CarStyle

October 1, 2024

[1]:
```
import tensorflow as tf
import os
import cv2
import math
import json
import numpy as np
from matplotlib import pyplot as plt
from keras.applications import MobileNetV3Large
from keras.models import Model
from keras.layers import Dense, GlobalAveragePooling2D
from keras.metrics import Precision, Recall, SparseCategoricalAccuracy
```

[2]:
```
print("Num GPUs Available: ", len(tf.config.list_physical_devices('GPU')))
gpus = tf.config.experimental.list_physical_devices('GPU')
if gpus:
    try:
        for gpu in gpus:
            tf.config.experimental.set_memory_growth(gpu, True)
        logical_gpus = tf.config.experimental.list_logical_devices('GPU')
        print(len(gpus), "Physical GPUs,", len(logical_gpus), "Logical GPUs")
    except RuntimeError as e:
        print(e)
```

```
Num GPUs Available:  1
1 Physical GPUs, 1 Logical GPUs
```

[3]:
```
base_dir = 'Styles'
train_dir = os.path.join(base_dir, 'train')
val_dir = os.path.join(base_dir, 'valid')
test_dir = os.path.join(base_dir, 'test')

img_size = (224, 224)
batch_size = 32

train_data = tf.keras.utils.image_dataset_from_directory(
    train_dir,
    image_size=img_size,
    batch_size=batch_size,
```

```
    label_mode='int',
    interpolation='bilinear'
)

val_data = tf.keras.utils.image_dataset_from_directory(
    val_dir,
    image_size=img_size,
    batch_size=batch_size,
    label_mode='int',
    interpolation='bilinear'
)

test_data = tf.keras.utils.image_dataset_from_directory(
    test_dir,
    image_size=img_size,
    batch_size=batch_size,
    label_mode='int',
    interpolation='bilinear'
)
```

```
Found 5350 files belonging to 7 classes.
Found 1397 files belonging to 7 classes.
Found 802 files belonging to 7 classes.
```

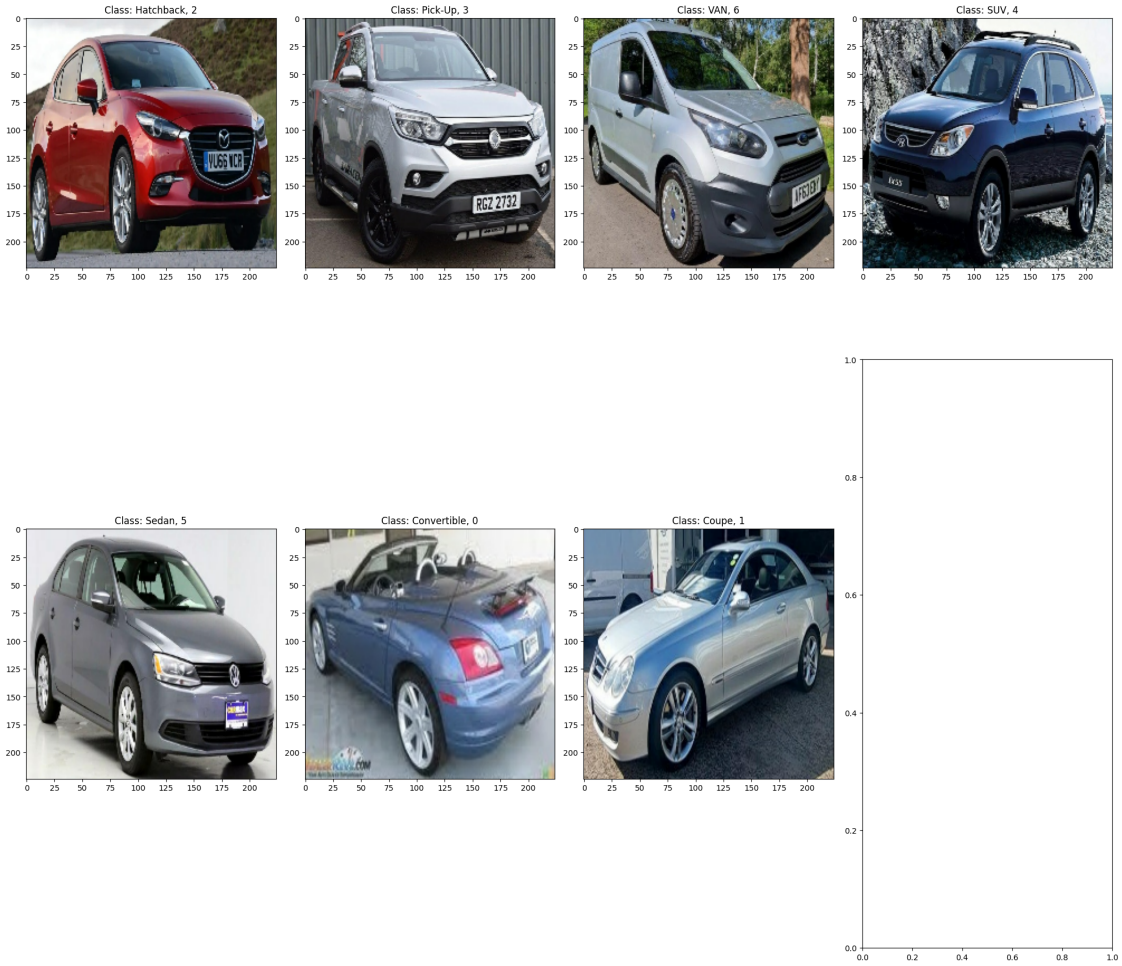
[4]:
```
class_names = train_data.class_names
print("Class names test:", class_names)

with open('CarStyle map.json', 'w') as f:
    json.dump(class_names, f)

data_iterator = train_data.as_numpy_iterator()
```

```
Class names test: ['Convertible', 'Coupe', 'Hatchback', 'Pick-Up', 'SUV',
'Sedan', 'VAN']
```

[5]:
```
batch = data_iterator.next()
num_classes = len(class_names)
```

[6]:
```
ncols = 4
nrows = math.ceil(num_classes / ncols)
fig, ax = plt.subplots(nrows=nrows, ncols=ncols, figsize=(20, 20))

if nrows == 1:
    ax = ax.flatten()
elif ncols == 1:
    ax = ax.flatten()

plotted = set()
```

```
count = 0
while count < num_classes:
    batch = next(data_iterator)

    for idx, img in enumerate(batch[0]):
        label = batch[1][idx]
        if label not in plotted:
            ax_idx = count if nrows == 1 or ncols == 1 else (count // ncols,␣
 ↪count % ncols)
            ax[ax_idx].imshow(img.astype(int))
            ax[ax_idx].title.set_text(f"Class: {class_names[label]}, {label}")
            plotted.add(label)
            count += 1

        if count == num_classes:
            break

plt.tight_layout()
plt.show()
```



[7]:
```
base_model = MobileNetV3Large(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)
base_model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/mobilenet_v3/weights_mobilenet_v3_large_224_1.0_float_no_top_v2.h5
12683000/12683000 [==============================] - 0s 0us/step
Model: "MobilenetV3large"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 rescaling (Rescaling)          (None, 224, 224, 3)  0
['input_1[0][0]']

 Conv (Conv2D)                  (None, 112, 112, 16  432
['rescaling[0][0]']
                                )

 Conv/BatchNorm (BatchNormaliza  (None, 112, 112, 16  64         ['Conv[0][0]']
 tion)                          )

 tf.__operators__.add (TFOpLamb  (None, 112, 112, 16  0
['Conv/BatchNorm[0][0]']
 da)                            )

 re_lu (ReLU)                   (None, 112, 112, 16  0
['tf.__operators__.add[0][0]']
                                )

 tf.math.multiply (TFOpLambda)  (None, 112, 112, 16  0           ['re_lu[0][0]']
                                )

 multiply (Multiply)            (None, 112, 112, 16  0
['Conv/BatchNorm[0][0]',
                                )
'tf.math.multiply[0][0]']
```

```
 expanded_conv/depthwise (Depth  (None, 112, 112, 16  144
['multiply[0][0]']
 wiseConv2D)                    )

 expanded_conv/depthwise/BatchN  (None, 112, 112, 16  64
['expanded_conv/depthwise[0][0]']
 orm (BatchNormalization)       )

 re_lu_1 (ReLU)                 (None, 112, 112, 16  0
['expanded_conv/depthwise/BatchNo
                                )                                 rm[0][0]']

 expanded_conv/project (Conv2D)  (None, 112, 112, 16  256
['re_lu_1[0][0]']
                                )

 expanded_conv/project/BatchNor  (None, 112, 112, 16  64
['expanded_conv/project[0][0]']
 m (BatchNormalization)         )

 expanded_conv/Add (Add)        (None, 112, 112, 16  0
['multiply[0][0]',
                                )
'expanded_conv/project/BatchNorm
                                                                  [0][0]']

 expanded_conv_1/expand (Conv2D  (None, 112, 112, 64  1024
['expanded_conv/Add[0][0]']
 )                              )

 expanded_conv_1/expand/BatchNo  (None, 112, 112, 64  256
['expanded_conv_1/expand[0][0]']
 rm (BatchNormalization)        )

 re_lu_2 (ReLU)                 (None, 112, 112, 64  0
['expanded_conv_1/expand/BatchNor
                                )                                 m[0][0]']

 expanded_conv_1/depthwise/pad   (None, 113, 113, 64  0
['re_lu_2[0][0]']
 (ZeroPadding2D)                )

 expanded_conv_1/depthwise (Dep  (None, 56, 56, 64)  576
['expanded_conv_1/depthwise/pad[0
 thwiseConv2D)                                                    ][0]']

 expanded_conv_1/depthwise/Batc  (None, 56, 56, 64)  256
['expanded_conv_1/depthwise[0][0]
```

```
 hNorm (BatchNormalization)                                          ']

 re_lu_3 (ReLU)                 (None, 56, 56, 64)   0
['expanded_conv_1/depthwise/Batch
                                                                     Norm[0][0]']

 expanded_conv_1/project (Conv2  (None, 56, 56, 24)  1536
['re_lu_3[0][0]']
 D)

 expanded_conv_1/project/BatchN  (None, 56, 56, 24)  96
['expanded_conv_1/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_2/expand (Conv2D  (None, 56, 56, 72)  1728
['expanded_conv_1/project/BatchNo
 )                                                                   rm[0][0]']

 expanded_conv_2/expand/BatchNo  (None, 56, 56, 72)  288
['expanded_conv_2/expand[0][0]']
 rm (BatchNormalization)

 re_lu_4 (ReLU)                 (None, 56, 56, 72)   0
['expanded_conv_2/expand/BatchNor
                                                                     m[0][0]']

 expanded_conv_2/depthwise (Dep  (None, 56, 56, 72)  648
['re_lu_4[0][0]']
 thwiseConv2D)

 expanded_conv_2/depthwise/Batc  (None, 56, 56, 72)  288
['expanded_conv_2/depthwise[0][0]
 hNorm (BatchNormalization)                                          ']

 re_lu_5 (ReLU)                 (None, 56, 56, 72)   0
['expanded_conv_2/depthwise/Batch
                                                                     Norm[0][0]']

 expanded_conv_2/project (Conv2  (None, 56, 56, 24)  1728
['re_lu_5[0][0]']
 D)

 expanded_conv_2/project/BatchN  (None, 56, 56, 24)  96
['expanded_conv_2/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_2/Add (Add)      (None, 56, 56, 24)   0
['expanded_conv_1/project/BatchNo
```

```
                                                                 rm[0][0]',
'expanded_conv_2/project/BatchNo
                                                                 rm[0][0]']

 expanded_conv_3/expand (Conv2D  (None, 56, 56, 72)  1728
['expanded_conv_2/Add[0][0]']
 )

 expanded_conv_3/expand/BatchNo  (None, 56, 56, 72)  288
['expanded_conv_3/expand[0][0]']
 rm (BatchNormalization)

 re_lu_6 (ReLU)                 (None, 56, 56, 72)   0
['expanded_conv_3/expand/BatchNor
                                                                 m[0][0]']

 expanded_conv_3/depthwise/pad   (None, 59, 59, 72)  0
['re_lu_6[0][0]']
 (ZeroPadding2D)

 expanded_conv_3/depthwise (Dep  (None, 28, 28, 72)  1800
['expanded_conv_3/depthwise/pad[0
 thwiseConv2D)                                                   ][0]']

 expanded_conv_3/depthwise/Batc  (None, 28, 28, 72)  288
['expanded_conv_3/depthwise[0][0]
 hNorm (BatchNormalization)                                      ']

 re_lu_7 (ReLU)                 (None, 28, 28, 72)   0
['expanded_conv_3/depthwise/Batch
                                                                 Norm[0][0]']

 expanded_conv_3/squeeze_excite  (None, 1, 1, 72)    0
['re_lu_7[0][0]']
 /AvgPool (GlobalAveragePooling
 2D)

 expanded_conv_3/squeeze_excite  (None, 1, 1, 24)    1752
['expanded_conv_3/squeeze_excite/
 /Conv (Conv2D)                                                  AvgPool[0][0]']

 expanded_conv_3/squeeze_excite  (None, 1, 1, 24)    0
['expanded_conv_3/squeeze_excite/
 /Relu (ReLU)                                                    Conv[0][0]']

 expanded_conv_3/squeeze_excite  (None, 1, 1, 72)    1800
['expanded_conv_3/squeeze_excite/
 /Conv_1 (Conv2D)                                                Relu[0][0]']
```

```
 tf.__operators__.add_1 (TFOpLa  (None, 1, 1, 72)    0
['expanded_conv_3/squeeze_excite/
 mbda)                                                           Conv_1[0][0]']

 re_lu_8 (ReLU)                 (None, 1, 1, 72)     0
['tf.__operators__.add_1[0][0]']

 tf.math.multiply_1 (TFOpLambda  (None, 1, 1, 72)    0
['re_lu_8[0][0]']
 )

 expanded_conv_3/squeeze_excite  (None, 28, 28, 72)  0
['re_lu_7[0][0]',
 /Mul (Multiply)
'tf.math.multiply_1[0][0]']

 expanded_conv_3/project (Conv2  (None, 28, 28, 40)  2880
['expanded_conv_3/squeeze_excite/
 D)                                                              Mul[0][0]']

 expanded_conv_3/project/BatchN  (None, 28, 28, 40)  160
['expanded_conv_3/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_4/expand (Conv2D  (None, 28, 28, 120)  4800
['expanded_conv_3/project/BatchNo
 )                                                               rm[0][0]']

 expanded_conv_4/expand/BatchNo  (None, 28, 28, 120)  480
['expanded_conv_4/expand[0][0]']
 rm (BatchNormalization)

 re_lu_9 (ReLU)                 (None, 28, 28, 120)  0
['expanded_conv_4/expand/BatchNor
                                                                 m[0][0]']

 expanded_conv_4/depthwise (Dep  (None, 28, 28, 120)  3000
['re_lu_9[0][0]']
 thwiseConv2D)

 expanded_conv_4/depthwise/Batc  (None, 28, 28, 120)  480
['expanded_conv_4/depthwise[0][0]
 hNorm (BatchNormalization)                                      ']

 re_lu_10 (ReLU)                (None, 28, 28, 120)  0
['expanded_conv_4/depthwise/Batch
                                                                 Norm[0][0]']
```

```
 expanded_conv_4/squeeze_excite  (None, 1, 1, 120)   0
['re_lu_10[0][0]']
 /AvgPool (GlobalAveragePooling
 2D)

 expanded_conv_4/squeeze_excite  (None, 1, 1, 32)    3872
['expanded_conv_4/squeeze_excite/
 /Conv (Conv2D)                                                  AvgPool[0][0]']

 expanded_conv_4/squeeze_excite  (None, 1, 1, 32)    0
['expanded_conv_4/squeeze_excite/
 /Relu (ReLU)                                                    Conv[0][0]']

 expanded_conv_4/squeeze_excite  (None, 1, 1, 120)   3960
['expanded_conv_4/squeeze_excite/
 /Conv_1 (Conv2D)                                                Relu[0][0]']

 tf.__operators__.add_2 (TFOpLa  (None, 1, 1, 120)   0
['expanded_conv_4/squeeze_excite/
 mbda)                                                           Conv_1[0][0]']

 re_lu_11 (ReLU)                (None, 1, 1, 120)    0
['tf.__operators__.add_2[0][0]']

 tf.math.multiply_2 (TFOpLambda  (None, 1, 1, 120)   0
['re_lu_11[0][0]']
 )

 expanded_conv_4/squeeze_excite  (None, 28, 28, 120)  0
['re_lu_10[0][0]',
 /Mul (Multiply)
'tf.math.multiply_2[0][0]']

 expanded_conv_4/project (Conv2  (None, 28, 28, 40)  4800
['expanded_conv_4/squeeze_excite/
 D)                                                              Mul[0][0]']

 expanded_conv_4/project/BatchN  (None, 28, 28, 40)  160
['expanded_conv_4/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_4/Add (Add)      (None, 28, 28, 40)   0
['expanded_conv_3/project/BatchNo
                                                                 rm[0][0]',
'expanded_conv_4/project/BatchNo
                                                                 rm[0][0]']
```

```
 expanded_conv_5/expand (Conv2D  (None, 28, 28, 120)  4800
['expanded_conv_4/Add[0][0]']
 )

 expanded_conv_5/expand/BatchNo  (None, 28, 28, 120)  480
['expanded_conv_5/expand[0][0]']
 rm (BatchNormalization)

 re_lu_12 (ReLU)                (None, 28, 28, 120)  0
['expanded_conv_5/expand/BatchNor
                                                                  m[0][0]']

 expanded_conv_5/depthwise (Dep  (None, 28, 28, 120)  3000
['re_lu_12[0][0]']
 thwiseConv2D)

 expanded_conv_5/depthwise/Batc  (None, 28, 28, 120)  480
['expanded_conv_5/depthwise[0][0]
 hNorm (BatchNormalization)                                       ']

 re_lu_13 (ReLU)                (None, 28, 28, 120)  0
['expanded_conv_5/depthwise/Batch
                                                                  Norm[0][0]']

 expanded_conv_5/squeeze_excite  (None, 1, 1, 120)   0
['re_lu_13[0][0]']
 /AvgPool (GlobalAveragePooling
 2D)

 expanded_conv_5/squeeze_excite  (None, 1, 1, 32)    3872
['expanded_conv_5/squeeze_excite/
 /Conv (Conv2D)                                                   AvgPool[0][0]']

 expanded_conv_5/squeeze_excite  (None, 1, 1, 32)    0
['expanded_conv_5/squeeze_excite/
 /Relu (ReLU)                                                     Conv[0][0]']

 expanded_conv_5/squeeze_excite  (None, 1, 1, 120)   3960
['expanded_conv_5/squeeze_excite/
 /Conv_1 (Conv2D)                                                 Relu[0][0]']

 tf.__operators__.add_3 (TFOpLa  (None, 1, 1, 120)   0
['expanded_conv_5/squeeze_excite/
 mbda)                                                            Conv_1[0][0]']

 re_lu_14 (ReLU)                (None, 1, 1, 120)    0
['tf.__operators__.add_3[0][0]']
```

```
 tf.math.multiply_3 (TFOpLambda  (None, 1, 1, 120)   0
['re_lu_14[0][0]']
 )

 expanded_conv_5/squeeze_excite  (None, 28, 28, 120)  0
['re_lu_13[0][0]',
 /Mul (Multiply)
'tf.math.multiply_3[0][0]']

 expanded_conv_5/project (Conv2  (None, 28, 28, 40)  4800
['expanded_conv_5/squeeze_excite/
 D)                                                                Mul[0][0]']

 expanded_conv_5/project/BatchN  (None, 28, 28, 40)  160
['expanded_conv_5/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_5/Add (Add)      (None, 28, 28, 40)   0
['expanded_conv_4/Add[0][0]',
'expanded_conv_5/project/BatchNo
                                                                  rm[0][0]']

 expanded_conv_6/expand (Conv2D  (None, 28, 28, 240)  9600
['expanded_conv_5/Add[0][0]']
 )

 expanded_conv_6/expand/BatchNo  (None, 28, 28, 240)  960
['expanded_conv_6/expand[0][0]']
 rm (BatchNormalization)

 tf.__operators__.add_4 (TFOpLa  (None, 28, 28, 240)  0
['expanded_conv_6/expand/BatchNor
 mbda)                                                            m[0][0]']

 re_lu_15 (ReLU)                (None, 28, 28, 240)  0
['tf.__operators__.add_4[0][0]']

 tf.math.multiply_4 (TFOpLambda  (None, 28, 28, 240)  0
['re_lu_15[0][0]']
 )

 multiply_1 (Multiply)          (None, 28, 28, 240)  0
['expanded_conv_6/expand/BatchNor
                                                                  m[0][0]',
'tf.math.multiply_4[0][0]']

 expanded_conv_6/depthwise/pad   (None, 29, 29, 240)  0
['multiply_1[0][0]']
```

```
 (ZeroPadding2D)

 expanded_conv_6/depthwise (Dep  (None, 14, 14, 240)  2160
['expanded_conv_6/depthwise/pad[0
 thwiseConv2D)                                                    ][0]']

 expanded_conv_6/depthwise/Batc  (None, 14, 14, 240)  960
['expanded_conv_6/depthwise[0][0]
 hNorm (BatchNormalization)                                       ']

 tf.__operators__.add_5 (TFOpLa  (None, 14, 14, 240)  0
['expanded_conv_6/depthwise/Batch
 mbda)                                                            Norm[0][0]']

 re_lu_16 (ReLU)                (None, 14, 14, 240)  0
['tf.__operators__.add_5[0][0]']

 tf.math.multiply_5 (TFOpLambda  (None, 14, 14, 240)  0
['re_lu_16[0][0]']
 )

 multiply_2 (Multiply)          (None, 14, 14, 240)  0
['expanded_conv_6/depthwise/Batch
                                                                  Norm[0][0]',
'tf.math.multiply_5[0][0]']

 expanded_conv_6/project (Conv2  (None, 14, 14, 80)  19200
['multiply_2[0][0]']
 D)

 expanded_conv_6/project/BatchN  (None, 14, 14, 80)  320
['expanded_conv_6/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_7/expand (Conv2D  (None, 14, 14, 200)  16000
['expanded_conv_6/project/BatchNo
 )                                                                rm[0][0]']

 expanded_conv_7/expand/BatchNo  (None, 14, 14, 200)  800
['expanded_conv_7/expand[0][0]']
 rm (BatchNormalization)

 tf.__operators__.add_6 (TFOpLa  (None, 14, 14, 200)  0
['expanded_conv_7/expand/BatchNor
 mbda)                                                            m[0][0]']

 re_lu_17 (ReLU)                (None, 14, 14, 200)  0
['tf.__operators__.add_6[0][0]']
```

```
 tf.math.multiply_6 (TFOpLambda  (None, 14, 14, 200)  0
['re_lu_17[0][0]']
 )

 multiply_3 (Multiply)          (None, 14, 14, 200)  0
['expanded_conv_7/expand/BatchNor
                                                                  m[0][0]',
'tf.math.multiply_6[0][0]']

 expanded_conv_7/depthwise (Dep  (None, 14, 14, 200)  1800
['multiply_3[0][0]']
 thwiseConv2D)

 expanded_conv_7/depthwise/Batc  (None, 14, 14, 200)  800
['expanded_conv_7/depthwise[0][0]
 hNorm (BatchNormalization)                                        ']

 tf.__operators__.add_7 (TFOpLa  (None, 14, 14, 200)  0
['expanded_conv_7/depthwise/Batch
 mbda)                                                            Norm[0][0]']

 re_lu_18 (ReLU)                (None, 14, 14, 200)  0
['tf.__operators__.add_7[0][0]']

 tf.math.multiply_7 (TFOpLambda  (None, 14, 14, 200)  0
['re_lu_18[0][0]']
 )

 multiply_4 (Multiply)          (None, 14, 14, 200)  0
['expanded_conv_7/depthwise/Batch
                                                                  Norm[0][0]',
'tf.math.multiply_7[0][0]']

 expanded_conv_7/project (Conv2  (None, 14, 14, 80)  16000
['multiply_4[0][0]']
 D)

 expanded_conv_7/project/BatchN  (None, 14, 14, 80)  320
['expanded_conv_7/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_7/Add (Add)      (None, 14, 14, 80)   0
['expanded_conv_6/project/BatchNo
                                                                  rm[0][0]',
'expanded_conv_7/project/BatchNo
                                                                  rm[0][0]']
```

```
 expanded_conv_8/expand (Conv2D  (None, 14, 14, 184)  14720
['expanded_conv_7/Add[0][0]']
 )

 expanded_conv_8/expand/BatchNo  (None, 14, 14, 184)  736
['expanded_conv_8/expand[0][0]']
 rm (BatchNormalization)

 tf.__operators__.add_8 (TFOpLa  (None, 14, 14, 184)  0
['expanded_conv_8/expand/BatchNor
 mbda)                                                           m[0][0]']

 re_lu_19 (ReLU)                (None, 14, 14, 184)  0
['tf.__operators__.add_8[0][0]']

 tf.math.multiply_8 (TFOpLambda  (None, 14, 14, 184)  0
['re_lu_19[0][0]']
 )

 multiply_5 (Multiply)          (None, 14, 14, 184)  0
['expanded_conv_8/expand/BatchNor
                                                                 m[0][0]',
'tf.math.multiply_8[0][0]']

 expanded_conv_8/depthwise (Dep  (None, 14, 14, 184)  1656
['multiply_5[0][0]']
 thwiseConv2D)

 expanded_conv_8/depthwise/Batc  (None, 14, 14, 184)  736
['expanded_conv_8/depthwise[0][0]
 hNorm (BatchNormalization)                                      ']

 tf.__operators__.add_9 (TFOpLa  (None, 14, 14, 184)  0
['expanded_conv_8/depthwise/Batch
 mbda)                                                           Norm[0][0]']

 re_lu_20 (ReLU)                (None, 14, 14, 184)  0
['tf.__operators__.add_9[0][0]']

 tf.math.multiply_9 (TFOpLambda  (None, 14, 14, 184)  0
['re_lu_20[0][0]']
 )

 multiply_6 (Multiply)          (None, 14, 14, 184)  0
['expanded_conv_8/depthwise/Batch
                                                                 Norm[0][0]',
'tf.math.multiply_9[0][0]']
```

```
 expanded_conv_8/project (Conv2  (None, 14, 14, 80)  14720
['multiply_6[0][0]']
 D)

 expanded_conv_8/project/BatchN  (None, 14, 14, 80)  320
['expanded_conv_8/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_8/Add (Add)      (None, 14, 14, 80)   0
['expanded_conv_7/Add[0][0]',
'expanded_conv_8/project/BatchNo
                                                                  rm[0][0]']

 expanded_conv_9/expand (Conv2D  (None, 14, 14, 184)  14720
['expanded_conv_8/Add[0][0]']
 )

 expanded_conv_9/expand/BatchNo  (None, 14, 14, 184)  736
['expanded_conv_9/expand[0][0]']
 rm (BatchNormalization)

 tf.__operators__.add_10 (TFOpL  (None, 14, 14, 184)  0
['expanded_conv_9/expand/BatchNor
 ambda)                                                           m[0][0]']

 re_lu_21 (ReLU)                (None, 14, 14, 184)  0
['tf.__operators__.add_10[0][0]']

 tf.math.multiply_10 (TFOpLambd  (None, 14, 14, 184)  0
['re_lu_21[0][0]']
 a)

 multiply_7 (Multiply)          (None, 14, 14, 184)  0
['expanded_conv_9/expand/BatchNor
                                                                  m[0][0]',
'tf.math.multiply_10[0][0]']

 expanded_conv_9/depthwise (Dep  (None, 14, 14, 184)  1656
['multiply_7[0][0]']
 thwiseConv2D)

 expanded_conv_9/depthwise/Batc  (None, 14, 14, 184)  736
['expanded_conv_9/depthwise[0][0]
 hNorm (BatchNormalization)                                       ']

 tf.__operators__.add_11 (TFOpL  (None, 14, 14, 184)  0
['expanded_conv_9/depthwise/Batch
 ambda)                                                           Norm[0][0]']
```

```
 re_lu_22 (ReLU)                (None, 14, 14, 184)  0
['tf.__operators__.add_11[0][0]']

 tf.math.multiply_11 (TFOpLambd  (None, 14, 14, 184)  0
['re_lu_22[0][0]']
 a)

 multiply_8 (Multiply)          (None, 14, 14, 184)  0
['expanded_conv_9/depthwise/Batch
                                                                  Norm[0][0]',
'tf.math.multiply_11[0][0]']

 expanded_conv_9/project (Conv2  (None, 14, 14, 80)  14720
['multiply_8[0][0]']
 D)

 expanded_conv_9/project/BatchN  (None, 14, 14, 80)  320
['expanded_conv_9/project[0][0]']
 orm (BatchNormalization)

 expanded_conv_9/Add (Add)      (None, 14, 14, 80)   0
['expanded_conv_8/Add[0][0]',
'expanded_conv_9/project/BatchNo
                                                                  rm[0][0]']

 expanded_conv_10/expand (Conv2  (None, 14, 14, 480)  38400
['expanded_conv_9/Add[0][0]']
 D)

 expanded_conv_10/expand/BatchN  (None, 14, 14, 480)  1920
['expanded_conv_10/expand[0][0]']
 orm (BatchNormalization)

 tf.__operators__.add_12 (TFOpL  (None, 14, 14, 480)  0
['expanded_conv_10/expand/BatchNo
 ambda)                                                           rm[0][0]']

 re_lu_23 (ReLU)                (None, 14, 14, 480)  0
['tf.__operators__.add_12[0][0]']

 tf.math.multiply_12 (TFOpLambd  (None, 14, 14, 480)  0
['re_lu_23[0][0]']
 a)

 multiply_9 (Multiply)          (None, 14, 14, 480)  0
['expanded_conv_10/expand/BatchNo
                                                                  rm[0][0]',
```

```
'tf.math.multiply_12[0][0]']

 expanded_conv_10/depthwise (De  (None, 14, 14, 480)  4320
['multiply_9[0][0]']
 pthwiseConv2D)

 expanded_conv_10/depthwise/Bat  (None, 14, 14, 480)  1920
['expanded_conv_10/depthwise[0][0
 chNorm (BatchNormalization)                                    ]']

 tf.__operators__.add_13 (TFOpL  (None, 14, 14, 480)  0
['expanded_conv_10/depthwise/Batc
 ambda)                                                         hNorm[0][0]']

 re_lu_24 (ReLU)                (None, 14, 14, 480)  0
['tf.__operators__.add_13[0][0]']

 tf.math.multiply_13 (TFOpLambd  (None, 14, 14, 480)  0
['re_lu_24[0][0]']
 a)

 multiply_10 (Multiply)         (None, 14, 14, 480)  0
['expanded_conv_10/depthwise/Batc
                                                                hNorm[0][0]',
'tf.math.multiply_13[0][0]']

 expanded_conv_10/squeeze_excit  (None, 1, 1, 480)   0
['multiply_10[0][0]']
 e/AvgPool (GlobalAveragePoolin
 g2D)

 expanded_conv_10/squeeze_excit  (None, 1, 1, 120)   57720
['expanded_conv_10/squeeze_excite
 e/Conv (Conv2D)
/AvgPool[0][0]']

 expanded_conv_10/squeeze_excit  (None, 1, 1, 120)   0
['expanded_conv_10/squeeze_excite
 e/Relu (ReLU)                                                  /Conv[0][0]']

 expanded_conv_10/squeeze_excit  (None, 1, 1, 480)   58080
['expanded_conv_10/squeeze_excite
 e/Conv_1 (Conv2D)                                              /Relu[0][0]']

 tf.__operators__.add_14 (TFOpL  (None, 1, 1, 480)   0
['expanded_conv_10/squeeze_excite
 ambda)                                                         /Conv_1[0][0]']
```

```
 re_lu_25 (ReLU)                (None, 1, 1, 480)    0
['tf.__operators__.add_14[0][0]']

 tf.math.multiply_14 (TFOpLambd  (None, 1, 1, 480)   0
['re_lu_25[0][0]']
 a)

 expanded_conv_10/squeeze_excit  (None, 14, 14, 480)  0
['multiply_10[0][0]',
 e/Mul (Multiply)
'tf.math.multiply_14[0][0]']

 expanded_conv_10/project (Conv  (None, 14, 14, 112)  53760
['expanded_conv_10/squeeze_excite
 2D)                                                              /Mul[0][0]']

 expanded_conv_10/project/Batch  (None, 14, 14, 112)  448
['expanded_conv_10/project[0][0]'
 Norm (BatchNormalization)                                        ]

 expanded_conv_11/expand (Conv2  (None, 14, 14, 672)  75264
['expanded_conv_10/project/BatchN
 D)                                                               orm[0][0]']

 expanded_conv_11/expand/BatchN  (None, 14, 14, 672)  2688
['expanded_conv_11/expand[0][0]']
 orm (BatchNormalization)

 tf.__operators__.add_15 (TFOpL  (None, 14, 14, 672)  0
['expanded_conv_11/expand/BatchNo
 ambda)                                                           rm[0][0]']

 re_lu_26 (ReLU)                (None, 14, 14, 672)  0
['tf.__operators__.add_15[0][0]']

 tf.math.multiply_15 (TFOpLambd  (None, 14, 14, 672)  0
['re_lu_26[0][0]']
 a)

 multiply_11 (Multiply)         (None, 14, 14, 672)  0
['expanded_conv_11/expand/BatchNo
                                                                  rm[0][0]',
'tf.math.multiply_15[0][0]']

 expanded_conv_11/depthwise (De  (None, 14, 14, 672)  6048
['multiply_11[0][0]']
 pthwiseConv2D)
```

```
 expanded_conv_11/depthwise/Bat  (None, 14, 14, 672)  2688
['expanded_conv_11/depthwise[0][0
 chNorm (BatchNormalization)                                    ]']

 tf.__operators__.add_16 (TFOpL  (None, 14, 14, 672)  0
['expanded_conv_11/depthwise/Batc
 ambda)                                                         hNorm[0][0]']

 re_lu_27 (ReLU)                (None, 14, 14, 672)  0
['tf.__operators__.add_16[0][0]']

 tf.math.multiply_16 (TFOpLambd  (None, 14, 14, 672)  0
['re_lu_27[0][0]']
 a)

 multiply_12 (Multiply)         (None, 14, 14, 672)  0
['expanded_conv_11/depthwise/Batc
                                                                hNorm[0][0]',
'tf.math.multiply_16[0][0]']

 expanded_conv_11/squeeze_excit  (None, 1, 1, 672)   0
['multiply_12[0][0]']
 e/AvgPool (GlobalAveragePoolin
 g2D)

 expanded_conv_11/squeeze_excit  (None, 1, 1, 168)   113064
['expanded_conv_11/squeeze_excite
 e/Conv (Conv2D)
/AvgPool[0][0]']

 expanded_conv_11/squeeze_excit  (None, 1, 1, 168)   0
['expanded_conv_11/squeeze_excite
 e/Relu (ReLU)                                                  /Conv[0][0]']

 expanded_conv_11/squeeze_excit  (None, 1, 1, 672)   113568
['expanded_conv_11/squeeze_excite
 e/Conv_1 (Conv2D)                                              /Relu[0][0]']

 tf.__operators__.add_17 (TFOpL  (None, 1, 1, 672)   0
['expanded_conv_11/squeeze_excite
 ambda)                                                         /Conv_1[0][0]']

 re_lu_28 (ReLU)                (None, 1, 1, 672)    0
['tf.__operators__.add_17[0][0]']

 tf.math.multiply_17 (TFOpLambd  (None, 1, 1, 672)   0
['re_lu_28[0][0]']
 a)
```

```
 expanded_conv_11/squeeze_excit  (None, 14, 14, 672)  0
['multiply_12[0][0]',
 e/Mul (Multiply)
'tf.math.multiply_17[0][0]']

 expanded_conv_11/project (Conv  (None, 14, 14, 112)  75264
['expanded_conv_11/squeeze_excite
 2D)                                                              /Mul[0][0]']

 expanded_conv_11/project/Batch  (None, 14, 14, 112)  448
['expanded_conv_11/project[0][0]'
 Norm (BatchNormalization)                                        ]

 expanded_conv_11/Add (Add)     (None, 14, 14, 112)  0
['expanded_conv_10/project/BatchN
                                                                  orm[0][0]',
'expanded_conv_11/project/BatchN
                                                                  orm[0][0]']

 expanded_conv_12/expand (Conv2  (None, 14, 14, 672)  75264
['expanded_conv_11/Add[0][0]']
 D)

 expanded_conv_12/expand/BatchN  (None, 14, 14, 672)  2688
['expanded_conv_12/expand[0][0]']
 orm (BatchNormalization)

 tf.__operators__.add_18 (TFOpL  (None, 14, 14, 672)  0
['expanded_conv_12/expand/BatchNo
 ambda)                                                           rm[0][0]']

 re_lu_29 (ReLU)                (None, 14, 14, 672)  0
['tf.__operators__.add_18[0][0]']

 tf.math.multiply_18 (TFOpLambd  (None, 14, 14, 672)  0
['re_lu_29[0][0]']
 a)

 multiply_13 (Multiply)         (None, 14, 14, 672)  0
['expanded_conv_12/expand/BatchNo
                                                                  rm[0][0]',
'tf.math.multiply_18[0][0]']

 expanded_conv_12/depthwise/pad  (None, 17, 17, 672)  0
['multiply_13[0][0]']
  (ZeroPadding2D)
```

```
 expanded_conv_12/depthwise (De  (None, 7, 7, 672)   16800
['expanded_conv_12/depthwise/pad[
 pthwiseConv2D)                                                  0][0]']

 expanded_conv_12/depthwise/Bat  (None, 7, 7, 672)   2688
['expanded_conv_12/depthwise[0][0
 chNorm (BatchNormalization)                                     ]']

 tf.__operators__.add_19 (TFOpL  (None, 7, 7, 672)   0
['expanded_conv_12/depthwise/Batc
 ambda)                                                          hNorm[0][0]']

 re_lu_30 (ReLU)                (None, 7, 7, 672)    0
['tf.__operators__.add_19[0][0]']

 tf.math.multiply_19 (TFOpLambd  (None, 7, 7, 672)   0
['re_lu_30[0][0]']
 a)

 multiply_14 (Multiply)         (None, 7, 7, 672)    0
['expanded_conv_12/depthwise/Batc
                                                                 hNorm[0][0]',
'tf.math.multiply_19[0][0]']

 expanded_conv_12/squeeze_excit  (None, 1, 1, 672)   0
['multiply_14[0][0]']
 e/AvgPool (GlobalAveragePoolin
 g2D)

 expanded_conv_12/squeeze_excit  (None, 1, 1, 168)   113064
['expanded_conv_12/squeeze_excite
 e/Conv (Conv2D)
/AvgPool[0][0]']

 expanded_conv_12/squeeze_excit  (None, 1, 1, 168)   0
['expanded_conv_12/squeeze_excite
 e/Relu (ReLU)                                                   /Conv[0][0]']

 expanded_conv_12/squeeze_excit  (None, 1, 1, 672)   113568
['expanded_conv_12/squeeze_excite
 e/Conv_1 (Conv2D)                                               /Relu[0][0]']

 tf.__operators__.add_20 (TFOpL  (None, 1, 1, 672)   0
['expanded_conv_12/squeeze_excite
 ambda)                                                          /Conv_1[0][0]']

 re_lu_31 (ReLU)                (None, 1, 1, 672)    0
['tf.__operators__.add_20[0][0]']
```

```
 tf.math.multiply_20 (TFOpLambd  (None, 1, 1, 672)   0
['re_lu_31[0][0]']
 a)

 expanded_conv_12/squeeze_excit  (None, 7, 7, 672)   0
['multiply_14[0][0]',
 e/Mul (Multiply)
'tf.math.multiply_20[0][0]']

 expanded_conv_12/project (Conv  (None, 7, 7, 160)   107520
['expanded_conv_12/squeeze_excite
 2D)                                                              /Mul[0][0]']

 expanded_conv_12/project/Batch  (None, 7, 7, 160)   640
['expanded_conv_12/project[0][0]'
 Norm (BatchNormalization)                                        ]

 expanded_conv_13/expand (Conv2  (None, 7, 7, 960)   153600
['expanded_conv_12/project/BatchN
 D)                                                               orm[0][0]']

 expanded_conv_13/expand/BatchN  (None, 7, 7, 960)   3840
['expanded_conv_13/expand[0][0]']
 orm (BatchNormalization)

 tf.__operators__.add_21 (TFOpL  (None, 7, 7, 960)   0
['expanded_conv_13/expand/BatchNo
 ambda)                                                           rm[0][0]']

 re_lu_32 (ReLU)                (None, 7, 7, 960)    0
['tf.__operators__.add_21[0][0]']

 tf.math.multiply_21 (TFOpLambd  (None, 7, 7, 960)   0
['re_lu_32[0][0]']
 a)

 multiply_15 (Multiply)         (None, 7, 7, 960)    0
['expanded_conv_13/expand/BatchNo
                                                                  rm[0][0]',
'tf.math.multiply_21[0][0]']

 expanded_conv_13/depthwise (De  (None, 7, 7, 960)   24000
['multiply_15[0][0]']
 pthwiseConv2D)

 expanded_conv_13/depthwise/Bat  (None, 7, 7, 960)   3840
['expanded_conv_13/depthwise[0][0
```

```
 chNorm (BatchNormalization)                                          ']']

 tf.__operators__.add_22 (TFOpL  (None, 7, 7, 960)   0
['expanded_conv_13/depthwise/Batc
 ambda)                                                               hNorm[0][0]']

 re_lu_33 (ReLU)                (None, 7, 7, 960)    0
['tf.__operators__.add_22[0][0]']

 tf.math.multiply_22 (TFOpLambd  (None, 7, 7, 960)   0
['re_lu_33[0][0]']
 a)

 multiply_16 (Multiply)         (None, 7, 7, 960)    0
['expanded_conv_13/depthwise/Batc
                                                                      hNorm[0][0]',
'tf.math.multiply_22[0][0]']

 expanded_conv_13/squeeze_excit  (None, 1, 1, 960)   0
['multiply_16[0][0]']
 e/AvgPool (GlobalAveragePoolin
 g2D)

 expanded_conv_13/squeeze_excit  (None, 1, 1, 240)   230640
['expanded_conv_13/squeeze_excite
 e/Conv (Conv2D)
/AvgPool[0][0]']

 expanded_conv_13/squeeze_excit  (None, 1, 1, 240)   0
['expanded_conv_13/squeeze_excite
 e/Relu (ReLU)                                                        /Conv[0][0]']

 expanded_conv_13/squeeze_excit  (None, 1, 1, 960)   231360
['expanded_conv_13/squeeze_excite
 e/Conv_1 (Conv2D)                                                    /Relu[0][0]']

 tf.__operators__.add_23 (TFOpL  (None, 1, 1, 960)   0
['expanded_conv_13/squeeze_excite
 ambda)                                                               /Conv_1[0][0]']

 re_lu_34 (ReLU)                (None, 1, 1, 960)    0
['tf.__operators__.add_23[0][0]']

 tf.math.multiply_23 (TFOpLambd  (None, 1, 1, 960)   0
['re_lu_34[0][0]']
 a)

 expanded_conv_13/squeeze_excit  (None, 7, 7, 960)   0
```

```
['multiply_16[0][0]',
 e/Mul (Multiply)
'tf.math.multiply_23[0][0]']

 expanded_conv_13/project (Conv  (None, 7, 7, 160)   153600
['expanded_conv_13/squeeze_excite
 2D)                                                          /Mul[0][0]']

 expanded_conv_13/project/Batch  (None, 7, 7, 160)   640
['expanded_conv_13/project[0][0]'
 Norm (BatchNormalization)                                    ]

 expanded_conv_13/Add (Add)     (None, 7, 7, 160)    0
['expanded_conv_12/project/BatchN
                                                              orm[0][0]',
'expanded_conv_13/project/BatchN
                                                              orm[0][0]']

 expanded_conv_14/expand (Conv2  (None, 7, 7, 960)   153600
['expanded_conv_13/Add[0][0]']
 D)

 expanded_conv_14/expand/BatchN  (None, 7, 7, 960)   3840
['expanded_conv_14/expand[0][0]']
 orm (BatchNormalization)

 tf.__operators__.add_24 (TFOpL  (None, 7, 7, 960)   0
['expanded_conv_14/expand/BatchNo
 ambda)                                                       rm[0][0]']

 re_lu_35 (ReLU)                (None, 7, 7, 960)    0
['tf.__operators__.add_24[0][0]']

 tf.math.multiply_24 (TFOpLambd  (None, 7, 7, 960)   0
['re_lu_35[0][0]']
 a)

 multiply_17 (Multiply)         (None, 7, 7, 960)    0
['expanded_conv_14/expand/BatchNo
                                                              rm[0][0]',
'tf.math.multiply_24[0][0]']

 expanded_conv_14/depthwise (De  (None, 7, 7, 960)   24000
['multiply_17[0][0]']
 pthwiseConv2D)

 expanded_conv_14/depthwise/Bat  (None, 7, 7, 960)   3840
['expanded_conv_14/depthwise[0][0
```

```
 chNorm (BatchNormalization)                                    ]']

 tf.__operators__.add_25 (TFOpL  (None, 7, 7, 960)   0
['expanded_conv_14/depthwise/Batc
 ambda)                                                         hNorm[0][0]']

 re_lu_36 (ReLU)                (None, 7, 7, 960)    0
['tf.__operators__.add_25[0][0]']

 tf.math.multiply_25 (TFOpLambd  (None, 7, 7, 960)   0
['re_lu_36[0][0]']
 a)

 multiply_18 (Multiply)         (None, 7, 7, 960)    0
['expanded_conv_14/depthwise/Batc
                                                                hNorm[0][0]',
'tf.math.multiply_25[0][0]']

 expanded_conv_14/squeeze_excit  (None, 1, 1, 960)   0
['multiply_18[0][0]']
 e/AvgPool (GlobalAveragePoolin
 g2D)

 expanded_conv_14/squeeze_excit  (None, 1, 1, 240)   230640
['expanded_conv_14/squeeze_excite
 e/Conv (Conv2D)
/AvgPool[0][0]']

 expanded_conv_14/squeeze_excit  (None, 1, 1, 240)   0
['expanded_conv_14/squeeze_excite
 e/Relu (ReLU)                                                  /Conv[0][0]']

 expanded_conv_14/squeeze_excit  (None, 1, 1, 960)   231360
['expanded_conv_14/squeeze_excite
 e/Conv_1 (Conv2D)                                              /Relu[0][0]']

 tf.__operators__.add_26 (TFOpL  (None, 1, 1, 960)   0
['expanded_conv_14/squeeze_excite
 ambda)                                                         /Conv_1[0][0]']

 re_lu_37 (ReLU)                (None, 1, 1, 960)    0
['tf.__operators__.add_26[0][0]']

 tf.math.multiply_26 (TFOpLambd  (None, 1, 1, 960)   0
['re_lu_37[0][0]']
 a)

 expanded_conv_14/squeeze_excit  (None, 7, 7, 960)   0
```

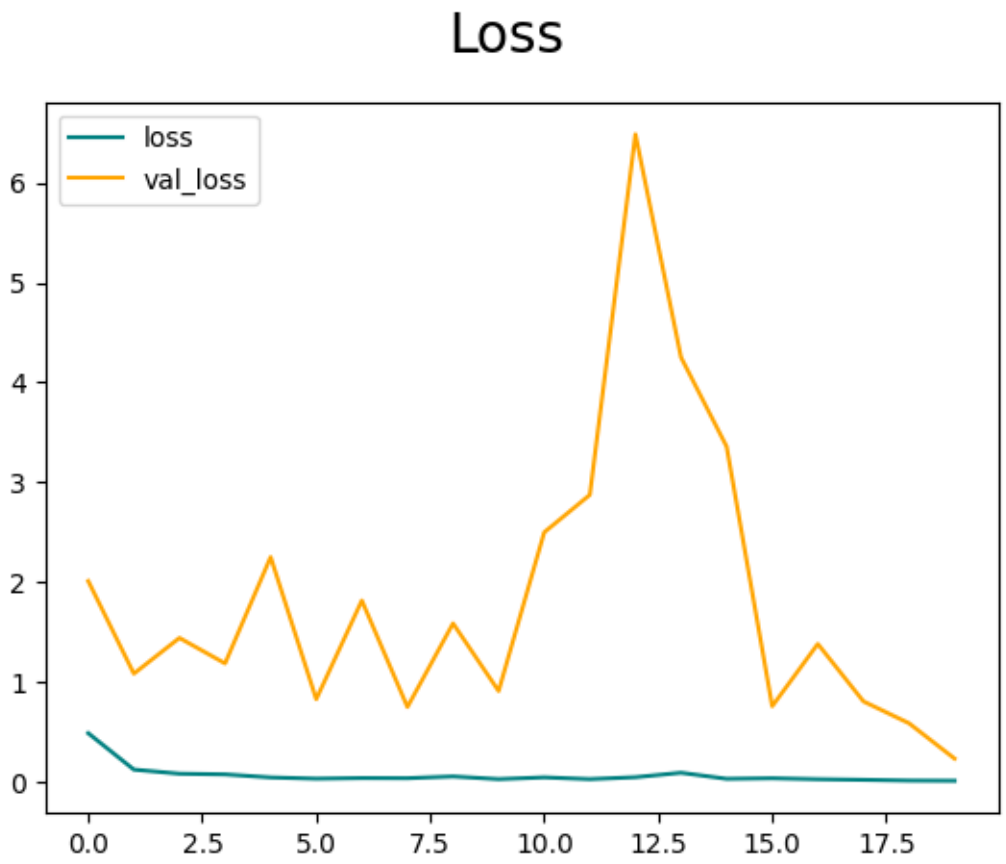
```
['multiply_18[0][0]',
 e/Mul (Multiply)
'tf.math.multiply_26[0][0]']

 expanded_conv_14/project (Conv  (None, 7, 7, 160)   153600
['expanded_conv_14/squeeze_excite
 2D)                                                          /Mul[0][0]']

 expanded_conv_14/project/Batch  (None, 7, 7, 160)   640
['expanded_conv_14/project[0][0]'
 Norm (BatchNormalization)                                    ]

 expanded_conv_14/Add (Add)     (None, 7, 7, 160)    0
['expanded_conv_13/Add[0][0]',
'expanded_conv_14/project/BatchN
                                                              orm[0][0]']

 Conv_1 (Conv2D)                (None, 7, 7, 960)    153600
['expanded_conv_14/Add[0][0]']

 Conv_1/BatchNorm (BatchNormali  (None, 7, 7, 960)   3840
['Conv_1[0][0]']
 zation)

 tf.__operators__.add_27 (TFOpL  (None, 7, 7, 960)   0
['Conv_1/BatchNorm[0][0]']
 ambda)

 re_lu_38 (ReLU)                (None, 7, 7, 960)    0
['tf.__operators__.add_27[0][0]']

 tf.math.multiply_27 (TFOpLambd  (None, 7, 7, 960)   0
['re_lu_38[0][0]']
 a)

 multiply_19 (Multiply)         (None, 7, 7, 960)    0
['Conv_1/BatchNorm[0][0]',
'tf.math.multiply_27[0][0]']

==================================================================================
==================
Total params: 2,996,352
Trainable params: 2,971,952
Non-trainable params: 24,400
----------------------------------------------------------------------------------
------------------
```

[8]:
```
x = base_model.output
x = GlobalAveragePooling2D()(x)
output = Dense(num_classes, activation='softmax')(x)
model = Model(inputs=base_model.input, outputs=output)

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir='logs')

hist = model.fit(train_data, epochs=20, validation_data=val_data,␣
 ↪callbacks=[tensorboard_callback])
```

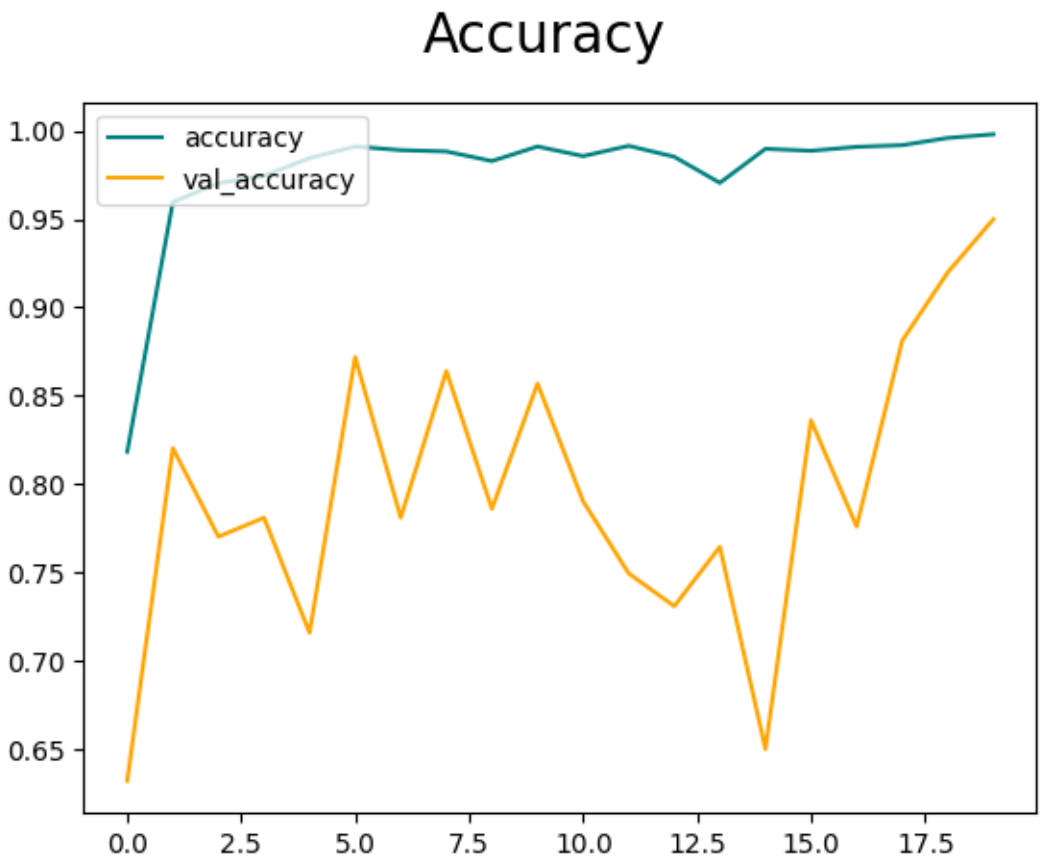
```
Epoch 1/20
168/168 [==============================] - 17s 60ms/step - loss: 0.4880 -
accuracy: 0.8183 - val_loss: 2.0115 - val_accuracy: 0.6321
Epoch 2/20
168/168 [==============================] - 10s 60ms/step - loss: 0.1235 -
accuracy: 0.9596 - val_loss: 1.0839 - val_accuracy: 0.8203
Epoch 3/20
168/168 [==============================] - 9s 55ms/step - loss: 0.0823 -
accuracy: 0.9703 - val_loss: 1.4419 - val_accuracy: 0.7702
Epoch 4/20
168/168 [==============================] - 9s 55ms/step - loss: 0.0756 -
accuracy: 0.9744 - val_loss: 1.1865 - val_accuracy: 0.7810
Epoch 5/20
168/168 [==============================] - 9s 55ms/step - loss: 0.0449 -
accuracy: 0.9845 - val_loss: 2.2512 - val_accuracy: 0.7158
Epoch 6/20
168/168 [==============================] - 10s 56ms/step - loss: 0.0327 -
accuracy: 0.9910 - val_loss: 0.8285 - val_accuracy: 0.8719
Epoch 7/20
168/168 [==============================] - 10s 56ms/step - loss: 0.0387 -
accuracy: 0.9890 - val_loss: 1.8162 - val_accuracy: 0.7810
Epoch 8/20
168/168 [==============================] - 10s 56ms/step - loss: 0.0375 -
accuracy: 0.9882 - val_loss: 0.7503 - val_accuracy: 0.8640
Epoch 9/20
168/168 [==============================] - 10s 57ms/step - loss: 0.0549 -
accuracy: 0.9828 - val_loss: 1.5872 - val_accuracy: 0.7860
Epoch 10/20
168/168 [==============================] - 9s 55ms/step - loss: 0.0279 -
accuracy: 0.9910 - val_loss: 0.9103 - val_accuracy: 0.8568
Epoch 11/20
168/168 [==============================] - 10s 56ms/step - loss: 0.0456 -
accuracy: 0.9856 - val_loss: 2.4992 - val_accuracy: 0.7903
Epoch 12/20
```

```
168/168 [==============================] - 9s 55ms/step - loss: 0.0279 -
accuracy: 0.9914 - val_loss: 2.8744 - val_accuracy: 0.7495
Epoch 13/20
168/168 [==============================] - 10s 61ms/step - loss: 0.0473 -
accuracy: 0.9852 - val_loss: 6.4843 - val_accuracy: 0.7309
Epoch 14/20
168/168 [==============================] - 9s 54ms/step - loss: 0.0919 -
accuracy: 0.9705 - val_loss: 4.2515 - val_accuracy: 0.7645
Epoch 15/20
168/168 [==============================] - 9s 54ms/step - loss: 0.0311 -
accuracy: 0.9897 - val_loss: 3.3578 - val_accuracy: 0.6500
Epoch 16/20
168/168 [==============================] - 9s 55ms/step - loss: 0.0367 -
accuracy: 0.9886 - val_loss: 0.7579 - val_accuracy: 0.8361
Epoch 17/20
168/168 [==============================] - 9s 53ms/step - loss: 0.0270 -
accuracy: 0.9908 - val_loss: 1.3820 - val_accuracy: 0.7759
Epoch 18/20
168/168 [==============================] - 9s 53ms/step - loss: 0.0210 -
accuracy: 0.9918 - val_loss: 0.8066 - val_accuracy: 0.8812
Epoch 19/20
168/168 [==============================] - 9s 54ms/step - loss: 0.0136 -
accuracy: 0.9959 - val_loss: 0.5875 - val_accuracy: 0.9198
Epoch 20/20
168/168 [==============================] - 9s 54ms/step - loss: 0.0115 -
accuracy: 0.9979 - val_loss: 0.2333 - val_accuracy: 0.9499
```

[9]:
```
fig = plt.figure()
plt .plot(hist.history['loss'], color='teal', label='loss')
plt.plot(hist.history['val_loss'], color='orange', label='val_loss')
fig.suptitle('Loss', fontsize=20)
plt.legend(loc="upper left")
plt.show()
```



[10]:
```
fig = plt.figure()
plt.plot(hist.history['accuracy'], color='teal', label='accuracy')
plt.plot(hist.history['val_accuracy'], color='orange', label='val_accuracy')
fig.suptitle('Accuracy', fontsize=20)
plt.legend(loc="upper left")
plt.show()
```



[11]:
```
pre = Precision()
re = Recall()
acc = SparseCategoricalAccuracy()
```

[12]:
```
for batch in test_data.as_numpy_iterator():
    X, y = batch
    yhat = model.predict(X)

    yhat_classes = tf.argmax(yhat, axis=1)

    pre.update_state(y, yhat_classes)
    re.update_state(y, yhat_classes)
    acc.update_state(y, yhat)
```

```
1/1 [==============================] - 0s 474ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 25ms/step
```

```
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 469ms/step
```

[13]:
```
print(f"Precision: {pre.result().numpy() * 100 : .2f}%")
print(f"Recall: {re.result().numpy() * 100 : .2f}%")
print(f"Accuracy: {acc.result().numpy() * 100 : .2f}%")
```

```
Precision:  99.52%
Recall:  98.41%
Accuracy:  95.51%
```

[14]:
```
img = cv2.imread('Styles/test/Hatchback/8_jpg.rf.
 ↪c314c1d6777942876503fa1482c82240.jpg')

img_resized = cv2.resize(img, img_size)
img_expanded = np.expand_dims(img_resized, axis=0)

yhat = model.predict(img_expanded)
predicted_class = tf.argmax(yhat, axis=1).numpy()[0]

plt.imshow(img)
plt.title(f'Predicted class: {predicted_class}')
plt.axis('off')
plt.show()
```

```
1/1 [==============================] - 1s 678ms/step
```

[15]:
```
print(f'Predicted class is: {class_names[predicted_class]}')
for idx, prob in enumerate(yhat[0]):
    print(f"Model probability for {class_names[idx]} is {prob * 100:.2f}%")
```

```
Predicted class is: Hatchback
Model probability for Convertible is 0.00%
Model probability for Coupe is 0.00%
Model probability for Hatchback is 100.00%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.00%
Model probability for Sedan is 0.00%
Model probability for VAN is 0.00%
```

[16]:
```
model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}%␣
↪MobileNetV3Large.h5"
model.save(os.path.join('models', model_file_name))
```

[ ]:
```

```