CarStyle

October 1, 2024

```python
[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 DenseNet121
     from keras.models import Model
     from keras.layers import Dense, GlobalAveragePooling2D
     from keras.metrics import Precision, Recall, SparseCategoricalAccuracy
```

```python
[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
```

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

[6]:
```python
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()
```
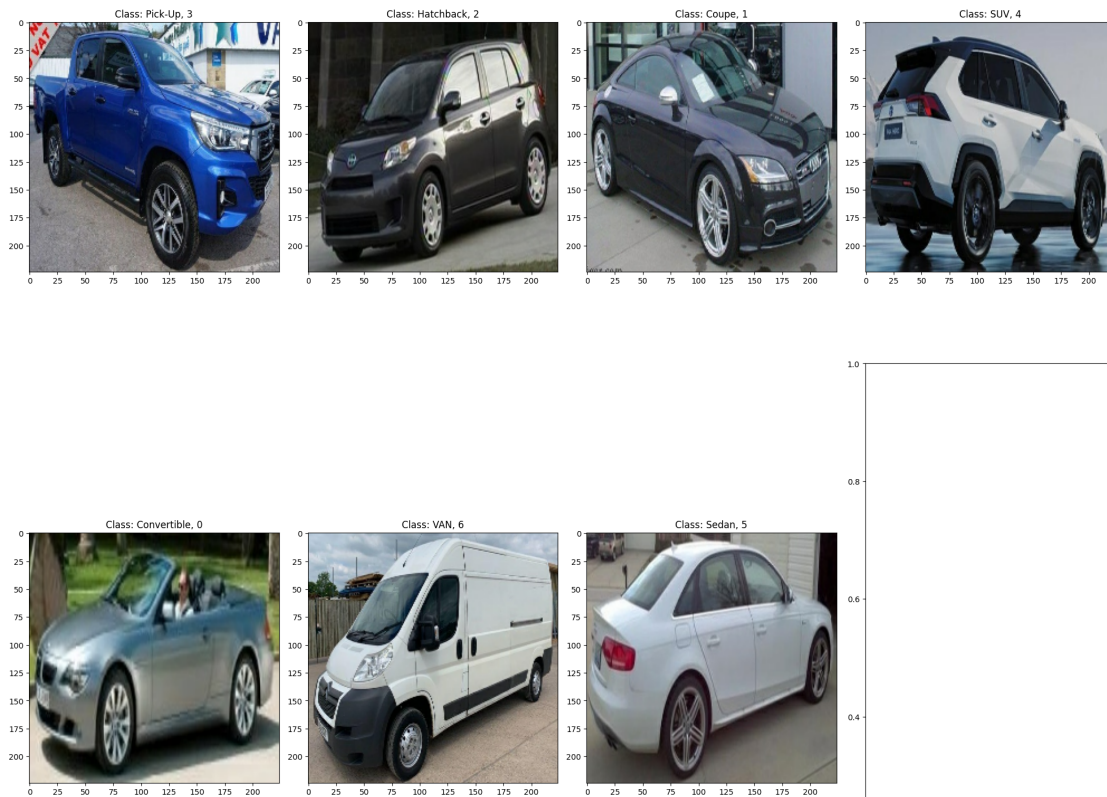
2

```python
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()
```


Class: Pick-Up, 3   Class: Hatchback, 2   Class: Coupe, 1   Class: SUV, 4

Class: Convertible, 0   Class: VAN, 6   Class: Sedan, 5

```
[7]: base_model = DenseNet121(
         weights='imagenet',
         include_top=False,
         input_shape=(224, 224, 3)
     )
     base_model.summary()
```

```
Model: "densenet121"

--------------------------------------------------------------------------------
------------------
 Layer (type)                  Output Shape         Param #    Connected to
================================================================================
================
 input_1 (InputLayer)          [(None, 224, 224, 3  0          []
                               )]

 zero_padding2d (ZeroPadding2D) (None, 230, 230, 3)  0          ['input_1[0][0]']

 conv1/conv (Conv2D)           (None, 112, 112, 64  9408       ['zero_padding2d[0][0]']
                               )

 conv1/bn (BatchNormalization)  (None, 112, 112, 64  256        ['conv1/conv[0][0]']
                               )

 conv1/relu (Activation)       (None, 112, 112, 64  0          ['conv1/bn[0][0]']
                               )

 zero_padding2d_1 (ZeroPadding2  (None, 114, 114, 64  0          ['conv1/relu[0][0]']
 D)                            )

 pool1 (MaxPooling2D)          (None, 56, 56, 64)   0          ['zero_padding2d_1[0][0]']

 conv2_block1_0_bn (BatchNormal  (None, 56, 56, 64)   256        ['pool1[0][0]']
 ization)

 conv2_block1_0_relu (Activatio  (None, 56, 56, 64)   0
```

4

```
['conv2_block1_0_bn[0][0]']
 n)

 conv2_block1_1_conv (Conv2D)    (None, 56, 56, 128)   8192
['conv2_block1_0_relu[0][0]']

 conv2_block1_1_bn (BatchNormal  (None, 56, 56, 128)   512
['conv2_block1_1_conv[0][0]']
 ization)

 conv2_block1_1_relu (Activatio  (None, 56, 56, 128)   0
['conv2_block1_1_bn[0][0]']
 n)

 conv2_block1_2_conv (Conv2D)    (None, 56, 56, 32)    36864
['conv2_block1_1_relu[0][0]']

 conv2_block1_concat (Concatena  (None, 56, 56, 96)    0           ['pool1[0][0]',
 te)
'conv2_block1_2_conv[0][0]']

 conv2_block2_0_bn (BatchNormal  (None, 56, 56, 96)    384
['conv2_block1_concat[0][0]']
 ization)

 conv2_block2_0_relu (Activatio  (None, 56, 56, 96)    0
['conv2_block2_0_bn[0][0]']
 n)

 conv2_block2_1_conv (Conv2D)    (None, 56, 56, 128)   12288
['conv2_block2_0_relu[0][0]']

 conv2_block2_1_bn (BatchNormal  (None, 56, 56, 128)   512
['conv2_block2_1_conv[0][0]']
 ization)

 conv2_block2_1_relu (Activatio  (None, 56, 56, 128)   0
['conv2_block2_1_bn[0][0]']
 n)

 conv2_block2_2_conv (Conv2D)    (None, 56, 56, 32)    36864
['conv2_block2_1_relu[0][0]']

 conv2_block2_concat (Concatena  (None, 56, 56, 128)   0
['conv2_block1_concat[0][0]',
 te)
'conv2_block2_2_conv[0][0]']
```

```
 conv2_block3_0_bn (BatchNormal   (None, 56, 56, 128)   512
['conv2_block2_concat[0][0]']
 ization)

 conv2_block3_0_relu (Activatio   (None, 56, 56, 128)   0
['conv2_block3_0_bn[0][0]']
 n)

 conv2_block3_1_conv (Conv2D)     (None, 56, 56, 128)   16384
['conv2_block3_0_relu[0][0]']

 conv2_block3_1_bn (BatchNormal   (None, 56, 56, 128)   512
['conv2_block3_1_conv[0][0]']
 ization)

 conv2_block3_1_relu (Activatio   (None, 56, 56, 128)   0
['conv2_block3_1_bn[0][0]']
 n)

 conv2_block3_2_conv (Conv2D)     (None, 56, 56, 32)    36864
['conv2_block3_1_relu[0][0]']

 conv2_block3_concat (Concatena   (None, 56, 56, 160)   0
['conv2_block2_concat[0][0]',
 te)
'conv2_block3_2_conv[0][0]']

 conv2_block4_0_bn (BatchNormal   (None, 56, 56, 160)   640
['conv2_block3_concat[0][0]']
 ization)

 conv2_block4_0_relu (Activatio   (None, 56, 56, 160)   0
['conv2_block4_0_bn[0][0]']
 n)

 conv2_block4_1_conv (Conv2D)     (None, 56, 56, 128)   20480
['conv2_block4_0_relu[0][0]']

 conv2_block4_1_bn (BatchNormal   (None, 56, 56, 128)   512
['conv2_block4_1_conv[0][0]']
 ization)

 conv2_block4_1_relu (Activatio   (None, 56, 56, 128)   0
['conv2_block4_1_bn[0][0]']
 n)

 conv2_block4_2_conv (Conv2D)     (None, 56, 56, 32)    36864
['conv2_block4_1_relu[0][0]']
```

```
conv2_block4_concat (Concatena  (None, 56, 56, 192)  0
['conv2_block3_concat[0][0]',
 te)
'conv2_block4_2_conv[0][0]']

 conv2_block5_0_bn (BatchNormal  (None, 56, 56, 192)  768
['conv2_block4_concat[0][0]']
 ization)

 conv2_block5_0_relu (Activatio  (None, 56, 56, 192)  0
['conv2_block5_0_bn[0][0]']
 n)

 conv2_block5_1_conv (Conv2D)   (None, 56, 56, 128)  24576
['conv2_block5_0_relu[0][0]']

 conv2_block5_1_bn (BatchNormal  (None, 56, 56, 128)  512
['conv2_block5_1_conv[0][0]']
 ization)

 conv2_block5_1_relu (Activatio  (None, 56, 56, 128)  0
['conv2_block5_1_bn[0][0]']
 n)

 conv2_block5_2_conv (Conv2D)   (None, 56, 56, 32)   36864
['conv2_block5_1_relu[0][0]']

 conv2_block5_concat (Concatena  (None, 56, 56, 224)  0
['conv2_block4_concat[0][0]',
 te)
'conv2_block5_2_conv[0][0]']

 conv2_block6_0_bn (BatchNormal  (None, 56, 56, 224)  896
['conv2_block5_concat[0][0]']
 ization)

 conv2_block6_0_relu (Activatio  (None, 56, 56, 224)  0
['conv2_block6_0_bn[0][0]']
 n)

 conv2_block6_1_conv (Conv2D)   (None, 56, 56, 128)  28672
['conv2_block6_0_relu[0][0]']

 conv2_block6_1_bn (BatchNormal  (None, 56, 56, 128)  512
['conv2_block6_1_conv[0][0]']
 ization)
```

```
conv2_block6_1_relu (Activatio   (None, 56, 56, 128)   0
['conv2_block6_1_bn[0][0]']
 n)

conv2_block6_2_conv (Conv2D)     (None, 56, 56, 32)    36864
['conv2_block6_1_relu[0][0]']

conv2_block6_concat (Concatena   (None, 56, 56, 256)   0
['conv2_block5_concat[0][0]',
 te)
'conv2_block6_2_conv[0][0]']

pool2_bn (BatchNormalization)    (None, 56, 56, 256)   1024
