CarStyle

October 2, 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 EfficientNetV2B0
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.
```

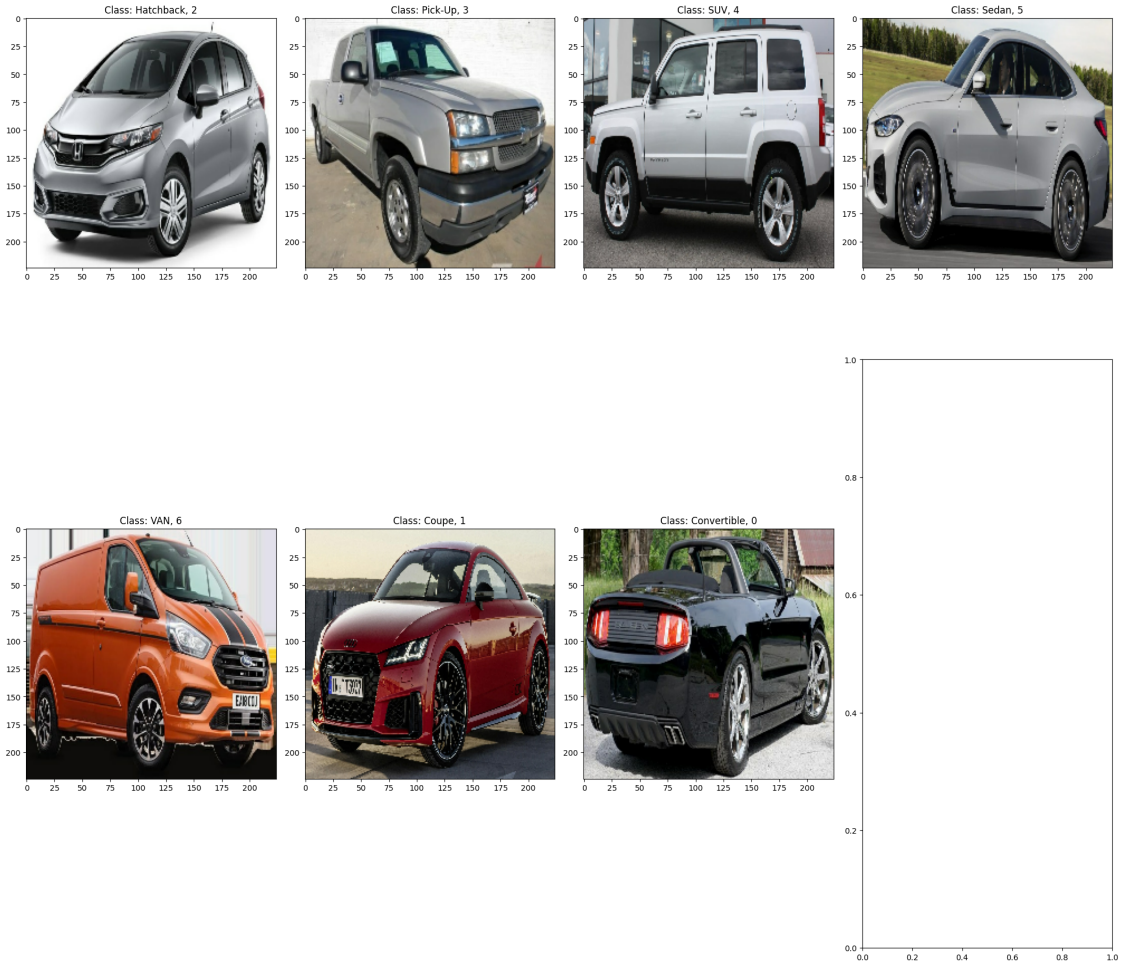
[4]:
```
class_names = train_data.class_names
print("Class names test:", class_names)

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 = EfficientNetV2B0(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)
base_model.summary()
```

```
Model: "efficientnetv2-b0"
__________________________________________________________________________________________________
 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]']

 normalization (Normalization)  (None, 224, 224, 3)  0
['rescaling[0][0]']

 stem_conv (Conv2D)             (None, 112, 112, 32  864
['normalization[0][0]']
                                )

 stem_bn (BatchNormalization)   (None, 112, 112, 32  128
['stem_conv[0][0]']
                                )

 stem_activation (Activation)   (None, 112, 112, 32  0
['stem_bn[0][0]']
                                )

 block1a_project_conv (Conv2D)  (None, 112, 112, 16  4608
['stem_activation[0][0]']
                                )

 block1a_project_bn (BatchNorma  (None, 112, 112, 16  64
['block1a_project_conv[0][0]']
 lization)                      )

 block1a_project_activation (Ac  (None, 112, 112, 16  0
['block1a_project_bn[0][0]']
 tivation)                      )
```

```
 block2a_expand_conv (Conv2D)   (None, 56, 56, 64)   9216
['block1a_project_activation[0][0
                                                                ]']

 block2a_expand_bn (BatchNormal  (None, 56, 56, 64)  256
['block2a_expand_conv[0][0]']
 ization)

 block2a_expand_activation (Act  (None, 56, 56, 64)  0
['block2a_expand_bn[0][0]']
 ivation)

 block2a_project_conv (Conv2D)  (None, 56, 56, 32)   2048
['block2a_expand_activation[0][0]
                                                                ']

 block2a_project_bn (BatchNorma  (None, 56, 56, 32)  128
['block2a_project_conv[0][0]']
 lization)

 block2b_expand_conv (Conv2D)   (None, 56, 56, 128)  36864
['block2a_project_bn[0][0]']

 block2b_expand_bn (BatchNormal  (None, 56, 56, 128)  512
['block2b_expand_conv[0][0]']
 ization)

 block2b_expand_activation (Act  (None, 56, 56, 128)  0
['block2b_expand_bn[0][0]']
 ivation)

 block2b_project_conv (Conv2D)  (None, 56, 56, 32)   4096
['block2b_expand_activation[0][0]
                                                                ']

 block2b_project_bn (BatchNorma  (None, 56, 56, 32)  128
['block2b_project_conv[0][0]']
 lization)

 block2b_drop (Dropout)         (None, 56, 56, 32)   0
['block2b_project_bn[0][0]']

 block2b_add (Add)              (None, 56, 56, 32)   0
['block2b_drop[0][0]',
'block2a_project_bn[0][0]']

 block3a_expand_conv (Conv2D)   (None, 28, 28, 128)  36864
```

```
['block2b_add[0][0]']

 block3a_expand_bn (BatchNormal  (None, 28, 28, 128)  512
['block3a_expand_conv[0][0]']
 ization)

 block3a_expand_activation (Act  (None, 28, 28, 128)  0
['block3a_expand_bn[0][0]']
 ivation)

 block3a_project_conv (Conv2D)  (None, 28, 28, 48)   6144
['block3a_expand_activation[0][0]
                                                                 ']

 block3a_project_bn (BatchNorma  (None, 28, 28, 48)  192
['block3a_project_conv[0][0]']
 lization)

 block3b_expand_conv (Conv2D)   (None, 28, 28, 192)  82944
['block3a_project_bn[0][0]']

 block3b_expand_bn (BatchNormal  (None, 28, 28, 192)  768
['block3b_expand_conv[0][0]']
 ization)

 block3b_expand_activation (Act  (None, 28, 28, 192)  0
['block3b_expand_bn[0][0]']
 ivation)

 block3b_project_conv (Conv2D)  (None, 28, 28, 48)   9216
['block3b_expand_activation[0][0]
                                                                 ']

 block3b_project_bn (BatchNorma  (None, 28, 28, 48)  192
['block3b_project_conv[0][0]']
 lization)

 block3b_drop (Dropout)         (None, 28, 28, 48)   0
['block3b_project_bn[0][0]']

 block3b_add (Add)              (None, 28, 28, 48)   0
['block3b_drop[0][0]',
'block3a_project_bn[0][0]']

 block4a_expand_conv (Conv2D)   (None, 28, 28, 192)  9216
['block3b_add[0][0]']

 block4a_expand_bn (BatchNormal  (None, 28, 28, 192)  768
```

```
['block4a_expand_conv[0][0]']
 ization)

 block4a_expand_activation (Act  (None, 28, 28, 192)  0
['block4a_expand_bn[0][0]']
 ivation)

 block4a_dwconv2 (DepthwiseConv  (None, 14, 14, 192)  1728
['block4a_expand_activation[0][0]
 2D)                                                                ']

 block4a_bn (BatchNormalization  (None, 14, 14, 192)  768
['block4a_dwconv2[0][0]']
 )

 block4a_activation (Activation  (None, 14, 14, 192)  0
['block4a_bn[0][0]']
 )

 block4a_se_squeeze (GlobalAver  (None, 192)         0
['block4a_activation[0][0]']
 agePooling2D)

 block4a_se_reshape (Reshape)   (None, 1, 1, 192)    0
['block4a_se_squeeze[0][0]']

 block4a_se_reduce (Conv2D)     (None, 1, 1, 12)     2316
['block4a_se_reshape[0][0]']

 block4a_se_expand (Conv2D)     (None, 1, 1, 192)    2496
['block4a_se_reduce[0][0]']

 block4a_se_excite (Multiply)   (None, 14, 14, 192)  0
['block4a_activation[0][0]',
'block4a_se_expand[0][0]']

 block4a_project_conv (Conv2D)  (None, 14, 14, 96)   18432
['block4a_se_excite[0][0]']

 block4a_project_bn (BatchNorma  (None, 14, 14, 96)  384
['block4a_project_conv[0][0]']
 lization)

 block4b_expand_conv (Conv2D)   (None, 14, 14, 384)  36864
['block4a_project_bn[0][0]']

 block4b_expand_bn (BatchNormal  (None, 14, 14, 384)  1536
['block4b_expand_conv[0][0]']
```

```
 ization)

 block4b_expand_activation (Act  (None, 14, 14, 384)  0
['block4b_expand_bn[0][0]']
 ivation)

 block4b_dwconv2 (DepthwiseConv  (None, 14, 14, 384)  3456
['block4b_expand_activation[0][0]
 2D)                                                              ']

 block4b_bn (BatchNormalization  (None, 14, 14, 384)  1536
['block4b_dwconv2[0][0]']
 )

 block4b_activation (Activation  (None, 14, 14, 384)  0
['block4b_bn[0][0]']
 )

 block4b_se_squeeze (GlobalAver  (None, 384)         0
['block4b_activation[0][0]']
 agePooling2D)

 block4b_se_reshape (Reshape)   (None, 1, 1, 384)    0
['block4b_se_squeeze[0][0]']

 block4b_se_reduce (Conv2D)     (None, 1, 1, 24)     9240
['block4b_se_reshape[0][0]']

 block4b_se_expand (Conv2D)     (None, 1, 1, 384)    9600
['block4b_se_reduce[0][0]']

 block4b_se_excite (Multiply)   (None, 14, 14, 384)  0
['block4b_activation[0][0]',
'block4b_se_expand[0][0]']

 block4b_project_conv (Conv2D)  (None, 14, 14, 96)   36864
['block4b_se_excite[0][0]']

 block4b_project_bn (BatchNorma  (None, 14, 14, 96)  384
['block4b_project_conv[0][0]']
 lization)

 block4b_drop (Dropout)         (None, 14, 14, 96)   0
['block4b_project_bn[0][0]']

 block4b_add (Add)              (None, 14, 14, 96)   0
['block4b_drop[0][0]',
'block4a_project_bn[0][0]']
```

```
 block4c_expand_conv (Conv2D)   (None, 14, 14, 384)  36864
['block4b_add[0][0]']

 block4c_expand_bn (BatchNormal  (None, 14, 14, 384)  1536
['block4c_expand_conv[0][0]']
 ization)

 block4c_expand_activation (Act  (None, 14, 14, 384)  0
['block4c_expand_bn[0][0]']
 ivation)

 block4c_dwconv2 (DepthwiseConv  (None, 14, 14, 384)  3456
['block4c_expand_activation[0][0]
 2D)                                                              ']

 block4c_bn (BatchNormalization  (None, 14, 14, 384)  1536
['block4c_dwconv2[0][0]']
 )

 block4c_activation (Activation  (None, 14, 14, 384)  0
['block4c_bn[0][0]']
 )

 block4c_se_squeeze (GlobalAver  (None, 384)         0
['block4c_activation[0][0]']
 agePooling2D)

 block4c_se_reshape (Reshape)   (None, 1, 1, 384)    0
['block4c_se_squeeze[0][0]']

 block4c_se_reduce (Conv2D)     (None, 1, 1, 24)     9240
['block4c_se_reshape[0][0]']

 block4c_se_expand (Conv2D)     (None, 1, 1, 384)    9600
['block4c_se_reduce[0][0]']

 block4c_se_excite (Multiply)   (None, 14, 14, 384)  0
['block4c_activation[0][0]',
'block4c_se_expand[0][0]']

 block4c_project_conv (Conv2D)  (None, 14, 14, 96)   36864
['block4c_se_excite[0][0]']

 block4c_project_bn (BatchNorma  (None, 14, 14, 96)  384
['block4c_project_conv[0][0]']
 lization)
```

```
 block4c_drop (Dropout)         (None, 14, 14, 96)   0
['block4c_project_bn[0][0]']

 block4c_add (Add)              (None, 14, 14, 96)   0
['block4c_drop[0][0]',
'block4b_add[0][0]']

 block5a_expand_conv (Conv2D)   (None, 14, 14, 576)  55296
['block4c_add[0][0]']

 block5a_expand_bn (BatchNormal  (None, 14, 14, 576)  2304
['block5a_expand_conv[0][0]']
 ization)

 block5a_expand_activation (Act  (None, 14, 14, 576)  0
['block5a_expand_bn[0][0]']
 ivation)

 block5a_dwconv2 (DepthwiseConv  (None, 14, 14, 576)  5184
['block5a_expand_activation[0][0]
 2D)                                                              ']

 block5a_bn (BatchNormalization  (None, 14, 14, 576)  2304
['block5a_dwconv2[0][0]']
 )

 block5a_activation (Activation  (None, 14, 14, 576)  0
['block5a_bn[0][0]']
 )

 block5a_se_squeeze (GlobalAver  (None, 576)         0
['block5a_activation[0][0]']
 agePooling2D)

 block5a_se_reshape (Reshape)   (None, 1, 1, 576)    0
['block5a_se_squeeze[0][0]']

 block5a_se_reduce (Conv2D)     (None, 1, 1, 24)     13848
['block5a_se_reshape[0][0]']

 block5a_se_expand (Conv2D)     (None, 1, 1, 576)    14400
['block5a_se_reduce[0][0]']

 block5a_se_excite (Multiply)   (None, 14, 14, 576)  0
['block5a_activation[0][0]',
'block5a_se_expand[0][0]']

 block5a_project_conv (Conv2D)  (None, 14, 14, 112)  64512
```

```
['block5a_se_excite[0][0]']

 block5a_project_bn (BatchNorma  (None, 14, 14, 112)  448
['block5a_project_conv[0][0]']
 lization)

 block5b_expand_conv (Conv2D)   (None, 14, 14, 672)  75264
['block5a_project_bn[0][0]']

 block5b_expand_bn (BatchNormal  (None, 14, 14, 672)  2688
['block5b_expand_conv[0][0]']
 ization)

 block5b_expand_activation (Act  (None, 14, 14, 672)  0
['block5b_expand_bn[0][0]']
 ivation)

 block5b_dwconv2 (DepthwiseConv  (None, 14, 14, 672)  6048
['block5b_expand_activation[0][0]
 2D)                                                              ']

 block5b_bn (BatchNormalization  (None, 14, 14, 672)  2688
['block5b_dwconv2[0][0]']
 )

 block5b_activation (Activation  (None, 14, 14, 672)  0
['block5b_bn[0][0]']
 )

 block5b_se_squeeze (GlobalAver  (None, 672)         0
['block5b_activation[0][0]']
 agePooling2D)

 block5b_se_reshape (Reshape)   (None, 1, 1, 672)    0
['block5b_se_squeeze[0][0]']

 block5b_se_reduce (Conv2D)     (None, 1, 1, 28)     18844
['block5b_se_reshape[0][0]']

 block5b_se_expand (Conv2D)     (None, 1, 1, 672)    19488
['block5b_se_reduce[0][0]']

 block5b_se_excite (Multiply)   (None, 14, 14, 672)  0
['block5b_activation[0][0]',
'block5b_se_expand[0][0]']

 block5b_project_conv (Conv2D)  (None, 14, 14, 112)  75264
['block5b_se_excite[0][0]']
```

```
 block5b_project_bn (BatchNorma  (None, 14, 14, 112)  448
['block5b_project_conv[0][0]']
 lization)

 block5b_drop (Dropout)         (None, 14, 14, 112)  0
['block5b_project_bn[0][0]']

 block5b_add (Add)              (None, 14, 14, 112)  0
['block5b_drop[0][0]',
'block5a_project_bn[0][0]']

 block5c_expand_conv (Conv2D)   (None, 14, 14, 672)  75264
['block5b_add[0][0]']

 block5c_expand_bn (BatchNormal  (None, 14, 14, 672)  2688
['block5c_expand_conv[0][0]']
 ization)

 block5c_expand_activation (Act  (None, 14, 14, 672)  0
['block5c_expand_bn[0][0]']
 ivation)

 block5c_dwconv2 (DepthwiseConv  (None, 14, 14, 672)  6048
['block5c_expand_activation[0][0]
 2D)                                                              ']

 block5c_bn (BatchNormalization  (None, 14, 14, 672)  2688
['block5c_dwconv2[0][0]']
 )

 block5c_activation (Activation  (None, 14, 14, 672)  0
['block5c_bn[0][0]']
 )

 block5c_se_squeeze (GlobalAver  (None, 672)         0
['block5c_activation[0][0]']
 agePooling2D)

 block5c_se_reshape (Reshape)   (None, 1, 1, 672)    0
['block5c_se_squeeze[0][0]']

 block5c_se_reduce (Conv2D)     (None, 1, 1, 28)     18844
['block5c_se_reshape[0][0]']

 block5c_se_expand (Conv2D)     (None, 1, 1, 672)    19488
['block5c_se_reduce[0][0]']
```

```
 block5c_se_excite (Multiply)   (None, 14, 14, 672)  0
['block5c_activation[0][0]',
'block5c_se_expand[0][0]']

 block5c_project_conv (Conv2D)  (None, 14, 14, 112)  75264
['block5c_se_excite[0][0]']

 block5c_project_bn (BatchNorma  (None, 14, 14, 112)  448
['block5c_project_conv[0][0]']
 lization)

 block5c_drop (Dropout)         (None, 14, 14, 112)  0
['block5c_project_bn[0][0]']

 block5c_add (Add)              (None, 14, 14, 112)  0
['block5c_drop[0][0]',
'block5b_add[0][0]']

 block5d_expand_conv (Conv2D)   (None, 14, 14, 672)  75264
['block5c_add[0][0]']

 block5d_expand_bn (BatchNormal  (None, 14, 14, 672)  2688
['block5d_expand_conv[0][0]']
 ization)

 block5d_expand_activation (Act  (None, 14, 14, 672)  0
['block5d_expand_bn[0][0]']
 ivation)

 block5d_dwconv2 (DepthwiseConv  (None, 14, 14, 672)  6048
['block5d_expand_activation[0][0]
 2D)                                                              ']

 block5d_bn (BatchNormalization  (None, 14, 14, 672)  2688
['block5d_dwconv2[0][0]']
 )

 block5d_activation (Activation  (None, 14, 14, 672)  0
['block5d_bn[0][0]']
 )

 block5d_se_squeeze (GlobalAver  (None, 672)         0
['block5d_activation[0][0]']
 agePooling2D)

 block5d_se_reshape (Reshape)   (None, 1, 1, 672)    0
['block5d_se_squeeze[0][0]']
```

```
 block5d_se_reduce (Conv2D)     (None, 1, 1, 28)     18844
['block5d_se_reshape[0][0]']

 block5d_se_expand (Conv2D)     (None, 1, 1, 672)    19488
['block5d_se_reduce[0][0]']

 block5d_se_excite (Multiply)   (None, 14, 14, 672)  0
['block5d_activation[0][0]',
'block5d_se_expand[0][0]']

 block5d_project_conv (Conv2D)  (None, 14, 14, 112)  75264
['block5d_se_excite[0][0]']

 block5d_project_bn (BatchNorma  (None, 14, 14, 112)  448
['block5d_project_conv[0][0]']
 lization)

 block5d_drop (Dropout)         (None, 14, 14, 112)  0
['block5d_project_bn[0][0]']

 block5d_add (Add)              (None, 14, 14, 112)  0
['block5d_drop[0][0]',
'block5c_add[0][0]']

 block5e_expand_conv (Conv2D)   (None, 14, 14, 672)  75264
['block5d_add[0][0]']

 block5e_expand_bn (BatchNormal  (None, 14, 14, 672)  2688
['block5e_expand_conv[0][0]']
 ization)

 block5e_expand_activation (Act  (None, 14, 14, 672)  0
['block5e_expand_bn[0][0]']
 ivation)

 block5e_dwconv2 (DepthwiseConv  (None, 14, 14, 672)  6048
['block5e_expand_activation[0][0]
 2D)                                                              ']

 block5e_bn (BatchNormalization  (None, 14, 14, 672)  2688
['block5e_dwconv2[0][0]']
 )

 block5e_activation (Activation  (None, 14, 14, 672)  0
['block5e_bn[0][0]']
 )

 block5e_se_squeeze (GlobalAver  (None, 672)         0
```

```
['block5e_activation[0][0]']
 agePooling2D)

 block5e_se_reshape (Reshape)   (None, 1, 1, 672)    0
['block5e_se_squeeze[0][0]']

 block5e_se_reduce (Conv2D)     (None, 1, 1, 28)     18844
['block5e_se_reshape[0][0]']

 block5e_se_expand (Conv2D)     (None, 1, 1, 672)    19488
['block5e_se_reduce[0][0]']

 block5e_se_excite (Multiply)   (None, 14, 14, 672)  0
['block5e_activation[0][0]',
'block5e_se_expand[0][0]']

 block5e_project_conv (Conv2D)  (None, 14, 14, 112)  75264
['block5e_se_excite[0][0]']

 block5e_project_bn (BatchNorma  (None, 14, 14, 112)  448
['block5e_project_conv[0][0]']
 lization)

 block5e_drop (Dropout)         (None, 14, 14, 112)  0
['block5e_project_bn[0][0]']

 block5e_add (Add)              (None, 14, 14, 112)  0
['block5e_drop[0][0]',
'block5d_add[0][0]']

 block6a_expand_conv (Conv2D)   (None, 14, 14, 672)  75264
['block5e_add[0][0]']

 block6a_expand_bn (BatchNormal  (None, 14, 14, 672)  2688
['block6a_expand_conv[0][0]']
 ization)

 block6a_expand_activation (Act  (None, 14, 14, 672)  0
['block6a_expand_bn[0][0]']
 ivation)

 block6a_dwconv2 (DepthwiseConv  (None, 7, 7, 672)   6048
['block6a_expand_activation[0][0]
 2D)                                                              ']

 block6a_bn (BatchNormalization  (None, 7, 7, 672)   2688
['block6a_dwconv2[0][0]']
 )
```

```
 block6a_activation (Activation  (None, 7, 7, 672)   0
['block6a_bn[0][0]']
 )

 block6a_se_squeeze (GlobalAver  (None, 672)         0
['block6a_activation[0][0]']
 agePooling2D)

 block6a_se_reshape (Reshape)   (None, 1, 1, 672)    0
['block6a_se_squeeze[0][0]']

 block6a_se_reduce (Conv2D)     (None, 1, 1, 28)     18844
['block6a_se_reshape[0][0]']

 block6a_se_expand (Conv2D)     (None, 1, 1, 672)    19488
['block6a_se_reduce[0][0]']

 block6a_se_excite (Multiply)   (None, 7, 7, 672)    0
['block6a_activation[0][0]',
'block6a_se_expand[0][0]']

 block6a_project_conv (Conv2D)  (None, 7, 7, 192)    129024
['block6a_se_excite[0][0]']

 block6a_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6a_project_conv[0][0]']
 lization)

 block6b_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6a_project_bn[0][0]']

 block6b_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6b_expand_conv[0][0]']
 ization)

 block6b_expand_activation (Act  (None, 7, 7, 1152)  0
['block6b_expand_bn[0][0]']
 ivation)

 block6b_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6b_expand_activation[0][0]
 2D)                                                                  ']

 block6b_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6b_dwconv2[0][0]']
 )
```

```
 block6b_activation (Activation  (None, 7, 7, 1152)  0
['block6b_bn[0][0]']
 )

 block6b_se_squeeze (GlobalAver  (None, 1152)        0
['block6b_activation[0][0]']
 agePooling2D)

 block6b_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6b_se_squeeze[0][0]']

 block6b_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6b_se_reshape[0][0]']

 block6b_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6b_se_reduce[0][0]']

 block6b_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6b_activation[0][0]',
'block6b_se_expand[0][0]']

 block6b_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6b_se_excite[0][0]']

 block6b_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6b_project_conv[0][0]']
 lization)

 block6b_drop (Dropout)         (None, 7, 7, 192)    0
['block6b_project_bn[0][0]']

 block6b_add (Add)              (None, 7, 7, 192)    0
['block6b_drop[0][0]',
'block6a_project_bn[0][0]']

 block6c_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6b_add[0][0]']

 block6c_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6c_expand_conv[0][0]']
 ization)

 block6c_expand_activation (Act  (None, 7, 7, 1152)  0
['block6c_expand_bn[0][0]']
 ivation)

 block6c_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6c_expand_activation[0][0]
```

```
 2D)                                                                  ']

 block6c_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6c_dwconv2[0][0]']
 )

 block6c_activation (Activation  (None, 7, 7, 1152)  0
['block6c_bn[0][0]']
 )

 block6c_se_squeeze (GlobalAver  (None, 1152)        0
['block6c_activation[0][0]']
 agePooling2D)

 block6c_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6c_se_squeeze[0][0]']

 block6c_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6c_se_reshape[0][0]']

 block6c_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6c_se_reduce[0][0]']

 block6c_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6c_activation[0][0]',
'block6c_se_expand[0][0]']

 block6c_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6c_se_excite[0][0]']

 block6c_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6c_project_conv[0][0]']
 lization)

 block6c_drop (Dropout)         (None, 7, 7, 192)    0
['block6c_project_bn[0][0]']

 block6c_add (Add)              (None, 7, 7, 192)    0
['block6c_drop[0][0]',
'block6b_add[0][0]']

 block6d_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6c_add[0][0]']

 block6d_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6d_expand_conv[0][0]']
 ization)
```

```
 block6d_expand_activation (Act  (None, 7, 7, 1152)  0
['block6d_expand_bn[0][0]']
 ivation)

 block6d_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6d_expand_activation[0][0]
 2D)                                                              ']

 block6d_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6d_dwconv2[0][0]']
 )

 block6d_activation (Activation  (None, 7, 7, 1152)  0
['block6d_bn[0][0]']
 )

 block6d_se_squeeze (GlobalAver  (None, 1152)        0
['block6d_activation[0][0]']
 agePooling2D)

 block6d_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6d_se_squeeze[0][0]']

 block6d_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6d_se_reshape[0][0]']

 block6d_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6d_se_reduce[0][0]']

 block6d_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6d_activation[0][0]',
'block6d_se_expand[0][0]']

 block6d_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6d_se_excite[0][0]']

 block6d_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6d_project_conv[0][0]']
 lization)

 block6d_drop (Dropout)         (None, 7, 7, 192)    0
['block6d_project_bn[0][0]']

 block6d_add (Add)              (None, 7, 7, 192)    0
['block6d_drop[0][0]',
'block6c_add[0][0]']

 block6e_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
```

```
['block6d_add[0][0]']

 block6e_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6e_expand_conv[0][0]']
 ization)

 block6e_expand_activation (Act  (None, 7, 7, 1152)  0
['block6e_expand_bn[0][0]']
 ivation)

 block6e_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6e_expand_activation[0][0]
 2D)                                                              ']

 block6e_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6e_dwconv2[0][0]']
 )

 block6e_activation (Activation  (None, 7, 7, 1152)  0
['block6e_bn[0][0]']
 )

 block6e_se_squeeze (GlobalAver  (None, 1152)        0
['block6e_activation[0][0]']
 agePooling2D)

 block6e_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6e_se_squeeze[0][0]']

 block6e_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6e_se_reshape[0][0]']

 block6e_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6e_se_reduce[0][0]']

 block6e_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6e_activation[0][0]',
'block6e_se_expand[0][0]']

 block6e_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6e_se_excite[0][0]']

 block6e_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6e_project_conv[0][0]']
 lization)

 block6e_drop (Dropout)         (None, 7, 7, 192)    0
['block6e_project_bn[0][0]']
```

```
 block6e_add (Add)              (None, 7, 7, 192)    0
['block6e_drop[0][0]',
'block6d_add[0][0]']

 block6f_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6e_add[0][0]']

 block6f_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6f_expand_conv[0][0]']
 ization)

 block6f_expand_activation (Act  (None, 7, 7, 1152)  0
['block6f_expand_bn[0][0]']
 ivation)

 block6f_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6f_expand_activation[0][0]
 2D)                                                              ']

 block6f_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6f_dwconv2[0][0]']
 )

 block6f_activation (Activation  (None, 7, 7, 1152)  0
['block6f_bn[0][0]']
 )

 block6f_se_squeeze (GlobalAver  (None, 1152)        0
['block6f_activation[0][0]']
 agePooling2D)

 block6f_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6f_se_squeeze[0][0]']

 block6f_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6f_se_reshape[0][0]']

 block6f_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6f_se_reduce[0][0]']

 block6f_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6f_activation[0][0]',
'block6f_se_expand[0][0]']

 block6f_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6f_se_excite[0][0]']
```

```
 block6f_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6f_project_conv[0][0]']
 lization)

 block6f_drop (Dropout)         (None, 7, 7, 192)    0
['block6f_project_bn[0][0]']

 block6f_add (Add)              (None, 7, 7, 192)    0
['block6f_drop[0][0]',
'block6e_add[0][0]']

 block6g_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6f_add[0][0]']

 block6g_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6g_expand_conv[0][0]']
 ization)

 block6g_expand_activation (Act  (None, 7, 7, 1152)  0
['block6g_expand_bn[0][0]']
 ivation)

 block6g_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6g_expand_activation[0][0]
 2D)                                                              ']

 block6g_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6g_dwconv2[0][0]']
 )

 block6g_activation (Activation  (None, 7, 7, 1152)  0
['block6g_bn[0][0]']
 )

 block6g_se_squeeze (GlobalAver  (None, 1152)        0
['block6g_activation[0][0]']
 agePooling2D)

 block6g_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6g_se_squeeze[0][0]']

 block6g_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
['block6g_se_reshape[0][0]']

 block6g_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6g_se_reduce[0][0]']

 block6g_se_excite (Multiply)   (None, 7, 7, 1152)   0
```

```
['block6g_activation[0][0]',
'block6g_se_expand[0][0]']

 block6g_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6g_se_excite[0][0]']

 block6g_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6g_project_conv[0][0]']
 lization)

 block6g_drop (Dropout)         (None, 7, 7, 192)    0
['block6g_project_bn[0][0]']

 block6g_add (Add)              (None, 7, 7, 192)    0
['block6g_drop[0][0]',
'block6f_add[0][0]']

 block6h_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184
['block6g_add[0][0]']

 block6h_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608
['block6h_expand_conv[0][0]']
 ization)

 block6h_expand_activation (Act  (None, 7, 7, 1152)  0
['block6h_expand_bn[0][0]']
 ivation)

 block6h_dwconv2 (DepthwiseConv  (None, 7, 7, 1152)  10368
['block6h_expand_activation[0][0]
 2D)                                                              ']

 block6h_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6h_dwconv2[0][0]']
 )

 block6h_activation (Activation  (None, 7, 7, 1152)  0
['block6h_bn[0][0]']
 )

 block6h_se_squeeze (GlobalAver  (None, 1152)        0
['block6h_activation[0][0]']
 agePooling2D)

 block6h_se_reshape (Reshape)   (None, 1, 1, 1152)   0
['block6h_se_squeeze[0][0]']

 block6h_se_reduce (Conv2D)     (None, 1, 1, 48)     55344
```

```
['block6h_se_reshape[0][0]']

 block6h_se_expand (Conv2D)     (None, 1, 1, 1152)   56448
['block6h_se_reduce[0][0]']

 block6h_se_excite (Multiply)   (None, 7, 7, 1152)   0
['block6h_activation[0][0]',
'block6h_se_expand[0][0]']

 block6h_project_conv (Conv2D)  (None, 7, 7, 192)    221184
['block6h_se_excite[0][0]']

 block6h_project_bn (BatchNorma  (None, 7, 7, 192)   768
['block6h_project_conv[0][0]']
 lization)

 block6h_drop (Dropout)         (None, 7, 7, 192)    0
['block6h_project_bn[0][0]']

 block6h_add (Add)              (None, 7, 7, 192)    0
['block6h_drop[0][0]',
'block6g_add[0][0]']

 top_conv (Conv2D)              (None, 7, 7, 1280)   245760
['block6h_add[0][0]']

 top_bn (BatchNormalization)    (None, 7, 7, 1280)   5120
['top_conv[0][0]']

 top_activation (Activation)    (None, 7, 7, 1280)   0
['top_bn[0][0]']

==================================================================================
==================
Total params: 5,919,312
Trainable params: 5,858,704
Non-trainable params: 60,608
----------------------------------------------------------------------------------
------------------
```

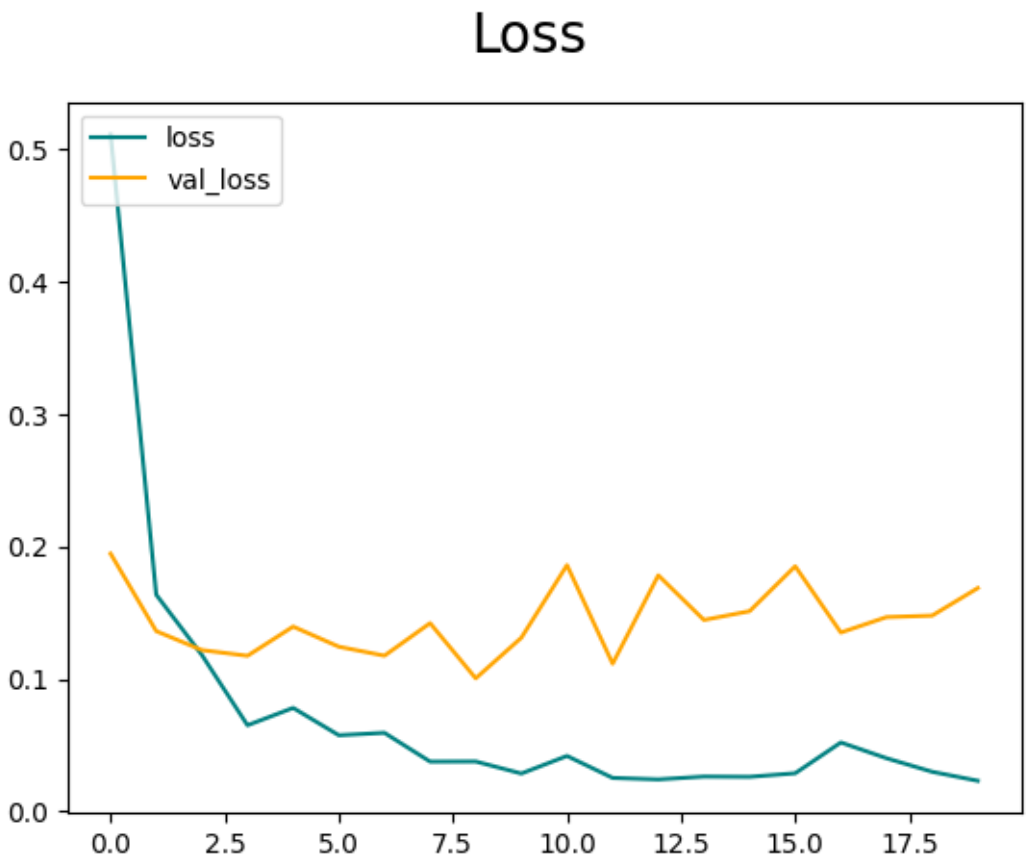
[8]:
```
x = base_model.output
x = GlobalAveragePooling2D()(x)
output = Dense(num_classes, activation='softmax')(x)
model = Model(inputs=base_model.input, outputs=output)

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])
```

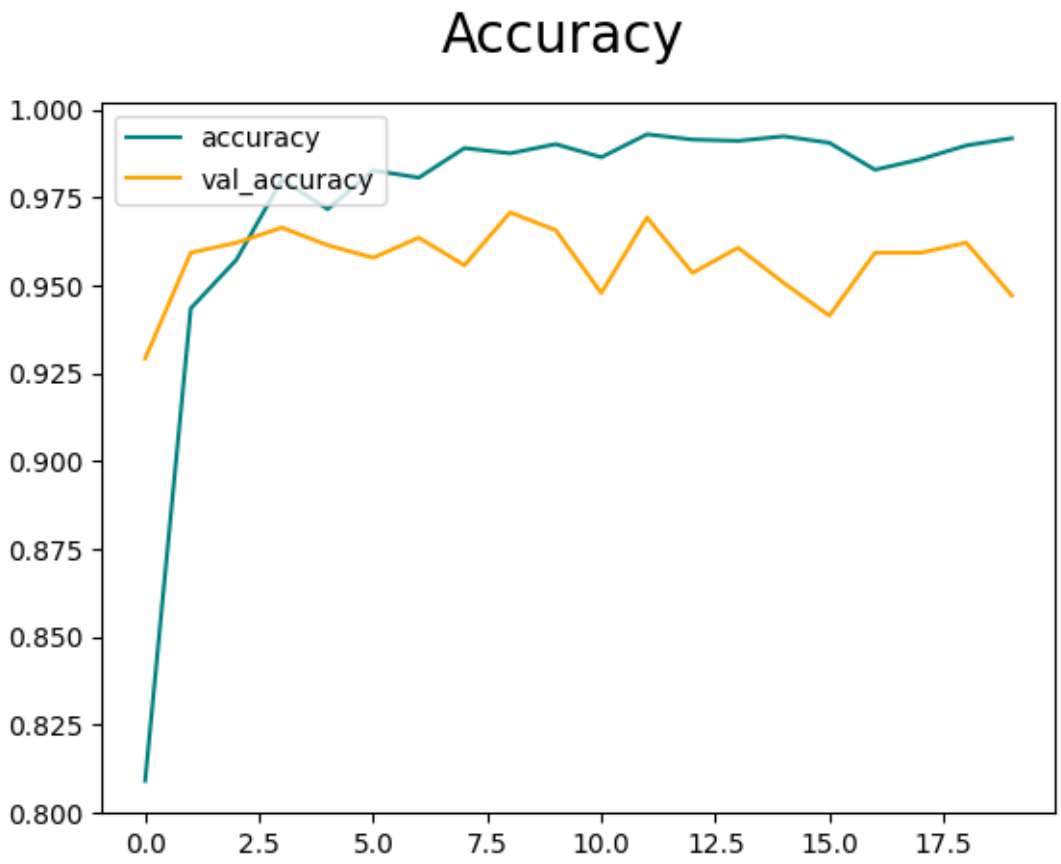
```
Epoch 1/20
168/168 [==============================] - 19s 65ms/step - loss: 0.5109 -
accuracy: 0.8090 - val_loss: 0.1945 - val_accuracy: 0.9291
Epoch 2/20
168/168 [==============================] - 11s 63ms/step - loss: 0.1636 -
accuracy: 0.9434 - val_loss: 0.1361 - val_accuracy: 0.9592
Epoch 3/20
168/168 [==============================] - 11s 64ms/step - loss: 0.1181 -
accuracy: 0.9572 - val_loss: 0.1218 - val_accuracy: 0.9621
Epoch 4/20
168/168 [==============================] - 11s 63ms/step - loss: 0.0651 -
accuracy: 0.9800 - val_loss: 0.1175 - val_accuracy: 0.9664
Epoch 5/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0781 -
accuracy: 0.9716 - val_loss: 0.1395 - val_accuracy: 0.9613
Epoch 6/20
168/168 [==============================] - 11s 63ms/step - loss: 0.0575 -
accuracy: 0.9826 - val_loss: 0.1243 - val_accuracy: 0.9578
Epoch 7/20
168/168 [==============================] - 11s 64ms/step - loss: 0.0593 -
accuracy: 0.9806 - val_loss: 0.1175 - val_accuracy: 0.9635
Epoch 8/20
168/168 [==============================] - 11s 64ms/step - loss: 0.0376 -
accuracy: 0.9890 - val_loss: 0.1421 - val_accuracy: 0.9556
Epoch 9/20
168/168 [==============================] - 11s 64ms/step - loss: 0.0377 -
accuracy: 0.9875 - val_loss: 0.1005 - val_accuracy: 0.9707
Epoch 10/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0286 -
accuracy: 0.9901 - val_loss: 0.1311 - val_accuracy: 0.9656
Epoch 11/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0419 -
accuracy: 0.9864 - val_loss: 0.1859 - val_accuracy: 0.9477
Epoch 12/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0253 -
accuracy: 0.9929 - val_loss: 0.1115 - val_accuracy: 0.9692
Epoch 13/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0242 -
accuracy: 0.9914 - val_loss: 0.1782 - val_accuracy: 0.9535
Epoch 14/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0263 -
```

```
accuracy: 0.9910 - val_loss: 0.1445 - val_accuracy: 0.9606
Epoch 15/20
168/168 [==============================] - 10s 60ms/step - loss: 0.0262 -
accuracy: 0.9923 - val_loss: 0.1511 - val_accuracy: 0.9506
Epoch 16/20
168/168 [==============================] - 11s 63ms/step - loss: 0.0288 -
accuracy: 0.9905 - val_loss: 0.1850 - val_accuracy: 0.9413
Epoch 17/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0521 -
accuracy: 0.9828 - val_loss: 0.1350 - val_accuracy: 0.9592
Epoch 18/20
168/168 [==============================] - 11s 62ms/step - loss: 0.0402 -
accuracy: 0.9858 - val_loss: 0.1467 - val_accuracy: 0.9592
Epoch 19/20
168/168 [==============================] - 11s 65ms/step - loss: 0.0300 -
accuracy: 0.9897 - val_loss: 0.1478 - val_accuracy: 0.9621
Epoch 20/20
168/168 [==============================] - 11s 64ms/step - loss: 0.0232 -
accuracy: 0.9918 - val_loss: 0.1686 - val_accuracy: 0.9470
```

[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 [==============================] - 1s 706ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
```

```
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 1s 696ms/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:  98.89%
Recall:  99.68%
Accuracy:  96.38%
```

[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 686ms/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 99.98%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.02%
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}%␣
↪EfficientNetV2B0.h5"
model.save(os.path.join('CarBackEnd/models/CarStyles', model_file_name))
```

[ ]:
```

```