Project-Detection_of_Lung_Infection

October 19, 2022

1 Following operations should be performed using Keras

- Import the necessary libraries
- Plot the sample images for all the classes
- Plot the distribution of images across the classes
- Build a data augmentation for train data to create new data with translation, rescale and flip, and rotation transformations. Rescale the image at 48x48
- Build a data augmentation for test data to create new data and rescale the image at 48x48
- Read images directly from the train folder and test folder using the appropriate function

[1]:
```
import warnings
warnings.filterwarnings('ignore')
```

[2]:
```
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator,load_img
import matplotlib.pyplot as plt
import os
from keras.models import Sequential,Model
from keras.layers import␣
↪Conv2D,Dense,Flatten,Dropout,BatchNormalization,MaxPooling2D
from keras.callbacks import EarlyStopping
from keras.applications.mobilenet_v2 import MobileNetV2
from keras.applications import DenseNet121
from glob import glob
import numpy as np
from sklearn.metrics import confusion_matrix,classification_report
import seaborn as sns

print('Tensorflow Version:',tf.__version__)
```

```
Tensorflow Version: 2.9.2
```

[3]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[4]:
```
from zipfile import ZipFile
file_name = "/content/drive/MyDrive/Colab Files/
 ↪Dataset_Detection_of_Lung_Infection.zip"

with ZipFile(file_name,'r') as zip:
    zip.extractall()
    print('Done')
```

```
Done
```

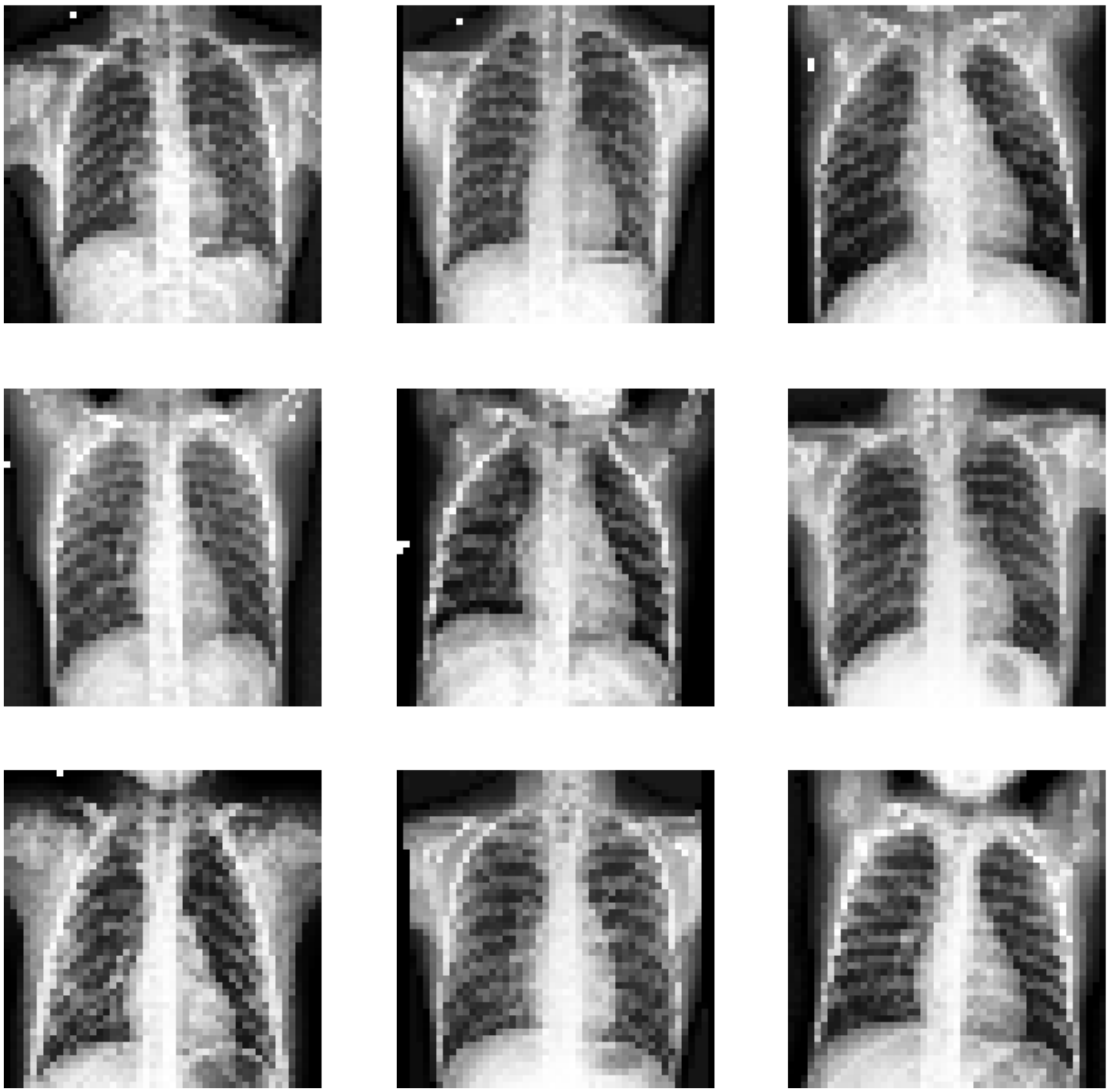
[5]:
```
folders = glob('/content/data/train/*')
```