['conv2_block6_concat[0][0]']

pool2_relu (Activation)          (None, 56, 56, 256)   0
['pool2_bn[0][0]']

pool2_conv (Conv2D)              (None, 56, 56, 128)   32768
['pool2_relu[0][0]']

pool2_pool (AveragePooling2D)    (None, 28, 28, 128)   0
['pool2_conv[0][0]']

conv3_block1_0_bn (BatchNormal   (None, 28, 28, 128)   512
['pool2_pool[0][0]']
 ization)

conv3_block1_0_relu (Activatio   (None, 28, 28, 128)   0
['conv3_block1_0_bn[0][0]']
 n)

conv3_block1_1_conv (Conv2D)     (None, 28, 28, 128)   16384
['conv3_block1_0_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_conv (Conv2D)     (None, 28, 28, 32)    36864
['conv3_block1_1_relu[0][0]']

conv3_block1_concat (Concatena   (None, 28, 28, 160)   0
['pool2_pool[0][0]',
```

```
 te)
'conv3_block1_2_conv[0][0]']

 conv3_block2_0_bn (BatchNormal  (None, 28, 28, 160)  640
['conv3_block1_concat[0][0]']
 ization)

 conv3_block2_0_relu (Activatio  (None, 28, 28, 160)  0
['conv3_block2_0_bn[0][0]']
 n)

 conv3_block2_1_conv (Conv2D)   (None, 28, 28, 128)  20480
['conv3_block2_0_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_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block2_1_relu[0][0]']

 conv3_block2_concat (Concatena  (None, 28, 28, 192)  0
['conv3_block1_concat[0][0]',
 te)
'conv3_block2_2_conv[0][0]']

 conv3_block3_0_bn (BatchNormal  (None, 28, 28, 192)  768
['conv3_block2_concat[0][0]']
 ization)

 conv3_block3_0_relu (Activatio  (None, 28, 28, 192)  0
['conv3_block3_0_bn[0][0]']
 n)

 conv3_block3_1_conv (Conv2D)   (None, 28, 28, 128)  24576
['conv3_block3_0_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_conv (Conv2D)    (None, 28, 28, 32)    36864
['conv3_block3_1_relu[0][0]']

 conv3_block3_concat (Concatena  (None, 28, 28, 224)   0
['conv3_block2_concat[0][0]',
 te)
'conv3_block3_2_conv[0][0]']

 conv3_block4_0_bn (BatchNormal  (None, 28, 28, 224)   896
['conv3_block3_concat[0][0]']
 ization)

 conv3_block4_0_relu (Activatio  (None, 28, 28, 224)   0
['conv3_block4_0_bn[0][0]']
 n)

 conv3_block4_1_conv (Conv2D)    (None, 28, 28, 128)   28672
['conv3_block4_0_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_conv (Conv2D)    (None, 28, 28, 32)    36864
['conv3_block4_1_relu[0][0]']

 conv3_block4_concat (Concatena  (None, 28, 28, 256)   0
['conv3_block3_concat[0][0]',
 te)
'conv3_block4_2_conv[0][0]']

 conv3_block5_0_bn (BatchNormal  (None, 28, 28, 256)   1024
['conv3_block4_concat[0][0]']
 ization)

 conv3_block5_0_relu (Activatio  (None, 28, 28, 256)   0
['conv3_block5_0_bn[0][0]']
 n)

 conv3_block5_1_conv (Conv2D)    (None, 28, 28, 128)   32768
['conv3_block5_0_relu[0][0]']

 conv3_block5_1_bn (BatchNormal  (None, 28, 28, 128)   512
```

```
                                                    ['conv3_block5_1_conv[0][0]']
 ization)

 conv3_block5_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block5_1_bn[0][0]']
 n)

 conv3_block5_2_conv (Conv2D)    (None, 28, 28, 32)    36864
['conv3_block5_1_relu[0][0]']

 conv3_block5_concat (Concatena  (None, 28, 28, 288)  0
['conv3_block4_concat[0][0]',
 te)
'conv3_block5_2_conv[0][0]']

 conv3_block6_0_bn (BatchNormal  (None, 28, 28, 288)  1152
['conv3_block5_concat[0][0]']
 ization)

 conv3_block6_0_relu (Activatio  (None, 28, 28, 288)  0
['conv3_block6_0_bn[0][0]']
 n)

 conv3_block6_1_conv (Conv2D)    (None, 28, 28, 128)  36864
['conv3_block6_0_relu[0][0]']

 conv3_block6_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block6_1_conv[0][0]']
 ization)

 conv3_block6_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block6_1_bn[0][0]']
 n)

 conv3_block6_2_conv (Conv2D)    (None, 28, 28, 32)    36864
['conv3_block6_1_relu[0][0]']

 conv3_block6_concat (Concatena  (None, 28, 28, 320)  0
['conv3_block5_concat[0][0]',
 te)
'conv3_block6_2_conv[0][0]']

 conv3_block7_0_bn (BatchNormal  (None, 28, 28, 320)  1280
['conv3_block6_concat[0][0]']
 ization)

 conv3_block7_0_relu (Activatio  (None, 28, 28, 320)  0
['conv3_block7_0_bn[0][0]']
```

```
n)

conv3_block7_1_conv (Conv2D)    (None, 28, 28, 128)  40960
['conv3_block7_0_relu[0][0]']

conv3_block7_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block7_1_conv[0][0]']
ization)

conv3_block7_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block7_1_bn[0][0]']
n)

conv3_block7_2_conv (Conv2D)    (None, 28, 28, 32)   36864
['conv3_block7_1_relu[0][0]']

conv3_block7_concat (Concatena  (None, 28, 28, 352)  0
['conv3_block6_concat[0][0]',
te)
'conv3_block7_2_conv[0][0]']

conv3_block8_0_bn (BatchNormal  (None, 28, 28, 352)  1408
['conv3_block7_concat[0][0]']
ization)

conv3_block8_0_relu (Activatio  (None, 28, 28, 352)  0
['conv3_block8_0_bn[0][0]']
n)

conv3_block8_1_conv (Conv2D)    (None, 28, 28, 128)  45056
['conv3_block8_0_relu[0][0]']

conv3_block8_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block8_1_conv[0][0]']
ization)

conv3_block8_1_relu (Activatio  (None, 28, 28, 128)  0
['conv3_block8_1_bn[0][0]']
n)

conv3_block8_2_conv (Conv2D)    (None, 28, 28, 32)   36864
['conv3_block8_1_relu[0][0]']

conv3_block8_concat (Concatena  (None, 28, 28, 384)  0
['conv3_block7_concat[0][0]',
te)
'conv3_block8_2_conv[0][0]']
```

```
conv3_block9_0_bn (BatchNormal   (None, 28, 28, 384)   1536
['conv3_block8_concat[0][0]']
 ization)

 conv3_block9_0_relu (Activatio   (None, 28, 28, 384)   0
['conv3_block9_0_bn[0][0]']
 n)

 conv3_block9_1_conv (Conv2D)     (None, 28, 28, 128)   49152
['conv3_block9_0_relu[0][0]']

 conv3_block9_1_bn (BatchNormal   (None, 28, 28, 128)   512
['conv3_block9_1_conv[0][0]']
 ization)

 conv3_block9_1_relu (Activatio   (None, 28, 28, 128)   0
['conv3_block9_1_bn[0][0]']
 n)

 conv3_block9_2_conv (Conv2D)     (None, 28, 28, 32)    36864
['conv3_block9_1_relu[0][0]']

 conv3_block9_concat (Concatena   (None, 28, 28, 416)   0
['conv3_block8_concat[0][0]',
 te)
'conv3_block9_2_conv[0][0]']

 conv3_block10_0_bn (BatchNorma   (None, 28, 28, 416)   1664
['conv3_block9_concat[0][0]']
 lization)

 conv3_block10_0_relu (Activati   (None, 28, 28, 416)   0
['conv3_block10_0_bn[0][0]']
 on)

 conv3_block10_1_conv (Conv2D)    (None, 28, 28, 128)   53248
