Daniel Garcia | Deep Learning 2

October 28, 2022

[1]:
```
import numpy as np
import pandas as pd
import os
import tensorflow as tf
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from tensorflow.keras import layers
from tensorflow.keras.optimizers import RMSprop, Adam, SGD
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import regularizers
from keras.callbacks import ReduceLROnPlateau, EarlyStopping
from keras.models import Sequential
from keras.layers import Dense, Conv2D, MaxPool2D, Flatten, Dropout,␣
↪BatchNormalization
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ReduceLROnPlateau
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from PIL import Image
import keras
from keras.preprocessing.image import ImageDataGenerator
from keras.applications.vgg16 import VGG16
from tensorflow.keras import layers
from keras.models import Model
from sklearn.metrics import confusion_matrix, accuracy_score, roc_curve,␣
↪roc_auc_score, classification_report
import scikitplot as skplt
import seaborn as sns
import random
import glob
```

0.1 Input Layer

Source: Intel Image https://www.kaggle.com/datasets/puneet6060/intel-image-classification

[2]:
```
image_generator = ImageDataGenerator(rescale = 1.0/255,
                                     shear_range = 0.2,
```

```
                                        zoom_range = 0.5,
                                        horizontal_flip = True,
                                        rotation_range=10,
                                        width_shift_range=0.2,
                                        brightness_range=[0.2,1.2],
                                        validation_split=0.25)

pathway_train = 'desktop/Intel_images/seg_train/seg_train'

train = image_generator.flow_from_directory(batch_size=80,
                                                    directory=pathway_train,
                                                    shuffle=True,
                                                    target_size=(150,150),
                                                    subset="training",
                                                    class_mode='categorical')

val = image_generator.flow_from_directory(batch_size=80,
                                                    directory=pathway_train,
                                                    shuffle=True,
                                                    target_size=(150,150),
                                                    subset="validation",
                                                    class_mode='categorical')

pathway_test = 'desktop/Intel_images/seg_test/seg_test'

test_image_gen = ImageDataGenerator(rescale=1./255)
test = test_image_gen.flow_from_directory(pathway_train,
                                          target_size=(150,150), batch_size=80,␣
 ↪shuffle=False)
```

```
Found 10528 images belonging to 6 classes.
Found 3506 images belonging to 6 classes.
Found 14034 images belonging to 6 classes.
```

[3]:
```
def plot_loss_accuracy(history):
    plt.figure(figsize = (15,5))
    plt.subplot(121)
    plt.title('LOSS OF MODEL')
    plt.plot(history.history['loss'], color='blue', label='train')
    plt.plot(history.history['val_loss'], color='orange', label='test')

    plt.subplot(122)
    plt.title('ACCURACY OF MODEL')
    plt.plot(history.history['accuracy'], color='blue', label='train')
    plt.plot(history.history['val_accuracy'], color='orange', label='test')
    plt.legend(['training', 'validation'])
    plt.show()
```

0.2 Baselina: VGG16

[4]:
```
from tensorflow.keras.applications import VGG16

VGG16_model = VGG16(include_top=False, input_shape=(150, 150, 3), weights␣
 ↪='imagenet')
VGG16_model.trainable = True

CNN = layers.Flatten()(VGG16_model.layers[-1].output)
CNN = layers.Dropout(0.4)(CNN)

CNN = layers.Dense(128, activation='relu')(CNN)
output = layers.Dense(6, activation='softmax')(CNN)
VGG16_model = Model(inputs=VGG16_model.inputs, outputs=output)

VGG16_model.summary()
```

```
Metal device set to: Apple M1

2022-10-28 14:31:43.548607: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-10-28 14:31:43.548715: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)

Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 150, 150, 3)]     0

 block1_conv1 (Conv2D)       (None, 150, 150, 64)      1792

 block1_conv2 (Conv2D)       (None, 150, 150, 64)      36928

 block1_pool (MaxPooling2D)  (None, 75, 75, 64)        0

 block2_conv1 (Conv2D)       (None, 75, 75, 128)       73856

 block2_conv2 (Conv2D)       (None, 75, 75, 128)       147584

 block2_pool (MaxPooling2D)  (None, 37, 37, 128)       0

 block3_conv1 (Conv2D)       (None, 37, 37, 256)       295168
```

```
 block3_conv2 (Conv2D)       (None, 37, 37, 256)       590080

 block3_conv3 (Conv2D)       (None, 37, 37, 256)       590080

 block3_pool (MaxPooling2D)  (None, 18, 18, 256)       0

 block4_conv1 (Conv2D)       (None, 18, 18, 512)       1180160

 block4_conv2 (Conv2D)       (None, 18, 18, 512)       2359808

 block4_conv3 (Conv2D)       (None, 18, 18, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 9, 9, 512)         0

 block5_conv1 (Conv2D)       (None, 9, 9, 512)         2359808

 block5_conv2 (Conv2D)       (None, 9, 9, 512)         2359808

 block5_conv3 (Conv2D)       (None, 9, 9, 512)         2359808

 block5_pool (MaxPooling2D)  (None, 4, 4, 512)         0

 flatten (Flatten)           (None, 8192)              0

 dropout (Dropout)           (None, 8192)              0

 dense (Dense)               (None, 128)               1048704

 dense_1 (Dense)             (None, 6)                 774

=================================================================
Total params: 15,764,166
Trainable params: 15,764,166
Non-trainable params: 0
_________________________________________________________________
```

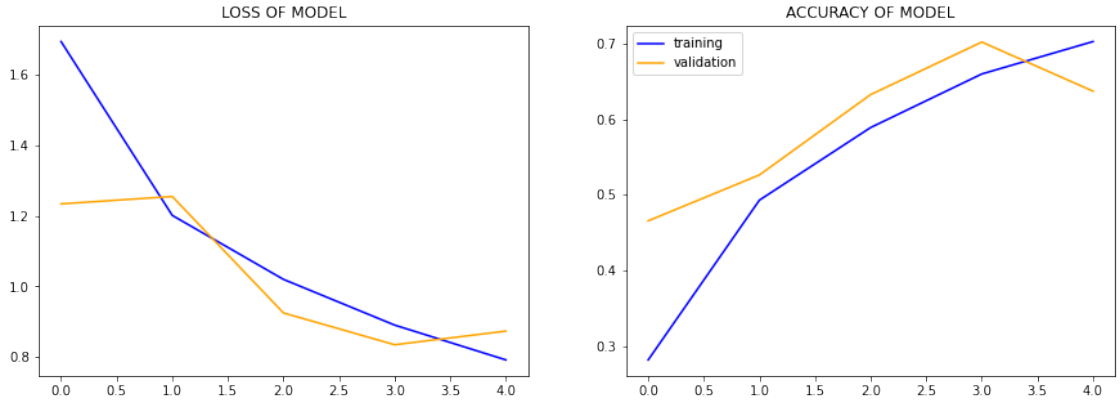
VGG16 Model Data Fit

Learning Rage = 0.001
Epochs = 5

[5]:
```
callbacks = EarlyStopping(monitor = 'val_loss', mode = 'min', verbose = 1,␣
 ↪patience = 3)

VGG16_model.compile(
    optimizer=tf.keras.optimizers.Adam(0.001),  # learning rate = 0.1
    loss=tf.keras.losses.CategoricalCrossentropy(
    from_logits=False, name='categorical_crossentropy'),
```

```
    metrics=[tf.keras.metrics.CategoricalAccuracy(
    name='accuracy')])

history_VGG = VGG16_model.fit(train, epochs=5, validation_data=val, callbacks␣
 ↪=[callbacks])
plot_loss_accuracy(history_VGG)
```

```
Epoch 1/5

2022-10-28 14:31:44.172508: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-10-28 14:31:44.624751: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - ETA: 0s - loss: 1.6929 - accuracy:
0.2813

2022-10-28 14:37:05.782368: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - 357s 3s/step - loss: 1.6929 -
accuracy: 0.2813 - val_loss: 1.2336 - val_accuracy: 0.4655
Epoch 2/5
132/132 [==============================] - 396s 3s/step - loss: 1.2010 -
accuracy: 0.4929 - val_loss: 1.2545 - val_accuracy: 0.5262
Epoch 3/5
132/132 [==============================] - 414s 3s/step - loss: 1.0200 -
accuracy: 0.5890 - val_loss: 0.9250 - val_accuracy: 0.6326
Epoch 4/5
132/132 [==============================] - 403s 3s/step - loss: 0.8906 -
accuracy: 0.6600 - val_loss: 0.8350 - val_accuracy: 0.7022
Epoch 5/5
132/132 [==============================] - 396s 3s/step - loss: 0.7921 -
accuracy: 0.7029 - val_loss: 0.8735 - val_accuracy: 0.6372
```



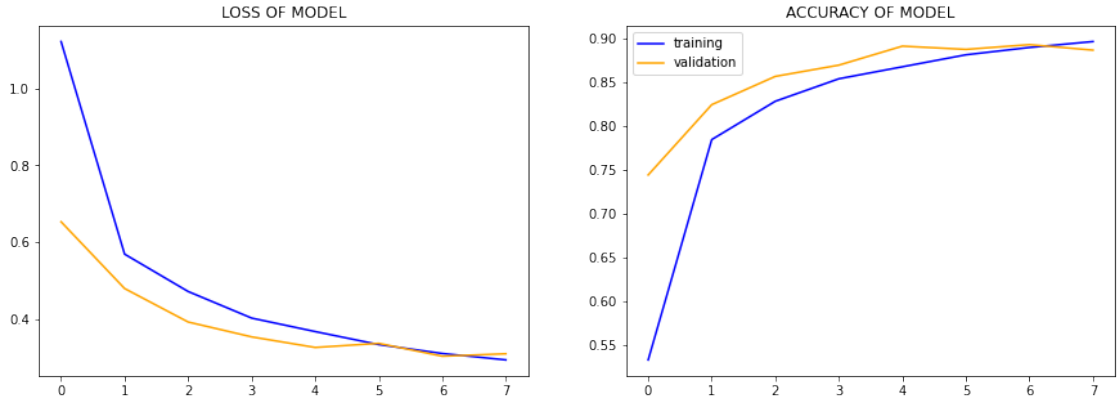
0.2.1 VGG16 Optimization

Learning Rage = 0.00001
Epochs = 10

[7]:
```
VGG16_opt_model = VGG16(include_top=False, input_shape=(150, 150, 3), weights␣
↪='imagenet')
VGG16_opt_model.trainable = True

CNN = layers.Flatten()(VGG16_opt_model.layers[-1].output)
CNN = layers.Dropout(0.4)(CNN)

CNN = layers.Dense(128, activation='relu')(CNN)
output = layers.Dense(6, activation='softmax')(CNN)
VGG16_opt_model = Model(inputs=VGG16_opt_model.inputs, outputs=output)

VGG16_opt_model.compile(
    optimizer=tf.keras.optimizers.Adam(1e-5),  # learning rate = 0.00001
    loss=tf.keras.losses.CategoricalCrossentropy(
    from_logits=False, name='categorical_crossentropy'),
    metrics=[tf.keras.metrics.CategoricalAccuracy(
    name='accuracy')])

history_VGG16_Opt = VGG16_opt_model.fit(train, epochs=8, validation_data=val,␣
↪callbacks =[callbacks])
plot_loss_accuracy(history_VGG16_Opt)
```

```
Epoch 1/8

2022-10-28 16:18:56.223081: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - ETA: 0s - loss: 1.1211 - accuracy:
0.5330

2022-10-28 16:24:37.656815: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - 379s 3s/step - loss: 1.1211 -
accuracy: 0.5330 - val_loss: 0.6532 - val_accuracy: 0.7439
Epoch 2/8
132/132 [==============================] - 421s 3s/step - loss: 0.5692 -
accuracy: 0.7842 - val_loss: 0.4799 - val_accuracy: 0.8240
Epoch 3/8
132/132 [==============================] - 444s 3s/step - loss: 0.4722 -
```

```
accuracy: 0.8279 - val_loss: 0.3930 - val_accuracy: 0.8562
Epoch 4/8
132/132 [==============================] - 436s 3s/step - loss: 0.4031 -
accuracy: 0.8535 - val_loss: 0.3544 - val_accuracy: 0.8691
Epoch 5/8
132/132 [==============================] - 436s 3s/step - loss: 0.3681 -
accuracy: 0.8672 - val_loss: 0.3269 - val_accuracy: 0.8908
Epoch 6/8
132/132 [==============================] - 436s 3s/step - loss: 0.3344 -
accuracy: 0.8809 - val_loss: 0.3375 - val_accuracy: 0.8871
Epoch 7/8
132/132 [==============================] - 442s 3s/step - loss: 0.3112 -
accuracy: 0.8892 - val_loss: 0.3042 - val_accuracy: 0.8925
Epoch 8/8
132/132 [==============================] - 440s 3s/step - loss: 0.2946 -
accuracy: 0.8960 - val_loss: 0.3105 - val_accuracy: 0.8862
```



0.3 EfficientNet Model

EfficientNet Model Data Fit

Learning Rage = 0.00001
Epochs = 8

[8]:
```
from tensorflow.keras.applications import EfficientNetB2

EfficientNet_model = EfficientNetB2(include_top=False, input_shape=(150, 150,␣
↪3), weights ='imagenet')
EfficientNet_model.trainable = True

CNN2 = layers.Flatten()(EfficientNet_model.layers[-1].output)
CNN2 = layers.Dropout(0.4)(CNN2) # 0.1, 0.2, 0.3, 0.4
```

```
CNN2 = layers.Dense(128, activation='relu')(CNN2) #128, 64, 512
output2 = layers.Dense(6, activation='softmax')(CNN2)
EfficientNet_model = Model(inputs=EfficientNet_model.inputs, outputs=output2)

EfficientNet_model.summary()
```

```
Downloading data from https://storage.googleapis.com/keras-
applications/efficientnetb2_notop.h5
31790344/31790344 [==============================] - 3s 0us/step
Model: "model_3"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 input_4 (InputLayer)           [(None, 150, 150, 3  0           []
                                )]

 rescaling (Rescaling)          (None, 150, 150, 3)  0
['input_4[0][0]']

 normalization (Normalization)  (None, 150, 150, 3)  7
['rescaling[0][0]']

 tf.math.truediv (TFOpLambda)   (None, 150, 150, 3)  0
['normalization[0][0]']

 stem_conv_pad (ZeroPadding2D)  (None, 151, 151, 3)  0
['tf.math.truediv[0][0]']

 stem_conv (Conv2D)             (None, 75, 75, 32)   864
['stem_conv_pad[0][0]']

 stem_bn (BatchNormalization)   (None, 75, 75, 32)   128
['stem_conv[0][0]']

 stem_activation (Activation)   (None, 75, 75, 32)   0
['stem_bn[0][0]']

 block1a_dwconv (DepthwiseConv2  (None, 75, 75, 32)  288
['stem_activation[0][0]']
 D)

 block1a_bn (BatchNormalization  (None, 75, 75, 32)  128
['block1a_dwconv[0][0]']
 )

 block1a_activation (Activation  (None, 75, 75, 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, 75, 75, 32)   0
['block1a_activation[0][0]',
'block1a_se_expand[0][0]']

 block1a_project_conv (Conv2D)  (None, 75, 75, 16)   512
['block1a_se_excite[0][0]']

 block1a_project_bn (BatchNorma  (None, 75, 75, 16)  64
['block1a_project_conv[0][0]']
 lization)

 block1b_dwconv (DepthwiseConv2  (None, 75, 75, 16)  144
['block1a_project_bn[0][0]']
 D)

 block1b_bn (BatchNormalization  (None, 75, 75, 16)  64
['block1b_dwconv[0][0]']
 )

 block1b_activation (Activation  (None, 75, 75, 16)  0
['block1b_bn[0][0]']
 )

 block1b_se_squeeze (GlobalAver  (None, 16)          0
['block1b_activation[0][0]']
 agePooling2D)

 block1b_se_reshape (Reshape)   (None, 1, 1, 16)     0
['block1b_se_squeeze[0][0]']

 block1b_se_reduce (Conv2D)     (None, 1, 1, 4)      68
['block1b_se_reshape[0][0]']
```

```
 block1b_se_expand (Conv2D)     (None, 1, 1, 16)     80
['block1b_se_reduce[0][0]']

 block1b_se_excite (Multiply)   (None, 75, 75, 16)   0
['block1b_activation[0][0]',
'block1b_se_expand[0][0]']

 block1b_project_conv (Conv2D)  (None, 75, 75, 16)   256
['block1b_se_excite[0][0]']

 block1b_project_bn (BatchNorma  (None, 75, 75, 16)  64
['block1b_project_conv[0][0]']
 lization)

 block1b_drop (Dropout)         (None, 75, 75, 16)   0
['block1b_project_bn[0][0]']

 block1b_add (Add)              (None, 75, 75, 16)   0
['block1b_drop[0][0]',
'block1a_project_bn[0][0]']

 block2a_expand_conv (Conv2D)   (None, 75, 75, 96)   1536
['block1b_add[0][0]']

 block2a_expand_bn (BatchNormal  (None, 75, 75, 96)  384
['block2a_expand_conv[0][0]']
 ization)

 block2a_expand_activation (Act  (None, 75, 75, 96)  0
['block2a_expand_bn[0][0]']
 ivation)

 block2a_dwconv_pad (ZeroPaddin  (None, 77, 77, 96)  0
['block2a_expand_activation[0][0]
 g2D)                                                                ']

 block2a_dwconv (DepthwiseConv2  (None, 38, 38, 96)  864
['block2a_dwconv_pad[0][0]']
 D)

 block2a_bn (BatchNormalization  (None, 38, 38, 96)  384
['block2a_dwconv[0][0]']
 )

 block2a_activation (Activation  (None, 38, 38, 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, 38, 38, 96)   0
['block2a_activation[0][0]',
'block2a_se_expand[0][0]']

 block2a_project_conv (Conv2D)  (None, 38, 38, 24)   2304
['block2a_se_excite[0][0]']

 block2a_project_bn (BatchNorma  (None, 38, 38, 24)  96
['block2a_project_conv[0][0]']
 lization)

 block2b_expand_conv (Conv2D)   (None, 38, 38, 144)  3456
['block2a_project_bn[0][0]']

 block2b_expand_bn (BatchNormal  (None, 38, 38, 144)  576
['block2b_expand_conv[0][0]']
 ization)

 block2b_expand_activation (Act  (None, 38, 38, 144)  0
['block2b_expand_bn[0][0]']
 ivation)

 block2b_dwconv (DepthwiseConv2  (None, 38, 38, 144)  1296
['block2b_expand_activation[0][0]
 D)                                                              ']

 block2b_bn (BatchNormalization  (None, 38, 38, 144)  576
['block2b_dwconv[0][0]']
 )

 block2b_activation (Activation  (None, 38, 38, 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, 38, 38, 144)  0
['block2b_activation[0][0]',
'block2b_se_expand[0][0]']

 block2b_project_conv (Conv2D)  (None, 38, 38, 24)   3456
['block2b_se_excite[0][0]']

 block2b_project_bn (BatchNorma  (None, 38, 38, 24)  96
['block2b_project_conv[0][0]']
 lization)

 block2b_drop (Dropout)         (None, 38, 38, 24)   0
['block2b_project_bn[0][0]']

 block2b_add (Add)              (None, 38, 38, 24)   0
['block2b_drop[0][0]',
'block2a_project_bn[0][0]']

 block2c_expand_conv (Conv2D)   (None, 38, 38, 144)  3456
['block2b_add[0][0]']

 block2c_expand_bn (BatchNormal  (None, 38, 38, 144)  576
['block2c_expand_conv[0][0]']
 ization)

 block2c_expand_activation (Act  (None, 38, 38, 144)  0
['block2c_expand_bn[0][0]']
 ivation)

 block2c_dwconv (DepthwiseConv2  (None, 38, 38, 144)  1296
['block2c_expand_activation[0][0]
 D)                                                              ']

 block2c_bn (BatchNormalization  (None, 38, 38, 144)  576
['block2c_dwconv[0][0]']
```

```
 )

 block2c_activation (Activation  (None, 38, 38, 144)  0
['block2c_bn[0][0]']
 )

 block2c_se_squeeze (GlobalAver  (None, 144)         0
['block2c_activation[0][0]']
 agePooling2D)

 block2c_se_reshape (Reshape)   (None, 1, 1, 144)    0
['block2c_se_squeeze[0][0]']

 block2c_se_reduce (Conv2D)     (None, 1, 1, 6)      870
['block2c_se_reshape[0][0]']

 block2c_se_expand (Conv2D)     (None, 1, 1, 144)    1008
['block2c_se_reduce[0][0]']

 block2c_se_excite (Multiply)   (None, 38, 38, 144)  0
['block2c_activation[0][0]',
'block2c_se_expand[0][0]']

 block2c_project_conv (Conv2D)  (None, 38, 38, 24)   3456
['block2c_se_excite[0][0]']

 block2c_project_bn (BatchNorma  (None, 38, 38, 24)  96
['block2c_project_conv[0][0]']
 lization)

 block2c_drop (Dropout)         (None, 38, 38, 24)   0
['block2c_project_bn[0][0]']

 block2c_add (Add)              (None, 38, 38, 24)   0
['block2c_drop[0][0]',
'block2b_add[0][0]']

 block3a_expand_conv (Conv2D)   (None, 38, 38, 144)  3456
['block2c_add[0][0]']

 block3a_expand_bn (BatchNormal  (None, 38, 38, 144)  576
['block3a_expand_conv[0][0]']
 ization)

 block3a_expand_activation (Act  (None, 38, 38, 144)  0
['block3a_expand_bn[0][0]']
 ivation)
```

```
 block3a_dwconv_pad (ZeroPaddin  (None, 41, 41, 144)  0
['block3a_expand_activation[0][0]
 g2D)                                                              ']

 block3a_dwconv (DepthwiseConv2  (None, 19, 19, 144)  3600
['block3a_dwconv_pad[0][0]']
 D)

 block3a_bn (BatchNormalization  (None, 19, 19, 144)  576
['block3a_dwconv[0][0]']
 )

 block3a_activation (Activation  (None, 19, 19, 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, 19, 19, 144)  0
['block3a_activation[0][0]',
'block3a_se_expand[0][0]']

 block3a_project_conv (Conv2D)  (None, 19, 19, 48)   6912
['block3a_se_excite[0][0]']

 block3a_project_bn (BatchNorma  (None, 19, 19, 48)  192
['block3a_project_conv[0][0]']
 lization)

 block3b_expand_conv (Conv2D)   (None, 19, 19, 288)  13824
['block3a_project_bn[0][0]']

 block3b_expand_bn (BatchNormal  (None, 19, 19, 288)  1152
['block3b_expand_conv[0][0]']
 ization)

 block3b_expand_activation (Act  (None, 19, 19, 288)  0
```

```
['block3b_expand_bn[0][0]']
 ivation)

 block3b_dwconv (DepthwiseConv2  (None, 19, 19, 288)  7200
['block3b_expand_activation[0][0]
 D)                                                              ']

 block3b_bn (BatchNormalization  (None, 19, 19, 288)  1152
['block3b_dwconv[0][0]']
 )

 block3b_activation (Activation  (None, 19, 19, 288)  0
['block3b_bn[0][0]']
 )

 block3b_se_squeeze (GlobalAver  (None, 288)         0
['block3b_activation[0][0]']
 agePooling2D)

 block3b_se_reshape (Reshape)   (None, 1, 1, 288)    0
['block3b_se_squeeze[0][0]']

 block3b_se_reduce (Conv2D)     (None, 1, 1, 12)     3468
['block3b_se_reshape[0][0]']

 block3b_se_expand (Conv2D)     (None, 1, 1, 288)    3744
['block3b_se_reduce[0][0]']

 block3b_se_excite (Multiply)   (None, 19, 19, 288)  0
['block3b_activation[0][0]',
'block3b_se_expand[0][0]']

 block3b_project_conv (Conv2D)  (None, 19, 19, 48)   13824
['block3b_se_excite[0][0]']

 block3b_project_bn (BatchNorma  (None, 19, 19, 48)  192
['block3b_project_conv[0][0]']
 lization)

 block3b_drop (Dropout)         (None, 19, 19, 48)   0
['block3b_project_bn[0][0]']

 block3b_add (Add)              (None, 19, 19, 48)   0
['block3b_drop[0][0]',
'block3a_project_bn[0][0]']

 block3c_expand_conv (Conv2D)   (None, 19, 19, 288)  13824
['block3b_add[0][0]']
```

```
 block3c_expand_bn (BatchNormal  (None, 19, 19, 288)  1152
['block3c_expand_conv[0][0]']
 ization)

 block3c_expand_activation (Act  (None, 19, 19, 288)  0
['block3c_expand_bn[0][0]']
 ivation)

 block3c_dwconv (DepthwiseConv2  (None, 19, 19, 288)  7200
['block3c_expand_activation[0][0]
 D)                                                              ']

 block3c_bn (BatchNormalization  (None, 19, 19, 288)  1152
['block3c_dwconv[0][0]']
 )

 block3c_activation (Activation  (None, 19, 19, 288)  0
['block3c_bn[0][0]']
 )

 block3c_se_squeeze (GlobalAver  (None, 288)         0
['block3c_activation[0][0]']
 agePooling2D)

 block3c_se_reshape (Reshape)   (None, 1, 1, 288)    0
['block3c_se_squeeze[0][0]']

 block3c_se_reduce (Conv2D)     (None, 1, 1, 12)     3468
['block3c_se_reshape[0][0]']

 block3c_se_expand (Conv2D)     (None, 1, 1, 288)    3744
['block3c_se_reduce[0][0]']

 block3c_se_excite (Multiply)   (None, 19, 19, 288)  0
['block3c_activation[0][0]',
'block3c_se_expand[0][0]']

 block3c_project_conv (Conv2D)  (None, 19, 19, 48)   13824
['block3c_se_excite[0][0]']

 block3c_project_bn (BatchNorma  (None, 19, 19, 48)  192
['block3c_project_conv[0][0]']
 lization)

 block3c_drop (Dropout)         (None, 19, 19, 48)   0
['block3c_project_bn[0][0]']
```

```
 block3c_add (Add)              (None, 19, 19, 48)   0
['block3c_drop[0][0]',
'block3b_add[0][0]']

 block4a_expand_conv (Conv2D)   (None, 19, 19, 288)  13824
['block3c_add[0][0]']

 block4a_expand_bn (BatchNormal  (None, 19, 19, 288)  1152
['block4a_expand_conv[0][0]']
 ization)

 block4a_expand_activation (Act  (None, 19, 19, 288)  0
['block4a_expand_bn[0][0]']
 ivation)

 block4a_dwconv_pad (ZeroPaddin  (None, 21, 21, 288)  0
['block4a_expand_activation[0][0]
 g2D)                                                              ']

 block4a_dwconv (DepthwiseConv2  (None, 10, 10, 288)  2592
['block4a_dwconv_pad[0][0]']
 D)

 block4a_bn (BatchNormalization  (None, 10, 10, 288)  1152
['block4a_dwconv[0][0]']
 )

 block4a_activation (Activation  (None, 10, 10, 288)  0
['block4a_bn[0][0]']
 )

 block4a_se_squeeze (GlobalAver  (None, 288)         0
['block4a_activation[0][0]']
 agePooling2D)

 block4a_se_reshape (Reshape)   (None, 1, 1, 288)    0
['block4a_se_squeeze[0][0]']

 block4a_se_reduce (Conv2D)     (None, 1, 1, 12)     3468
['block4a_se_reshape[0][0]']

 block4a_se_expand (Conv2D)     (None, 1, 1, 288)    3744
['block4a_se_reduce[0][0]']

 block4a_se_excite (Multiply)   (None, 10, 10, 288)  0
['block4a_activation[0][0]',
'block4a_se_expand[0][0]']
```

```
 block4a_project_conv (Conv2D)  (None, 10, 10, 88)   25344
['block4a_se_excite[0][0]']

 block4a_project_bn (BatchNorma  (None, 10, 10, 88)  352
['block4a_project_conv[0][0]']
 lization)

 block4b_expand_conv (Conv2D)   (None, 10, 10, 528)  46464
['block4a_project_bn[0][0]']

 block4b_expand_bn (BatchNormal  (None, 10, 10, 528)  2112
['block4b_expand_conv[0][0]']
 ization)

 block4b_expand_activation (Act  (None, 10, 10, 528)  0
['block4b_expand_bn[0][0]']
 ivation)

 block4b_dwconv (DepthwiseConv2  (None, 10, 10, 528)  4752
['block4b_expand_activation[0][0]
 D)                                                              ']

 block4b_bn (BatchNormalization  (None, 10, 10, 528)  2112
['block4b_dwconv[0][0]']
 )

 block4b_activation (Activation  (None, 10, 10, 528)  0
['block4b_bn[0][0]']
 )

 block4b_se_squeeze (GlobalAver  (None, 528)         0
['block4b_activation[0][0]']
 agePooling2D)

 block4b_se_reshape (Reshape)   (None, 1, 1, 528)    0
['block4b_se_squeeze[0][0]']

 block4b_se_reduce (Conv2D)     (None, 1, 1, 22)     11638
['block4b_se_reshape[0][0]']

 block4b_se_expand (Conv2D)     (None, 1, 1, 528)    12144
['block4b_se_reduce[0][0]']

 block4b_se_excite (Multiply)   (None, 10, 10, 528)  0
['block4b_activation[0][0]',
'block4b_se_expand[0][0]']

 block4b_project_conv (Conv2D)  (None, 10, 10, 88)   46464
```

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

 block4b_project_bn (BatchNorma  (None, 10, 10, 88)  352
['block4b_project_conv[0][0]']
 lization)

 block4b_drop (Dropout)         (None, 10, 10, 88)   0
['block4b_project_bn[0][0]']

 block4b_add (Add)              (None, 10, 10, 88)   0
['block4b_drop[0][0]',
'block4a_project_bn[0][0]']

 block4c_expand_conv (Conv2D)   (None, 10, 10, 528)  46464
['block4b_add[0][0]']

 block4c_expand_bn (BatchNormal  (None, 10, 10, 528)  2112
['block4c_expand_conv[0][0]']
 ization)

 block4c_expand_activation (Act  (None, 10, 10, 528)  0
['block4c_expand_bn[0][0]']
 ivation)

 block4c_dwconv (DepthwiseConv2  (None, 10, 10, 528)  4752
['block4c_expand_activation[0][0]
 D)                                                                  ']

 block4c_bn (BatchNormalization  (None, 10, 10, 528)  2112
['block4c_dwconv[0][0]']
 )

 block4c_activation (Activation  (None, 10, 10, 528)  0
['block4c_bn[0][0]']
 )

 block4c_se_squeeze (GlobalAver  (None, 528)         0
['block4c_activation[0][0]']
 agePooling2D)

 block4c_se_reshape (Reshape)   (None, 1, 1, 528)    0
['block4c_se_squeeze[0][0]']

 block4c_se_reduce (Conv2D)     (None, 1, 1, 22)     11638
['block4c_se_reshape[0][0]']

 block4c_se_expand (Conv2D)     (None, 1, 1, 528)    12144
['block4c_se_reduce[0][0]']
```

```
 block4c_se_excite (Multiply)   (None, 10, 10, 528)  0
['block4c_activation[0][0]',
'block4c_se_expand[0][0]']

 block4c_project_conv (Conv2D)  (None, 10, 10, 88)   46464
['block4c_se_excite[0][0]']

 block4c_project_bn (BatchNorma  (None, 10, 10, 88)  352
['block4c_project_conv[0][0]']
 lization)

 block4c_drop (Dropout)         (None, 10, 10, 88)   0
['block4c_project_bn[0][0]']

 block4c_add (Add)              (None, 10, 10, 88)   0
['block4c_drop[0][0]',
'block4b_add[0][0]']

 block4d_expand_conv (Conv2D)   (None, 10, 10, 528)  46464
['block4c_add[0][0]']

 block4d_expand_bn (BatchNormal  (None, 10, 10, 528)  2112
['block4d_expand_conv[0][0]']
 ization)

 block4d_expand_activation (Act  (None, 10, 10, 528)  0
['block4d_expand_bn[0][0]']
 ivation)

 block4d_dwconv (DepthwiseConv2  (None, 10, 10, 528)  4752
['block4d_expand_activation[0][0]
 D)                                                              ']

 block4d_bn (BatchNormalization  (None, 10, 10, 528)  2112
['block4d_dwconv[0][0]']
 )

 block4d_activation (Activation  (None, 10, 10, 528)  0
['block4d_bn[0][0]']
 )

 block4d_se_squeeze (GlobalAver  (None, 528)         0
['block4d_activation[0][0]']
 agePooling2D)

 block4d_se_reshape (Reshape)   (None, 1, 1, 528)    0
['block4d_se_squeeze[0][0]']
```

```
 block4d_se_reduce (Conv2D)     (None, 1, 1, 22)     11638
['block4d_se_reshape[0][0]']

 block4d_se_expand (Conv2D)     (None, 1, 1, 528)    12144
['block4d_se_reduce[0][0]']

 block4d_se_excite (Multiply)   (None, 10, 10, 528)  0
['block4d_activation[0][0]',
'block4d_se_expand[0][0]']

 block4d_project_conv (Conv2D)  (None, 10, 10, 88)   46464
['block4d_se_excite[0][0]']

 block4d_project_bn (BatchNorma  (None, 10, 10, 88)  352
['block4d_project_conv[0][0]']
 lization)

 block4d_drop (Dropout)         (None, 10, 10, 88)   0
['block4d_project_bn[0][0]']

 block4d_add (Add)              (None, 10, 10, 88)   0
['block4d_drop[0][0]',
'block4c_add[0][0]']

 block5a_expand_conv (Conv2D)   (None, 10, 10, 528)  46464
['block4d_add[0][0]']

 block5a_expand_bn (BatchNormal  (None, 10, 10, 528)  2112
['block5a_expand_conv[0][0]']
 ization)

 block5a_expand_activation (Act  (None, 10, 10, 528)  0
['block5a_expand_bn[0][0]']
 ivation)

 block5a_dwconv (DepthwiseConv2  (None, 10, 10, 528)  13200
['block5a_expand_activation[0][0]
 D)                                                              ']

 block5a_bn (BatchNormalization  (None, 10, 10, 528)  2112
['block5a_dwconv[0][0]']
 )

 block5a_activation (Activation  (None, 10, 10, 528)  0
['block5a_bn[0][0]']
 )
```

```
 block5a_se_squeeze (GlobalAver  (None, 528)         0
['block5a_activation[0][0]']
 agePooling2D)

 block5a_se_reshape (Reshape)   (None, 1, 1, 528)    0
['block5a_se_squeeze[0][0]']

 block5a_se_reduce (Conv2D)     (None, 1, 1, 22)     11638
['block5a_se_reshape[0][0]']

 block5a_se_expand (Conv2D)     (None, 1, 1, 528)    12144
['block5a_se_reduce[0][0]']

 block5a_se_excite (Multiply)   (None, 10, 10, 528)  0
['block5a_activation[0][0]',
'block5a_se_expand[0][0]']

 block5a_project_conv (Conv2D)  (None, 10, 10, 120)  63360
['block5a_se_excite[0][0]']

 block5a_project_bn (BatchNorma  (None, 10, 10, 120)  480
['block5a_project_conv[0][0]']
 lization)

 block5b_expand_conv (Conv2D)   (None, 10, 10, 720)  86400
['block5a_project_bn[0][0]']

 block5b_expand_bn (BatchNormal  (None, 10, 10, 720)  2880
['block5b_expand_conv[0][0]']
 ization)

 block5b_expand_activation (Act  (None, 10, 10, 720)  0
['block5b_expand_bn[0][0]']
 ivation)

 block5b_dwconv (DepthwiseConv2  (None, 10, 10, 720)  18000
['block5b_expand_activation[0][0]
 D)                                                              ']

 block5b_bn (BatchNormalization  (None, 10, 10, 720)  2880
['block5b_dwconv[0][0]']
 )

 block5b_activation (Activation  (None, 10, 10, 720)  0
['block5b_bn[0][0]']
 )

 block5b_se_squeeze (GlobalAver  (None, 720)         0
```

```
['block5b_activation[0][0]']
 agePooling2D)

 block5b_se_reshape (Reshape)   (None, 1, 1, 720)    0
['block5b_se_squeeze[0][0]']

 block5b_se_reduce (Conv2D)     (None, 1, 1, 30)     21630
['block5b_se_reshape[0][0]']

 block5b_se_expand (Conv2D)     (None, 1, 1, 720)    22320
['block5b_se_reduce[0][0]']

 block5b_se_excite (Multiply)   (None, 10, 10, 720)  0
['block5b_activation[0][0]',
'block5b_se_expand[0][0]']

 block5b_project_conv (Conv2D)  (None, 10, 10, 120)  86400
['block5b_se_excite[0][0]']

 block5b_project_bn (BatchNorma  (None, 10, 10, 120)  480
['block5b_project_conv[0][0]']
 lization)

 block5b_drop (Dropout)         (None, 10, 10, 120)  0
['block5b_project_bn[0][0]']

 block5b_add (Add)              (None, 10, 10, 120)  0
['block5b_drop[0][0]',
'block5a_project_bn[0][0]']

 block5c_expand_conv (Conv2D)   (None, 10, 10, 720)  86400
['block5b_add[0][0]']

 block5c_expand_bn (BatchNormal  (None, 10, 10, 720)  2880
['block5c_expand_conv[0][0]']
 ization)

 block5c_expand_activation (Act  (None, 10, 10, 720)  0
['block5c_expand_bn[0][0]']
 ivation)

 block5c_dwconv (DepthwiseConv2  (None, 10, 10, 720)  18000
['block5c_expand_activation[0][0]
 D)                                                              ']

 block5c_bn (BatchNormalization  (None, 10, 10, 720)  2880
['block5c_dwconv[0][0]']
 )
```

```
 block5c_activation (Activation  (None, 10, 10, 720)  0
['block5c_bn[0][0]']
 )

 block5c_se_squeeze (GlobalAver  (None, 720)         0
['block5c_activation[0][0]']
 agePooling2D)

 block5c_se_reshape (Reshape)   (None, 1, 1, 720)    0
['block5c_se_squeeze[0][0]']

 block5c_se_reduce (Conv2D)     (None, 1, 1, 30)     21630
['block5c_se_reshape[0][0]']

 block5c_se_expand (Conv2D)     (None, 1, 1, 720)    22320
['block5c_se_reduce[0][0]']

 block5c_se_excite (Multiply)   (None, 10, 10, 720)  0
['block5c_activation[0][0]',
'block5c_se_expand[0][0]']

 block5c_project_conv (Conv2D)  (None, 10, 10, 120)  86400
['block5c_se_excite[0][0]']

 block5c_project_bn (BatchNorma  (None, 10, 10, 120)  480
['block5c_project_conv[0][0]']
 lization)

 block5c_drop (Dropout)         (None, 10, 10, 120)  0
['block5c_project_bn[0][0]']

 block5c_add (Add)              (None, 10, 10, 120)  0
['block5c_drop[0][0]',
'block5b_add[0][0]']

 block5d_expand_conv (Conv2D)   (None, 10, 10, 720)  86400
['block5c_add[0][0]']

 block5d_expand_bn (BatchNormal  (None, 10, 10, 720)  2880
['block5d_expand_conv[0][0]']
 ization)

 block5d_expand_activation (Act  (None, 10, 10, 720)  0
['block5d_expand_bn[0][0]']
 ivation)

 block5d_dwconv (DepthwiseConv2  (None, 10, 10, 720)  18000
```

```
['block5d_expand_activation[0][0]
 D)                                                                  ']

 block5d_bn (BatchNormalization  (None, 10, 10, 720)  2880
['block5d_dwconv[0][0]']
 )

 block5d_activation (Activation  (None, 10, 10, 720)  0
['block5d_bn[0][0]']
 )

 block5d_se_squeeze (GlobalAver  (None, 720)         0
['block5d_activation[0][0]']
 agePooling2D)

 block5d_se_reshape (Reshape)   (None, 1, 1, 720)    0
['block5d_se_squeeze[0][0]']

 block5d_se_reduce (Conv2D)     (None, 1, 1, 30)     21630
['block5d_se_reshape[0][0]']

 block5d_se_expand (Conv2D)     (None, 1, 1, 720)    22320
['block5d_se_reduce[0][0]']

 block5d_se_excite (Multiply)   (None, 10, 10, 720)  0
['block5d_activation[0][0]',
'block5d_se_expand[0][0]']

 block5d_project_conv (Conv2D)  (None, 10, 10, 120)  86400
['block5d_se_excite[0][0]']

 block5d_project_bn (BatchNorma  (None, 10, 10, 120)  480
['block5d_project_conv[0][0]']
 lization)

 block5d_drop (Dropout)         (None, 10, 10, 120)  0
['block5d_project_bn[0][0]']

 block5d_add (Add)              (None, 10, 10, 120)  0
['block5d_drop[0][0]',
'block5c_add[0][0]']

 block6a_expand_conv (Conv2D)   (None, 10, 10, 720)  86400
['block5d_add[0][0]']

 block6a_expand_bn (BatchNormal  (None, 10, 10, 720)  2880
['block6a_expand_conv[0][0]']
 ization)
```

```
 block6a_expand_activation (Act  (None, 10, 10, 720)  0
['block6a_expand_bn[0][0]']
 ivation)

 block6a_dwconv_pad (ZeroPaddin  (None, 13, 13, 720)  0
['block6a_expand_activation[0][0]
 g2D)                                                                ']

 block6a_dwconv (DepthwiseConv2  (None, 5, 5, 720)   18000
['block6a_dwconv_pad[0][0]']
 D)

 block6a_bn (BatchNormalization  (None, 5, 5, 720)   2880
['block6a_dwconv[0][0]']
 )

 block6a_activation (Activation  (None, 5, 5, 720)   0
['block6a_bn[0][0]']
 )

 block6a_se_squeeze (GlobalAver  (None, 720)         0
['block6a_activation[0][0]']
 agePooling2D)

 block6a_se_reshape (Reshape)   (None, 1, 1, 720)    0
['block6a_se_squeeze[0][0]']

 block6a_se_reduce (Conv2D)     (None, 1, 1, 30)     21630
['block6a_se_reshape[0][0]']

 block6a_se_expand (Conv2D)     (None, 1, 1, 720)    22320
['block6a_se_reduce[0][0]']

 block6a_se_excite (Multiply)   (None, 5, 5, 720)    0
['block6a_activation[0][0]',
'block6a_se_expand[0][0]']

 block6a_project_conv (Conv2D)  (None, 5, 5, 208)    149760
['block6a_se_excite[0][0]']

 block6a_project_bn (BatchNorma  (None, 5, 5, 208)   832
['block6a_project_conv[0][0]']
 lization)

 block6b_expand_conv (Conv2D)   (None, 5, 5, 1248)   259584
['block6a_project_bn[0][0]']
```

```
 block6b_expand_bn (BatchNormal  (None, 5, 5, 1248)  4992
['block6b_expand_conv[0][0]']
 ization)

 block6b_expand_activation (Act  (None, 5, 5, 1248)  0
['block6b_expand_bn[0][0]']
 ivation)

 block6b_dwconv (DepthwiseConv2  (None, 5, 5, 1248)  31200
['block6b_expand_activation[0][0]
 D)                                                              ']

 block6b_bn (BatchNormalization  (None, 5, 5, 1248)  4992
['block6b_dwconv[0][0]']
 )

 block6b_activation (Activation  (None, 5, 5, 1248)  0
['block6b_bn[0][0]']
 )

 block6b_se_squeeze (GlobalAver  (None, 1248)        0
['block6b_activation[0][0]']
 agePooling2D)

 block6b_se_reshape (Reshape)   (None, 1, 1, 1248)   0
['block6b_se_squeeze[0][0]']

 block6b_se_reduce (Conv2D)     (None, 1, 1, 52)     64948
['block6b_se_reshape[0][0]']

 block6b_se_expand (Conv2D)     (None, 1, 1, 1248)   66144
['block6b_se_reduce[0][0]']

 block6b_se_excite (Multiply)   (None, 5, 5, 1248)   0
['block6b_activation[0][0]',
'block6b_se_expand[0][0]']

 block6b_project_conv (Conv2D)  (None, 5, 5, 208)    259584
['block6b_se_excite[0][0]']

 block6b_project_bn (BatchNorma  (None, 5, 5, 208)   832
['block6b_project_conv[0][0]']
 lization)

 block6b_drop (Dropout)         (None, 5, 5, 208)    0
['block6b_project_bn[0][0]']

 block6b_add (Add)              (None, 5, 5, 208)    0
```

```
['block6b_drop[0][0]',
'block6a_project_bn[0][0]']

 block6c_expand_conv (Conv2D)   (None, 5, 5, 1248)   259584
['block6b_add[0][0]']

 block6c_expand_bn (BatchNormal  (None, 5, 5, 1248)  4992
['block6c_expand_conv[0][0]']
 ization)

 block6c_expand_activation (Act  (None, 5, 5, 1248)  0
['block6c_expand_bn[0][0]']
 ivation)

 block6c_dwconv (DepthwiseConv2  (None, 5, 5, 1248)  31200
['block6c_expand_activation[0][0]
 D)                                                              ']

 block6c_bn (BatchNormalization  (None, 5, 5, 1248)  4992
['block6c_dwconv[0][0]']
 )

 block6c_activation (Activation  (None, 5, 5, 1248)  0
['block6c_bn[0][0]']
 )

 block6c_se_squeeze (GlobalAver  (None, 1248)        0
['block6c_activation[0][0]']
 agePooling2D)

 block6c_se_reshape (Reshape)   (None, 1, 1, 1248)   0
['block6c_se_squeeze[0][0]']

 block6c_se_reduce (Conv2D)     (None, 1, 1, 52)     64948
['block6c_se_reshape[0][0]']

 block6c_se_expand (Conv2D)     (None, 1, 1, 1248)   66144
['block6c_se_reduce[0][0]']

 block6c_se_excite (Multiply)   (None, 5, 5, 1248)   0
['block6c_activation[0][0]',
'block6c_se_expand[0][0]']

 block6c_project_conv (Conv2D)  (None, 5, 5, 208)    259584
['block6c_se_excite[0][0]']

 block6c_project_bn (BatchNorma  (None, 5, 5, 208)   832
['block6c_project_conv[0][0]']
```

```
 lization)

 block6c_drop (Dropout)         (None, 5, 5, 208)    0
['block6c_project_bn[0][0]']

 block6c_add (Add)              (None, 5, 5, 208)    0
['block6c_drop[0][0]',
'block6b_add[0][0]']

 block6d_expand_conv (Conv2D)   (None, 5, 5, 1248)   259584
['block6c_add[0][0]']

 block6d_expand_bn (BatchNormal  (None, 5, 5, 1248)  4992
['block6d_expand_conv[0][0]']
 ization)

 block6d_expand_activation (Act  (None, 5, 5, 1248)  0
['block6d_expand_bn[0][0]']
 ivation)

 block6d_dwconv (DepthwiseConv2  (None, 5, 5, 1248)  31200
['block6d_expand_activation[0][0]
 D)                                                              ']

 block6d_bn (BatchNormalization  (None, 5, 5, 1248)  4992
['block6d_dwconv[0][0]']
 )

 block6d_activation (Activation  (None, 5, 5, 1248)  0
['block6d_bn[0][0]']
 )

 block6d_se_squeeze (GlobalAver  (None, 1248)        0
['block6d_activation[0][0]']
 agePooling2D)

 block6d_se_reshape (Reshape)   (None, 1, 1, 1248)   0
['block6d_se_squeeze[0][0]']

 block6d_se_reduce (Conv2D)     (None, 1, 1, 52)     64948
['block6d_se_reshape[0][0]']

 block6d_se_expand (Conv2D)     (None, 1, 1, 1248)   66144
['block6d_se_reduce[0][0]']

 block6d_se_excite (Multiply)   (None, 5, 5, 1248)   0
['block6d_activation[0][0]',
'block6d_se_expand[0][0]']
```

```
 block6d_project_conv (Conv2D)  (None, 5, 5, 208)    259584
['block6d_se_excite[0][0]']

 block6d_project_bn (BatchNorma  (None, 5, 5, 208)   832
['block6d_project_conv[0][0]']
 lization)

 block6d_drop (Dropout)         (None, 5, 5, 208)    0
['block6d_project_bn[0][0]']

 block6d_add (Add)              (None, 5, 5, 208)    0
['block6d_drop[0][0]',
'block6c_add[0][0]']

 block6e_expand_conv (Conv2D)   (None, 5, 5, 1248)   259584
['block6d_add[0][0]']

 block6e_expand_bn (BatchNormal  (None, 5, 5, 1248)  4992
['block6e_expand_conv[0][0]']
 ization)

 block6e_expand_activation (Act  (None, 5, 5, 1248)  0
['block6e_expand_bn[0][0]']
 ivation)

 block6e_dwconv (DepthwiseConv2  (None, 5, 5, 1248)  31200
['block6e_expand_activation[0][0]
 D)                                                              ']

 block6e_bn (BatchNormalization  (None, 5, 5, 1248)  4992
['block6e_dwconv[0][0]']
 )

 block6e_activation (Activation  (None, 5, 5, 1248)  0
['block6e_bn[0][0]']
 )

 block6e_se_squeeze (GlobalAver  (None, 1248)        0
['block6e_activation[0][0]']
 agePooling2D)

 block6e_se_reshape (Reshape)   (None, 1, 1, 1248)   0
['block6e_se_squeeze[0][0]']

 block6e_se_reduce (Conv2D)     (None, 1, 1, 52)     64948
['block6e_se_reshape[0][0]']
```

```
 block6e_se_expand (Conv2D)     (None, 1, 1, 1248)   66144
['block6e_se_reduce[0][0]']

 block6e_se_excite (Multiply)   (None, 5, 5, 1248)   0
['block6e_activation[0][0]',
'block6e_se_expand[0][0]']

 block6e_project_conv (Conv2D)  (None, 5, 5, 208)    259584
['block6e_se_excite[0][0]']

 block6e_project_bn (BatchNorma  (None, 5, 5, 208)   832
['block6e_project_conv[0][0]']
 lization)

 block6e_drop (Dropout)         (None, 5, 5, 208)    0
['block6e_project_bn[0][0]']

 block6e_add (Add)              (None, 5, 5, 208)    0
['block6e_drop[0][0]',
'block6d_add[0][0]']

 block7a_expand_conv (Conv2D)   (None, 5, 5, 1248)   259584
['block6e_add[0][0]']

 block7a_expand_bn (BatchNormal  (None, 5, 5, 1248)  4992
['block7a_expand_conv[0][0]']
 ization)

 block7a_expand_activation (Act  (None, 5, 5, 1248)  0
['block7a_expand_bn[0][0]']
 ivation)

 block7a_dwconv (DepthwiseConv2  (None, 5, 5, 1248)  11232
['block7a_expand_activation[0][0]
 D)                                                              ']

 block7a_bn (BatchNormalization  (None, 5, 5, 1248)  4992
['block7a_dwconv[0][0]']
 )

 block7a_activation (Activation  (None, 5, 5, 1248)  0
['block7a_bn[0][0]']
 )

 block7a_se_squeeze (GlobalAver  (None, 1248)        0
['block7a_activation[0][0]']
 agePooling2D)
```

```
 block7a_se_reshape (Reshape)   (None, 1, 1, 1248)   0
['block7a_se_squeeze[0][0]']

 block7a_se_reduce (Conv2D)     (None, 1, 1, 52)     64948
['block7a_se_reshape[0][0]']

 block7a_se_expand (Conv2D)     (None, 1, 1, 1248)   66144
['block7a_se_reduce[0][0]']

 block7a_se_excite (Multiply)   (None, 5, 5, 1248)   0
['block7a_activation[0][0]',
'block7a_se_expand[0][0]']

 block7a_project_conv (Conv2D)  (None, 5, 5, 352)    439296
['block7a_se_excite[0][0]']

 block7a_project_bn (BatchNorma  (None, 5, 5, 352)   1408
['block7a_project_conv[0][0]']
 lization)

 block7b_expand_conv (Conv2D)   (None, 5, 5, 2112)   743424
['block7a_project_bn[0][0]']

 block7b_expand_bn (BatchNormal  (None, 5, 5, 2112)  8448
['block7b_expand_conv[0][0]']
 ization)

 block7b_expand_activation (Act  (None, 5, 5, 2112)  0
['block7b_expand_bn[0][0]']
 ivation)

 block7b_dwconv (DepthwiseConv2  (None, 5, 5, 2112)  19008
['block7b_expand_activation[0][0]
 D)                                                              ']

 block7b_bn (BatchNormalization  (None, 5, 5, 2112)  8448
['block7b_dwconv[0][0]']
 )

 block7b_activation (Activation  (None, 5, 5, 2112)  0
['block7b_bn[0][0]']
 )

 block7b_se_squeeze (GlobalAver  (None, 2112)        0
['block7b_activation[0][0]']
 agePooling2D)

 block7b_se_reshape (Reshape)   (None, 1, 1, 2112)   0
```

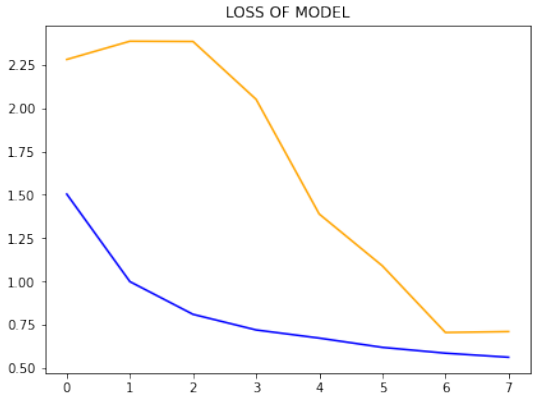
```
['block7b_se_squeeze[0][0]']

 block7b_se_reduce (Conv2D)     (None, 1, 1, 88)     185944
['block7b_se_reshape[0][0]']

 block7b_se_expand (Conv2D)     (None, 1, 1, 2112)   187968
['block7b_se_reduce[0][0]']

 block7b_se_excite (Multiply)   (None, 5, 5, 2112)   0
['block7b_activation[0][0]',
'block7b_se_expand[0][0]']

 block7b_project_conv (Conv2D)  (None, 5, 5, 352)    743424
['block7b_se_excite[0][0]']

 block7b_project_bn (BatchNorma  (None, 5, 5, 352)   1408
['block7b_project_conv[0][0]']
 lization)

 block7b_drop (Dropout)         (None, 5, 5, 352)    0
['block7b_project_bn[0][0]']

 block7b_add (Add)              (None, 5, 5, 352)    0
['block7b_drop[0][0]',
'block7a_project_bn[0][0]']

 top_conv (Conv2D)              (None, 5, 5, 1408)   495616
['block7b_add[0][0]']

 top_bn (BatchNormalization)    (None, 5, 5, 1408)   5632
['top_conv[0][0]']

 top_activation (Activation)    (None, 5, 5, 1408)   0
['top_bn[0][0]']

 flatten_3 (Flatten)            (None, 35200)        0
['top_activation[0][0]']

 dropout_3 (Dropout)            (None, 35200)        0
['flatten_3[0][0]']

 dense_6 (Dense)                (None, 128)          4505728
['dropout_3[0][0]']

 dense_7 (Dense)                (None, 6)            774
['dense_6[0][0]']

==================================================================================
```

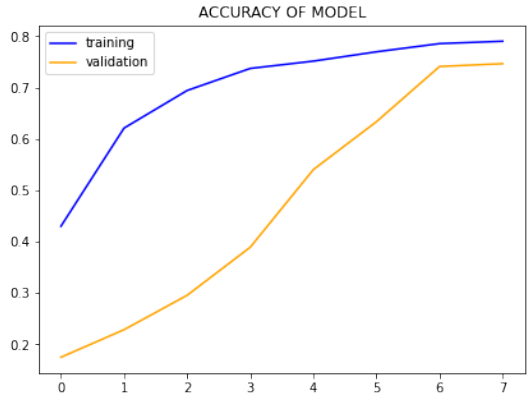
```
==================
Total params: 12,275,071
Trainable params: 12,207,496
Non-trainable params: 67,575
_________________________________________________________________________________
_________________
```

[9]:
```
EfficientNet_model.compile(
    optimizer=tf.keras.optimizers.Adam(1e-5),  # learning rate
    loss=tf.keras.losses.CategoricalCrossentropy(
    from_logits=False, name='categorical_crossentropy'),
    metrics=[tf.keras.metrics.CategoricalAccuracy(
    name='accuracy')])

history_EfficientNet = EfficientNet_model.fit(train, epochs=8,␣
 ↪validation_data=val, callbacks =[callbacks])
plot_loss_accuracy(history_EfficientNet)
```

```
Epoch 1/8

2022-10-28 17:21:04.487705: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - ETA: 0s - loss: 1.5041 - accuracy:
0.4299

2022-10-28 17:25:39.387496: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113]
Plugin optimizer for device_type GPU is enabled.

132/132 [==============================] - 305s 2s/step - loss: 1.5041 -
accuracy: 0.4299 - val_loss: 2.2800 - val_accuracy: 0.1748
Epoch 2/8
132/132 [==============================] - 316s 2s/step - loss: 1.0002 -
accuracy: 0.6210 - val_loss: 2.3851 - val_accuracy: 0.2285
Epoch 3/8
132/132 [==============================] - 324s 2s/step - loss: 0.8117 -
accuracy: 0.6942 - val_loss: 2.3836 - val_accuracy: 0.2955
Epoch 4/8
132/132 [==============================] - 328s 2s/step - loss: 0.7218 -
accuracy: 0.7372 - val_loss: 2.0501 - val_accuracy: 0.3890
Epoch 5/8
132/132 [==============================] - 326s 2s/step - loss: 0.6749 -
accuracy: 0.7514 - val_loss: 1.3895 - val_accuracy: 0.5402
Epoch 6/8
132/132 [==============================] - 312s 2s/step - loss: 0.6214 -
accuracy: 0.7696 - val_loss: 1.0912 - val_accuracy: 0.6335
Epoch 7/8
132/132 [==============================] - 315s 2s/step - loss: 0.5880 -
```

```
accuracy: 0.7855 - val_loss: 0.7071 - val_accuracy: 0.7410
Epoch 8/8
132/132 [==============================] - 320s 2s/step - loss: 0.5645 -
accuracy: 0.7902 - val_loss: 0.7124 - val_accuracy: 0.7464
```





0.4 Performance

Accuracy, AUC, ROC and Cnfusion matrix

[11]:
```
def performance(test_pred, test_data, val_pred, val_data):

    #AUC
    class_report = classification_report(val_data.classes, val_pred.
 ↪argmax(axis=1))
    print("classification_report of validation dataset :\n")
    print(class_report)
    print("#"*60)
    class_report = classification_report(test_data.classes, test_pred.
 ↪argmax(axis=1))
    print("classification_report of test dataset:\n")
    print(class_report)
    print("#"*60)
    acc = accuracy_score(val_pred.argmax(axis=1), val_data.classes)
    print('validation_accuracy: %.3f' % (acc))

    #ROC
    auc_score = roc_auc_score(val_data.classes, val_pred,  multi_class = 'ovo')
    print('auc score of validation dataset =',auc_score)
    print("#"*60)
    print("#"*60)
    acc = accuracy_score(test_pred.argmax(axis=1), test_data.classes)
    print(acc)
    print('test_accuracy: %.3f' % (acc))
```

```
    auc_score = roc_auc_score(test_data.classes, test_pred,  multi_class =␣
↪'ovo')
    print('auc score of test dataset =',auc_score)
    print("#"*60)

    # Confusion Matrix
    plt.figure(figsize = (10,7))
    cm_val = confusion_matrix(val_pred.argmax(axis=1), val_data.classes)
    plt.title("Confusion_matrix of validation dataset")
    sns.heatmap(cm_val, annot = True, fmt='d')
    plt.show()
    print("#"*60)
    plt.figure(figsize = (10,7))
    plt.title ("Confusion_matrix of test dataset")
    cm_test = confusion_matrix(test_pred.argmax(axis=1), test_data.classes)
    sns.heatmap(cm_test, annot = True, fmt='d')
    plt.show()
    print("#"*60)
    skplt.metrics.plot_roc(val_data.classes, val_pred, figsize = (8,7))
    plt.title ("ROC curve on validation dataset")
    plt.show()
    skplt.metrics.plot_roc(test_data.classes, test_pred, figsize = (8,7))
    plt.title ("ROC curve on test dataset")
    plt.show()

    return

val = image_generator.flow_from_directory(batch_size=80,
                                          directory=pathway_train,
                                          shuffle=False,
                                          target_size=(150,150),
                                          subset="validation",
                                          class_mode='categorical')
```

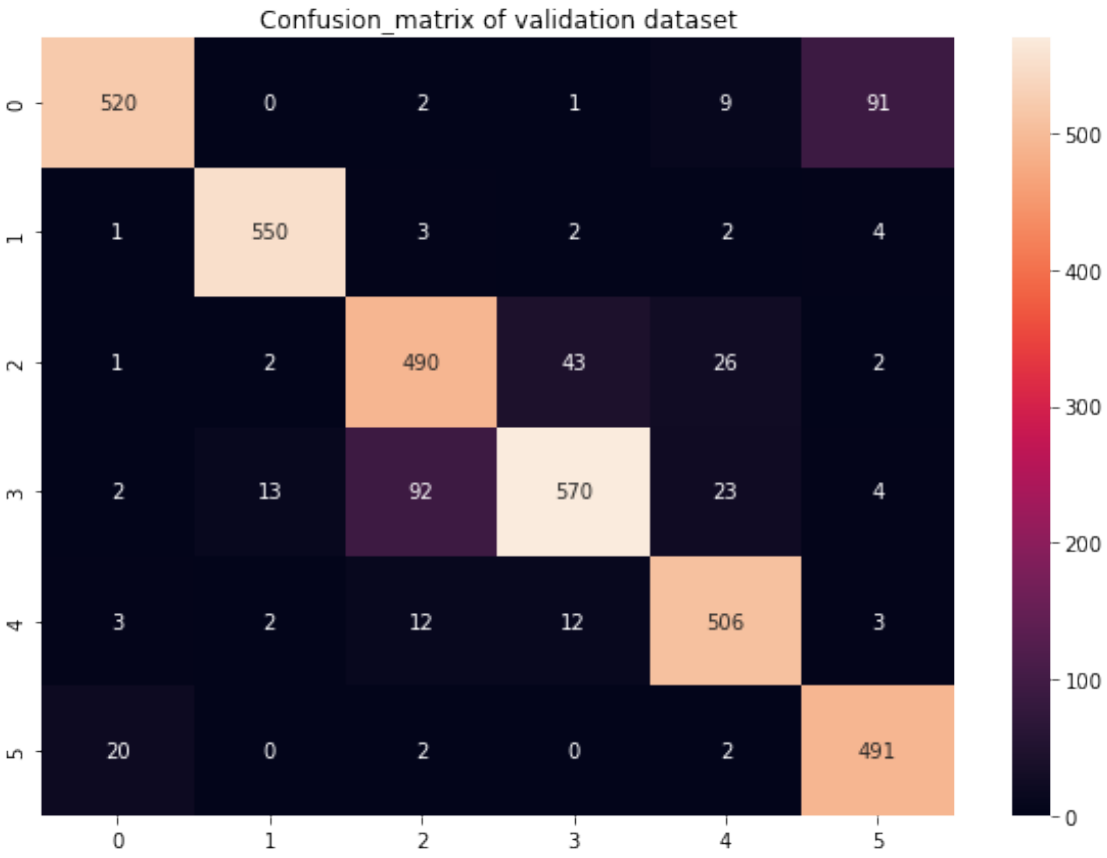
```
Found 3506 images belonging to 6 classes.
```

0.5 Best Model Performance

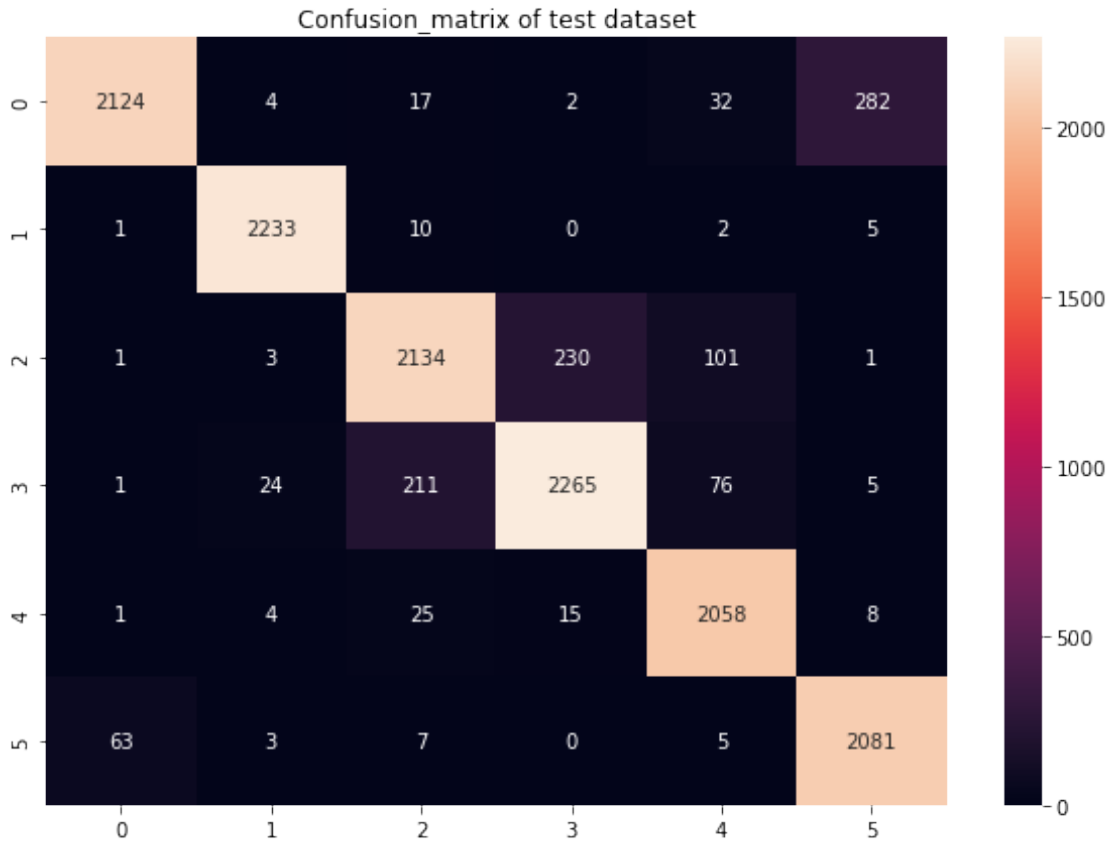
[12]:
```
test_VGG = VGG16_opt_model.predict(test)
val_VGG = VGG16_opt_model.predict(val)

performance(test_VGG, test, val_VGG, val)
```

```
176/176 [==============================] - 115s 655ms/step
44/44 [==============================] - 31s 718ms/step
classification_report of validation dataset :

              precision    recall  f1-score   support
```

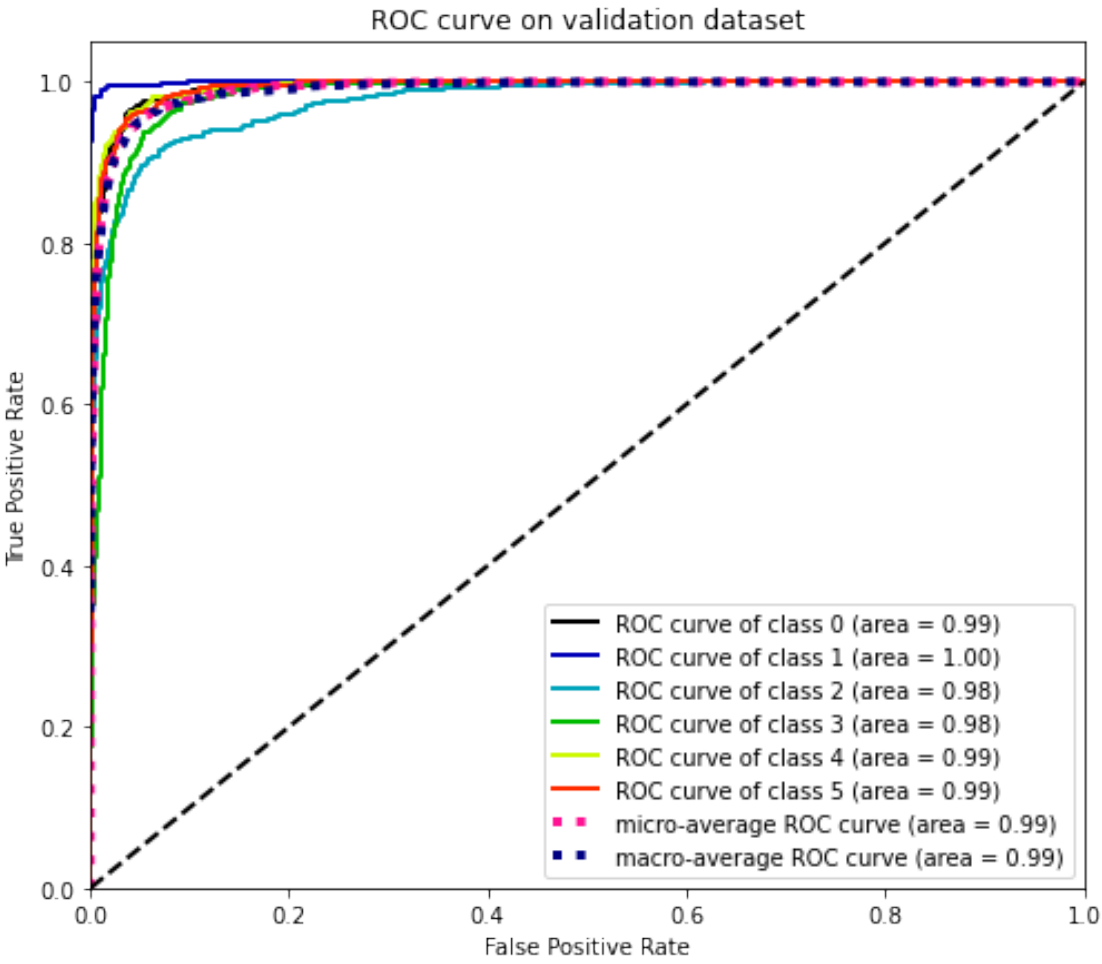
```
              0       0.83      0.95      0.89       547
              1       0.98      0.97      0.97       567
              2       0.87      0.82      0.84       601
              3       0.81      0.91      0.86       628
              4       0.94      0.89      0.92       568
              5       0.95      0.83      0.88       595

    accuracy                           0.89      3506
   macro avg       0.90      0.89      0.89      3506
weighted avg       0.90      0.89      0.89      3506

############################################################
classification_report of test dataset:

              precision    recall  f1-score   support

              0       0.86      0.97      0.91      2191
              1       0.99      0.98      0.99      2271
              2       0.86      0.89      0.88      2404
              3       0.88      0.90      0.89      2512
              4       0.97      0.91      0.94      2274
              5       0.96      0.87      0.92      2382

    accuracy                           0.92     14034
   macro avg       0.92      0.92      0.92     14034
weighted avg       0.92      0.92      0.92     14034

############################################################
validation_accuracy: 0.892
auc score of validation dataset = 0.9896447621241677
############################################################
############################################################
0.9188399600969075
test_accuracy: 0.919
auc score of test dataset = 0.9939794942579222
############################################################
```

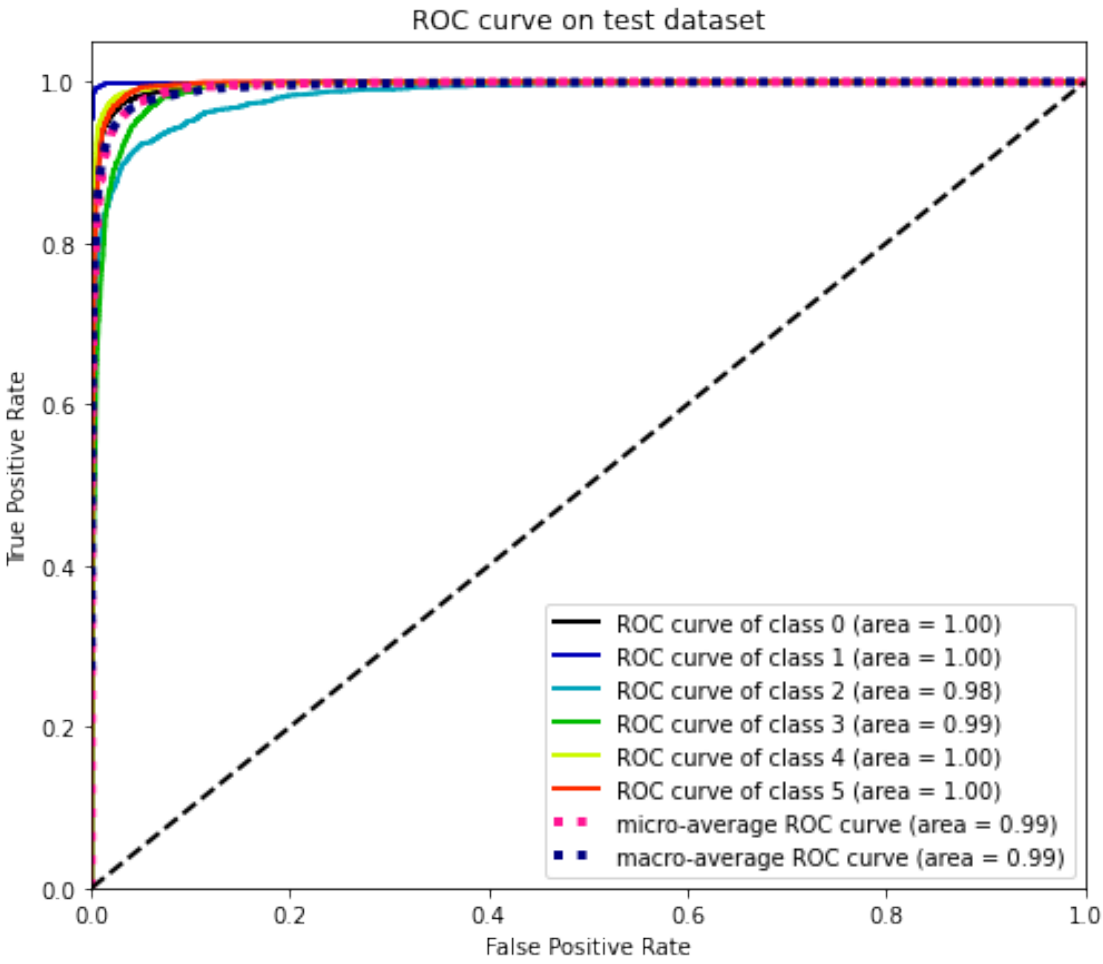

Confusion_matrix of validation dataset
520 0 2 1 9 91
1 550 3 2 2 4
1 2 490 43 26 2
2 13 92 570 23 4
3 2 12 12 506 3
20 0 2 0 2 491
0 1 2 3 4 5
500 400 300 200 100 0

##


Confusion_matrix of test dataset
2124 4 17 2 32 282
1 2233 10 0 2 5
1 3 2134 230 101 1
1 24 211 2265 76 5
1 4 25 15 2058 8
63 3 7 0 5 2081
0 1 2 3 4 5
2000 1500 1000 500 0

##

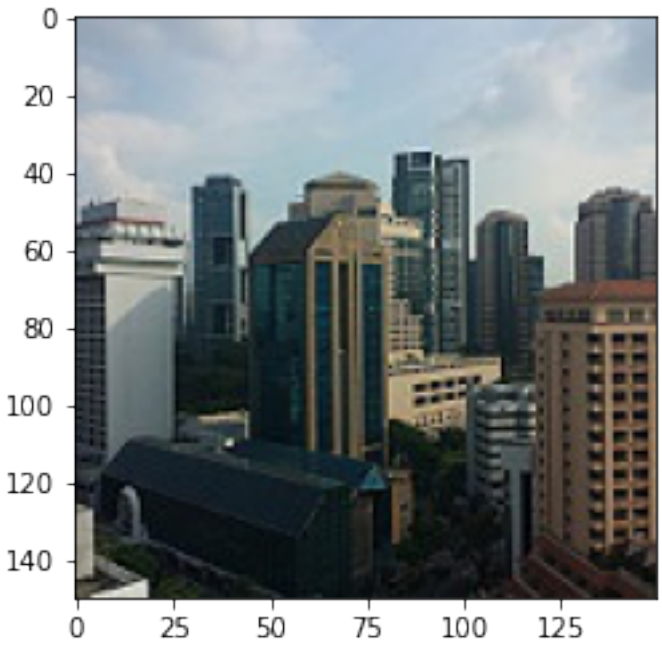

ROC curve on validation dataset
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve of class 0 (area = 0.99)
ROC curve of class 1 (area = 1.00)
ROC curve of class 2 (area = 0.98)
ROC curve of class 3 (area = 0.98)
ROC curve of class 4 (area = 0.99)
ROC curve of class 5 (area = 0.99)
micro-average ROC curve (area = 0.99)
macro-average ROC curve (area = 0.99)



0.6 Best Model Application

[20]:
```
from keras.preprocessing import image

pathway = random.choice(glob.glob("desktop/Intel_images/seg_pred/seg_pred/*"))
labels = list(train.class_indices.keys())
sample = tf.keras.utils.load_img(pathway, target_size=(150, 150))
x = tf.keras.utils.img_to_array(sample)
x = np.expand_dims(x, axis=0)

VGG_pred = VGG16_opt_model.predict(x)
n = np.argmax(VGG_pred)
plt.imshow(sample)
plt.show()
print(f"It is a {labels[n]}" )
```

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




```
It is a buildings
```