Deep Learning in Practice

Anis Koubaa

The Vehicle Type Classification Project

In this notebook, we will present how to perform a classification of car brands. We will use different state of the art classifiers in Tensorflow 2.0 and Keras.

Summary

- **Name:** Anis Koubaa
- **Date:** 20 September 2020
- **Use Case:** Vehicle Type
- **Algorithm:** MobileNetV2
- **Number of training images:** 603
- **Number of classes:** 7
- **Batch Size:** 64
- **Optimizer:** Adam
- **Learning Rate:** 0.0001
- **Loss Type:**CategoricalCrossentropy
- **Transfer Learning:** Yes | Imagenet

Comments: We obtained 100% on the validation accuracy on vehicle types, on validation dataset.

Let's get started.

We first need to load the requires libraries

```
# import the necessary packages
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import AveragePooling2D, GlobalAveragePooling2D, Batch
#from tensorflow.keras.applications import ResNet50
#from tensorflow.keras.applications import Xception
from tensorflow.keras.applications import MobileNetV2
from tensorflow.keras.layers import AveragePooling2D
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense
from tensorflow.keras.layers import Input
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
```

```
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.utils import to_categorical
from sklearn.preprocessing import LabelBinarizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from imutils import paths
import matplotlib.pyplot as plt
import numpy as np
import argparse
import cv2
import os
import sys
import tensorflow as tf
import h5py
import numpy as np
import sys


print(tf.__version__)
```

```
2.3.0
```

Then, we mount Google Drive to be able to access the files located on it

We now specify the path the dataset located on Google Drive

```
TYPE='type'
model_type='mobilenetv2'
user='anis'
iteration='1'

first_time_training=True

PROJECT_PATH='/content/drive/My Drive/udemy-deep-learning-in-practice/03-transfer-l
print('PROJECT_PATH: ',PROJECT_PATH)
HDF5_DATASET_PATH=PROJECT_PATH+'datasets/vehicle-type-dataset-SIZE224-train-dev-tes
print('HDF5_DATASET_PATH: ', HDF5_DATASET_PATH)
ACCURACY_LOSS_OUPUT_FILE=PROJECT_PATH+'log/'+model_type+'/'+model_type+'-by-'+TYPE+
TARGET_CLASSIFICATION_MODEL=PROJECT_PATH+'trained-models/'+model_type+'/'+'vehicle-
print('TARGET_CLASSIFICATION_MODEL: ',TARGET_CLASSIFICATION_MODEL)
CHECKPOINT_PATH = PROJECT_PATH+'checkpoints/'+model_type+'/'+'by-'+TYPE+'-'+model_t
print('CHECKPOINT_PATH: ',CHECKPOINT_PATH)
LOGFILE_PATH=PROJECT_PATH+'log/'+model_type+'/'+model_type+'-by-'+TYPE+'-training-l
print('LOGFILE_PATH: ',LOGFILE_PATH)
```

```
PROJECT_PATH:  /content/drive/My Drive/udemy-deep-learning-in-practice/03-trar
HDF5_DATASET_PATH:  /content/drive/My Drive/udemy-deep-learning-in-practice/03
TARGET_CLASSIFICATION_MODEL:  /content/drive/My Drive/udemy-deep-learning-in-p
CHECKPOINT_PATH:  /content/drive/My Drive/udemy-deep-learning-in-practice/03-t
LOGFILE_PATH:  /content/drive/My Drive/udemy-deep-learning-in-practice/03-trar
```

```
# place the head FC model on top of the base model (this will become
# the actual model we will train)
model = Model(inputs=baseModel.input, outputs=headModel)


# loop over all layers in the base model and freeze them so they will
# *not* be updated during the first training process
for layer in baseModel.layers:
    layer.trainable = True

model.summary()
```

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

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

```
sys.path.append(PROJECT_PATH)
import anis_koubaa_udemy_computer_vision_lib
from anis_koubaa_udemy_computer_vision_lib import *
```

Load the Dataset

```
def load_dataset_from_hdf5_file(hdf_file_path):
  hf = h5py.File(hdf_file_path, "r")
  trainX= np.array(hf["trainX"]).astype("f8")
  ascii_train_labels = np.array(hf["trainLabels"]).astype("S65")
  trainY=np.array(hf["trainY"]).astype("int")

  devX= np.array(hf["devX"]).astype("f8")
  ascii_dev_labels = np.array(hf["devLabels"]).astype("S65")
  devY=np.array(hf["devY"]).astype("int")

  testX= np.array(hf["testX"]).astype("f8")
  ascii_test_labels = np.array(hf["testLabels"]).astype("S65")
  testY=np.array(hf["testY"]).astype("int")

  trainLabels = np.array([n.decode('unicode_escape') for n in ascii_train_labels])
  devLabels = np.array([n.decode('unicode_escape') for n in ascii_dev_labels])
  testLabels = np.array([n.decode('unicode_escape') for n in ascii_test_labels])

  print("trainX.shape: ",trainX.shape)
  print("trainY.shape: ",trainY.shape)
  print("trainLabels.shape: ",trainLabels.shape)
  print("devX.shape: ",devX.shape)
  print("devY.shape: ",devY.shape)
  print("devLabels.shape: ",devLabels.shape)
  print("testX.shape: ",testX.shape)
  print("testY.shape: ",testY.shape)
  print("testLabels.shape: ",testLabels.shape)

  return trainX, trainY, trainLabels, devX,devY,devLabels,testX,testY,testLabels
```

```
trainX, trainY, trainLabels, devX,devY,devLabels,testX,testY,testLabels=load_datase
```

```
trainX.shape:  (603, 224, 224, 3)
trainY.shape:  (603, 7)
trainLabels.shape:  (603,)
devX.shape:  (75, 224, 224, 3)
```

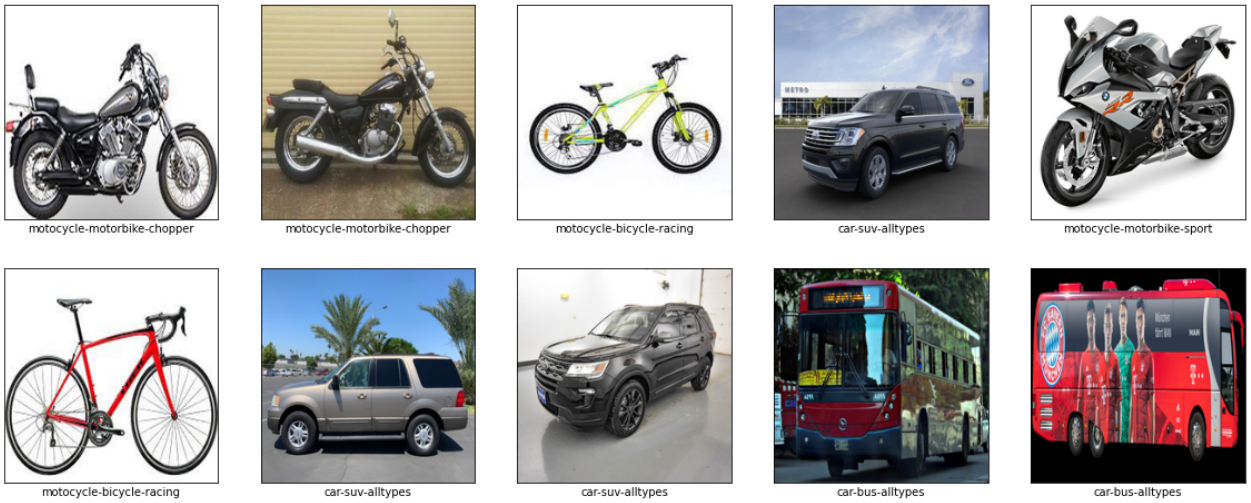
```
IMAGE_SIZE=trainX.shape[1]
print(IMAGE_SIZE)
```

```
224
```

```
number_of_classes=np.unique(trainLabels).size
```

Dataset Visualization

```
anis_koubaa_udemy_computer_vision_lib.plot_sample_from_dataset(trainX, trainLabels,
```




```
anis_koubaa_udemy_computer_vision_lib.plot_sample_from_dataset(devX, devLabels,rows
```

```
anis_koubaa_udemy_computer_vision_lib.plot_sample_from_dataset(testX, testLabels,ro
```

Training Configuration

Data Augmentation

```
# initialize the training data augmentation object
trainAug = ImageDataGenerator(
  rotation_range=20)
  #fill_mode="nearest")
  #brightness_range=[0.2,1.0])
  #horizontal_flip=True)


# load the network, ensuring the head FC layer sets are left
# off
if (first_time_training==True):
    print('training for first time')
    baseModel = MobileNetV2(weights="imagenet", include_top=False, input_shape=(IMA
```

```
 training for first time
```

```
    # construct the head of the model that will be placed on top of the
    # the base model
    headModel = baseModel.output
    headModel = AveragePooling2D(pool_size=(4, 4))(headModel)
    headModel = Flatten(name="flatten")(headModel)
    headModel = Dense(128, activation="relu")(headModel)
    headModel = BatchNormalization()(headModel)
    headModel = Dense(64, activation="relu")(headModel)
    headModel = Dropout(0.5)(headModel)
    headModel = BatchNormalization()(headModel)
    headModel = Dense(number_of_classes, activation="softmax")(headModel)
```

Model: "functional_1"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 224, 224, 3)	0	
Conv1_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	input_1[0][0]
Conv1 (Conv2D)	(None, 112, 112, 32)	864	Conv1_pad[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]
expanded_conv_depthwise_BN (Bat	(None, 112, 112, 32)	128	expanded_conv
expanded_conv_depthwise_relu (R	(None, 112, 112, 32)	0	expanded_conv
expanded_conv_project (Conv2D)	(None, 112, 112, 16)	512	expanded_conv
expanded_conv_project_BN (Batch	(None, 112, 112, 16)	64	expanded_conv
block_1_expand (Conv2D)	(None, 112, 112, 96)	1536	expanded_conv
block_1_expand_BN (BatchNormali	(None, 112, 112, 96)	384	block_1_expan
block_1_expand_relu (ReLU)	(None, 112, 112, 96)	0	block_1_expan
block_1_pad (ZeroPadding2D)	(None, 113, 113, 96)	0	block_1_expan
block_1_depthwise (DepthwiseCon	(None, 56, 56, 96)	864	block_1_pad[0
block_1_depthwise_BN (BatchNorm	(None, 56, 56, 96)	384	block_1_depth
block_1_depthwise_relu (ReLU)	(None, 56, 56, 96)	0	block_1_depth
block_1_project (Conv2D)	(None, 56, 56, 24)	2304	block_1_depth
block_1_project_BN (BatchNormal	(None, 56, 56, 24)	96	block_1_proje
block_2_expand (Conv2D)	(None, 56, 56, 144)	3456	block_1_proje
block_2_expand_BN (BatchNormali	(None, 56, 56, 144)	576	block_2_expan
block_2_expand_relu (ReLU)	(None, 56, 56, 144)	0	block_2_expan
block_2_depthwise (DepthwiseCon	(None, 56, 56, 144)	1296	block_2_expan
block_2_depthwise_BN (BatchNorm	(None, 56, 56, 144)	576	block_2_depth
block_2_depthwise_relu (ReLU)	(None, 56, 56, 144)	0	block_2_depth
block_2_project (Conv2D)	(None, 56, 56, 24)	3456	block_2_depth
block_2_project_BN (BatchNormal	(None, 56, 56, 24)	96	block_2_proje
block_2_add (Add)	(None, 56, 56, 24)	0	block_1_proje block_2_proje

block_3_expand (Conv2D)	(None, 56, 56, 144)	3456	block_2_add[0
block_3_expand_BN (BatchNormali	(None, 56, 56, 144)	576	block_3_expan
block_3_expand_relu (ReLU)	(None, 56, 56, 144)	0	block_3_expan
block_3_pad (ZeroPadding2D)	(None, 57, 57, 144)	0	block_3_expan
block_3_depthwise (DepthwiseCon	(None, 28, 28, 144)	1296	block_3_pad[0
block_3_depthwise_BN (BatchNorm	(None, 28, 28, 144)	576	block_3_depth
block_3_depthwise_relu (ReLU)	(None, 28, 28, 144)	0	block_3_depth
block_3_project (Conv2D)	(None, 28, 28, 32)	4608	block_3_depth
block_3_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_3_proje
block_4_expand (Conv2D)	(None, 28, 28, 192)	6144	block_3_proje
block_4_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_4_expan
block_4_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_4_expan
block_4_depthwise (DepthwiseCon	(None, 28, 28, 192)	1728	block_4_expan
block_4_depthwise_BN (BatchNorm	(None, 28, 28, 192)	768	block_4_depth
block_4_depthwise_relu (ReLU)	(None, 28, 28, 192)	0	block_4_depth
block_4_project (Conv2D)	(None, 28, 28, 32)	6144	block_4_depth
block_4_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_4_proje
block_4_add (Add)	(None, 28, 28, 32)	0	block_3_proje block_4_proje
block_5_expand (Conv2D)	(None, 28, 28, 192)	6144	block_4_add[0
block_5_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_5_expan
block_5_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_5_expan
block_5_depthwise (DepthwiseCon	(None, 28, 28, 192)	1728	block_5_expan
block_5_depthwise_BN (BatchNorm	(None, 28, 28, 192)	768	block_5_depth
block_5_depthwise_relu (ReLU)	(None, 28, 28, 192)	0	block_5_depth
block_5_project (Conv2D)	(None, 28, 28, 32)	6144	block_5_depth
block_5_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_5_proje
block_5_add (Add)	(None, 28, 28, 32)	0	block_4_add[0 block_5_proje
block_6_expand (Conv2D)	(None, 28, 28, 192)	6144	block_5_add[0
block_6_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_6_expan
block_6_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_6_expan

block_6_pad (ZeroPadding2D)	(None, 29, 29, 192)	0	block_6_expan
block_6_depthwise (DepthwiseCon	(None, 14, 14, 192)	1728	block_6_pad[0
block_6_depthwise_BN (BatchNorm	(None, 14, 14, 192)	768	block_6_depth
block_6_depthwise_relu (ReLU)	(None, 14, 14, 192)	0	block_6_depth
block_6_project (Conv2D)	(None, 14, 14, 64)	12288	block_6_depth
block_6_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_6_proje
block_7_expand (Conv2D)	(None, 14, 14, 384)	24576	block_6_proje
block_7_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_7_expan
block_7_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_7_expan
block_7_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_7_expan
block_7_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_7_depth
block_7_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_7_depth
block_7_project (Conv2D)	(None, 14, 14, 64)	24576	block_7_depth
block_7_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_7_proje
block_7_add (Add)	(None, 14, 14, 64)	0	block_6_proje block_7_proje
block_8_expand (Conv2D)	(None, 14, 14, 384)	24576	block_7_add[0
block_8_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_8_expan
block_8_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_8_expan
block_8_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_8_expan
block_8_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_8_depth
block_8_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_8_depth
block_8_project (Conv2D)	(None, 14, 14, 64)	24576	block_8_depth
block_8_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_8_proje
block_8_add (Add)	(None, 14, 14, 64)	0	block_7_add[0 block_8_proje
block_9_expand (Conv2D)	(None, 14, 14, 384)	24576	block_8_add[0
block_9_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_9_expan
block_9_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_9_expan
block_9_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_9_expan
block_9_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_9_depth
block_9_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_9_depth

block_9_project (Conv2D)	(None, 14, 14, 64)	24576	block_9_depth
block_9_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_9_proje
block_9_add (Add)	(None, 14, 14, 64)	0	block_8_add[0 block_9_proje
block_10_expand (Conv2D)	(None, 14, 14, 384)	24576	block_9_add[0
block_10_expand_BN (BatchNormal	(None, 14, 14, 384)	1536	block_10_expa
block_10_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_10_expa
block_10_depthwise (DepthwiseCo	(None, 14, 14, 384)	3456	block_10_expa
block_10_depthwise_BN (BatchNor	(None, 14, 14, 384)	1536	block_10_dept
block_10_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_10_dept
block_10_project (Conv2D)	(None, 14, 14, 96)	36864	block_10_dept
block_10_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_10_proj
block_11_expand (Conv2D)	(None, 14, 14, 576)	55296	block_10_proj
block_11_expand_BN (BatchNormal	(None, 14, 14, 576)	2304	block_11_expa
block_11_expand_relu (ReLU)	(None, 14, 14, 576)	0	block_11_expa
block_11_depthwise (DepthwiseCo	(None, 14, 14, 576)	5184	block_11_expa
block_11_depthwise_BN (BatchNor	(None, 14, 14, 576)	2304	block_11_dept
block_11_depthwise_relu (ReLU)	(None, 14, 14, 576)	0	block_11_dept
block_11_project (Conv2D)	(None, 14, 14, 96)	55296	block_11_dept
block_11_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_11_proj
block_11_add (Add)	(None, 14, 14, 96)	0	block_10_proj block_11_proj
block_12_expand (Conv2D)	(None, 14, 14, 576)	55296	block_11_add[
block_12_expand_BN (BatchNormal	(None, 14, 14, 576)	2304	block_12_expa
block_12_expand_relu (ReLU)	(None, 14, 14, 576)	0	block_12_expa
block_12_depthwise (DepthwiseCo	(None, 14, 14, 576)	5184	block_12_expa
block_12_depthwise_BN (BatchNor	(None, 14, 14, 576)	2304	block_12_dept
block_12_depthwise_relu (ReLU)	(None, 14, 14, 576)	0	block_12_dept
block_12_project (Conv2D)	(None, 14, 14, 96)	55296	block_12_dept
block_12_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_12_proj
block_12_add (Add)	(None, 14, 14, 96)	0	block_11_add[block_12_proj
block_13_expand (Conv2D)	(None, 14, 14, 576)	55296	block_12_add[

```
block_13_expand (Conv2D)        (None, 14, 14, 576)  55296       block_12_add[
__________________________________________________________________________
block_13_expand_BN (BatchNormal (None, 14, 14, 576)  2304        block_13_expa
__________________________________________________________________________
block_13_expand_relu (ReLU)     (None, 14, 14, 576)  0           block_13_expa
__________________________________________________________________________
block_13_pad (ZeroPadding2D)    (None, 15, 15, 576)  0           block_13_expa
__________________________________________________________________________
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)    5184        block_13_pad[
__________________________________________________________________________
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)    2304        block_13_dept
__________________________________________________________________________
block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)    0           block_13_dept
__________________________________________________________________________
block_13_project (Conv2D)       (None, 7, 7, 160)    92160       block_13_dept
__________________________________________________________________________
block_13_project_BN (BatchNorma (None, 7, 7, 160)    640         block_13_proj
__________________________________________________________________________
block_14_expand (Conv2D)        (None, 7, 7, 960)    153600      block_13_proj
__________________________________________________________________________
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_14_expa
__________________________________________________________________________
block_14_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_14_expa
__________________________________________________________________________
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_14_expa
__________________________________________________________________________
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_14_dept
__________________________________________________________________________
block_14_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_14_dept
__________________________________________________________________________
block_14_project (Conv2D)       (None, 7, 7, 160)    153600      block_14_dept
__________________________________________________________________________
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640         block_14_proj
__________________________________________________________________________
block_14_add (Add)              (None, 7, 7, 160)    0           block_13_proj
                                                                 block_14_proj
__________________________________________________________________________
block_15_expand (Conv2D)        (None, 7, 7, 960)    153600      block_14_add[
__________________________________________________________________________
block_15_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_15_expa
__________________________________________________________________________
block_15_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_15_expa
__________________________________________________________________________
block_15_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_15_expa
__________________________________________________________________________
block_15_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_15_dept
__________________________________________________________________________
block_15_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_15_dept
__________________________________________________________________________
block_15_project (Conv2D)       (None, 7, 7, 160)    153600      block_15_dept
__________________________________________________________________________
block_15_project_BN (BatchNorma (None, 7, 7, 160)    640         block_15_proj
```

```
#disable this instruction if you train for the first time
#enable it when you for the second time or after
if (first_time_training==False):
    model = tf.keras.models.load_model(TARGET_CLASSIFICATION_MODEL)

#for layer in model.layers[0:-8]:
#    layer.trainable = False

#    model.summary()
```

```
#     model.summary()
```

```
model.summary()
```

Model: "functional_1"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 224, 224, 3)	0	
Conv1_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	input_1[0][0]
Conv1 (Conv2D)	(None, 112, 112, 32)	864	Conv1_pad[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]
expanded_conv_depthwise_BN (Bat	(None, 112, 112, 32)	128	expanded_conv
expanded_conv_depthwise_relu (R	(None, 112, 112, 32)	0	expanded_conv
expanded_conv_project (Conv2D)	(None, 112, 112, 16)	512	expanded_conv
expanded_conv_project_BN (Batch	(None, 112, 112, 16)	64	expanded_conv
block_1_expand (Conv2D)	(None, 112, 112, 96)	1536	expanded_conv
block_1_expand_BN (BatchNormali	(None, 112, 112, 96)	384	block_1_expan
block_1_expand_relu (ReLU)	(None, 112, 112, 96)	0	block_1_expan
block_1_pad (ZeroPadding2D)	(None, 113, 113, 96)	0	block_1_expan
block_1_depthwise (DepthwiseCon	(None, 56, 56, 96)	864	block_1_pad[0
block_1_depthwise_BN (BatchNorm	(None, 56, 56, 96)	384	block_1_depth
block_1_depthwise_relu (ReLU)	(None, 56, 56, 96)	0	block_1_depth
block_1_project (Conv2D)	(None, 56, 56, 24)	2304	block_1_depth
block_1_project_BN (BatchNormal	(None, 56, 56, 24)	96	block_1_proje
block_2_expand (Conv2D)	(None, 56, 56, 144)	3456	block_1_proje
block_2_expand_BN (BatchNormali	(None, 56, 56, 144)	576	block_2_expan
block_2_expand_relu (ReLU)	(None, 56, 56, 144)	0	block_2_expan
block_2_depthwise (DepthwiseCon	(None, 56, 56, 144)	1296	block_2_expan
block_2_depthwise_BN (BatchNorm	(None, 56, 56, 144)	576	block_2_depth
block_2_depthwise_relu (ReLU)	(None, 56, 56, 144)	0	block_2_depth
block_2_project (Conv2D)	(None, 56, 56, 24)	3456	block_2_depth
block_2_project_BN (BatchNormal	(None, 56, 56, 24)	96	block_2_proje
block_2_add (Add)	(None, 56, 56, 24)	0	block_1_proje block_2_proje

block_3_expand (Conv2D)	(None, 56, 56, 144)	3456	block_2_add[0
block_3_expand_BN (BatchNormali	(None, 56, 56, 144)	576	block_3_expan
block_3_expand_relu (ReLU)	(None, 56, 56, 144)	0	block_3_expan
block_3_pad (ZeroPadding2D)	(None, 57, 57, 144)	0	block_3_expan
block_3_depthwise (DepthwiseCon	(None, 28, 28, 144)	1296	block_3_pad[0
block_3_depthwise_BN (BatchNorm	(None, 28, 28, 144)	576	block_3_depth
block_3_depthwise_relu (ReLU)	(None, 28, 28, 144)	0	block_3_depth
block_3_project (Conv2D)	(None, 28, 28, 32)	4608	block_3_depth
block_3_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_3_proje
block_4_expand (Conv2D)	(None, 28, 28, 192)	6144	block_3_proje
block_4_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_4_expan
block_4_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_4_expan
block_4_depthwise (DepthwiseCon	(None, 28, 28, 192)	1728	block_4_expan
block_4_depthwise_BN (BatchNorm	(None, 28, 28, 192)	768	block_4_depth
block_4_depthwise_relu (ReLU)	(None, 28, 28, 192)	0	block_4_depth
block_4_project (Conv2D)	(None, 28, 28, 32)	6144	block_4_depth
block_4_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_4_proje
block_4_add (Add)	(None, 28, 28, 32)	0	block_3_proje block_4_proje
block_5_expand (Conv2D)	(None, 28, 28, 192)	6144	block_4_add[0
block_5_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_5_expan
block_5_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_5_expan
block_5_depthwise (DepthwiseCon	(None, 28, 28, 192)	1728	block_5_expan
block_5_depthwise_BN (BatchNorm	(None, 28, 28, 192)	768	block_5_depth
block_5_depthwise_relu (ReLU)	(None, 28, 28, 192)	0	block_5_depth
block_5_project (Conv2D)	(None, 28, 28, 32)	6144	block_5_depth
block_5_project_BN (BatchNormal	(None, 28, 28, 32)	128	block_5_proje
block_5_add (Add)	(None, 28, 28, 32)	0	block_4_add[0 block_5_proje
block_6_expand (Conv2D)	(None, 28, 28, 192)	6144	block_5_add[0
block_6_expand_BN (BatchNormali	(None, 28, 28, 192)	768	block_6_expan
block_6_expand_relu (ReLU)	(None, 28, 28, 192)	0	block_6_expan

block_6_pad (ZeroPadding2D)	(None, 29, 29, 192)	0	block_6_expan
block_6_depthwise (DepthwiseCon	(None, 14, 14, 192)	1728	block_6_pad[0
block_6_depthwise_BN (BatchNorm	(None, 14, 14, 192)	768	block_6_depth
block_6_depthwise_relu (ReLU)	(None, 14, 14, 192)	0	block_6_depth
block_6_project (Conv2D)	(None, 14, 14, 64)	12288	block_6_depth
block_6_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_6_proje
block_7_expand (Conv2D)	(None, 14, 14, 384)	24576	block_6_proje
block_7_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_7_expan
block_7_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_7_expan
block_7_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_7_expan
block_7_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_7_depth
block_7_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_7_depth
block_7_project (Conv2D)	(None, 14, 14, 64)	24576	block_7_depth
block_7_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_7_proje
block_7_add (Add)	(None, 14, 14, 64)	0	block_6_proje block_7_proje
block_8_expand (Conv2D)	(None, 14, 14, 384)	24576	block_7_add[0
block_8_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_8_expan
block_8_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_8_expan
block_8_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_8_expan
block_8_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_8_depth
block_8_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_8_depth
block_8_project (Conv2D)	(None, 14, 14, 64)	24576	block_8_depth
block_8_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_8_proje
block_8_add (Add)	(None, 14, 14, 64)	0	block_7_add[0 block_8_proje
block_9_expand (Conv2D)	(None, 14, 14, 384)	24576	block_8_add[0
block_9_expand_BN (BatchNormali	(None, 14, 14, 384)	1536	block_9_expan
block_9_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_9_expan
block_9_depthwise (DepthwiseCon	(None, 14, 14, 384)	3456	block_9_expan
block_9_depthwise_BN (BatchNorm	(None, 14, 14, 384)	1536	block_9_depth
block_9_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_9_depth

block_9_project (Conv2D)	(None, 14, 14, 64)	24576	block_9_depth
block_9_project_BN (BatchNormal	(None, 14, 14, 64)	256	block_9_proje
block_9_add (Add)	(None, 14, 14, 64)	0	block_8_add[0 block_9_proje
block_10_expand (Conv2D)	(None, 14, 14, 384)	24576	block_9_add[0
block_10_expand_BN (BatchNormal	(None, 14, 14, 384)	1536	block_10_expa
block_10_expand_relu (ReLU)	(None, 14, 14, 384)	0	block_10_expa
block_10_depthwise (DepthwiseCo	(None, 14, 14, 384)	3456	block_10_expa
block_10_depthwise_BN (BatchNor	(None, 14, 14, 384)	1536	block_10_dept
block_10_depthwise_relu (ReLU)	(None, 14, 14, 384)	0	block_10_dept
block_10_project (Conv2D)	(None, 14, 14, 96)	36864	block_10_dept
block_10_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_10_proj
block_11_expand (Conv2D)	(None, 14, 14, 576)	55296	block_10_proj
block_11_expand_BN (BatchNormal	(None, 14, 14, 576)	2304	block_11_expa
block_11_expand_relu (ReLU)	(None, 14, 14, 576)	0	block_11_expa
block_11_depthwise (DepthwiseCo	(None, 14, 14, 576)	5184	block_11_expa
block_11_depthwise_BN (BatchNor	(None, 14, 14, 576)	2304	block_11_dept
block_11_depthwise_relu (ReLU)	(None, 14, 14, 576)	0	block_11_dept
block_11_project (Conv2D)	(None, 14, 14, 96)	55296	block_11_dept
block_11_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_11_proj
block_11_add (Add)	(None, 14, 14, 96)	0	block_10_proj block_11_proj
block_12_expand (Conv2D)	(None, 14, 14, 576)	55296	block_11_add[
block_12_expand_BN (BatchNormal	(None, 14, 14, 576)	2304	block_12_expa
block_12_expand_relu (ReLU)	(None, 14, 14, 576)	0	block_12_expa
block_12_depthwise (DepthwiseCo	(None, 14, 14, 576)	5184	block_12_expa
block_12_depthwise_BN (BatchNor	(None, 14, 14, 576)	2304	block_12_dept
block_12_depthwise_relu (ReLU)	(None, 14, 14, 576)	0	block_12_dept
block_12_project (Conv2D)	(None, 14, 14, 96)	55296	block_12_dept
block_12_project_BN (BatchNorma	(None, 14, 14, 96)	384	block_12_proj
block_12_add (Add)	(None, 14, 14, 96)	0	block_11_add[block_12_proj
block_13_expand (Conv2D)	(None, 14, 14, 576)	55296	block_12_add[

```
block_13_expand (Conv2D)        (None, 14, 14, 576)  55296       block_12_add[
__________________________________________________________________________
block_13_expand_BN (BatchNormal (None, 14, 14, 576)  2304        block_13_expa
__________________________________________________________________________
block_13_expand_relu (ReLU)     (None, 14, 14, 576)  0           block_13_expa
__________________________________________________________________________
block_13_pad (ZeroPadding2D)    (None, 15, 15, 576)  0           block_13_expa
__________________________________________________________________________
block_13_depthwise (DepthwiseCo (None, 7, 7, 576)    5184        block_13_pad[
__________________________________________________________________________
block_13_depthwise_BN (BatchNor (None, 7, 7, 576)    2304        block_13_dept
__________________________________________________________________________
block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)    0           block_13_dept
__________________________________________________________________________
block_13_project (Conv2D)       (None, 7, 7, 160)    92160       block_13_dept
__________________________________________________________________________
block_13_project_BN (BatchNorma (None, 7, 7, 160)    640         block_13_proj
__________________________________________________________________________
block_14_expand (Conv2D)        (None, 7, 7, 960)    153600      block_13_proj
__________________________________________________________________________
block_14_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_14_expa
__________________________________________________________________________
block_14_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_14_expa
__________________________________________________________________________
block_14_depthwise (DepthwiseCo (None, 7, 7, 960)    8640        block_14_expa
__________________________________________________________________________
block_14_depthwise_BN (BatchNor (None, 7, 7, 960)    3840        block_14_dept
__________________________________________________________________________
block_14_depthwise_relu (ReLU)  (None, 7, 7, 960)    0           block_14_dept
__________________________________________________________________________
block_14_project (Conv2D)       (None, 7, 7, 160)    153600      block_14_dept
__________________________________________________________________________
block_14_project_BN (BatchNorma (None, 7, 7, 160)    640         block_14_proj
__________________________________________________________________________
block_14_add (Add)              (None, 7, 7, 160)    0           block_13_proj
                                                                 block_14_proj
__________________________________________________________________________
block_15_expand (Conv2D)        (None, 7, 7, 960)    153600      block_14_add[
__________________________________________________________________________
block_15_expand_BN (BatchNormal (None, 7, 7, 960)    3840        block_15_expa
__________________________________________________________________________
block_15_expand_relu (ReLU)     (None, 7, 7, 960)    0           block_15_expa
```

```
#import tf.keras.callbacks.Callback
from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.callbacks import CSVLogger
import pickle
#!mkdir -p '/content/drive/My Drive/anis-koubaa-projects/car-classification-project

cp1= ModelCheckpoint(filepath=CHECKPOINT_PATH, monitor='val_accuracy', save_best_on
csv_logger = CSVLogger(LOGFILE_PATH,append=True)

callbacks_list = [cp1,csv_logger]


#SET THE HYPERPARAMETERS OF THE TRAINING

# initialize the initial learning rate, number of epochs to train for,
# and batch size
INIT_LR = 1e-4
```

```
INITIAL_EPOCH=0
EPOCHS = INITIAL_EPOCH+100
BS = 64


# compile our model
print("[INFO] compiling model...")

#opt=tf.keras.optimizers.Adagrad(learning_rate=INIT_LR, initial_accumulator_value=0
opt = Adam(lr=INIT_LR, decay=INIT_LR / EPOCHS)
#opt = SGD (learning_rate=INIT_LR, momentum = 0.9, decay=INIT_LR / EPOCHS)
```

```
[INFO] compiling model...
```

```
#COMPILE THE MODEL
model.compile(loss=tf.keras.losses.CategoricalCrossentropy(from_logits=True), optim
```

```
#create folder if they do not exists
LOG_PATH=PROJECT_PATH+'log/'+model_type+'/'
if not os.path.exists(LOG_PATH):
    os.makedirs(LOG_PATH)
LOG_PATH=PROJECT_PATH+'checkpoints/'+model_type+'/'
if not os.path.exists(LOG_PATH):
    os.makedirs(LOG_PATH)
```

```
# train the head of the network
print("[INFO] training head...")
history = model.fit(
  trainAug.flow(trainX, trainY, batch_size=BS),
  steps_per_epoch=len(trainX) // BS,
  validation_data=(devX, devY),
  validation_steps=len(devX) // BS,
  epochs=EPOCHS, callbacks=callbacks_list, initial_epoch=INITIAL_EPOCH)
```

```
[INFO] training head...
Epoch 1/100
2/9 [=====>.....................] - ETA: 1s - loss: 1.9681 - accuracy: 0.10
9/9 [==============================] - ETA: 0s - loss: 1.9302 - accuracy: 0.17
Epoch 00001: val_accuracy improved from -inf to 0.25333, saving model to /cont
9/9 [==============================] - 7s 758ms/step - loss: 1.9302 - accuracy
Epoch 2/100
9/9 [==============================] - ETA: 0s - loss: 1.7864 - accuracy: 0.41
Epoch 00002: val_accuracy improved from 0.25333 to 0.50667, saving model to /c
9/9 [==============================] - 6s 669ms/step - loss: 1.7864 - accuracy
Epoch 3/100
9/9 [==============================] - ETA: 0s - loss: 1.6811 - accuracy: 0.56
Epoch 00003: val_accuracy improved from 0.50667 to 0.68000, saving model to /c
9/9 [==============================] - 6s 662ms/step - loss: 1.6811 - accuracy
Epoch 4/100
9/9 [==============================] - ETA: 0s - loss: 1.5912 - accuracy: 0.72
Epoch 00004: val_accuracy improved from 0.68000 to 0.73333, saving model to /c
9/9 [==============================] - 6s 713ms/step - loss: 1.5912 - accuracy
Epoch 5/100
9/9 [==============================] - ETA: 0s - loss: 1.5424 - accuracy: 0.76
Epoch 00005: val_accuracy improved from 0.73333 to 0.81333, saving model to /c
9/9 [==============================] - 6s 706ms/step - loss: 1.5424 - accuracy
Epoch 6/100
9/9 [==============================] - ETA: 0s - loss: 1.4903 - accuracy: 0.81
Epoch 00006: val_accuracy improved from 0.81333 to 0.85333, saving model to /c
9/9 [==============================] - 6s 658ms/step - loss: 1.4903 - accuracy
Epoch 7/100
9/9 [==============================] - ETA: 0s - loss: 1.4554 - accuracy: 0.83
Epoch 00007: val_accuracy did not improve from 0.85333
9/9 [==============================] - 5s 569ms/step - loss: 1.4554 - accuracy
Epoch 8/100
9/9 [==============================] - ETA: 0s - loss: 1.4155 - accuracy: 0.87
Epoch 00008: val_accuracy improved from 0.85333 to 0.88000, saving model to /c
9/9 [==============================] - 6s 701ms/step - loss: 1.4155 - accuracy
Epoch 9/100
9/9 [==============================] - ETA: 0s - loss: 1.3753 - accuracy: 0.91
Epoch 00009: val_accuracy improved from 0.88000 to 0.89333, saving model to /c
9/9 [==============================] - 6s 681ms/step - loss: 1.3753 - accuracy
Epoch 10/100
9/9 [==============================] - ETA: 0s - loss: 1.3639 - accuracy: 0.93
Epoch 00010: val_accuracy did not improve from 0.89333
9/9 [==============================] - 5s 550ms/step - loss: 1.3639 - accuracy
Epoch 11/100
9/9 [==============================] - ETA: 0s - loss: 1.3454 - accuracy: 0.93
Epoch 00011: val_accuracy did not improve from 0.89333
9/9 [==============================] - 5s 578ms/step - loss: 1.3454 - accuracy
Epoch 12/100
9/9 [==============================] - ETA: 0s - loss: 1.3221 - accuracy: 0.96
Epoch 00012: val_accuracy did not improve from 0.89333
9/9 [==============================] - 5s 555ms/step - loss: 1.3221 - accuracy
Epoch 13/100
9/9 [==============================] - ETA: 0s - loss: 1.3134 - accuracy: 0.96
Epoch 00013: val_accuracy did not improve from 0.89333
9/9 [==============================] - 5s 550ms/step - loss: 1.3134 - accuracy
Epoch 14/100
9/9 [==============================] - ETA: 0s - loss: 1.2878 - accuracy: 0.98
Epoch 00014: val_accuracy improved from 0.89333 to 0.90667, saving model to /c
9/9 [==============================] - 7s 752ms/step - loss: 1.2878 - accuracy
Epoch 15/100
9/9 [==============================] - ETA: 0s - loss: 1.2964 - accuracy: 0.96
Epoch 00015: val_accuracy improved from 0.90667 to 0.96000, saving model to /c
```

```
9/9 [==============================] - 7s 727ms/step - loss: 1.2964 - accuracy
Epoch 16/100
9/9 [==============================] - ETA: 0s - loss: 1.2801 - accuracy: 0.96
Epoch 00016: val_accuracy did not improve from 0.96000
9/9 [==============================] - 5s 552ms/step - loss: 1.2801 - accuracy
Epoch 17/100
9/9 [==============================] - ETA: 0s - loss: 1.2789 - accuracy: 0.97
Epoch 00017: val_accuracy did not improve from 0.96000
9/9 [==============================] - 5s 576ms/step - loss: 1.2789 - accuracy
Epoch 18/100
9/9 [==============================] - ETA: 0s - loss: 1.2663 - accuracy: 0.98
Epoch 00018: val_accuracy did not improve from 0.96000
9/9 [==============================] - 6s 619ms/step - loss: 1.2663 - accuracy
Epoch 19/100
9/9 [==============================] - ETA: 0s - loss: 1.2602 - accuracy: 0.99
Epoch 00019: val_accuracy did not improve from 0.96000
9/9 [==============================] - 5s 570ms/step - loss: 1.2602 - accuracy
Epoch 20/100
9/9 [==============================] - ETA: 0s - loss: 1.2476 - accuracy: 0.99
Epoch 00020: val_accuracy improved from 0.96000 to 0.97333, saving model to /c
9/9 [==============================] - 7s 744ms/step - loss: 1.2476 - accuracy
Epoch 21/100
9/9 [==============================] - ETA: 0s - loss: 1.2570 - accuracy: 0.98
Epoch 00021: val_accuracy did not improve from 0.97333
9/9 [==============================] - 6s 630ms/step - loss: 1.2570 - accuracy
Epoch 22/100
9/9 [==============================] - ETA: 0s - loss: 1.2436 - accuracy: 0.99
Epoch 00022: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 574ms/step - loss: 1.2436 - accuracy
Epoch 23/100
9/9 [==============================] - ETA: 0s - loss: 1.2470 - accuracy: 0.99
Epoch 00023: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 572ms/step - loss: 1.2470 - accuracy
Epoch 24/100
9/9 [==============================] - ETA: 0s - loss: 1.2408 - accuracy: 0.99
Epoch 00024: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 574ms/step - loss: 1.2408 - accuracy
Epoch 25/100
9/9 [==============================] - ETA: 0s - loss: 1.2410 - accuracy: 0.99
Epoch 00025: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 579ms/step - loss: 1.2410 - accuracy
Epoch 26/100
9/9 [==============================] - ETA: 0s - loss: 1.2394 - accuracy: 0.99
Epoch 00026: val_accuracy did not improve from 0.97333
9/9 [==============================] - 6s 621ms/step - loss: 1.2394 - accuracy
Epoch 27/100
9/9 [==============================] - ETA: 0s - loss: 1.2353 - accuracy: 0.99
Epoch 00027: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 569ms/step - loss: 1.2353 - accuracy
Epoch 28/100
9/9 [==============================] - ETA: 0s - loss: 1.2244 - accuracy: 0.99
Epoch 00028: val_accuracy did not improve from 0.97333
9/9 [==============================] - 6s 612ms/step - loss: 1.2244 - accuracy
Epoch 29/100
9/9 [==============================] - ETA: 0s - loss: 1.2320 - accuracy: 0.99
Epoch 00029: val_accuracy did not improve from 0.97333
9/9 [==============================] - 5s 565ms/step - loss: 1.2320 - accuracy
Epoch 30/100
9/9 [==============================] - ETA: 0s - loss: 1.2350 - accuracy: 0.99
Epoch 00030: val_accuracy improved from 0.97333 to 0.98667, saving model to /c
9/9 [==============================] - 6s 712ms/step - loss: 1.2350 - accuracy
Epoch 31/100
```

```
9/9 [==============================] - ETA: 0s - loss: 1.2333 - accuracy: 0.99
Epoch 00031: val_accuracy improved from 0.98667 to 1.00000, saving model to /c
9/9 [==============================] - 6s 667ms/step - loss: 1.2333 - accuracy
Epoch 32/100
9/9 [==============================] - ETA: 0s - loss: 1.2205 - accuracy: 0.99
Epoch 00032: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.2205 - accuracy
Epoch 33/100
9/9 [==============================] - ETA: 0s - loss: 1.2249 - accuracy: 1.00
Epoch 00033: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 570ms/step - loss: 1.2249 - accuracy
Epoch 34/100
9/9 [==============================] - ETA: 0s - loss: 1.2224 - accuracy: 1.00
Epoch 00034: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 570ms/step - loss: 1.2224 - accuracy
Epoch 35/100
9/9 [==============================] - ETA: 0s - loss: 1.2262 - accuracy: 0.99
Epoch 00035: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.2262 - accuracy
Epoch 36/100
9/9 [==============================] - ETA: 0s - loss: 1.2213 - accuracy: 0.99
Epoch 00036: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 565ms/step - loss: 1.2213 - accuracy
Epoch 37/100
9/9 [==============================] - ETA: 0s - loss: 1.2163 - accuracy: 0.99
Epoch 00037: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 554ms/step - loss: 1.2163 - accuracy
Epoch 38/100
9/9 [==============================] - ETA: 0s - loss: 1.2198 - accuracy: 0.99
Epoch 00038: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 574ms/step - loss: 1.2198 - accuracy
Epoch 39/100
9/9 [==============================] - ETA: 0s - loss: 1.2145 - accuracy: 0.99
Epoch 00039: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 628ms/step - loss: 1.2145 - accuracy
Epoch 40/100
9/9 [==============================] - ETA: 0s - loss: 1.2109 - accuracy: 1.00
Epoch 00040: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 570ms/step - loss: 1.2109 - accuracy
Epoch 41/100
9/9 [==============================] - ETA: 0s - loss: 1.2127 - accuracy: 0.99
Epoch 00041: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.2127 - accuracy
Epoch 42/100
9/9 [==============================] - ETA: 0s - loss: 1.2084 - accuracy: 0.99
Epoch 00042: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.2084 - accuracy
Epoch 43/100
9/9 [==============================] - ETA: 0s - loss: 1.2137 - accuracy: 1.00
Epoch 00043: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.2137 - accuracy
Epoch 44/100
9/9 [==============================] - ETA: 0s - loss: 1.2110 - accuracy: 0.99
Epoch 00044: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 613ms/step - loss: 1.2110 - accuracy
Epoch 45/100
9/9 [==============================] - ETA: 0s - loss: 1.2049 - accuracy: 0.99
Epoch 00045: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.2049 - accuracy
Epoch 46/100
9/9 [==============================] - ETA: 0s - loss: 1.2088 - accuracy: 0.99
Epoch 00046: val_accuracy did not improve from 1.00000
```

```
Epoch 00046: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 570ms/step - loss: 1.2088 - accuracy
Epoch 47/100
9/9 [==============================] - ETA: 0s - loss: 1.2100 - accuracy: 1.00
Epoch 00047: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 616ms/step - loss: 1.2100 - accuracy
Epoch 48/100
9/9 [==============================] - ETA: 0s - loss: 1.2060 - accuracy: 1.00
Epoch 00048: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.2060 - accuracy
Epoch 49/100
9/9 [==============================] - ETA: 0s - loss: 1.2114 - accuracy: 0.99
Epoch 00049: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 611ms/step - loss: 1.2114 - accuracy
Epoch 50/100
9/9 [==============================] - ETA: 0s - loss: 1.2086 - accuracy: 0.99
Epoch 00050: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.2086 - accuracy
Epoch 51/100
9/9 [==============================] - ETA: 0s - loss: 1.2044 - accuracy: 0.99
Epoch 00051: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.2044 - accuracy
Epoch 52/100
9/9 [==============================] - ETA: 0s - loss: 1.2064 - accuracy: 0.99
Epoch 00052: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 613ms/step - loss: 1.2064 - accuracy
Epoch 53/100
9/9 [==============================] - ETA: 0s - loss: 1.2077 - accuracy: 0.99
Epoch 00053: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 552ms/step - loss: 1.2077 - accuracy
Epoch 54/100
9/9 [==============================] - ETA: 0s - loss: 1.1996 - accuracy: 1.00
Epoch 00054: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 619ms/step - loss: 1.1996 - accuracy
Epoch 55/100
9/9 [==============================] - ETA: 0s - loss: 1.2030 - accuracy: 0.99
Epoch 00055: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 573ms/step - loss: 1.2030 - accuracy
Epoch 56/100
9/9 [==============================] - ETA: 0s - loss: 1.2042 - accuracy: 1.00
Epoch 00056: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 568ms/step - loss: 1.2042 - accuracy
Epoch 57/100
9/9 [==============================] - ETA: 0s - loss: 1.2021 - accuracy: 0.99
Epoch 00057: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 626ms/step - loss: 1.2021 - accuracy
Epoch 58/100
9/9 [==============================] - ETA: 0s - loss: 1.2058 - accuracy: 0.99
Epoch 00058: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 610ms/step - loss: 1.2058 - accuracy
Epoch 59/100
9/9 [==============================] - ETA: 0s - loss: 1.1991 - accuracy: 1.00
Epoch 00059: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.1991 - accuracy
Epoch 60/100
9/9 [==============================] - ETA: 0s - loss: 1.2046 - accuracy: 0.99
Epoch 00060: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.2046 - accuracy
Epoch 61/100
9/9 [==============================] - ETA: 0s - loss: 1.2000 - accuracy: 1.00
Epoch 00061: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 574ms/step - loss: 1.2000 - accuracy
Epoch 62/100
```

```
Epoch 62/100
9/9 [==============================] - ETA: 0s - loss: 1.1942 - accuracy: 1.00
Epoch 00062: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 575ms/step - loss: 1.1942 - accuracy
Epoch 63/100
9/9 [==============================] - ETA: 0s - loss: 1.2051 - accuracy: 1.00
Epoch 00063: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.2051 - accuracy
Epoch 64/100
9/9 [==============================] - ETA: 0s - loss: 1.1972 - accuracy: 0.99
Epoch 00064: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 567ms/step - loss: 1.1972 - accuracy
Epoch 65/100
9/9 [==============================] - ETA: 0s - loss: 1.1974 - accuracy: 0.99
Epoch 00065: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 568ms/step - loss: 1.1974 - accuracy
Epoch 66/100
9/9 [==============================] - ETA: 0s - loss: 1.1989 - accuracy: 0.99
Epoch 00066: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 573ms/step - loss: 1.1989 - accuracy
Epoch 67/100
9/9 [==============================] - ETA: 0s - loss: 1.1963 - accuracy: 1.00
Epoch 00067: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 630ms/step - loss: 1.1963 - accuracy
Epoch 68/100
9/9 [==============================] - ETA: 0s - loss: 1.1923 - accuracy: 1.00
Epoch 00068: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 570ms/step - loss: 1.1923 - accuracy
Epoch 69/100
9/9 [==============================] - ETA: 0s - loss: 1.2015 - accuracy: 1.00
Epoch 00069: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 575ms/step - loss: 1.2015 - accuracy
Epoch 70/100
9/9 [==============================] - ETA: 0s - loss: 1.1953 - accuracy: 1.00
Epoch 00070: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 573ms/step - loss: 1.1953 - accuracy
Epoch 71/100
9/9 [==============================] - ETA: 0s - loss: 1.1984 - accuracy: 1.00
Epoch 00071: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 575ms/step - loss: 1.1984 - accuracy
Epoch 72/100
9/9 [==============================] - ETA: 0s - loss: 1.1969 - accuracy: 1.00
Epoch 00072: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 621ms/step - loss: 1.1969 - accuracy
Epoch 73/100
9/9 [==============================] - ETA: 0s - loss: 1.1974 - accuracy: 0.99
Epoch 00073: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 560ms/step - loss: 1.1974 - accuracy
Epoch 74/100
9/9 [==============================] - ETA: 0s - loss: 1.1963 - accuracy: 1.00
Epoch 00074: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 615ms/step - loss: 1.1963 - accuracy
Epoch 75/100
9/9 [==============================] - ETA: 0s - loss: 1.1952 - accuracy: 1.00
Epoch 00075: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 636ms/step - loss: 1.1952 - accuracy
Epoch 76/100
9/9 [==============================] - ETA: 0s - loss: 1.1884 - accuracy: 0.99
Epoch 00076: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.1884 - accuracy
Epoch 77/100
9/9 [==============================] - ETA: 0s - loss: 1.1923 - accuracy: 1.00
```

```
Epoch 00077: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.1923 - accuracy
Epoch 78/100
9/9 [==============================] - ETA: 0s - loss: 1.1937 - accuracy: 1.00
Epoch 00078: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 567ms/step - loss: 1.1937 - accuracy
Epoch 79/100
9/9 [==============================] - ETA: 0s - loss: 1.1913 - accuracy: 1.00
Epoch 00079: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 567ms/step - loss: 1.1913 - accuracy
Epoch 80/100
9/9 [==============================] - ETA: 0s - loss: 1.1931 - accuracy: 1.00
Epoch 00080: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 568ms/step - loss: 1.1931 - accuracy
Epoch 81/100
9/9 [==============================] - ETA: 0s - loss: 1.1919 - accuracy: 1.00
Epoch 00081: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.1919 - accuracy
Epoch 82/100
9/9 [==============================] - ETA: 0s - loss: 1.1915 - accuracy: 0.99
Epoch 00082: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 614ms/step - loss: 1.1915 - accuracy
Epoch 83/100
9/9 [==============================] - ETA: 0s - loss: 1.1913 - accuracy: 0.99
Epoch 00083: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 573ms/step - loss: 1.1913 - accuracy
Epoch 84/100
9/9 [==============================] - ETA: 0s - loss: 1.1931 - accuracy: 0.99
Epoch 00084: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 628ms/step - loss: 1.1931 - accuracy
Epoch 85/100
9/9 [==============================] - ETA: 0s - loss: 1.1925 - accuracy: 0.99
Epoch 00085: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 567ms/step - loss: 1.1925 - accuracy
Epoch 86/100
9/9 [==============================] - ETA: 0s - loss: 1.1941 - accuracy: 0.99
Epoch 00086: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 568ms/step - loss: 1.1941 - accuracy
Epoch 87/100
9/9 [==============================] - ETA: 0s - loss: 1.1906 - accuracy: 1.00
Epoch 00087: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 613ms/step - loss: 1.1906 - accuracy
Epoch 88/100
9/9 [==============================] - ETA: 0s - loss: 1.1870 - accuracy: 1.00
Epoch 00088: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 611ms/step - loss: 1.1870 - accuracy
Epoch 89/100
9/9 [==============================] - ETA: 0s - loss: 1.1909 - accuracy: 1.00
Epoch 00089: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 564ms/step - loss: 1.1909 - accuracy
Epoch 90/100
9/9 [==============================] - ETA: 0s - loss: 1.1914 - accuracy: 1.00
Epoch 00090: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.1914 - accuracy
Epoch 91/100
9/9 [==============================] - ETA: 0s - loss: 1.1887 - accuracy: 1.00
Epoch 00091: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 571ms/step - loss: 1.1887 - accuracy
Epoch 92/100
9/9 [==============================] - ETA: 0s - loss: 1.2003 - accuracy: 0.99
Epoch 00092: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 572ms/step - loss: 1.2003 - accuracy
```

```
Epoch 93/100
9/9 [==============================] - ETA: 0s - loss: 1.1905 - accuracy: 1.00
Epoch 00093: val_accuracy did not improve from 1.00000
9/9 [==============================] - 6s 628ms/step - loss: 1.1905 - accuracy
Epoch 94/100
9/9 [==============================] - ETA: 0s - loss: 1.1940 - accuracy: 0.99
Epoch 00094: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 575ms/step - loss: 1.1940 - accuracy
Epoch 95/100
9/9 [==============================] - ETA: 0s - loss: 1.1887 - accuracy: 1.00
Epoch 00095: val_accuracy did not improve from 1.00000
9/9 [==============================] - 5s 569ms/step - loss: 1.1887 - accuracy
Epoch 96/100
9/9 [==============================] - ETA: 0s - loss: 1.1872 - accuracy: 0.99
Epoch 00096: val_accuracy did not improve from 1.00000
```

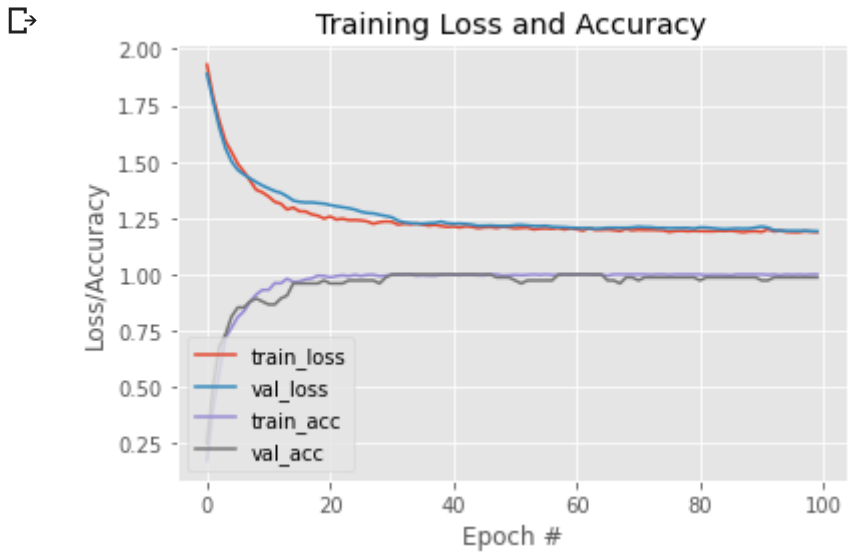
```
LOG_PATH=PROJECT_PATH+'trained-models/'+model_type+'/'
if not os.path.exists(LOG_PATH):
    os.makedirs(LOG_PATH)
model.save(TARGET_CLASSIFICATION_MODEL)
```

```
Epoch 98/100
```

See Results

```
9/9 [==============================] - ETA: 0s - loss: 1.1894 - accuracy: 1.00
```

```
anis_koubaa_udemy_computer_vision_lib.plot_loss_accuracy_from_csv(LOGFILE_PATH)
```



Double-click (or enter) to edit