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 ResNet50V2
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.
```

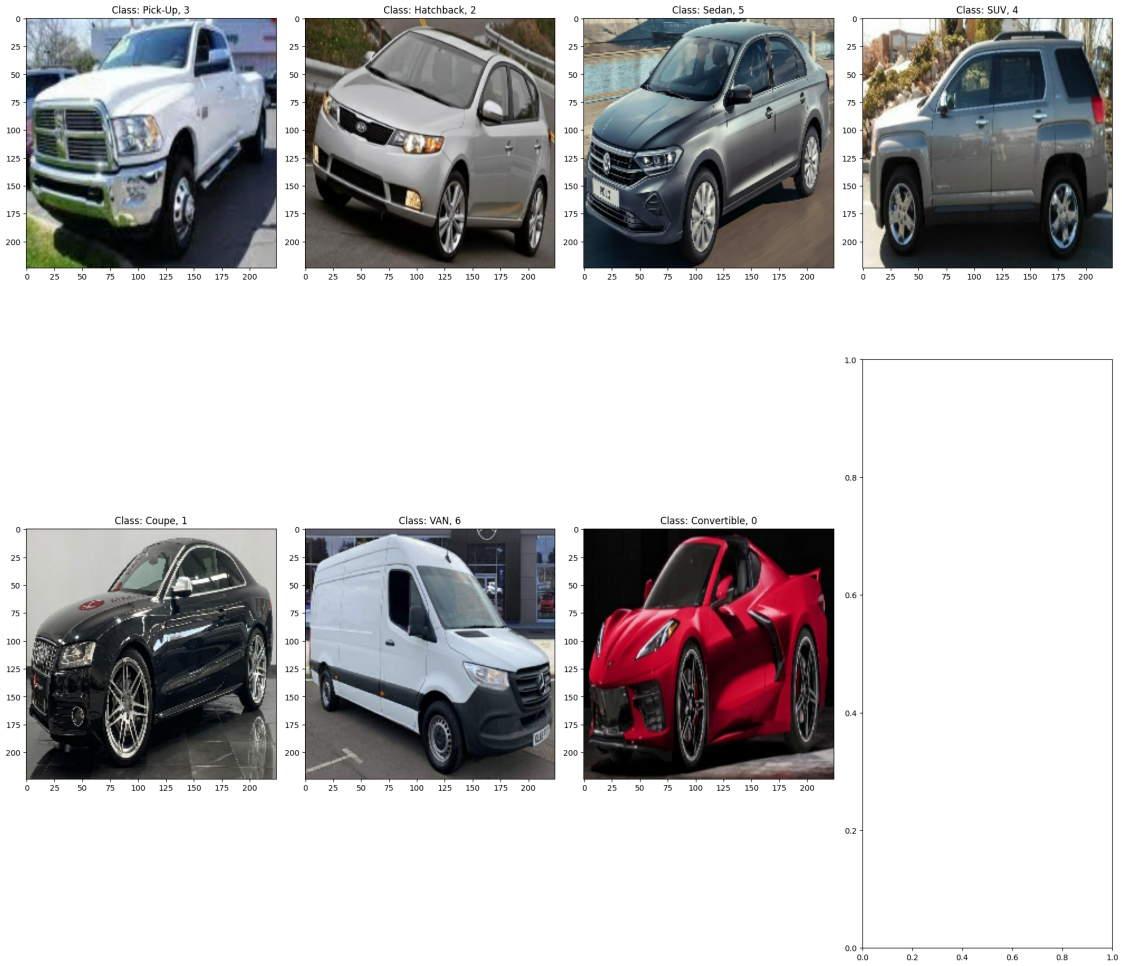
[4]:
```
class_names = train_data.class_names
print("Class names test:", class_names)

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 = ResNet50V2(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)
base_model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet50v2_weights_tf_dim_ordering_tf_kernels_notop.h5
94668760/94668760 [==============================] - 12s 0us/step
Model: "resnet50v2"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 conv1_pad (ZeroPadding2D)      (None, 230, 230, 3)  0
['input_1[0][0]']

 conv1_conv (Conv2D)            (None, 112, 112, 64  9472
['conv1_pad[0][0]']
                                )

 pool1_pad (ZeroPadding2D)      (None, 114, 114, 64  0
['conv1_conv[0][0]']
                                )

 pool1_pool (MaxPooling2D)      (None, 56, 56, 64)   0
['pool1_pad[0][0]']

 conv2_block1_preact_bn (BatchN  (None, 56, 56, 64)  256
['pool1_pool[0][0]']
 ormalization)

 conv2_block1_preact_relu (Acti  (None, 56, 56, 64)  0
['conv2_block1_preact_bn[0][0]']
 vation)

 conv2_block1_1_conv (Conv2D)   (None, 56, 56, 64)   4096
['conv2_block1_preact_relu[0][0]'
                                                                  ]
```

```
 conv2_block1_1_bn (BatchNormal  (None, 56, 56, 64)  256
['conv2_block1_1_conv[0][0]']
 ization)

 conv2_block1_1_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block1_1_bn[0][0]']
 n)

 conv2_block1_2_pad (ZeroPaddin  (None, 58, 58, 64)  0
['conv2_block1_1_relu[0][0]']
 g2D)

 conv2_block1_2_conv (Conv2D)   (None, 56, 56, 64)   36864
['conv2_block1_2_pad[0][0]']

 conv2_block1_2_bn (BatchNormal  (None, 56, 56, 64)  256
['conv2_block1_2_conv[0][0]']
 ization)

 conv2_block1_2_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block1_2_bn[0][0]']
 n)

 conv2_block1_0_conv (Conv2D)   (None, 56, 56, 256)  16640
['conv2_block1_preact_relu[0][0]'
                                                                 ]

 conv2_block1_3_conv (Conv2D)   (None, 56, 56, 256)  16640
['conv2_block1_2_relu[0][0]']

 conv2_block1_out (Add)         (None, 56, 56, 256)  0
['conv2_block1_0_conv[0][0]',
'conv2_block1_3_conv[0][0]']

 conv2_block2_preact_bn (BatchN  (None, 56, 56, 256)  1024
['conv2_block1_out[0][0]']
 ormalization)

 conv2_block2_preact_relu (Acti  (None, 56, 56, 256)  0
['conv2_block2_preact_bn[0][0]']
 vation)

 conv2_block2_1_conv (Conv2D)   (None, 56, 56, 64)   16384
['conv2_block2_preact_relu[0][0]'
                                                                 ]

 conv2_block2_1_bn (BatchNormal  (None, 56, 56, 64)  256
['conv2_block2_1_conv[0][0]']
```

```
 ization)

 conv2_block2_1_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block2_1_bn[0][0]']
 n)

 conv2_block2_2_pad (ZeroPaddin  (None, 58, 58, 64)  0
['conv2_block2_1_relu[0][0]']
 g2D)

 conv2_block2_2_conv (Conv2D)   (None, 56, 56, 64)   36864
['conv2_block2_2_pad[0][0]']

 conv2_block2_2_bn (BatchNormal  (None, 56, 56, 64)  256
['conv2_block2_2_conv[0][0]']
 ization)

 conv2_block2_2_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block2_2_bn[0][0]']
 n)

 conv2_block2_3_conv (Conv2D)   (None, 56, 56, 256)  16640
['conv2_block2_2_relu[0][0]']

 conv2_block2_out (Add)         (None, 56, 56, 256)  0
['conv2_block1_out[0][0]',
'conv2_block2_3_conv[0][0]']

 conv2_block3_preact_bn (BatchN  (None, 56, 56, 256)  1024
['conv2_block2_out[0][0]']
 ormalization)

 conv2_block3_preact_relu (Acti  (None, 56, 56, 256)  0
['conv2_block3_preact_bn[0][0]']
 vation)

 conv2_block3_1_conv (Conv2D)   (None, 56, 56, 64)   16384
['conv2_block3_preact_relu[0][0]'
                                                                ]

 conv2_block3_1_bn (BatchNormal  (None, 56, 56, 64)  256
['conv2_block3_1_conv[0][0]']
 ization)

 conv2_block3_1_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block3_1_bn[0][0]']
 n)
```

```
 conv2_block3_2_pad (ZeroPaddin  (None, 58, 58, 64)  0
['conv2_block3_1_relu[0][0]']
 g2D)

 conv2_block3_2_conv (Conv2D)   (None, 28, 28, 64)   36864
['conv2_block3_2_pad[0][0]']

 conv2_block3_2_bn (BatchNormal  (None, 28, 28, 64)  256
['conv2_block3_2_conv[0][0]']
 ization)

 conv2_block3_2_relu (Activatio  (None, 28, 28, 64)  0
['conv2_block3_2_bn[0][0]']
 n)

 max_pooling2d (MaxPooling2D)   (None, 28, 28, 256)  0
['conv2_block2_out[0][0]']

 conv2_block3_3_conv (Conv2D)   (None, 28, 28, 256)  16640
['conv2_block3_2_relu[0][0]']

 conv2_block3_out (Add)         (None, 28, 28, 256)  0
['max_pooling2d[0][0]',
'conv2_block3_3_conv[0][0]']

 conv3_block1_preact_bn (BatchN  (None, 28, 28, 256)  1024
['conv2_block3_out[0][0]']
 ormalization)

 conv3_block1_preact_relu (Acti  (None, 28, 28, 256)  0
['conv3_block1_preact_bn[0][0]']
 vation)

 conv3_block1_1_conv (Conv2D)   (None, 28, 28, 128)  32768
['conv3_block1_preact_relu[0][0]'
                                                                ]

 conv3_block1_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block1_1_conv[0][0]']
 ization)

 conv3_block1_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block1_1_bn[0][0]']
 n)

 conv3_block1_2_pad (ZeroPaddin  (None, 30, 30, 128)  0
['conv3_block1_1_relu[0][0]']
 g2D)
```

```
 conv3_block1_2_conv (Conv2D)   (None, 28, 28, 128)  147456
['conv3_block1_2_pad[0][0]']

 conv3_block1_2_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block1_2_conv[0][0]']
 ization)

 conv3_block1_2_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block1_2_bn[0][0]']
 n)

 conv3_block1_0_conv (Conv2D)   (None, 28, 28, 512)  131584
['conv3_block1_preact_relu[0][0]'
                                                                 ]

 conv3_block1_3_conv (Conv2D)   (None, 28, 28, 512)  66048
['conv3_block1_2_relu[0][0]']

 conv3_block1_out (Add)         (None, 28, 28, 512)  0
['conv3_block1_0_conv[0][0]',
'conv3_block1_3_conv[0][0]']

 conv3_block2_preact_bn (BatchN  (None, 28, 28, 512)  2048
['conv3_block1_out[0][0]']
 ormalization)

 conv3_block2_preact_relu (Acti  (None, 28, 28, 512)  0
['conv3_block2_preact_bn[0][0]']
 vation)

 conv3_block2_1_conv (Conv2D)   (None, 28, 28, 128)  65536
['conv3_block2_preact_relu[0][0]'
                                                                 ]

 conv3_block2_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block2_1_conv[0][0]']
 ization)

 conv3_block2_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block2_1_bn[0][0]']
 n)

 conv3_block2_2_pad (ZeroPaddin  (None, 30, 30, 128)  0
['conv3_block2_1_relu[0][0]']
 g2D)

 conv3_block2_2_conv (Conv2D)   (None, 28, 28, 128)  147456
```

```
['conv3_block2_2_pad[0][0]']

 conv3_block2_2_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block2_2_conv[0][0]']
 ization)

 conv3_block2_2_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block2_2_bn[0][0]']
 n)

 conv3_block2_3_conv (Conv2D)   (None, 28, 28, 512)  66048
['conv3_block2_2_relu[0][0]']

 conv3_block2_out (Add)         (None, 28, 28, 512)  0
['conv3_block1_out[0][0]',
'conv3_block2_3_conv[0][0]']

 conv3_block3_preact_bn (BatchN  (None, 28, 28, 512)  2048
['conv3_block2_out[0][0]']
 ormalization)

 conv3_block3_preact_relu (Acti  (None, 28, 28, 512)  0
['conv3_block3_preact_bn[0][0]']
 vation)

 conv3_block3_1_conv (Conv2D)   (None, 28, 28, 128)  65536
['conv3_block3_preact_relu[0][0]'
                                                                ]

 conv3_block3_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block3_1_conv[0][0]']
 ization)

 conv3_block3_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block3_1_bn[0][0]']
 n)

 conv3_block3_2_pad (ZeroPaddin  (None, 30, 30, 128)  0
['conv3_block3_1_relu[0][0]']
 g2D)

 conv3_block3_2_conv (Conv2D)   (None, 28, 28, 128)  147456
['conv3_block3_2_pad[0][0]']

 conv3_block3_2_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block3_2_conv[0][0]']
 ization)
```

```
 conv3_block3_2_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block3_2_bn[0][0]']
 n)

 conv3_block3_3_conv (Conv2D)   (None, 28, 28, 512)  66048
['conv3_block3_2_relu[0][0]']

 conv3_block3_out (Add)         (None, 28, 28, 512)  0
['conv3_block2_out[0][0]',
'conv3_block3_3_conv[0][0]']

 conv3_block4_preact_bn (BatchN  (None, 28, 28, 512)  2048
['conv3_block3_out[0][0]']
 ormalization)

 conv3_block4_preact_relu (Acti  (None, 28, 28, 512)  0
['conv3_block4_preact_bn[0][0]']
 vation)

 conv3_block4_1_conv (Conv2D)   (None, 28, 28, 128)  65536
['conv3_block4_preact_relu[0][0]'
                                                                 ]

 conv3_block4_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block4_1_conv[0][0]']
 ization)

 conv3_block4_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block4_1_bn[0][0]']
 n)

 conv3_block4_2_pad (ZeroPaddin  (None, 30, 30, 128)  0
['conv3_block4_1_relu[0][0]']
 g2D)

 conv3_block4_2_conv (Conv2D)   (None, 14, 14, 128)  147456
['conv3_block4_2_pad[0][0]']

 conv3_block4_2_bn (BatchNormal  (None, 14, 14, 128)  512
['conv3_block4_2_conv[0][0]']
 ization)

 conv3_block4_2_relu (Activatio  (None, 14, 14, 128)  0
['conv3_block4_2_bn[0][0]']
 n)

 max_pooling2d_1 (MaxPooling2D)  (None, 14, 14, 512)  0
['conv3_block3_out[0][0]']
```

```
 conv3_block4_3_conv (Conv2D)   (None, 14, 14, 512)  66048
['conv3_block4_2_relu[0][0]']

 conv3_block4_out (Add)         (None, 14, 14, 512)  0
['max_pooling2d_1[0][0]',
'conv3_block4_3_conv[0][0]']

 conv4_block1_preact_bn (BatchN  (None, 14, 14, 512)  2048
['conv3_block4_out[0][0]']
 ormalization)

 conv4_block1_preact_relu (Acti  (None, 14, 14, 512)  0
['conv4_block1_preact_bn[0][0]']
 vation)

 conv4_block1_1_conv (Conv2D)   (None, 14, 14, 256)  131072
['conv4_block1_preact_relu[0][0]'
                                                                 ]

 conv4_block1_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block1_1_conv[0][0]']
 ization)

 conv4_block1_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block1_1_bn[0][0]']
 n)

 conv4_block1_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block1_1_relu[0][0]']
 g2D)

 conv4_block1_2_conv (Conv2D)   (None, 14, 14, 256)  589824
['conv4_block1_2_pad[0][0]']

 conv4_block1_2_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block1_2_conv[0][0]']
 ization)

 conv4_block1_2_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block1_2_bn[0][0]']
 n)

 conv4_block1_0_conv (Conv2D)   (None, 14, 14, 1024  525312
['conv4_block1_preact_relu[0][0]'
                                )                                ]

 conv4_block1_3_conv (Conv2D)   (None, 14, 14, 1024  263168
```

```
['conv4_block1_2_relu[0][0]']
                                )

 conv4_block1_out (Add)         (None, 14, 14, 1024  0
['conv4_block1_0_conv[0][0]',
                                )
'conv4_block1_3_conv[0][0]']

 conv4_block2_preact_bn (BatchN  (None, 14, 14, 1024  4096
['conv4_block1_out[0][0]']
 ormalization)                  )

 conv4_block2_preact_relu (Acti  (None, 14, 14, 1024  0
['conv4_block2_preact_bn[0][0]']
 vation)                        )

 conv4_block2_1_conv (Conv2D)   (None, 14, 14, 256)  262144
['conv4_block2_preact_relu[0][0]'
                                                                  ]

 conv4_block2_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block2_1_conv[0][0]']
 ization)

 conv4_block2_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block2_1_bn[0][0]']
 n)

 conv4_block2_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block2_1_relu[0][0]']
 g2D)

 conv4_block2_2_conv (Conv2D)   (None, 14, 14, 256)  589824
['conv4_block2_2_pad[0][0]']

 conv4_block2_2_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block2_2_conv[0][0]']
 ization)

 conv4_block2_2_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block2_2_bn[0][0]']
 n)

 conv4_block2_3_conv (Conv2D)   (None, 14, 14, 1024  263168
['conv4_block2_2_relu[0][0]']
                                )

 conv4_block2_out (Add)         (None, 14, 14, 1024  0
```

```
['conv4_block1_out[0][0]',
                                )
'conv4_block2_3_conv[0][0]']

 conv4_block3_preact_bn (BatchN  (None, 14, 14, 1024  4096
['conv4_block2_out[0][0]']
 ormalization)                  )

 conv4_block3_preact_relu (Acti  (None, 14, 14, 1024  0
['conv4_block3_preact_bn[0][0]']
 vation)                        )

 conv4_block3_1_conv (Conv2D)   (None, 14, 14, 256)  262144
['conv4_block3_preact_relu[0][0]'
                                                                ]

 conv4_block3_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block3_1_conv[0][0]']
 ization)

 conv4_block3_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block3_1_bn[0][0]']
 n)

 conv4_block3_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block3_1_relu[0][0]']
 g2D)

 conv4_block3_2_conv (Conv2D)   (None, 14, 14, 256)  589824
['conv4_block3_2_pad[0][0]']

 conv4_block3_2_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block3_2_conv[0][0]']
 ization)

 conv4_block3_2_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block3_2_bn[0][0]']
 n)

 conv4_block3_3_conv (Conv2D)   (None, 14, 14, 1024  263168
['conv4_block3_2_relu[0][0]']
                                )

 conv4_block3_out (Add)         (None, 14, 14, 1024  0
['conv4_block2_out[0][0]',
                                )
'conv4_block3_3_conv[0][0]']
```

```
 conv4_block4_preact_bn (BatchN  (None, 14, 14, 1024  4096
['conv4_block3_out[0][0]']
 ormalization)                  )

 conv4_block4_preact_relu (Acti  (None, 14, 14, 1024  0
['conv4_block4_preact_bn[0][0]']
 vation)                        )

 conv4_block4_1_conv (Conv2D)   (None, 14, 14, 256)  262144
['conv4_block4_preact_relu[0][0]'
                                                                 ]

 conv4_block4_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block4_1_conv[0][0]']
 ization)

 conv4_block4_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block4_1_bn[0][0]']
 n)

 conv4_block4_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block4_1_relu[0][0]']
 g2D)

 conv4_block4_2_conv (Conv2D)   (None, 14, 14, 256)  589824
['conv4_block4_2_pad[0][0]']

 conv4_block4_2_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block4_2_conv[0][0]']
 ization)

 conv4_block4_2_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block4_2_bn[0][0]']
 n)

 conv4_block4_3_conv (Conv2D)   (None, 14, 14, 1024  263168
['conv4_block4_2_relu[0][0]']
                                )

 conv4_block4_out (Add)         (None, 14, 14, 1024  0
['conv4_block3_out[0][0]',
                                )
'conv4_block4_3_conv[0][0]']

 conv4_block5_preact_bn (BatchN  (None, 14, 14, 1024  4096
['conv4_block4_out[0][0]']
 ormalization)                  )
```

```
 conv4_block5_preact_relu (Acti  (None, 14, 14, 1024  0
['conv4_block5_preact_bn[0][0]']
 vation)                        )

 conv4_block5_1_conv (Conv2D)   (None, 14, 14, 256)  262144
['conv4_block5_preact_relu[0][0]'
                                                                ]

 conv4_block5_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block5_1_conv[0][0]']
 ization)

 conv4_block5_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block5_1_bn[0][0]']
 n)

 conv4_block5_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block5_1_relu[0][0]']
 g2D)

 conv4_block5_2_conv (Conv2D)   (None, 14, 14, 256)  589824
['conv4_block5_2_pad[0][0]']

 conv4_block5_2_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block5_2_conv[0][0]']
 ization)

 conv4_block5_2_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block5_2_bn[0][0]']
 n)

 conv4_block5_3_conv (Conv2D)   (None, 14, 14, 1024  263168
['conv4_block5_2_relu[0][0]']
                                )

 conv4_block5_out (Add)         (None, 14, 14, 1024  0
['conv4_block4_out[0][0]',
                                )
'conv4_block5_3_conv[0][0]']

 conv4_block6_preact_bn (BatchN  (None, 14, 14, 1024  4096
['conv4_block5_out[0][0]']
 ormalization)                  )

 conv4_block6_preact_relu (Acti  (None, 14, 14, 1024  0
['conv4_block6_preact_bn[0][0]']
 vation)                        )
```

```
 conv4_block6_1_conv (Conv2D)   (None, 14, 14, 256)  262144
['conv4_block6_preact_relu[0][0]'
                                                                 ]

 conv4_block6_1_bn (BatchNormal  (None, 14, 14, 256)  1024
['conv4_block6_1_conv[0][0]']
 ization)

 conv4_block6_1_relu (Activatio  (None, 14, 14, 256)  0
['conv4_block6_1_bn[0][0]']
 n)

 conv4_block6_2_pad (ZeroPaddin  (None, 16, 16, 256)  0
['conv4_block6_1_relu[0][0]']
 g2D)

 conv4_block6_2_conv (Conv2D)   (None, 7, 7, 256)    589824
['conv4_block6_2_pad[0][0]']

 conv4_block6_2_bn (BatchNormal  (None, 7, 7, 256)   1024
['conv4_block6_2_conv[0][0]']
 ization)

 conv4_block6_2_relu (Activatio  (None, 7, 7, 256)   0
['conv4_block6_2_bn[0][0]']
 n)

 max_pooling2d_2 (MaxPooling2D)  (None, 7, 7, 1024)  0
['conv4_block5_out[0][0]']

 conv4_block6_3_conv (Conv2D)   (None, 7, 7, 1024)   263168
['conv4_block6_2_relu[0][0]']

 conv4_block6_out (Add)         (None, 7, 7, 1024)   0
['max_pooling2d_2[0][0]',
'conv4_block6_3_conv[0][0]']

 conv5_block1_preact_bn (BatchN  (None, 7, 7, 1024)  4096
['conv4_block6_out[0][0]']
 ormalization)

 conv5_block1_preact_relu (Acti  (None, 7, 7, 1024)  0
['conv5_block1_preact_bn[0][0]']
 vation)

 conv5_block1_1_conv (Conv2D)   (None, 7, 7, 512)    524288
['conv5_block1_preact_relu[0][0]'
                                                                 ]
```

```
 conv5_block1_1_bn (BatchNormal  (None, 7, 7, 512)   2048
['conv5_block1_1_conv[0][0]']
 ization)

 conv5_block1_1_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block1_1_bn[0][0]']
 n)

 conv5_block1_2_pad (ZeroPaddin  (None, 9, 9, 512)   0
['conv5_block1_1_relu[0][0]']
 g2D)

 conv5_block1_2_conv (Conv2D)   (None, 7, 7, 512)    2359296
['conv5_block1_2_pad[0][0]']

 conv5_block1_2_bn (BatchNormal  (None, 7, 7, 512)   2048
['conv5_block1_2_conv[0][0]']
 ization)

 conv5_block1_2_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block1_2_bn[0][0]']
 n)

 conv5_block1_0_conv (Conv2D)   (None, 7, 7, 2048)   2099200
['conv5_block1_preact_relu[0][0]'
                                                                 ]

 conv5_block1_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624
['conv5_block1_2_relu[0][0]']

 conv5_block1_out (Add)         (None, 7, 7, 2048)   0
['conv5_block1_0_conv[0][0]',
'conv5_block1_3_conv[0][0]']

 conv5_block2_preact_bn (BatchN  (None, 7, 7, 2048)  8192
['conv5_block1_out[0][0]']
 ormalization)

 conv5_block2_preact_relu (Acti  (None, 7, 7, 2048)  0
['conv5_block2_preact_bn[0][0]']
 vation)

 conv5_block2_1_conv (Conv2D)   (None, 7, 7, 512)    1048576
['conv5_block2_preact_relu[0][0]'
                                                                 ]

 conv5_block2_1_bn (BatchNormal  (None, 7, 7, 512)   2048
```

```
['conv5_block2_1_conv[0][0]']
 ization)

 conv5_block2_1_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block2_1_bn[0][0]']
 n)

 conv5_block2_2_pad (ZeroPaddin  (None, 9, 9, 512)   0
['conv5_block2_1_relu[0][0]']
 g2D)

 conv5_block2_2_conv (Conv2D)   (None, 7, 7, 512)    2359296
['conv5_block2_2_pad[0][0]']

 conv5_block2_2_bn (BatchNormal  (None, 7, 7, 512)   2048
['conv5_block2_2_conv[0][0]']
 ization)

 conv5_block2_2_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block2_2_bn[0][0]']
 n)

 conv5_block2_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624
['conv5_block2_2_relu[0][0]']

 conv5_block2_out (Add)         (None, 7, 7, 2048)   0
['conv5_block1_out[0][0]',
'conv5_block2_3_conv[0][0]']

 conv5_block3_preact_bn (BatchN  (None, 7, 7, 2048)  8192
['conv5_block2_out[0][0]']
 ormalization)

 conv5_block3_preact_relu (Acti  (None, 7, 7, 2048)  0
['conv5_block3_preact_bn[0][0]']
 vation)

 conv5_block3_1_conv (Conv2D)   (None, 7, 7, 512)    1048576
['conv5_block3_preact_relu[0][0]'
                                                                ]

 conv5_block3_1_bn (BatchNormal  (None, 7, 7, 512)   2048
['conv5_block3_1_conv[0][0]']
 ization)

 conv5_block3_1_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block3_1_bn[0][0]']
 n)
```

```
 conv5_block3_2_pad (ZeroPaddin  (None, 9, 9, 512)   0
['conv5_block3_1_relu[0][0]']
 g2D)

 conv5_block3_2_conv (Conv2D)   (None, 7, 7, 512)    2359296
['conv5_block3_2_pad[0][0]']

 conv5_block3_2_bn (BatchNormal  (None, 7, 7, 512)   2048
['conv5_block3_2_conv[0][0]']
 ization)

 conv5_block3_2_relu (Activatio  (None, 7, 7, 512)   0
['conv5_block3_2_bn[0][0]']
 n)

 conv5_block3_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624
['conv5_block3_2_relu[0][0]']

 conv5_block3_out (Add)         (None, 7, 7, 2048)   0
['conv5_block2_out[0][0]',
'conv5_block3_3_conv[0][0]']

 post_bn (BatchNormalization)   (None, 7, 7, 2048)   8192
['conv5_block3_out[0][0]']

 post_relu (Activation)         (None, 7, 7, 2048)   0
['post_bn[0][0]']

==================================================================================
==================
Total params: 23,564,800
Trainable params: 23,519,360
Non-trainable params: 45,440
----------------------------------------------------------------------------------
------------------
```

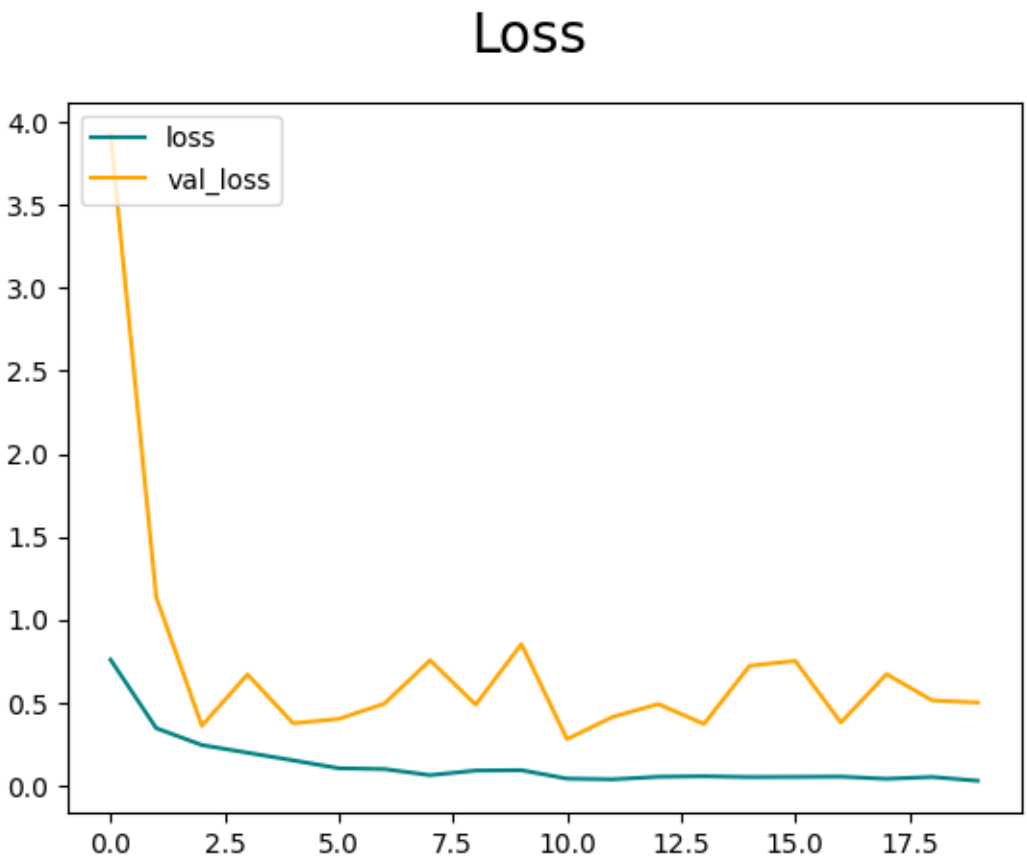
[8]:
```
x = base_model.output
x = GlobalAveragePooling2D()(x)
output = Dense(num_classes, activation='softmax')(x)
model = Model(inputs=base_model.input, outputs=output)

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])
```

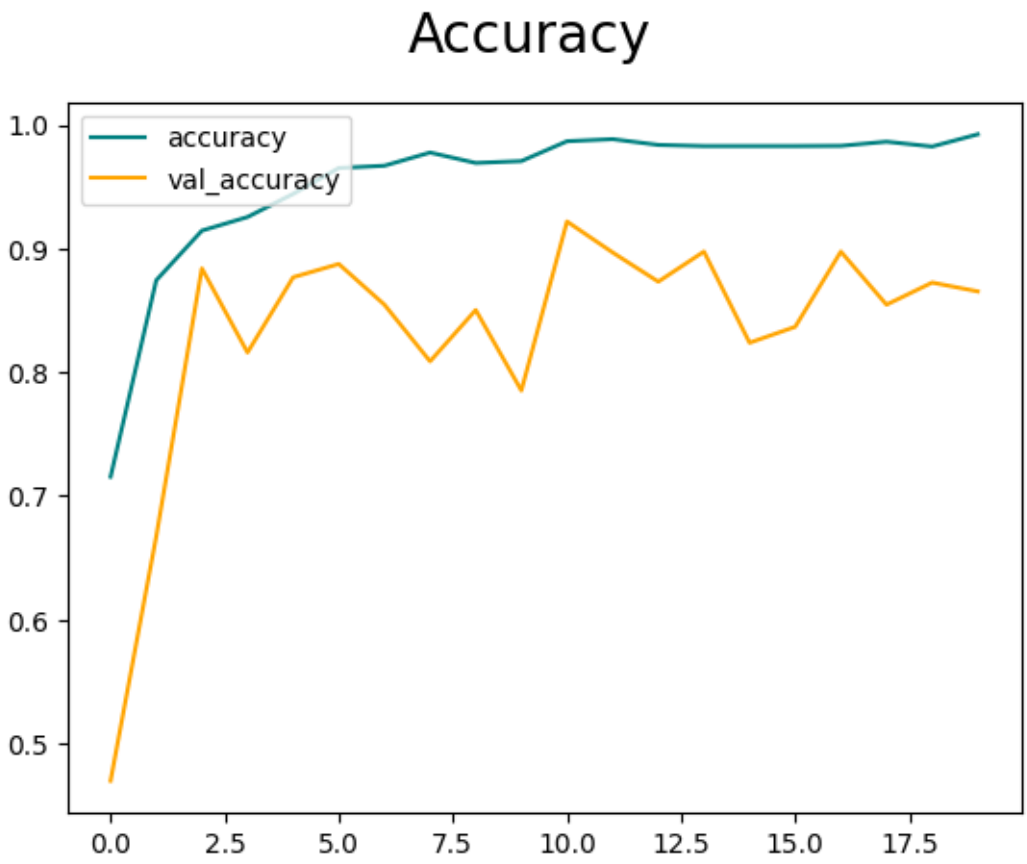
```
Epoch 1/20
168/168 [==============================] - 23s 91ms/step - loss: 0.7578 -
accuracy: 0.7155 - val_loss: 3.9274 - val_accuracy: 0.4696
Epoch 2/20
168/168 [==============================] - 16s 92ms/step - loss: 0.3444 -
accuracy: 0.8744 - val_loss: 1.1339 - val_accuracy: 0.6671
Epoch 3/20
168/168 [==============================] - 16s 93ms/step - loss: 0.2427 -
accuracy: 0.9146 - val_loss: 0.3591 - val_accuracy: 0.8840
Epoch 4/20
168/168 [==============================] - 15s 91ms/step - loss: 0.1964 -
accuracy: 0.9256 - val_loss: 0.6689 - val_accuracy: 0.8160
Epoch 5/20
168/168 [==============================] - 16s 91ms/step - loss: 0.1502 -
accuracy: 0.9443 - val_loss: 0.3738 - val_accuracy: 0.8769
Epoch 6/20
168/168 [==============================] - 16s 95ms/step - loss: 0.1027 -
accuracy: 0.9652 - val_loss: 0.4003 - val_accuracy: 0.8876
Epoch 7/20
168/168 [==============================] - 16s 92ms/step - loss: 0.0977 -
accuracy: 0.9671 - val_loss: 0.4927 - val_accuracy: 0.8547
Epoch 8/20
168/168 [==============================] - 16s 93ms/step - loss: 0.0610 -
accuracy: 0.9778 - val_loss: 0.7541 - val_accuracy: 0.8089
Epoch 9/20
168/168 [==============================] - 16s 93ms/step - loss: 0.0888 -
accuracy: 0.9693 - val_loss: 0.4863 - val_accuracy: 0.8504
Epoch 10/20
168/168 [==============================] - 16s 92ms/step - loss: 0.0909 -
accuracy: 0.9708 - val_loss: 0.8518 - val_accuracy: 0.7853
Epoch 11/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0402 -
accuracy: 0.9869 - val_loss: 0.2784 - val_accuracy: 0.9220
Epoch 12/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0359 -
accuracy: 0.9886 - val_loss: 0.4122 - val_accuracy: 0.8969
Epoch 13/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0513 -
accuracy: 0.9839 - val_loss: 0.4900 - val_accuracy: 0.8733
Epoch 14/20
168/168 [==============================] - 16s 96ms/step - loss: 0.0543 -
accuracy: 0.9830 - val_loss: 0.3697 - val_accuracy: 0.8976
Epoch 15/20
168/168 [==============================] - 17s 98ms/step - loss: 0.0495 -
```

```
accuracy: 0.9830 - val_loss: 0.7207 - val_accuracy: 0.8239
Epoch 16/20
168/168 [==============================] - 17s 98ms/step - loss: 0.0504 -
accuracy: 0.9830 - val_loss: 0.7510 - val_accuracy: 0.8368
Epoch 17/20
168/168 [==============================] - 16s 97ms/step - loss: 0.0521 -
accuracy: 0.9832 - val_loss: 0.3784 - val_accuracy: 0.8976
Epoch 18/20
168/168 [==============================] - 17s 98ms/step - loss: 0.0389 -
accuracy: 0.9865 - val_loss: 0.6708 - val_accuracy: 0.8547
Epoch 19/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0500 -
accuracy: 0.9826 - val_loss: 0.5124 - val_accuracy: 0.8726
Epoch 20/20
168/168 [==============================] - 16s 96ms/step - loss: 0.0271 -
accuracy: 0.9925 - val_loss: 0.4992 - val_accuracy: 0.8654
```

[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 388ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
```

```
1/1 [==============================] - 0s 21ms/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 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/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 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 385ms/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:  97.77%
Recall:  97.77%
Accuracy:  87.66%
```

[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 383ms/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 0.07%
Model probability for Coupe is 3.04%
Model probability for Hatchback is 85.75%
Model probability for Pick-Up is 2.16%
Model probability for SUV is 7.95%
Model probability for Sedan is 0.04%
Model probability for VAN is 0.98%
```

[16]:
```
model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}% ResNet50V2.h5"
model.save(os.path.join('models', model_file_name))
```

[ ]:
```

```