CarStyle

October 2, 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 EfficientNetB0
     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()
```
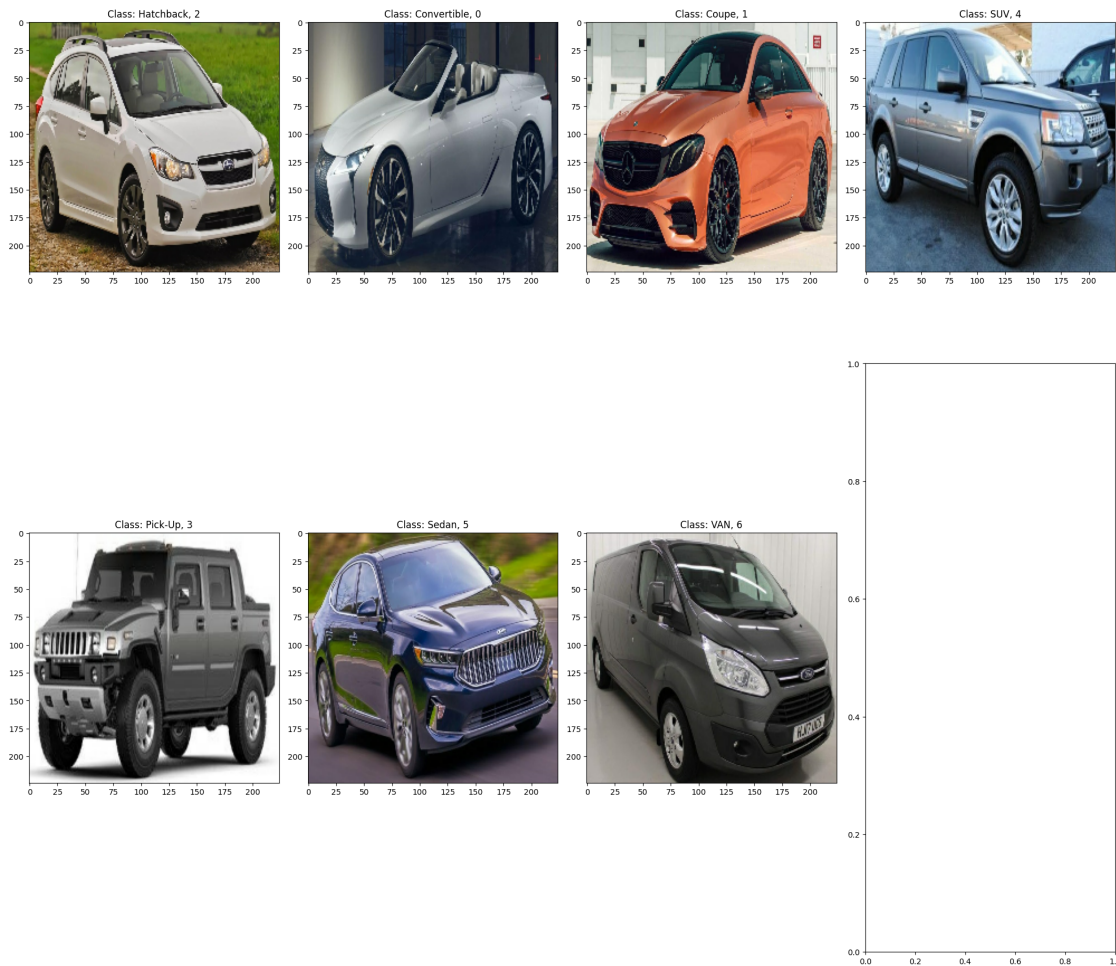
```python
count = 0
while count < num_classes:
    batch = next(data_iterator)

    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()
```

```
[7]: base_model = EfficientNetB0(
         weights='imagenet',
         include_top=False,
         input_shape=(224, 224, 3)
     )
     base_model.summary()
```

Model: "efficientnetb0"

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

 rescaling (Rescaling)   (None, 224, 224, 3)   0
['input_1[0][0]']

 normalization (Normalization) (None, 224, 224, 3) 7
['rescaling[0][0]']

 rescaling_1 (Rescaling)   (None, 224, 224, 3)   0
['normalization[0][0]']

 stem_conv_pad (ZeroPadding2D) (None, 225, 225, 3) 0
['rescaling_1[0][0]']

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

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

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

 block1a_dwconv (DepthwiseConv2 (None, 112, 112, 32   288
['stem_activation[0][0]']
 D)   )

 block1a_bn (BatchNormalization (None, 112, 112, 32   128
```

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```
['block1a_dwconv[0][0]']
 )                             )

 block1a_activation (Activation  (None, 112, 112, 32  0
['block1a_bn[0][0]']
 )                             )

 block1a_se_squeeze (GlobalAver  (None, 32)          0
['block1a_activation[0][0]']
 agePooling2D)

 block1a_se_reshape (Reshape)    (None, 1, 1, 32)    0
['block1a_se_squeeze[0][0]']

 block1a_se_reduce (Conv2D)      (None, 1, 1, 8)     264
['block1a_se_reshape[0][0]']

 block1a_se_expand (Conv2D)      (None, 1, 1, 32)    288
['block1a_se_reduce[0][0]']

 block1a_se_excite (Multiply)    (None, 112, 112, 32  0
['block1a_activation[0][0]',
                                )
'block1a_se_expand[0][0]']

 block1a_project_conv (Conv2D)   (None, 112, 112, 16  512
['block1a_se_excite[0][0]']
                                )

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

 block2a_expand_conv (Conv2D)    (None, 112, 112, 96  1536
['block1a_project_bn[0][0]']
                                )

 block2a_expand_bn (BatchNormal  (None, 112, 112, 96  384
['block2a_expand_conv[0][0]']
 ization)                      )

 block2a_expand_activation (Act  (None, 112, 112, 96  0
['block2a_expand_bn[0][0]']
 ivation)                      )

 block2a_dwconv_pad (ZeroPaddin  (None, 113, 113, 96  0
['block2a_expand_activation[0][0]
 g2D)                          )                                         ']
```

```
block2a_dwconv (DepthwiseConv2    (None, 56, 56, 96)   864
['block2a_dwconv_pad[0][0]']
 D)

 block2a_bn (BatchNormalization   (None, 56, 56, 96)   384
['block2a_dwconv[0][0]']
 )

 block2a_activation (Activation   (None, 56, 56, 96)   0
['block2a_bn[0][0]']
 )

 block2a_se_squeeze (GlobalAver   (None, 96)           0
['block2a_activation[0][0]']
 agePooling2D)

 block2a_se_reshape (Reshape)     (None, 1, 1, 96)     0
['block2a_se_squeeze[0][0]']

 block2a_se_reduce (Conv2D)       (None, 1, 1, 4)      388
['block2a_se_reshape[0][0]']

 block2a_se_expand (Conv2D)       (None, 1, 1, 96)     480
['block2a_se_reduce[0][0]']

 block2a_se_excite (Multiply)     (None, 56, 56, 96)   0
['block2a_activation[0][0]',
'block2a_se_expand[0][0]']

 block2a_project_conv (Conv2D)    (None, 56, 56, 24)   2304
['block2a_se_excite[0][0]']

 block2a_project_bn (BatchNorma   (None, 56, 56, 24)   96
['block2a_project_conv[0][0]']
 lization)

 block2b_expand_conv (Conv2D)     (None, 56, 56, 144)  3456
['block2a_project_bn[0][0]']

 block2b_expand_bn (BatchNormal   (None, 56, 56, 144)  576
['block2b_expand_conv[0][0]']
 ization)

 block2b_expand_activation (Act   (None, 56, 56, 144)  0
['block2b_expand_bn[0][0]']
 ivation)
```

```
block2b_dwconv (DepthwiseConv2   (None, 56, 56, 144)   1296
['block2b_expand_activation[0][0]
 D)                                                                  ']

block2b_bn (BatchNormalization   (None, 56, 56, 144)   576
['block2b_dwconv[0][0]']
 )

block2b_activation (Activation   (None, 56, 56, 144)   0
['block2b_bn[0][0]']
 )

block2b_se_squeeze (GlobalAver   (None, 144)           0
['block2b_activation[0][0]'
 agePooling2D)

block2b_se_reshape (Reshape)     (None, 1, 1, 144)     0
['block2b_se_squeeze[0][0]']

block2b_se_reduce (Conv2D)       (None, 1, 1, 6)       870
['block2b_se_reshape[0][0]']

block2b_se_expand (Conv2D)       (None, 1, 1, 144)     1008
['block2b_se_reduce[0][0]']

block2b_se_excite (Multiply)     (None, 56, 56, 144)   0
['block2b_activation[0][0]',
 'block2b_se_expand[0][0]']

block2b_project_conv (Conv2D)    (None, 56, 56, 24)    3456
['block2b_se_excite[0][0]']

block2b_project_bn (BatchNorma   (None, 56, 56, 24)    96
['block2b_project_conv[0][0]']
 lization)

block2b_drop (Dropout)           (None, 56, 56, 24)    0
['block2b_project_bn[0][0]']

block2b_add (Add)                (None, 56, 56, 24)    0
['block2b_drop[0][0]',
 'block2a_project_bn[0][0]']

block3a_expand_conv (Conv2D)     (None, 56, 56, 144)   3456
['block2b_add[0][0]']

block3a_expand_bn (BatchNormal   (None, 56, 56, 144)   576
['block3a_expand_conv[0][0]']
```

ization)

block3a_expand_activation (Act   (None, 56, 56, 144)   0
['block3a_expand_bn[0][0]']
ivation)

block3a_dwconv_pad (ZeroPaddin   (None, 59, 59, 144)   0
['block3a_expand_activation[0][0]
g2D)   ']

block3a_dwconv (DepthwiseConv2   (None, 28, 28, 144)   3600
['block3a_dwconv_pad[0][0]']
D)

block3a_bn (BatchNormalization   (None, 28, 28, 144)   576
['block3a_dwconv[0][0]']
)

block3a_activation (Activation   (None, 28, 28, 144)   0
['block3a_bn[0][0]']
)

block3a_se_squeeze (GlobalAver   (None, 144)   0
['block3a_activation[0][0]']
agePooling2D)

block3a_se_reshape (Reshape)   (None, 1, 1, 144)   0
['block3a_se_squeeze[0][0]']

block3a_se_reduce (Conv2D)   (None, 1, 1, 6)   870
['block3a_se_reshape[0][0]']

block3a_se_expand (Conv2D)   (None, 1, 1, 144)   1008
['block3a_se_reduce[0][0]']

block3a_se_excite (Multiply)   (None, 28, 28, 144)   0
['block3a_activation[0][0]',
'block3a_se_expand[0][0]']

block3a_project_conv (Conv2D)   (None, 28, 28, 40)   5760
['block3a_se_excite[0][0]']

block3a_project_bn (BatchNorma   (None, 28, 28, 40)   160
['block3a_project_conv[0][0]']
lization)

block3b_expand_conv (Conv2D)   (None, 28, 28, 240)   9600
['block3a_project_bn[0][0]']

```
 block3b_expand_bn (BatchNormal   (None, 28, 28, 240)   960
['block3b_expand_conv[0][0]']
 ization)

 block3b_expand_activation (Act   (None, 28, 28, 240)   0
['block3b_expand_bn[0][0]']
 ivation)

 block3b_dwconv (DepthwiseConv2   (None, 28, 28, 240)   6000
['block3b_expand_activation[0][0]
 D)                                                                          ']

 block3b_bn (BatchNormalization   (None, 28, 28, 240)   960
['block3b_dwconv[0][0]']
 )

 block3b_activation (Activation   (None, 28, 28, 240)   0
['block3b_bn[0][0]']
 )

 block3b_se_squeeze (GlobalAver   (None, 240)           0
['block3b_activation[0][0]']
 agePooling2D)

 block3b_se_reshape (Reshape)     (None, 1, 1, 240)     0
['block3b_se_squeeze[0][0]']

 block3b_se_reduce (Conv2D)       (None, 1, 1, 10)      2410
['block3b_se_reshape[0][0]']

 block3b_se_expand (Conv2D)       (None, 1, 1, 240)     2640
['block3b_se_reduce[0][0]']

 block3b_se_excite (Multiply)     (None, 28, 28, 240)   0
['block3b_activation[0][0]',
'block3b_se_expand[0][0]']

 block3b_project_conv (Conv2D)    (None, 28, 28, 40)    9600
['block3b_se_excite[0][0]']

 block3b_project_bn (BatchNorma   (None, 28, 28, 40)    160
['block3b_project_conv[0][0]']
 lization)

 block3b_drop (Dropout)           (None, 28, 28, 40)    0
['block3b_project_bn[0][0]']
```

```
block3b_add (Add)              (None, 28, 28, 40)    0
['block3b_drop[0][0]',
'block3a_project_bn[0][0]']

block4a_expand_conv (Conv2D)   (None, 28, 28, 240)   9600
['block3b_add[0][0]']

block4a_expand_bn (BatchNormal  (None, 28, 28, 240)  960
['block4a_expand_conv[0][0]']
 ization)

block4a_expand_activation (Act  (None, 28, 28, 240)  0
['block4a_expand_bn[0][0]']
 ivation)

block4a_dwconv_pad (ZeroPaddin  (None, 29, 29, 240)  0
['block4a_expand_activation[0][0]
 g2D)                                                             ']

block4a_dwconv (DepthwiseConv2  (None, 14, 14, 240)  2160
['block4a_dwconv_pad[0][0]']
 D)

block4a_bn (BatchNormalization  (None, 14, 14, 240)  960
['block4a_dwconv[0][0]']
 )

block4a_activation (Activation  (None, 14, 14, 240)  0
['block4a_bn[0][0]']
 )

block4a_se_squeeze (GlobalAver  (None, 240)           0
['block4a_activation[0][0]']
 agePooling2D)

block4a_se_reshape (Reshape)   (None, 1, 1, 240)     0
['block4a_se_squeeze[0][0]']

block4a_se_reduce (Conv2D)     (None, 1, 1, 10)      2410
['block4a_se_reshape[0][0]']

block4a_se_expand (Conv2D)     (None, 1, 1, 240)     2640
['block4a_se_reduce[0][0]']

block4a_se_excite (Multiply)   (None, 14, 14, 240)   0
['block4a_activation[0][0]',
'block4a_se_expand[0][0]']
```

```
 block4a_project_conv (Conv2D)   (None, 14, 14, 80)    19200
['block4a_se_excite[0][0]']

 block4a_project_bn (BatchNorma   (None, 14, 14, 80)    320
['block4a_project_conv[0][0]']
 lization)

 block4b_expand_conv (Conv2D)    (None, 14, 14, 480)   38400
['block4a_project_bn[0][0]']

 block4b_expand_bn (BatchNormal   (None, 14, 14, 480)   1920
['block4b_expand_conv[0][0]']
 ization)

 block4b_expand_activation (Act   (None, 14, 14, 480)   0
['block4b_expand_bn[0][0]']
 ivation)

 block4b_dwconv (DepthwiseConv2   (None, 14, 14, 480)   4320
['block4b_expand_activation[0][0]
 D)                                                                    ']

 block4b_bn (BatchNormalization   (None, 14, 14, 480)   1920
['block4b_dwconv[0][0]']
 )

 block4b_activation (Activation   (None, 14, 14, 480)   0
['block4b_bn[0][0]']
 )

 block4b_se_squeeze (GlobalAver   (None, 480)           0
['block4b_activation[0][0]']
 agePooling2D)

 block4b_se_reshape (Reshape)    (None, 1, 1, 480)     0
['block4b_se_squeeze[0][0]']

 block4b_se_reduce (Conv2D)      (None, 1, 1, 20)      9620
['block4b_se_reshape[0][0]']

 block4b_se_expand (Conv2D)      (None, 1, 1, 480)     10080
['block4b_se_reduce[0][0]']

 block4b_se_excite (Multiply)    (None, 14, 14, 480)   0
['block4b_activation[0][0]',
 'block4b_se_expand[0][0]']

 block4b_project_conv (Conv2D)   (None, 14, 14, 80)    38400
```

```
                                           ['block4b_se_excite[0][0]']

 block4b_project_bn (BatchNorma   (None, 14, 14, 80)   320
['block4b_project_conv[0][0]']
 lization)

 block4b_drop (Dropout)           (None, 14, 14, 80)    0
['block4b_project_bn[0][0]']

 block4b_add (Add)                (None, 14, 14, 80)    0
['block4b_drop[0][0]',
'block4a_project_bn[0][0]']

 block4c_expand_conv (Conv2D)    (None, 14, 14, 480)  38400
['block4b_add[0][0]']

 block4c_expand_bn (BatchNormal   (None, 14, 14, 480)  1920
['block4c_expand_conv[0][0]']
 ization)

 block4c_expand_activation (Act   (None, 14, 14, 480)   0
['block4c_expand_bn[0][0]']
 ivation)

 block4c_dwconv (DepthwiseConv2   (None, 14, 14, 480)  4320
['block4c_expand_activation[0][0]
 D)                                                                                       ']

 block4c_bn (BatchNormalization   (None, 14, 14, 480)  1920
['block4c_dwconv[0][0]']
 )

 block4c_activation (Activation   (None, 14, 14, 480)   0
['block4c_bn[0][0]']
 )

 block4c_se_squeeze (GlobalAver   (None, 480)           0
['block4c_activation[0][0]']
 agePooling2D)

 block4c_se_reshape (Reshape)     (None, 1, 1, 480)     0
['block4c_se_squeeze[0][0]']

 block4c_se_reduce (Conv2D)       (None, 1, 1, 20)     9620
['block4c_se_reshape[0][0]']

 block4c_se_expand (Conv2D)       (None, 1, 1, 480)   10080
['block4c_se_reduce[0][0]']
```

```
block4c_se_excite (Multiply)    (None, 14, 14, 480)   0
['block4c_activation[0][0]',
'block4c_se_expand[0][0]']

block4c_project_conv (Conv2D)   (None, 14, 14, 80)    38400
['block4c_se_excite[0][0]']

block4c_project_bn (BatchNorma   (None, 14, 14, 80)    320
['block4c_project_conv[0][0]']
lization)

block4c_drop (Dropout)          (None, 14, 14, 80)    0
['block4c_project_bn[0][0]']

block4c_add (Add)               (None, 14, 14, 80)    0
['block4c_drop[0][0]',
'block4b_add[0][0]']

block5a_expand_conv (Conv2D)    (None, 14, 14, 480)   38400
['block4c_add[0][0]']

block5a_expand_bn (BatchNormal   (None, 14, 14, 480)   1920
['block5a_expand_conv[0][0]']
ization)

block5a_expand_activation (Act   (None, 14, 14, 480)   0
['block5a_expand_bn[0][0]']
ivation)

block5a_dwconv (DepthwiseConv2   (None, 14, 14, 480)   12000
['block5a_expand_activation[0][0]
D)                                                                          ']

block5a_bn (BatchNormalization   (None, 14, 14, 480)   1920
['block5a_dwconv[0][0]']
)

block5a_activation (Activation   (None, 14, 14, 480)   0
['block5a_bn[0][0]']
)

block5a_se_squeeze (GlobalAver   (None, 480)           0
['block5a_activation[0][0]']
agePooling2D)

block5a_se_reshape (Reshape)    (None, 1, 1, 480)     0
['block5a_se_squeeze[0][0]']
```

```
block5a_se_reduce (Conv2D)      (None, 1, 1, 20)     9620
['block5a_se_reshape[0][0]']


block5a_se_expand (Conv2D)      (None, 1, 1, 480)    10080
['block5a_se_reduce[0][0]']


block5a_se_excite (Multiply)    (None, 14, 14, 480)  0
['block5a_activation[0][0]',
'block5a_se_expand[0][0]']


block5a_project_conv (Conv2D)   (None, 14, 14, 112)  53760
['block5a_se_excite[0][0]']


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


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


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


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


block5b_dwconv (DepthwiseConv2  (None, 14, 14, 672)  16800
['block5b_expand_activation[0][0]
D)                                                                            ']


block5b_bn (BatchNormalization  (None, 14, 14, 672)  2688
['block5b_dwconv[0][0]']
)


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


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


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

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


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


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


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


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


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


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


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


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


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


block5c_dwconv (DepthwiseConv2  (None, 14, 14, 672)   16800
['block5c_expand_activation[0][0]
D)                                                                                ']


block5c_bn (BatchNormalization  (None, 14, 14, 672)   2688
['block5c_dwconv[0][0]']
)


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


block5c_se_squeeze (GlobalAver  (None, 672)           0
```

```
['block5c_activation[0][0]']
 agePooling2D)

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

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

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

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

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

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

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

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

 block6a_expand_conv (Conv2D)    (None, 14, 14, 672)  75264
['block5c_add[0][0]']

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

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

 block6a_dwconv_pad (ZeroPaddin  (None, 17, 17, 672)  0
['block6a_expand_activation[0][0]
 g2D)                                                                    ']

 block6a_dwconv (DepthwiseConv2  (None, 7, 7, 672)    16800
['block6a_dwconv_pad[0][0]']
 D)
```

```
block6a_bn (BatchNormalization    (None, 7, 7, 672)    2688
['block6a_dwconv[0][0]']
 )

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

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

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

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

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

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

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

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

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

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

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

 block6b_dwconv (DepthwiseConv2    (None, 7, 7, 1152)   28800
['block6b_expand_activation[0][0]
 D)                                                                            ']
```

```
block6b_bn (BatchNormalization   (None, 7, 7, 1152)   4608
['block6b_dwconv[0][0]']
)

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

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

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

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

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

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

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

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

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

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

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

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

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

```
 ivation)

 block6c_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800
['block6c_expand_activation[0][0]
 D)                                                                    ']

 block6c_bn (BatchNormalization  (None, 7, 7, 1152)  4608
['block6c_dwconv[0][0]']
 )

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

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

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

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

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

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

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

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

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

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

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

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

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

 block6d_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6d_expand_activation[0][0]
 D)                                                             ']

 block6d_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6d_dwconv[0][0]']
 )

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

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

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

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

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

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

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

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

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

 block6d_add (Add)               (None, 7, 7, 192)   0
```

```
['block6d_drop[0][0]',
 'block6c_add[0][0]']

 block7a_expand_conv (Conv2D)    (None, 7, 7, 1152)    221184
['block6d_add[0][0]']

 block7a_expand_bn (BatchNormal  (None, 7, 7, 1152)    4608
['block7a_expand_conv[0][0]']
 ization)

 block7a_expand_activation (Act  (None, 7, 7, 1152)    0
['block7a_expand_bn[0][0]']
 ivation)

 block7a_dwconv (DepthwiseConv2  (None, 7, 7, 1152)    10368
['block7a_expand_activation[0][0]
 D)                                                                  ']

 block7a_bn (BatchNormalization  (None, 7, 7, 1152)    4608
['block7a_dwconv[0][0]']
 )

 block7a_activation (Activation  (None, 7, 7, 1152)    0
['block7a_bn[0][0]']
 )

 block7a_se_squeeze (GlobalAver  (None, 1152)          0
['block7a_activation[0][0]']
 agePooling2D)

 block7a_se_reshape (Reshape)    (None, 1, 1, 1152)    0
['block7a_se_squeeze[0][0]']

 block7a_se_reduce (Conv2D)      (None, 1, 1, 48)      55344
['block7a_se_reshape[0][0]']

 block7a_se_expand (Conv2D)      (None, 1, 1, 1152)    56448
['block7a_se_reduce[0][0]']

 block7a_se_excite (Multiply)    (None, 7, 7, 1152)    0
['block7a_activation[0][0]',
 'block7a_se_expand[0][0]']

 block7a_project_conv (Conv2D)   (None, 7, 7, 320)     368640
['block7a_se_excite[0][0]']

 block7a_project_bn (BatchNorma  (None, 7, 7, 320)     1280
['block7a_project_conv[0][0]']
```

```
 lization)

 top_conv (Conv2D)              (None, 7, 7, 1280)   409600
 ['block7a_project_bn[0][0]']

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

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


=====================================================================
==================
Total params: 4,049,571
Trainable params: 4,007,548
Non-trainable params: 42,023

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

```python
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])
```

```
WARNING:tensorflow:Model failed to serialize as JSON. Ignoring… Unable to
serialize [2.0896919 2.1128857 2.1081853] to JSON. Unrecognized type <class
'tensorflow.python.framework.ops.EagerTensor'>.
Epoch 1/20
168/168 [==============================] - 23s 99ms/step - loss: 0.4996 -
accuracy: 0.8224 - val_loss: 0.2165 - val_accuracy: 0.9241
Epoch 2/20
168/168 [==============================] - 16s 93ms/step - loss: 0.1403 -
accuracy: 0.9505 - val_loss: 0.1505 - val_accuracy: 0.9535
Epoch 3/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0805 -
accuracy: 0.9708 - val_loss: 0.2050 - val_accuracy: 0.9384
Epoch 4/20
168/168 [==============================] - 15s 91ms/step - loss: 0.0866 -
accuracy: 0.9710 - val_loss: 0.2676 - val_accuracy: 0.9148
```

```
Epoch 5/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0606 -
accuracy: 0.9796 - val_loss: 0.1097 - val_accuracy: 0.9664
Epoch 6/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0374 -
accuracy: 0.9869 - val_loss: 0.1199 - val_accuracy: 0.9649
Epoch 7/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0555 -
accuracy: 0.9796 - val_loss: 0.2486 - val_accuracy: 0.9363
Epoch 8/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0429 -
accuracy: 0.9858 - val_loss: 0.1529 - val_accuracy: 0.9513
Epoch 9/20
168/168 [==============================] - 15s 90ms/step - loss: 0.0423 -
accuracy: 0.9880 - val_loss: 0.2639 - val_accuracy: 0.9370
Epoch 10/20
168/168 [==============================] - 15s 91ms/step - loss: 0.0594 -
accuracy: 0.9813 - val_loss: 0.1243 - val_accuracy: 0.9628
Epoch 11/20
168/168 [==============================] - 16s 93ms/step - loss: 0.0473 -
accuracy: 0.9854 - val_loss: 0.1252 - val_accuracy: 0.9578
Epoch 12/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0453 -
accuracy: 0.9841 - val_loss: 0.1016 - val_accuracy: 0.9678
Epoch 13/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0174 -
accuracy: 0.9944 - val_loss: 0.1148 - val_accuracy: 0.9692
Epoch 14/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0286 -
accuracy: 0.9925 - val_loss: 0.1078 - val_accuracy: 0.9671
Epoch 15/20
168/168 [==============================] - 16s 95ms/step - loss: 0.0144 -
accuracy: 0.9957 - val_loss: 0.0763 - val_accuracy: 0.9778
Epoch 16/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0086 -
accuracy: 0.9978 - val_loss: 0.1061 - val_accuracy: 0.9707
Epoch 17/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0167 -
accuracy: 0.9948 - val_loss: 0.1926 - val_accuracy: 0.9506
Epoch 18/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0450 -
accuracy: 0.9869 - val_loss: 0.3687 - val_accuracy: 0.9234
Epoch 19/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0321 -
accuracy: 0.9893 - val_loss: 0.3089 - val_accuracy: 0.9213
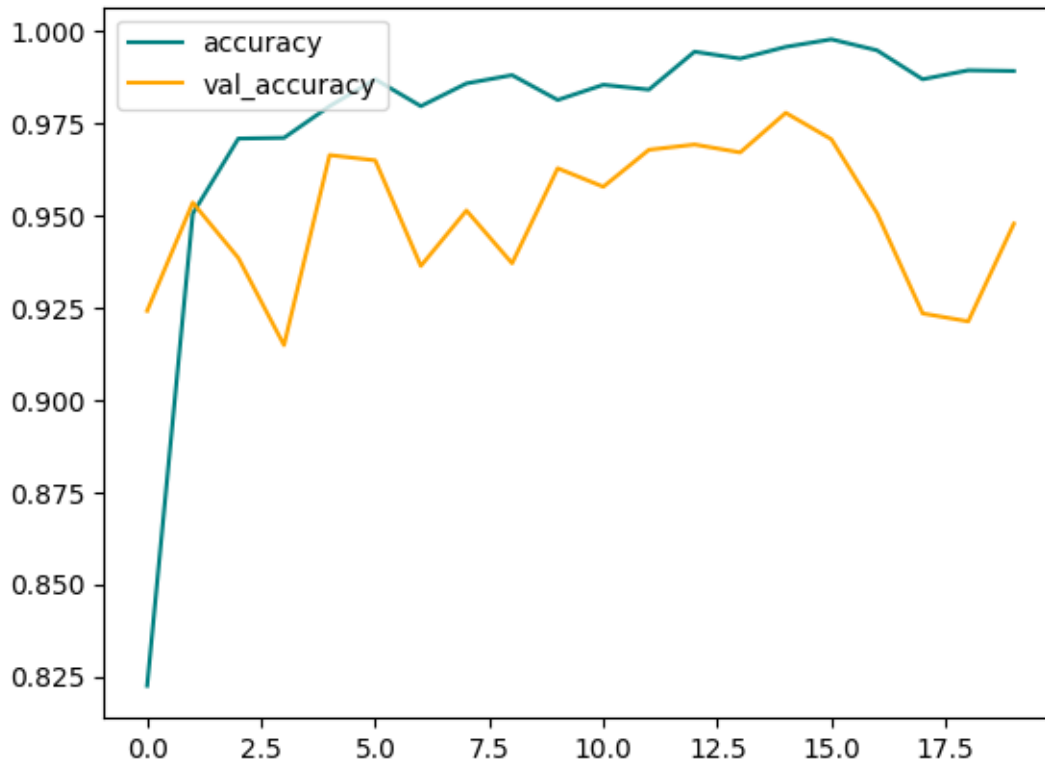Epoch 20/20
168/168 [==============================] - 16s 94ms/step - loss: 0.0334 -
accuracy: 0.9892 - val_loss: 0.2199 - val_accuracy: 0.9477
```

```
[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()
```

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 633ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 19ms/step
```

```
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 1s 688ms/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:  99.68%
Recall:  98.41%
Accuracy:  92.77%
```

[14]:
```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 615ms/step
```

Predicted class: 2


```
[15]: print(f'Predicted class is: {class_names[predicted_class]}')
      for idx, prob in enumerate(yhat[0]):
          print(f"Model probability for {class_names[idx]} is {prob * 100:.2f}%")
```

```
Predicted class is: Hatchback
Model probability for Convertible is 0.00%
Model probability for Coupe is 0.00%
Model probability for Hatchback is 88.94%
Model probability for Pick-Up is 0.00%
Model probability for SUV is 0.00%
Model probability for Sedan is 10.90%
Model probability for VAN is 0.16%
```

```
[16]: model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}% EfficientNetB0.
      ↪h5"
      model.save(os.path.join('CarBackEnd/models/CarStyles', model_file_name))
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[16], line 2
      1 model_file_name = f"CarStyle{acc.result().numpy() * 100 : .2f}%␣
  ↪EfficientNetB0.h5"
----> 2 model.save(os.path.join('CarBackEnd/models/CarStyles', model_file_name))

File ~\anaconda3\envs\py310\lib\site-packages\keras\utils\traceback_utils.py:70 ␣
  ↪in filter_traceback.<locals>.error_handler(*args, **kwargs)
```

```
    67         filtered_tb = _process_traceback_frames(e.__traceback__)
    68         # To get the full stack trace, call:
    69         # `tf.debugging.disable_traceback_filtering()`
---> 70         raise e.with_traceback(filtered_tb) from None
    71 finally:
    72     del filtered_tb

File ~\anaconda3\envs\py310\lib\json\__init__.py:238, in dumps(obj, skipkeys,
 ↪ensure_ascii, check_circular, allow_nan, cls, indent, separators, default,
 ↪sort_keys, **kw)
    232 if cls is None:
    233     cls = JSONEncoder
    234 return cls(
    235     skipkeys=skipkeys, ensure_ascii=ensure_ascii,
    236     check_circular=check_circular, allow_nan=allow_nan, indent=indent,
    237     separators=separators, default=default, sort_keys=sort_keys,
--> 238     **kw).encode(obj)

File ~\anaconda3\envs\py310\lib\json\encoder.py:199, in JSONEncoder.encode(self
 ↪o)
    195         return encode_basestring(o)
    196 # This doesn't pass the iterator directly to ''.join() because the
    197 # exceptions aren't as detailed.  The list call should be roughly
    198 # equivalent to the PySequence_Fast that ''.join() would do.
--> 199 chunks = self.iterencode(o, _one_shot=True)
    200 if not isinstance(chunks, (list, tuple)):
    201     chunks = list(chunks)

File ~\anaconda3\envs\py310\lib\json\encoder.py:257, in JSONEncoder.
 ↪iterencode(self, o, _one_shot)
    252 else:
    253     _iterencode = _make_iterencode(
    254         markers, self.default, _encoder, self.indent, floatstr,
    255         self.key_separator, self.item_separator, self.sort_keys,
    256         self.skipkeys, _one_shot)
--> 257 return _iterencode(o, 0)

TypeError: Unable to serialize [2.0896919 2.1128857 2.1081853] to JSON.
 ↪Unrecognized type <class 'tensorflow.python.framework.ops.EagerTensor'>.
```

[ ]: