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 InceptionV3
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 = InceptionV3(
    weights='imagenet',
    include_top=False,
    input_shape=(224, 224, 3)
)
base_model.summary()
```

```
Model: "inception_v3"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 conv2d (Conv2D)                (None, 111, 111, 32  864
['input_1[0][0]']
                                )

 batch_normalization (BatchNorm  (None, 111, 111, 32  96
['conv2d[0][0]']
 alization)                     )

 activation (Activation)        (None, 111, 111, 32  0
['batch_normalization[0][0]']
                                )

 conv2d_1 (Conv2D)              (None, 109, 109, 32  9216
['activation[0][0]']
                                )

 batch_normalization_1 (BatchNo  (None, 109, 109, 32  96
['conv2d_1[0][0]']
 rmalization)                   )

 activation_1 (Activation)      (None, 109, 109, 32  0
['batch_normalization_1[0][0]']
                                )

 conv2d_2 (Conv2D)              (None, 109, 109, 64  18432
['activation_1[0][0]']
                                )

 batch_normalization_2 (BatchNo  (None, 109, 109, 64  192
```

```
['conv2d_2[0][0]']
 rmalization)                   )

 activation_2 (Activation)      (None, 109, 109, 64  0
['batch_normalization_2[0][0]']
                                )

 max_pooling2d (MaxPooling2D)   (None, 54, 54, 64)   0
['activation_2[0][0]']

 conv2d_3 (Conv2D)              (None, 54, 54, 80)   5120
['max_pooling2d[0][0]']

 batch_normalization_3 (BatchNo  (None, 54, 54, 80)  240
['conv2d_3[0][0]']
 rmalization)

 activation_3 (Activation)      (None, 54, 54, 80)   0
['batch_normalization_3[0][0]']

 conv2d_4 (Conv2D)              (None, 52, 52, 192)  138240
['activation_3[0][0]']

 batch_normalization_4 (BatchNo  (None, 52, 52, 192)  576
['conv2d_4[0][0]']
 rmalization)

 activation_4 (Activation)      (None, 52, 52, 192)  0
['batch_normalization_4[0][0]']

 max_pooling2d_1 (MaxPooling2D)  (None, 25, 25, 192)  0
['activation_4[0][0]']

 conv2d_8 (Conv2D)              (None, 25, 25, 64)   12288
['max_pooling2d_1[0][0]']

 batch_normalization_8 (BatchNo  (None, 25, 25, 64)  192
['conv2d_8[0][0]']
 rmalization)

 activation_8 (Activation)      (None, 25, 25, 64)   0
['batch_normalization_8[0][0]']

 conv2d_6 (Conv2D)              (None, 25, 25, 48)   9216
['max_pooling2d_1[0][0]']

 conv2d_9 (Conv2D)              (None, 25, 25, 96)   55296
['activation_8[0][0]']
```

```
 batch_normalization_6 (BatchNo  (None, 25, 25, 48)  144
['conv2d_6[0][0]']
 rmalization)

 batch_normalization_9 (BatchNo  (None, 25, 25, 96)  288
['conv2d_9[0][0]']
 rmalization)

 activation_6 (Activation)      (None, 25, 25, 48)   0
['batch_normalization_6[0][0]']

 activation_9 (Activation)      (None, 25, 25, 96)   0
['batch_normalization_9[0][0]']

 average_pooling2d (AveragePool  (None, 25, 25, 192)  0
['max_pooling2d_1[0][0]']
 ing2D)

 conv2d_5 (Conv2D)              (None, 25, 25, 64)   12288
['max_pooling2d_1[0][0]']

 conv2d_7 (Conv2D)              (None, 25, 25, 64)   76800
['activation_6[0][0]']

 conv2d_10 (Conv2D)             (None, 25, 25, 96)   82944
['activation_9[0][0]']

 conv2d_11 (Conv2D)             (None, 25, 25, 32)   6144
['average_pooling2d[0][0]']

 batch_normalization_5 (BatchNo  (None, 25, 25, 64)  192
['conv2d_5[0][0]']
 rmalization)

 batch_normalization_7 (BatchNo  (None, 25, 25, 64)  192
['conv2d_7[0][0]']
 rmalization)

 batch_normalization_10 (BatchN  (None, 25, 25, 96)  288
['conv2d_10[0][0]']
 ormalization)

 batch_normalization_11 (BatchN  (None, 25, 25, 32)  96
['conv2d_11[0][0]']
 ormalization)

 activation_5 (Activation)      (None, 25, 25, 64)   0
```

```
['batch_normalization_5[0][0]']

 activation_7 (Activation)      (None, 25, 25, 64)   0
['batch_normalization_7[0][0]']

 activation_10 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_10[0][0]']

 activation_11 (Activation)     (None, 25, 25, 32)   0
['batch_normalization_11[0][0]']

 mixed0 (Concatenate)           (None, 25, 25, 256)  0
['activation_5[0][0]',
'activation_7[0][0]',
'activation_10[0][0]',
'activation_11[0][0]']

 conv2d_15 (Conv2D)             (None, 25, 25, 64)   16384
['mixed0[0][0]']

 batch_normalization_15 (BatchN  (None, 25, 25, 64)  192
['conv2d_15[0][0]']
 ormalization)

 activation_15 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_15[0][0]']

 conv2d_13 (Conv2D)             (None, 25, 25, 48)   12288
['mixed0[0][0]']

 conv2d_16 (Conv2D)             (None, 25, 25, 96)   55296
['activation_15[0][0]']

 batch_normalization_13 (BatchN  (None, 25, 25, 48)  144
['conv2d_13[0][0]']
 ormalization)

 batch_normalization_16 (BatchN  (None, 25, 25, 96)  288
['conv2d_16[0][0]']
 ormalization)

 activation_13 (Activation)     (None, 25, 25, 48)   0
['batch_normalization_13[0][0]']

 activation_16 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_16[0][0]']

 average_pooling2d_1 (AveragePo  (None, 25, 25, 256)  0
```

```
['mixed0[0][0]']
 oling2D)

 conv2d_12 (Conv2D)             (None, 25, 25, 64)   16384
['mixed0[0][0]']

 conv2d_14 (Conv2D)             (None, 25, 25, 64)   76800
['activation_13[0][0]']

 conv2d_17 (Conv2D)             (None, 25, 25, 96)   82944
['activation_16[0][0]']

 conv2d_18 (Conv2D)             (None, 25, 25, 64)   16384
['average_pooling2d_1[0][0]']

 batch_normalization_12 (BatchN  (None, 25, 25, 64)  192
['conv2d_12[0][0]']
 ormalization)

 batch_normalization_14 (BatchN  (None, 25, 25, 64)  192
['conv2d_14[0][0]']
 ormalization)

 batch_normalization_17 (BatchN  (None, 25, 25, 96)  288
['conv2d_17[0][0]']
 ormalization)

 batch_normalization_18 (BatchN  (None, 25, 25, 64)  192
['conv2d_18[0][0]']
 ormalization)

 activation_12 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_12[0][0]']

 activation_14 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_14[0][0]']

 activation_17 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_17[0][0]']

 activation_18 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_18[0][0]']

 mixed1 (Concatenate)           (None, 25, 25, 288)  0
['activation_12[0][0]',
'activation_14[0][0]',
'activation_17[0][0]',
'activation_18[0][0]']
```

```
 conv2d_22 (Conv2D)             (None, 25, 25, 64)   18432
['mixed1[0][0]']

 batch_normalization_22 (BatchN  (None, 25, 25, 64)  192
['conv2d_22[0][0]']
 ormalization)

 activation_22 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_22[0][0]']

 conv2d_20 (Conv2D)             (None, 25, 25, 48)   13824
['mixed1[0][0]']

 conv2d_23 (Conv2D)             (None, 25, 25, 96)   55296
['activation_22[0][0]']

 batch_normalization_20 (BatchN  (None, 25, 25, 48)  144
['conv2d_20[0][0]']
 ormalization)

 batch_normalization_23 (BatchN  (None, 25, 25, 96)  288
['conv2d_23[0][0]']
 ormalization)

 activation_20 (Activation)     (None, 25, 25, 48)   0
['batch_normalization_20[0][0]']

 activation_23 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_23[0][0]']

 average_pooling2d_2 (AveragePo  (None, 25, 25, 288)  0
['mixed1[0][0]']
 oling2D)

 conv2d_19 (Conv2D)             (None, 25, 25, 64)   18432
['mixed1[0][0]']

 conv2d_21 (Conv2D)             (None, 25, 25, 64)   76800
['activation_20[0][0]']

 conv2d_24 (Conv2D)             (None, 25, 25, 96)   82944
['activation_23[0][0]']

 conv2d_25 (Conv2D)             (None, 25, 25, 64)   18432
['average_pooling2d_2[0][0]']

 batch_normalization_19 (BatchN  (None, 25, 25, 64)  192
```

```
['conv2d_19[0][0]']
 ormalization)

 batch_normalization_21 (BatchN  (None, 25, 25, 64)  192
['conv2d_21[0][0]']
 ormalization)

 batch_normalization_24 (BatchN  (None, 25, 25, 96)  288
['conv2d_24[0][0]']
 ormalization)

 batch_normalization_25 (BatchN  (None, 25, 25, 64)  192
['conv2d_25[0][0]']
 ormalization)

 activation_19 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_19[0][0]']

 activation_21 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_21[0][0]']

 activation_24 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_24[0][0]']

 activation_25 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_25[0][0]']

 mixed2 (Concatenate)           (None, 25, 25, 288)  0
['activation_19[0][0]',
'activation_21[0][0]',
'activation_24[0][0]',
'activation_25[0][0]']

 conv2d_27 (Conv2D)             (None, 25, 25, 64)   18432
['mixed2[0][0]']

 batch_normalization_27 (BatchN  (None, 25, 25, 64)  192
['conv2d_27[0][0]']
 ormalization)

 activation_27 (Activation)     (None, 25, 25, 64)   0
['batch_normalization_27[0][0]']

 conv2d_28 (Conv2D)             (None, 25, 25, 96)   55296
['activation_27[0][0]']

 batch_normalization_28 (BatchN  (None, 25, 25, 96)  288
['conv2d_28[0][0]']
```

```
 ormalization)

 activation_28 (Activation)     (None, 25, 25, 96)   0
['batch_normalization_28[0][0]']

 conv2d_26 (Conv2D)             (None, 12, 12, 384)  995328
['mixed2[0][0]']

 conv2d_29 (Conv2D)             (None, 12, 12, 96)   82944
['activation_28[0][0]']

 batch_normalization_26 (BatchN  (None, 12, 12, 384)  1152
['conv2d_26[0][0]']
 ormalization)

 batch_normalization_29 (BatchN  (None, 12, 12, 96)  288
['conv2d_29[0][0]']
 ormalization)

 activation_26 (Activation)     (None, 12, 12, 384)  0
['batch_normalization_26[0][0]']

 activation_29 (Activation)     (None, 12, 12, 96)   0
['batch_normalization_29[0][0]']

 max_pooling2d_2 (MaxPooling2D)  (None, 12, 12, 288)  0
['mixed2[0][0]']

 mixed3 (Concatenate)           (None, 12, 12, 768)  0
['activation_26[0][0]',
'activation_29[0][0]',
'max_pooling2d_2[0][0]']

 conv2d_34 (Conv2D)             (None, 12, 12, 128)  98304
['mixed3[0][0]']

 batch_normalization_34 (BatchN  (None, 12, 12, 128)  384
['conv2d_34[0][0]']
 ormalization)

 activation_34 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_34[0][0]']

 conv2d_35 (Conv2D)             (None, 12, 12, 128)  114688
['activation_34[0][0]']

 batch_normalization_35 (BatchN  (None, 12, 12, 128)  384
['conv2d_35[0][0]']
```

```
 ormalization)

 activation_35 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_35[0][0]']

 conv2d_31 (Conv2D)             (None, 12, 12, 128)  98304
['mixed3[0][0]']

 conv2d_36 (Conv2D)             (None, 12, 12, 128)  114688
['activation_35[0][0]']

 batch_normalization_31 (BatchN  (None, 12, 12, 128)  384
['conv2d_31[0][0]']
 ormalization)

 batch_normalization_36 (BatchN  (None, 12, 12, 128)  384
['conv2d_36[0][0]']
 ormalization)

 activation_31 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_31[0][0]']

 activation_36 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_36[0][0]']

 conv2d_32 (Conv2D)             (None, 12, 12, 128)  114688
['activation_31[0][0]']

 conv2d_37 (Conv2D)             (None, 12, 12, 128)  114688
['activation_36[0][0]']

 batch_normalization_32 (BatchN  (None, 12, 12, 128)  384
['conv2d_32[0][0]']
 ormalization)

 batch_normalization_37 (BatchN  (None, 12, 12, 128)  384
['conv2d_37[0][0]']
 ormalization)

 activation_32 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_32[0][0]']

 activation_37 (Activation)     (None, 12, 12, 128)  0
['batch_normalization_37[0][0]']

 average_pooling2d_3 (AveragePo  (None, 12, 12, 768)  0
['mixed3[0][0]']
 oling2D)
```

```
 conv2d_30 (Conv2D)             (None, 12, 12, 192)  147456
['mixed3[0][0]']

 conv2d_33 (Conv2D)             (None, 12, 12, 192)  172032
['activation_32[0][0]']

 conv2d_38 (Conv2D)             (None, 12, 12, 192)  172032
['activation_37[0][0]']

 conv2d_39 (Conv2D)             (None, 12, 12, 192)  147456
['average_pooling2d_3[0][0]']

 batch_normalization_30 (BatchN  (None, 12, 12, 192)  576
['conv2d_30[0][0]']
 ormalization)

 batch_normalization_33 (BatchN  (None, 12, 12, 192)  576
['conv2d_33[0][0]']
 ormalization)

 batch_normalization_38 (BatchN  (None, 12, 12, 192)  576
['conv2d_38[0][0]']
 ormalization)

 batch_normalization_39 (BatchN  (None, 12, 12, 192)  576
['conv2d_39[0][0]']
 ormalization)

 activation_30 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_30[0][0]']

 activation_33 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_33[0][0]']

 activation_38 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_38[0][0]']

 activation_39 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_39[0][0]']

 mixed4 (Concatenate)           (None, 12, 12, 768)  0
['activation_30[0][0]',
'activation_33[0][0]',
'activation_38[0][0]',
'activation_39[0][0]']

 conv2d_44 (Conv2D)             (None, 12, 12, 160)  122880
```

```
['mixed4[0][0]']

 batch_normalization_44 (BatchN  (None, 12, 12, 160)  480
['conv2d_44[0][0]']
 ormalization)

 activation_44 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_44[0][0]']

 conv2d_45 (Conv2D)             (None, 12, 12, 160)  179200
['activation_44[0][0]']

 batch_normalization_45 (BatchN  (None, 12, 12, 160)  480
['conv2d_45[0][0]']
 ormalization)

 activation_45 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_45[0][0]']

 conv2d_41 (Conv2D)             (None, 12, 12, 160)  122880
['mixed4[0][0]']

 conv2d_46 (Conv2D)             (None, 12, 12, 160)  179200
['activation_45[0][0]']

 batch_normalization_41 (BatchN  (None, 12, 12, 160)  480
['conv2d_41[0][0]']
 ormalization)

 batch_normalization_46 (BatchN  (None, 12, 12, 160)  480
['conv2d_46[0][0]']
 ormalization)

 activation_41 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_41[0][0]']

 activation_46 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_46[0][0]']

 conv2d_42 (Conv2D)             (None, 12, 12, 160)  179200
['activation_41[0][0]']

 conv2d_47 (Conv2D)             (None, 12, 12, 160)  179200
['activation_46[0][0]']

 batch_normalization_42 (BatchN  (None, 12, 12, 160)  480
['conv2d_42[0][0]']
 ormalization)
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```
 batch_normalization_47 (BatchN  (None, 12, 12, 160)  480
['conv2d_47[0][0]']
 ormalization)

 activation_42 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_42[0][0]']

 activation_47 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_47[0][0]']

 average_pooling2d_4 (AveragePo  (None, 12, 12, 768)  0
['mixed4[0][0]']
 oling2D)

 conv2d_40 (Conv2D)             (None, 12, 12, 192)  147456
['mixed4[0][0]']

 conv2d_43 (Conv2D)             (None, 12, 12, 192)  215040
['activation_42[0][0]']

 conv2d_48 (Conv2D)             (None, 12, 12, 192)  215040
['activation_47[0][0]']

 conv2d_49 (Conv2D)             (None, 12, 12, 192)  147456
['average_pooling2d_4[0][0]']

 batch_normalization_40 (BatchN  (None, 12, 12, 192)  576
['conv2d_40[0][0]']
 ormalization)

 batch_normalization_43 (BatchN  (None, 12, 12, 192)  576
['conv2d_43[0][0]']
 ormalization)

 batch_normalization_48 (BatchN  (None, 12, 12, 192)  576
['conv2d_48[0][0]']
 ormalization)

 batch_normalization_49 (BatchN  (None, 12, 12, 192)  576
['conv2d_49[0][0]']
 ormalization)

 activation_40 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_40[0][0]']

 activation_43 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_43[0][0]']
```

```
 activation_48 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_48[0][0]']

 activation_49 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_49[0][0]']

 mixed5 (Concatenate)           (None, 12, 12, 768)  0
['activation_40[0][0]',
'activation_43[0][0]',
'activation_48[0][0]',
'activation_49[0][0]']

 conv2d_54 (Conv2D)             (None, 12, 12, 160)  122880
['mixed5[0][0]']

 batch_normalization_54 (BatchN  (None, 12, 12, 160)  480
['conv2d_54[0][0]']
 ormalization)

 activation_54 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_54[0][0]']

 conv2d_55 (Conv2D)             (None, 12, 12, 160)  179200
['activation_54[0][0]']

 batch_normalization_55 (BatchN  (None, 12, 12, 160)  480
['conv2d_55[0][0]']
 ormalization)

 activation_55 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_55[0][0]']

 conv2d_51 (Conv2D)             (None, 12, 12, 160)  122880
['mixed5[0][0]']

 conv2d_56 (Conv2D)             (None, 12, 12, 160)  179200
['activation_55[0][0]']

 batch_normalization_51 (BatchN  (None, 12, 12, 160)  480
['conv2d_51[0][0]']
 ormalization)

 batch_normalization_56 (BatchN  (None, 12, 12, 160)  480
['conv2d_56[0][0]']
 ormalization)

 activation_51 (Activation)     (None, 12, 12, 160)  0
```

```
['batch_normalization_51[0][0]']

 activation_56 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_56[0][0]']

 conv2d_52 (Conv2D)             (None, 12, 12, 160)  179200
['activation_51[0][0]']

 conv2d_57 (Conv2D)             (None, 12, 12, 160)  179200
['activation_56[0][0]']

 batch_normalization_52 (BatchN  (None, 12, 12, 160)  480
['conv2d_52[0][0]']
 ormalization)

 batch_normalization_57 (BatchN  (None, 12, 12, 160)  480
['conv2d_57[0][0]']
 ormalization)

 activation_52 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_52[0][0]']

 activation_57 (Activation)     (None, 12, 12, 160)  0
['batch_normalization_57[0][0]']

 average_pooling2d_5 (AveragePo  (None, 12, 12, 768)  0
['mixed5[0][0]']
 oling2D)

 conv2d_50 (Conv2D)             (None, 12, 12, 192)  147456
['mixed5[0][0]']

 conv2d_53 (Conv2D)             (None, 12, 12, 192)  215040
['activation_52[0][0]']

 conv2d_58 (Conv2D)             (None, 12, 12, 192)  215040
['activation_57[0][0]']

 conv2d_59 (Conv2D)             (None, 12, 12, 192)  147456
['average_pooling2d_5[0][0]']

 batch_normalization_50 (BatchN  (None, 12, 12, 192)  576
['conv2d_50[0][0]']
 ormalization)

 batch_normalization_53 (BatchN  (None, 12, 12, 192)  576
['conv2d_53[0][0]']
 ormalization)
```

```
 batch_normalization_58 (BatchN  (None, 12, 12, 192)  576
['conv2d_58[0][0]']
 ormalization)

 batch_normalization_59 (BatchN  (None, 12, 12, 192)  576
['conv2d_59[0][0]']
 ormalization)

 activation_50 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_50[0][0]']

 activation_53 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_53[0][0]']

 activation_58 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_58[0][0]']

 activation_59 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_59[0][0]']

 mixed6 (Concatenate)           (None, 12, 12, 768)  0
['activation_50[0][0]',
'activation_53[0][0]',
'activation_58[0][0]',
'activation_59[0][0]']

 conv2d_64 (Conv2D)             (None, 12, 12, 192)  147456
['mixed6[0][0]']

 batch_normalization_64 (BatchN  (None, 12, 12, 192)  576
['conv2d_64[0][0]']
 ormalization)

 activation_64 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_64[0][0]']

 conv2d_65 (Conv2D)             (None, 12, 12, 192)  258048
['activation_64[0][0]']

 batch_normalization_65 (BatchN  (None, 12, 12, 192)  576
['conv2d_65[0][0]']
 ormalization)

 activation_65 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_65[0][0]']

 conv2d_61 (Conv2D)             (None, 12, 12, 192)  147456
```

```
['mixed6[0][0]']

 conv2d_66 (Conv2D)             (None, 12, 12, 192)  258048
['activation_65[0][0]']

 batch_normalization_61 (BatchN  (None, 12, 12, 192)  576
['conv2d_61[0][0]']
 ormalization)

 batch_normalization_66 (BatchN  (None, 12, 12, 192)  576
['conv2d_66[0][0]']
 ormalization)

 activation_61 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_61[0][0]']

 activation_66 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_66[0][0]']

 conv2d_62 (Conv2D)             (None, 12, 12, 192)  258048
['activation_61[0][0]']

 conv2d_67 (Conv2D)             (None, 12, 12, 192)  258048
['activation_66[0][0]']

 batch_normalization_62 (BatchN  (None, 12, 12, 192)  576
['conv2d_62[0][0]']
 ormalization)

 batch_normalization_67 (BatchN  (None, 12, 12, 192)  576
['conv2d_67[0][0]']
 ormalization)

 activation_62 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_62[0][0]']

 activation_67 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_67[0][0]']

 average_pooling2d_6 (AveragePo  (None, 12, 12, 768)  0
['mixed6[0][0]']
 oling2D)

 conv2d_60 (Conv2D)             (None, 12, 12, 192)  147456
['mixed6[0][0]']

 conv2d_63 (Conv2D)             (None, 12, 12, 192)  258048
['activation_62[0][0]']
```

```
 conv2d_68 (Conv2D)             (None, 12, 12, 192)  258048
['activation_67[0][0]']

 conv2d_69 (Conv2D)             (None, 12, 12, 192)  147456
['average_pooling2d_6[0][0]']

 batch_normalization_60 (BatchN  (None, 12, 12, 192)  576
['conv2d_60[0][0]']
 ormalization)

 batch_normalization_63 (BatchN  (None, 12, 12, 192)  576
['conv2d_63[0][0]']
 ormalization)

 batch_normalization_68 (BatchN  (None, 12, 12, 192)  576
['conv2d_68[0][0]']
 ormalization)

 batch_normalization_69 (BatchN  (None, 12, 12, 192)  576
['conv2d_69[0][0]']
 ormalization)

 activation_60 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_60[0][0]']

 activation_63 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_63[0][0]']

 activation_68 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_68[0][0]']

 activation_69 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_69[0][0]']

 mixed7 (Concatenate)           (None, 12, 12, 768)  0
['activation_60[0][0]',
'activation_63[0][0]',
'activation_68[0][0]',
'activation_69[0][0]']

 conv2d_72 (Conv2D)             (None, 12, 12, 192)  147456
['mixed7[0][0]']

 batch_normalization_72 (BatchN  (None, 12, 12, 192)  576
['conv2d_72[0][0]']
 ormalization)
```

```
 activation_72 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_72[0][0]']

 conv2d_73 (Conv2D)             (None, 12, 12, 192)  258048
['activation_72[0][0]']

 batch_normalization_73 (BatchN  (None, 12, 12, 192)  576
['conv2d_73[0][0]']
 ormalization)

 activation_73 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_73[0][0]']

 conv2d_70 (Conv2D)             (None, 12, 12, 192)  147456
['mixed7[0][0]']

 conv2d_74 (Conv2D)             (None, 12, 12, 192)  258048
['activation_73[0][0]']

 batch_normalization_70 (BatchN  (None, 12, 12, 192)  576
['conv2d_70[0][0]']
 ormalization)

 batch_normalization_74 (BatchN  (None, 12, 12, 192)  576
['conv2d_74[0][0]']
 ormalization)

 activation_70 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_70[0][0]']

 activation_74 (Activation)     (None, 12, 12, 192)  0
['batch_normalization_74[0][0]']

 conv2d_71 (Conv2D)             (None, 5, 5, 320)    552960
['activation_70[0][0]']

 conv2d_75 (Conv2D)             (None, 5, 5, 192)    331776
['activation_74[0][0]']

 batch_normalization_71 (BatchN  (None, 5, 5, 320)   960
['conv2d_71[0][0]']
 ormalization)

 batch_normalization_75 (BatchN  (None, 5, 5, 192)   576
['conv2d_75[0][0]']
 ormalization)

 activation_71 (Activation)     (None, 5, 5, 320)    0
```

```
['batch_normalization_71[0][0]']

 activation_75 (Activation)     (None, 5, 5, 192)    0
['batch_normalization_75[0][0]']

 max_pooling2d_3 (MaxPooling2D)  (None, 5, 5, 768)   0
['mixed7[0][0]']

 mixed8 (Concatenate)           (None, 5, 5, 1280)   0
['activation_71[0][0]',
'activation_75[0][0]',
'max_pooling2d_3[0][0]']

 conv2d_80 (Conv2D)             (None, 5, 5, 448)    573440
['mixed8[0][0]']

 batch_normalization_80 (BatchN  (None, 5, 5, 448)   1344
['conv2d_80[0][0]']
 ormalization)

 activation_80 (Activation)     (None, 5, 5, 448)    0
['batch_normalization_80[0][0]']

 conv2d_77 (Conv2D)             (None, 5, 5, 384)    491520
['mixed8[0][0]']

 conv2d_81 (Conv2D)             (None, 5, 5, 384)    1548288
['activation_80[0][0]']

 batch_normalization_77 (BatchN  (None, 5, 5, 384)   1152
['conv2d_77[0][0]']
 ormalization)

 batch_normalization_81 (BatchN  (None, 5, 5, 384)   1152
['conv2d_81[0][0]']
 ormalization)

 activation_77 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_77[0][0]']

 activation_81 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_81[0][0]']

 conv2d_78 (Conv2D)             (None, 5, 5, 384)    442368
['activation_77[0][0]']

 conv2d_79 (Conv2D)             (None, 5, 5, 384)    442368
['activation_77[0][0]']
```

```
 conv2d_82 (Conv2D)             (None, 5, 5, 384)    442368
['activation_81[0][0]']

 conv2d_83 (Conv2D)             (None, 5, 5, 384)    442368
['activation_81[0][0]']

 average_pooling2d_7 (AveragePo  (None, 5, 5, 1280)  0
['mixed8[0][0]']
 oling2D)

 conv2d_76 (Conv2D)             (None, 5, 5, 320)    409600
['mixed8[0][0]']

 batch_normalization_78 (BatchN  (None, 5, 5, 384)   1152
['conv2d_78[0][0]']
 ormalization)

 batch_normalization_79 (BatchN  (None, 5, 5, 384)   1152
['conv2d_79[0][0]']
 ormalization)

 batch_normalization_82 (BatchN  (None, 5, 5, 384)   1152
['conv2d_82[0][0]']
 ormalization)

 batch_normalization_83 (BatchN  (None, 5, 5, 384)   1152
['conv2d_83[0][0]']
 ormalization)

 conv2d_84 (Conv2D)             (None, 5, 5, 192)    245760
['average_pooling2d_7[0][0]']

 batch_normalization_76 (BatchN  (None, 5, 5, 320)   960
['conv2d_76[0][0]']
 ormalization)

 activation_78 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_78[0][0]']

 activation_79 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_79[0][0]']

 activation_82 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_82[0][0]']

 activation_83 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_83[0][0]']
```

```
 batch_normalization_84 (BatchN  (None, 5, 5, 192)   576
['conv2d_84[0][0]']
 ormalization)

 activation_76 (Activation)     (None, 5, 5, 320)    0
['batch_normalization_76[0][0]']

 mixed9_0 (Concatenate)         (None, 5, 5, 768)    0
['activation_78[0][0]',
'activation_79[0][0]']

 concatenate (Concatenate)      (None, 5, 5, 768)    0
['activation_82[0][0]',
'activation_83[0][0]']

 activation_84 (Activation)     (None, 5, 5, 192)    0
['batch_normalization_84[0][0]']

 mixed9 (Concatenate)           (None, 5, 5, 2048)   0
['activation_76[0][0]',
'mixed9_0[0][0]',
'concatenate[0][0]',
'activation_84[0][0]']

 conv2d_89 (Conv2D)             (None, 5, 5, 448)    917504
['mixed9[0][0]']

 batch_normalization_89 (BatchN  (None, 5, 5, 448)   1344
['conv2d_89[0][0]']
 ormalization)

 activation_89 (Activation)     (None, 5, 5, 448)    0
['batch_normalization_89[0][0]']

 conv2d_86 (Conv2D)             (None, 5, 5, 384)    786432
['mixed9[0][0]']

 conv2d_90 (Conv2D)             (None, 5, 5, 384)    1548288
['activation_89[0][0]']

 batch_normalization_86 (BatchN  (None, 5, 5, 384)   1152
['conv2d_86[0][0]']
 ormalization)

 batch_normalization_90 (BatchN  (None, 5, 5, 384)   1152
['conv2d_90[0][0]']
 ormalization)
```

```
 activation_86 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_86[0][0]']

 activation_90 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_90[0][0]']

 conv2d_87 (Conv2D)             (None, 5, 5, 384)    442368
['activation_86[0][0]']

 conv2d_88 (Conv2D)             (None, 5, 5, 384)    442368
['activation_86[0][0]']

 conv2d_91 (Conv2D)             (None, 5, 5, 384)    442368
['activation_90[0][0]']

 conv2d_92 (Conv2D)             (None, 5, 5, 384)    442368
['activation_90[0][0]']

 average_pooling2d_8 (AveragePo  (None, 5, 5, 2048)  0
['mixed9[0][0]']
 oling2D)

 conv2d_85 (Conv2D)             (None, 5, 5, 320)    655360
['mixed9[0][0]']

 batch_normalization_87 (BatchN  (None, 5, 5, 384)   1152
['conv2d_87[0][0]']
 ormalization)

 batch_normalization_88 (BatchN  (None, 5, 5, 384)   1152
['conv2d_88[0][0]']
 ormalization)

 batch_normalization_91 (BatchN  (None, 5, 5, 384)   1152
['conv2d_91[0][0]']
 ormalization)

 batch_normalization_92 (BatchN  (None, 5, 5, 384)   1152
['conv2d_92[0][0]']
 ormalization)

 conv2d_93 (Conv2D)             (None, 5, 5, 192)    393216
['average_pooling2d_8[0][0]']

 batch_normalization_85 (BatchN  (None, 5, 5, 320)   960
['conv2d_85[0][0]']
 ormalization)
```

```
 activation_87 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_87[0][0]']

 activation_88 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_88[0][0]']

 activation_91 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_91[0][0]']

 activation_92 (Activation)     (None, 5, 5, 384)    0
['batch_normalization_92[0][0]']

 batch_normalization_93 (BatchN  (None, 5, 5, 192)   576
['conv2d_93[0][0]']
 ormalization)

 activation_85 (Activation)     (None, 5, 5, 320)    0
['batch_normalization_85[0][0]']

 mixed9_1 (Concatenate)         (None, 5, 5, 768)    0
['activation_87[0][0]',
'activation_88[0][0]']

 concatenate_1 (Concatenate)    (None, 5, 5, 768)    0
['activation_91[0][0]',
'activation_92[0][0]']

 activation_93 (Activation)     (None, 5, 5, 192)    0
['batch_normalization_93[0][0]']

 mixed10 (Concatenate)          (None, 5, 5, 2048)   0
['activation_85[0][0]',
'mixed9_1[0][0]',
'concatenate_1[0][0]',
'activation_93[0][0]']

==================================================================================
==================
Total params: 21,802,784
Trainable params: 21,768,352
Non-trainable params: 34,432
----------------------------------------------------------------------------------
------------------
```

[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'])

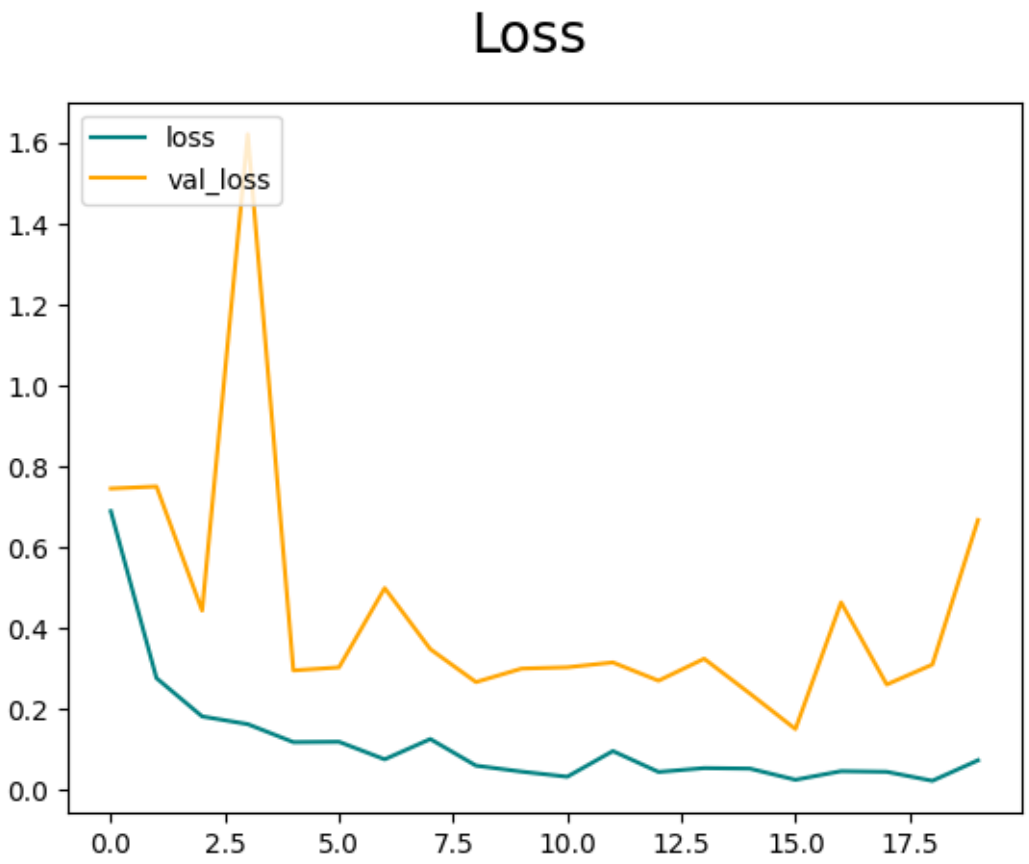
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir='logs')

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

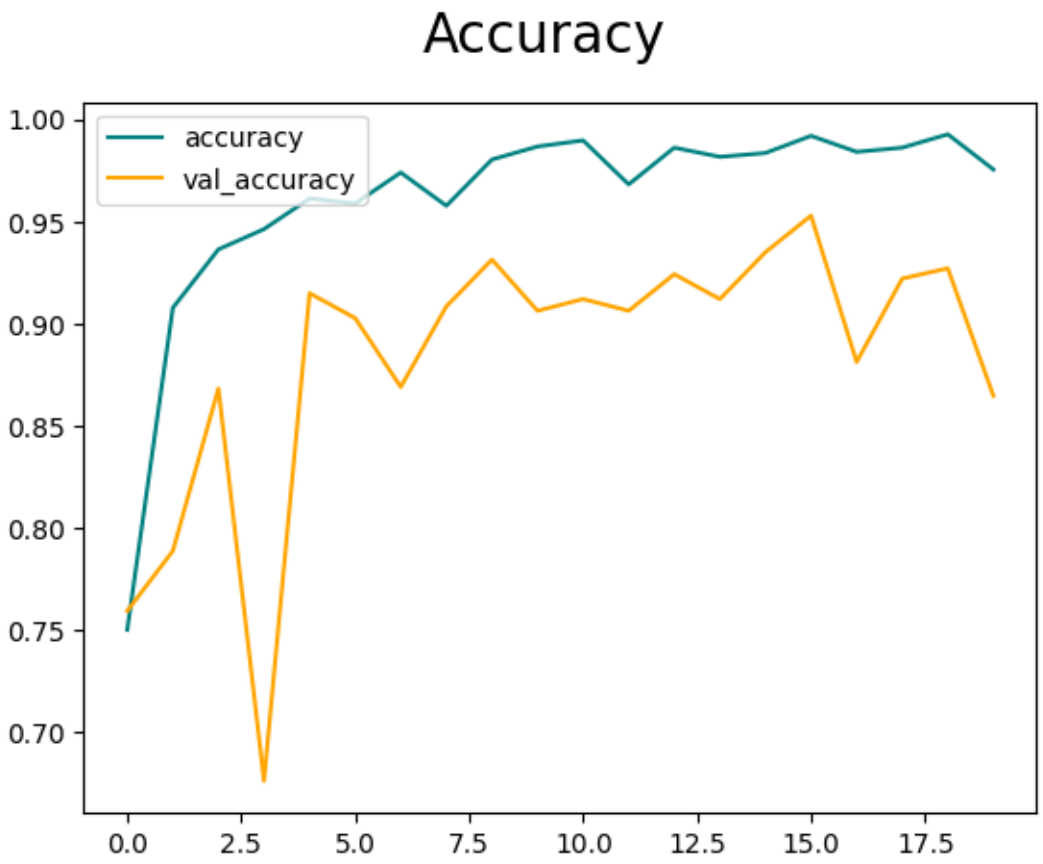
```
Epoch 1/20
168/168 [==============================] - 25s 99ms/step - loss: 0.6890 -
accuracy: 0.7503 - val_loss: 0.7450 - val_accuracy: 0.7595
Epoch 2/20
168/168 [==============================] - 15s 91ms/step - loss: 0.2768 -
accuracy: 0.9077 - val_loss: 0.7499 - val_accuracy: 0.7888
Epoch 3/20
168/168 [==============================] - 15s 91ms/step - loss: 0.1823 -
accuracy: 0.9363 - val_loss: 0.4436 - val_accuracy: 0.8683
Epoch 4/20
168/168 [==============================] - 16s 92ms/step - loss: 0.1632 -
accuracy: 0.9462 - val_loss: 1.6195 - val_accuracy: 0.6764
Epoch 5/20
168/168 [==============================] - 15s 91ms/step - loss: 0.1187 -
accuracy: 0.9611 - val_loss: 0.2958 - val_accuracy: 0.9148
Epoch 6/20
168/168 [==============================] - 15s 91ms/step - loss: 0.1196 -
accuracy: 0.9587 - val_loss: 0.3034 - val_accuracy: 0.9026
Epoch 7/20
168/168 [==============================] - 15s 91ms/step - loss: 0.0763 -
accuracy: 0.9738 - val_loss: 0.4992 - val_accuracy: 0.8690
Epoch 8/20
168/168 [==============================] - 16s 91ms/step - loss: 0.1264 -
accuracy: 0.9576 - val_loss: 0.3483 - val_accuracy: 0.9084
Epoch 9/20
168/168 [==============================] - 15s 91ms/step - loss: 0.0607 -
accuracy: 0.9802 - val_loss: 0.2670 - val_accuracy: 0.9313
Epoch 10/20
168/168 [==============================] - 16s 92ms/step - loss: 0.0460 -
accuracy: 0.9865 - val_loss: 0.3004 - val_accuracy: 0.9062
Epoch 11/20
168/168 [==============================] - 16s 93ms/step - loss: 0.0334 -
accuracy: 0.9895 - val_loss: 0.3036 - val_accuracy: 0.9120
Epoch 12/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0967 -
accuracy: 0.9680 - val_loss: 0.3155 - val_accuracy: 0.9062
```

```
Epoch 13/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0452 -
accuracy: 0.9860 - val_loss: 0.2705 - val_accuracy: 0.9241
Epoch 14/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0547 -
accuracy: 0.9815 - val_loss: 0.3247 - val_accuracy: 0.9120
Epoch 15/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0535 -
accuracy: 0.9834 - val_loss: 0.2389 - val_accuracy: 0.9349
Epoch 16/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0259 -
accuracy: 0.9918 - val_loss: 0.1511 - val_accuracy: 0.9528
Epoch 17/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0471 -
accuracy: 0.9839 - val_loss: 0.4638 - val_accuracy: 0.8812
Epoch 18/20
168/168 [==============================] - 16s 96ms/step - loss: 0.0455 -
accuracy: 0.9860 - val_loss: 0.2610 - val_accuracy: 0.9220
Epoch 19/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0234 -
accuracy: 0.9925 - val_loss: 0.3103 - val_accuracy: 0.9270
Epoch 20/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0739 -
accuracy: 0.9753 - val_loss: 0.6673 - val_accuracy: 0.8647
```

[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 657ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/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 21ms/step
1/1 [==============================] - 0s 22ms/step
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1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 1s 550ms/step
```

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

```
Precision:  99.68%
Recall:  98.57%
Accuracy:  85.29%
```

[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 547ms/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: Sedan
Model probability for Convertible is 0.05%
Model probability for Coupe is 1.55%
Model probability for Hatchback is 8.74%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.02%
Model probability for Sedan is 89.64%
Model probability for VAN is 0.00%
```

[16]:
```
model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}% InceptionV3.h5"
model.save(os.path.join('CarBackEnd/models/CarStyles', model_file_name))
```

[ ]:
```

```