, test_size=0.2, stratify=y)
```

```
[16]: X_train, X_val, y_train, y_val = train_test_split( X_1, y_1, shuffle=True, random_state = 100, test_size=0.25, stratify=y_1)
```

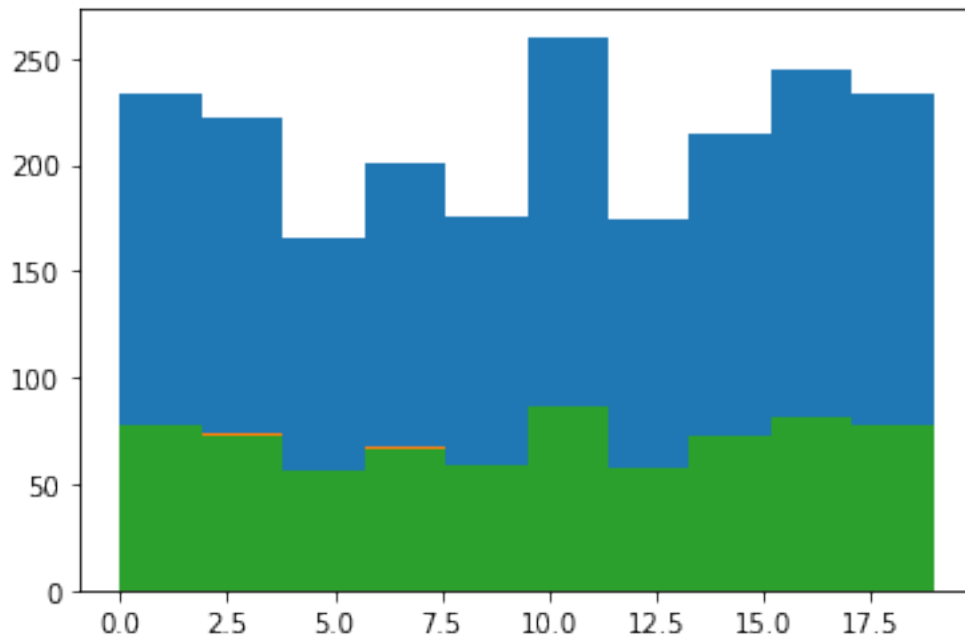
```
[17]: y_val
```

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

```
2, 7, 13, 17, 12, 0, 18, 15, 3, 4, 6, 3, 3, 18, 1, 15, 6,
2, 18, 1, 18, 2, 0, 5, 2, 19, 2, 8])
```

```
[18]: plt.hist(y_train)
      plt.hist(y_test)
      plt.hist(y_val)
```

```
[18]: (array([77., 73., 56., 66., 59., 87., 58., 73., 81., 78.]),
      array([ 0. ,  1.9,  3.8,  5.7,  7.6,  9.5, 11.4, 13.3, 15.2, 17.1, 19. ]),
      <a list of 10 Patch objects>)
```



```
[19]: y_train = tf.keras.utils.to_categorical(y_train, num_classes)
      y_test = tf.keras.utils.to_categorical(y_test, num_classes)
      y_val = tf.keras.utils.to_categorical(y_val, num_classes)
```

```
[20]: print(X_test.shape)
      print(X_val.shape)
      print(X_train.shape)
```

```
(708, 224, 224, 3)
(708, 224, 224, 3)
(2124, 224, 224, 3)
```

```
[21]: from keras.preprocessing.image import ImageDataGenerator
      '''
      train_datagen = ImageDataGenerator(rescale = 1./255,
                                          rotation_range=10,
```

```

        horizontal_flip=True,
        brightness_range = [0.5,1.5],
        validation_split=0.2)

training_set = train_datagen.flow_from_directory(train_path,
                                                target_size = IMAGE_SIZE,
                                                batch_size = 32,
                                                class_mode = 'categorical',
                                                subset='training')

testing_set = train_datagen.flow_from_directory(train_path,
                                                target_size = IMAGE_SIZE,
                                                batch_size = 32,
                                                class_mode = 'categorical',
                                                subset='validation')

'''

from keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(rescale = 1./255,
                                   rotation_range=10,
                                   horizontal_flip=True,
                                   width_shift_range = 0.2,
                                   height_shift_range = 0.1,
                                   zoom_range = 0.2,
                                   brightness_range = [0.5,1.5])

training_set = train_datagen.flow(x = X_train,y = y_train,batch_size = 32)

testing_set = train_datagen.flow(x = X_test,y= y_test,batch_size = 32)

validation_set = train_datagen.flow(x= X_val, y = y_val, batch_size=32)

```

[22]: *# re-size all the images to this*

```

IMAGE_SIZE = [224, 224]

# add preprocessing layer to the front of VGG
#vgg = VGG16(input_shape=IMAGE_SIZE + [3], weights='imagenet',
→include_top=False)
vgg = MobileNetV2(include_top=False,weights='imagenet', input_shape=(224,224,3))

# don't train existing weights

vgg.trainable=True

```

```
# useful for getting number of classes
folders = glob(train_path+'/*')

print("Number of classes = ", len(folders))
```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h5

9412608/9406464 [=====] - 0s 0us/step
9420800/9406464 [=====] - 0s 0us/step
Number of classes = 20

```
[23]: '''
unfrozen_layer = -43 # InceptionV3
#unfrozen_layer = -1 # VGG16
for l in vgg.layers[unfrozen_layer:]:
    l.trainable = True
'''
vgg.summary()
for l in vgg.layers:
    print(l, l.trainable)
```

Model: "mobilenetv2_1.00_224"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 224, 224, 3)]	0	
Conv1 (Conv2D)	(None, 112, 112, 32)	864	input_1[0][0]
bn_Conv1 (BatchNormalization)	(None, 112, 112, 32)	128	Conv1[0][0]
Conv1_relu (ReLU)	(None, 112, 112, 32)	0	bn_Conv1[0][0]
expanded_conv_depthwise (Depthwise Conv2D)	(None, 112, 112, 32)	288	Conv1_relu[0][0]
expanded_conv_depthwise_BN (BatchNormalization)	(None, 112, 112, 32)	128	expanded_conv_depthwise[0][0]

expanded_conv_depthwise_relu (R (None, 112, 112, 32) 0
expanded_conv_depthwise_BN[0][0]

expanded_conv_project (Conv2D) (None, 112, 112, 16) 512
expanded_conv_depthwise_relu[0][0]

expanded_conv_project_BN (Batch (None, 112, 112, 16) 64
expanded_conv_project[0][0]

block_1_expand (Conv2D) (None, 112, 112, 96) 1536
expanded_conv_project_BN[0][0]

block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384
block_1_expand[0][0]

block_1_expand_relu (ReLU) (None, 112, 112, 96) 0
block_1_expand_BN[0][0]

block_1_pad (ZeroPadding2D) (None, 113, 113, 96) 0
block_1_expand_relu[0][0]

block_1_depthwise (DepthwiseCon (None, 56, 56, 96) 864
block_1_pad[0][0]

block_1_depthwise_BN (BatchNorm (None, 56, 56, 96) 384
block_1_depthwise[0][0]

block_1_depthwise_relu (ReLU) (None, 56, 56, 96) 0
block_1_depthwise_BN[0][0]

block_1_project (Conv2D) (None, 56, 56, 24) 2304
block_1_depthwise_relu[0][0]

block_1_project_BN (BatchNormal (None, 56, 56, 24) 96
block_1_project[0][0]

```

-----
block_2_expand (Conv2D)          (None, 56, 56, 144)  3456
block_1_project_BN[0][0]

```

```

-----
block_2_expand_BN (BatchNormali (None, 56, 56, 144)  576
block_2_expand[0][0]

```

```

-----
block_2_expand_relu (ReLU)       (None, 56, 56, 144)  0
block_2_expand_BN[0][0]

```

```

-----
block_2_depthwise (DepthwiseCon (None, 56, 56, 144)  1296
block_2_expand_relu[0][0]

```

```

-----
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144)  576
block_2_depthwise[0][0]

```

```

-----
block_2_depthwise_relu (ReLU)    (None, 56, 56, 144)  0
block_2_depthwise_BN[0][0]

```

```

-----
block_2_project (Conv2D)         (None, 56, 56, 24)   3456
block_2_depthwise_relu[0][0]

```

```

-----
block_2_project_BN (BatchNormal (None, 56, 56, 24)   96
block_2_project[0][0]

```

```

-----
block_2_add (Add)                (None, 56, 56, 24)   0
block_1_project_BN[0][0]
block_2_project_BN[0][0]

```

```

-----
block_3_expand (Conv2D)          (None, 56, 56, 144)  3456
block_2_add[0][0]

```

```

-----
block_3_expand_BN (BatchNormali (None, 56, 56, 144)  576
block_3_expand[0][0]

```

```

-----
block_3_expand_relu (ReLU)       (None, 56, 56, 144)  0
block_3_expand_BN[0][0]

```

```

-----
-----
block_3_pad (ZeroPadding2D)      (None, 57, 57, 144)  0
block_3_expand_relu[0][0]
-----
-----
block_3_depthwise (DepthwiseCon (None, 28, 28, 144)  1296
block_3_pad[0][0]
-----
-----
block_3_depthwise_BN (BatchNorm (None, 28, 28, 144)  576
block_3_depthwise[0][0]
-----
-----
block_3_depthwise_relu (ReLU)    (None, 28, 28, 144)  0
block_3_depthwise_BN[0][0]
-----
-----
block_3_project (Conv2D)         (None, 28, 28, 32)   4608
block_3_depthwise_relu[0][0]
-----
-----
block_3_project_BN (BatchNormal (None, 28, 28, 32)   128
block_3_project[0][0]
-----
-----
block_4_expand (Conv2D)          (None, 28, 28, 192)  6144
block_3_project_BN[0][0]
-----
-----
block_4_expand_BN (BatchNormali (None, 28, 28, 192)  768
block_4_expand[0][0]
-----
-----
block_4_expand_relu (ReLU)       (None, 28, 28, 192)  0
block_4_expand_BN[0][0]
-----
-----
block_4_depthwise (DepthwiseCon (None, 28, 28, 192)  1728
block_4_expand_relu[0][0]
-----
-----
block_4_depthwise_BN (BatchNorm (None, 28, 28, 192)  768
block_4_depthwise[0][0]
-----
-----
block_4_depthwise_relu (ReLU)    (None, 28, 28, 192)  0
block_4_depthwise_BN[0][0]

```

```

-----
-----
block_4_project (Conv2D)          (None, 28, 28, 32)    6144
block_4_depthwise_relu[0][0]
-----

-----
block_4_project_BN (BatchNormal (None, 28, 28, 32)    128
block_4_project[0][0]
-----

-----
block_4_add (Add)                  (None, 28, 28, 32)    0
block_3_project_BN[0][0]
block_4_project_BN[0][0]
-----

-----
block_5_expand (Conv2D)            (None, 28, 28, 192)   6144
block_4_add[0][0]
-----

-----
block_5_expand_BN (BatchNormali (None, 28, 28, 192)   768
block_5_expand[0][0]
-----

-----
block_5_expand_relu (ReLU)         (None, 28, 28, 192)   0
block_5_expand_BN[0][0]
-----

-----
block_5_depthwise (DepthwiseCon (None, 28, 28, 192)   1728
block_5_expand_relu[0][0]
-----

-----
block_5_depthwise_BN (BatchNorm (None, 28, 28, 192)   768
block_5_depthwise[0][0]
-----

-----
block_5_depthwise_relu (ReLU)      (None, 28, 28, 192)   0
block_5_depthwise_BN[0][0]
-----

-----
block_5_project (Conv2D)           (None, 28, 28, 32)    6144
block_5_depthwise_relu[0][0]
-----

-----
block_5_project_BN (BatchNormal (None, 28, 28, 32)    128
block_5_project[0][0]
-----

-----
block_5_add (Add)                   (None, 28, 28, 32)    0

```

```

block_4_add[0][0]
block_5_project_BN[0][0]
-----
-----
block_6_expand (Conv2D)          (None, 28, 28, 192)  6144
block_5_add[0][0]
-----
-----
block_6_expand_BN (BatchNormali (None, 28, 28, 192)  768
block_6_expand[0][0]
-----
-----
block_6_expand_relu (ReLU)       (None, 28, 28, 192)  0
block_6_expand_BN[0][0]
-----
-----
block_6_pad (ZeroPadding2D)      (None, 29, 29, 192)  0
block_6_expand_relu[0][0]
-----
-----
block_6_depthwise (DepthwiseCon (None, 14, 14, 192)  1728
block_6_pad[0][0]
-----
-----
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192)  768
block_6_depthwise[0][0]
-----
-----
block_6_depthwise_relu (ReLU)    (None, 14, 14, 192)  0
block_6_depthwise_BN[0][0]
-----
-----
block_6_project (Conv2D)         (None, 14, 14, 64)   12288
block_6_depthwise_relu[0][0]
-----
-----
block_6_project_BN (BatchNormal (None, 14, 14, 64)   256
block_6_project[0][0]
-----
-----
block_7_expand (Conv2D)          (None, 14, 14, 384)  24576
block_6_project_BN[0][0]
-----
-----
block_7_expand_BN (BatchNormali (None, 14, 14, 384)  1536
block_7_expand[0][0]
-----
-----

```

```

block_7_expand_relu (ReLU)          (None, 14, 14, 384)  0
block_7_expand_BN[0][0]
-----

block_7_depthwise (DepthwiseCon (None, 14, 14, 384)  3456
block_7_expand_relu[0][0]
-----

block_7_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
block_7_depthwise[0][0]
-----

block_7_depthwise_relu (ReLU)      (None, 14, 14, 384)  0
block_7_depthwise_BN[0][0]
-----

block_7_project (Conv2D)            (None, 14, 14, 64)   24576
block_7_depthwise_relu[0][0]
-----

block_7_project_BN (BatchNormal (None, 14, 14, 64)   256
block_7_project[0][0]
-----

block_7_add (Add)                   (None, 14, 14, 64)   0
block_6_project_BN[0][0]
block_7_project_BN[0][0]
-----

block_8_expand (Conv2D)             (None, 14, 14, 384)  24576
block_7_add[0][0]
-----

block_8_expand_BN (BatchNormali (None, 14, 14, 384)  1536
block_8_expand[0][0]
-----

block_8_expand_relu (ReLU)          (None, 14, 14, 384)  0
block_8_expand_BN[0][0]
-----

block_8_depthwise (DepthwiseCon (None, 14, 14, 384)  3456
block_8_expand_relu[0][0]
-----

block_8_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
block_8_depthwise[0][0]
-----

```

```

-----
block_8_depthwise_relu (ReLU)      (None, 14, 14, 384)  0
block_8_depthwise_BN[0][0]
-----

-----
block_8_project (Conv2D)           (None, 14, 14, 64)   24576
block_8_depthwise_relu[0][0]
-----

-----
block_8_project_BN (BatchNormal (None, 14, 14, 64)   256
block_8_project[0][0]
-----

-----
block_8_add (Add)                  (None, 14, 14, 64)   0
block_7_add[0][0]
block_8_project_BN[0][0]
-----

-----
block_9_expand (Conv2D)            (None, 14, 14, 384)  24576
block_8_add[0][0]
-----

-----
block_9_expand_BN (BatchNormali (None, 14, 14, 384)  1536
block_9_expand[0][0]
-----

-----
block_9_expand_relu (ReLU)         (None, 14, 14, 384)  0
block_9_expand_BN[0][0]
-----

-----
block_9_depthwise (DepthwiseCon (None, 14, 14, 384)  3456
block_9_expand_relu[0][0]
-----

-----
block_9_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536
block_9_depthwise[0][0]
-----

-----
block_9_depthwise_relu (ReLU)      (None, 14, 14, 384)  0
block_9_depthwise_BN[0][0]
-----

-----
block_9_project (Conv2D)           (None, 14, 14, 64)   24576
block_9_depthwise_relu[0][0]
-----

-----
block_9_project_BN (BatchNormal (None, 14, 14, 64)   256
block_9_project[0][0]

```

```

-----
-----
block_9_add (Add) (None, 14, 14, 64) 0
block_8_add[0][0]
block_9_project_BN[0][0]
-----
-----
block_10_expand (Conv2D) (None, 14, 14, 384) 24576
block_9_add[0][0]
-----
-----
block_10_expand_BN (BatchNormal (None, 14, 14, 384) 1536
block_10_expand[0][0]
-----
-----
block_10_expand_relu (ReLU) (None, 14, 14, 384) 0
block_10_expand_BN[0][0]
-----
-----
block_10_depthwise (DepthwiseCo (None, 14, 14, 384) 3456
block_10_expand_relu[0][0]
-----
-----
block_10_depthwise_BN (BatchNor (None, 14, 14, 384) 1536
block_10_depthwise[0][0]
-----
-----
block_10_depthwise_relu (ReLU) (None, 14, 14, 384) 0
block_10_depthwise_BN[0][0]
-----
-----
block_10_project (Conv2D) (None, 14, 14, 96) 36864
block_10_depthwise_relu[0][0]
-----
-----
block_10_project_BN (BatchNorma (None, 14, 14, 96) 384
block_10_project[0][0]
-----
-----
block_11_expand (Conv2D) (None, 14, 14, 576) 55296
block_10_project_BN[0][0]
-----
-----
block_11_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_11_expand[0][0]
-----
-----
block_11_expand_relu (ReLU) (None, 14, 14, 576) 0

```

block_11_expand_BN[0][0]

block_11_depthwise (DepthwiseCo (None, 14, 14, 576) 5184
block_11_expand_relu[0][0]

block_11_depthwise_BN (BatchNor (None, 14, 14, 576) 2304
block_11_depthwise[0][0]

block_11_depthwise_relu (ReLU) (None, 14, 14, 576) 0
block_11_depthwise_BN[0][0]

block_11_project (Conv2D) (None, 14, 14, 96) 55296
block_11_depthwise_relu[0][0]

block_11_project_BN (BatchNorma (None, 14, 14, 96) 384
block_11_project[0][0]

block_11_add (Add) (None, 14, 14, 96) 0
block_10_project_BN[0][0]
block_11_project_BN[0][0]

block_12_expand (Conv2D) (None, 14, 14, 576) 55296
block_11_add[0][0]

block_12_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_12_expand[0][0]

block_12_expand_relu (ReLU) (None, 14, 14, 576) 0
block_12_expand_BN[0][0]

block_12_depthwise (DepthwiseCo (None, 14, 14, 576) 5184
block_12_expand_relu[0][0]

block_12_depthwise_BN (BatchNor (None, 14, 14, 576) 2304
block_12_depthwise[0][0]


```

block_12_depthwise_relu (ReLU) (None, 14, 14, 576) 0
block_12_depthwise_BN[0][0]
-----
block_12_project (Conv2D) (None, 14, 14, 96) 55296
block_12_depthwise_relu[0][0]
-----
block_12_project_BN (BatchNorma (None, 14, 14, 96) 384
block_12_project[0][0]
-----
block_12_add (Add) (None, 14, 14, 96) 0
block_11_add[0][0]
block_12_project_BN[0][0]
-----
block_13_expand (Conv2D) (None, 14, 14, 576) 55296
block_12_add[0][0]
-----
block_13_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_13_expand[0][0]
-----
block_13_expand_relu (ReLU) (None, 14, 14, 576) 0
block_13_expand_BN[0][0]
-----
block_13_pad (ZeroPadding2D) (None, 15, 15, 576) 0
block_13_expand_relu[0][0]
-----
block_13_depthwise (DepthwiseCo (None, 7, 7, 576) 5184
block_13_pad[0][0]
-----
block_13_depthwise_BN (BatchNor (None, 7, 7, 576) 2304
block_13_depthwise[0][0]
-----
block_13_depthwise_relu (ReLU) (None, 7, 7, 576) 0
block_13_depthwise_BN[0][0]
-----
block_13_project (Conv2D) (None, 7, 7, 160) 92160
block_13_depthwise_relu[0][0]
-----

```

```

-----
block_13_project_BN (BatchNorma (None, 7, 7, 160)    640
block_13_project[0][0]
-----

-----
block_14_expand (Conv2D)          (None, 7, 7, 960)    153600
block_13_project_BN[0][0]
-----

-----
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840
block_14_expand[0][0]
-----

-----
block_14_expand_relu (ReLU)       (None, 7, 7, 960)    0
block_14_expand_BN[0][0]
-----

-----
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640
block_14_expand_relu[0][0]
-----

-----
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840
block_14_depthwise[0][0]
-----

-----
block_14_depthwise_relu (ReLU)    (None, 7, 7, 960)    0
block_14_depthwise_BN[0][0]
-----

-----
block_14_project (Conv2D)          (None, 7, 7, 160)    153600
block_14_depthwise_relu[0][0]
-----

-----
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640
block_14_project[0][0]
-----

-----
block_14_add (Add)                 (None, 7, 7, 160)    0
block_13_project_BN[0][0]
block_14_project_BN[0][0]
-----

-----
block_15_expand (Conv2D)          (None, 7, 7, 960)    153600
block_14_add[0][0]
-----

-----
block_15_expand_BN (BatchNormal (None, 7, 7, 960)    3840
block_15_expand[0][0]

```

```

-----
-----
block_15_expand_relu (ReLU)      (None, 7, 7, 960)    0
block_15_expand_BN[0][0]
-----
-----
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)    8640
block_15_expand_relu[0][0]
-----
-----
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)    3840
block_15_depthwise[0][0]
-----
-----
block_15_depthwise_relu (ReLU)   (None, 7, 7, 960)    0
block_15_depthwise_BN[0][0]
-----
-----
block_15_project (Conv2D)         (None, 7, 7, 160)    153600
block_15_depthwise_relu[0][0]
-----
-----
block_15_project_BN (BatchNorma (None, 7, 7, 160)    640
block_15_project[0][0]
-----
-----
block_15_add (Add)                (None, 7, 7, 160)    0
block_14_add[0][0]
block_15_project_BN[0][0]
-----
-----
block_16_expand (Conv2D)          (None, 7, 7, 960)    153600
block_15_add[0][0]
-----
-----
block_16_expand_BN (BatchNormal (None, 7, 7, 960)    3840
block_16_expand[0][0]
-----
-----
block_16_expand_relu (ReLU)      (None, 7, 7, 960)    0
block_16_expand_BN[0][0]
-----
-----
block_16_depthwise (DepthwiseCo (None, 7, 7, 960)    8640
block_16_expand_relu[0][0]
-----
-----
block_16_depthwise_BN (BatchNor (None, 7, 7, 960)    3840

```

```

block_16_depthwise[0][0]

-----

block_16_depthwise_relu (ReLU) (None, 7, 7, 960) 0
block_16_depthwise_BN[0][0]

-----

block_16_project (Conv2D) (None, 7, 7, 320) 307200
block_16_depthwise_relu[0][0]

-----

block_16_project_BN (BatchNorma (None, 7, 7, 320) 1280
block_16_project[0][0]

-----

Conv_1 (Conv2D) (None, 7, 7, 1280) 409600
block_16_project_BN[0][0]

-----

Conv_1_bn (BatchNormalization) (None, 7, 7, 1280) 5120 Conv_1[0][0]

-----

out_relu (ReLU) (None, 7, 7, 1280) 0 Conv_1_bn[0][0]
=====
=====
Total params: 2,257,984
Trainable params: 2,223,872
Non-trainable params: 34,112

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```

```

[24]: x = GlobalAveragePooling2D()(vgg.get_layer('out_relu').output)
      x = Dropout(0.8)(x)
      prediction = Dense(len(folders), activation='softmax')(x)

      # create a model object
      model = Model(inputs=vgg.input, outputs=prediction)

```

```
# view the structure of the model
model.summary()
```

Model: "model"

```
-----
Layer (type)                 Output Shape          Param #   Connected to
=====
input_1 (InputLayer)         [(None, 224, 224, 3) 0
-----
Conv1 (Conv2D)                (None, 112, 112, 32) 864        input_1[0][0]
-----
bn_Conv1 (BatchNormalization) (None, 112, 112, 32) 128        Conv1[0][0]
-----
Conv1_relu (ReLU)            (None, 112, 112, 32) 0          bn_Conv1[0][0]
-----
expanded_conv_depthwise (Depthw (None, 112, 112, 32) 288
Conv1_relu[0][0]
-----
expanded_conv_depthwise_BN (Bat (None, 112, 112, 32) 128
expanded_conv_depthwise[0][0]
-----
expanded_conv_depthwise_relu (R (None, 112, 112, 32) 0
expanded_conv_depthwise_BN[0][0]
-----
expanded_conv_project (Conv2D) (None, 112, 112, 16) 512
expanded_conv_depthwise_relu[0][0]
-----
expanded_conv_project_BN (Batch (None, 112, 112, 16) 64
expanded_conv_project[0][0]
-----
block_1_expand (Conv2D)       (None, 112, 112, 96) 1536
expanded_conv_project_BN[0][0]
-----
block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384
```



```

block_1_expand[0][0]
-----
-----
block_1_expand_relu (ReLU)      (None, 112, 112, 96) 0
block_1_expand_BN[0][0]
-----
-----
block_1_pad (ZeroPadding2D)     (None, 113, 113, 96) 0
block_1_expand_relu[0][0]
-----
-----
block_1_depthwise (DepthwiseCon (None, 56, 56, 96) 864
block_1_pad[0][0]
-----
-----
block_1_depthwise_BN (BatchNorm (None, 56, 56, 96) 384
block_1_depthwise[0][0]
-----
-----
block_1_depthwise_relu (ReLU)   (None, 56, 56, 96) 0
block_1_depthwise_BN[0][0]
-----
-----
block_1_project (Conv2D)        (None, 56, 56, 24) 2304
block_1_depthwise_relu[0][0]
-----
-----
block_1_project_BN (BatchNormal (None, 56, 56, 24) 96
block_1_project[0][0]
-----
-----
block_2_expand (Conv2D)         (None, 56, 56, 144) 3456
block_1_project_BN[0][0]
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-----
block_2_expand_BN (BatchNormali (None, 56, 56, 144) 576
block_2_expand[0][0]
-----
-----
block_2_expand_relu (ReLU)      (None, 56, 56, 144) 0
block_2_expand_BN[0][0]
-----
-----
block_2_depthwise (DepthwiseCon (None, 56, 56, 144) 1296
block_2_expand_relu[0][0]
-----
-----
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144) 576

```

block_2_depthwise[0][0]

block_2_depthwise_relu (ReLU) (None, 56, 56, 144) 0
block_2_depthwise_BN[0][0]

block_2_project (Conv2D) (None, 56, 56, 24) 3456
block_2_depthwise_relu[0][0]

block_2_project_BN (BatchNormal (None, 56, 56, 24) 96
block_2_project[0][0]

block_2_add (Add) (None, 56, 56, 24) 0
block_1_project_BN[0][0]
block_2_project_BN[0][0]

block_3_expand (Conv2D) (None, 56, 56, 144) 3456
block_2_add[0][0]

block_3_expand_BN (BatchNormali (None, 56, 56, 144) 576
block_3_expand[0][0]

block_3_expand_relu (ReLU) (None, 56, 56, 144) 0
block_3_expand_BN[0][0]

block_3_pad (ZeroPadding2D) (None, 57, 57, 144) 0
block_3_expand_relu[0][0]

block_3_depthwise (DepthwiseCon (None, 28, 28, 144) 1296
block_3_pad[0][0]

block_3_depthwise_BN (BatchNorm (None, 28, 28, 144) 576
block_3_depthwise[0][0]

block_3_depthwise_relu (ReLU) (None, 28, 28, 144) 0
block_3_depthwise_BN[0][0]

block_3_project (Conv2D) (None, 28, 28, 32) 4608
block_3_depthwise_relu[0][0]

block_3_project_BN (BatchNormal (None, 28, 28, 32) 128
block_3_project[0][0]

block_4_expand (Conv2D) (None, 28, 28, 192) 6144
block_3_project_BN[0][0]

block_4_expand_BN (BatchNormali (None, 28, 28, 192) 768
block_4_expand[0][0]

block_4_expand_relu (ReLU) (None, 28, 28, 192) 0
block_4_expand_BN[0][0]

block_4_depthwise (DepthwiseCon (None, 28, 28, 192) 1728
block_4_expand_relu[0][0]

block_4_depthwise_BN (BatchNorm (None, 28, 28, 192) 768
block_4_depthwise[0][0]

block_4_depthwise_relu (ReLU) (None, 28, 28, 192) 0
block_4_depthwise_BN[0][0]

block_4_project (Conv2D) (None, 28, 28, 32) 6144
block_4_depthwise_relu[0][0]

block_4_project_BN (BatchNormal (None, 28, 28, 32) 128
block_4_project[0][0]

block_4_add (Add) (None, 28, 28, 32) 0
block_3_project_BN[0][0]
block_4_project_BN[0][0]

block_5_expand (Conv2D) (None, 28, 28, 192) 6144
block_4_add[0][0]

block_5_expand_BN (BatchNormali (None, 28, 28, 192) 768
block_5_expand[0][0]

block_5_expand_relu (ReLU) (None, 28, 28, 192) 0
block_5_expand_BN[0][0]

block_5_depthwise (DepthwiseCon (None, 28, 28, 192) 1728
block_5_expand_relu[0][0]

block_5_depthwise_BN (BatchNorm (None, 28, 28, 192) 768
block_5_depthwise[0][0]

block_5_depthwise_relu (ReLU) (None, 28, 28, 192) 0
block_5_depthwise_BN[0][0]

block_5_project (Conv2D) (None, 28, 28, 32) 6144
block_5_depthwise_relu[0][0]

block_5_project_BN (BatchNormal (None, 28, 28, 32) 128
block_5_project[0][0]

block_5_add (Add) (None, 28, 28, 32) 0
block_4_add[0][0]
block_5_project_BN[0][0]

block_6_expand (Conv2D) (None, 28, 28, 192) 6144
block_5_add[0][0]

block_6_expand_BN (BatchNormali (None, 28, 28, 192) 768
block_6_expand[0][0]

block_6_expand_relu (ReLU) (None, 28, 28, 192) 0
block_6_expand_BN[0][0]

block_6_pad (ZeroPadding2D) (None, 29, 29, 192) 0
block_6_expand_relu[0][0]

```

-----
-----
block_6_depthwise (DepthwiseCon (None, 14, 14, 192) 1728
block_6_pad[0][0]
-----
-----
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192) 768
block_6_depthwise[0][0]
-----
-----
block_6_depthwise_relu (ReLU) (None, 14, 14, 192) 0
block_6_depthwise_BN[0][0]
-----
-----
block_6_project (Conv2D) (None, 14, 14, 64) 12288
block_6_depthwise_relu[0][0]
-----
-----
block_6_project_BN (BatchNormal (None, 14, 14, 64) 256
block_6_project[0][0]
-----
-----
block_7_expand (Conv2D) (None, 14, 14, 384) 24576
block_6_project_BN[0][0]
-----
-----
block_7_expand_BN (BatchNormali (None, 14, 14, 384) 1536
block_7_expand[0][0]
-----
-----
block_7_expand_relu (ReLU) (None, 14, 14, 384) 0
block_7_expand_BN[0][0]
-----
-----
block_7_depthwise (DepthwiseCon (None, 14, 14, 384) 3456
block_7_expand_relu[0][0]
-----
-----
block_7_depthwise_BN (BatchNorm (None, 14, 14, 384) 1536
block_7_depthwise[0][0]
-----
-----
block_7_depthwise_relu (ReLU) (None, 14, 14, 384) 0
block_7_depthwise_BN[0][0]
-----
-----
block_7_project (Conv2D) (None, 14, 14, 64) 24576
block_7_depthwise_relu[0][0]

```

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-----
-----
block_7_project_BN (BatchNormal (None, 14, 14, 64) 256
block_7_project[0][0]
-----
-----
block_7_add (Add) (None, 14, 14, 64) 0
block_6_project_BN[0][0]
block_7_project_BN[0][0]
-----
-----
block_8_expand (Conv2D) (None, 14, 14, 384) 24576
block_7_add[0][0]
-----
-----
block_8_expand_BN (BatchNormali (None, 14, 14, 384) 1536
block_8_expand[0][0]
-----
-----
block_8_expand_relu (ReLU) (None, 14, 14, 384) 0
block_8_expand_BN[0][0]
-----
-----
block_8_depthwise (DepthwiseCon (None, 14, 14, 384) 3456
block_8_expand_relu[0][0]
-----
-----
block_8_depthwise_BN (BatchNorm (None, 14, 14, 384) 1536
block_8_depthwise[0][0]
-----
-----
block_8_depthwise_relu (ReLU) (None, 14, 14, 384) 0
block_8_depthwise_BN[0][0]
-----
-----
block_8_project (Conv2D) (None, 14, 14, 64) 24576
block_8_depthwise_relu[0][0]
-----
-----
block_8_project_BN (BatchNormal (None, 14, 14, 64) 256
block_8_project[0][0]
-----
-----
block_8_add (Add) (None, 14, 14, 64) 0
block_7_add[0][0]
block_8_project_BN[0][0]
-----
-----

```

block_9_expand (Conv2D) (None, 14, 14, 384) 24576
block_8_add[0][0]

block_9_expand_BN (BatchNormali (None, 14, 14, 384) 1536
block_9_expand[0][0]

block_9_expand_relu (ReLU) (None, 14, 14, 384) 0
block_9_expand_BN[0][0]

block_9_depthwise (DepthwiseCon (None, 14, 14, 384) 3456
block_9_expand_relu[0][0]

block_9_depthwise_BN (BatchNorm (None, 14, 14, 384) 1536
block_9_depthwise[0][0]

block_9_depthwise_relu (ReLU) (None, 14, 14, 384) 0
block_9_depthwise_BN[0][0]

block_9_project (Conv2D) (None, 14, 14, 64) 24576
block_9_depthwise_relu[0][0]

block_9_project_BN (BatchNormal (None, 14, 14, 64) 256
block_9_project[0][0]

block_9_add (Add) (None, 14, 14, 64) 0
block_8_add[0][0]
block_9_project_BN[0][0]

block_10_expand (Conv2D) (None, 14, 14, 384) 24576
block_9_add[0][0]

block_10_expand_BN (BatchNormal (None, 14, 14, 384) 1536
block_10_expand[0][0]

block_10_expand_relu (ReLU) (None, 14, 14, 384) 0
block_10_expand_BN[0][0]

block_10_depthwise (DepthwiseCo (None, 14, 14, 384) 3456
block_10_expand_relu[0][0]

block_10_depthwise_BN (BatchNor (None, 14, 14, 384) 1536
block_10_depthwise[0][0]

block_10_depthwise_relu (ReLU) (None, 14, 14, 384) 0
block_10_depthwise_BN[0][0]

block_10_project (Conv2D) (None, 14, 14, 96) 36864
block_10_depthwise_relu[0][0]

block_10_project_BN (BatchNorma (None, 14, 14, 96) 384
block_10_project[0][0]

block_11_expand (Conv2D) (None, 14, 14, 576) 55296
block_10_project_BN[0][0]

block_11_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_11_expand[0][0]

block_11_expand_relu (ReLU) (None, 14, 14, 576) 0
block_11_expand_BN[0][0]

block_11_depthwise (DepthwiseCo (None, 14, 14, 576) 5184
block_11_expand_relu[0][0]

block_11_depthwise_BN (BatchNor (None, 14, 14, 576) 2304
block_11_depthwise[0][0]

block_11_depthwise_relu (ReLU) (None, 14, 14, 576) 0
block_11_depthwise_BN[0][0]

block_11_project (Conv2D) (None, 14, 14, 96) 55296
block_11_depthwise_relu[0][0]

block_11_project_BN (BatchNorma (None, 14, 14, 96) 384
block_11_project[0][0]

block_11_add (Add) (None, 14, 14, 96) 0
block_10_project_BN[0][0]
block_11_project_BN[0][0]

block_12_expand (Conv2D) (None, 14, 14, 576) 55296
block_11_add[0][0]

block_12_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_12_expand[0][0]

block_12_expand_relu (ReLU) (None, 14, 14, 576) 0
block_12_expand_BN[0][0]

block_12_depthwise (DepthwiseCo (None, 14, 14, 576) 5184
block_12_expand_relu[0][0]

block_12_depthwise_BN (BatchNor (None, 14, 14, 576) 2304
block_12_depthwise[0][0]

block_12_depthwise_relu (ReLU) (None, 14, 14, 576) 0
block_12_depthwise_BN[0][0]

block_12_project (Conv2D) (None, 14, 14, 96) 55296
block_12_depthwise_relu[0][0]

block_12_project_BN (BatchNorma (None, 14, 14, 96) 384
block_12_project[0][0]

block_12_add (Add) (None, 14, 14, 96) 0
block_11_add[0][0]
block_12_project_BN[0][0]

block_13_expand (Conv2D) (None, 14, 14, 576) 55296

```

block_12_add[0][0]
-----

-----
block_13_expand_BN (BatchNormal (None, 14, 14, 576) 2304
block_13_expand[0][0]
-----

-----
block_13_expand_relu (ReLU) (None, 14, 14, 576) 0
block_13_expand_BN[0][0]
-----

-----
block_13_pad (ZeroPadding2D) (None, 15, 15, 576) 0
block_13_expand_relu[0][0]
-----

-----
block_13_depthwise (DepthwiseCo (None, 7, 7, 576) 5184
block_13_pad[0][0]
-----

-----
block_13_depthwise_BN (BatchNor (None, 7, 7, 576) 2304
block_13_depthwise[0][0]
-----

-----
block_13_depthwise_relu (ReLU) (None, 7, 7, 576) 0
block_13_depthwise_BN[0][0]
-----

-----
block_13_project (Conv2D) (None, 7, 7, 160) 92160
block_13_depthwise_relu[0][0]
-----

-----
block_13_project_BN (BatchNorma (None, 7, 7, 160) 640
block_13_project[0][0]
-----

-----
block_14_expand (Conv2D) (None, 7, 7, 960) 153600
block_13_project_BN[0][0]
-----

-----
block_14_expand_BN (BatchNormal (None, 7, 7, 960) 3840
block_14_expand[0][0]
-----

-----
block_14_expand_relu (ReLU) (None, 7, 7, 960) 0
block_14_expand_BN[0][0]
-----

-----
block_14_depthwise (DepthwiseCo (None, 7, 7, 960) 8640

```

block_14_expand_relu[0][0]

block_14_depthwise_BN (BatchNor (None, 7, 7, 960) 3840
block_14_depthwise[0][0]

block_14_depthwise_relu (ReLU) (None, 7, 7, 960) 0
block_14_depthwise_BN[0][0]

block_14_project (Conv2D) (None, 7, 7, 160) 153600
block_14_depthwise_relu[0][0]

block_14_project_BN (BatchNorma (None, 7, 7, 160) 640
block_14_project[0][0]

block_14_add (Add) (None, 7, 7, 160) 0
block_13_project_BN[0][0]
block_14_project_BN[0][0]

block_15_expand (Conv2D) (None, 7, 7, 960) 153600
block_14_add[0][0]

block_15_expand_BN (BatchNormal (None, 7, 7, 960) 3840
block_15_expand[0][0]

block_15_expand_relu (ReLU) (None, 7, 7, 960) 0
block_15_expand_BN[0][0]

block_15_depthwise (DepthwiseCo (None, 7, 7, 960) 8640
block_15_expand_relu[0][0]

block_15_depthwise_BN (BatchNor (None, 7, 7, 960) 3840
block_15_depthwise[0][0]

block_15_depthwise_relu (ReLU) (None, 7, 7, 960) 0
block_15_depthwise_BN[0][0]

block_15_project (Conv2D)	(None, 7, 7, 160)	153600
block_15_depthwise_relu[0][0]		

block_15_project_BN (BatchNorma	(None, 7, 7, 160)	640
block_15_project[0][0]		

block_15_add (Add)	(None, 7, 7, 160)	0
block_14_add[0][0]		
block_15_project_BN[0][0]		

block_16_expand (Conv2D)	(None, 7, 7, 960)	153600
block_15_add[0][0]		

block_16_expand_BN (BatchNormal	(None, 7, 7, 960)	3840
block_16_expand[0][0]		

block_16_expand_relu (ReLU)	(None, 7, 7, 960)	0
block_16_expand_BN[0][0]		

block_16_depthwise (DepthwiseCo	(None, 7, 7, 960)	8640
block_16_expand_relu[0][0]		

block_16_depthwise_BN (BatchNor	(None, 7, 7, 960)	3840
block_16_depthwise[0][0]		

block_16_depthwise_relu (ReLU)	(None, 7, 7, 960)	0
block_16_depthwise_BN[0][0]		

block_16_project (Conv2D)	(None, 7, 7, 320)	307200
block_16_depthwise_relu[0][0]		

block_16_project_BN (BatchNorma	(None, 7, 7, 320)	1280
block_16_project[0][0]		

Conv_1 (Conv2D)	(None, 7, 7, 1280)	409600
block_16_project_BN[0][0]		

```

-----
Conv_1_bn (BatchNormalization) (None, 7, 7, 1280) 5120 Conv_1[0][0]
-----
out_relu (ReLU) (None, 7, 7, 1280) 0 Conv_1_bn[0][0]
-----
global_average_pooling2d (GlobalAveragePooling2D) (None, 1280) 0 out_relu[0][0]
-----
dropout (Dropout) (None, 1280) 0
global_average_pooling2d[0][0]
-----
dense (Dense) (None, 20) 25620 dropout[0][0]
=====
Total params: 2,283,604
Trainable params: 2,249,492
Non-trainable params: 34,112
-----

```

```

[25]: drive_path_checkpoint = '/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/pickle/checkpoint/holly_MobileNet_2.hdf5'
model_checkpoint = ModelCheckpoint(
    filepath=drive_path_checkpoint,
    save_weights_only=True,
    monitor='val_accuracy',
    mode='max',
    save_best_only=True, save_freq='epoch')

```

```

[26]: # tell the model what cost and optimization method to use
model.compile(
    loss='categorical_crossentropy',
    optimizer=tf.keras.optimizers.Adam(1e-4),
    metrics=['accuracy',
             tf.keras.metrics.Precision(),
             tf.keras.metrics.Recall()]
)

```

```

[27]: r = model.fit(
    training_set,
    validation_data=testing_set,
    epochs=64,
    callbacks = [model_checkpoint]
)

```

Epoch 1/64

67/67 [=====] - 94s 572ms/step - loss: 3.9832 - accuracy: 0.0622 - precision: 0.0664 - recall: 0.0117 - val_loss: 3.2644 - val_accuracy: 0.0805 - val_precision: 0.1024 - val_recall: 0.0087
Epoch 2/64
67/67 [=====] - 34s 509ms/step - loss: 3.0313 - accuracy: 0.1071 - precision: 0.1070 - recall: 0.0073 - val_loss: 3.2795 - val_accuracy: 0.1088 - val_precision: 0.1261 - val_recall: 0.0067
Epoch 3/64
67/67 [=====] - 34s 511ms/step - loss: 2.7347 - accuracy: 0.1781 - precision: 0.1474 - recall: 0.0078 - val_loss: 3.8654 - val_accuracy: 0.1384 - val_precision: 0.2138 - val_recall: 0.0143
Epoch 4/64
67/67 [=====] - 35s 515ms/step - loss: 2.4077 - accuracy: 0.2708 - precision: 0.2395 - recall: 0.0193 - val_loss: 4.0460 - val_accuracy: 0.1568 - val_precision: 0.3032 - val_recall: 0.0295
Epoch 5/64
67/67 [=====] - 34s 513ms/step - loss: 2.1056 - accuracy: 0.3631 - precision: 0.3259 - recall: 0.0364 - val_loss: 3.6691 - val_accuracy: 0.1808 - val_precision: 0.3906 - val_recall: 0.0536
Epoch 6/64
67/67 [=====] - 34s 511ms/step - loss: 1.7947 - accuracy: 0.4349 - precision: 0.3994 - recall: 0.0614 - val_loss: 3.6404 - val_accuracy: 0.1766 - val_precision: 0.4380 - val_recall: 0.0814
Epoch 7/64
67/67 [=====] - 34s 508ms/step - loss: 1.4892 - accuracy: 0.5416 - precision: 0.4410 - recall: 0.0902 - val_loss: 3.4426 - val_accuracy: 0.1949 - val_precision: 0.4828 - val_recall: 0.1147
Epoch 8/64
67/67 [=====] - 34s 504ms/step - loss: 1.1976 - accuracy: 0.6129 - precision: 0.4882 - recall: 0.1243 - val_loss: 3.1087 - val_accuracy: 0.2768 - val_precision: 0.5284 - val_recall: 0.1508
Epoch 9/64
67/67 [=====] - 34s 507ms/step - loss: 0.9635 - accuracy: 0.7007 - precision: 0.5350 - recall: 0.1608 - val_loss: 2.7948 - val_accuracy: 0.3164 - val_precision: 0.5685 - val_recall: 0.1872
Epoch 10/64
67/67 [=====] - 34s 509ms/step - loss: 0.8120 - accuracy: 0.7446 - precision: 0.5765 - recall: 0.1977 - val_loss: 2.3808 - val_accuracy: 0.3376 - val_precision: 0.6049 - val_recall: 0.2243
Epoch 11/64
67/67 [=====] - 34s 510ms/step - loss: 0.6894 - accuracy: 0.7863 - precision: 0.6107 - recall: 0.2337 - val_loss: 2.1364 - val_accuracy: 0.3969 - val_precision: 0.6342 - val_recall: 0.2591
Epoch 12/64
67/67 [=====] - 34s 513ms/step - loss: 0.5762 - accuracy: 0.8144 - precision: 0.6405 - recall: 0.2685 - val_loss: 2.0099 - val_accuracy: 0.4435 - val_precision: 0.6607 - val_recall: 0.2920
Epoch 13/64

67/67 [=====] - 34s 513ms/step - loss: 0.4591 - accuracy: 0.8558 - precision: 0.6663 - recall: 0.3012 - val_loss: 1.6664 - val_accuracy: 0.5226 - val_precision: 0.6855 - val_recall: 0.3247
Epoch 14/64

67/67 [=====] - 35s 515ms/step - loss: 0.4245 - accuracy: 0.8581 - precision: 0.6902 - recall: 0.3329 - val_loss: 1.7042 - val_accuracy: 0.5099 - val_precision: 0.7048 - val_recall: 0.3538
Epoch 15/64

67/67 [=====] - 35s 520ms/step - loss: 0.3336 - accuracy: 0.8984 - precision: 0.7091 - recall: 0.3618 - val_loss: 1.3807 - val_accuracy: 0.6116 - val_precision: 0.7231 - val_recall: 0.3819
Epoch 16/64

67/67 [=====] - 35s 528ms/step - loss: 0.2811 - accuracy: 0.9079 - precision: 0.7281 - recall: 0.3897 - val_loss: 1.5845 - val_accuracy: 0.5438 - val_precision: 0.7389 - val_recall: 0.4072
Epoch 17/64

67/67 [=====] - 34s 508ms/step - loss: 0.2604 - accuracy: 0.9233 - precision: 0.7419 - recall: 0.4138 - val_loss: 1.2526 - val_accuracy: 0.6271 - val_precision: 0.7530 - val_recall: 0.4308
Epoch 18/64

67/67 [=====] - 34s 511ms/step - loss: 0.2341 - accuracy: 0.9236 - precision: 0.7563 - recall: 0.4371 - val_loss: 1.4304 - val_accuracy: 0.5946 - val_precision: 0.7651 - val_recall: 0.4527
Epoch 19/64

67/67 [=====] - 34s 510ms/step - loss: 0.1866 - accuracy: 0.9464 - precision: 0.7677 - recall: 0.4585 - val_loss: 1.0678 - val_accuracy: 0.6992 - val_precision: 0.7762 - val_recall: 0.4733
Epoch 20/64

67/67 [=====] - 35s 516ms/step - loss: 0.1714 - accuracy: 0.9488 - precision: 0.7791 - recall: 0.4792 - val_loss: 0.7050 - val_accuracy: 0.7867 - val_precision: 0.7876 - val_recall: 0.4934
Epoch 21/64

67/67 [=====] - 34s 512ms/step - loss: 0.1321 - accuracy: 0.9611 - precision: 0.7907 - recall: 0.4991 - val_loss: 0.7550 - val_accuracy: 0.7712 - val_precision: 0.7983 - val_recall: 0.5123
Epoch 22/64

67/67 [=====] - 34s 508ms/step - loss: 0.1098 - accuracy: 0.9720 - precision: 0.8012 - recall: 0.5177 - val_loss: 0.7125 - val_accuracy: 0.7910 - val_precision: 0.8077 - val_recall: 0.5298
Epoch 23/64

67/67 [=====] - 34s 509ms/step - loss: 0.1118 - accuracy: 0.9670 - precision: 0.8103 - recall: 0.5348 - val_loss: 0.6226 - val_accuracy: 0.8192 - val_precision: 0.8164 - val_recall: 0.5464
Epoch 24/64

67/67 [=====] - 34s 512ms/step - loss: 0.1218 - accuracy: 0.9672 - precision: 0.8187 - recall: 0.5510 - val_loss: 0.7826 - val_accuracy: 0.7811 - val_precision: 0.8239 - val_recall: 0.5613
Epoch 25/64

67/67 [=====] - 34s 510ms/step - loss: 0.1098 -
accuracy: 0.9628 - precision: 0.8254 - recall: 0.5652 - val_loss: 0.6634 -
val_accuracy: 0.8093 - val_precision: 0.8303 - val_recall: 0.5751
Epoch 26/64

67/67 [=====] - 34s 509ms/step - loss: 0.1202 -
accuracy: 0.9638 - precision: 0.8320 - recall: 0.5790 - val_loss: 0.5821 -
val_accuracy: 0.8107 - val_precision: 0.8364 - val_recall: 0.5881
Epoch 27/64

67/67 [=====] - 34s 507ms/step - loss: 0.0798 -
accuracy: 0.9756 - precision: 0.8380 - recall: 0.5918 - val_loss: 0.6806 -
val_accuracy: 0.7994 - val_precision: 0.8420 - val_recall: 0.6004
Epoch 28/64

67/67 [=====] - 34s 507ms/step - loss: 0.0798 -
accuracy: 0.9779 - precision: 0.8433 - recall: 0.6037 - val_loss: 0.7928 -
val_accuracy: 0.7698 - val_precision: 0.8467 - val_recall: 0.6116
Epoch 29/64

67/67 [=====] - 34s 508ms/step - loss: 0.0862 -
accuracy: 0.9772 - precision: 0.8478 - recall: 0.6148 - val_loss: 0.7497 -
val_accuracy: 0.7910 - val_precision: 0.8509 - val_recall: 0.6222
Epoch 30/64

67/67 [=====] - 34s 507ms/step - loss: 0.0841 -
accuracy: 0.9764 - precision: 0.8520 - recall: 0.6252 - val_loss: 0.7217 -
val_accuracy: 0.8008 - val_precision: 0.8550 - val_recall: 0.6322
Epoch 31/64

67/67 [=====] - 34s 512ms/step - loss: 0.0818 -
accuracy: 0.9696 - precision: 0.8559 - recall: 0.6349 - val_loss: 0.5524 -
val_accuracy: 0.8234 - val_precision: 0.8587 - val_recall: 0.6415
Epoch 32/64

67/67 [=====] - 34s 511ms/step - loss: 0.0568 -
accuracy: 0.9831 - precision: 0.8598 - recall: 0.6443 - val_loss: 0.5812 -
val_accuracy: 0.8291 - val_precision: 0.8627 - val_recall: 0.6508
Epoch 33/64

67/67 [=====] - 34s 507ms/step - loss: 0.0774 -
accuracy: 0.9819 - precision: 0.8637 - recall: 0.6533 - val_loss: 0.4815 -
val_accuracy: 0.8573 - val_precision: 0.8665 - val_recall: 0.6596
Epoch 34/64

67/67 [=====] - 34s 507ms/step - loss: 0.0436 -
accuracy: 0.9862 - precision: 0.8675 - recall: 0.6621 - val_loss: 0.4499 -
val_accuracy: 0.8517 - val_precision: 0.8703 - val_recall: 0.6681
Epoch 35/64

67/67 [=====] - 34s 505ms/step - loss: 0.0597 -
accuracy: 0.9833 - precision: 0.8711 - recall: 0.6705 - val_loss: 0.5466 -
val_accuracy: 0.8531 - val_precision: 0.8735 - val_recall: 0.6761
Epoch 36/64

67/67 [=====] - 34s 506ms/step - loss: 0.0527 -
accuracy: 0.9848 - precision: 0.8743 - recall: 0.6783 - val_loss: 0.5085 -
val_accuracy: 0.8658 - val_precision: 0.8765 - val_recall: 0.6835
Epoch 37/64

67/67 [=====] - 34s 506ms/step - loss: 0.0518 -
accuracy: 0.9830 - precision: 0.8773 - recall: 0.6857 - val_loss: 0.4399 -
val_accuracy: 0.8672 - val_precision: 0.8794 - val_recall: 0.6908
Epoch 38/64

67/67 [=====] - 34s 507ms/step - loss: 0.0458 -
accuracy: 0.9877 - precision: 0.8802 - recall: 0.6929 - val_loss: 0.5017 -
val_accuracy: 0.8376 - val_precision: 0.8822 - val_recall: 0.6976
Epoch 39/64

67/67 [=====] - 34s 506ms/step - loss: 0.0467 -
accuracy: 0.9882 - precision: 0.8828 - recall: 0.6995 - val_loss: 0.4062 -
val_accuracy: 0.8715 - val_precision: 0.8847 - val_recall: 0.7040
Epoch 40/64

67/67 [=====] - 34s 513ms/step - loss: 0.0435 -
accuracy: 0.9849 - precision: 0.8854 - recall: 0.7058 - val_loss: 0.4348 -
val_accuracy: 0.8743 - val_precision: 0.8872 - val_recall: 0.7102
Epoch 41/64

67/67 [=====] - 34s 506ms/step - loss: 0.0528 -
accuracy: 0.9833 - precision: 0.8879 - recall: 0.7120 - val_loss: 0.4755 -
val_accuracy: 0.8573 - val_precision: 0.8897 - val_recall: 0.7161
Epoch 42/64

67/67 [=====] - 34s 506ms/step - loss: 0.0439 -
accuracy: 0.9832 - precision: 0.8902 - recall: 0.7177 - val_loss: 0.5265 -
val_accuracy: 0.8489 - val_precision: 0.8917 - val_recall: 0.7215
Epoch 43/64

67/67 [=====] - 34s 507ms/step - loss: 0.0474 -
accuracy: 0.9853 - precision: 0.8922 - recall: 0.7230 - val_loss: 0.4414 -
val_accuracy: 0.8799 - val_precision: 0.8938 - val_recall: 0.7268
Epoch 44/64

67/67 [=====] - 34s 504ms/step - loss: 0.0489 -
accuracy: 0.9844 - precision: 0.8943 - recall: 0.7283 - val_loss: 0.5234 -
val_accuracy: 0.8644 - val_precision: 0.8957 - val_recall: 0.7319
Epoch 45/64

67/67 [=====] - 34s 505ms/step - loss: 0.0357 -
accuracy: 0.9881 - precision: 0.8961 - recall: 0.7333 - val_loss: 0.4909 -
val_accuracy: 0.8588 - val_precision: 0.8975 - val_recall: 0.7368
Epoch 46/64

67/67 [=====] - 34s 507ms/step - loss: 0.0351 -
accuracy: 0.9879 - precision: 0.8980 - recall: 0.7382 - val_loss: 0.5704 -
val_accuracy: 0.8559 - val_precision: 0.8993 - val_recall: 0.7415
Epoch 47/64

67/67 [=====] - 34s 506ms/step - loss: 0.0368 -
accuracy: 0.9891 - precision: 0.8997 - recall: 0.7428 - val_loss: 0.4735 -
val_accuracy: 0.8602 - val_precision: 0.9009 - val_recall: 0.7460
Epoch 48/64

67/67 [=====] - 34s 504ms/step - loss: 0.0507 -
accuracy: 0.9870 - precision: 0.9013 - recall: 0.7472 - val_loss: 0.4785 -
val_accuracy: 0.8672 - val_precision: 0.9025 - val_recall: 0.7503
Epoch 49/64

67/67 [=====] - 34s 502ms/step - loss: 0.0452 -
accuracy: 0.9842 - precision: 0.9028 - recall: 0.7514 - val_loss: 0.4913 -
val_accuracy: 0.8701 - val_precision: 0.9039 - val_recall: 0.7543
Epoch 50/64

67/67 [=====] - 34s 505ms/step - loss: 0.0368 -
accuracy: 0.9895 - precision: 0.9043 - recall: 0.7554 - val_loss: 0.6178 -
val_accuracy: 0.8376 - val_precision: 0.9053 - val_recall: 0.7581
Epoch 51/64

67/67 [=====] - 34s 505ms/step - loss: 0.0500 -
accuracy: 0.9812 - precision: 0.9055 - recall: 0.7592 - val_loss: 0.3558 -
val_accuracy: 0.8983 - val_precision: 0.9067 - val_recall: 0.7619
Epoch 52/64

67/67 [=====] - 34s 504ms/step - loss: 0.0472 -
accuracy: 0.9859 - precision: 0.9071 - recall: 0.7630 - val_loss: 0.4604 -
val_accuracy: 0.8686 - val_precision: 0.9081 - val_recall: 0.7656
Epoch 53/64

67/67 [=====] - 34s 507ms/step - loss: 0.0375 -
accuracy: 0.9892 - precision: 0.9084 - recall: 0.7666 - val_loss: 0.3985 -
val_accuracy: 0.8898 - val_precision: 0.9094 - val_recall: 0.7692
Epoch 54/64

67/67 [=====] - 34s 505ms/step - loss: 0.0255 -
accuracy: 0.9928 - precision: 0.9098 - recall: 0.7703 - val_loss: 0.6056 -
val_accuracy: 0.8517 - val_precision: 0.9106 - val_recall: 0.7727
Epoch 55/64

67/67 [=====] - 35s 521ms/step - loss: 0.0409 -
accuracy: 0.9881 - precision: 0.9108 - recall: 0.7735 - val_loss: 0.5339 -
val_accuracy: 0.8701 - val_precision: 0.9117 - val_recall: 0.7759
Epoch 56/64

67/67 [=====] - 35s 521ms/step - loss: 0.0368 -
accuracy: 0.9861 - precision: 0.9119 - recall: 0.7768 - val_loss: 0.5519 -
val_accuracy: 0.8686 - val_precision: 0.9128 - val_recall: 0.7790
Epoch 57/64

67/67 [=====] - 34s 511ms/step - loss: 0.0389 -
accuracy: 0.9883 - precision: 0.9130 - recall: 0.7799 - val_loss: 0.3401 -
val_accuracy: 0.9025 - val_precision: 0.9139 - val_recall: 0.7822
Epoch 58/64

67/67 [=====] - 34s 504ms/step - loss: 0.0415 -
accuracy: 0.9876 - precision: 0.9142 - recall: 0.7831 - val_loss: 0.6268 -
val_accuracy: 0.8277 - val_precision: 0.9149 - val_recall: 0.7851
Epoch 59/64

67/67 [=====] - 34s 501ms/step - loss: 0.0361 -
accuracy: 0.9852 - precision: 0.9150 - recall: 0.7859 - val_loss: 0.5284 -
val_accuracy: 0.8771 - val_precision: 0.9158 - val_recall: 0.7879
Epoch 60/64

67/67 [=====] - 34s 505ms/step - loss: 0.0156 -
accuracy: 0.9937 - precision: 0.9160 - recall: 0.7888 - val_loss: 0.3400 -
val_accuracy: 0.9011 - val_precision: 0.9169 - val_recall: 0.7909
Epoch 61/64

```

67/67 [=====] - 34s 501ms/step - loss: 0.0374 -
accuracy: 0.9878 - precision: 0.9172 - recall: 0.7917 - val_loss: 0.3195 -
val_accuracy: 0.9167 - val_precision: 0.9180 - val_recall: 0.7937
Epoch 62/64
67/67 [=====] - 34s 503ms/step - loss: 0.0603 -
accuracy: 0.9814 - precision: 0.9182 - recall: 0.7945 - val_loss: 0.3635 -
val_accuracy: 0.9011 - val_precision: 0.9190 - val_recall: 0.7964
Epoch 63/64
67/67 [=====] - 34s 503ms/step - loss: 0.0277 -
accuracy: 0.9902 - precision: 0.9193 - recall: 0.7973 - val_loss: 0.5179 -
val_accuracy: 0.8658 - val_precision: 0.9199 - val_recall: 0.7991
Epoch 64/64
67/67 [=====] - 34s 502ms/step - loss: 0.0220 -
accuracy: 0.9959 - precision: 0.9201 - recall: 0.7998 - val_loss: 0.3582 -
val_accuracy: 0.9040 - val_precision: 0.9208 - val_recall: 0.8016

```

```

[28]: model_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/pickle/transferMobileNet_holly_2_dataset.h5'
      model.save(model_path)

```

```

/usr/local/lib/python3.7/dist-packages/keras/utils/generic_utils.py:497:
CustomMaskWarning: Custom mask layers require a config and must override
get_config. When loading, the custom mask layer must be passed to the
custom_objects argument.
category=CustomMaskWarning)

```

```

[29]: model_path = '/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/pickle/transferMobileNet_holly_2_dataset_test.h5'
      tf.keras.models.save_model(
          model, model_path, overwrite=False, include_optimizer=True,
          ↳save_format='h5',
          signatures=None, options=None, save_traces=True
      )

```

```

/usr/local/lib/python3.7/dist-packages/keras/utils/generic_utils.py:497:
CustomMaskWarning: Custom mask layers require a config and must override
get_config. When loading, the custom mask layer must be passed to the
custom_objects argument.
category=CustomMaskWarning)

```

```

[41]: img_weight = model.weights

```

```

[42]: outfile = open('/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/pickle/checkpoint/transferMobileNet_holly_2_dataset.
      ↳pickle', 'wb')
      pickle.dump(img_weight, outfile)
      outfile.close()

```

```
[35]: # If you want to load a model
#model2 = load_model('/content/drive/My Drive/Colab Notebooks/ProjectData/
↳FaceRecognition/pickle/transferMobileNet_holly_1_dataset.h5')
#model.load_weights('/content/drive/My Drive/Colab Notebooks/ProjectData/
↳FaceRecognition/pickle/checkpoint/holly_MobileNet_1.hdf5')
```

```
[32]: preds = model.evaluate(validation_set)
```

23/23 [=====] - 8s 328ms/step - loss: 0.4536 -
accuracy: 0.8686 - precision: 0.9208 - recall: 0.8020

```
[33]: test_loss, test_accuracy, test_precision, test_recall = preds
print("Test Loss = ", test_loss)
print("Test Accuracy", test_accuracy)
print("Test Precision", test_precision)
print("Test Recall", test_recall)
```

Test Loss = 0.45358893275260925
Test Accuracy 0.8686440587043762
Test Precision 0.9207698106765747
Test Recall 0.80196613073349

```
[34]: cv2_imshow(X_val[0])
xx = X_val[0].astype(np.float32)
xx /= 255.0
```



```
[35]: y_cat = np.argmax(y_val, axis=1)
```

```
[36]: ev = model.evaluate(x=X_val, y= y_val)
```

```
23/23 [=====] - 4s 39ms/step - loss: 4.1320 - accuracy: 0.0678 - precision: 0.9198 - recall: 0.8004
```

```
[37]: y_cat
```

```
[37]: array([13,  2, 18, 11, 10,  2, 10, 16, 14, 14, 18, 11,  2,  3, 19, 10,  1,
           9,  6,  2,  5, 19, 17,  6, 11,  7,  1,  8,  3, 11, 16,  0, 18,  9,
           0, 11, 12,  4, 16, 16,  9, 17, 11,  9, 18,  0, 15,  8, 14, 13,  1,
           9,  1,  4,  8, 18, 12, 19,  4, 19, 11, 11, 16, 18,  1, 10,  4, 14,
           3,  1, 16,  5, 16, 17,  4,  4,  3, 10, 14, 14,  3, 11,  7,  3,  9,
          18,  1, 18, 13,  6, 16,  3,  1,  5, 16, 16,  6, 13, 11,  9,  4,  4,
          18,  0, 11, 19, 15, 16, 13, 19,  6, 19, 11,  2, 10, 16, 12,  8,  1,
           3,  0,  0, 13,  0,  6,  9, 17, 14, 11, 16,  8,  6, 10,  2,  9,  1,
          16, 11, 19, 13, 10,  8, 16,  6, 15,  0, 12, 18,  8, 17,  6,  7, 19,
          13, 11,  2, 17, 16, 17,  4,  2, 15, 16,  7, 14,  5,  1, 17, 13,  3,
          15, 16,  1,  9,  0, 18,  9,  6, 16,  4, 18, 11,  0,  8, 18,  3, 15,
          17,  0,  2, 19, 14, 11,  9, 18,  6,  3, 19, 13,  8, 12, 11,  9,  0,
          16,  6, 15,  3,  2,  0, 11,  3,  2,  1, 14,  6,  6,  9,  8,  2, 10,
           2,  5, 15, 13, 15,  6, 10,  4,  1,  7, 17, 12, 19, 13,  1, 15,  5,
          10,  6, 10,  2, 13,  0,  8, 18,  9, 11, 11, 15,  6,  4, 15,  6,  2,
          18, 19,  1, 19, 17, 17, 19, 19, 15,  6,  1, 15,  9,  6, 13, 10, 19,
          13, 19,  1, 14, 17, 12, 11, 17,  3, 18,  8,  4,  9, 19,  1,  7, 18,
           5, 10,  6,  3, 17, 16, 11, 13,  5, 13, 17, 12, 17, 16,  9, 11,  7,
          10,  9, 18,  7, 16,  8,  5, 16, 17,  6, 16, 17,  2, 16,  0,  4,  2,
           3, 19, 14,  3,  1,  1,  0, 12, 11, 14, 14, 15,  3, 17, 17, 18,  6,
           3, 15,  2, 11, 13,  3, 17,  9, 14,  4,  0,  7,  4,  5,  0, 10,  7,
          11, 13, 12,  0, 18,  0, 18, 15,  8, 15, 14, 10,  1,  1,  3, 19,  4,
           9,  2,  4, 18,  8,  8, 16, 17,  5, 10,  4, 10, 10,  8, 15, 13, 14,
           7,  7, 11, 18,  0, 16,  6,  3, 15,  0,  8,  0, 12, 11,  2, 14, 12,
           4, 10, 11, 11,  1, 19, 18, 12, 18, 19, 15, 17,  4,  3, 14,  7, 14,
          10,  6, 19,  0, 14, 18, 10, 15,  6, 12, 16, 17, 11,  6,  4, 12, 14,
          17, 14, 11,  9,  0, 15, 10,  8, 19, 13,  6, 19,  4, 10, 14,  7, 12,
          17, 14, 16, 19, 13, 14,  5,  6, 16, 12,  7,  6,  0, 13, 16, 13,  6,
           4, 16,  3,  2, 19, 10, 18,  1,  4,  9, 14, 18,  4, 16,  1,  3,  9,
           1, 10, 16,  9, 15, 19, 17,  3,  5,  3,  3, 12, 11, 10, 17, 18, 16,
          17,  3,  7, 16,  6, 12,  0,  8, 11, 14, 16, 17, 15, 14, 11, 19,  9,
          15,  6, 16, 10, 16, 10, 16,  4, 14,  2, 13,  4, 15,  9, 14, 11, 16,
          11,  9, 10, 17, 14,  4,  1,  4, 19,  0, 18, 10, 12,  6, 16, 10,  3,
           9, 14,  6,  7,  8, 18,  0,  6,  8, 10,  5, 11,  2,  4,  1, 13, 18,
          14, 10,  2, 17,  4,  3, 12, 10, 16, 15,  5, 18, 12,  6,  1,  2,  2,
           3, 10,  1, 18,  7, 19, 12,  9, 13,  8,  1,  0,  6,  2, 10, 13, 11,
          13, 19, 17, 12, 18,  1, 18,  6, 16, 14, 19, 12,  8,  4, 11, 15,  3,
           0,  1, 14,  5,  7, 15,  7,  1,  9, 10,  5, 13,  2,  9, 19,  1,  1,
           4, 10, 17, 14,  1,  1, 15,  6,  7,  9,  6,  4,  2,  4, 14, 11, 11,
          10,  9,  7, 14, 11,  5,  3, 10,  0, 15,  1,  0, 13, 19, 11,  3,  2,
           2,  7, 13, 17, 12,  0, 18, 15,  3,  4,  6,  3,  3, 18,  1, 15,  6,
```

```
2, 18, 1, 18, 2, 0, 5, 2, 19, 2, 8])
```

```
[45]: count = 0
for img,actual in zip(X_val, y_cat):
    img1 = img
    img = img.astype(np.float32) / 255.0
    np_img = img[np.newaxis, :, :, :]
    preds = model.predict(np_img)
    out = np.argmax(preds)
    name = labelEncoder.get(out)
    if actual == out:
        count += 1
    cv2_imshow(img1)
    print('Actual = ', labelEncoder.get(actual)[5:], 'Predicted = ', name[5:])
    print('-----\n\n')

    #cv2_imshow(img)
    #print('Actual = ', labelEncoder.get(actual), 'Predicted = ', name)
```

Output hidden; open in <https://colab.research.google.com> to view.

```
[ ]: print("Out of Sample Accuracy = ", count/len(y_cat))
```

```
[39]: NB_EPOCHS = 64
      #np.abs(np.subtract(val_loss_trace,loss_trace))
      m = []
      for i in range(1,NB_EPOCHS+1):
          m.append(i)
```

```
[40]: plot_save = '/content/drive/My Drive/Colab Notebooks/ProjectData/
      ↳FaceRecognition/plots/
      ↳holly_test_train_split(checkpoint_holly_MobileNet_2_test)/'
      !mkdir '{plot_save}'

      loss_trace = r.history['loss']
      val_loss_trace = r.history['val_loss']
      delta = np.abs(np.subtract(val_loss_trace,loss_trace))
      min_lo = np.argmin(delta) +1# +1 because the indexing starts from 1
      plt.axvline(x=min_lo,c = 'k', linestyle='-.')
      s = 'Min loss difference is =',delta[min_lo-1]

      plt.plot(m,delta, c = 'g')
      plt.plot(m,loss_trace, c='r')
      plt.plot(m,val_loss_trace, c='b')
      plt.xlabel('Epoch Number')
      plt.ylabel('Loss')
```

```

plt.legend([s, 'Abs(train loss - test loss)', 'Training loss', 'Validation_
→loss'], loc='upper right')
plt.savefig(plot_save+'loss.png')
plt.show()

accuracy_trace = r.history['accuracy']
val_accuracy_trace = r.history['val_accuracy']

max_acc = np.argmax(val_accuracy_trace) + 1 # +1 because the indexing starts_
→from 1
plt.axvline(x=max_acc, c = 'k', linestyle='-.')
s0 = 'Max Accuracy on Testset is =', val_accuracy_trace[max_acc-1]

plt.plot(m, accuracy_trace, c='r')
plt.plot(m, val_accuracy_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Accuracy')
plt.legend([s0, 'Training acc', 'Validation acc'], loc='lower right')
plt.savefig(plot_save+'acc.png')
plt.show()

precision_trace = r.history['precision']
val_precision_trace = r.history['val_precision']

max_pre = np.argmax(val_precision_trace) + 1 # +1 because the indexing starts_
→from 1
plt.axvline(x=max_pre, c = 'k', linestyle='-.')
s1 = 'Max Precision on Testset is =', val_precision_trace[max_pre-1]

plt.plot(m, precision_trace, c='r')
plt.plot(m, val_precision_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Precison')
plt.legend([s1, 'Training precisison', 'Validation precision'], loc='lower_
→right')
plt.savefig(plot_save+'pre.png')
plt.show()

recall_trace = r.history['recall']
val_recall_trace = r.history['val_recall']

```

```

max_recall = np.argmax(val_recall_trace) +1 # +1 because the indexing starts
→from 1
plt.axvline(x=max_recall,c = 'k', linestyle='-.')
s2 = 'Max Recall on Testset is =',val_recall_trace[max_recall-1]

plt.plot(m,recall_trace, c='r')
plt.plot(m,val_recall_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('Recall')
plt.legend([s2, 'Training recall', 'Validation recall'], loc='lower right')
plt.savefig(plot_save+'recall.png')
plt.show()

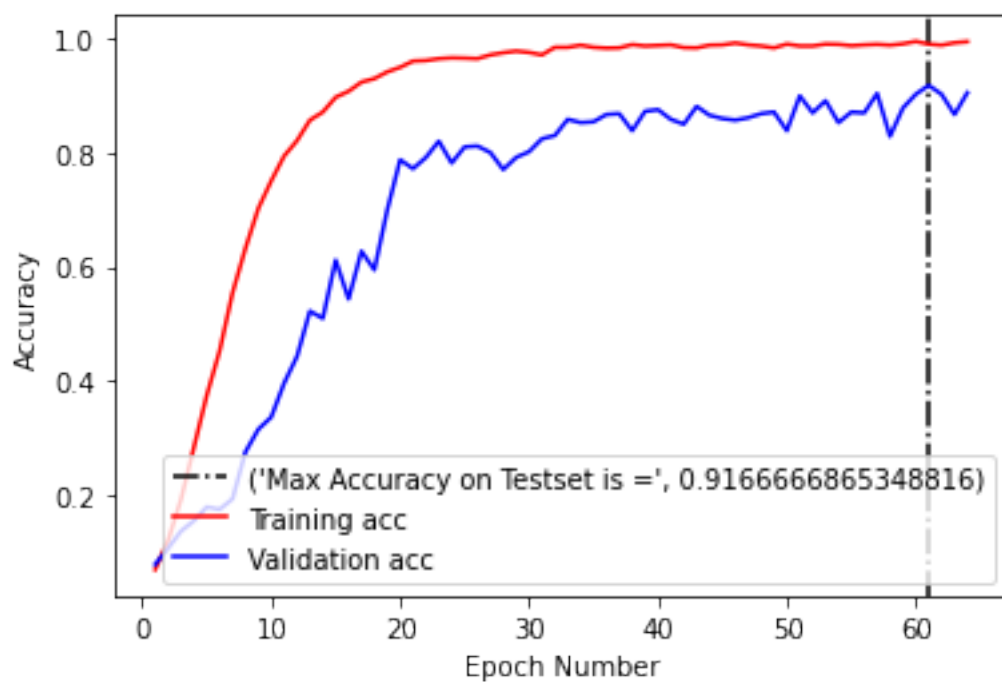
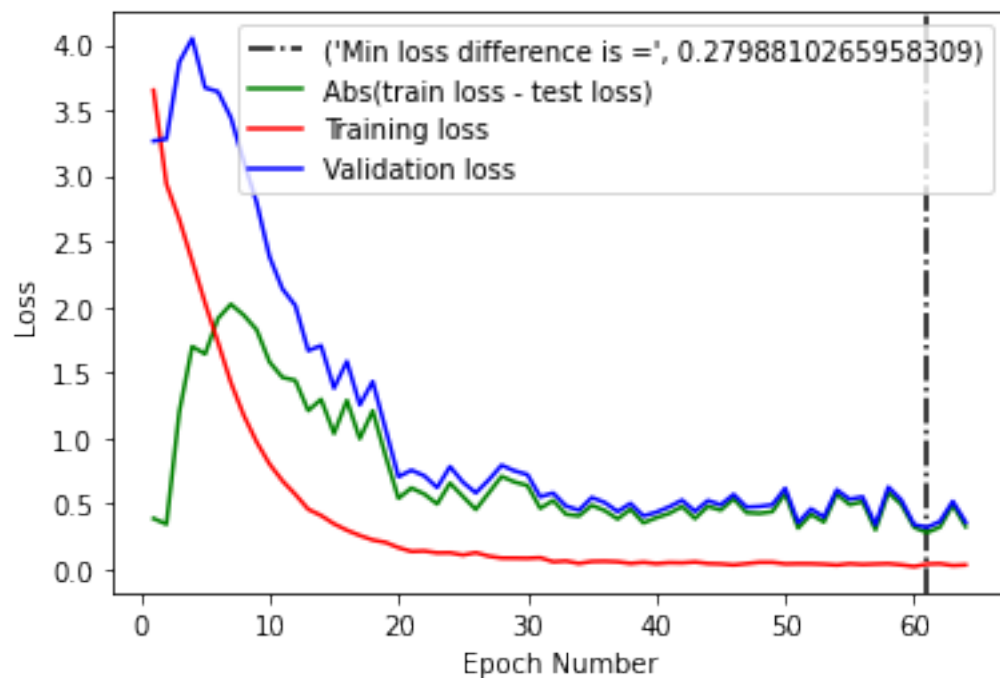
f1_score = 2*(np.multiply(precision_trace , recall_trace))/(np.
→add(precision_trace ,recall_trace))
val_f1_score = 2*(np.multiply(val_precision_trace , val_recall_trace))/(np.
→add(val_precision_trace ,val_recall_trace))

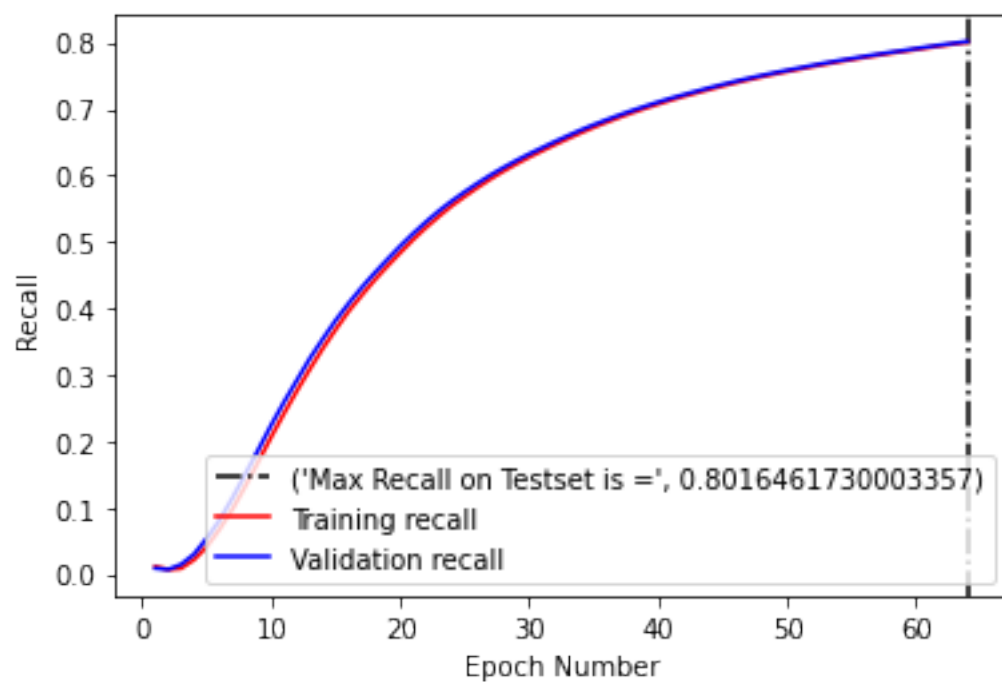
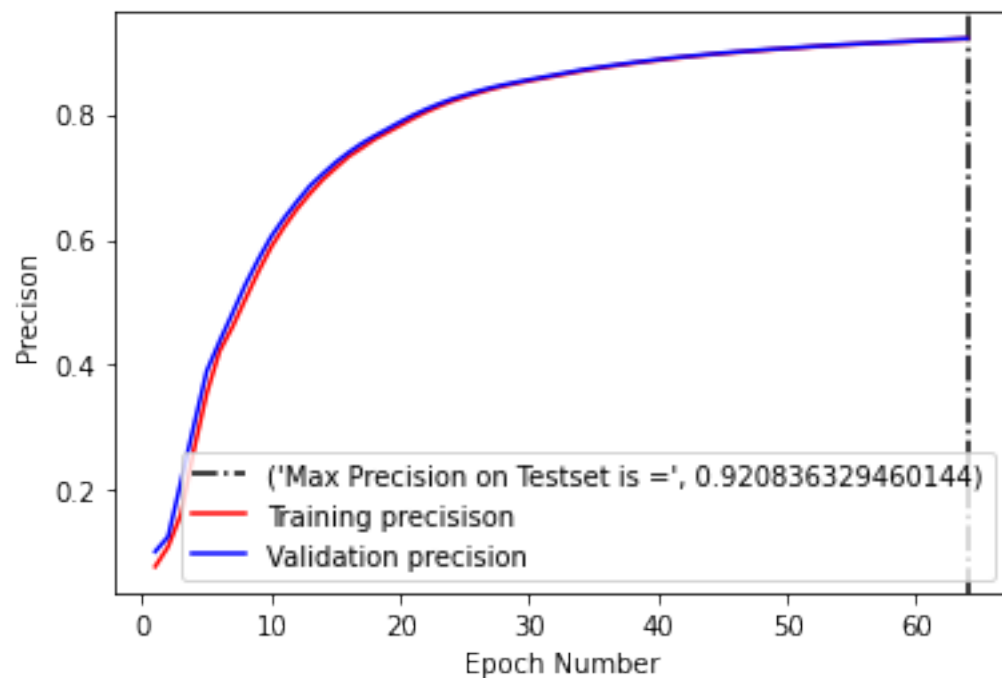
f1_trace = f1_score
val_recall_trace = val_f1_score

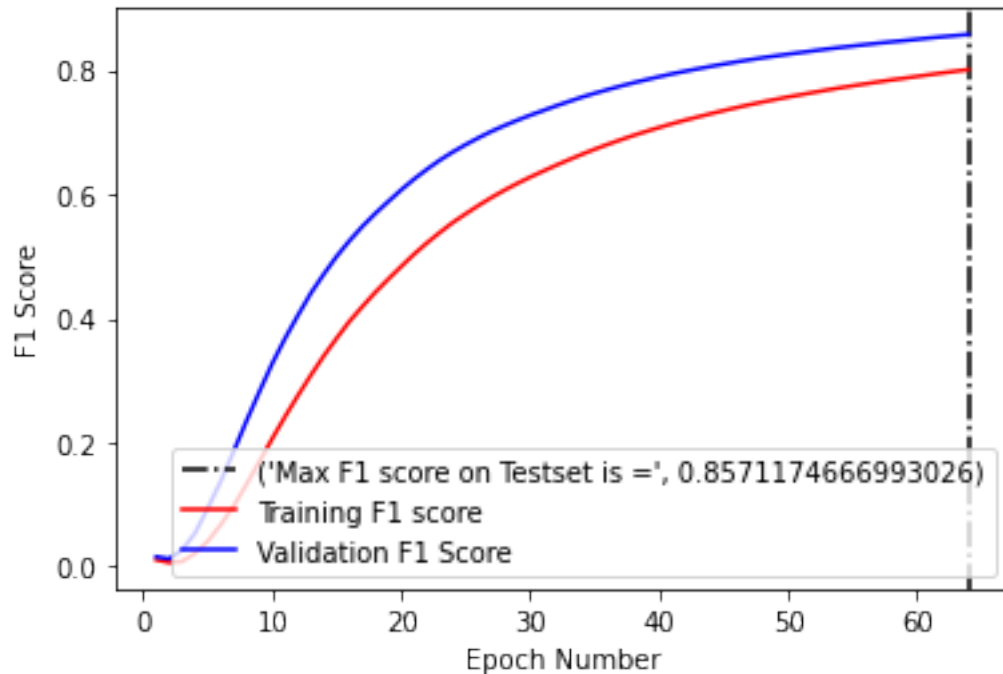
max_f1 = np.argmax(val_f1_score) +1 # +1 because the indexing starts from 1
plt.axvline(x=max_f1,c = 'k', linestyle='-.')
s3 = 'Max F1 score on Testset is =',val_f1_score[max_f1-1]

plt.plot(m,recall_trace, c='r')
plt.plot(m,val_recall_trace, c='b')
plt.xlabel('Epoch Number')
plt.ylabel('F1 Score')
plt.legend([s3, 'Training F1 score', 'Validation F1 Score'], loc='lower right')
plt.savefig(plot_save+'f1.png')
plt.show()

```





[34]: delta

[34]: array([0.19526958, 0.50082946, 0.78491998, 0.97639704, 1.14457297,
1.06516719, 0.72714484, 0.98575008, 1.0870626 , 1.15515399,
1.17374057, 1.04473025, 0.77131969, 0.83597994, 0.58045527,
0.65904495, 0.77399996, 0.63790347, 1.02128492, 0.55944136,
0.77147141, 0.50878549, 0.41847786, 0.53288539, 0.49613889,
0.33872102, 0.5840486 , 0.31435278, 0.33630261, 0.34017517,
0.39900458, 0.36987109])

[48]: path = '/content/drive/My Drive/Colab Notebooks/ProjectData/FaceRecognition/
→faceMobileNet_TransferLearning.ipynb'

[51]: !pip install -U notebook-as-pdf
!pyppeteer-install

Collecting notebook-as-pdf

Downloading https://files.pythonhosted.org/packages/be/aa/33c6dc40a09b01d77a657e95461932463e4c061ba623e6bbc4f6ab15634d/notebook_as_pdf-0.5.0-py3-none-any.whl

Collecting PyPDF2

Downloading <https://files.pythonhosted.org/packages/b4/01/68fcc0d43daf4c6bdb6b33cc3f77bda531c86b174cac56ef0ffdb96faab/PyPDF2-1.26.0.tar.gz> (77kB)

|| 81kB 5.6MB/s

Requirement already satisfied, skipping upgrade: nbconvert in
/usr/local/lib/python3.7/dist-packages (from notebook-as-pdf) (5.6.1)

Collecting pyppeteer

Downloading <https://files.pythonhosted.org/packages/4a/05/ea3250282e46fd a60df1f1d5246bb8cdc022abb89969c61a98ea28fd6b82/pyppeteer-0.2.5-py3-none-any.whl> (87kB)

|| 92kB 7.8MB/s

Requirement already satisfied, skipping upgrade: jupyter-core in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (4.7.1)
Requirement already satisfied, skipping upgrade: testpath in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (0.5.0)
Requirement already satisfied, skipping upgrade: pandocfilters>=1.4.1 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (1.4.3)
Requirement already satisfied, skipping upgrade: bleach in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (3.3.0)
Requirement already satisfied, skipping upgrade: pygments in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (2.6.1)
Requirement already satisfied, skipping upgrade: entrypoints>=0.2.2 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (0.3)
Requirement already satisfied, skipping upgrade: Jinja2>=2.4 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (2.11.3)

Requirement already satisfied, skipping upgrade: defusedxml in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (0.7.1)
Requirement already satisfied, skipping upgrade: traitlets>=4.2 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (5.0.5)
Requirement already satisfied, skipping upgrade: nbformat>=4.4 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (5.1.3)
Requirement already satisfied, skipping upgrade: mistune<2,>=0.8.1 in /usr/local/lib/python3.7/dist-packages (from nbconvert->notebook-as-pdf) (0.8.4)
Collecting urllib3<2.0.0,>=1.25.8

Downloading <https://files.pythonhosted.org/packages/0c/cd/1e2ec680ec7b09 846dc6e605f5a7709dfb9d7128e51a026e7154e18a234e/urllib3-1.26.5-py2.py3-none-any.whl> (138kB)

|| 143kB 41.7MB/s

Collecting importlib-metadata<3.0.0,>=2.1.1; python_version < "3.8"

Downloading https://files.pythonhosted.org/packages/98/b8/8ec57a8ef46fbe7f1853 18c7ff7df9a06c9df451d9a59a067bfa851bb828/importlib_metadata-2.1.1-py2.py3-none-any.whl

Requirement already satisfied, skipping upgrade: appdirs<2.0.0,>=1.4.3 in /usr/local/lib/python3.7/dist-packages (from pyppeteer->notebook-as-pdf) (1.4.4)
Collecting websockets<9.0,>=8.1

Downloading https://files.pythonhosted.org/packages/5a/0b/3ebc752392a368 af14dd24ee041683416ac6d2463eead94b311b11e41c82/websockets-8.1-cp37-cp37m-manylinux2010_x86_64.whl (79kB)

|| 81kB 10.1MB/s

Collecting pyee<9.0.0,>=8.1.0

Downloading <https://files.pythonhosted.org/packages/0d/0a/933b3931107e1da18696 3fd9bb9bceb9a613cff034cb0fb3b0c61003f357/pyee-8.1.0-py2.py3-none-any.whl>

Collecting tqdm<5.0.0,>=4.42.1

Downloading <https://files.pythonhosted.org/packages/42/d7/f357d98e9b5034>

```

6bcb6095fe3ad205d8db3174eb5edb03edfe7c4099576d/tqdm-4.61.0-py2.py3-none-any.whl
(75kB)
  || 81kB 11.1MB/s
Requirement already satisfied, skipping upgrade: packaging in
/usr/local/lib/python3.7/dist-packages (from bleach->nbconvert->notebook-as-pdf)
(20.9)
Requirement already satisfied, skipping upgrade: webencodings in
/usr/local/lib/python3.7/dist-packages (from bleach->nbconvert->notebook-as-pdf)
(0.5.1)
Requirement already satisfied, skipping upgrade: six>=1.9.0 in
/usr/local/lib/python3.7/dist-packages (from bleach->nbconvert->notebook-as-pdf)
(1.15.0)
Requirement already satisfied, skipping upgrade: MarkupSafe>=0.23 in
/usr/local/lib/python3.7/dist-packages (from jinja2>=2.4->nbconvert->notebook-
as-pdf) (2.0.1)
Requirement already satisfied, skipping upgrade: ipython-genutils in
/usr/local/lib/python3.7/dist-packages (from traitlets>=4.2->nbconvert
->notebook-as-pdf) (0.2.0)
Requirement already satisfied, skipping upgrade: jsonschema!=2.5.0,>=2.4 in
/usr/local/lib/python3.7/dist-packages (from nbformat>=4.4->nbconvert->notebook-
as-pdf) (2.6.0)
Requirement already satisfied, skipping upgrade: zipp>=0.5 in
/usr/local/lib/python3.7/dist-packages (from importlib-metadata<3.0.0,>=2.1.1;
python_version < "3.8"->pyppeteer->notebook-as-pdf) (3.4.1)
Requirement already satisfied, skipping upgrade: pyparsing>=2.0.2 in
/usr/local/lib/python3.7/dist-packages (from packaging->bleach->nbconvert
->notebook-as-pdf) (2.4.7)
Building wheels for collected packages: PyPDF2
  Building wheel for PyPDF2 (setup.py) ... done
  Created wheel for PyPDF2: filename=PyPDF2-1.26.0-cp37-none-any.whl size=61085
sha256=eb279614e1e923f24be282d3668774c2e2557e12ea9f3417453b071fab2b6db5
  Stored in directory: /root/.cache/pip/wheels/53/84/19/35bc977c8bf5f0c23a8a011a
a958acd4da4bbd7a229315c1b7
Successfully built PyPDF2
ERROR: requests 2.23.0 has requirement
urllib3!=1.25.0,!1.25.1,<1.26,>=1.21.1, but you'll have urllib3 1.26.5 which is
incompatible.
ERROR: datascience 0.10.6 has requirement folium==0.2.1, but you'll have
folium 0.8.3 which is incompatible.
Installing collected packages: PyPDF2, urllib3, importlib-metadata, websockets,
pyee, tqdm, pyppeteer, notebook-as-pdf
  Found existing installation: urllib3 1.24.3
  Uninstalling urllib3-1.24.3:
    Successfully uninstalled urllib3-1.24.3
  Found existing installation: importlib-metadata 4.0.1
  Uninstalling importlib-metadata-4.0.1:
    Successfully uninstalled importlib-metadata-4.0.1

```

```
Found existing installation: tqdm 4.41.1
Uninstalling tqdm-4.41.1:
  Successfully uninstalled tqdm-4.41.1
Successfully installed PyPDF2-1.26.0 importlib-metadata-2.1.1 notebook-as-
pdf-0.5.0 pyee-8.1.0 pypeteer-0.2.5 tqdm-4.61.0 urllib3-1.26.5 websockets-8.1
```

```
[W:pypeteer.chromium_downloader] start chromium download.
Download may take a few minutes.
100% 108773488/108773488 [00:00<00:00, 166708898.78it/s]
[W:pypeteer.chromium_downloader]
chromium download done.
[W:pypeteer.chromium_downloader] chromium extracted to:
/root/.local/share/pypeteer/local-chromium/588429
```

```
[!]: sudo apt-get install texlive-xetex texlive-fonts-recommended
→texlive-generic-recommended
```

```
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following package was automatically installed and is no longer required:
  libnvidia-common-460
Use 'sudo apt autoremove' to remove it.
The following additional packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
  libruby2.5 libsynchronet1 libtexlua52 libtexluajit2 libzip-0-13 lmodern
  poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
  ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
  rubygems-integration tlutils tex-common tex-gyre texlive-base
  texlive-binaries texlive-latex-base texlive-latex-extra
  texlive-latex-recommended texlive-pictures texlive-plain-generic tipa
Suggested packages:
  fonts-noto apache2 | lighttpd | httpd poppler-utils ghostscript
  fonts-japanese-mincho | fonts-ipafont-mincho fonts-japanese-gothic
  | fonts-ipafont-gothic fonts-arphic-ukai fonts-arphic-uming fonts-nanum ri
  ruby-dev bundler debhelper gv | postscript-viewer perl-tk xpdf-reader
  | pdf-viewer texlive-fonts-recommended-doc texlive-latex-base-doc
  python-pygments icc-profiles libfile-which-perl
  libspreadsheet-parseexcel-perl texlive-latex-extra-doc
  texlive-latex-recommended-doc texlive-pstricks dot2tex prerex ruby-tcltk
  | libtcltk-ruby texlive-pictures-doc vprerex
The following NEW packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
```

```

libruby2.5 libsynctex1 libtexlua52 libtexlua52 libzip-0-13 lmodern
poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
rubygems-integration tluils tex-common tex-gyre texlive-base
texlive-binaries texlive-fonts-recommended texlive-generic-recommended
texlive-latex-base texlive-latex-extra texlive-latex-recommended
texlive-pictures texlive-plain-generic texlive-xetex tipa
0 upgraded, 47 newly installed, 0 to remove and 34 not upgraded.
Need to get 146 MB of archives.
After this operation, 460 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-droid-fallback
all 1:6.0.1r16-1.1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lato all 2.0-2
[2,698 kB]
Get:3 http://archive.ubuntu.com/ubuntu bionic/main amd64 poppler-data all
0.4.8-2 [1,479 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic/main amd64 tex-common all 6.09
[33.0 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lmodern all
2.004.5-3 [4,551 kB]
Get:6 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-noto-mono all
20171026-2 [75.5 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic/universe amd64 fonts-texgyre all
20160520-1 [8,761 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic/main amd64 javascript-common all
11 [6,066 B]
Get:9 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsfilters1
amd64 1.20.2-0ubuntu3.1 [108 kB]
Get:10 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsimage2
amd64 2.2.7-1ubuntu2.8 [18.6 kB]
Get:11 http://archive.ubuntu.com/ubuntu bionic/main amd64 libijs-0.35 amd64
0.35-13 [15.5 kB]
Get:12 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjbig2dec0 amd64
0.13-6 [55.9 kB]
Get:13 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9-common
all 9.26~dfsg+0-0ubuntu0.18.04.14 [5,092 kB]
Get:14 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9 amd64
9.26~dfsg+0-0ubuntu0.18.04.14 [2,265 kB]
Get:15 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjs-jquery all
3.2.1-1 [152 kB]
Get:16 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libkpathsea6
amd64 2017.20170613.44572-8ubuntu0.1 [54.9 kB]
Get:17 http://archive.ubuntu.com/ubuntu bionic/main amd64 libpotrace0 amd64
1.14-2 [17.4 kB]
Get:18 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libptexenc1
amd64 2017.20170613.44572-8ubuntu0.1 [34.5 kB]
Get:19 http://archive.ubuntu.com/ubuntu bionic/main amd64 rubygems-integration
all 1.11 [4,994 B]

```

Get:20 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 ruby2.5 amd64 2.5.1-1ubuntu1.9 [48.6 kB]
Get:21 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby amd64 1:2.5.1 [5,712 B]
Get:22 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 rake all 12.3.1-1ubuntu0.1 [44.9 kB]
Get:23 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby-did-you-mean all 1.2.0-2 [9,700 B]
Get:24 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby-minitest all 5.10.3-1 [38.6 kB]
Get:25 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby-net-telnet all 0.1.1-2 [12.6 kB]
Get:26 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby-power-assert all 0.3.0-1 [7,952 B]
Get:27 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 ruby-test-unit all 3.2.5-1 [61.1 kB]
Get:28 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 libruby2.5 amd64 2.5.1-1ubuntu1.9 [3,072 kB]
Get:29 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 libsyntax1 amd64 2017.20170613.44572-8ubuntu0.1 [41.4 kB]
Get:30 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 libtexlua52 amd64 2017.20170613.44572-8ubuntu0.1 [91.2 kB]
Get:31 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 libtexluajit2 amd64 2017.20170613.44572-8ubuntu0.1 [230 kB]
Get:32 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 libzip-0-13 amd64 0.13.62-3.1ubuntu0.18.04.1 [26.0 kB]
Get:33 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 lmodern all 2.004.5-3 [9,631 kB]
Get:34 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 preview-latex-style all 11.91-1ubuntu1 [185 kB]
Get:35 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 t1utils amd64 1.41-2 [56.0 kB]
Get:36 <http://archive.ubuntu.com/ubuntu> bionic/universe amd64 tex-gyre all 20160520-1 [4,998 kB]
Get:37 <http://archive.ubuntu.com/ubuntu> bionic-updates/main amd64 texlive-binaries amd64 2017.20170613.44572-8ubuntu0.1 [8,179 kB]
Get:38 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 texlive-base all 2017.20180305-1 [18.7 MB]
Get:39 <http://archive.ubuntu.com/ubuntu> bionic/universe amd64 texlive-fonts-recommended all 2017.20180305-1 [5,262 kB]
Get:40 <http://archive.ubuntu.com/ubuntu> bionic/universe amd64 texlive-generic-generic all 2017.20180305-2 [23.6 MB]
Get:41 <http://archive.ubuntu.com/ubuntu> bionic/universe amd64 texlive-generic-recommended all 2017.20180305-1 [15.9 kB]
Get:42 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 texlive-latex-base all 2017.20180305-1 [951 kB]
Get:43 <http://archive.ubuntu.com/ubuntu> bionic/main amd64 texlive-latex-recommended all 2017.20180305-1 [14.9 MB]


```

Get:44 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-pictures
all 2017.20180305-1 [4,026 kB]
Get:45 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-latex-
extra all 2017.20180305-2 [10.6 MB]
Get:46 http://archive.ubuntu.com/ubuntu bionic/universe amd64 tipa all 2:1.3-20
[2,978 kB]
Get:47 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-xetex all
2017.20180305-1 [10.7 MB]
Fetched 146 MB in 8s (18.1 MB/s)
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 76,
<> line 47.)
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
debconf: (This frontend requires a controlling tty.)
debconf: falling back to frontend: Teletype
dpkg-preconfigure: unable to re-open stdin:
Selecting previously unselected package fonts-droid-fallback.
(Reading database ... 160706 files and directories currently installed.)
Preparing to unpack .../00-fonts-droid-fallback_1%3a6.0.1r16-1.1_all.deb ...
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1) ...
Selecting previously unselected package fonts-lato.
Preparing to unpack .../01-fonts-lato_2.0-2_all.deb ...
Unpacking fonts-lato (2.0-2) ...
Selecting previously unselected package poppler-data.
Preparing to unpack .../02-poppler-data_0.4.8-2_all.deb ...
Unpacking poppler-data (0.4.8-2) ...
Selecting previously unselected package tex-common.
Preparing to unpack .../03-tex-common_6.09_all.deb ...
Unpacking tex-common (6.09) ...
Selecting previously unselected package fonts-lmodern.
Preparing to unpack .../04-fonts-lmodern_2.004.5-3_all.deb ...
Unpacking fonts-lmodern (2.004.5-3) ...
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack .../05-fonts-noto-mono_20171026-2_all.deb ...
Unpacking fonts-noto-mono (20171026-2) ...
Selecting previously unselected package fonts-texgyre.
Preparing to unpack .../06-fonts-texgyre_20160520-1_all.deb ...
Unpacking fonts-texgyre (20160520-1) ...
Selecting previously unselected package javascript-common.
Preparing to unpack .../07-javascript-common_11_all.deb ...
Unpacking javascript-common (11) ...
Selecting previously unselected package libcupsfilters1:amd64.
Preparing to unpack .../08-libcupsfilters1_1.20.2-0ubuntu3.1_amd64.deb ...
Unpacking libcupsfilters1:amd64 (1.20.2-0ubuntu3.1) ...
Selecting previously unselected package libcupsimage2:amd64.
Preparing to unpack .../09-libcupsimage2_2.2.7-1ubuntu2.8_amd64.deb ...

```

```

Unpacking libcupsimage2:amd64 (2.2.7-1ubuntu2.8) ...
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack .../10-libijs-0.35_0.35-13_amd64.deb ...
Unpacking libijs-0.35:amd64 (0.35-13) ...
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack .../11-libjbig2dec0_0.13-6_amd64.deb ...
Unpacking libjbig2dec0:amd64 (0.13-6) ...
Selecting previously unselected package libgs9-common.
Preparing to unpack .../12-libgs9-common_9.26~dfsg+0-0ubuntu0.18.04.14_all.deb
...
Unpacking libgs9-common (9.26~dfsg+0-0ubuntu0.18.04.14) ...
Selecting previously unselected package libgs9:amd64.
Preparing to unpack .../13-libgs9_9.26~dfsg+0-0ubuntu0.18.04.14_amd64.deb ...
Unpacking libgs9:amd64 (9.26~dfsg+0-0ubuntu0.18.04.14) ...
Selecting previously unselected package libjs-jquery.
Preparing to unpack .../14-libjs-jquery_3.2.1-1_all.deb ...
Unpacking libjs-jquery (3.2.1-1) ...
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack .../15-libkpathsea6_2017.20170613.44572-8ubuntu0.1_amd64.deb
...
Unpacking libkpathsea6:amd64 (2017.20170613.44572-8ubuntu0.1) ...
Selecting previously unselected package libpotrace0.
Preparing to unpack .../16-libpotrace0_1.14-2_amd64.deb ...
Unpacking libpotrace0 (1.14-2) ...
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack .../17-libptexenc1_2017.20170613.44572-8ubuntu0.1_amd64.deb
...
Unpacking libptexenc1:amd64 (2017.20170613.44572-8ubuntu0.1) ...
Selecting previously unselected package rubygems-integration.
Preparing to unpack .../18-rubygems-integration_1.11_all.deb ...
Unpacking rubygems-integration (1.11) ...
Selecting previously unselected package ruby2.5.
Preparing to unpack .../19-ruby2.5_2.5.1-1ubuntu1.9_amd64.deb ...
Unpacking ruby2.5 (2.5.1-1ubuntu1.9) ...
Selecting previously unselected package ruby.
Preparing to unpack .../20-ruby_1%3a2.5.1_amd64.deb ...
Unpacking ruby (1:2.5.1) ...
Selecting previously unselected package rake.
Preparing to unpack .../21-rake_12.3.1-1ubuntu0.1_all.deb ...
Unpacking rake (12.3.1-1ubuntu0.1) ...
Selecting previously unselected package ruby-did-you-mean.
Preparing to unpack .../22-ruby-did-you-mean_1.2.0-2_all.deb ...
Unpacking ruby-did-you-mean (1.2.0-2) ...
Selecting previously unselected package ruby-minitest.
Preparing to unpack .../23-ruby-minitest_5.10.3-1_all.deb ...
Unpacking ruby-minitest (5.10.3-1) ...
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack .../24-ruby-net-telnet_0.1.1-2_all.deb ...

```

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Unpacking ruby-net-telnet (0.1.1-2) ...
Selecting previously unselected package ruby-power-assert.
Preparing to unpack .../25-ruby-power-assert_0.3.0-1_all.deb ...
Unpacking ruby-power-assert (0.3.0-1) ...
Selecting previously unselected package ruby-test-unit.
Preparing to unpack .../26-ruby-test-unit_3.2.5-1_all.deb ...
Unpacking ruby-test-unit (3.2.5-1) ...
Selecting previously unselected package libruby2.5:amd64.
Preparing to unpack .../27-libruby2.5_2.5.1-1ubuntu1.9_amd64.deb ...
Unpacking libruby2.5:amd64 (2.5.1-1ubuntu1.9) ...
Selecting previously unselected package libsyntax1:amd64.
Preparing to unpack .../28-libsyntax1_2017.20170613.44572-8ubuntu0.1_amd64.deb
...
Unpacking libsyntax1:amd64 (2017.20170613.44572-8ubuntu0.1) ...
Selecting previously unselected package libtexlua52:amd64.
Preparing to unpack .../29-libtexlua52_2017.20170613.44572-8ubuntu0.1_amd64.deb
...
Unpacking libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) ...
Selecting previously unselected package libtexlua52:amd64.
Preparing to unpack
.../30-libtexlua52_2017.20170613.44572-8ubuntu0.1_amd64.deb ...
Unpacking libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) ...
Selecting previously unselected package libzip-0-13:amd64.
Preparing to unpack .../31-libzip-0-13_0.13.62-3.1ubuntu0.18.04.1_amd64.deb ...
Unpacking libzip-0-13:amd64 (0.13.62-3.1ubuntu0.18.04.1) ...
Selecting previously unselected package lmodern.
Preparing to unpack .../32-lmodern_2.004.5-3_all.deb ...
Unpacking lmodern (2.004.5-3) ...

```

```
[3]: !jupyter-nbconvert --to pdf '/content/drive/My Drive/Colab Notebooks/
↳ProjectData/FaceRecognition/faceMobileNet_TransferLearning.ipynb'
```

```

[NbConvertApp] Converting notebook /content/drive/My Drive/Colab
Notebooks/ProjectData/FaceRecognition/faceMobileNet_TransferLearning.ipynb to
pdf
/usr/local/lib/python2.7/dist-packages/nbconvert/filters/datatypefilter.py:41:
UserWarning: Your element with mimetype(s) [u'application/vnd.colab-display-
data+json'] is not able to be represented.
  mimetypes=output.keys())
[NbConvertApp] Support files will be in faceMobileNet_TransferLearning_files/
[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
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[NbConvertApp] Making directory ./faceMobileNet_TransferLearning_files
[NbConvertApp] Writing 236237 bytes to ./notebook.tex
[NbConvertApp] Building PDF
Traceback (most recent call last):
  File "/usr/local/bin/jupyter-nbconvert", line 8, in <module>
    sys.exit(main())
  File "/usr/local/lib/python2.7/dist-packages/jupyter_core/application.py",
line 267, in launch_instance
    return super(JupyterApp, cls).launch_instance(argv=argv, **kwargs)
  File "/usr/local/lib/python2.7/dist-packages/traitlets/config/application.py",
line 658, in launch_instance
    app.start()
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
338, in start
    self.convert_notebooks()
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
508, in convert_notebooks
    self.convert_single_notebook(notebook_filename)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
479, in convert_single_notebook
    output, resources = self.export_single_notebook(notebook_filename,
resources, input_buffer=input_buffer)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/nbconvertapp.py", line
408, in export_single_notebook
    output, resources = self.exporter.from_filename(notebook_filename,
resources=resources)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/exporter.py",
line 179, in from_filename
    return self.from_file(f, resources=resources, **kw)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/exporter.py",
line 197, in from_file
    return self.from_notebook_node(nbformat.read(file_stream, as_version=4),
resources=resources, **kw)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
178, in from_notebook_node
    rc = self.run_latex(tex_file)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
149, in run_latex
    self.latex_count, log_error)
  File "/usr/local/lib/python2.7/dist-packages/nbconvert/exporters/pdf.py", line
111, in run_command
    "at {link}.".format(formatter=command_list[0], link=link))
OSError: xelatex not found on PATH, if you have not installed xelatex you may
need to do so. Find further instructions at
https://nbconvert.readthedocs.io/en/latest/install.html#installing-tex.

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