[6]:
```
len(folders)
```

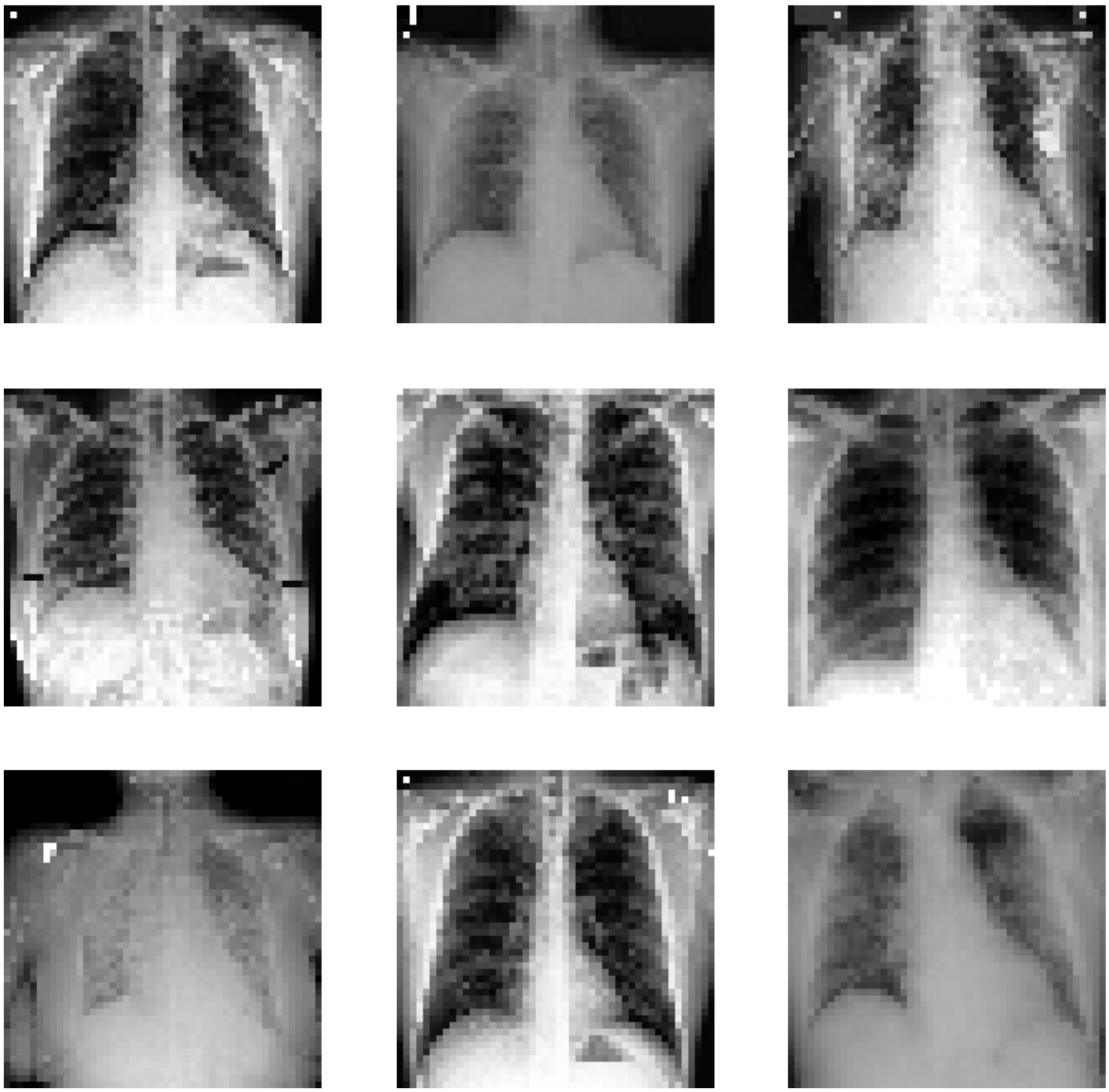
[6]: 3

[7]:
```
picture_size = 48
folder_path = '/content/data/'
```

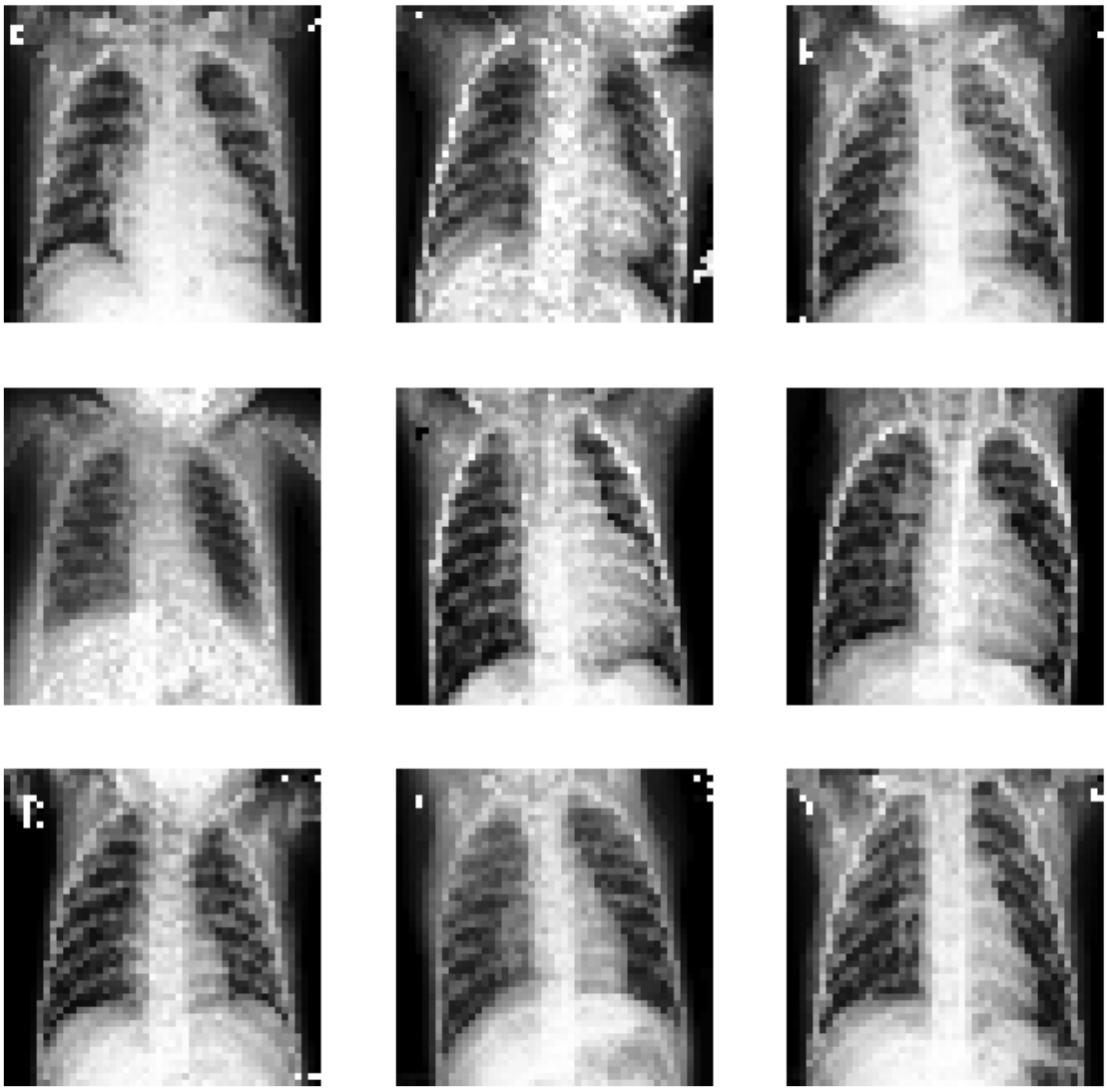
[8]:
```
expression = 'Healthy'

plt.figure(figsize= (12,12))
for i in range(1, 10, 1):
    plt.subplot(3,3,i)
    img = load_img(folder_path+"train/"+expression+"/"+ os.listdir(folder_path␣
 ↪+ "train/" + expression)[i],
                   target_size=(picture_size, picture_size))
    plt.imshow(img)
    plt.axis('off')
plt.show()
```



[9]:
```
expression = 'Type 1 disease'

plt.figure(figsize= (12,12))
for i in range(1, 10, 1):
    plt.subplot(3,3,i)
    img = load_img(folder_path+"train/"+expression+"/"+ os.listdir(folder_path␣
 ↪+ "train/" + expression)[i],
                   target_size=(picture_size, picture_size))
    plt.imshow(img)
    plt.axis('off')
plt.show()
```



[10]:
```
expression = 'Type 2 disease'

plt.figure(figsize= (12,12))
for i in range(1, 10, 1):
    plt.subplot(3,3,i)
    img = load_img(folder_path+"train/"+expression+"/"+ os.listdir(folder_path␣
 ↪+ "train/" + expression)[i],
                   target_size=(picture_size, picture_size))
    plt.imshow(img)
    plt.axis('off')
plt.show()
```



[11]:
```
train_dir = '/content/data/train'
test_dir = '/content/data/test'

train_healthy_dir = '/content/data/train/Healthy'
train_Type1disease_dir = '/content/data/train/Type 1 disease'
train_Type2disease_dir = '/content/data/train/Type 2 disease'

test_healthy_dir = '/content/data/test/healthy'
test_Type1disease_dir = '/content/data/test/Type 1 disease'
test_Type2disease_dir = '/content/data/test/Type 2 disease'

dir_list =␣
 ↪[train_healthy_dir,train_Type1disease_dir,train_Type2disease_dir,test_healthy_dir,test_Type
```

```
          test_Type2disease_dir]

for d in dir_list:
    print(d,len(os.listdir(d)))
```

```
/content/data/train/Healthy 70
/content/data/train/Type 1 disease 111
/content/data/train/Type 2 disease 70
/content/data/test/healthy 20
/content/data/test/Type 1 disease 26
/content/data/test/Type 2 disease 20
```

[12]:
```
# image generator

train_datagen = ImageDataGenerator(rescale=1./255,
                                   shear_range=0.2,
                                   zoom_range=0.2,
                                   horizontal_flip=True)

train_generator = train_datagen.flow_from_directory(train_dir,
                                                    target_size=(224,224),
                                                    batch_size=32,
                                                    class_mode='categorical')

validation_datagen = ImageDataGenerator(rescale=1./255)

validation_generator = validation_datagen.flow_from_directory(test_dir,
                                                              ␣
 ↪target_size=(224,224),
                                                               batch_size=32,
                                                              ␣
 ↪class_mode='categorical')
```

```
Found 251 images belonging to 3 classes.
Found 66 images belonging to 3 classes.
```

2 Build 3 CNN model with:

3 1. CNN Architecture:

- Add convolutional layers with different filters, max pool layers, dropout layers, and batch normalization layers
- Use Relu as an activation function
- Take the loss function as categorical cross-entropy
- Take rmsprop as an optimizer

- Use early stopping with the patience of two epochs and monitor the validation loss or accuracy
- Try with ten numbers epoch
- Train the model using a generator and test the accuracy of the test data at every epoch
- Plot the training and validation accuracy, and the loss
- Observe the precision, recall the F1-score for all classes for both grayscale and color models, and determine if the model's classes are good

[13]:
```
model_cnn = Sequential()

# 1st CNN layer
model_cnn.add(Conv2D(16,(3,3),activation='relu',input_shape=(224,224,3)))
model_cnn.add(BatchNormalization())
model_cnn.add(MaxPooling2D(2,2))
model_cnn.add(Dropout(0.25))

# 2nd CNN Layer
model_cnn.add(Conv2D(32,(3,3),activation='relu'))
model_cnn.add(BatchNormalization())
model_cnn.add(MaxPooling2D(2,2))
model_cnn.add(Dropout(0.25))

# 3rd CNN layer
model_cnn.add(Conv2D(64,(3,3),activation='relu'))
model_cnn.add(BatchNormalization())
model_cnn.add(MaxPooling2D(2,2))
model_cnn.add(Dropout(0.25))

# 4th CNN Layer
model_cnn.add(Conv2D(64,(3,3),activation='relu'))
model_cnn.add(BatchNormalization())
model_cnn.add(MaxPooling2D(2,2))
model_cnn.add(Dropout(0.25))

model_cnn.add(Flatten())

# Fully connected layer
model_cnn.add(Dense(512,activation='relu'))
model_cnn.add(BatchNormalization())
model_cnn.add(Dropout(0.25))

model_cnn.add(Dense(3,activation='softmax'))
```

[14]:
```
model_cnn.compile(loss='categorical_crossentropy',
                  optimizer='rmsprop',
                  metrics=['accuracy'])
```

[15]:
```
model_cnn.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 222, 222, 16)      448

 batch_normalization (BatchN  (None, 222, 222, 16)     64
 ormalization)

 max_pooling2d (MaxPooling2D  (None, 111, 111, 16)     0
 )

 dropout (Dropout)           (None, 111, 111, 16)      0

 conv2d_1 (Conv2D)           (None, 109, 109, 32)      4640

 batch_normalization_1 (Batc  (None, 109, 109, 32)     128
 hNormalization)

 max_pooling2d_1 (MaxPooling  (None, 54, 54, 32)       0
 2D)

 dropout_1 (Dropout)         (None, 54, 54, 32)        0

 conv2d_2 (Conv2D)           (None, 52, 52, 64)        18496

 batch_normalization_2 (Batc  (None, 52, 52, 64)       256
 hNormalization)

 max_pooling2d_2 (MaxPooling  (None, 26, 26, 64)       0
 2D)

 dropout_2 (Dropout)         (None, 26, 26, 64)        0

 conv2d_3 (Conv2D)           (None, 24, 24, 64)        36928

 batch_normalization_3 (Batc  (None, 24, 24, 64)       256
 hNormalization)

 max_pooling2d_3 (MaxPooling  (None, 12, 12, 64)       0
 2D)

 dropout_3 (Dropout)         (None, 12, 12, 64)        0

 flatten (Flatten)           (None, 9216)              0
```

```
 dense (Dense)                (None, 512)               4719104

 batch_normalization_4 (Batc  (None, 512)               2048
 hNormalization)

 dropout_4 (Dropout)          (None, 512)               0

 dense_1 (Dense)              (None, 3)                 1539

=================================================================
Total params: 4,783,907
Trainable params: 4,782,531
Non-trainable params: 1,376
_________________________________________________________________
```

[16]:
```
early_stopping =␣
↪EarlyStopping(patience=2,monitor='val_loss',restore_best_weights=True)
```