['conv3_block10_0_relu[0][0]']

 conv3_block10_1_bn (BatchNorma   (None, 28, 28, 128)   512
['conv3_block10_1_conv[0][0]']
 lization)

 conv3_block10_1_relu (Activati   (None, 28, 28, 128)   0
['conv3_block10_1_bn[0][0]']
 on)

 conv3_block10_2_conv (Conv2D)    (None, 28, 28, 32)    36864
['conv3_block10_1_relu[0][0]']
```

```
conv3_block10_concat (Concaten   (None, 28, 28, 448)   0
['conv3_block9_concat[0][0]',
 ate)
'conv3_block10_2_conv[0][0]']


 conv3_block11_0_bn (BatchNorma   (None, 28, 28, 448)   1792
['conv3_block10_concat[0][0]']
 lization)


 conv3_block11_0_relu (Activati   (None, 28, 28, 448)   0
['conv3_block11_0_bn[0][0]']
 on)


 conv3_block11_1_conv (Conv2D)   (None, 28, 28, 128)   57344
['conv3_block11_0_relu[0][0]']


 conv3_block11_1_bn (BatchNorma   (None, 28, 28, 128)   512
['conv3_block11_1_conv[0][0]']
 lization)


 conv3_block11_1_relu (Activati   (None, 28, 28, 128)   0
['conv3_block11_1_bn[0][0]']
 on)


 conv3_block11_2_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block11_1_relu[0][0]']


 conv3_block11_concat (Concaten   (None, 28, 28, 480)   0
['conv3_block10_concat[0][0]',
 ate)
'conv3_block11_2_conv[0][0]']


 conv3_block12_0_bn (BatchNorma   (None, 28, 28, 480)   1920
['conv3_block11_concat[0][0]']
 lization)


 conv3_block12_0_relu (Activati   (None, 28, 28, 480)   0
['conv3_block12_0_bn[0][0]']
 on)


 conv3_block12_1_conv (Conv2D)   (None, 28, 28, 128)   61440
['conv3_block12_0_relu[0][0]']


 conv3_block12_1_bn (BatchNorma   (None, 28, 28, 128)   512
['conv3_block12_1_conv[0][0]']
 lization)
```

```
conv3_block12_1_relu (Activati   (None, 28, 28, 128)   0
['conv3_block12_1_bn[0][0]']
 on)

 conv3_block12_2_conv (Conv2D)   (None, 28, 28, 32)    36864
['conv3_block12_1_relu[0][0]']

 conv3_block12_concat (Concaten   (None, 28, 28, 512)   0
['conv3_block11_concat[0][0]',
 ate)
'conv3_block12_2_conv[0][0]']

 pool3_bn (BatchNormalization)   (None, 28, 28, 512)   2048
['conv3_block12_concat[0][0]']

 pool3_relu (Activation)         (None, 28, 28, 512)   0
['pool3_bn[0][0]']

 pool3_conv (Conv2D)             (None, 28, 28, 256)   131072
['pool3_relu[0][0]']

 pool3_pool (AveragePooling2D)   (None, 14, 14, 256)   0
['pool3_conv[0][0]']

 conv4_block1_0_bn (BatchNormal   (None, 14, 14, 256)   1024
['pool3_pool[0][0]']
 ization)

 conv4_block1_0_relu (Activatio   (None, 14, 14, 256)   0
['conv4_block1_0_bn[0][0]']
 n)

 conv4_block1_1_conv (Conv2D)    (None, 14, 14, 128)   32768
['conv4_block1_0_relu[0][0]']

 conv4_block1_1_bn (BatchNormal   (None, 14, 14, 128)   512
['conv4_block1_1_conv[0][0]']
 ization)

 conv4_block1_1_relu (Activatio   (None, 14, 14, 128)   0
['conv4_block1_1_bn[0][0]']
 n)

 conv4_block1_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block1_1_relu[0][0]']

 conv4_block1_concat (Concatena   (None, 14, 14, 288)   0
['pool3_pool[0][0]',
```

```
 te)
'conv4_block1_2_conv[0][0]']

 conv4_block2_0_bn (BatchNormal  (None, 14, 14, 288)  1152
['conv4_block1_concat[0][0]']
 ization)

 conv4_block2_0_relu (Activatio  (None, 14, 14, 288)  0
['conv4_block2_0_bn[0][0]']
 n)

 conv4_block2_1_conv (Conv2D)    (None, 14, 14, 128)  36864
['conv4_block2_0_relu[0][0]']

 conv4_block2_1_bn (BatchNormal  (None, 14, 14, 128)  512
['conv4_block2_1_conv[0][0]']
 ization)

 conv4_block2_1_relu (Activatio  (None, 14, 14, 128)  0
['conv4_block2_1_bn[0][0]']
 n)

 conv4_block2_2_conv (Conv2D)    (None, 14, 14, 32)   36864
['conv4_block2_1_relu[0][0]']

 conv4_block2_concat (Concatena  (None, 14, 14, 320)  0
['conv4_block1_concat[0][0]',
 te)
'conv4_block2_2_conv[0][0]']

 conv4_block3_0_bn (BatchNormal  (None, 14, 14, 320)  1280
['conv4_block2_concat[0][0]']
 ization)

 conv4_block3_0_relu (Activatio  (None, 14, 14, 320)  0
['conv4_block3_0_bn[0][0]']
 n)

 conv4_block3_1_conv (Conv2D)    (None, 14, 14, 128)  40960
['conv4_block3_0_relu[0][0]']

 conv4_block3_1_bn (BatchNormal  (None, 14, 14, 128)  512
['conv4_block3_1_conv[0][0]']
 ization)

 conv4_block3_1_relu (Activatio  (None, 14, 14, 128)  0
['conv4_block3_1_bn[0][0]']
 n)
```

```
 conv4_block3_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block3_1_relu[0][0]']

 conv4_block3_concat (Concatena  (None, 14, 14, 352)  0
['conv4_block2_concat[0][0]',
 te)
'conv4_block3_2_conv[0][0]']

 conv4_block4_0_bn (BatchNormal  (None, 14, 14, 352)  1408
['conv4_block3_concat[0][0]']
 ization)

 conv4_block4_0_relu (Activatio  (None, 14, 14, 352)  0
['conv4_block4_0_bn[0][0]']
 n)

 conv4_block4_1_conv (Conv2D)    (None, 14, 14, 128)  45056
['conv4_block4_0_relu[0][0]']

 conv4_block4_1_bn (BatchNormal  (None, 14, 14, 128)  512
['conv4_block4_1_conv[0][0]']
 ization)

 conv4_block4_1_relu (Activatio  (None, 14, 14, 128)  0
['conv4_block4_1_bn[0][0]']
 n)

 conv4_block4_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block4_1_relu[0][0]']

 conv4_block4_concat (Concatena  (None, 14, 14, 384)  0
['conv4_block3_concat[0][0]',
 te)
'conv4_block4_2_conv[0][0]']

 conv4_block5_0_bn (BatchNormal  (None, 14, 14, 384)  1536
['conv4_block4_concat[0][0]']
 ization)

 conv4_block5_0_relu (Activatio  (None, 14, 14, 384)  0
['conv4_block5_0_bn[0][0]']
 n)

 conv4_block5_1_conv (Conv2D)    (None, 14, 14, 128)  49152
['conv4_block5_0_relu[0][0]']

 conv4_block5_1_bn (BatchNormal  (None, 14, 14, 128)  512
```

```
                                                  ['conv4_block5_1_conv[0][0]']
 ization)

 conv4_block5_1_relu (Activatio   (None, 14, 14, 128)   0
                                                  ['conv4_block5_1_bn[0][0]']
 n)

 conv4_block5_2_conv (Conv2D)     (None, 14, 14, 32)     36864
                                                  ['conv4_block5_1_relu[0][0]']

 conv4_block5_concat (Concatena   (None, 14, 14, 416)    0
                                                  ['conv4_block4_concat[0][0]',
 te)
                                                  'conv4_block5_2_conv[0][0]']

 conv4_block6_0_bn (BatchNormal   (None, 14, 14, 416)    1664
                                                  ['conv4_block5_concat[0][0]']
 ization)

 conv4_block6_0_relu (Activatio   (None, 14, 14, 416)    0
                                                  ['conv4_block6_0_bn[0][0]']
 n)

 conv4_block6_1_conv (Conv2D)     (None, 14, 14, 128)    53248
                                                  ['conv4_block6_0_relu[0][0]']

 conv4_block6_1_bn (BatchNormal   (None, 14, 14, 128)    512
                                                  ['conv4_block6_1_conv[0][0]']
 ization)

 conv4_block6_1_relu (Activatio   (None, 14, 14, 128)    0
                                                  ['conv4_block6_1_bn[0][0]']
 n)

 conv4_block6_2_conv (Conv2D)     (None, 14, 14, 32)     36864
                                                  ['conv4_block6_1_relu[0][0]']

 conv4_block6_concat (Concatena   (None, 14, 14, 448)    0
                                                  ['conv4_block5_concat[0][0]',
 te)
                                                  'conv4_block6_2_conv[0][0]']

 conv4_block7_0_bn (BatchNormal   (None, 14, 14, 448)    1792
                                                  ['conv4_block6_concat[0][0]']
 ization)

 conv4_block7_0_relu (Activatio   (None, 14, 14, 448)    0
                                                  ['conv4_block7_0_bn[0][0]']
```

```
 n)

 conv4_block7_1_conv (Conv2D)    (None, 14, 14, 128)  57344
['conv4_block7_0_relu[0][0]']

 conv4_block7_1_bn (BatchNormal   (None, 14, 14, 128)  512
['conv4_block7_1_conv[0][0]']
 ization)

 conv4_block7_1_relu (Activatio   (None, 14, 14, 128)  0
['conv4_block7_1_bn[0][0]']
 n)

 conv4_block7_2_conv (Conv2D)    (None, 14, 14, 32)   36864
['conv4_block7_1_relu[0][0]']

 conv4_block7_concat (Concatena   (None, 14, 14, 480)  0
['conv4_block6_concat[0][0]',
 te)
'conv4_block7_2_conv[0][0]']

 conv4_block8_0_bn (BatchNormal   (None, 14, 14, 480)  1920
['conv4_block7_concat[0][0]']
 ization)

 conv4_block8_0_relu (Activatio   (None, 14, 14, 480)  0
['conv4_block8_0_bn[0][0]']
 n)

 conv4_block8_1_conv (Conv2D)    (None, 14, 14, 128)  61440
['conv4_block8_0_relu[0][0]']

 conv4_block8_1_bn (BatchNormal   (None, 14, 14, 128)  512
['conv4_block8_1_conv[0][0]']
 ization)

 conv4_block8_1_relu (Activatio   (None, 14, 14, 128)  0
['conv4_block8_1_bn[0][0]']
 n)

 conv4_block8_2_conv (Conv2D)    (None, 14, 14, 32)   36864
['conv4_block8_1_relu[0][0]']

 conv4_block8_concat (Concatena   (None, 14, 14, 512)  0
['conv4_block7_concat[0][0]',
 te)
'conv4_block8_2_conv[0][0]']
```

```
conv4_block9_0_bn (BatchNormal    (None, 14, 14, 512)   2048
['conv4_block8_concat[0][0]']
 ization)

 conv4_block9_0_relu (Activatio   (None, 14, 14, 512)   0
['conv4_block9_0_bn[0][0]']
 n)

 conv4_block9_1_conv (Conv2D)     (None, 14, 14, 128)   65536
['conv4_block9_0_relu[0][0]']

 conv4_block9_1_bn (BatchNormal   (None, 14, 14, 128)   512
['conv4_block9_1_conv[0][0]']
 ization)

 conv4_block9_1_relu (Activatio   (None, 14, 14, 128)   0
['conv4_block9_1_bn[0][0]']
 n)

 conv4_block9_2_conv (Conv2D)     (None, 14, 14, 32)    36864
['conv4_block9_1_relu[0][0]']

 conv4_block9_concat (Concatena   (None, 14, 14, 544)   0
['conv4_block8_concat[0][0]',
 te)
'conv4_block9_2_conv[0][0]']

 conv4_block10_0_bn (BatchNorma   (None, 14, 14, 544)   2176
['conv4_block9_concat[0][0]']
 lization)

 conv4_block10_0_relu (Activati   (None, 14, 14, 544)   0
['conv4_block10_0_bn[0][0]']
 on)

 conv4_block10_1_conv (Conv2D)    (None, 14, 14, 128)   69632
['conv4_block10_0_relu[0][0]']

 conv4_block10_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block10_1_conv[0][0]']
 lization)

 conv4_block10_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block10_1_bn[0][0]']
 on)

 conv4_block10_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block10_1_relu[0][0]']
```

```
conv4_block10_concat (Concaten   (None, 14, 14, 576)   0
['conv4_block9_concat[0][0]',
 ate)
'conv4_block10_2_conv[0][0]']


 conv4_block11_0_bn (BatchNorma   (None, 14, 14, 576)   2304
['conv4_block10_concat[0][0]']
 lization)


 conv4_block11_0_relu (Activati   (None, 14, 14, 576)   0
['conv4_block11_0_bn[0][0]']
 on)


 conv4_block11_1_conv (Conv2D)   (None, 14, 14, 128)   73728
['conv4_block11_0_relu[0][0]']


 conv4_block11_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block11_1_conv[0][0]']
 lization)


 conv4_block11_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block11_1_bn[0][0]']
 on)


 conv4_block11_2_conv (Conv2D)   (None, 14, 14, 32)   36864
['conv4_block11_1_relu[0][0]']


 conv4_block11_concat (Concaten   (None, 14, 14, 608)   0
['conv4_block10_concat[0][0]',
 ate)
'conv4_block11_2_conv[0][0]']


 conv4_block12_0_bn (BatchNorma   (None, 14, 14, 608)   2432
['conv4_block11_concat[0][0]']
 lization)


 conv4_block12_0_relu (Activati   (None, 14, 14, 608)   0
['conv4_block12_0_bn[0][0]']
 on)


 conv4_block12_1_conv (Conv2D)   (None, 14, 14, 128)   77824
['conv4_block12_0_relu[0][0]']


 conv4_block12_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block12_1_conv[0][0]']
 lization)
```

```
conv4_block12_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block12_1_bn[0][0]']
 on)

 conv4_block12_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block12_1_relu[0][0]']

 conv4_block12_concat (Concaten  (None, 14, 14, 640)   0
['conv4_block11_concat[0][0]',
 ate)
'conv4_block12_2_conv[0][0]']

 conv4_block13_0_bn (BatchNorma  (None, 14, 14, 640)   2560
['conv4_block12_concat[0][0]']
 lization)

 conv4_block13_0_relu (Activati  (None, 14, 14, 640)   0
['conv4_block13_0_bn[0][0]']
 on)

 conv4_block13_1_conv (Conv2D)   (None, 14, 14, 128)   81920
['conv4_block13_0_relu[0][0]']

 conv4_block13_1_bn (BatchNorma  (None, 14, 14, 128)   512
['conv4_block13_1_conv[0][0]']
 lization)

 conv4_block13_1_relu (Activati  (None, 14, 14, 128)   0
['conv4_block13_1_bn[0][0]']
 on)

 conv4_block13_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block13_1_relu[0][0]']

 conv4_block13_concat (Concaten  (None, 14, 14, 672)   0
['conv4_block12_concat[0][0]',
 ate)
'conv4_block13_2_conv[0][0]']

 conv4_block14_0_bn (BatchNorma  (None, 14, 14, 672)   2688
['conv4_block13_concat[0][0]']
 lization)

 conv4_block14_0_relu (Activati  (None, 14, 14, 672)   0
['conv4_block14_0_bn[0][0]']
 on)

 conv4_block14_1_conv (Conv2D)   (None, 14, 14, 128)   86016
```

```
                                         ['conv4_block14_0_relu[0][0]']

 conv4_block14_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block14_1_conv[0][0]']
 lization)

 conv4_block14_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block14_1_bn[0][0]']
 on)

 conv4_block14_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block14_1_relu[0][0]']

 conv4_block14_concat (Concaten   (None, 14, 14, 704)   0
['conv4_block13_concat[0][0]',
 ate)
'conv4_block14_2_conv[0][0]']

 conv4_block15_0_bn (BatchNorma   (None, 14, 14, 704)   2816
['conv4_block14_concat[0][0]']
 lization)

 conv4_block15_0_relu (Activati   (None, 14, 14, 704)   0
['conv4_block15_0_bn[0][0]']
 on)

 conv4_block15_1_conv (Conv2D)    (None, 14, 14, 128)   90112
['conv4_block15_0_relu[0][0]']

 conv4_block15_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block15_1_conv[0][0]']
 lization)

 conv4_block15_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block15_1_bn[0][0]']
 on)

 conv4_block15_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block15_1_relu[0][0]']

 conv4_block15_concat (Concaten   (None, 14, 14, 736)   0
['conv4_block14_concat[0][0]',
 ate)
'conv4_block15_2_conv[0][0]']

 conv4_block16_0_bn (BatchNorma   (None, 14, 14, 736)   2944
['conv4_block15_concat[0][0]']
 lization)
```

```
 conv4_block16_0_relu (Activati   (None, 14, 14, 736)   0
['conv4_block16_0_bn[0][0]']
 on)

 conv4_block16_1_conv (Conv2D)    (None, 14, 14, 128)   94208
['conv4_block16_0_relu[0][0]']

 conv4_block16_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block16_1_conv[0][0]']
 lization)

 conv4_block16_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block16_1_bn[0][0]']
 on)

 conv4_block16_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block16_1_relu[0][0]']

 conv4_block16_concat (Concaten   (None, 14, 14, 768)   0
['conv4_block15_concat[0][0]',
 ate)
'conv4_block16_2_conv[0][0]']

 conv4_block17_0_bn (BatchNorma   (None, 14, 14, 768)   3072
['conv4_block16_concat[0][0]']
 lization)

 conv4_block17_0_relu (Activati   (None, 14, 14, 768)   0
['conv4_block17_0_bn[0][0]']
 on)

 conv4_block17_1_conv (Conv2D)    (None, 14, 14, 128)   98304
['conv4_block17_0_relu[0][0]']

 conv4_block17_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block17_1_conv[0][0]']
 lization)

 conv4_block17_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block17_1_bn[0][0]']
 on)

 conv4_block17_2_conv (Conv2D)    (None, 14, 14, 32)    36864
['conv4_block17_1_relu[0][0]']

 conv4_block17_concat (Concaten   (None, 14, 14, 800)   0
['conv4_block16_concat[0][0]',
```

```
 ate)
'conv4_block17_2_conv[0][0]'

 conv4_block18_0_bn (BatchNorma   (None, 14, 14, 800)   3200
['conv4_block17_concat[0][0]'
 lization)

 conv4_block18_0_relu (Activati   (None, 14, 14, 800)   0
['conv4_block18_0_bn[0][0]']
 on)

 conv4_block18_1_conv (Conv2D)   (None, 14, 14, 128)   102400
['conv4_block18_0_relu[0][0]']

 conv4_block18_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block18_1_conv[0][0]']
 lization)

 conv4_block18_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block18_1_bn[0][0]']
 on)

 conv4_block18_2_conv (Conv2D)   (None, 14, 14, 32)   36864
['conv4_block18_1_relu[0][0]']

 conv4_block18_concat (Concaten   (None, 14, 14, 832)   0
['conv4_block17_concat[0][0]',
 ate)
'conv4_block18_2_conv[0][0]'

 conv4_block19_0_bn (BatchNorma   (None, 14, 14, 832)   3328
['conv4_block18_concat[0][0]']
 lization)

 conv4_block19_0_relu (Activati   (None, 14, 14, 832)   0
['conv4_block19_0_bn[0][0]']
 on)

 conv4_block19_1_conv (Conv2D)   (None, 14, 14, 128)   106496
['conv4_block19_0_relu[0][0]']

 conv4_block19_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block19_1_conv[0][0]']
 lization)

 conv4_block19_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block19_1_bn[0][0]']
 on)
```

```
conv4_block19_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block19_1_relu[0][0]']

 conv4_block19_concat (Concaten  (None, 14, 14, 864)   0
['conv4_block18_concat[0][0]',
 ate)
'conv4_block19_2_conv[0][0]']

 conv4_block20_0_bn (BatchNorma  (None, 14, 14, 864)   3456
['conv4_block19_concat[0][0]']
 lization)

 conv4_block20_0_relu (Activati  (None, 14, 14, 864)   0
['conv4_block20_0_bn[0][0]']
 on)

 conv4_block20_1_conv (Conv2D)   (None, 14, 14, 128)   110592
['conv4_block20_0_relu[0][0]']

 conv4_block20_1_bn (BatchNorma  (None, 14, 14, 128)   512
['conv4_block20_1_conv[0][0]']
 lization)

 conv4_block20_1_relu (Activati  (None, 14, 14, 128)   0
['conv4_block20_1_bn[0][0]']
 on)

 conv4_block20_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block20_1_relu[0][0]']

 conv4_block20_concat (Concaten  (None, 14, 14, 896)   0
['conv4_block19_concat[0][0]',
 ate)
'conv4_block20_2_conv[0][0]']

 conv4_block21_0_bn (BatchNorma  (None, 14, 14, 896)   3584
['conv4_block20_concat[0][0]']
 lization)

 conv4_block21_0_relu (Activati  (None, 14, 14, 896)   0
['conv4_block21_0_bn[0][0]']
 on)

 conv4_block21_1_conv (Conv2D)   (None, 14, 14, 128)   114688
['conv4_block21_0_relu[0][0]']

 conv4_block21_1_bn (BatchNorma  (None, 14, 14, 128)   512
```

```
                                             ['conv4_block21_1_conv[0][0]']
 lization)

 conv4_block21_1_relu (Activati  (None, 14, 14, 128)  0
['conv4_block21_1_bn[0][0]']
 on)

 conv4_block21_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block21_1_relu[0][0]']

 conv4_block21_concat (Concaten  (None, 14, 14, 928)   0
['conv4_block20_concat[0][0]',
 ate)
'conv4_block21_2_conv[0][0]']

 conv4_block22_0_bn (BatchNorma  (None, 14, 14, 928)   3712
['conv4_block21_concat[0][0]']
 lization)

 conv4_block22_0_relu (Activati  (None, 14, 14, 928)   0
['conv4_block22_0_bn[0][0]']
 on)

 conv4_block22_1_conv (Conv2D)   (None, 14, 14, 128)   118784
['conv4_block22_0_relu[0][0]']

 conv4_block22_1_bn (BatchNorma  (None, 14, 14, 128)   512
['conv4_block22_1_conv[0][0]']
 lization)

 conv4_block22_1_relu (Activati  (None, 14, 14, 128)   0
['conv4_block22_1_bn[0][0]']
 on)

 conv4_block22_2_conv (Conv2D)   (None, 14, 14, 32)    36864
['conv4_block22_1_relu[0][0]']

 conv4_block22_concat (Concaten  (None, 14, 14, 960)   0
['conv4_block21_concat[0][0]',
 ate)
'conv4_block22_2_conv[0][0]']

 conv4_block23_0_bn (BatchNorma  (None, 14, 14, 960)   3840
['conv4_block22_concat[0][0]']
 lization)

 conv4_block23_0_relu (Activati  (None, 14, 14, 960)   0
['conv4_block23_0_bn[0][0]']
```

```
 on)

 conv4_block23_1_conv (Conv2D)   (None, 14, 14, 128)   122880
['conv4_block23_0_relu[0][0]']

 conv4_block23_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block23_1_conv[0][0]']
 lization)

 conv4_block23_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block23_1_bn[0][0]']
 on)

 conv4_block23_2_conv (Conv2D)   (None, 14, 14, 32)   36864
['conv4_block23_1_relu[0][0]']

 conv4_block23_concat (Concaten   (None, 14, 14, 992)   0
['conv4_block22_concat[0][0]',
 ate)
'conv4_block23_2_conv[0][0]']

 conv4_block24_0_bn (BatchNorma   (None, 14, 14, 992)   3968
['conv4_block23_concat[0][0]']
 lization)

 conv4_block24_0_relu (Activati   (None, 14, 14, 992)   0
['conv4_block24_0_bn[0][0]']
 on)

 conv4_block24_1_conv (Conv2D)   (None, 14, 14, 128)   126976
['conv4_block24_0_relu[0][0]']

 conv4_block24_1_bn (BatchNorma   (None, 14, 14, 128)   512
['conv4_block24_1_conv[0][0]']
 lization)

 conv4_block24_1_relu (Activati   (None, 14, 14, 128)   0
['conv4_block24_1_bn[0][0]']
 on)

 conv4_block24_2_conv (Conv2D)   (None, 14, 14, 32)   36864
['conv4_block24_1_relu[0][0]']

 conv4_block24_concat (Concaten   (None, 14, 14, 1024   0
['conv4_block23_concat[0][0]',
 ate)                             )
'conv4_block24_2_conv[0][0]']
```

```
pool4_bn (BatchNormalization)     (None, 14, 14, 1024   4096
['conv4_block24_concat[0][0]']
                                  )

pool4_relu (Activation)           (None, 14, 14, 1024   0
['pool4_bn[0][0]']
                                  )

pool4_conv (Conv2D)               (None, 14, 14, 512)   524288
['pool4_relu[0][0]']

pool4_pool (AveragePooling2D)     (None, 7, 7, 512)     0
['pool4_conv[0][0]']

conv5_block1_0_bn (BatchNormal    (None, 7, 7, 512)     2048
['pool4_pool[0][0]']
 ization)

conv5_block1_0_relu (Activatio    (None, 7, 7, 512)     0
['conv5_block1_0_bn[0][0]']
 n)

conv5_block1_1_conv (Conv2D)      (None, 7, 7, 128)     65536
['conv5_block1_0_relu[0][0]']

conv5_block1_1_bn (BatchNormal    (None, 7, 7, 128)     512
['conv5_block1_1_conv[0][0]']
 ization)

conv5_block1_1_relu (Activatio    (None, 7, 7, 128)     0
['conv5_block1_1_bn[0][0]']
 n)

conv5_block1_2_conv (Conv2D)      (None, 7, 7, 32)      36864
['conv5_block1_1_relu[0][0]']

conv5_block1_concat (Concatena    (None, 7, 7, 544)     0
['pool4_pool[0][0]',
 te)
'conv5_block1_2_conv[0][0]']

conv5_block2_0_bn (BatchNormal    (None, 7, 7, 544)     2176
['conv5_block1_concat[0][0]']
 ization)

conv5_block2_0_relu (Activatio    (None, 7, 7, 544)     0
['conv5_block2_0_bn[0][0]']
 n)
```

```
 conv5_block2_1_conv (Conv2D)   (None, 7, 7, 128)    69632
['conv5_block2_0_relu[0][0]']

 conv5_block2_1_bn (BatchNormal  (None, 7, 7, 128)    512
['conv5_block2_1_conv[0][0]']
 ization)

 conv5_block2_1_relu (Activatio  (None, 7, 7, 128)    0
['conv5_block2_1_bn[0][0]']
 n)

 conv5_block2_2_conv (Conv2D)   (None, 7, 7, 32)     36864
['conv5_block2_1_relu[0][0]']

 conv5_block2_concat (Concatena  (None, 7, 7, 576)    0
['conv5_block1_concat[0][0]',
 te)
'conv5_block2_2_conv[0][0]']

 conv5_block3_0_bn (BatchNormal  (None, 7, 7, 576)    2304
['conv5_block2_concat[0][0]']
 ization)

 conv5_block3_0_relu (Activatio  (None, 7, 7, 576)    0
['conv5_block3_0_bn[0][0]']
 n)

 conv5_block3_1_conv (Conv2D)   (None, 7, 7, 128)    73728
['conv5_block3_0_relu[0][0]']

 conv5_block3_1_bn (BatchNormal  (None, 7, 7, 128)    512
['conv5_block3_1_conv[0][0]']
 ization)

 conv5_block3_1_relu (Activatio  (None, 7, 7, 128)    0
['conv5_block3_1_bn[0][0]']
 n)

 conv5_block3_2_conv (Conv2D)   (None, 7, 7, 32)     36864
['conv5_block3_1_relu[0][0]']

 conv5_block3_concat (Concatena  (None, 7, 7, 608)    0
['conv5_block2_concat[0][0]',
 te)
'conv5_block3_2_conv[0][0]']

 conv5_block4_0_bn (BatchNormal  (None, 7, 7, 608)    2432
```

```
                                       ['conv5_block3_concat[0][0]']
 ization)

 conv5_block4_0_relu (Activatio   (None, 7, 7, 608)    0
                                       ['conv5_block4_0_bn[0][0]']
 n)

 conv5_block4_1_conv (Conv2D)     (None, 7, 7, 128)    77824
                                       ['conv5_block4_0_relu[0][0]']

 conv5_block4_1_bn (BatchNormal   (None, 7, 7, 128)    512
                                       ['conv5_block4_1_conv[0][0]']
 ization)

 conv5_block4_1_relu (Activatio   (None, 7, 7, 128)    0
                                       ['conv5_block4_1_bn[0][0]']
 n)

 conv5_block4_2_conv (Conv2D)     (None, 7, 7, 32)     36864
                                       ['conv5_block4_1_relu[0][0]']

 conv5_block4_concat (Concatena   (None, 7, 7, 640)    0
                                       ['conv5_block3_concat[0][0]',
 te)
                                       'conv5_block4_2_conv[0][0]']

 conv5_block5_0_bn (BatchNormal   (None, 7, 7, 640)    2560
                                       ['conv5_block4_concat[0][0]']
 ization)

 conv5_block5_0_relu (Activatio   (None, 7, 7, 640)    0
                                       ['conv5_block5_0_bn[0][0]']
 n)

 conv5_block5_1_conv (Conv2D)     (None, 7, 7, 128)    81920
                                       ['conv5_block5_0_relu[0][0]']

 conv5_block5_1_bn (BatchNormal   (None, 7, 7, 128)    512
                                       ['conv5_block5_1_conv[0][0]']
 ization)

 conv5_block5_1_relu (Activatio   (None, 7, 7, 128)    0
                                       ['conv5_block5_1_bn[0][0]']
 n)

 conv5_block5_2_conv (Conv2D)     (None, 7, 7, 32)     36864
                                       ['conv5_block5_1_relu[0][0]']
```

```
conv5_block5_concat (Concatena  (None, 7, 7, 672)   0    ['conv5_block4_concat[0][0]',
 te)
'conv5_block5_2_conv[0][0]']


 conv5_block6_0_bn (BatchNormal  (None, 7, 7, 672)   2688  ['conv5_block5_concat[0][0]']
 ization)


 conv5_block6_0_relu (Activatio  (None, 7, 7, 672)   0    ['conv5_block6_0_bn[0][0]']
 n)


 conv5_block6_1_conv (Conv2D)   (None, 7, 7, 128)   86016  ['conv5_block6_0_relu[0][0]']


 conv5_block6_1_bn (BatchNormal  (None, 7, 7, 128)   512   ['conv5_block6_1_conv[0][0]']
 ization)


 conv5_block6_1_relu (Activatio  (None, 7, 7, 128)   0    ['conv5_block6_1_bn[0][0]']
 n)


 conv5_block6_2_conv (Conv2D)   (None, 7, 7, 32)   36864  ['conv5_block6_1_relu[0][0]']


 conv5_block6_concat (Concatena  (None, 7, 7, 704)   0    ['conv5_block5_concat[0][0]',
 te)
'conv5_block6_2_conv[0][0]']


 conv5_block7_0_bn (BatchNormal  (None, 7, 7, 704)   2816  ['conv5_block6_concat[0][0]']
 ization)


 conv5_block7_0_relu (Activatio  (None, 7, 7, 704)   0    ['conv5_block7_0_bn[0][0]']
 n)


 conv5_block7_1_conv (Conv2D)   (None, 7, 7, 128)   90112  ['conv5_block7_0_relu[0][0]']


 conv5_block7_1_bn (BatchNormal  (None, 7, 7, 128)   512   ['conv5_block7_1_conv[0][0]']
 ization)


 conv5_block7_1_relu (Activatio  (None, 7, 7, 128)   0
```

```
['conv5_block7_1_bn[0][0]']
 n)

 conv5_block7_2_conv (Conv2D)    (None, 7, 7, 32)      36864
['conv5_block7_1_relu[0][0]']

 conv5_block7_concat (Concatena  (None, 7, 7, 736)    0
['conv5_block6_concat[0][0]',
 te)
'conv5_block7_2_conv[0][0]']

 conv5_block8_0_bn (BatchNormal  (None, 7, 7, 736)    2944
['conv5_block7_concat[0][0]']
 ization)

 conv5_block8_0_relu (Activatio  (None, 7, 7, 736)    0
['conv5_block8_0_bn[0][0]']
 n)

 conv5_block8_1_conv (Conv2D)    (None, 7, 7, 128)     94208
['conv5_block8_0_relu[0][0]']

 conv5_block8_1_bn (BatchNormal  (None, 7, 7, 128)    512
['conv5_block8_1_conv[0][0]']
 ization)

 conv5_block8_1_relu (Activatio  (None, 7, 7, 128)    0
['conv5_block8_1_bn[0][0]']
 n)

 conv5_block8_2_conv (Conv2D)    (None, 7, 7, 32)      36864
['conv5_block8_1_relu[0][0]']

 conv5_block8_concat (Concatena  (None, 7, 7, 768)    0
['conv5_block7_concat[0][0]',
 te)
'conv5_block8_2_conv[0][0]']

 conv5_block9_0_bn (BatchNormal  (None, 7, 7, 768)    3072
['conv5_block8_concat[0][0]']
 ization)

 conv5_block9_0_relu (Activatio  (None, 7, 7, 768)    0
['conv5_block9_0_bn[0][0]']
 n)

 conv5_block9_1_conv (Conv2D)    (None, 7, 7, 128)     98304
['conv5_block9_0_relu[0][0]']
```

```
conv5_block9_1_bn (BatchNormal   (None, 7, 7, 128)    512       ['conv5_block9_1_conv[0][0]']
ization)

conv5_block9_1_relu (Activatio   (None, 7, 7, 128)    0         ['conv5_block9_1_bn[0][0]']
n)

conv5_block9_2_conv (Conv2D)     (None, 7, 7, 32)     36864     ['conv5_block9_1_relu[0][0]']

conv5_block9_concat (Concatena   (None, 7, 7, 800)    0         ['conv5_block8_concat[0][0]',
te)                                                              'conv5_block9_2_conv[0][0]']

conv5_block10_0_bn (BatchNorma   (None, 7, 7, 800)    3200      ['conv5_block9_concat[0][0]']
lization)

conv5_block10_0_relu (Activati   (None, 7, 7, 800)    0         ['conv5_block10_0_bn[0][0]']
on)

conv5_block10_1_conv (Conv2D)    (None, 7, 7, 128)    102400    ['conv5_block10_0_relu[0][0]']

conv5_block10_1_bn (BatchNorma   (None, 7, 7, 128)    512       ['conv5_block10_1_conv[0][0]']
lization)

conv5_block10_1_relu (Activati   (None, 7, 7, 128)    0         ['conv5_block10_1_bn[0][0]']
on)

conv5_block10_2_conv (Conv2D)    (None, 7, 7, 32)     36864     ['conv5_block10_1_relu[0][0]']

conv5_block10_concat (Concaten   (None, 7, 7, 832)    0         ['conv5_block9_concat[0][0]',
ate)                                                             'conv5_block10_2_conv[0][0]']

conv5_block11_0_bn (BatchNorma   (None, 7, 7, 832)    3328      ['conv5_block10_concat[0][0]']
lization)
```

```
conv5_block11_0_relu (Activati  (None, 7, 7, 832)   0
['conv5_block11_0_bn[0][0]']
 on)

 conv5_block11_1_conv (Conv2D)  (None, 7, 7, 128)   106496
['conv5_block11_0_relu[0][0]']

 conv5_block11_1_bn (BatchNorma  (None, 7, 7, 128)   512
['conv5_block11_1_conv[0][0]']
 lization)

 conv5_block11_1_relu (Activati  (None, 7, 7, 128)   0
['conv5_block11_1_bn[0][0]']
 on)

 conv5_block11_2_conv (Conv2D)  (None, 7, 7, 32)    36864
['conv5_block11_1_relu[0][0]']

 conv5_block11_concat (Concaten  (None, 7, 7, 864)   0
['conv5_block10_concat[0][0]',
 ate)
'conv5_block11_2_conv[0][0]']

 conv5_block12_0_bn (BatchNorma  (None, 7, 7, 864)   3456
['conv5_block11_concat[0][0]']
 lization)

 conv5_block12_0_relu (Activati  (None, 7, 7, 864)   0
['conv5_block12_0_bn[0][0]']
 on)

 conv5_block12_1_conv (Conv2D)  (None, 7, 7, 128)   110592
['conv5_block12_0_relu[0][0]']

 conv5_block12_1_bn (BatchNorma  (None, 7, 7, 128)   512
['conv5_block12_1_conv[0][0]']
 lization)

 conv5_block12_1_relu (Activati  (None, 7, 7, 128)   0
['conv5_block12_1_bn[0][0]']
 on)

 conv5_block12_2_conv (Conv2D)  (None, 7, 7, 32)    36864
['conv5_block12_1_relu[0][0]']

 conv5_block12_concat (Concaten  (None, 7, 7, 896)   0
['conv5_block11_concat[0][0]',
 ate)
```

```
'conv5_block12_2_conv[0][0]']

 conv5_block13_0_bn (BatchNorma   (None, 7, 7, 896)    3584
['conv5_block12_concat[0][0]']
 lization)

 conv5_block13_0_relu (Activati   (None, 7, 7, 896)    0
['conv5_block13_0_bn[0][0]']
 on)

 conv5_block13_1_conv (Conv2D)    (None, 7, 7, 128)    114688
['conv5_block13_0_relu[0][0]']

 conv5_block13_1_bn (BatchNorma   (None, 7, 7, 128)    512
['conv5_block13_1_conv[0][0]']
 lization)

 conv5_block13_1_relu (Activati   (None, 7, 7, 128)    0
['conv5_block13_1_bn[0][0]']
 on)

 conv5_block13_2_conv (Conv2D)    (None, 7, 7, 32)     36864
['conv5_block13_1_relu[0][0]']

 conv5_block13_concat (Concaten   (None, 7, 7, 928)    0
['conv5_block12_concat[0][0]',
 ate)
'conv5_block13_2_conv[0][0]']

 conv5_block14_0_bn (BatchNorma   (None, 7, 7, 928)    3712
['conv5_block13_concat[0][0]']
 lization)

 conv5_block14_0_relu (Activati   (None, 7, 7, 928)    0
['conv5_block14_0_bn[0][0]']
 on)

 conv5_block14_1_conv (Conv2D)    (None, 7, 7, 128)    118784
['conv5_block14_0_relu[0][0]']

 conv5_block14_1_bn (BatchNorma   (None, 7, 7, 128)    512
['conv5_block14_1_conv[0][0]']
 lization)

 conv5_block14_1_relu (Activati   (None, 7, 7, 128)    0
['conv5_block14_1_bn[0][0]']
 on)
```

```
conv5_block14_2_conv (Conv2D)   (None, 7, 7, 32)    36864
['conv5_block14_1_relu[0][0]']


conv5_block14_concat (Concaten  (None, 7, 7, 960)   0
['conv5_block13_concat[0][0]',
 ate)
'conv5_block14_2_conv[0][0]']


conv5_block15_0_bn (BatchNorma  (None, 7, 7, 960)   3840
['conv5_block14_concat[0][0]']
 lization)


conv5_block15_0_relu (Activati  (None, 7, 7, 960)   0
['conv5_block15_0_bn[0][0]']
 on)


conv5_block15_1_conv (Conv2D)   (None, 7, 7, 128)   122880
['conv5_block15_0_relu[0][0]']


conv5_block15_1_bn (BatchNorma  (None, 7, 7, 128)   512
['conv5_block15_1_conv[0][0]']
 lization)


conv5_block15_1_relu (Activati  (None, 7, 7, 128)   0
['conv5_block15_1_bn[0][0]']
 on)


conv5_block15_2_conv (Conv2D)   (None, 7, 7, 32)    36864
['conv5_block15_1_relu[0][0]']


conv5_block15_concat (Concaten  (None, 7, 7, 992)   0
['conv5_block14_concat[0][0]',
 ate)
'conv5_block15_2_conv[0][0]']


conv5_block16_0_bn (BatchNorma  (None, 7, 7, 992)   3968
['conv5_block15_concat[0][0]']
 lization)


conv5_block16_0_relu (Activati  (None, 7, 7, 992)   0
['conv5_block16_0_bn[0][0]']
 on)


conv5_block16_1_conv (Conv2D)   (None, 7, 7, 128)   126976
['conv5_block16_0_relu[0][0]']


conv5_block16_1_bn (BatchNorma  (None, 7, 7, 128)   512
['conv5_block16_1_conv[0][0]']
```

```
 lization)

 conv5_block16_1_relu (Activati   (None, 7, 7, 128)    0
['conv5_block16_1_bn[0][0]']
 on)

 conv5_block16_2_conv (Conv2D)   (None, 7, 7, 32)     36864
['conv5_block16_1_relu[0][0]']

 conv5_block16_concat (Concaten  (None, 7, 7, 1024)   0
['conv5_block15_concat[0][0]',
 ate)
'conv5_block16_2_conv[0][0]']

 bn (BatchNormalization)         (None, 7, 7, 1024)   4096
['conv5_block16_concat[0][0]']

 relu (Activation)               (None, 7, 7, 1024)   0            ['bn[0][0]']

 ================================================================================
==================
Total params: 7,037,504
Trainable params: 6,953,856
Non-trainable params: 83,648

--------------------------------------------------------------------------------
------------------
```

```
[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])
```
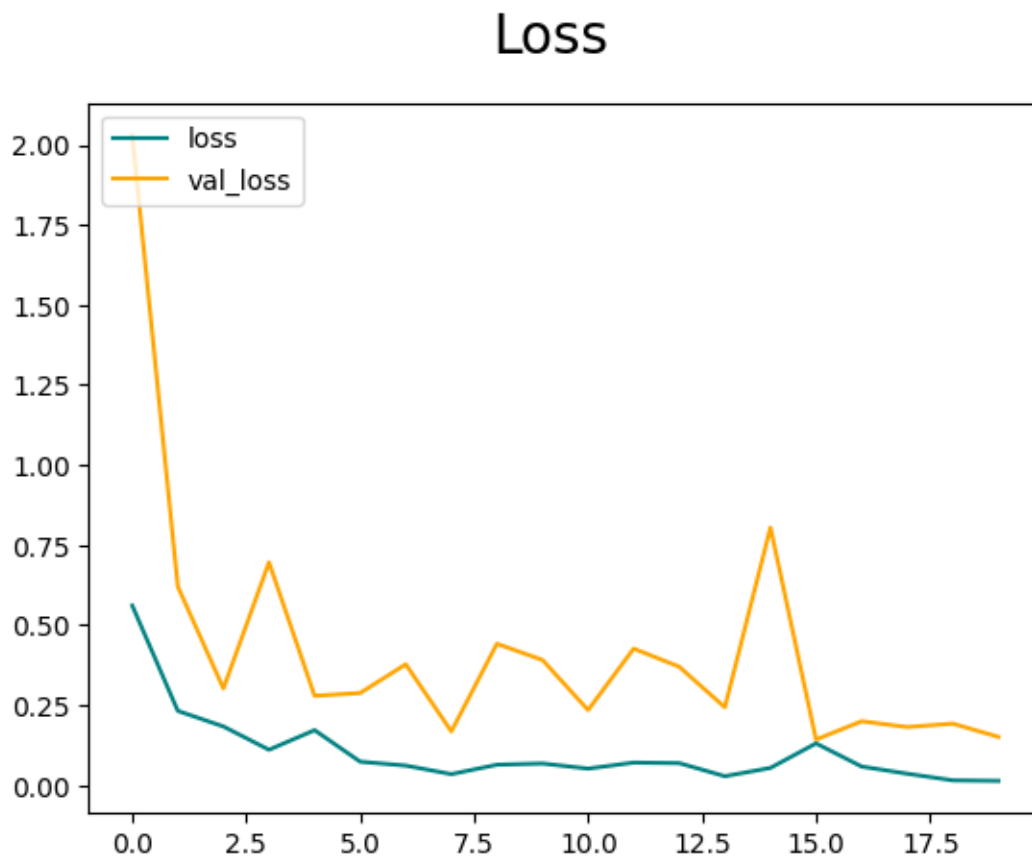
```
Epoch 1/20
168/168 [==============================] - 52s 150ms/step - loss: 0.5610 -
accuracy: 0.7972 - val_loss: 2.0303 - val_accuracy: 0.5061
Epoch 2/20
168/168 [==============================] - 25s 146ms/step - loss: 0.2321 -
accuracy: 0.9161 - val_loss: 0.6204 - val_accuracy: 0.8382
Epoch 3/20
```

```
168/168 [==============================] - 24s 145ms/step - loss: 0.1835 -
accuracy: 0.9359 - val_loss: 0.3021 - val_accuracy: 0.9141
Epoch 4/20
168/168 [==============================] - 25s 145ms/step - loss: 0.1107 -
accuracy: 0.9617 - val_loss: 0.6961 - val_accuracy: 0.7810
Epoch 5/20
168/168 [==============================] - 24s 144ms/step - loss: 0.1720 -
accuracy: 0.9398 - val_loss: 0.2793 - val_accuracy: 0.9162
Epoch 6/20
168/168 [==============================] - 25s 148ms/step - loss: 0.0735 -
accuracy: 0.9729 - val_loss: 0.2880 - val_accuracy: 0.9055
Epoch 7/20
168/168 [==============================] - 24s 145ms/step - loss: 0.0613 -
accuracy: 0.9791 - val_loss: 0.3778 - val_accuracy: 0.8984
Epoch 8/20
168/168 [==============================] - 24s 144ms/step - loss: 0.0347 -
accuracy: 0.9892 - val_loss: 0.1681 - val_accuracy: 0.9470
Epoch 9/20
168/168 [==============================] - 25s 147ms/step - loss: 0.0640 -
accuracy: 0.9779 - val_loss: 0.4418 - val_accuracy: 0.8855
Epoch 10/20
168/168 [==============================] - 25s 147ms/step - loss: 0.0678 -
accuracy: 0.9759 - val_loss: 0.3911 - val_accuracy: 0.8941
Epoch 11/20
168/168 [==============================] - 24s 144ms/step - loss: 0.0519 -
accuracy: 0.9834 - val_loss: 0.2348 - val_accuracy: 0.9306
Epoch 12/20
168/168 [==============================] - 25s 147ms/step - loss: 0.0706 -
accuracy: 0.9772 - val_loss: 0.4267 - val_accuracy: 0.8912
Epoch 13/20
168/168 [==============================] - 25s 149ms/step - loss: 0.0689 -
accuracy: 0.9763 - val_loss: 0.3699 - val_accuracy: 0.8919
Epoch 14/20
168/168 [==============================] - 25s 150ms/step - loss: 0.0282 -
accuracy: 0.9907 - val_loss: 0.2435 - val_accuracy: 0.9341
Epoch 15/20
168/168 [==============================] - 26s 152ms/step - loss: 0.0540 -
accuracy: 0.9802 - val_loss: 0.8049 - val_accuracy: 0.8282
Epoch 16/20
168/168 [==============================] - 26s 151ms/step - loss: 0.1308 -
accuracy: 0.9589 - val_loss: 0.1426 - val_accuracy: 0.9563
Epoch 17/20
168/168 [==============================] - 26s 152ms/step - loss: 0.0583 -
accuracy: 0.9806 - val_loss: 0.1998 - val_accuracy: 0.9384
Epoch 18/20
168/168 [==============================] - 26s 151ms/step - loss: 0.0360 -
accuracy: 0.9886 - val_loss: 0.1818 - val_accuracy: 0.9470
Epoch 19/20
```
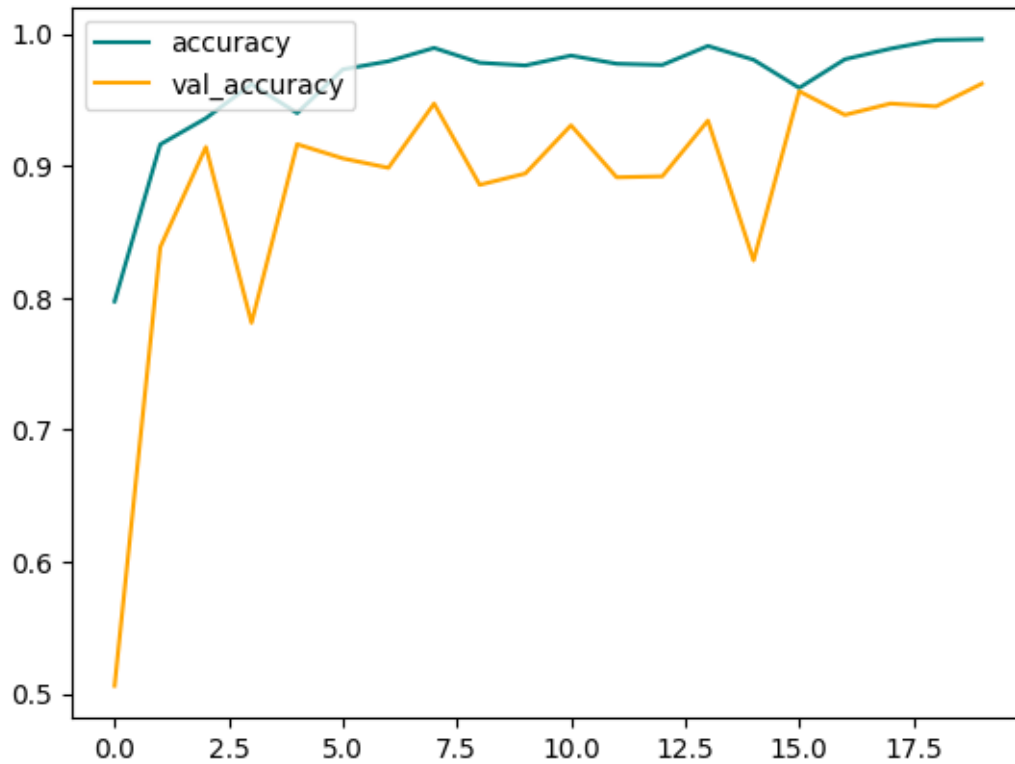
```
168/168 [==============================] - 26s 154ms/step - loss: 0.0152 -
accuracy: 0.9951 - val_loss: 0.1923 - val_accuracy: 0.9449
Epoch 20/20
168/168 [==============================] - 26s 153ms/step - loss: 0.0135 -
accuracy: 0.9957 - val_loss: 0.1510 - val_accuracy: 0.9621
```

[9]:
```python
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()
```

Loss

[10]:
```python
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()
```

Accuracy


```
[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 858ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 28ms/step
```

```
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 1s 950ms/step
```

[13]:
```python
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:  99.36%
Recall:  99.36%
Accuracy:  95.76%
```

[16]:
```python
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 818ms/step
```

Predicted class: 2

[17]:
```python
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 0.03%
Model probability for Hatchback is 99.59%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.02%
Model probability for Sedan is 0.35%
Model probability for VAN is 0.02%

[18]:
```python
model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}% DenseNet121.h5"
model.save(os.path.join('models', model_file_name))
```

[ ]: