In [1]:

```
import os
#os.environ["CUDA_VISIBLE_DEVICES"] = ""
#os.environ["AUTOGRAPH_VERBOSITY"] = "10"
os.environ["TF_FORCE_GPU_ALLOW_GROWTH"] = "true"

from platform import python_version
import warnings
import time
import datetime as dt
from sklearn.metrics import classification_report, confusion_matrix
import multiprocessing as mp
import shutil

import matplotlib.pyplot as plt
import matplotlib.image as mpimg

import tensorflow as tf
from tensorflow.keras import backend as K
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications.mobilenet_v2 import MobileNetV2, preprocess_i
nput, decode_predictions
from tensorflow.keras.models import *
from tensorflow.keras.layers import *
from tensorflow.keras.optimizers import *
from tensorflow.keras.utils import *
from tensorflow.keras.callbacks import *
from tensorflow.keras.initializers import *

import pandas as pd
import numpy as np
import seaborn as sn

from PIL import Image
import xml.etree.ElementTree as ET
import psutil
import random

warnings.filterwarnings("ignore")
%matplotlib inline

print("py", python_version())
print("tf", tf.__version__)
print("keras", tf.keras.__version__)
mem = psutil.virtual_memory()
print("mem", mem.total/1024/1024)
cpu = mp.cpu_count()
print("cpu", cpu)

# %system nvidia-smi
#%system rocm-smi
```

```
py 3.7.3
tf 2.1.0
keras 2.2.4-tf
mem 15475.94140625
cpu 4

/home/roman/anaconda3/lib/python3.7/site-packages/statsmodels/tools/
_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Us
e the functions in the public API at pandas.testing instead.
  import pandas.util.testing as tm
```

In [2]:

```
# Variables

epochs = 100
batch_size = 150
testsplit = .2
targetx = 224
targety = 224
learning_rate = 0.0001
classes = 120
seed = random.randint(1, 1000)

data_dir = "/home/roman/!!!Python/Neyroseti/6/DZ6/2-Dog-Test-Keras/kaggle/input/
Images/"
annotations_dir = "/home/roman/!!!Python/Neyroseti/6/DZ6/2-Dog-Test-Keras/kaggl
e/input/Annotation/"
cropped_dir = "/home/roman/!!!Python/Neyroseti/6/DZ6/2-Dog-Test-Keras/kaggle/wor
king/cropped/"
```

In [3]:

```
# Crop images using provided annotations
# look at cropping_images.py
```

In [4]:

```
# Keras image data readers

datagen = ImageDataGenerator(
        shear_range=0.1,
        zoom_range=0.1,
        brightness_range=[0.9,1.1],
        horizontal_flip=True,
        validation_split=testsplit,
        preprocessing_function=preprocess_input
)

train_generator = datagen.flow_from_directory(
        cropped_dir,
        target_size=(targetx, targety),
        batch_size=batch_size,
        class_mode='categorical',
        shuffle=True,
        seed=seed,
        subset="training"
)

test_generator = datagen.flow_from_directory(
        cropped_dir,
        target_size=(targetx, targety),
        batch_size=batch_size,
        class_mode='categorical',
        shuffle=False,
        seed=seed,
        subset="validation"
)
```

```
Found 15712 images belonging to 120 classes.
Found 3866 images belonging to 120 classes.
```

In [5]:

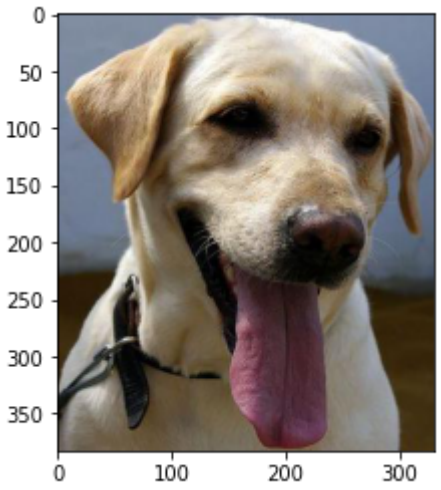
```
# Sample image

img = train_generator.filepaths[np.random.random_integers(low=0, high=train_gene
rator.samples)]
print(img)
img = mpimg.imread(img)
plt.imshow(img)
```

```
/home/roman/!!!Python/Neyroseti/6/DZ6/2-Dog-Test-Keras/kaggle/workin
g/cropped/n02099712-Labrador_retriever/n02099712_4133.jpg
```

Out[5]:

```
<matplotlib.image.AxesImage at 0x7f2fe3432048>
```



In [6]:

```
# Keras callbacks

checkpoint = ModelCheckpoint('dog_breed_classifier.h5',
                             monitor='val_accuracy',
                             save_best_only=True,
                             verbose=1,
                             mode='auto',
                             save_weights_only=False,
                             period=1)

#https://github.com/keras-team/keras/issues/3358
tensorboard = TensorBoard(log_dir="./logs-"+dt.datetime.now().strftime("%m%d%Y%
H%M%S"),
                          histogram_freq=0,
                          batch_size=batch_size,
                          write_graph=False,
                          update_freq='epoch')

def epoch_end(epoch, logs):
    message = "End of epoch "+str(epoch)+". Learning rate: "+str(K.eval(model.op
timizer.lr))
    os.system('echo '+message)

def epoch_begin(epoch, logs):
    print("Learning rate: ", K.eval(model.optimizer.lr))

def train_begin(logs):
    os.system("echo Beginning training")

earlystop = EarlyStopping(monitor='val_accuracy',
                          min_delta=.0001,
                          patience=20,
                          verbose=1,
                          mode='auto',
                          baseline=None,
                          restore_best_weights=True)

reducelr = ReduceLROnPlateau(monitor='val_accuracy',
                             factor=np.sqrt(.1),
                             patience=5,
                             verbose=1,
                             mode='auto',
                             min_delta=.0001,
                             cooldown=0,
                             min_lr=0.0000001)

lambdacb = LambdaCallback(on_epoch_begin=epoch_begin,
                          on_epoch_end=epoch_end,
                          on_batch_begin=None,
                          on_batch_end=None,
                          on_train_begin=train_begin,
                          on_train_end=None)
```

```
WARNING:tensorflow:`period` argument is deprecated. Please use `save
_freq` to specify the frequency in number of samples seen.
WARNING:tensorflow:`batch_size` is no longer needed in the `TensorBo
ard` Callback and will be ignored in TensorFlow 2.0.
```

In [9]:

```
# Define new top layers and compile model

base_model = MobileNetV2(include_top=False, weights='imagenet', input_shape=(tar
getx, targety, 3))

x = base_model.output
x = GlobalAveragePooling2D()(x)
# x = Dropout(rate = .2)(x)
x = BatchNormalization()(x)
x = Dense(1280, activation='relu',  kernel_initializer=glorot_uniform(seed), bia
s_initializer='zeros')(x)
# x = Dropout(rate = .2)(x)
x = BatchNormalization()(x)
predictions = Dense(classes, activation='softmax', kernel_initializer='random_un
iform', bias_initializer='zeros')(x)

model = Model(inputs=base_model.input, outputs=predictions)

optimizer = Adam(lr=learning_rate)
# optimizer = RMSprop(lr=learning_rate)

loss = "categorical_crossentropy"
# loss = "kullback_leibler_divergence"

for layer in model.layers:
    layer.trainable = True
# for layer in model.layers[-2:]:
#     layer.trainable = True

model.compile(optimizer=optimizer,
              loss=loss,
              metrics=["accuracy"])

model.summary()
for i, layer in enumerate(model.layers):
    print(i, layer.name, layer.trainable)
```

```
Downloading data from https://github.com/JonathanCMitchell/mobilenet
_v2_keras/releases/download/v1.1/mobilenet_v2_weights_tf_dim_orderin
g_tf_kernels_1.0_224_no_top.h5
9412608/9406464 [==============================] - 2s 0us/step
Model: "model"
__________________________________________________________________
_______________
Layer (type)                 Output Shape              Param #
Con
nected to
==================================================================
===============
input_3 (InputLayer)         [(None, 224, 224, 3) 0
__________________________________________________________________
_______________
Conv1_pad (ZeroPadding2D)    (None, 225, 225, 3)  0
inp
ut_3[0][0]
__________________________________________________________________
_______________
Conv1 (Conv2D)               (None, 112, 112, 32) 864
Con
v1_pad[0][0]
__________________________________________________________________
_______________
bn_Conv1 (BatchNormalization)   (None, 112, 112, 32) 128
Con
v1[0][0]
__________________________________________________________________
_______________
Conv1_relu (ReLU)            (None, 112, 112, 32) 0
bn_
Conv1[0][0]
__________________________________________________________________
_______________
expanded_conv_depthwise (Depthw (None, 112, 112, 32) 288
Con
v1_relu[0][0]
__________________________________________________________________
_______________
expanded_conv_depthwise_BN (Bat (None, 112, 112, 32) 128
exp
anded_conv_depthwise[0][0]
__________________________________________________________________
_______________
expanded_conv_depthwise_relu (R (None, 112, 112, 32) 0
exp
anded_conv_depthwise_BN[0][0]
__________________________________________________________________
_______________
expanded_conv_project (Conv2D)  (None, 112, 112, 16) 512
exp
anded_conv_depthwise_relu[0][0
__________________________________________________________________
_______________
expanded_conv_project_BN (Batch (None, 112, 112, 16) 64
exp
anded_conv_project[0][0]
__________________________________________________________________
_______________
block_1_expand (Conv2D)      (None, 112, 112, 96) 1536
exp
anded_conv_project_BN[0][0]
__________________________________________________________________
_______________
block_1_expand_BN (BatchNormali (None, 112, 112, 96) 384
blo
ck_1_expand[0][0]
__________________________________________________________________
_______________
block_1_expand_relu (ReLU)   (None, 112, 112, 96) 0
blo
ck_1_expand_BN[0][0]
__________________________________________________________________
_______________
```

```
__________________________________
block_1_pad (ZeroPadding2D)     (None, 113, 113, 96) 0           blo
ck_1_expand_relu[0][0]
__________________________________________________________________
__________________________________
block_1_depthwise (DepthwiseCon (None, 56, 56, 96)   864         blo
ck_1_pad[0][0]
__________________________________________________________________
__________________________________
block_1_depthwise_BN (BatchNorm (None, 56, 56, 96)   384         blo
ck_1_depthwise[0][0]
__________________________________________________________________
__________________________________
block_1_depthwise_relu (ReLU)   (None, 56, 56, 96)   0           blo
ck_1_depthwise_BN[0][0]
__________________________________________________________________
__________________________________
block_1_project (Conv2D)        (None, 56, 56, 24)   2304        blo
ck_1_depthwise_relu[0][0]
__________________________________________________________________
__________________________________
block_1_project_BN (BatchNormal (None, 56, 56, 24)   96          blo
ck_1_project[0][0]
__________________________________________________________________
__________________________________
block_2_expand (Conv2D)         (None, 56, 56, 144)  3456        blo
ck_1_project_BN[0][0]
__________________________________________________________________
__________________________________
block_2_expand_BN (BatchNormali (None, 56, 56, 144)  576         blo
ck_2_expand[0][0]
__________________________________________________________________
__________________________________
block_2_expand_relu (ReLU)      (None, 56, 56, 144)  0           blo
ck_2_expand_BN[0][0]
__________________________________________________________________
__________________________________
block_2_depthwise (DepthwiseCon (None, 56, 56, 144)  1296        blo
ck_2_expand_relu[0][0]
__________________________________________________________________
__________________________________
block_2_depthwise_BN (BatchNorm (None, 56, 56, 144)  576         blo
ck_2_depthwise[0][0]
__________________________________________________________________
__________________________________
block_2_depthwise_relu (ReLU)   (None, 56, 56, 144)  0           blo
ck_2_depthwise_BN[0][0]
__________________________________________________________________
__________________________________
block_2_project (Conv2D)        (None, 56, 56, 24)   3456        blo
ck_2_depthwise_relu[0][0]
__________________________________________________________________
__________________________________
block_2_project_BN (BatchNormal (None, 56, 56, 24)   96          blo
ck_2_project[0][0]
__________________________________________________________________
__________________________________
block_2_add (Add)               (None, 56, 56, 24)   0           blo
ck_1_project_BN[0][0]
                                                                 blo
ck_2_project_BN[0][0]
```

```
____________________________________________________________________________________________
____________________________________
block_3_expand (Conv2D)          (None, 56, 56, 144)  3456        blo
ck_2_add[0][0]
____________________________________________________________________________________________
____________________________________
block_3_expand_BN (BatchNormali (None, 56, 56, 144)  576         blo
ck_3_expand[0][0]
____________________________________________________________________________________________
____________________________________
block_3_expand_relu (ReLU)       (None, 56, 56, 144)  0           blo
ck_3_expand_BN[0][0]
____________________________________________________________________________________________
____________________________________
block_3_pad (ZeroPadding2D)      (None, 57, 57, 144)  0           blo
ck_3_expand_relu[0][0]
____________________________________________________________________________________________
____________________________________
block_3_depthwise (DepthwiseCon (None, 28, 28, 144)  1296        blo
ck_3_pad[0][0]
____________________________________________________________________________________________
____________________________________
block_3_depthwise_BN (BatchNorm (None, 28, 28, 144)  576         blo
ck_3_depthwise[0][0]
____________________________________________________________________________________________
____________________________________
block_3_depthwise_relu (ReLU)    (None, 28, 28, 144)  0           blo
ck_3_depthwise_BN[0][0]
____________________________________________________________________________________________
____________________________________
block_3_project (Conv2D)         (None, 28, 28, 32)   4608        blo
ck_3_depthwise_relu[0][0]
____________________________________________________________________________________________
____________________________________
block_3_project_BN (BatchNormal (None, 28, 28, 32)   128         blo
ck_3_project[0][0]
____________________________________________________________________________________________
____________________________________
block_4_expand (Conv2D)          (None, 28, 28, 192)  6144        blo
ck_3_project_BN[0][0]
____________________________________________________________________________________________
____________________________________
block_4_expand_BN (BatchNormali (None, 28, 28, 192)  768         blo
ck_4_expand[0][0]
____________________________________________________________________________________________
____________________________________
block_4_expand_relu (ReLU)       (None, 28, 28, 192)  0           blo
ck_4_expand_BN[0][0]
____________________________________________________________________________________________
____________________________________
block_4_depthwise (DepthwiseCon (None, 28, 28, 192)  1728        blo
ck_4_expand_relu[0][0]
____________________________________________________________________________________________
____________________________________
block_4_depthwise_BN (BatchNorm (None, 28, 28, 192)  768         blo
ck_4_depthwise[0][0]
____________________________________________________________________________________________
____________________________________
block_4_depthwise_relu (ReLU)    (None, 28, 28, 192)  0           blo
ck_4_depthwise_BN[0][0]
____________________________________________________________________________________________
```

```
_____
block_4_project (Conv2D)        (None, 28, 28, 32)   6144        blo
ck_4_depthwise_relu[0][0]
_____
_____
block_4_project_BN (BatchNormal (None, 28, 28, 32)   128         blo
ck_4_project[0][0]
_____
_____
block_4_add (Add)               (None, 28, 28, 32)   0           blo
ck_3_project_BN[0][0]
                                                                 blo
ck_4_project_BN[0][0]
_____
_____
block_5_expand (Conv2D)         (None, 28, 28, 192)  6144        blo
ck_4_add[0][0]
_____
_____
block_5_expand_BN (BatchNormali (None, 28, 28, 192)  768         blo
ck_5_expand[0][0]
_____
_____
block_5_expand_relu (ReLU)      (None, 28, 28, 192)  0           blo
ck_5_expand_BN[0][0]
_____
_____
block_5_depthwise (DepthwiseCon (None, 28, 28, 192)  1728        blo
ck_5_expand_relu[0][0]
_____
_____
block_5_depthwise_BN (BatchNorm (None, 28, 28, 192)  768         blo
ck_5_depthwise[0][0]
_____
_____
block_5_depthwise_relu (ReLU)   (None, 28, 28, 192)  0           blo
ck_5_depthwise_BN[0][0]
_____
_____
block_5_project (Conv2D)        (None, 28, 28, 32)   6144        blo
ck_5_depthwise_relu[0][0]
_____
_____
block_5_project_BN (BatchNormal (None, 28, 28, 32)   128         blo
ck_5_project[0][0]
_____
_____
block_5_add (Add)               (None, 28, 28, 32)   0           blo
ck_4_add[0][0]
                                                                 blo
ck_5_project_BN[0][0]
_____
_____
block_6_expand (Conv2D)         (None, 28, 28, 192)  6144        blo
ck_5_add[0][0]
_____
_____
block_6_expand_BN (BatchNormali (None, 28, 28, 192)  768         blo
ck_6_expand[0][0]
_____
_____
```

```
block_6_expand_relu (ReLU)      (None, 28, 28, 192)  0           blo
ck_6_expand_BN[0][0]
__________________________________________________________________
_____________
block_6_pad (ZeroPadding2D)     (None, 29, 29, 192)  0           blo
ck_6_expand_relu[0][0]
__________________________________________________________________
_____________
block_6_depthwise (DepthwiseCon (None, 14, 14, 192)  1728        blo
ck_6_pad[0][0]
__________________________________________________________________
_____________
block_6_depthwise_BN (BatchNorm (None, 14, 14, 192)  768         blo
ck_6_depthwise[0][0]
__________________________________________________________________
_____________
block_6_depthwise_relu (ReLU)   (None, 14, 14, 192)  0           blo
ck_6_depthwise_BN[0][0]
__________________________________________________________________
_____________
block_6_project (Conv2D)        (None, 14, 14, 64)   12288       blo
ck_6_depthwise_relu[0][0]
__________________________________________________________________
_____________
block_6_project_BN (BatchNormal (None, 14, 14, 64)   256         blo
ck_6_project[0][0]
__________________________________________________________________
_____________
block_7_expand (Conv2D)         (None, 14, 14, 384)  24576       blo
ck_6_project_BN[0][0]
__________________________________________________________________
_____________
block_7_expand_BN (BatchNormali (None, 14, 14, 384)  1536        blo
ck_7_expand[0][0]
__________________________________________________________________
_____________
block_7_expand_relu (ReLU)      (None, 14, 14, 384)  0           blo
ck_7_expand_BN[0][0]
__________________________________________________________________
_____________
block_7_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        blo
ck_7_expand_relu[0][0]
__________________________________________________________________
_____________
block_7_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        blo
ck_7_depthwise[0][0]
__________________________________________________________________
_____________
block_7_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           blo
ck_7_depthwise_BN[0][0]
__________________________________________________________________
_____________
block_7_project (Conv2D)        (None, 14, 14, 64)   24576       blo
ck_7_depthwise_relu[0][0]
__________________________________________________________________
_____________
block_7_project_BN (BatchNormal (None, 14, 14, 64)   256         blo
ck_7_project[0][0]
__________________________________________________________________
_____________
block_7_add (Add)               (None, 14, 14, 64)   0           blo
```

```
ck_6_project_BN[0][0]
                                                                 blo
ck_7_project_BN[0][0]
__________________________________________________________________________________
_____________________________
block_8_expand (Conv2D)         (None, 14, 14, 384)  24576       blo
ck_7_add[0][0]
__________________________________________________________________________________
_____________________________
block_8_expand_BN (BatchNormali (None, 14, 14, 384)  1536        blo
ck_8_expand[0][0]
__________________________________________________________________________________
_____________________________
block_8_expand_relu (ReLU)      (None, 14, 14, 384)  0           blo
ck_8_expand_BN[0][0]
__________________________________________________________________________________
_____________________________
block_8_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        blo
ck_8_expand_relu[0][0]
__________________________________________________________________________________
_____________________________
block_8_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        blo
ck_8_depthwise[0][0]
__________________________________________________________________________________
_____________________________
block_8_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           blo
ck_8_depthwise_BN[0][0]
__________________________________________________________________________________
_____________________________
block_8_project (Conv2D)        (None, 14, 14, 64)   24576       blo
ck_8_depthwise_relu[0][0]
__________________________________________________________________________________
_____________________________
block_8_project_BN (BatchNormal (None, 14, 14, 64)   256         blo
ck_8_project[0][0]
__________________________________________________________________________________
_____________________________
block_8_add (Add)               (None, 14, 14, 64)   0           blo
ck_7_add[0][0]
                                                                 blo
ck_8_project_BN[0][0]
__________________________________________________________________________________
_____________________________
block_9_expand (Conv2D)         (None, 14, 14, 384)  24576       blo
ck_8_add[0][0]
__________________________________________________________________________________
_____________________________
block_9_expand_BN (BatchNormali (None, 14, 14, 384)  1536        blo
ck_9_expand[0][0]
__________________________________________________________________________________
_____________________________
block_9_expand_relu (ReLU)      (None, 14, 14, 384)  0           blo
ck_9_expand_BN[0][0]
__________________________________________________________________________________
_____________________________
block_9_depthwise (DepthwiseCon (None, 14, 14, 384)  3456        blo
ck_9_expand_relu[0][0]
__________________________________________________________________________________
_____________________________
block_9_depthwise_BN (BatchNorm (None, 14, 14, 384)  1536        blo
ck_9_depthwise[0][0]
```

```
__________________________________________________________________________________________________
____________________________________
block_9_depthwise_relu (ReLU)   (None, 14, 14, 384)  0           blo
ck_9_depthwise_BN[0][0]
__________________________________________________________________________________________________
____________________________________
block_9_project (Conv2D)        (None, 14, 14, 64)   24576       blo
ck_9_depthwise_relu[0][0]
__________________________________________________________________________________________________
____________________________________
block_9_project_BN (BatchNormal (None, 14, 14, 64)   256         blo
ck_9_project[0][0]
__________________________________________________________________________________________________
____________________________________
block_9_add (Add)               (None, 14, 14, 64)   0           blo
ck_8_add[0][0]
                                                                 blo
ck_9_project_BN[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_expand (Conv2D)        (None, 14, 14, 384)  24576       blo
ck_9_add[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_expand_BN (BatchNormal (None, 14, 14, 384)  1536        blo
ck_10_expand[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_expand_relu (ReLU)     (None, 14, 14, 384)  0           blo
ck_10_expand_BN[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_depthwise (DepthwiseCo (None, 14, 14, 384)  3456        blo
ck_10_expand_relu[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_depthwise_BN (BatchNor (None, 14, 14, 384)  1536        blo
ck_10_depthwise[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_depthwise_relu (ReLU)  (None, 14, 14, 384)  0           blo
ck_10_depthwise_BN[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_project (Conv2D)       (None, 14, 14, 96)   36864       blo
ck_10_depthwise_relu[0][0]
__________________________________________________________________________________________________
____________________________________
block_10_project_BN (BatchNorma (None, 14, 14, 96)   384         blo
ck_10_project[0][0]
__________________________________________________________________________________________________
____________________________________
block_11_expand (Conv2D)        (None, 14, 14, 576)  55296       blo
ck_10_project_BN[0][0]
__________________________________________________________________________________________________
____________________________________
block_11_expand_BN (BatchNormal (None, 14, 14, 576)  2304        blo
ck_11_expand[0][0]
__________________________________________________________________________________________________
____________________________________
block_11_expand_relu (ReLU)     (None, 14, 14, 576)  0           blo
```

```
ck_11_expand_BN[0][0]
__________________________________________________________________________________
_____________________________
block_11_depthwise (DepthwiseCo (None, 14, 14, 576)  5184        blo
ck_11_expand_relu[0][0]
__________________________________________________________________________________
_____________________________
block_11_depthwise_BN (BatchNor (None, 14, 14, 576)  2304        blo
ck_11_depthwise[0][0]
__________________________________________________________________________________
_____________________________
block_11_depthwise_relu (ReLU)  (None, 14, 14, 576)  0           blo
ck_11_depthwise_BN[0][0]
__________________________________________________________________________________
_____________________________
block_11_project (Conv2D)       (None, 14, 14, 96)   55296       blo
ck_11_depthwise_relu[0][0]
__________________________________________________________________________________
_____________________________
block_11_project_BN (BatchNorma (None, 14, 14, 96)   384         blo
ck_11_project[0][0]
__________________________________________________________________________________
_____________________________
block_11_add (Add)              (None, 14, 14, 96)   0           blo
ck_10_project_BN[0][0]
                                                                 blo
ck_11_project_BN[0][0]
__________________________________________________________________________________
_____________________________
block_12_expand (Conv2D)        (None, 14, 14, 576)  55296       blo
ck_11_add[0][0]
__________________________________________________________________________________
_____________________________
block_12_expand_BN (BatchNormal (None, 14, 14, 576)  2304        blo
ck_12_expand[0][0]
__________________________________________________________________________________
_____________________________
block_12_expand_relu (ReLU)     (None, 14, 14, 576)  0           blo
ck_12_expand_BN[0][0]
__________________________________________________________________________________
_____________________________
block_12_depthwise (DepthwiseCo (None, 14, 14, 576)  5184        blo
ck_12_expand_relu[0][0]
__________________________________________________________________________________
_____________________________
block_12_depthwise_BN (BatchNor (None, 14, 14, 576)  2304        blo
ck_12_depthwise[0][0]
__________________________________________________________________________________
_____________________________
block_12_depthwise_relu (ReLU)  (None, 14, 14, 576)  0           blo
ck_12_depthwise_BN[0][0]
__________________________________________________________________________________
_____________________________
block_12_project (Conv2D)       (None, 14, 14, 96)   55296       blo
ck_12_depthwise_relu[0][0]
__________________________________________________________________________________
_____________________________
block_12_project_BN (BatchNorma (None, 14, 14, 96)   384         blo
ck_12_project[0][0]
__________________________________________________________________________________
_____________________________
```

```
block_12_add (Add)              (None, 14, 14, 96)   0           blo
ck_11_add[0][0]
                                                                 blo
ck_12_project_BN[0][0]
__________________________________________________________________
_______________________________
block_13_expand (Conv2D)        (None, 14, 14, 576)  55296       blo
ck_12_add[0][0]
__________________________________________________________________
_______________________________
block_13_expand_BN (BatchNormal (None, 14, 14, 576)  2304        blo
ck_13_expand[0][0]
__________________________________________________________________
_______________________________
block_13_expand_relu (ReLU)     (None, 14, 14, 576)  0           blo
ck_13_expand_BN[0][0]
__________________________________________________________________
_______________________________
block_13_pad (ZeroPadding2D)    (None, 15, 15, 576)  0           blo
ck_13_expand_relu[0][0]
__________________________________________________________________
_______________________________
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)    5184        blo
ck_13_pad[0][0]
__________________________________________________________________
_______________________________
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)    2304        blo
ck_13_depthwise[0][0]
__________________________________________________________________
_______________________________
block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)    0           blo
ck_13_depthwise_BN[0][0]
__________________________________________________________________
_______________________________
block_13_project (Conv2D)       (None, 7, 7, 160)    92160       blo
ck_13_depthwise_relu[0][0]
__________________________________________________________________
_______________________________
block_13_project_BN (BatchNorma (None, 7, 7, 160)    640         blo
ck_13_project[0][0]
__________________________________________________________________
_______________________________
block_14_expand (Conv2D)        (None, 7, 7, 960)    153600      blo
ck_13_project_BN[0][0]
__________________________________________________________________
_______________________________
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840        blo
ck_14_expand[0][0]
__________________________________________________________________
_______________________________
block_14_expand_relu (ReLU)     (None, 7, 7, 960)    0           blo
ck_14_expand_BN[0][0]
__________________________________________________________________
_______________________________
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        blo
ck_14_expand_relu[0][0]
__________________________________________________________________
_______________________________
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        blo
ck_14_depthwise[0][0]
__________________________________________________________________
```

```
__________________________________
block_14_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           blo
ck_14_depthwise_BN[0][0]
__________________________________________________________________
__________________________________
block_14_project (Conv2D)       (None, 7, 7, 160)    153600      blo
ck_14_depthwise_relu[0][0]
__________________________________________________________________
__________________________________
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640         blo
ck_14_project[0][0]
__________________________________________________________________
__________________________________
block_14_add (Add)              (None, 7, 7, 160)    0           blo
ck_13_project_BN[0][0]
                                                                 blo
ck_14_project_BN[0][0]
__________________________________________________________________
__________________________________
block_15_expand (Conv2D)        (None, 7, 7, 960)    153600      blo
ck_14_add[0][0]
__________________________________________________________________
__________________________________
block_15_expand_BN (BatchNormal (None, 7, 7, 960)    3840        blo
ck_15_expand[0][0]
__________________________________________________________________
__________________________________
block_15_expand_relu (ReLU)     (None, 7, 7, 960)    0           blo
ck_15_expand_BN[0][0]
__________________________________________________________________
__________________________________
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        blo
ck_15_expand_relu[0][0]
__________________________________________________________________
__________________________________
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        blo
ck_15_depthwise[0][0]
__________________________________________________________________
__________________________________
block_15_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           blo
ck_15_depthwise_BN[0][0]
__________________________________________________________________
__________________________________
block_15_project (Conv2D)       (None, 7, 7, 160)    153600      blo
ck_15_depthwise_relu[0][0]
__________________________________________________________________
__________________________________
block_15_project_BN (BatchNorma (None, 7, 7, 160)    640         blo
ck_15_project[0][0]
__________________________________________________________________
__________________________________
block_15_add (Add)              (None, 7, 7, 160)    0           blo
ck_14_add[0][0]
                                                                 blo
ck_15_project_BN[0][0]
__________________________________________________________________
__________________________________
block_16_expand (Conv2D)        (None, 7, 7, 960)    153600      blo
ck_15_add[0][0]
__________________________________________________________________
__________________________________
```

```
block_16_expand_BN (BatchNormal (None, 7, 7, 960)    3840        blo
ck_16_expand[0][0]
__________________________________________________________________
_____________________________
block_16_expand_relu (ReLU)     (None, 7, 7, 960)    0           blo
ck_16_expand_BN[0][0]
__________________________________________________________________
_____________________________
block_16_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        blo
ck_16_expand_relu[0][0]
__________________________________________________________________
_____________________________
block_16_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        blo
ck_16_depthwise[0][0]
__________________________________________________________________
_____________________________
block_16_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           blo
ck_16_depthwise_BN[0][0]
__________________________________________________________________
_____________________________
block_16_project (Conv2D)       (None, 7, 7, 320)    307200      blo
ck_16_depthwise_relu[0][0]
__________________________________________________________________
_____________________________
block_16_project_BN (BatchNorma (None, 7, 7, 320)    1280        blo
ck_16_project[0][0]
__________________________________________________________________
_____________________________
Conv_1 (Conv2D)                 (None, 7, 7, 1280)   409600      blo
ck_16_project_BN[0][0]
__________________________________________________________________
_____________________________
Conv_1_bn (BatchNormalization)  (None, 7, 7, 1280)   5120        Con
v_1[0][0]
__________________________________________________________________
_____________________________
out_relu (ReLU)                 (None, 7, 7, 1280)   0           Con
v_1_bn[0][0]
__________________________________________________________________
_____________________________
global_average_pooling2d (Globa (None, 1280)         0           out
_relu[0][0]
__________________________________________________________________
_____________________________
batch_normalization (BatchNorma (None, 1280)         5120        glo
bal_average_pooling2d[0][0]
__________________________________________________________________
_____________________________
dense (Dense)                   (None, 1280)         1639680     bat
ch_normalization[0][0]
__________________________________________________________________
_____________________________
batch_normalization_1 (BatchNor (None, 1280)         5120        den
se[0][0]
__________________________________________________________________
_____________________________
dense_1 (Dense)                 (None, 120)          153720      bat
ch_normalization_1[0][0]
==================================================================
==============================
Total params: 4,061,624
```

```
Trainable params: 4,022,392
Non-trainable params: 39,232
_________________________________________________________________
_________________________________
0 input_3 True
1 Conv1_pad True
2 Conv1 True
3 bn_Conv1 True
4 Conv1_relu True
5 expanded_conv_depthwise True
6 expanded_conv_depthwise_BN True
7 expanded_conv_depthwise_relu True
8 expanded_conv_project True
9 expanded_conv_project_BN True
10 block_1_expand True
11 block_1_expand_BN True
12 block_1_expand_relu True
13 block_1_pad True
14 block_1_depthwise True
15 block_1_depthwise_BN True
16 block_1_depthwise_relu True
17 block_1_project True
18 block_1_project_BN True
19 block_2_expand True
20 block_2_expand_BN True
21 block_2_expand_relu True
22 block_2_depthwise True
23 block_2_depthwise_BN True
24 block_2_depthwise_relu True
25 block_2_project True
26 block_2_project_BN True
27 block_2_add True
28 block_3_expand True
29 block_3_expand_BN True
30 block_3_expand_relu True
31 block_3_pad True
32 block_3_depthwise True
33 block_3_depthwise_BN True
34 block_3_depthwise_relu True
35 block_3_project True
36 block_3_project_BN True
37 block_4_expand True
38 block_4_expand_BN True
39 block_4_expand_relu True
40 block_4_depthwise True
41 block_4_depthwise_BN True
42 block_4_depthwise_relu True
43 block_4_project True
44 block_4_project_BN True
45 block_4_add True
46 block_5_expand True
47 block_5_expand_BN True
48 block_5_expand_relu True
49 block_5_depthwise True
50 block_5_depthwise_BN True
51 block_5_depthwise_relu True
52 block_5_project True
53 block_5_project_BN True
54 block_5_add True
55 block_6_expand True
56 block_6_expand_BN True
```

```
 57 block_6_expand_relu True
 58 block_6_pad True
 59 block_6_depthwise True
 60 block_6_depthwise_BN True
 61 block_6_depthwise_relu True
 62 block_6_project True
 63 block_6_project_BN True
 64 block_7_expand True
 65 block_7_expand_BN True
 66 block_7_expand_relu True
 67 block_7_depthwise True
 68 block_7_depthwise_BN True
 69 block_7_depthwise_relu True
 70 block_7_project True
 71 block_7_project_BN True
 72 block_7_add True
 73 block_8_expand True
 74 block_8_expand_BN True
 75 block_8_expand_relu True
 76 block_8_depthwise True
 77 block_8_depthwise_BN True
 78 block_8_depthwise_relu True
 79 block_8_project True
 80 block_8_project_BN True
 81 block_8_add True
 82 block_9_expand True
 83 block_9_expand_BN True
 84 block_9_expand_relu True
 85 block_9_depthwise True
 86 block_9_depthwise_BN True
 87 block_9_depthwise_relu True
 88 block_9_project True
 89 block_9_project_BN True
 90 block_9_add True
 91 block_10_expand True
 92 block_10_expand_BN True
 93 block_10_expand_relu True
 94 block_10_depthwise True
 95 block_10_depthwise_BN True
 96 block_10_depthwise_relu True
 97 block_10_project True
 98 block_10_project_BN True
 99 block_11_expand True
100 block_11_expand_BN True
101 block_11_expand_relu True
102 block_11_depthwise True
103 block_11_depthwise_BN True
104 block_11_depthwise_relu True
105 block_11_project True
106 block_11_project_BN True
107 block_11_add True
108 block_12_expand True
109 block_12_expand_BN True
110 block_12_expand_relu True
111 block_12_depthwise True
112 block_12_depthwise_BN True
113 block_12_depthwise_relu True
114 block_12_project True
115 block_12_project_BN True
116 block_12_add True
117 block_13_expand True
```

```
118 block_13_expand_BN True
119 block_13_expand_relu True
120 block_13_pad True
121 block_13_depthwise True
122 block_13_depthwise_BN True
123 block_13_depthwise_relu True
124 block_13_project True
125 block_13_project_BN True
126 block_14_expand True
127 block_14_expand_BN True
128 block_14_expand_relu True
129 block_14_depthwise True
130 block_14_depthwise_BN True
131 block_14_depthwise_relu True
132 block_14_project True
133 block_14_project_BN True
134 block_14_add True
135 block_15_expand True
136 block_15_expand_BN True
137 block_15_expand_relu True
138 block_15_depthwise True
139 block_15_depthwise_BN True
140 block_15_depthwise_relu True
141 block_15_project True
142 block_15_project_BN True
143 block_15_add True
144 block_16_expand True
145 block_16_expand_BN True
146 block_16_expand_relu True
147 block_16_depthwise True
148 block_16_depthwise_BN True
149 block_16_depthwise_relu True
150 block_16_project True
151 block_16_project_BN True
152 Conv_1 True
153 Conv_1_bn True
154 out_relu True
155 global_average_pooling2d True
156 batch_normalization True
157 dense True
158 batch_normalization_1 True
159 dense_1 True
```

In [ ]:

```
# Fit model

params = model.fit_generator(generator=train_generator,
                                  steps_per_epoch=len(train_generator),
                                  validation_data=test_generator,
                                  validation_steps=len(test_generator),
                                  epochs=epochs,
                                  callbacks=[reducelr, earlystop, lambdacb, tensor
board, checkpoint])
```

```
WARNING:tensorflow:From <ipython-input-10-5aa36a5f2732>:8: Model.fit
_generator (from tensorflow.python.keras.engine.training) is depreca
ted and will be removed in a future version.
Instructions for updating:
Please use Model.fit, which supports generators.
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
Train for 105 steps, validate for 26 steps
Learning rate:  1e-04
Epoch 1/100
104/105 [============================>.] - ETA: 30s - loss: 2.2757 -
accuracy: 0.4751
Epoch 00001: val_accuracy improved from -inf to 0.61718, saving mode
l to dog_breed_classifier.h5
105/105 [==============================] - 3407s 32s/step - loss: 2.
2644 - accuracy: 0.4773 - val_loss: 1.7087 - val_accuracy: 0.6172
Learning rate:  1e-04
Epoch 2/100
104/105 [============================>.] - ETA: 29s - loss: 0.7157 -
accuracy: 0.7991
Epoch 00002: val_accuracy improved from 0.61718 to 0.66632, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3329s 32s/step - loss: 0.
7142 - accuracy: 0.7998 - val_loss: 1.1969 - val_accuracy: 0.6663
Learning rate:  1e-04
Epoch 3/100
104/105 [============================>.] - ETA: 30s - loss: 0.4441 -
accuracy: 0.8769
Epoch 00003: val_accuracy improved from 0.66632 to 0.69064, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3355s 32s/step - loss: 0.
4444 - accuracy: 0.8768 - val_loss: 1.0488 - val_accuracy: 0.6906
Learning rate:  1e-04
Epoch 4/100
104/105 [============================>.] - ETA: 29s - loss: 0.2889 -
accuracy: 0.9274
Epoch 00004: val_accuracy improved from 0.69064 to 0.71650, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3293s 31s/step - loss: 0.
2896 - accuracy: 0.9272 - val_loss: 0.9548 - val_accuracy: 0.7165
Learning rate:  1e-04
Epoch 5/100
104/105 [============================>.] - ETA: 29s - loss: 0.1943 -
accuracy: 0.9569
Epoch 00005: val_accuracy did not improve from 0.71650
105/105 [==============================] - 3308s 32s/step - loss: 0.
1936 - accuracy: 0.9572 - val_loss: 0.9623 - val_accuracy: 0.7165
Learning rate:  1e-04
Epoch 6/100
104/105 [============================>.] - ETA: 28s - loss: 0.1325 -
accuracy: 0.9762
Epoch 00006: val_accuracy improved from 0.71650 to 0.74056, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3176s 30s/step - loss: 0.
1326 - accuracy: 0.9761 - val_loss: 0.8820 - val_accuracy: 0.7406
```

```
Learning rate:  1e-04
Epoch 7/100
104/105 [============================>.] - ETA: 28s - loss: 0.0928 -
accuracy: 0.9872
Epoch 00007: val_accuracy did not improve from 0.74056
105/105 [==============================] - 3144s 30s/step - loss: 0.
0928 - accuracy: 0.9871 - val_loss: 0.8772 - val_accuracy: 0.7390
Learning rate:  1e-04
Epoch 8/100
104/105 [============================>.] - ETA: 27s - loss: 0.0652 -
accuracy: 0.9934
Epoch 00008: val_accuracy improved from 0.74056 to 0.75375, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3115s 30s/step - loss: 0.
0651 - accuracy: 0.9935 - val_loss: 0.8343 - val_accuracy: 0.7538
Learning rate:  1e-04
Epoch 9/100
104/105 [============================>.] - ETA: 28s - loss: 0.0500 -
accuracy: 0.9948
Epoch 00009: val_accuracy improved from 0.75375 to 0.77186, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3149s 30s/step - loss: 0.
0501 - accuracy: 0.9947 - val_loss: 0.8127 - val_accuracy: 0.7719
Learning rate:  1e-04
Epoch 10/100
104/105 [============================>.] - ETA: 28s - loss: 0.0372 -
accuracy: 0.9972
Epoch 00010: val_accuracy improved from 0.77186 to 0.77367, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3163s 30s/step - loss: 0.
0372 - accuracy: 0.9971 - val_loss: 0.8001 - val_accuracy: 0.7737
Learning rate:  1e-04
Epoch 11/100
104/105 [============================>.] - ETA: 27s - loss: 0.0303 -
accuracy: 0.9979
Epoch 00011: val_accuracy improved from 0.77367 to 0.79229, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3118s 30s/step - loss: 0.
0305 - accuracy: 0.9978 - val_loss: 0.7418 - val_accuracy: 0.7923
Learning rate:  1e-04
Epoch 12/100
104/105 [============================>.] - ETA: 28s - loss: 0.0253 -
accuracy: 0.9981
Epoch 00012: val_accuracy did not improve from 0.79229
105/105 [==============================] - 3115s 30s/step - loss: 0.
0254 - accuracy: 0.9982 - val_loss: 0.7810 - val_accuracy: 0.7900
Learning rate:  1e-04
Epoch 13/100
104/105 [============================>.] - ETA: 27s - loss: 0.0206 -
accuracy: 0.9987
Epoch 00013: val_accuracy improved from 0.79229 to 0.79281, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3105s 30s/step - loss: 0.
0206 - accuracy: 0.9987 - val_loss: 0.7707 - val_accuracy: 0.7928
Learning rate:  1e-04
Epoch 14/100
104/105 [============================>.] - ETA: 27s - loss: 0.0184 -
accuracy: 0.9989
Epoch 00014: val_accuracy improved from 0.79281 to 0.79591, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3102s 30s/step - loss: 0.
```

```
0184 - accuracy: 0.9989 - val_loss: 0.7502 - val_accuracy: 0.7959
Learning rate:  1e-04
Epoch 15/100
104/105 [============================>.] - ETA: 27s - loss: 0.0153 -
accuracy: 0.9987
Epoch 00015: val_accuracy improved from 0.79591 to 0.79824, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3088s 29s/step - loss: 0.
0153 - accuracy: 0.9987 - val_loss: 0.7640 - val_accuracy: 0.7982
Learning rate:  1e-04
Epoch 16/100
104/105 [============================>.] - ETA: 27s - loss: 0.0132 -
accuracy: 0.9992
Epoch 00016: val_accuracy improved from 0.79824 to 0.79928, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3106s 30s/step - loss: 0.
0133 - accuracy: 0.9992 - val_loss: 0.7594 - val_accuracy: 0.7993
Learning rate:  1e-04
Epoch 17/100
104/105 [============================>.] - ETA: 27s - loss: 0.0125 -
accuracy: 0.9990
Epoch 00017: val_accuracy improved from 0.79928 to 0.80859, saving m
odel to dog_breed_classifier.h5
105/105 [==============================] - 3094s 29s/step - loss: 0.
0124 - accuracy: 0.9990 - val_loss: 0.7381 - val_accuracy: 0.8086
Learning rate:  1e-04
Epoch 18/100
104/105 [============================>.] - ETA: 27s - loss: 0.0108 -
accuracy: 0.9992
Epoch 00018: val_accuracy did not improve from 0.80859
105/105 [==============================] - 3095s 29s/step - loss: 0.
0108 - accuracy: 0.9992 - val_loss: 0.7780 - val_accuracy: 0.7959
Learning rate:  1e-04
Epoch 19/100
104/105 [============================>.] - ETA: 27s - loss: 0.0099 -
accuracy: 0.9991
Epoch 00019: val_accuracy did not improve from 0.80859
105/105 [==============================] - 3093s 29s/step - loss: 0.
0098 - accuracy: 0.9991 - val_loss: 0.7605 - val_accuracy: 0.8063
Learning rate:  1e-04
Epoch 20/100
104/105 [============================>.] - ETA: 27s - loss: 0.0088 -
accuracy: 0.9994
Epoch 00020: val_accuracy did not improve from 0.80859
105/105 [==============================] - 3093s 29s/step - loss: 0.
0088 - accuracy: 0.9994 - val_loss: 0.7729 - val_accuracy: 0.8013
Learning rate:  1e-04
Epoch 21/100
104/105 [============================>.] - ETA: 28s - loss: 0.0078 -
accuracy: 0.9997
Epoch 00021: val_accuracy did not improve from 0.80859
105/105 [==============================] - 3120s 30s/step - loss: 0.
0078 - accuracy: 0.9997 - val_loss: 0.7719 - val_accuracy: 0.8019
Learning rate:  1e-04
Epoch 22/100
 30/105 [=======>......................] - ETA: 36:21 - loss: 0.0085
- accuracy: 0.9993
```

In [ ]:

```
# Training and test loss/accuracy graphs

plt.title('Training and test accuracy')
plt.plot(params.epoch, params.history['accuracy'], label='Training accuracy')
plt.plot(params.epoch, params.history['val_accuracy'], label='Test accuracy')
plt.legend()

plt.subplot(1, 2, 2)
plt.title('Training and test loss')
plt.plot(params.epoch, params.history['loss'], label='Training loss')
plt.plot(params.epoch, params.history['val_loss'], label='Test loss')
plt.legend()

plt.show()
```

In [ ]:

```
# Sample prediction

# Randomly test an image from the test set

# model.load_weights('dog_breed_classifier.h5')

imageno=np.random.random_integers(low=0, high=test_generator.samples)

name = test_generator.filepaths[imageno]
print(name)
plt.imshow(mpimg.imread(name))

img = Image.open(test_generator.filepaths[imageno]).resize((targetx, targety))
probabilities = model.predict(preprocess_input(np.expand_dims(img, axis=0)))
breed_list = tuple(zip(test_generator.class_indices.values(), test_generator.cla
ss_indices.keys()))

for i in probabilities[0].argsort()[-5:][::-1]:
    print(probabilities[0][i], "  :  " , breed_list[i])
```

In [ ]:

```
# Classification report

test_generator.reset()
predictions = model.predict_generator(test_generator, steps=len(test_generator))
y = np.argmax(predictions, axis=1)

print('Classification Report')
cr = classification_report(y_true=test_generator.classes, y_pred=y, target_names
=test_generator.class_indices)
print(cr)
```

In [ ]:

```
# Confusion matrix

print('Confusion Matrix')
cm = confusion_matrix(test_generator.classes, y)
df = pd.DataFrame(cm, columns=test_generator.class_indices)
plt.figure(figsize=(80,80))
sn.heatmap(df, annot=True)
```

In [ ]:

```
# shutil.rmtree(cropped_dir)
```

In [ ]:

```

```