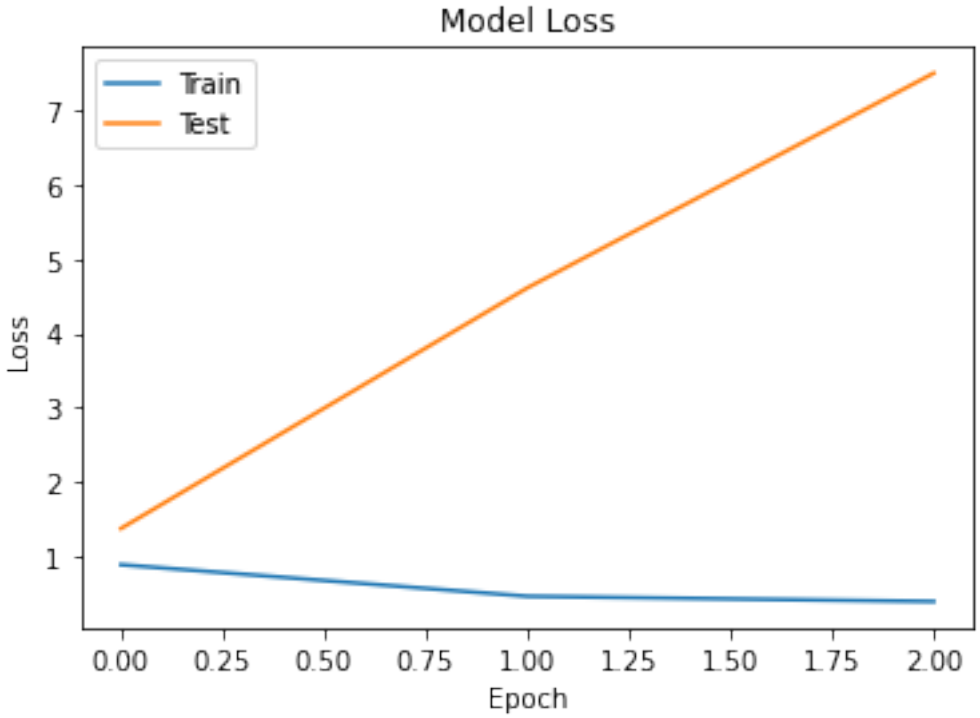
[17]:
```
 # Fit the model
history_cnn = model_cnn.fit(train_generator,
                            epochs=10,
                            batch_size=512,
                            verbose=1,
                            validation_data=validation_generator,
                            callbacks=early_stopping)
```

```
Epoch 1/10
8/8 [==============================] - 23s 2s/step - loss: 0.8889 - accuracy:
0.7450 - val_loss: 1.3755 - val_accuracy: 0.3030
Epoch 2/10
8/8 [==============================] - 12s 2s/step - loss: 0.4645 - accuracy:
0.8526 - val_loss: 4.6095 - val_accuracy: 0.3030
Epoch 3/10
8/8 [==============================] - 12s 2s/step - loss: 0.3945 - accuracy:
0.8845 - val_loss: 7.4954 - val_accuracy: 0.3030
```

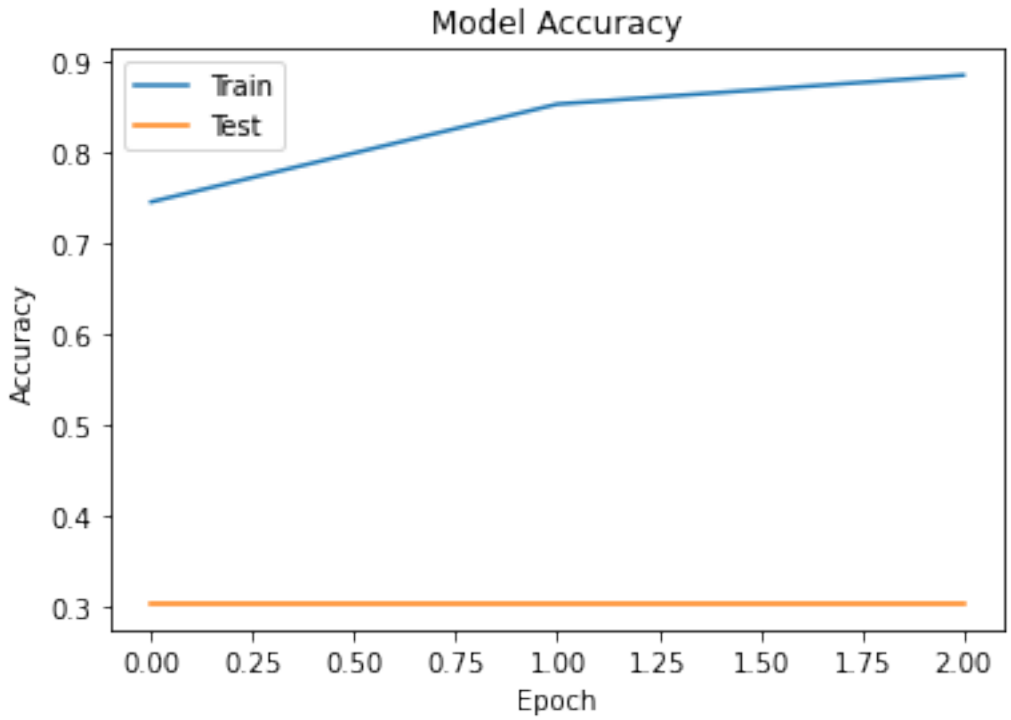
[18]:
```
# Evaluate the result
test_loss, test_acc = model_cnn.evaluate(validation_generator,verbose=1)

print('Model Accuracy:',test_acc)
print('Model Loss:',test_loss)
```

```
3/3 [==============================] - 2s 544ms/step - loss: 1.3755 - accuracy:
0.3030
Model Accuracy: 0.3030303120613098
Model Loss: 1.375476598739624
```

[19]:
```
# PLot the model loss
plt.plot(history_cnn.history['loss'],label='Train')
plt.plot(history_cnn.history['val_loss'],label='Test')
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(loc='best')
plt.show()
```



[20]:
```
# PLot the model Accuracy
plt.plot(history_cnn.history['accuracy'],label='Train')
plt.plot(history_cnn.history['val_accuracy'],label='Test')
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(loc='best')
plt.show()
```



4 2. Transfer learning using mobile net:

- Prepare data for the pre-trained mobile net model, with color mode as RGB
- Create an instance of a mobile net pre-trained model
- Add dense layer, dropout layer, batch normalization layer on the pre-trained model
- Create a final output layer with a SoftMax activation function
- Change the batch size activation function and optimize as rmsprop and observe if the accuracy increases
- Take the loss function as categorical cross-entropy
- Use early stopping with the patience of two epoch and call back function for preventing overfitting
- Try with ten numbers epoch
- Train the model using a generator and test the accuracy of the test data at every epoch
- Plot the training and validation accuracy, and the loss
- Observe the precision, recall the F1-score for all classes for both grayscale and color models, and determine if the model's classes are good

[21]:
```
IMAGE_SIZE = [224, 224]
mobilenet = MobileNetV2(input_shape=IMAGE_SIZE + [3], weights='imagenet',␣
↪include_top=False)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
ns/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h
5
9406464/9406464 [==============================] - 0s 0us/step
```

[22]:
```
# don't train existing weights
for layer in mobilenet.layers:
    layer.trainable = False
```

[23]:
```
# our layers - you can add more if you want
x = Flatten()(mobilenet.output)
```

[24]:
```
prediction = Dense(len(folders), activation='softmax')(x)

# create a model object
model_mobilenet = Model(inputs=mobilenet.input, outputs=prediction)
```

[25]:
```
# view the structure of the model
model_mobilenet.summary()
```

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

 Conv1 (Conv2D)                 (None, 112, 112, 32  864
['input_1[0][0]']
                                )

 bn_Conv1 (BatchNormalization)  (None, 112, 112, 32  128         ['Conv1[0][0]']
                                )

 Conv1_relu (ReLU)              (None, 112, 112, 32  0
['bn_Conv1[0][0]']
                                )

 expanded_conv_depthwise (Depth  (None, 112, 112, 32  288
['Conv1_relu[0][0]']
 wiseConv2D)                    )
```

```
 expanded_conv_depthwise_BN (Ba  (None, 112, 112, 32  128
['expanded_conv_depthwise[0][0]']
 tchNormalization)              )

 expanded_conv_depthwise_relu (  (None, 112, 112, 32  0
['expanded_conv_depthwise_BN[0][0
 ReLU)                          )                                ]']

 expanded_conv_project (Conv2D)  (None, 112, 112, 16  512
['expanded_conv_depthwise_relu[0]
                                )                                [0]']

 expanded_conv_project_BN (Batc  (None, 112, 112, 16  64
['expanded_conv_project[0][0]']
 hNormalization)                )

 block_1_expand (Conv2D)        (None, 112, 112, 96  1536
['expanded_conv_project_BN[0][0]'
                                )                                ]

 block_1_expand_BN (BatchNormal  (None, 112, 112, 96  384
['block_1_expand[0][0]']
 ization)                       )

 block_1_expand_relu (ReLU)     (None, 112, 112, 96  0
['block_1_expand_BN[0][0]']
                                )

 block_1_pad (ZeroPadding2D)    (None, 113, 113, 96  0
['block_1_expand_relu[0][0]']
                                )

 block_1_depthwise (DepthwiseCo  (None, 56, 56, 96)  864
['block_1_pad[0][0]']
 nv2D)

 block_1_depthwise_BN (BatchNor  (None, 56, 56, 96)  384
['block_1_depthwise[0][0]']
 malization)

 block_1_depthwise_relu (ReLU)  (None, 56, 56, 96)   0
['block_1_depthwise_BN[0][0]']

 block_1_project (Conv2D)       (None, 56, 56, 24)   2304
['block_1_depthwise_relu[0][0]']

 block_1_project_BN (BatchNorma  (None, 56, 56, 24)  96
```

```
['block_1_project[0][0]']
 lization)

 block_2_expand (Conv2D)        (None, 56, 56, 144)  3456
['block_1_project_BN[0][0]']

 block_2_expand_BN (BatchNormal  (None, 56, 56, 144)  576
['block_2_expand[0][0]']
 ization)

 block_2_expand_relu (ReLU)     (None, 56, 56, 144)  0
['block_2_expand_BN[0][0]']

 block_2_depthwise (DepthwiseCo  (None, 56, 56, 144)  1296
['block_2_expand_relu[0][0]']
 nv2D)

 block_2_depthwise_BN (BatchNor  (None, 56, 56, 144)  576
['block_2_depthwise[0][0]']
 malization)

 block_2_depthwise_relu (ReLU)  (None, 56, 56, 144)  0
['block_2_depthwise_BN[0][0]']

 block_2_project (Conv2D)       (None, 56, 56, 24)   3456
['block_2_depthwise_relu[0][0]']

 block_2_project_BN (BatchNorma  (None, 56, 56, 24)  96
['block_2_project[0][0]']
 lization)

 block_2_add (Add)              (None, 56, 56, 24)   0
['block_1_project_BN[0][0]',
'block_2_project_BN[0][0]']

 block_3_expand (Conv2D)        (None, 56, 56, 144)  3456
['block_2_add[0][0]']

 block_3_expand_BN (BatchNormal  (None, 56, 56, 144)  576
['block_3_expand[0][0]']
 ization)

 block_3_expand_relu (ReLU)     (None, 56, 56, 144)  0
['block_3_expand_BN[0][0]']

 block_3_pad (ZeroPadding2D)    (None, 57, 57, 144)  0
['block_3_expand_relu[0][0]']
```

```
 block_3_depthwise (DepthwiseCo  (None, 28, 28, 144)  1296
['block_3_pad[0][0]']
 nv2D)

 block_3_depthwise_BN (BatchNor  (None, 28, 28, 144)  576
['block_3_depthwise[0][0]']
 malization)

 block_3_depthwise_relu (ReLU)  (None, 28, 28, 144)  0
['block_3_depthwise_BN[0][0]']

 block_3_project (Conv2D)       (None, 28, 28, 32)   4608
['block_3_depthwise_relu[0][0]']

 block_3_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_3_project[0][0]']
 lization)

 block_4_expand (Conv2D)        (None, 28, 28, 192)  6144
['block_3_project_BN[0][0]']

 block_4_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_4_expand[0][0]']
 ization)

 block_4_expand_relu (ReLU)     (None, 28, 28, 192)  0
['block_4_expand_BN[0][0]']

 block_4_depthwise (DepthwiseCo  (None, 28, 28, 192)  1728
['block_4_expand_relu[0][0]']
 nv2D)

 block_4_depthwise_BN (BatchNor  (None, 28, 28, 192)  768
['block_4_depthwise[0][0]']
 malization)

 block_4_depthwise_relu (ReLU)  (None, 28, 28, 192)  0
['block_4_depthwise_BN[0][0]']

 block_4_project (Conv2D)       (None, 28, 28, 32)   6144
['block_4_depthwise_relu[0][0]']

 block_4_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_4_project[0][0]']
 lization)

 block_4_add (Add)              (None, 28, 28, 32)   0
['block_3_project_BN[0][0]',
```

```
'block_4_project_BN[0][0]']

 block_5_expand (Conv2D)        (None, 28, 28, 192)  6144
['block_4_add[0][0]']

 block_5_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_5_expand[0][0]']
 ization)

 block_5_expand_relu (ReLU)     (None, 28, 28, 192)  0
['block_5_expand_BN[0][0]']

 block_5_depthwise (DepthwiseCo  (None, 28, 28, 192)  1728
['block_5_expand_relu[0][0]']
 nv2D)

 block_5_depthwise_BN (BatchNor  (None, 28, 28, 192)  768
['block_5_depthwise[0][0]']
 malization)

 block_5_depthwise_relu (ReLU)  (None, 28, 28, 192)  0
['block_5_depthwise_BN[0][0]']

 block_5_project (Conv2D)       (None, 28, 28, 32)   6144
['block_5_depthwise_relu[0][0]']

 block_5_project_BN (BatchNorma  (None, 28, 28, 32)  128
['block_5_project[0][0]']
 lization)

 block_5_add (Add)              (None, 28, 28, 32)   0
['block_4_add[0][0]',
'block_5_project_BN[0][0]']

 block_6_expand (Conv2D)        (None, 28, 28, 192)  6144
['block_5_add[0][0]']

 block_6_expand_BN (BatchNormal  (None, 28, 28, 192)  768
['block_6_expand[0][0]']
 ization)

 block_6_expand_relu (ReLU)     (None, 28, 28, 192)  0
['block_6_expand_BN[0][0]']

 block_6_pad (ZeroPadding2D)    (None, 29, 29, 192)  0
['block_6_expand_relu[0][0]']

 block_6_depthwise (DepthwiseCo  (None, 14, 14, 192)  1728
```

```
['block_6_pad[0][0]']
 nv2D)

 block_6_depthwise_BN (BatchNor  (None, 14, 14, 192)  768
['block_6_depthwise[0][0]']
 malization)

 block_6_depthwise_relu (ReLU)  (None, 14, 14, 192)  0
['block_6_depthwise_BN[0][0]']

 block_6_project (Conv2D)       (None, 14, 14, 64)   12288
['block_6_depthwise_relu[0][0]']

 block_6_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_6_project[0][0]']
 lization)

 block_7_expand (Conv2D)        (None, 14, 14, 384)  24576
['block_6_project_BN[0][0]']

 block_7_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_7_expand[0][0]']
 ization)

 block_7_expand_relu (ReLU)     (None, 14, 14, 384)  0
['block_7_expand_BN[0][0]']

 block_7_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_7_expand_relu[0][0]']
 nv2D)

 block_7_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
['block_7_depthwise[0][0]']
 malization)

 block_7_depthwise_relu (ReLU)  (None, 14, 14, 384)  0
['block_7_depthwise_BN[0][0]']

 block_7_project (Conv2D)       (None, 14, 14, 64)   24576
['block_7_depthwise_relu[0][0]']

 block_7_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_7_project[0][0]']
 lization)

 block_7_add (Add)              (None, 14, 14, 64)   0
['block_6_project_BN[0][0]',
'block_7_project_BN[0][0]']
```

```
 block_8_expand (Conv2D)        (None, 14, 14, 384)  24576
['block_7_add[0][0]']

 block_8_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_8_expand[0][0]']
 ization)

 block_8_expand_relu (ReLU)     (None, 14, 14, 384)  0
['block_8_expand_BN[0][0]']

 block_8_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_8_expand_relu[0][0]']
 nv2D)

 block_8_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
['block_8_depthwise[0][0]']
 malization)

 block_8_depthwise_relu (ReLU)  (None, 14, 14, 384)  0
['block_8_depthwise_BN[0][0]']

 block_8_project (Conv2D)       (None, 14, 14, 64)   24576
['block_8_depthwise_relu[0][0]']

 block_8_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_8_project[0][0]']
 lization)

 block_8_add (Add)              (None, 14, 14, 64)   0
['block_7_add[0][0]',
'block_8_project_BN[0][0]']

 block_9_expand (Conv2D)        (None, 14, 14, 384)  24576
['block_8_add[0][0]']

 block_9_expand_BN (BatchNormal  (None, 14, 14, 384)  1536
['block_9_expand[0][0]']
 ization)

 block_9_expand_relu (ReLU)     (None, 14, 14, 384)  0
['block_9_expand_BN[0][0]']

 block_9_depthwise (DepthwiseCo  (None, 14, 14, 384)  3456
['block_9_expand_relu[0][0]']
 nv2D)

 block_9_depthwise_BN (BatchNor  (None, 14, 14, 384)  1536
```

```
['block_9_depthwise[0][0]']
 malization)

 block_9_depthwise_relu (ReLU)  (None, 14, 14, 384)  0
['block_9_depthwise_BN[0][0]']

 block_9_project (Conv2D)       (None, 14, 14, 64)   24576
['block_9_depthwise_relu[0][0]']

 block_9_project_BN (BatchNorma  (None, 14, 14, 64)  256
['block_9_project[0][0]']
 lization)

 block_9_add (Add)              (None, 14, 14, 64)   0
['block_8_add[0][0]',
'block_9_project_BN[0][0]']

 block_10_expand (Conv2D)       (None, 14, 14, 384)  24576
['block_9_add[0][0]']

 block_10_expand_BN (BatchNorma  (None, 14, 14, 384)  1536
['block_10_expand[0][0]']
 lization)

 block_10_expand_relu (ReLU)    (None, 14, 14, 384)  0
['block_10_expand_BN[0][0]']

 block_10_depthwise (DepthwiseC  (None, 14, 14, 384)  3456
['block_10_expand_relu[0][0]']
 onv2D)

 block_10_depthwise_BN (BatchNo  (None, 14, 14, 384)  1536
['block_10_depthwise[0][0]']
 rmalization)

 block_10_depthwise_relu (ReLU)  (None, 14, 14, 384)  0
['block_10_depthwise_BN[0][0]']

 block_10_project (Conv2D)      (None, 14, 14, 96)   36864
['block_10_depthwise_relu[0][0]']

 block_10_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_10_project[0][0]']
 alization)

 block_11_expand (Conv2D)       (None, 14, 14, 576)  55296
['block_10_project_BN[0][0]']
```

```
 block_11_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_11_expand[0][0]']
 lization)

 block_11_expand_relu (ReLU)    (None, 14, 14, 576)  0
['block_11_expand_BN[0][0]']

 block_11_depthwise (DepthwiseC  (None, 14, 14, 576)  5184
['block_11_expand_relu[0][0]']
 onv2D)

 block_11_depthwise_BN (BatchNo  (None, 14, 14, 576)  2304
['block_11_depthwise[0][0]']
 rmalization)

 block_11_depthwise_relu (ReLU)  (None, 14, 14, 576)  0
['block_11_depthwise_BN[0][0]']

 block_11_project (Conv2D)      (None, 14, 14, 96)   55296
['block_11_depthwise_relu[0][0]']

 block_11_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_11_project[0][0]']
 alization)

 block_11_add (Add)             (None, 14, 14, 96)   0
['block_10_project_BN[0][0]',
'block_11_project_BN[0][0]']

 block_12_expand (Conv2D)       (None, 14, 14, 576)  55296
['block_11_add[0][0]']

 block_12_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_12_expand[0][0]']
 lization)

 block_12_expand_relu (ReLU)    (None, 14, 14, 576)  0
['block_12_expand_BN[0][0]']

 block_12_depthwise (DepthwiseC  (None, 14, 14, 576)  5184
['block_12_expand_relu[0][0]']
 onv2D)

 block_12_depthwise_BN (BatchNo  (None, 14, 14, 576)  2304
['block_12_depthwise[0][0]']
 rmalization)

 block_12_depthwise_relu (ReLU)  (None, 14, 14, 576)  0
```

```
['block_12_depthwise_BN[0][0]']

 block_12_project (Conv2D)      (None, 14, 14, 96)   55296
['block_12_depthwise_relu[0][0]']

 block_12_project_BN (BatchNorm  (None, 14, 14, 96)  384
['block_12_project[0][0]']
 alization)

 block_12_add (Add)             (None, 14, 14, 96)   0
['block_11_add[0][0]',
'block_12_project_BN[0][0]']

 block_13_expand (Conv2D)       (None, 14, 14, 576)  55296
['block_12_add[0][0]']

 block_13_expand_BN (BatchNorma  (None, 14, 14, 576)  2304
['block_13_expand[0][0]']
 lization)

 block_13_expand_relu (ReLU)    (None, 14, 14, 576)  0
['block_13_expand_BN[0][0]']

 block_13_pad (ZeroPadding2D)   (None, 15, 15, 576)  0
['block_13_expand_relu[0][0]']

 block_13_depthwise (DepthwiseC  (None, 7, 7, 576)   5184
['block_13_pad[0][0]']
 onv2D)

 block_13_depthwise_BN (BatchNo  (None, 7, 7, 576)   2304
['block_13_depthwise[0][0]']
 rmalization)

 block_13_depthwise_relu (ReLU)  (None, 7, 7, 576)   0
['block_13_depthwise_BN[0][0]']

 block_13_project (Conv2D)      (None, 7, 7, 160)    92160
['block_13_depthwise_relu[0][0]']

 block_13_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_13_project[0][0]']
 alization)

 block_14_expand (Conv2D)       (None, 7, 7, 960)    153600
['block_13_project_BN[0][0]']

 block_14_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
```

```
['block_14_expand[0][0]']
 lization)

 block_14_expand_relu (ReLU)    (None, 7, 7, 960)    0
['block_14_expand_BN[0][0]']

 block_14_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_14_expand_relu[0][0]']
 onv2D)

 block_14_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
['block_14_depthwise[0][0]']
 rmalization)

 block_14_depthwise_relu (ReLU)  (None, 7, 7, 960)   0
['block_14_depthwise_BN[0][0]']

 block_14_project (Conv2D)      (None, 7, 7, 160)    153600
['block_14_depthwise_relu[0][0]']

 block_14_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_14_project[0][0]']
 alization)

 block_14_add (Add)             (None, 7, 7, 160)    0
['block_13_project_BN[0][0]',
'block_14_project_BN[0][0]']

 block_15_expand (Conv2D)       (None, 7, 7, 960)    153600
['block_14_add[0][0]']

 block_15_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
['block_15_expand[0][0]']
 lization)

 block_15_expand_relu (ReLU)    (None, 7, 7, 960)    0
['block_15_expand_BN[0][0]']

 block_15_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_15_expand_relu[0][0]']
 onv2D)

 block_15_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
['block_15_depthwise[0][0]']
 rmalization)

 block_15_depthwise_relu (ReLU)  (None, 7, 7, 960)   0
['block_15_depthwise_BN[0][0]']
```

```
 block_15_project (Conv2D)      (None, 7, 7, 160)    153600
['block_15_depthwise_relu[0][0]']

 block_15_project_BN (BatchNorm  (None, 7, 7, 160)   640
['block_15_project[0][0]']
 alization)

 block_15_add (Add)             (None, 7, 7, 160)    0
['block_14_add[0][0]',
'block_15_project_BN[0][0]']

 block_16_expand (Conv2D)       (None, 7, 7, 960)    153600
['block_15_add[0][0]']

 block_16_expand_BN (BatchNorma  (None, 7, 7, 960)   3840
['block_16_expand[0][0]']
 lization)

 block_16_expand_relu (ReLU)    (None, 7, 7, 960)    0
['block_16_expand_BN[0][0]']

 block_16_depthwise (DepthwiseC  (None, 7, 7, 960)   8640
['block_16_expand_relu[0][0]']
 onv2D)

 block_16_depthwise_BN (BatchNo  (None, 7, 7, 960)   3840
['block_16_depthwise[0][0]']
 rmalization)

 block_16_depthwise_relu (ReLU)  (None, 7, 7, 960)   0
['block_16_depthwise_BN[0][0]']

 block_16_project (Conv2D)      (None, 7, 7, 320)    307200
['block_16_depthwise_relu[0][0]']

 block_16_project_BN (BatchNorm  (None, 7, 7, 320)   1280
['block_16_project[0][0]']
 alization)

 Conv_1 (Conv2D)                (None, 7, 7, 1280)   409600
['block_16_project_BN[0][0]']

 Conv_1_bn (BatchNormalization)  (None, 7, 7, 1280)  5120
['Conv_1[0][0]']

 out_relu (ReLU)                (None, 7, 7, 1280)   0
['Conv_1_bn[0][0]']
```

```
 flatten_1 (Flatten)            (None, 62720)        0
['out_relu[0][0]']

 dense_2 (Dense)                (None, 3)            188163
['flatten_1[0][0]']

==================================================================================
==================
Total params: 2,446,147
Trainable params: 188,163
Non-trainable params: 2,257,984
----------------------------------------------------------------------------------
------------------
```

[26]:
```
# tell the model what cost and optimization method to use
model_mobilenet.
 ↪compile(optimizer='rmsprop',loss='categorical_crossentropy',metrics=['accuracy'])
```

[27]:
```
early_stopping =␣
 ↪EarlyStopping(patience=2,monitor='val_loss',restore_best_weights=True)
```

[28]:
```
history_mobilenet = model_mobilenet.fit(train_generator,
                                        epochs=10,
                                        batch_size=512,
                                        verbose=1,
                                        validation_data=validation_generator,
                                        callbacks=early_stopping)
```

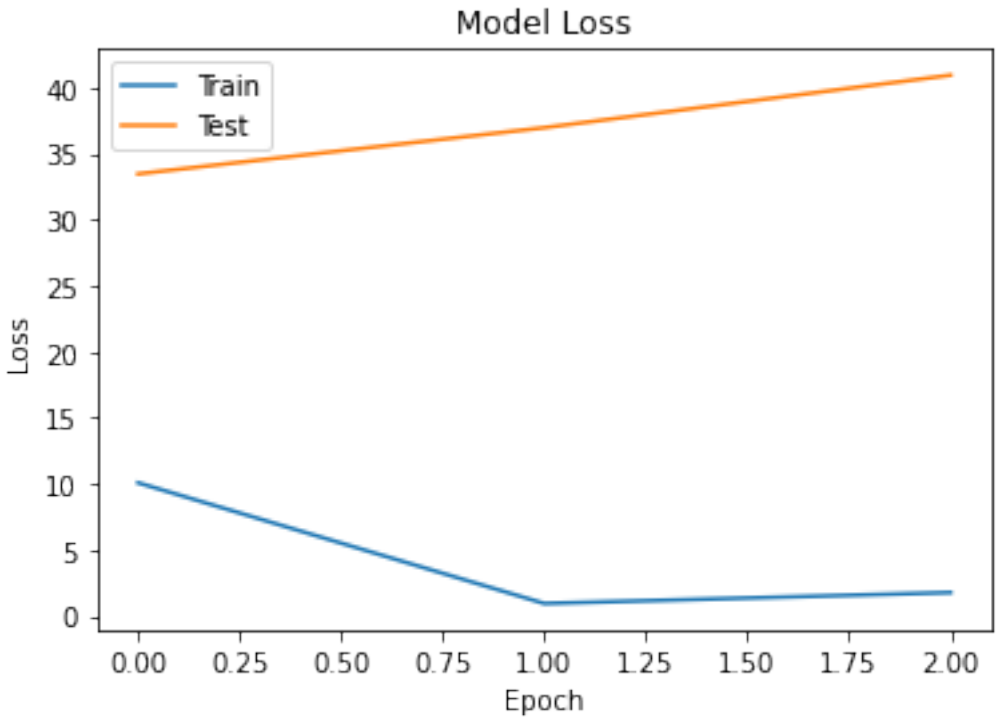
```
Epoch 1/10
8/8 [==============================] - 16s 2s/step - loss: 10.0916 - accuracy:
0.6215 - val_loss: 33.4734 - val_accuracy: 0.0455
Epoch 2/10
8/8 [==============================] - 12s 1s/step - loss: 0.9513 - accuracy:
0.8924 - val_loss: 36.9734 - val_accuracy: 0.2273
Epoch 3/10
8/8 [==============================] - 12s 2s/step - loss: 1.7792 - accuracy:
0.8526 - val_loss: 40.9474 - val_accuracy: 0.2727
```

[29]:
```
# Evaluate the result
test_loss, test_acc = model_mobilenet.evaluate(validation_generator,verbose=1)

print('Model Accuracy:',test_acc)
print('Model Loss:',test_loss)
```

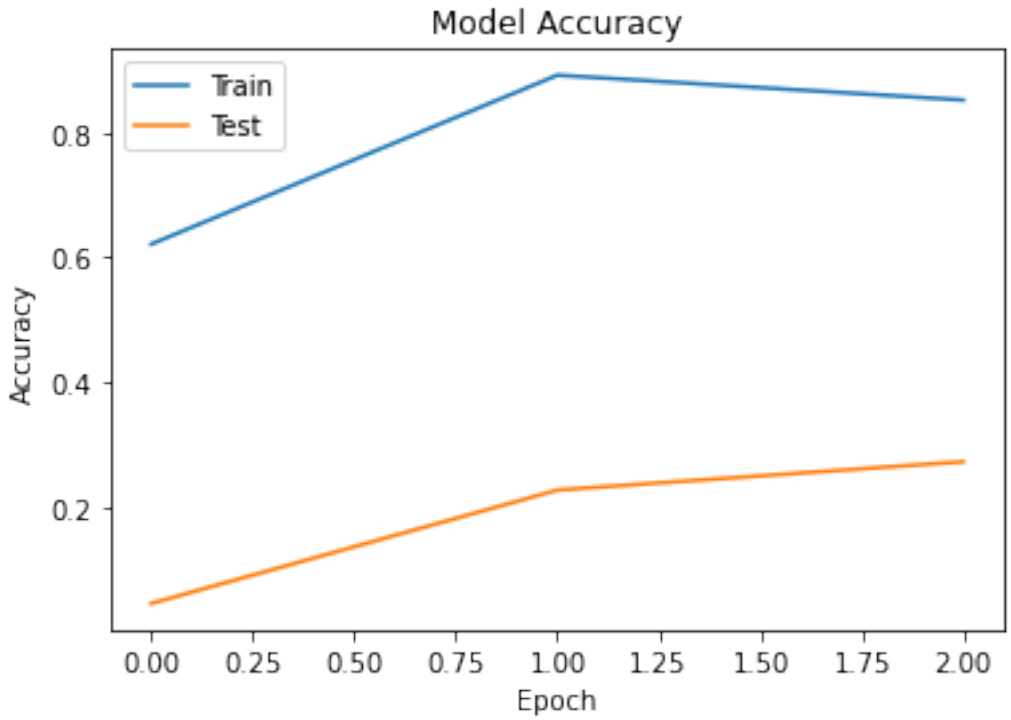
```
3/3 [==============================] - 1s 341ms/step - loss: 33.4734 - accuracy:
0.0455
Model Accuracy: 0.04545454680919647
```

```
Model Loss: 33.473411560058594
```

[30]:
```
# PLot the model loss
plt.plot(history_mobilenet.history['loss'],label='Train')
plt.plot(history_mobilenet.history['val_loss'],label='Test')
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(loc='best')
plt.show()
```



[31]:
```
# PLot the model Accuracy
plt.plot(history_mobilenet.history['accuracy'],label='Train')
plt.plot(history_mobilenet.history['val_accuracy'],label='Test')
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(loc='best')
plt.show()
```



5 3. Transfer Learning using Densenet121:

- Prepare the dataset for the transfer learning algorithm using Densenet121 with the image size as 224x224x3
- Freeze the top layers of the pre-trained model
- Add a dense layer at the end of the pre-trained model followed by a dropout layer and try various combinations to get an accuracy
- Add the final output layer with a SoftMax activation function
- Take loss function as categorical cross-entropy
- Take Adam as an optimizer
- Use early stopping to prevent overfitting
- Try with 15 number of epoch and batch size with seven, also try various values to see the impact on results
- Train the model using the generator and test the accuracy of the test data at every epoch
- Plot the training and validation accuracy, and the loss
- Observe the precision, recall the F1-score for all classes for both grayscale and color models, and determine if the model's classes are good

[32]:
```
IMAGE_SIZE = [224, 224]
den = DenseNet121(input_shape=IMAGE_SIZE + [3], weights='imagenet',␣
 ↪include_top=False)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/densenet/densenet121_weights_tf_dim_ordering_tf_kernels_notop.h5
29084464/29084464 [==============================] - 0s 0us/step
```

[33]:
```
# don't train existing weights
for layer in den.layers:
    layer.trainable = False
```

[34]:
```
# our layers - you can add more if you want
x = Flatten()(den.output)
```

[35]:
```
prediction = Dense(len(folders), activation='softmax')(x)

# create a model object
model_densenet = Model(inputs=den.input, outputs=prediction)
```

[36]:
```
# view the structure of the model
model_densenet.summary()
```

```
Model: "model_1"
__________________________________________________________________________________
__________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================
==================
 input_2 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 zero_padding2d (ZeroPadding2D)  (None, 230, 230, 3)  0
['input_2[0][0]']

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

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

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

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

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

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

 conv2_block1_0_relu (Activatio  (None, 56, 56, 64)  0
['conv2_block1_0_bn[0][0]']
 n)

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

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

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

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

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

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

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

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

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

 conv2_block2_1_relu (Activatio  (None, 56, 56, 128)  0
```

```
['conv2_block2_1_bn[0][0]']
 n)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv3_block1_1_conv (Conv2D)   (None, 28, 28, 128)  16384
['conv3_block1_0_relu[0][0]']

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

```
 ization)

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

 conv3_block1_2_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block1_1_relu[0][0]']

 conv3_block1_concat (Concatena  (None, 28, 28, 160)  0
['pool2_pool[0][0]',
 te)
'conv3_block1_2_conv[0][0]']

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

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

 conv3_block2_1_conv (Conv2D)   (None, 28, 28, 128)  20480
['conv3_block2_0_relu[0][0]']

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

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

 conv3_block2_2_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block2_1_relu[0][0]']

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

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

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

```
 conv3_block3_1_conv (Conv2D)   (None, 28, 28, 128)  24576
['conv3_block3_0_relu[0][0]']

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

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

 conv3_block3_2_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block3_1_relu[0][0]']

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

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

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

 conv3_block4_1_conv (Conv2D)   (None, 28, 28, 128)  28672
['conv3_block4_0_relu[0][0]']

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

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

 conv3_block4_2_conv (Conv2D)   (None, 28, 28, 32)   36864
['conv3_block4_1_relu[0][0]']

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

 conv3_block5_0_bn (BatchNormal  (None, 28, 28, 256)  1024
```

```
['conv3_block4_concat[0][0]']
 ization)

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

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

 conv3_block5_1_bn (BatchNormal  (None, 28, 28, 128)  512
['conv3_block5_1_conv[0][0]']
 ization)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv3_block8_1_relu (Activatio  (None, 28, 28, 128)  0
```

```
['conv3_block8_1_bn[0][0]']
 n)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
 ization)

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

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

 conv4_block1_concat (Concatena  (None, 14, 14, 288)  0
['pool3_pool[0][0]',
 te)
'conv4_block1_2_conv[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv4_block5_0_bn (BatchNormal  (None, 14, 14, 384)  1536
```

```
['conv4_block4_concat[0][0]']
 ization)

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

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

 conv4_block5_1_bn (BatchNormal  (None, 14, 14, 128)  512
['conv4_block5_1_conv[0][0]']
 ization)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv4_block8_1_relu (Activatio  (None, 14, 14, 128)  0
```

```
['conv4_block8_1_bn[0][0]']
 n)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
'conv4_block13_2_conv[0][0]']

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

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

 conv4_block14_1_conv (Conv2D)  (None, 14, 14, 128)  86016
['conv4_block14_0_relu[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
 lization)

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

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

 conv4_block17_concat (Concaten  (None, 14, 14, 800)  0
['conv4_block16_concat[0][0]',
 ate)
'conv4_block17_2_conv[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv4_block21_0_bn (BatchNorma  (None, 14, 14, 896)  3584
```

```
['conv4_block20_concat[0][0]']
 lization)

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

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

 conv4_block21_1_bn (BatchNorma  (None, 14, 14, 128)  512
['conv4_block21_1_conv[0][0]']
 lization)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv4_block24_1_relu (Activati  (None, 14, 14, 128)  0
```

```
['conv4_block24_1_bn[0][0]']
 on)

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

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

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

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

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

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

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

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

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

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

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

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

 conv5_block1_concat (Concatena  (None, 7, 7, 544)   0
```

```
['pool4_pool[0][0]',
 te)
'conv5_block1_2_conv[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

```
 n)

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

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

 conv5_block4_0_bn (BatchNormal  (None, 7, 7, 608)   2432
['conv5_block3_concat[0][0]']
 ization)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv5_block7_0_relu (Activatio  (None, 7, 7, 704)   0
```

```
['conv5_block7_0_bn[0][0]']
 n)

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

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

 conv5_block7_1_relu (Activatio  (None, 7, 7, 128)   0
['conv5_block7_1_bn[0][0]']
 n)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv5_block10_2_conv (Conv2D)  (None, 7, 7, 32)     36864
```

```
['conv5_block10_1_relu[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

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

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

 conv5_block12_concat (Concaten  (None, 7, 7, 896)   0
['conv5_block11_concat[0][0]',
 ate)
'conv5_block12_2_conv[0][0]']

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```
 lization)

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

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

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

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

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

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

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

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

 flatten_2 (Flatten)            (None, 50176)        0           ['relu[0][0]']

 dense_3 (Dense)                (None, 3)            150531
['flatten_2[0][0]']

==========================================================================
==================
Total params: 7,188,035
Trainable params: 150,531
Non-trainable params: 7,037,504
--------------------------------------------------------------------------
------------------
```

[37]:
```
# tell the model what cost and optimization method to use
model_densenet.compile(loss='categorical_crossentropy',
                       optimizer='adam',
                       metrics=['accuracy'])
```

[38]:
```
early_stopping =␣
↪EarlyStopping(patience=5,monitor='val_loss',restore_best_weights=True)
```

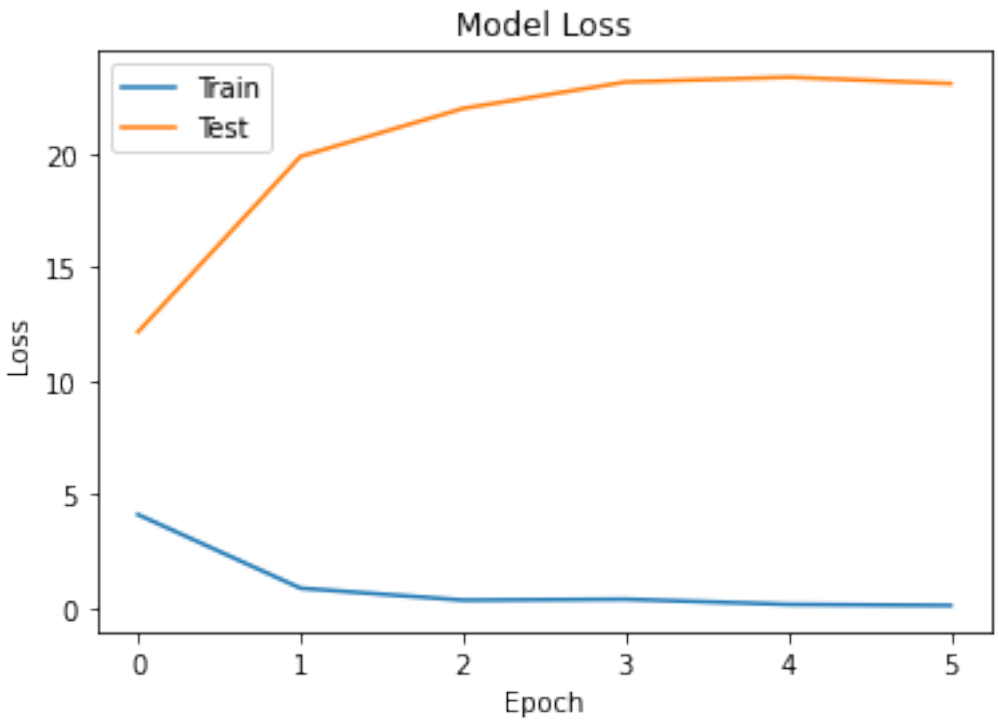
[39]:
```
history_densenet = model_densenet.fit(train_generator,
                              epochs=15,
                              verbose=1,
                              callbacks=early_stopping,
                              validation_data=validation_generator)
```

```
Epoch 1/15
8/8 [==============================] - 28s 2s/step - loss: 4.1203 - accuracy:
0.5378 - val_loss: 12.1492 - val_accuracy: 0.1212
Epoch 2/15
8/8 [==============================] - 12s 2s/step - loss: 0.8823 - accuracy:
0.8765 - val_loss: 19.8642 - val_accuracy: 0.0152
Epoch 3/15
8/8 [==============================] - 13s 2s/step - loss: 0.3559 - accuracy:
0.9442 - val_loss: 21.9738 - val_accuracy: 0.0303
Epoch 4/15
8/8 [==============================] - 12s 2s/step - loss: 0.3962 - accuracy:
0.9562 - val_loss: 23.1361 - val_accuracy: 0.0606
Epoch 5/15
8/8 [==============================] - 12s 2s/step - loss: 0.1701 - accuracy:
0.9522 - val_loss: 23.3491 - val_accuracy: 0.0455
Epoch 6/15
8/8 [==============================] - 13s 2s/step - loss: 0.1223 - accuracy:
0.9562 - val_loss: 23.0676 - val_accuracy: 0.0606
```

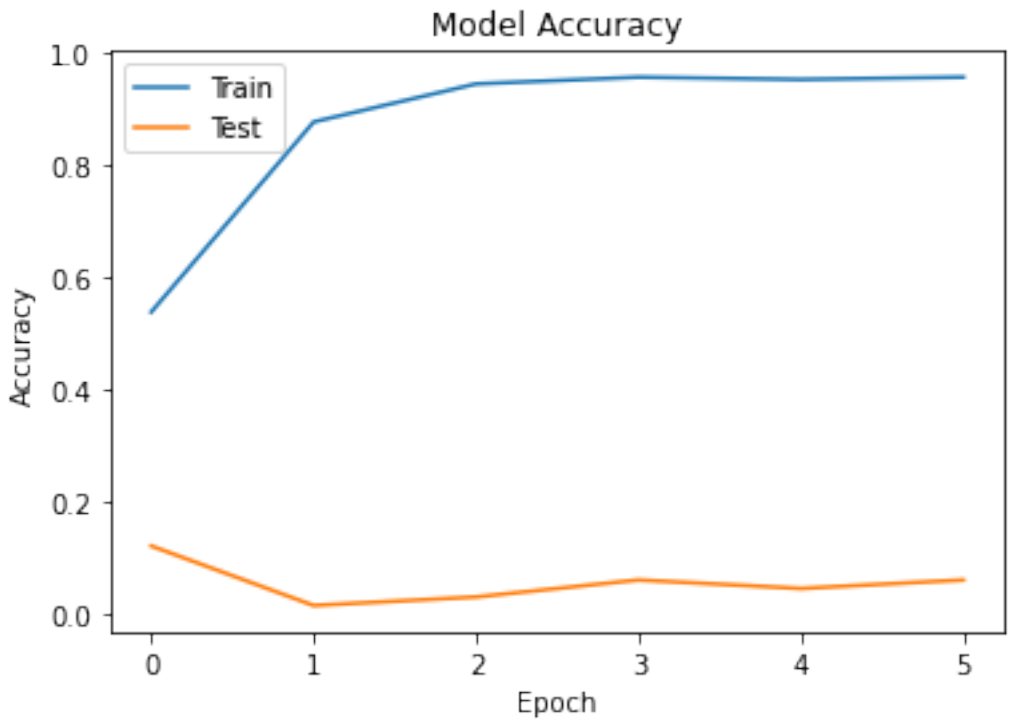
[40]:
```
# Evaluate the result
test_loss, test_acc = model_densenet.evaluate(validation_generator,verbose=1)

print('Model Accuracy:',test_acc)
print('Model Loss:',test_loss)
```

```
3/3 [==============================] - 1s 335ms/step - loss: 12.1492 - accuracy:
0.1212
Model Accuracy: 0.12121212482452393
Model Loss: 12.14915943145752
```

[41]:
```
# PLot the model loss
plt.plot(history_densenet.history['loss'],label='Train')
plt.plot(history_densenet.history['val_loss'],label='Test')
plt.title('Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(loc='best')
plt.show()
```

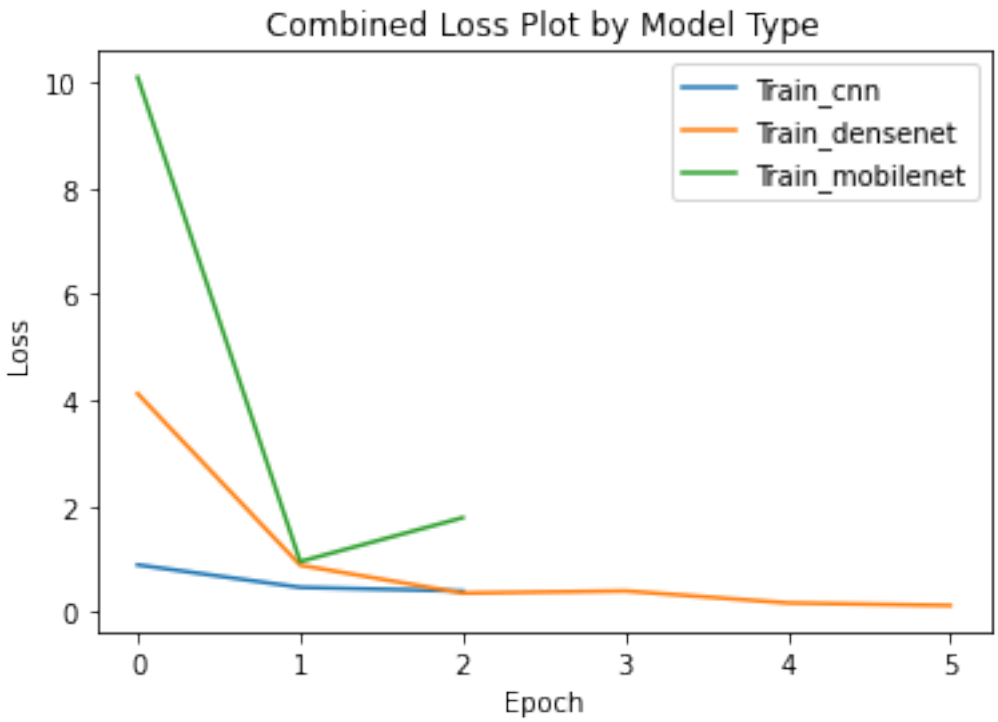


[42]:
```
# PLot the model Accuracy
plt.plot(history_densenet.history['accuracy'],label='Train')
plt.plot(history_densenet.history['val_accuracy'],label='Test')
plt.title('Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(loc='best')
plt.show()
```



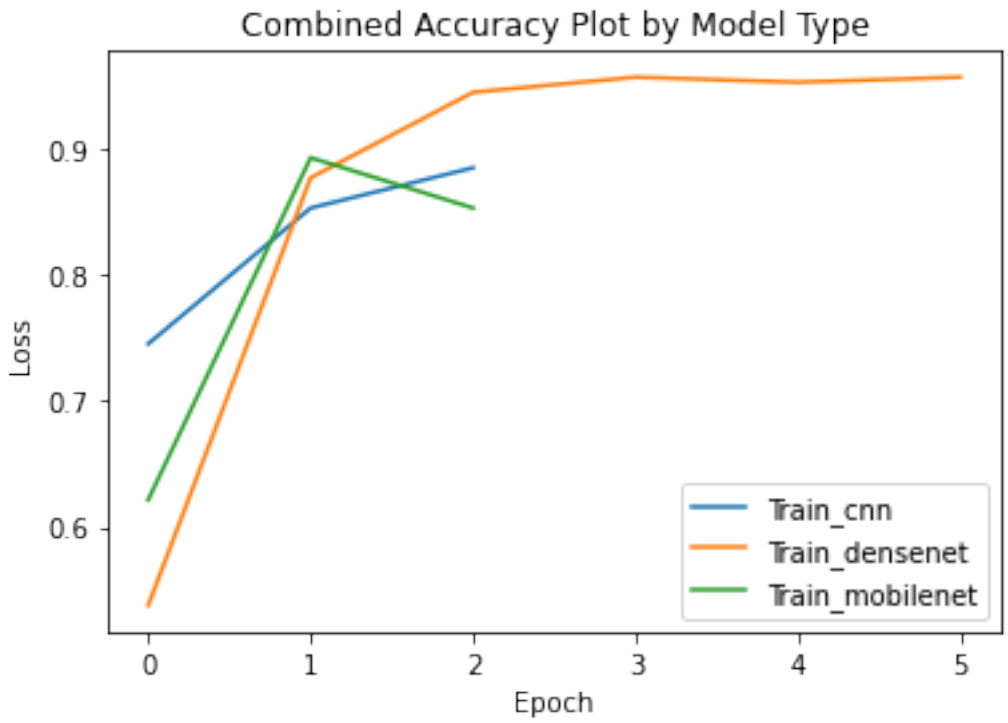
6 Combined the loss Plot

[44]:
```
# Plot the all loss result on one graph
plt.plot(history_cnn.history['loss'])
plt.plot(history_densenet.history['loss'])
plt.plot(history_mobilenet.history['loss'])

plt.title('Combined Loss Plot by Model Type')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train_cnn','Train_densenet','Train_mobilenet'],loc='best')
plt.show()
```



7 Combined the Accuracy PLot

[46]:
```
# Plot the all loss result on one graph
plt.plot(history_cnn.history['accuracy'])
plt.plot(history_densenet.history['accuracy'])
plt.plot(history_mobilenet.history['accuracy'])

plt.title('Combined Accuracy Plot by Model Type')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train_cnn','Train_densenet','Train_mobilenet'],loc='best')
plt.show()
```



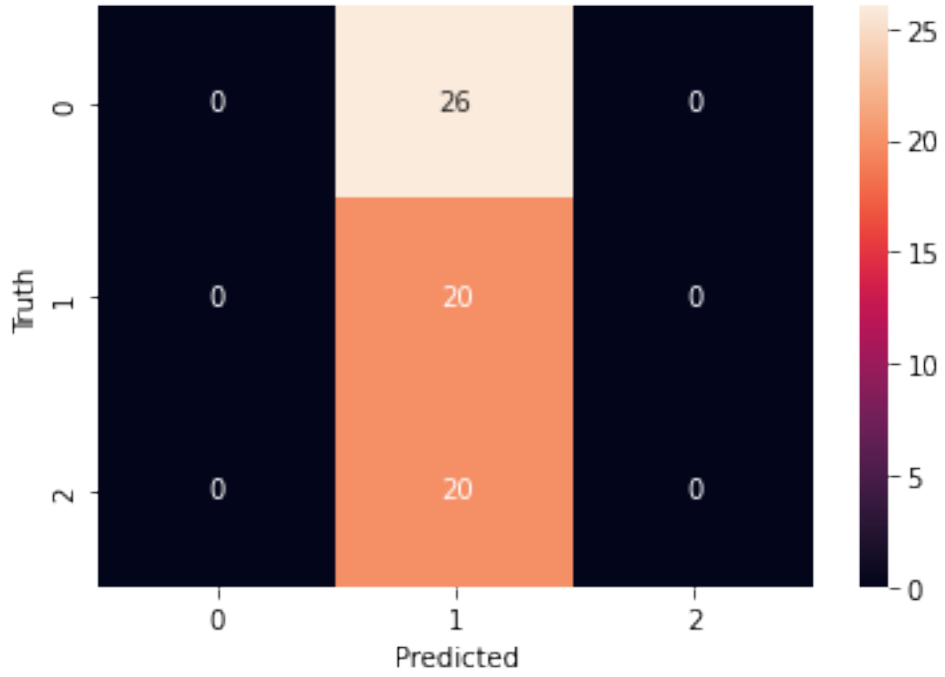
8 Final step:

- Compare all the models on the basis of accuracy, precision, recall, and f1-score

[47]:
```
# CNN model:-

y_pred = model_cnn.predict(validation_generator)
y_pred = np.argmax(y_pred, axis=1)
print('Confusion Matrix')
print(confusion_matrix(validation_generator.classes, y_pred))
cm = confusion_matrix(validation_generator.classes, y_pred)
sns.heatmap(cm, annot=True)
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

```
3/3 [==============================] - 1s 295ms/step
Confusion Matrix
[[ 0 26  0]
 [ 0 20  0]
 [ 0 20  0]]
```

[47]:
```
Text(33.0, 0.5, 'Truth')
```



[48]:
```
print(classification_report(validation_generator.classes,y_pred))
```

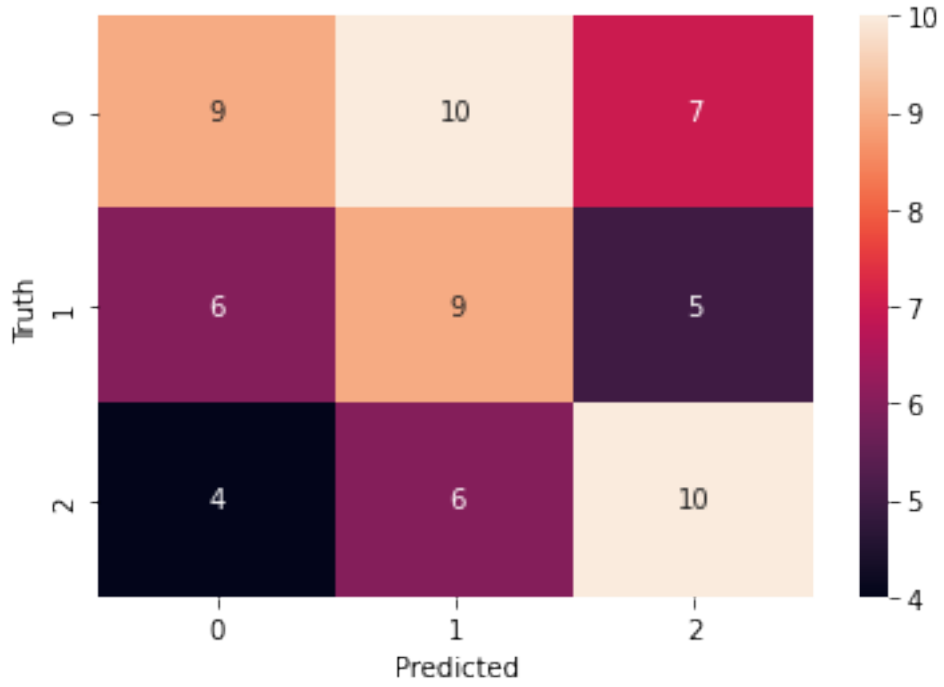
```
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        26
           1       0.30      1.00      0.47        20
           2       0.00      0.00      0.00        20

    accuracy                           0.30        66
   macro avg       0.10      0.33      0.16        66
weighted avg       0.09      0.30      0.14        66
```

[53]:
```
# DenseNet Pretrained model:-

y_pred = model_densenet.predict(validation_generator)
y_pred = np.argmax(y_pred, axis=1)
print('Confusion Matrix')
print(confusion_matrix(validation_generator.classes, y_pred))
cm = confusion_matrix(validation_generator.classes, y_pred)
sns.heatmap(cm, annot=True)
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

```
3/3 [==============================] - 3s 386ms/step
```

```
Confusion Matrix
[[ 9 10  7]
 [ 6  9  5]
 [ 4  6 10]]
```

[53]: `Text(33.0, 0.5, 'Truth')`



[54]:
```
print(classification_report(validation_generator.classes,y_pred))
```

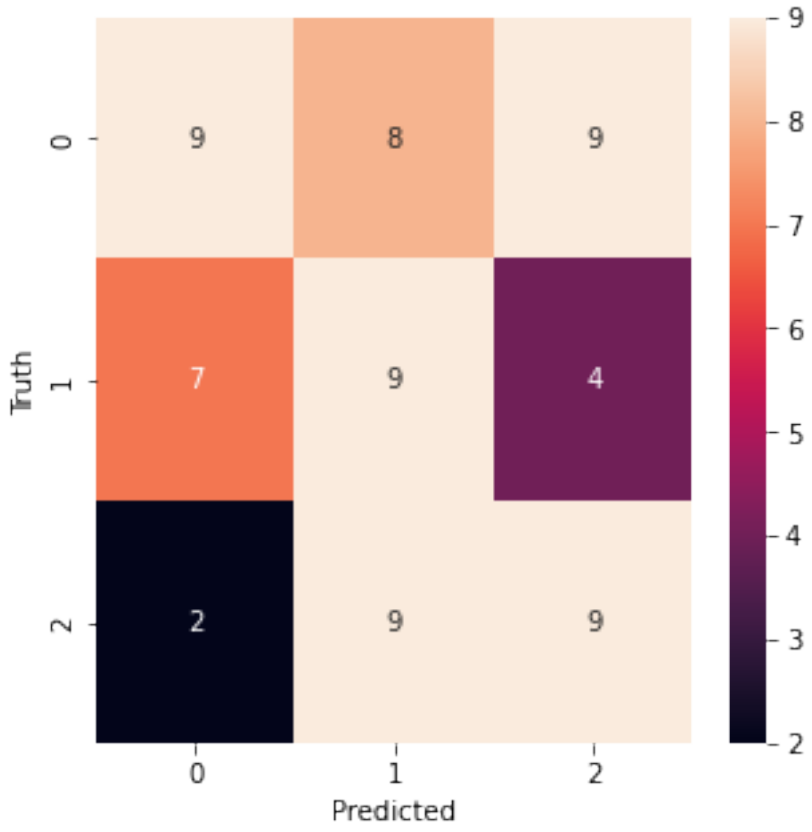
```
              precision    recall  f1-score   support

           0       0.47      0.35      0.40        26
           1       0.36      0.45      0.40        20
           2       0.45      0.50      0.48        20

    accuracy                           0.42        66
   macro avg       0.43      0.43      0.43        66
weighted avg       0.43      0.42      0.42        66
```

[55]:
```
# MobileNet Pretrained Model:-

y_pred = model_mobilenet.predict(validation_generator)
y_pred = np.argmax(y_pred, axis=1)
print('Confusion Matrix')
```

```
print(confusion_matrix(validation_generator.classes, y_pred))
cm = confusion_matrix(validation_generator.classes, y_pred)
plt.figure(figsize=(5,5))
sns.heatmap(cm, annot=True)
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

```
3/3 [==============================] - 1s 280ms/step
Confusion Matrix
[[9 8 9]
 [7 9 4]
 [2 9 9]]
```

[55]: Text(24.0, 0.5, 'Truth')



[56]:
```
print(classification_report(validation_generator.classes,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.50      0.35      0.41        26
           1       0.35      0.45      0.39        20
```

```
              2       0.41      0.45      0.43        20

       accuracy                           0.41        66
      macro avg       0.42      0.42      0.41        66
   weighted avg       0.43      0.41      0.41        66
```

[ ]: