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 MobileNetV2
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.
```

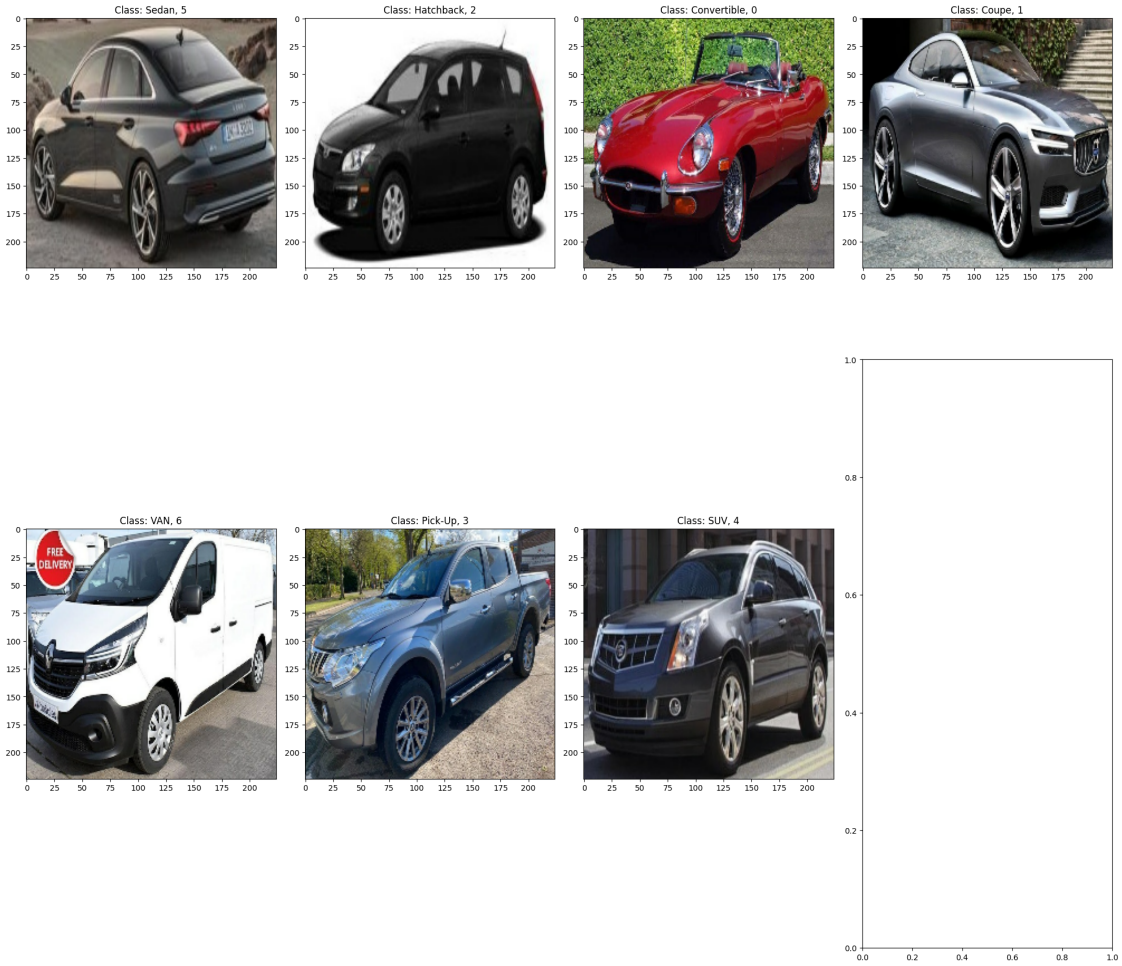
[4]:
```
class_names = train_data.class_names
print("Class names test:", class_names)

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 = MobileNetV2(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)
base_model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
ns/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h
5
9406464/9406464 [==============================] - 0s 0us/step
Model: "mobilenetv2_1.00_224"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 Conv1 (Conv2D)                 (None, 112, 112, 32  864
['input_1[0][0]']
                                )

 bn_Conv1 (BatchNormalization)  (None, 112, 112, 32  128         ['Conv1[0][0]']
                                )

 Conv1_relu (ReLU)              (None, 112, 112, 32  0
['bn_Conv1[0][0]']
                                )

 expanded_conv_depthwise (Depth  (None, 112, 112, 32  288
['Conv1_relu[0][0]']
 wiseConv2D)                    )

 expanded_conv_depthwise_BN (Ba  (None, 112, 112, 32  128
['expanded_conv_depthwise[0][0]']
 tchNormalization)              )

 expanded_conv_depthwise_relu (  (None, 112, 112, 32  0
['expanded_conv_depthwise_BN[0][0
 ReLU)                          )                               ]']

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

```
                                )                                 [0]']

 expanded_conv_project_BN (Batc  (None, 112, 112, 16  64
['expanded_conv_project[0][0]']
 hNormalization)                )

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

 block_1_expand_BN (BatchNormal  (None, 112, 112, 96  384
['block_1_expand[0][0]']
 ization)                       )

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

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

 block_1_depthwise (DepthwiseCo  (None, 56, 56, 96)  864
['block_1_pad[0][0]']
 nv2D)

 block_1_depthwise_BN (BatchNor  (None, 56, 56, 96)  384
['block_1_depthwise[0][0]']
 malization)

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

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

 block_1_project_BN (BatchNorma  (None, 56, 56, 24)  96
['block_1_project[0][0]']
 lization)

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

 block_2_expand_BN (BatchNormal  (None, 56, 56, 144)  576
['block_2_expand[0][0]']
 ization)

 block_2_expand_relu (ReLU)     (None, 56, 56, 144)  0
```

```
['block_2_expand_BN[0][0]']

 block_2_depthwise (DepthwiseCo  (None, 56, 56, 144)  1296
['block_2_expand_relu[0][0]']
 nv2D)

 block_2_depthwise_BN (BatchNor  (None, 56, 56, 144)  576
['block_2_depthwise[0][0]']
 malization)

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

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

 block_2_project_BN (BatchNorma  (None, 56, 56, 24)  96
['block_2_project[0][0]']
 lization)

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

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

 block_3_expand_BN (BatchNormal  (None, 56, 56, 144)  576
['block_3_expand[0][0]']
 ization)

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

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

 block_3_depthwise (DepthwiseCo  (None, 28, 28, 144)  1296
['block_3_pad[0][0]']
 nv2D)

 block_3_depthwise_BN (BatchNor  (None, 28, 28, 144)  576
['block_3_depthwise[0][0]']
 malization)

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

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

 block_3_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_3_project[0][0]']
 lization)

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

 block_4_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_4_expand[0][0]']
 ization)

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

 block_4_depthwise (DepthwiseCo  (None, 28, 28, 192)  1728
['block_4_expand_relu[0][0]']
 nv2D)

 block_4_depthwise_BN (BatchNor  (None, 28, 28, 192)  768
['block_4_depthwise[0][0]']
 malization)

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

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

 block_4_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_4_project[0][0]']
 lization)

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

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

 block_5_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_5_expand[0][0]']
 ization)

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

```
 block_5_depthwise (DepthwiseCo  (None, 28, 28, 192)  1728
['block_5_expand_relu[0][0]']
 nv2D)

 block_5_depthwise_BN (BatchNor  (None, 28, 28, 192)  768
['block_5_depthwise[0][0]']
 malization)

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

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

 block_5_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_5_project[0][0]']
 lization)

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

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

 block_6_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_6_expand[0][0]']
 ization)

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

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

 block_6_depthwise (DepthwiseCo  (None, 14, 14, 192)  1728
['block_6_pad[0][0]']
 nv2D)

 block_6_depthwise_BN (BatchNor  (None, 14, 14, 192)  768
['block_6_depthwise[0][0]']
 malization)

 block_6_depthwise_relu (ReLU)  (None, 14, 14, 192)  0
['block_6_depthwise_BN[0][0]']

 block_6_project (Conv2D)       (None, 14, 14, 64)   12288
```

```
['block_6_depthwise_relu[0][0]']

 block_6_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_6_project[0][0]']
 lization)

 block_7_expand (Conv2D)        (None, 14, 14, 384)  24576
['block_6_project_BN[0][0]']

 block_7_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_7_expand[0][0]']
 ization)

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

 block_7_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_7_expand_relu[0][0]']
 nv2D)

 block_7_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
['block_7_depthwise[0][0]']
 malization)

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

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

 block_7_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_7_project[0][0]']
 lization)

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

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

 block_8_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_8_expand[0][0]']
 ization)

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

```
 block_8_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_8_expand_relu[0][0]']
 nv2D)

 block_8_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
['block_8_depthwise[0][0]']
 malization)

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

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

 block_8_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_8_project[0][0]']
 lization)

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

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

 block_9_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_9_expand[0][0]']
 ization)

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

 block_9_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_9_expand_relu[0][0]']
 nv2D)

 block_9_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
['block_9_depthwise[0][0]']
 malization)

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

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

 block_9_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_9_project[0][0]']
```

```
 lization)

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

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

 block_10_expand_BN (BatchNorma  (None, 14, 14, 384)  1536
['block_10_expand[0][0]']
 lization)

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

 block_10_depthwise (DepthwiseC  (None, 14, 14, 384)  3456
['block_10_expand_relu[0][0]']
 onv2D)

 block_10_depthwise_BN (BatchNo  (None, 14, 14, 384)  1536
['block_10_depthwise[0][0]']
 rmalization)

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

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

 block_10_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_10_project[0][0]']
 alization)

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

 block_11_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_11_expand[0][0]']
 lization)

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

 block_11_depthwise (DepthwiseC  (None, 14, 14, 576)  5184
['block_11_expand_relu[0][0]']
 onv2D)
```

```
 block_11_depthwise_BN (BatchNo  (None, 14, 14, 576)  2304
['block_11_depthwise[0][0]']
 rmalization)

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

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

 block_11_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_11_project[0][0]']
 alization)

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

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

 block_12_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_12_expand[0][0]']
 lization)

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

 block_12_depthwise (DepthwiseC  (None, 14, 14, 576)  5184
['block_12_expand_relu[0][0]']
 onv2D)

 block_12_depthwise_BN (BatchNo  (None, 14, 14, 576)  2304
['block_12_depthwise[0][0]']
 rmalization)

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

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

 block_12_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_12_project[0][0]']
 alization)

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

```
'block_12_project_BN[0][0]']

 block_13_expand (Conv2D)       (None, 14, 14, 576)  55296
['block_12_add[0][0]']

 block_13_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_13_expand[0][0]']
 lization)

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

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

 block_13_depthwise (DepthwiseC  (None, 7, 7, 576)   5184
['block_13_pad[0][0]']
 onv2D)

 block_13_depthwise_BN (BatchNo  (None, 7, 7, 576)   2304
['block_13_depthwise[0][0]']
 rmalization)

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

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

 block_13_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_13_project[0][0]']
 alization)

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

 block_14_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
['block_14_expand[0][0]']
 lization)

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

 block_14_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_14_expand_relu[0][0]']
 onv2D)

 block_14_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
```

```
['block_14_depthwise[0][0]']
 rmalization)

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

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

 block_14_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_14_project[0][0]']
 alization)

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

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

 block_15_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
['block_15_expand[0][0]']
 lization)

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

 block_15_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_15_expand_relu[0][0]']
 onv2D)

 block_15_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
['block_15_depthwise[0][0]']
 rmalization)

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

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

 block_15_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_15_project[0][0]']
 alization)

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

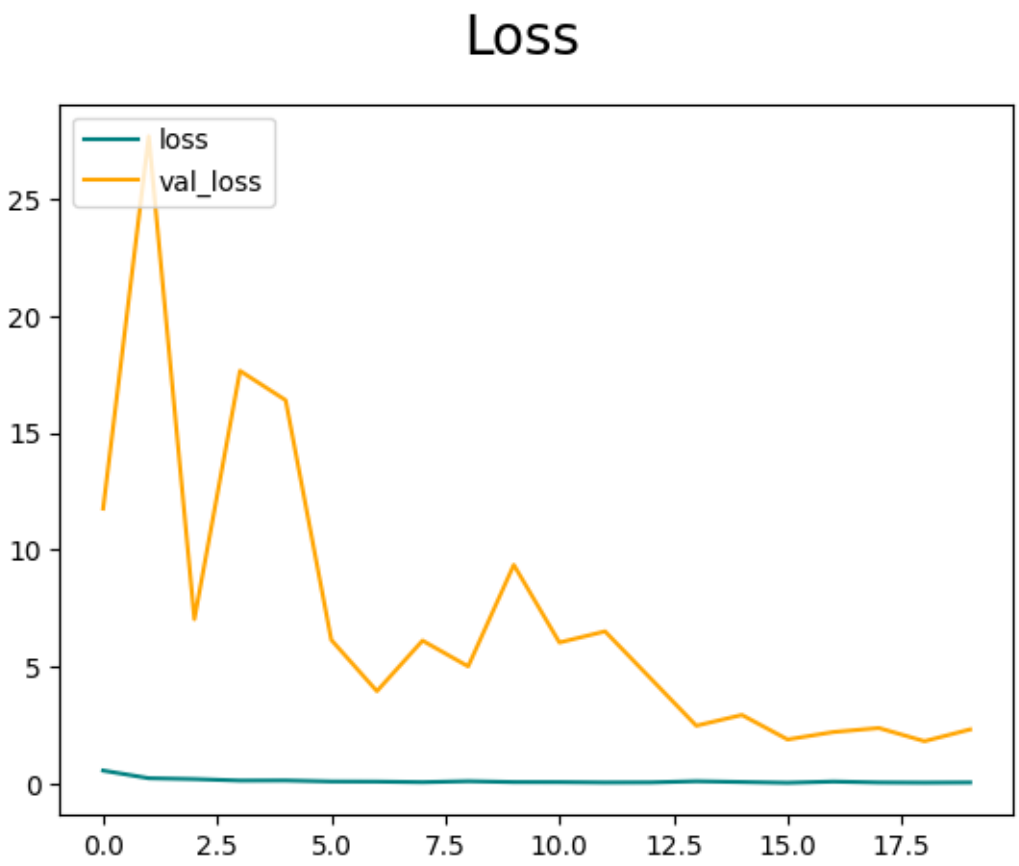
```
 block_16_expand (Conv2D)       (None, 7, 7, 960)    153600
['block_15_add[0][0]']

 block_16_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
['block_16_expand[0][0]']
 lization)

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

 block_16_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_16_expand_relu[0][0]']
 onv2D)

 block_16_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
['block_16_depthwise[0][0]']
 rmalization)

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

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

 block_16_project_BN (BatchNorm  (None, 7, 7, 320)   1280
['block_16_project[0][0]']
 alization)

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

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

 out_relu (ReLU)                (None, 7, 7, 1280)   0
['Conv_1_bn[0][0]']

==================================================================================
==================
Total params: 2,257,984
Trainable params: 2,223,872
Non-trainable params: 34,112
----------------------------------------------------------------------------------
------------------
```

[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])
```

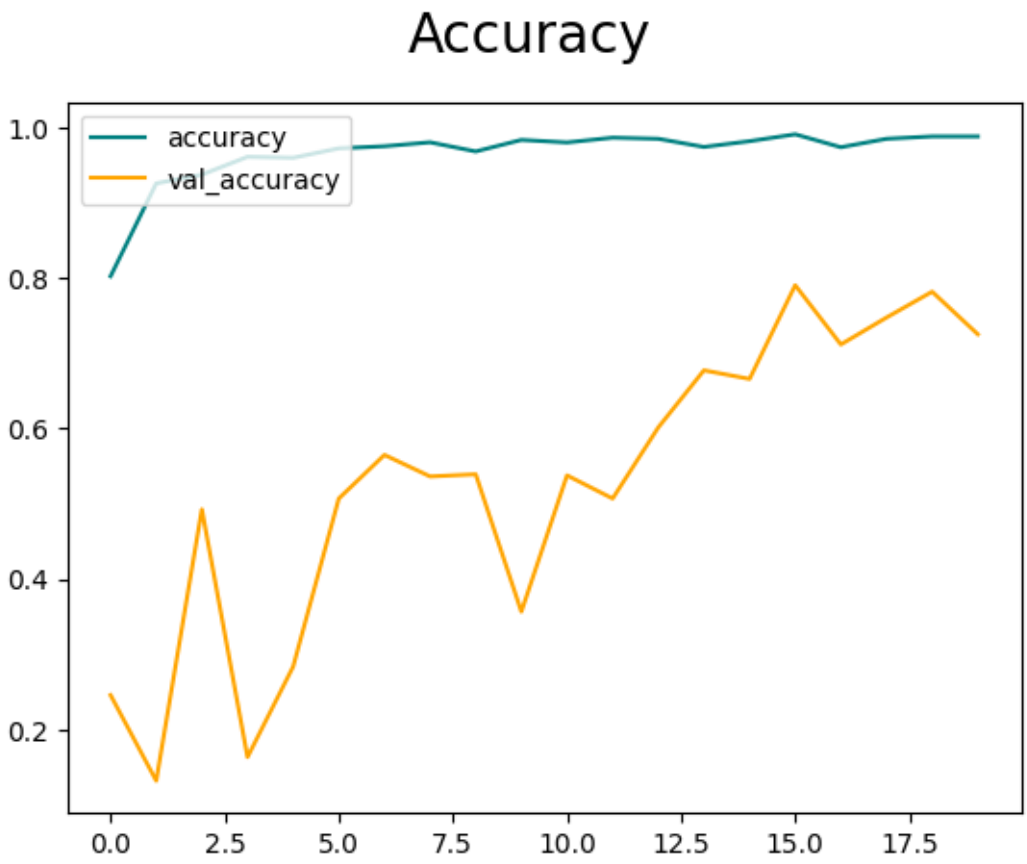
```
Epoch 1/20
168/168 [==============================] - 15s 65ms/step - loss: 0.5505 -
accuracy: 0.8022 - val_loss: 11.7613 - val_accuracy: 0.2455
Epoch 2/20
168/168 [==============================] - 11s 62ms/step - loss: 0.2229 -
accuracy: 0.9256 - val_loss: 27.6928 - val_accuracy: 0.1317
Epoch 3/20
168/168 [==============================] - 11s 62ms/step - loss: 0.1855 -
accuracy: 0.9372 - val_loss: 7.0287 - val_accuracy: 0.4925
Epoch 4/20
168/168 [==============================] - 11s 62ms/step - loss: 0.1231 -
accuracy: 0.9609 - val_loss: 17.6550 - val_accuracy: 0.1632
Epoch 5/20
168/168 [==============================] - 11s 62ms/step - loss: 0.1268 -
accuracy: 0.9596 - val_loss: 16.3998 - val_accuracy: 0.2835
Epoch 6/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0822 -
accuracy: 0.9721 - val_loss: 6.1426 - val_accuracy: 0.5068
Epoch 7/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0771 -
accuracy: 0.9750 - val_loss: 3.9482 - val_accuracy: 0.5648
Epoch 8/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0538 -
accuracy: 0.9802 - val_loss: 6.1115 - val_accuracy: 0.5361
Epoch 9/20
168/168 [==============================] - 11s 61ms/step - loss: 0.0937 -
accuracy: 0.9680 - val_loss: 5.0081 - val_accuracy: 0.5390
Epoch 10/20
168/168 [==============================] - 11s 63ms/step - loss: 0.0581 -
accuracy: 0.9834 - val_loss: 9.3525 - val_accuracy: 0.3565
Epoch 11/20
168/168 [==============================] - 11s 66ms/step - loss: 0.0559 -
accuracy: 0.9800 - val_loss: 6.0319 - val_accuracy: 0.5376
Epoch 12/20
```

```
168/168 [==============================] - 11s 65ms/step - loss: 0.0412 -
accuracy: 0.9864 - val_loss: 6.5066 - val_accuracy: 0.5068
Epoch 13/20
168/168 [==============================] - 11s 66ms/step - loss: 0.0445 -
accuracy: 0.9849 - val_loss: 4.4906 - val_accuracy: 0.6013
Epoch 14/20
168/168 [==============================] - 11s 66ms/step - loss: 0.0928 -
accuracy: 0.9740 - val_loss: 2.4691 - val_accuracy: 0.6772
Epoch 15/20
168/168 [==============================] - 11s 66ms/step - loss: 0.0603 -
accuracy: 0.9817 - val_loss: 2.9308 - val_accuracy: 0.6657
Epoch 16/20
168/168 [==============================] - 12s 68ms/step - loss: 0.0277 -
accuracy: 0.9908 - val_loss: 1.8812 - val_accuracy: 0.7903
Epoch 17/20
168/168 [==============================] - 12s 68ms/step - loss: 0.0790 -
accuracy: 0.9736 - val_loss: 2.1983 - val_accuracy: 0.7115
Epoch 18/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0411 -
accuracy: 0.9849 - val_loss: 2.3711 - val_accuracy: 0.7473
Epoch 19/20
168/168 [==============================] - 11s 66ms/step - loss: 0.0329 -
accuracy: 0.9880 - val_loss: 1.8073 - val_accuracy: 0.7817
Epoch 20/20
168/168 [==============================] - 12s 68ms/step - loss: 0.0406 -
accuracy: 0.9880 - val_loss: 2.3098 - val_accuracy: 0.7251
```

[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 394ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 25ms/step
```

```
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 446ms/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:  88.83%
Recall:  100.00%
Accuracy:  71.57%
```

[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 [==============================] - 0s 406ms/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 99.94%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.00%
Model probability for Sedan is 0.06%
Model probability for VAN is 0.00%
```

[16]:
```
model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}% MobileNetV2.h5"
model.save(os.path.join('models', model_file_name))
```

[ ]:
```

```