bg2502-take-at-home

October 27, 2023

1 Problem Set 1 (Take Home) - 40 points

bg2502: Kindly use the Outline to navigate through this notebook

1.1 PS 1.A - 20 points

In this video the author explains how to extract various visualizations of what CNNs learn. Your course site also covers the topic.

Using the CIFAR-10 dataset, train a ResNet-50 based CNN on the classification task of $K = 9$ classes (filter out the class `ship`) and create the following visualizations for first, middle and last blocks of ResNet-50. You are free to select a class to showcase such visualizations.

- Visualizing intermediate convnet outputs ("intermediate activations"). This is useful to understand how successive convnet layers transform their input.
- Visualizing convnets filters. This is useful to understand precisely what visual pattern or concept each filter in a convnet is receptive to.
- Visualizing heatmaps of class activation in an image. This is useful to understand which part of an image where identified as belonging to a given class, and thus allows to localize objects in images.

[ ]:
```
# Insert your code here
import numpy as np
import tensorflow as tf
from keras.models import Sequential, Model, load_model
from keras.layers import Flatten, Input, Dense, Add, Activation, Dropout,␣
 ↪Conv2D, MaxPooling2D,GlobalAveragePooling2D, GlobalMaxPooling2D,␣
 ↪AveragePooling2D, Resizing, ZeroPadding2D, BatchNormalization
from keras.optimizers import Adam, SGD
from keras.regularizers import l2
from keras.initializers import glorot_uniform
from keras.preprocessing import image
from keras.utils import to_categorical
from keras.preprocessing.image import ImageDataGenerator
from keras.preprocessing import image


from keras.applications import ResNet50
```

```
# from keras.applications.resnet50 import preprocess_input

from keras import backend as K

from keras.datasets import cifar10

from sklearn.preprocessing import LabelEncoder , OneHotEncoder

from matplotlib.pyplot import imshow
import matplotlib.pyplot as plt
```

1.1.1 PS 1.A Data preprocessing

[ ]:
```
# Load the CIFAR-10 dataset
(x_train, y_train), (x_test, y_test) = cifar10.load_data()

classes = len(np.unique(y_train))
classes
```

[ ]: 10

we know the number of classes and index associated from her https://www.tensorflow.org/api_docs/python/tf/keras/datasets/cifar10/load_data

The classes are: | Label | Description | |——-|————-| | 0 | airplane | | 1 | automobile | | 2 | bird | | 3 | cat | | 4 | deer | | 5 | dog | | 6 | frog | | 7 | horse | | 8 | ship | | 9 | truck |

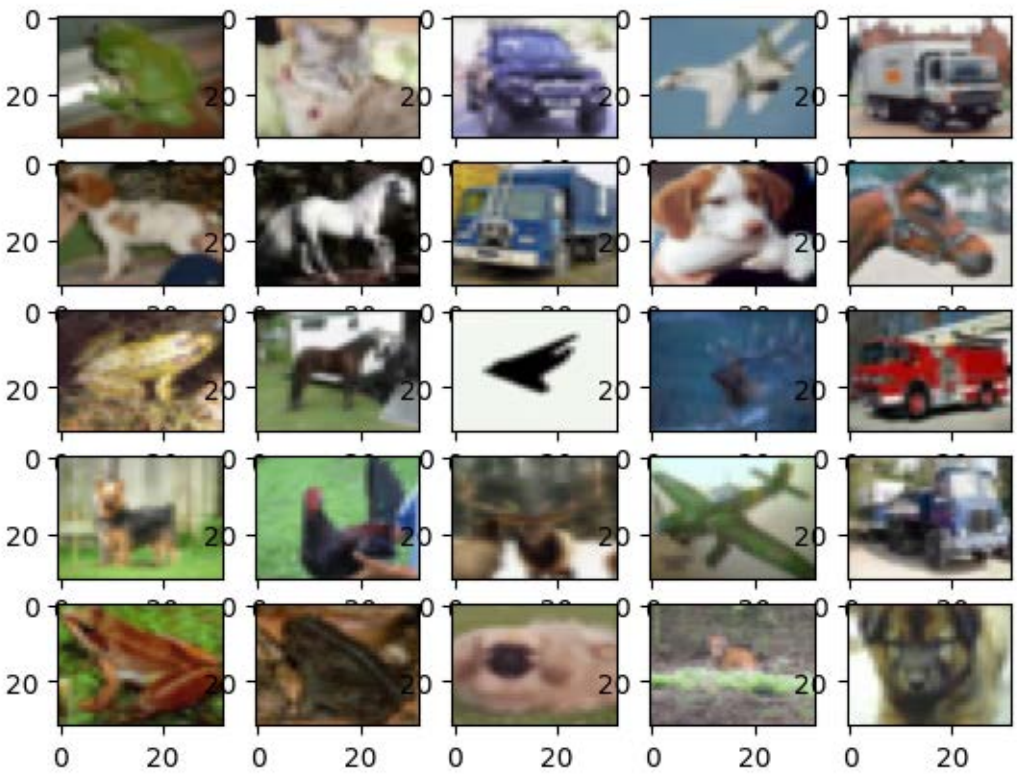
We have to exclude the class “ship with index 8”

[ ]:
```
# preprocess the CIFAR-10 dataset
index = np.where(y_train == 8)
# Filter the dataset for 9 out of 10 classes (exclude "ship index 8" class)
class_to_exclude = 8  # Adjust this class to exclude "ship"
x_train = x_train[y_train.flatten() != class_to_exclude]/ 255.0
y_train = y_train[y_train != class_to_exclude].astype(int)
x_test = x_test[y_test.flatten() != class_to_exclude] / 255.0
y_test = y_test[y_test != class_to_exclude].astype(int)

# number of classes K=9
k = 9
```

[ ]:
```
print(len(np.unique(y_train)), len(np.unique(x_train)), len(np.unique(y_test)),␣
  ↪len(np.unique(x_test)))
print(x_train.shape, y_train.shape, x_test.shape, y_test.shape)
```

```
9 256 9 256
(45000, 32, 32, 3) (45000,) (9000, 32, 32, 3) (9000,)
```

[ ]:
```
# visualize data by plotting images
fig, ax = plt.subplots(5, 5)
k = 5

for i in range(5):
    for j in range(5):
        ax[i][j].imshow(x_test[k], aspect='auto')
        k += 1

plt.show()
```



[ ]:
```
# A ResNet-50 model expects 224 × 224-pixel images
im_size = 224

x_train_resize = Resizing(height=im_size, width=im_size,␣
 ↪crop_to_aspect_ratio=True)(x_train)
x_test_resize = Resizing(height=im_size, width=im_size,␣
 ↪crop_to_aspect_ratio=True)(x_test)
```

[ ]:
```
print(x_train_resize.shape, y_train.shape, x_test_resize.shape, y_test.shape)
```

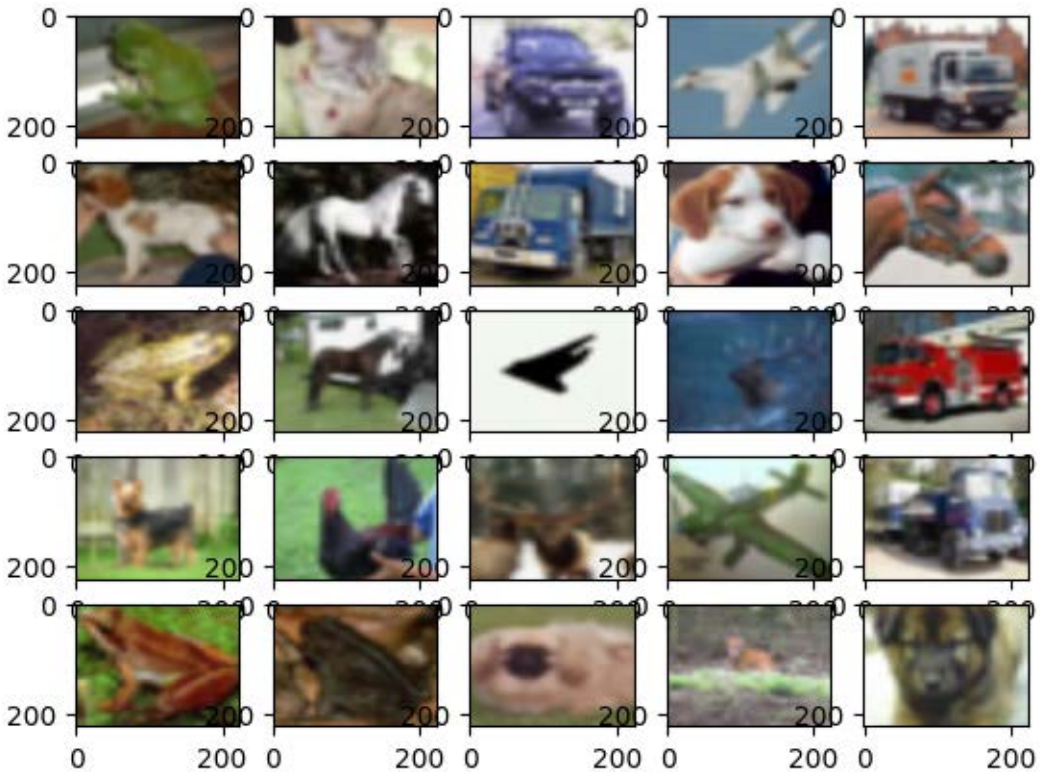
```
(45000, 224, 224, 3) (45000,) (9000, 224, 224, 3) (9000,)
```

[ ]:
```
# for y
y_labelencoder = LabelEncoder ()
y = y_labelencoder.fit_transform (y_train)
#print (y)

ytr=y_train.reshape(-1,1)
onehotencoder = OneHotEncoder()  #Converted  scalar output into vector output␣
 ↪where the correct class will be 1 and other will be 0
y_train_norm= onehotencoder.fit_transform(ytr).toarray()

yts=y_test.reshape(-1,1)
# onehotencoder = OneHotEncoder()  #Converted  scalar output into vector output␣
 ↪where the correct class will be 1 and other will be 0
y_test_norm= onehotencoder.transform(yts).toarray()
```

[ ]:
```
print(x_train_resize.shape, y_train_norm.shape, x_test_resize.shape,␣
 ↪y_test_norm.shape)
```

```
(45000, 224, 224, 3) (45000, 9) (9000, 224, 224, 3) (9000, 9)
```

[ ]:
```
# visualize data by plotting images
fig, ax = plt.subplots(5, 5)
k = 5

for i in range(5):
    for j in range(5):
        ax[i][j].imshow(x_test_resize[k], aspect='auto')
        k += 1

plt.show()
```



1.1.2 PS 1A. Let's build the ResNet50 architecture

Identity or Skip path Block

[ ]:
```
# x is input, y=F(x)
# identity block simply means input should be equal to output.
#  y = x + F(x)   the layers in a traditional network are learning the true␣
 ↪output H(x)
# F(x) = y - x   the layers in a residual network are learning the residual F(x)
# Hence, the name: Residual Block.


def identity_block(X, f, filters, stage, block):
    """

    Arguments:
    X -- input of shape (m, height, width, channel)
    f -- shape of the middle CONV's window for the main path
    filters -- python list of integers, defining the number of filters in the␣
 ↪CONV layers of the main path
    stage -- integer, used to name the layers, depending on their position in␣
 ↪the network
```

```
    block -- string/character, used to name the layers, depending on their␣
↪position in the network

    Returns:
    X -- output of the identity block, tensor of shape (n_H, n_W, n_C)
    """

    # defining name basis
    # conv_name_base = 'res' + str(stage) + block + '_branch'
    # bn_name_base = 'bn' + str(stage) + block + '_branch'
    conv_name_base = 'conv' + str(stage) + block + '_branch'
    bn_name_base = 'bn' + str(stage) + block + '_branch'

    # Retrieve Filters
    F1, F2, F3 = filters

    # Saving the input value.we need this later to add to the output.
    X_shortcut = X

    # First component of main path
    X = Conv2D(filters = F1, kernel_size = (1, 1), strides = (1,1), padding =␣
↪'valid', name = conv_name_base + '2a')(X)
    X = BatchNormalization(axis = 3, name = bn_name_base + '2a')(X)
    X = Activation('relu')(X)


    # Second component of main path (3 lines)
    X = Conv2D(filters = F2, kernel_size = (f, f), strides = (1,1), padding =␣
↪'same', name = conv_name_base + '2b')(X)
    X = BatchNormalization(axis = 3, name = bn_name_base + '2b')(X)
    X = Activation('relu')(X)

    # Third component of main path (2 lines)
    X = Conv2D(filters = F3, kernel_size = (1, 1), strides = (1,1), padding =␣
↪'valid', name = conv_name_base + '2c')(X)
    X = BatchNormalization(axis = 3, name = bn_name_base + '2c')(X)

    # Final step: Add shortcut value to main path, and pass it through a RELU␣
↪activation
    X = Add()([X, X_shortcut])
    X = Activation('relu')(X)


    return X
```

Convolutional BLock

```
[ ]: def convolutional_block(X, f, filters, stage, block, s = 2):

    # defining name basis
    # conv_name_base = 'res' + str(stage) + block + '_branch'
    # bn_name_base = 'bn' + str(stage) + block + '_branch'

    conv_name_base = 'conv' + str(stage) + block + '_branch'
    bn_name_base = 'bn' + str(stage) + block + '_branch'

    # Retrieve Filters
    F1, F2, F3 = filters

    # Save the input value
    X_shortcut = X


    # First layer
    X = Conv2D(F1, (1, 1), strides = (s,s), name = conv_name_base + '2a')(X) #␣
↪1,1 is filter size
    X = BatchNormalization(axis = 3, name = bn_name_base + '2a')(X)  #␣
↪normalization on channels
    X = Activation('relu')(X)


    # Second layer  (f,f)=3*3 filter by default
    X = Conv2D(filters = F2, kernel_size = (f, f), strides = (1,1), padding =␣
↪'same', name = conv_name_base + '2b')(X)
    X = BatchNormalization(axis = 3, name = bn_name_base + '2b')(X)
    X = Activation('relu')(X)


    # Third layer
    X = Conv2D(filters = F3, kernel_size = (1, 1), strides = (1,1), padding =␣
↪'valid', name = conv_name_base + '2c')(X)
    X = BatchNormalization(axis = 3, name = bn_name_base + '2c')(X)


    ##### SHORTCUT PATH ####
    X_shortcut = Conv2D(filters = F3, kernel_size = (1, 1), strides = (s,s),␣
↪padding = 'valid', name = conv_name_base + '1')(X_shortcut)
    X_shortcut = BatchNormalization(axis = 3, name = bn_name_base +␣
↪'1')(X_shortcut)

    # Final step: Add shortcut value here, and pass it through a RELU activation
    X = Add()([X, X_shortcut])
    X = Activation('relu')(X)
```

```
    return X
```

[ ]:
```
#Each ResNet block is either 2 layer deep
def ResNet50custom(input_shape=(64, 64, 3), classes=3):
    """
    Implementation of the ResNet50 architecture:
    CONV2D -> BATCHNORM -> RELU -> MAXPOOL -> CONVBLOCK -> IDBLOCK*2 ->␣
 ↪CONVBLOCK -> IDBLOCK*3
    -> CONVBLOCK -> IDBLOCK*5 -> CONVBLOCK -> IDBLOCK*2 -> AVGPOOL -> TOPLAYER

    """

    # Define the input as a tensor with shape input_shape
    X_input = Input(input_shape)

    # Zero-Padding
    X = ZeroPadding2D((3, 3))(X_input) #3,3 padding

    # Stage 1
    X = Conv2D(64, (7, 7), strides=(2, 2), name='conv1')(X) #64 filters of 7*7
    X = BatchNormalization(axis=3, name='bn_conv1')(X) #batchnorm applied on␣
 ↪channels
    X = Activation('relu')(X)
    X = MaxPooling2D((3, 3), strides=(2, 2))(X) #window size is 3*3

    # Stage 2
    X = convolutional_block(X, f=3, filters=[64, 64, 256], stage=2, block='a',␣
 ↪s=1)
    # convolutional_block is a function defined above. Convolutional_block have␣
 ↪3 layers.
    #filters=[64, 64, 256] first 64 is for 1st layer and 2nd 64 is for 2nd␣
 ↪layer and 256 is for 3rd layer of convultional block
    # below are the conv layers from convolutional_block function
    #X = Conv2D(F1, (1, 1), strides = (s,s), name = conv_name_base + '2a')(X)
    #X = Conv2D(F2, kernel_size = (f, f), strides = (1,1), padding = 'same',␣
 ↪name = conv_name_base + '2b')(X)
    #X = Conv2D(F3, (1, 1), strides = (s,s), name = conv_name_base + '2a')(X)

    X = identity_block(X, 3, [64, 64, 256], stage=2, block='b')
    #X = Conv2D(filters = F1, kernel_size = (1, 1), strides = (1,1), padding =␣
 ↪'valid', name = conv_name_base + '2a')(X)
    #X = Conv2D(filters = F2, kernel_size = (f, f), strides = (1,1), padding =␣
 ↪'same', name = conv_name_base + '2b')(X)
    #X = Conv2D(filters = F3, kernel_size = (1, 1), strides = (1,1), padding =␣
 ↪'valid', name = conv_name_base + '2c')(X)
```

```
    X = identity_block(X, 3, [64, 64, 256], stage=2, block='c')
    #X = Conv2D(filters = F1, kernel_size = (1, 1), strides = (1,1), padding =␣
↪'valid', name = conv_name_base + '2a')(X)
    #X = Conv2D(filters = F2, kernel_size = (f, f), strides = (1,1), padding =␣
↪'same', name = conv_name_base + '2b')(X)
    #X = Conv2D(filters = F3, kernel_size = (1, 1), strides = (1,1), padding =␣
↪'valid', name = conv_name_base + '2c')(X)


    ### START CODE HERE ###

    # Stage 3
    X = convolutional_block(X, f = 3, filters = [128, 128, 512], stage = 3,␣
↪block='a', s = 2)
    X = identity_block(X, 3, [128, 128, 512], stage=3, block='b')
    X = identity_block(X, 3, [128, 128, 512], stage=3, block='c')
    X = identity_block(X, 3, [128, 128, 512], stage=3, block='d')

    # Stage 4
    X = convolutional_block(X, f = 3, filters = [256, 256, 1024], stage = 4,␣
↪block='a', s = 2)
    X = identity_block(X, 3, [256, 256, 1024], stage=4, block='b')
    X = identity_block(X, 3, [256, 256, 1024], stage=4, block='c')
    X = identity_block(X, 3, [256, 256, 1024], stage=4, block='d')
    X = identity_block(X, 3, [256, 256, 1024], stage=4, block='e')
    X = identity_block(X, 3, [256, 256, 1024], stage=4, block='f')

    # Stage 5
    X = convolutional_block(X, f = 3, filters = [512, 512, 2048], stage = 5,␣
↪block='a', s = 2)
    X = identity_block(X, 3, [512, 512, 2048], stage=5, block='b')
    X = identity_block(X, 3, [512, 512, 2048], stage=5, block='c')

    # AVGPOOL
    X = AveragePooling2D((2,2), name="avg_pool")(X)

    ### END CODE HERE ###

    # output layer
    X = Flatten()(X)
    X = Dense(classes, activation='softmax', name='fc' + str(classes),␣
↪kernel_initializer = glorot_uniform(seed=0))(X)


    # Create model
    model = Model(inputs = X_input, outputs = X, name='ResNet50')
```

```
    return model
```

[ ]:
```
im_size = 224
k =9
model = ResNet50custom(input_shape = (im_size, im_size, 3), classes = k)
```

[ ]:
```
model.summary()
```

```
Model: "ResNet50"
__________________________________________________________________________________________________
 Layer (type)                Output Shape                 Param #   Connected to
==================================================================================================
 input_1 (InputLayer)        [(None, 224, 224, 3)]        0         []

 zero_padding2d (ZeroPaddin  (None, 230, 230, 3)          0
['input_1[0][0]']
 g2D)

 conv1 (Conv2D)              (None, 112, 112, 64)         9472
['zero_padding2d[0][0]']

 bn_conv1 (BatchNormalizati  (None, 112, 112, 64)         256
['conv1[0][0]']
 on)

 activation (Activation)     (None, 112, 112, 64)         0
['bn_conv1[0][0]']

 max_pooling2d (MaxPooling2  (None, 55, 55, 64)           0
['activation[0][0]']
 D)

 conv2a_branch2a (Conv2D)    (None, 55, 55, 64)           4160
['max_pooling2d[0][0]']

 bn2a_branch2a (BatchNormal  (None, 55, 55, 64)           256
['conv2a_branch2a[0][0]']
 ization)

 activation_1 (Activation)   (None, 55, 55, 64)           0
['bn2a_branch2a[0][0]']

 conv2a_branch2b (Conv2D)    (None, 55, 55, 64)           36928
['activation_1[0][0]']
```

```
 bn2a_branch2b (BatchNormal  (None, 55, 55, 64)          256
['conv2a_branch2b[0][0]']
 ization)

 activation_2 (Activation)   (None, 55, 55, 64)          0
['bn2a_branch2b[0][0]']

 conv2a_branch2c (Conv2D)    (None, 55, 55, 256)         16640
['activation_2[0][0]']

 conv2a_branch1 (Conv2D)     (None, 55, 55, 256)         16640
['max_pooling2d[0][0]']

 bn2a_branch2c (BatchNormal  (None, 55, 55, 256)         1024
['conv2a_branch2c[0][0]']
 ization)

 bn2a_branch1 (BatchNormali  (None, 55, 55, 256)         1024
['conv2a_branch1[0][0]']
 zation)

 add (Add)                   (None, 55, 55, 256)         0
['bn2a_branch2c[0][0]',
'bn2a_branch1[0][0]']

 activation_3 (Activation)   (None, 55, 55, 256)         0
['add[0][0]']

 conv2b_branch2a (Conv2D)    (None, 55, 55, 64)          16448
['activation_3[0][0]']

 bn2b_branch2a (BatchNormal  (None, 55, 55, 64)          256
['conv2b_branch2a[0][0]']
 ization)

 activation_4 (Activation)   (None, 55, 55, 64)          0
['bn2b_branch2a[0][0]']

 conv2b_branch2b (Conv2D)    (None, 55, 55, 64)          36928
['activation_4[0][0]']

 bn2b_branch2b (BatchNormal  (None, 55, 55, 64)          256
['conv2b_branch2b[0][0]']
 ization)

 activation_5 (Activation)   (None, 55, 55, 64)          0
['bn2b_branch2b[0][0]']
```

```
 conv2b_branch2c (Conv2D)    (None, 55, 55, 256)          16640
['activation_5[0][0]']

 bn2b_branch2c (BatchNormal  (None, 55, 55, 256)          1024
['conv2b_branch2c[0][0]']
 ization)

 add_1 (Add)                 (None, 55, 55, 256)          0
['bn2b_branch2c[0][0]',
'activation_3[0][0]']

 activation_6 (Activation)   (None, 55, 55, 256)          0
['add_1[0][0]']

 conv2c_branch2a (Conv2D)    (None, 55, 55, 64)           16448
['activation_6[0][0]']

 bn2c_branch2a (BatchNormal  (None, 55, 55, 64)           256
['conv2c_branch2a[0][0]']
 ization)

 activation_7 (Activation)   (None, 55, 55, 64)           0
['bn2c_branch2a[0][0]']

 conv2c_branch2b (Conv2D)    (None, 55, 55, 64)           36928
['activation_7[0][0]']

 bn2c_branch2b (BatchNormal  (None, 55, 55, 64)           256
['conv2c_branch2b[0][0]']
 ization)

 activation_8 (Activation)   (None, 55, 55, 64)           0
['bn2c_branch2b[0][0]']

 conv2c_branch2c (Conv2D)    (None, 55, 55, 256)          16640
['activation_8[0][0]']

 bn2c_branch2c (BatchNormal  (None, 55, 55, 256)          1024
['conv2c_branch2c[0][0]']
 ization)

 add_2 (Add)                 (None, 55, 55, 256)          0
['bn2c_branch2c[0][0]',
'activation_6[0][0]']

 activation_9 (Activation)   (None, 55, 55, 256)          0
['add_2[0][0]']
```

```
 conv3a_branch2a (Conv2D)    (None, 28, 28, 128)          32896
['activation_9[0][0]']

 bn3a_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3a_branch2a[0][0]']
 ization)

 activation_10 (Activation)  (None, 28, 28, 128)          0
['bn3a_branch2a[0][0]']

 conv3a_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_10[0][0]']

 bn3a_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3a_branch2b[0][0]']
 ization)

 activation_11 (Activation)  (None, 28, 28, 128)          0
['bn3a_branch2b[0][0]']

 conv3a_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_11[0][0]']

 conv3a_branch1 (Conv2D)     (None, 28, 28, 512)          131584
['activation_9[0][0]']

 bn3a_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3a_branch2c[0][0]']
 ization)

 bn3a_branch1 (BatchNormali  (None, 28, 28, 512)          2048
['conv3a_branch1[0][0]']
 zation)

 add_3 (Add)                 (None, 28, 28, 512)          0
['bn3a_branch2c[0][0]',
'bn3a_branch1[0][0]']

 activation_12 (Activation)  (None, 28, 28, 512)          0
['add_3[0][0]']

 conv3b_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_12[0][0]']

 bn3b_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3b_branch2a[0][0]']
 ization)
```

```
 activation_13 (Activation)  (None, 28, 28, 128)          0
['bn3b_branch2a[0][0]']

 conv3b_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_13[0][0]']

 bn3b_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3b_branch2b[0][0]']
 ization)

 activation_14 (Activation)  (None, 28, 28, 128)          0
['bn3b_branch2b[0][0]']

 conv3b_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_14[0][0]']

 bn3b_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3b_branch2c[0][0]']
 ization)

 add_4 (Add)                 (None, 28, 28, 512)          0
['bn3b_branch2c[0][0]',
'activation_12[0][0]']

 activation_15 (Activation)  (None, 28, 28, 512)          0
['add_4[0][0]']

 conv3c_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_15[0][0]']

 bn3c_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3c_branch2a[0][0]']
 ization)

 activation_16 (Activation)  (None, 28, 28, 128)          0
['bn3c_branch2a[0][0]']

 conv3c_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_16[0][0]']

 bn3c_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3c_branch2b[0][0]']
 ization)

 activation_17 (Activation)  (None, 28, 28, 128)          0
['bn3c_branch2b[0][0]']
```

```
 conv3c_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_17[0][0]']

 bn3c_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3c_branch2c[0][0]']
 ization)

 add_5 (Add)                 (None, 28, 28, 512)          0
['bn3c_branch2c[0][0]',
'activation_15[0][0]']

 activation_18 (Activation)  (None, 28, 28, 512)          0
['add_5[0][0]']

 conv3d_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_18[0][0]']

 bn3d_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3d_branch2a[0][0]']
 ization)

 activation_19 (Activation)  (None, 28, 28, 128)          0
['bn3d_branch2a[0][0]']

 conv3d_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_19[0][0]']

 bn3d_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3d_branch2b[0][0]']
 ization)

 activation_20 (Activation)  (None, 28, 28, 128)          0
['bn3d_branch2b[0][0]']

 conv3d_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_20[0][0]']

 bn3d_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3d_branch2c[0][0]']
 ization)

 add_6 (Add)                 (None, 28, 28, 512)          0
['bn3d_branch2c[0][0]',
'activation_18[0][0]']

 activation_21 (Activation)  (None, 28, 28, 512)          0
['add_6[0][0]']
```

```
 conv4a_branch2a (Conv2D)    (None, 14, 14, 256)          131328
['activation_21[0][0]']

 bn4a_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4a_branch2a[0][0]']
 ization)

 activation_22 (Activation)  (None, 14, 14, 256)          0
['bn4a_branch2a[0][0]']

 conv4a_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_22[0][0]']

 bn4a_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4a_branch2b[0][0]']
 ization)

 activation_23 (Activation)  (None, 14, 14, 256)          0
['bn4a_branch2b[0][0]']

 conv4a_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_23[0][0]']

 conv4a_branch1 (Conv2D)     (None, 14, 14, 1024)         525312
['activation_21[0][0]']

 bn4a_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4a_branch2c[0][0]']
 ization)

 bn4a_branch1 (BatchNormali  (None, 14, 14, 1024)         4096
['conv4a_branch1[0][0]']
 zation)

 add_7 (Add)                 (None, 14, 14, 1024)         0
['bn4a_branch2c[0][0]',
'bn4a_branch1[0][0]']

 activation_24 (Activation)  (None, 14, 14, 1024)         0
['add_7[0][0]']

 conv4b_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_24[0][0]']

 bn4b_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4b_branch2a[0][0]']
 ization)
```

```
 activation_25 (Activation)  (None, 14, 14, 256)          0
['bn4b_branch2a[0][0]']

 conv4b_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_25[0][0]']

 bn4b_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4b_branch2b[0][0]']
 ization)

 activation_26 (Activation)  (None, 14, 14, 256)          0
['bn4b_branch2b[0][0]']

 conv4b_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_26[0][0]']

 bn4b_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4b_branch2c[0][0]']
 ization)

 add_8 (Add)                 (None, 14, 14, 1024)         0
['bn4b_branch2c[0][0]',
'activation_24[0][0]']

 activation_27 (Activation)  (None, 14, 14, 1024)         0
['add_8[0][0]']

 conv4c_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_27[0][0]']

 bn4c_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4c_branch2a[0][0]']
 ization)

 activation_28 (Activation)  (None, 14, 14, 256)          0
['bn4c_branch2a[0][0]']

 conv4c_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_28[0][0]']

 bn4c_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4c_branch2b[0][0]']
 ization)

 activation_29 (Activation)  (None, 14, 14, 256)          0
['bn4c_branch2b[0][0]']

 conv4c_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
```

```
['activation_29[0][0]']

 bn4c_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4c_branch2c[0][0]']
 ization)

 add_9 (Add)                 (None, 14, 14, 1024)         0
['bn4c_branch2c[0][0]',
'activation_27[0][0]']

 activation_30 (Activation)  (None, 14, 14, 1024)         0
['add_9[0][0]']

 conv4d_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_30[0][0]']

 bn4d_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4d_branch2a[0][0]']
 ization)

 activation_31 (Activation)  (None, 14, 14, 256)          0
['bn4d_branch2a[0][0]']

 conv4d_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_31[0][0]']

 bn4d_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4d_branch2b[0][0]']
 ization)

 activation_32 (Activation)  (None, 14, 14, 256)          0
['bn4d_branch2b[0][0]']

 conv4d_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_32[0][0]']

 bn4d_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4d_branch2c[0][0]']
 ization)

 add_10 (Add)                (None, 14, 14, 1024)         0
['bn4d_branch2c[0][0]',
'activation_30[0][0]']

 activation_33 (Activation)  (None, 14, 14, 1024)         0
['add_10[0][0]']

 conv4e_branch2a (Conv2D)    (None, 14, 14, 256)          262400
```

```
['activation_33[0][0]']

 bn4e_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4e_branch2a[0][0]']
 ization)

 activation_34 (Activation)  (None, 14, 14, 256)          0
['bn4e_branch2a[0][0]']

 conv4e_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_34[0][0]']

 bn4e_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4e_branch2b[0][0]']
 ization)

 activation_35 (Activation)  (None, 14, 14, 256)          0
['bn4e_branch2b[0][0]']

 conv4e_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_35[0][0]']

 bn4e_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4e_branch2c[0][0]']
 ization)

 add_11 (Add)                (None, 14, 14, 1024)         0
['bn4e_branch2c[0][0]',
'activation_33[0][0]']

 activation_36 (Activation)  (None, 14, 14, 1024)         0
['add_11[0][0]']

 conv4f_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_36[0][0]']

 bn4f_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4f_branch2a[0][0]']
 ization)

 activation_37 (Activation)  (None, 14, 14, 256)          0
['bn4f_branch2a[0][0]']

 conv4f_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_37[0][0]']

 bn4f_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4f_branch2b[0][0]']
```

```
 ization)

 activation_38 (Activation)  (None, 14, 14, 256)          0
['bn4f_branch2b[0][0]']

 conv4f_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_38[0][0]']

 bn4f_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4f_branch2c[0][0]']
 ization)

 add_12 (Add)                (None, 14, 14, 1024)         0
['bn4f_branch2c[0][0]',
'activation_36[0][0]']

 activation_39 (Activation)  (None, 14, 14, 1024)         0
['add_12[0][0]']

 conv5a_branch2a (Conv2D)    (None, 7, 7, 512)            524800
['activation_39[0][0]']

 bn5a_branch2a (BatchNormal  (None, 7, 7, 512)            2048
['conv5a_branch2a[0][0]']
 ization)

 activation_40 (Activation)  (None, 7, 7, 512)            0
['bn5a_branch2a[0][0]']

 conv5a_branch2b (Conv2D)    (None, 7, 7, 512)            2359808
['activation_40[0][0]']

 bn5a_branch2b (BatchNormal  (None, 7, 7, 512)            2048
['conv5a_branch2b[0][0]']
 ization)

 activation_41 (Activation)  (None, 7, 7, 512)            0
['bn5a_branch2b[0][0]']

 conv5a_branch2c (Conv2D)    (None, 7, 7, 2048)           1050624
['activation_41[0][0]']

 conv5a_branch1 (Conv2D)     (None, 7, 7, 2048)           2099200
['activation_39[0][0]']

 bn5a_branch2c (BatchNormal  (None, 7, 7, 2048)           8192
['conv5a_branch2c[0][0]']
 ization)
```

```
 bn5a_branch1 (BatchNormali  (None, 7, 7, 2048)          8192
['conv5a_branch1[0][0]']
 zation)

 add_13 (Add)                (None, 7, 7, 2048)          0
['bn5a_branch2c[0][0]',
'bn5a_branch1[0][0]']

 activation_42 (Activation)  (None, 7, 7, 2048)          0
['add_13[0][0]']

 conv5b_branch2a (Conv2D)    (None, 7, 7, 512)           1049088
['activation_42[0][0]']

 bn5b_branch2a (BatchNormal  (None, 7, 7, 512)           2048
['conv5b_branch2a[0][0]']
 ization)

 activation_43 (Activation)  (None, 7, 7, 512)           0
['bn5b_branch2a[0][0]']

 conv5b_branch2b (Conv2D)    (None, 7, 7, 512)           2359808
['activation_43[0][0]']

 bn5b_branch2b (BatchNormal  (None, 7, 7, 512)           2048
['conv5b_branch2b[0][0]']
 ization)

 activation_44 (Activation)  (None, 7, 7, 512)           0
['bn5b_branch2b[0][0]']

 conv5b_branch2c (Conv2D)    (None, 7, 7, 2048)          1050624
['activation_44[0][0]']

 bn5b_branch2c (BatchNormal  (None, 7, 7, 2048)          8192
['conv5b_branch2c[0][0]']
 ization)

 add_14 (Add)                (None, 7, 7, 2048)          0
['bn5b_branch2c[0][0]',
'activation_42[0][0]']

 activation_45 (Activation)  (None, 7, 7, 2048)          0
['add_14[0][0]']

 conv5c_branch2a (Conv2D)    (None, 7, 7, 512)           1049088
['activation_45[0][0]']
```

```
 bn5c_branch2a (BatchNormal  (None, 7, 7, 512)           2048
['conv5c_branch2a[0][0]']
 ization)

 activation_46 (Activation)  (None, 7, 7, 512)           0
['bn5c_branch2a[0][0]']

 conv5c_branch2b (Conv2D)    (None, 7, 7, 512)           2359808
['activation_46[0][0]']

 bn5c_branch2b (BatchNormal  (None, 7, 7, 512)           2048
['conv5c_branch2b[0][0]']
 ization)

 activation_47 (Activation)  (None, 7, 7, 512)           0
['bn5c_branch2b[0][0]']

 conv5c_branch2c (Conv2D)    (None, 7, 7, 2048)          1050624
['activation_47[0][0]']

 bn5c_branch2c (BatchNormal  (None, 7, 7, 2048)          8192
['conv5c_branch2c[0][0]']
 ization)

 add_15 (Add)                (None, 7, 7, 2048)          0
['bn5c_branch2c[0][0]',
'activation_45[0][0]']

 activation_48 (Activation)  (None, 7, 7, 2048)          0
['add_15[0][0]']

 avg_pool (AveragePooling2D  (None, 3, 3, 2048)          0
['activation_48[0][0]']
 )

 flatten (Flatten)           (None, 18432)               0
['avg_pool[0][0]']

 fc9 (Dense)                 (None, 9)                   165897
['flatten[0][0]']

==================================================================================
==================
Total params: 23753609 (90.61 MB)
Trainable params: 23700489 (90.41 MB)
Non-trainable params: 53120 (207.50 KB)
----------------------------------------------------------------------------------
```

1.1.3 PS1A. ResNet50 non custom

[ ]:
```
# Load ResNet-50 with custom input size
im_size = 224

base_model = ResNet50(input_shape=(im_size, im_size, 3), include_top=False,␣
 ↪weights=None)

# Adjust the feature map size before average pooling
x = base_model.layers[-1].output
x = AveragePooling2D(pool_size=(2, 2))(x)  # Reduce feature map size to 1x1
x = Flatten()(x)
output = Dense(9, activation='softmax')(x)

# Create a new model
model = Model(inputs=base_model.input, outputs=output)
```

[ ]:
```
model.summary()
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)       0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)      9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)      256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)      0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)      0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)        0
['pool1_pad[0][0]']
```

```
 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)
```

```
 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)
```

```
 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)
```

```
 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)
```

```
 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)
```

```
 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)
```

```
 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)
```

```
 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)
```

```
 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)
```

```
 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)
```

```
 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)
```

```
 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)
```

```
 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)
```

```
 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)
```

```
 average_pooling2d (Average  (None, 3, 3, 2048)          0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)               0
['average_pooling2d[0][0]']

 dense (Dense)               (None, 9)                   165897
['flatten[0][0]']

==================================================================================
==================
Total params: 23753609 (90.61 MB)
Trainable params: 23700489 (90.41 MB)
Non-trainable params: 53120 (207.50 KB)
----------------------------------------------------------------------------------
------------------
```

[ ]:
```
# Set hyperparameters
learning_rate = 0.001
beta1 = 0.9
beta2 = 0.999
epsilon = 1e-8
num_iterations = 1000
# optimizer = Adam(learning_rate=learning_rate, beta_1=beta1, beta_2=beta2,␣
 ↪epsilon=1e-8)
optimizer = SGD(learning_rate=learning_rate, momentum=0.9, nesterov=True)
model.compile(optimizer=optimizer, loss='categorical_crossentropy',␣
 ↪metrics=['accuracy'])
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

[ ]:
```
# Define a custom callback to track validation loss
class ValidationLoss(tf.keras.callbacks.Callback):
    def __init__(self):
        super(ValidationLoss, self).__init__()
        self.validation_losses = []

    def on_epoch_end(self, epoch, logs=None):
        self.validation_losses.append(logs['val_loss'])

# Define the custom learning rate scheduler
class CustomLRScheduler(tf.keras.callbacks.Callback):
    def on_epoch_begin(self, epoch, logs=None):
        new_lr = 0.001 / np.sqrt(epoch+1)
```

```
        K.set_value(self.model.optimizer.lr, new_lr)
        print(f'Epoch {epoch + 1}: Learning Rate = {new_lr}')
```

[ ]:
```
# x_train_resize.shape, y_train_norm.shape, x_test_resize.shape, y_test_norm.
 ↪shape
# model.fit(x_train_resize, x_train_resize, epochs = 10, batch_size = 128)
# model.fit(x_train_resize, y_train_norm, epochs=45, batch_size = 128,␣
 ↪validation_data=(x_test_resize, x_test_resize), verbose=0)
# Create a custom callback to track validation loss
val_loss_callback = ValidationLoss()
lr_scheduler = CustomLRScheduler()

model.fit(
    x=x_train_resize,  # Your training data
    y=y_train_norm,  # Your training labels
    batch_size=64,
    epochs=5,
    steps_per_epoch=10,
    validation_data=(x_test_resize, y_test_norm),
    callbacks=[val_loss_callback, lr_scheduler]
    # Other parameters like callbacks, verbose, etc.
)


model.save('model_my_custom_resnet50_aug2.h5')
```

```
Epoch 1: Learning Rate = 0.001
Epoch 1/5
10/10 [==============================] - 245s 26s/step - loss: 2.6025 -
accuracy: 0.3016 - val_loss: 10.6501 - val_accuracy: 0.1303
Epoch 2: Learning Rate = 0.0007071067811865475
Epoch 2/5
10/10 [==============================] - 249s 27s/step - loss: 2.8719 -
accuracy: 0.2797 - val_loss: 4.2490 - val_accuracy: 0.1624
Epoch 3: Learning Rate = 0.0005773502691896258
Epoch 3/5
10/10 [==============================] - 244s 26s/step - loss: 2.9668 -
accuracy: 0.2578 - val_loss: 3.3308 - val_accuracy: 0.1773
Epoch 4: Learning Rate = 0.0005
Epoch 4/5
10/10 [==============================] - 254s 27s/step - loss: 2.1763 -
accuracy: 0.3219 - val_loss: 5.5174 - val_accuracy: 0.1897
Epoch 5: Learning Rate = 0.0004472135954999579
Epoch 5/5
10/10 [==============================] - 245s 26s/step - loss: 2.5679 -
accuracy: 0.2703 - val_loss: 4.3503 - val_accuracy: 0.1356

/Users/banani/Library/Python/3.9/lib/python/site-
```

```
packages/keras/src/engine/training.py:3079: UserWarning: You are saving your
model as an HDF5 file via `model.save()`. This file format is considered legacy.
We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')`.
  saving_api.save_model(
```

[ ]:
```
model.save('model_resnet50_lr3.h5')
```

[ ]:
```
## Data augmentation

batch_size = 32
data_generator = tf.keras.preprocessing.image.ImageDataGenerator(
  width_shift_range=0.1, height_shift_range=0.1, horizontal_flip=True)

train_generator = data_generator.flow(x_train_resize,
                                      y_train_norm,
                                      batch_size)
steps_per_epoch = x_train_resize.shape[0] // batch_size
```

[ ]:
```
r = model.fit_generator(train_generator,
              validation_data=(x_test_resize, y_test_norm),
              batch_size=64,
              epochs=5,
              steps_per_epoch=10,
              callbacks=[val_loss_callback, lr_scheduler]
              )

model.save('model_resnet50_aug4.h5')
```

```
Epoch 1: Learning Rate = 0.001
Epoch 1/5
10/10 [==============================] - 219s 24s/step - loss: 3.6517 -
accuracy: 0.2594 - val_loss: 4.6119 - val_accuracy: 0.1868
Epoch 2: Learning Rate = 0.0007071067811865475
Epoch 2/5
10/10 [==============================] - 214s 23s/step - loss: 4.8421 -
accuracy: 0.2062 - val_loss: 2.7708 - val_accuracy: 0.1488
Epoch 3: Learning Rate = 0.0005773502691896258
Epoch 3/5
10/10 [==============================] - 217s 24s/step - loss: 4.4187 -
accuracy: 0.2562 - val_loss: 2.0583 - val_accuracy: 0.2217
Epoch 4: Learning Rate = 0.0005
Epoch 4/5
10/10 [==============================] - 219s 24s/step - loss: 3.4729 -
accuracy: 0.2562 - val_loss: 2.2416 - val_accuracy: 0.1591
Epoch 5: Learning Rate = 0.0004472135954999579
Epoch 5/5
10/10 [==============================] - 217s 24s/step - loss: 2.9785 -
```

```
accuracy: 0.3063 - val_loss: 2.1482 - val_accuracy: 0.1852
```

[ ]:
```
r = model.fit(train_generator,
              validation_data=(x_test_resize, y_test_norm),
              batch_size=64,
              epochs=10,
              steps_per_epoch=10,
              callbacks=[val_loss_callback, lr_scheduler]
              )

model.save('model_resnet50_aug3.h5')
```

```
Epoch 1/10
10/10 [==============================] - 314s 35s/step - loss: 2.0968 -
accuracy: 0.2250 - val_loss: 2.2848 - val_accuracy: 0.2092
Epoch 2/10
10/10 [==============================] - 201s 22s/step - loss: 2.0053 -
accuracy: 0.2594 - val_loss: 2.4074 - val_accuracy: 0.2038
Epoch 3/10
10/10 [==============================] - 202s 22s/step - loss: 2.1640 -
accuracy: 0.2188 - val_loss: 2.2850 - val_accuracy: 0.2204
Epoch 4/10
10/10 [==============================] - 205s 22s/step - loss: 2.2046 -
accuracy: 0.2281 - val_loss: 2.3327 - val_accuracy: 0.2210
Epoch 5/10
10/10 [==============================] - 213s 23s/step - loss: 2.0892 -
accuracy: 0.2594 - val_loss: 2.2663 - val_accuracy: 0.2052
Epoch 6/10
10/10 [==============================] - 199s 22s/step - loss: 2.1547 -
accuracy: 0.2313 - val_loss: 2.2064 - val_accuracy: 0.2120
Epoch 7/10
10/10 [==============================] - 200s 22s/step - loss: 2.0995 -
accuracy: 0.2781 - val_loss: 2.2011 - val_accuracy: 0.2298
Epoch 8/10
10/10 [==============================] - 198s 22s/step - loss: 2.0862 -
accuracy: 0.2281 - val_loss: 2.2361 - val_accuracy: 0.2410
Epoch 9/10
10/10 [==============================] - 201s 22s/step - loss: 1.9848 -
accuracy: 0.2812 - val_loss: 2.3769 - val_accuracy: 0.2199
Epoch 10/10
10/10 [==============================] - 202s 22s/step - loss: 2.1150 -
accuracy: 0.2031 - val_loss: 2.3380 - val_accuracy: 0.2232
```

1.1.4 Predict the architecture

[ ]:
```
predictions = model.predict(x_test_resize)
```

```
282/282 [==============================] - 190s 671ms/step
```

[ ]:
```
# Visualize predictions on test data
predicted_labels = (predictions > 0.5).astype(int)
sample_images = x_test_resize[:10]
sample_labels = y_test_norm[:10]
```

[ ]:
```
for i in range(10):
    plt.subplot(2, 5, i + 1)
    plt.imshow(sample_images[i])
    plt.title(f'Predicted: {predicted_labels[i][0]}\nActual:␣
 ↪{sample_labels[i][0]}')
    plt.axis('off')

plt.show()
```

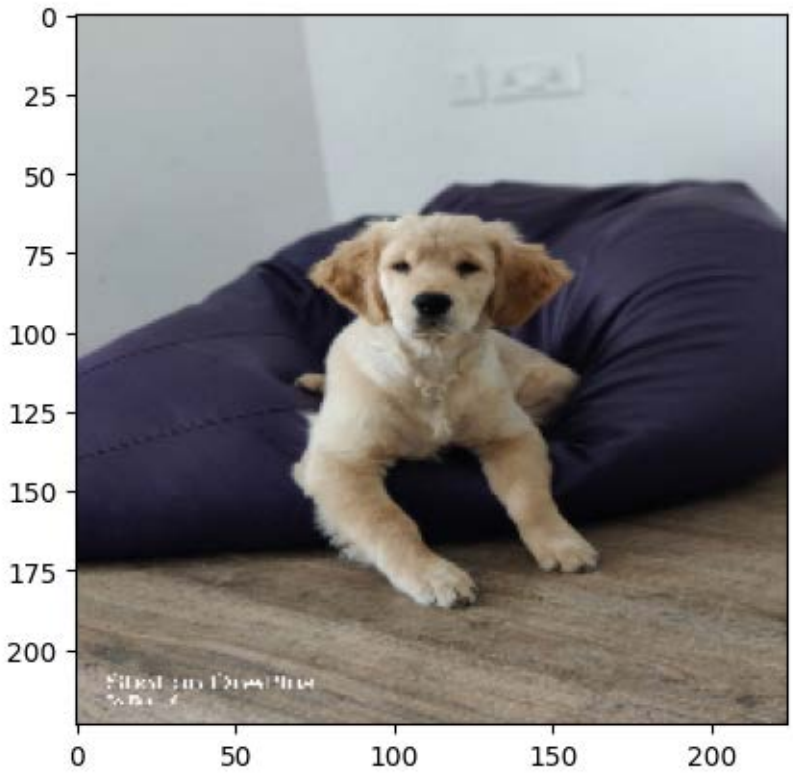
1.1.5 PS1A. Visualize Intermediate Activations

[ ]:
```
img_path='refs/dog_1.jpg'
# img_path='refs/dog.215.jpg'

# We preprocess the image into a 4D tensor
from keras.preprocessing import image
import numpy as np

im_size = 224
```

```
img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))
img_tensor = tf.keras.utils.img_to_array(img)
img_tensor = np.expand_dims(img_tensor, axis=0)
# the model was trained on inputs
# that were preprocessed in the following way:
img_tensor /= 255.

# Its shape is (1, 224, 224, 3)
print(img_tensor.shape)
```

```
(1, 224, 224, 3)
```

[ ]:
```
import matplotlib.pyplot as plt

plt.imshow(img_tensor[0])
plt.show()
```



Chosen layers

[ ]:
```
layers_to_visualize = [model.get_layer('conv1_relu'),
                       model.get_layer('conv3_block2_2_relu'),
                       model.get_layer('conv5_block3_2_relu')]
```

```
for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

[ ]:
```
act_input1 = model.input
# Extracts the outputs of the top 50 layers:
# layer_outputs = [layer.output for layer in model.layers[1:51]]
layer_outputs1 = [layer.output for layer in layers_to_visualize]

# First block :  conv1
# Middle block:  conv2c_branch2b
# Last block:    conv5c_branch2c

# layer_outputs = [layer.output for layer in layers_to_visualize]
# Creates a model that will return these outputs, given the model input:
activation_model1 = Model(inputs=act_input1, outputs=layer_outputs1)
activation_model1.summary()
```

```
Model: "model_1"
__________________________________________________________________________________
__________________
 Layer (type)                Output Shape              Param #   Connected to
==================================================================================
==================
 input_1 (InputLayer)        [(None, 224, 224, 3)]     0         []

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)       0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)      9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)      256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)      0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)      0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)        0
['pool1_pad[0][0]']
```

```
 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)
```

```
 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)
```

```
 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)
```

```
 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)
```

```
 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)
```

```
 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)
```

```
 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)
```

```
 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)
```

```
 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)
```

```
 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)
```

```
 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)
```

```
 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)
```

```
 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)
```

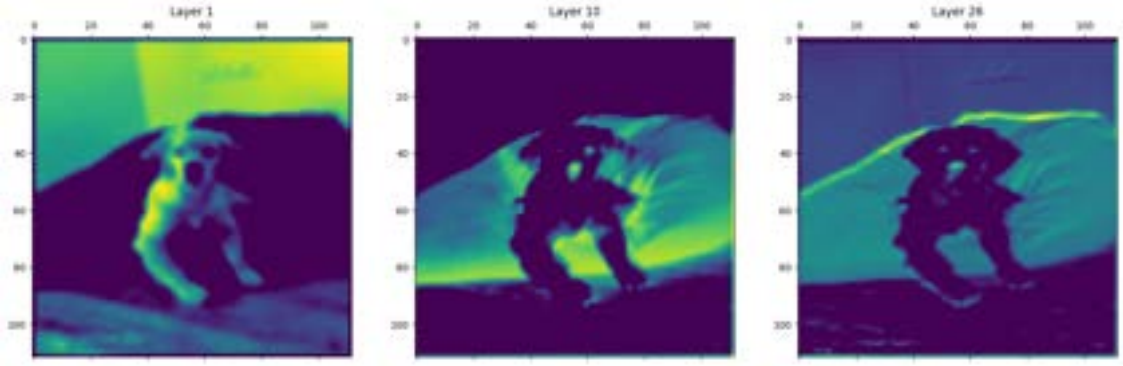
```
 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

==================================================================================
==================
Total params: 22528896 (85.94 MB)
Trainable params: 22479872 (85.75 MB)
Non-trainable params: 49024 (191.50 KB)
----------------------------------------------------------------------------------
------------------
```

First Layer Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

first_layer_activation = activations[0]
print(first_layer_activation.shape)
```

```
for activation in activations:
    print(activation.shape)

# for i in range(3):  # Loop through the channels
#     plt.matshow(first_layer_activation[0, :, :, i], cmap='viridis')
#     plt.show()
# plt.matshow(first_layer_activation[0, :, :, 0], cmap='viridis')
# plt.show()
# plt.matshow(first_layer_activation[0, :, :, 3], cmap='viridis')
# plt.show()

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(first_layer_activation[0, :, :, 6], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(first_layer_activation[0, :, :, 10], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(first_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 57ms/step
(1, 112, 112, 64)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```



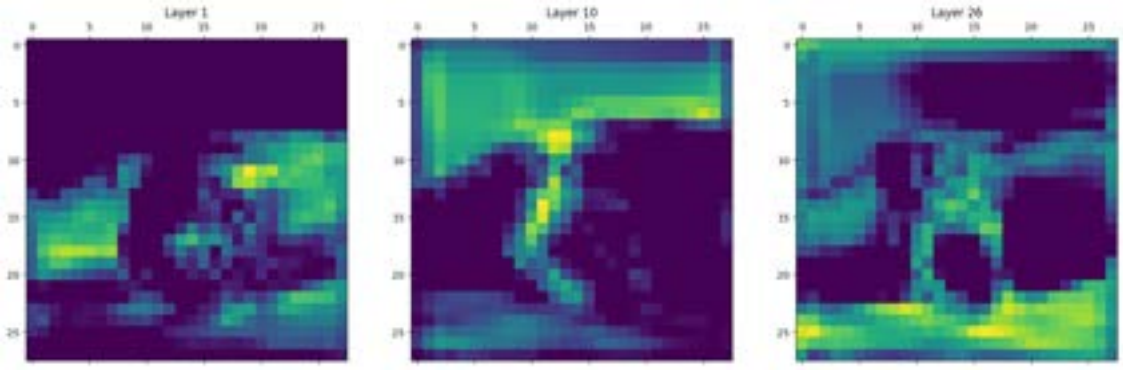
This one looks like a “bright green dots” detector, useful to encode dog eyes and nose and it gets further clear as we go deeper.

At this point, let’s go and plot a complete visualization of all the activations in the network.

Middle Layer Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

middle_layer_activation = activations[1]
print(middle_layer_activation.shape)

for activation in activations:
    print(activation.shape)

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(middle_layer_activation[0, :, :, 6], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(middle_layer_activation[0, :, :, 10], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(middle_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 57ms/step
(1, 28, 28, 128)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```



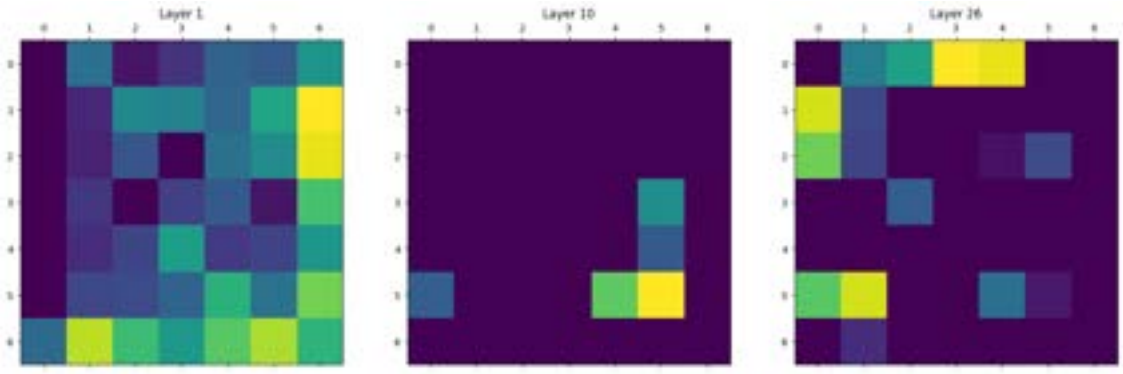
This one looks like the edges of the dog are more defined and some contours noticed in the deeper layers

At this point, let's go and plot a complete visualization of all the activations in the network.

Last Layer Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

last_layer_activation = activations[2]
print(first_layer_activation.shape)

for activation in activations:
    print(activation.shape)

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(last_layer_activation[0, :, :, 1], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(last_layer_activation[0, :, :, 11], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(last_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

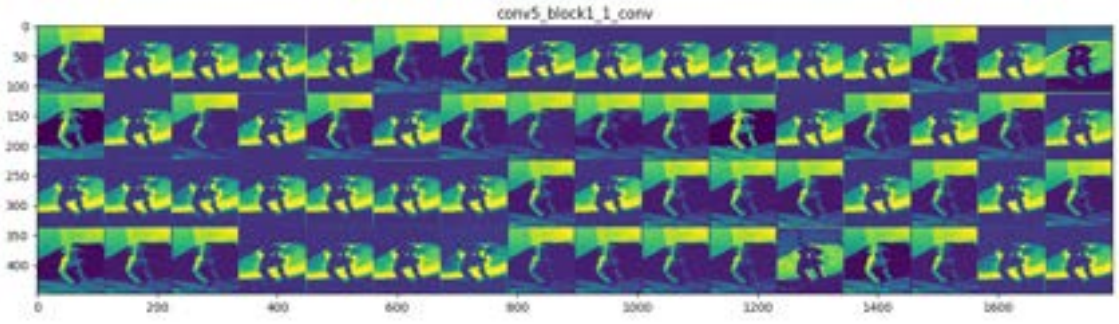
```
1/1 [==============================] - 0s 51ms/step
(1, 112, 112, 64)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```

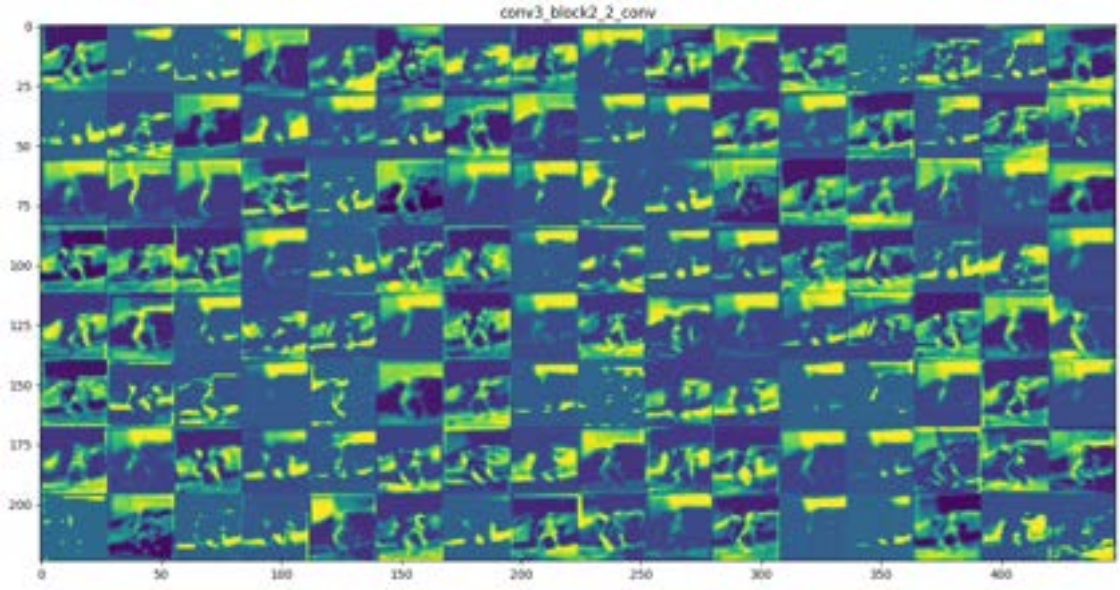


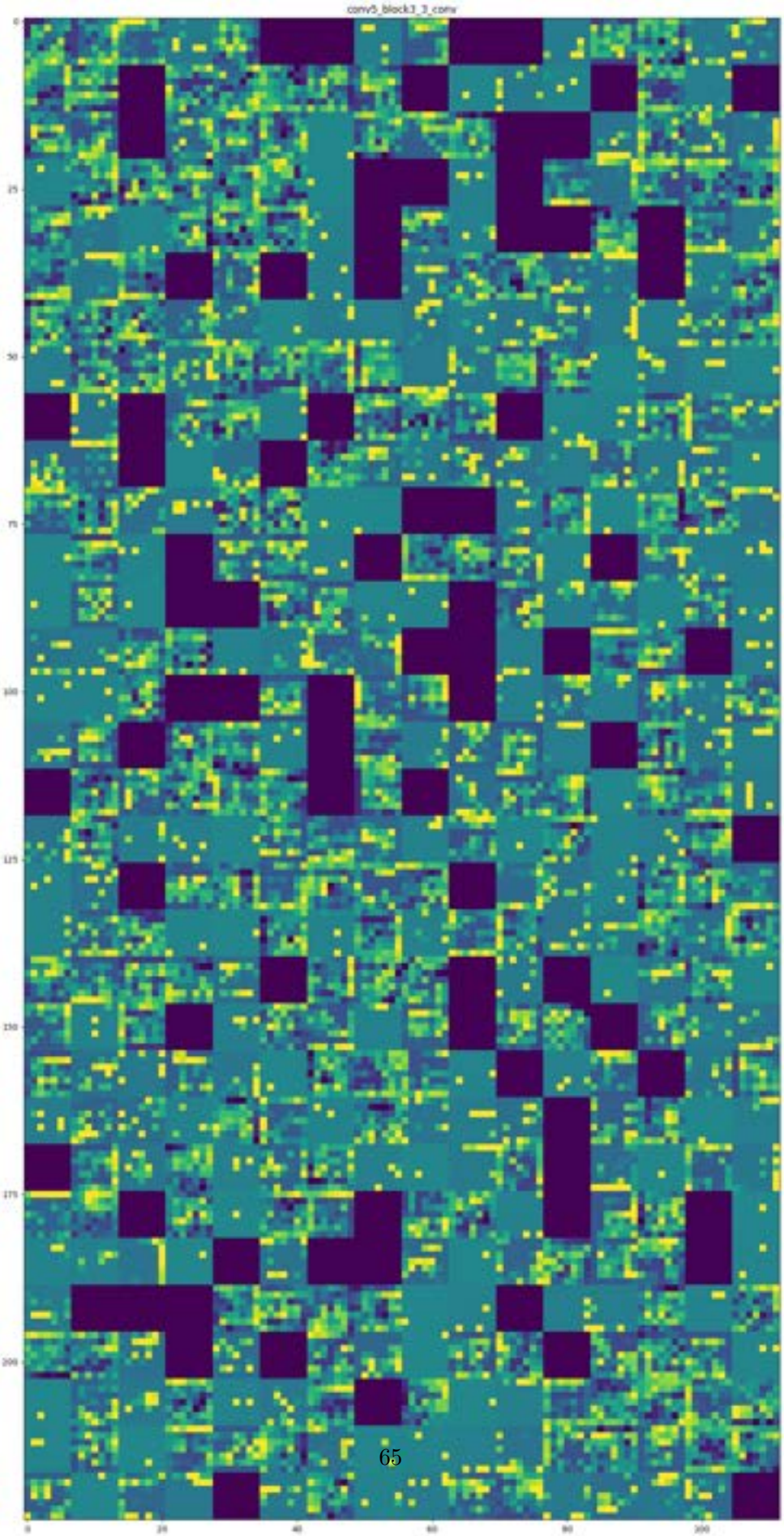
[ ]:
```
# These are the names of the layers, so can have them as part of our plot
layer_names = []
# layer_names = layers_to_visualize
# for layer in model.layers[:50]:
#     layer_names.append(layer.name)
# for layer in layers_to_visualize:
#     print(layer.name)
#     layer_names.append(layer.name)

layer_names = layers_to_visualize

images_per_row = 16

# Now let's display our feature maps
for layer_name, layer_activation in zip(layer_names, activations):
    # This is the number of features in the feature map
    n_features = layer_activation.shape[-1]

    # The feature map has shape (1, size, size, n_features)
    size = layer_activation.shape[1]

    # We will tile the activation channels in this matrix
    n_cols = n_features // images_per_row
    display_grid = np.zeros((size * n_cols, images_per_row * size))

    # We'll tile each filter into this big horizontal grid
    for col in range(n_cols):
        for row in range(images_per_row):
            channel_image = layer_activation[0,
                                             :, :,
                                             col * images_per_row + row]
            # Post-process the feature to make it visually palatable
            channel_image -= channel_image.mean()
            channel_image /= channel_image.std()
```

```
            channel_image *= 64
            channel_image += 128
            channel_image = np.clip(channel_image, 0, 255).astype('uint8')
            display_grid[col * size : (col + 1) * size,
                         row * size : (row + 1) * size] = channel_image

    # Display the grid
    scale = 1. / size
    plt.figure(figsize=(scale * display_grid.shape[1],
                        scale * display_grid.shape[0]))
    plt.title(layer_name)
    plt.grid(False)
    plt.imshow(display_grid, aspect='auto', cmap='viridis')

plt.show()
```

```
/var/folders/xy/1x8f1vlx569_ch145p3563j80000gn/T/ipykernel_13280/1408363524.py:3
7: RuntimeWarning: invalid value encountered in cast
  channel_image = np.clip(channel_image, 0, 255).astype('uint8')
```




conv3_block2_2_conv
0
25
50
75
100
125
150
175
200
0
50
100
150
200
250
300
350
400


conv5_block3_3_conv
0
25
50
75
100
125
150
175
200
0
20
40
60
80
100

Please scroll to view all the plots

1.1.6 Ignore - OLD_ CustomResNET50 Visualizing intermediate activations

Chose class Dog

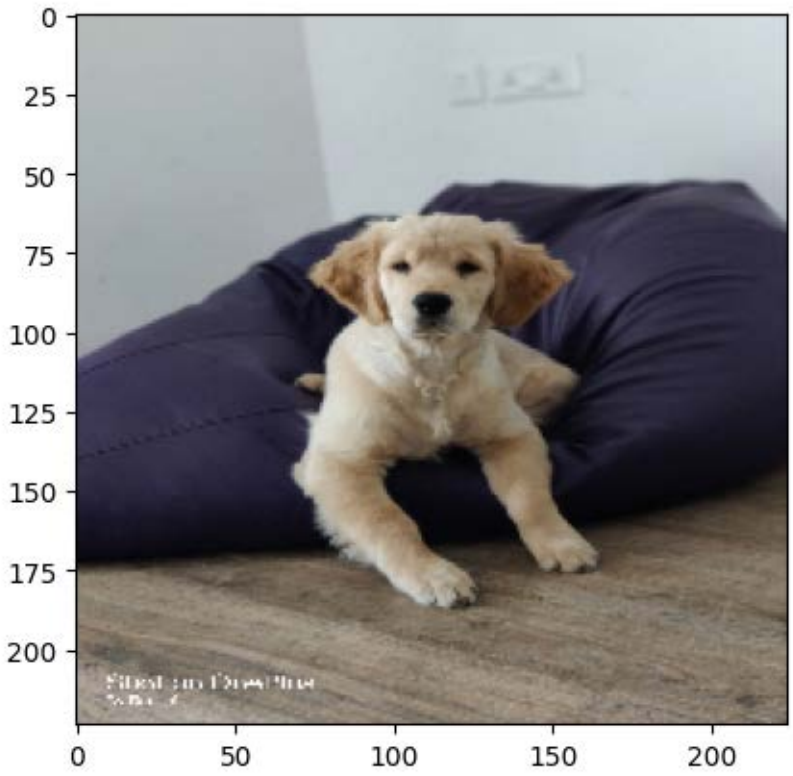
[ ]:
```
# import tensorflow as tf
model = tf.keras.models.load_model('model_my_custom_resnet50_lr.h5')
# model.summary()
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

[ ]:
```
# img_path = 'dogscats/subset/test/cats/cat.1700.jpg'
img_path='refs/dog_1.jpg'
# img_path='refs/dog.215.jpg'

# We preprocess the image into a 4D tensor
from keras.preprocessing import image
import numpy as np

im_size = 224

img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))
img_tensor = tf.keras.utils.img_to_array(img)
img_tensor = np.expand_dims(img_tensor, axis=0)
# Remember that the model was trained on inputs
# that were preprocessed in the following way:
img_tensor /= 255.

# Its shape is (1, 150, 150, 3)
print(img_tensor.shape)
```

```
(1, 224, 224, 3)
```

[ ]:
```
import matplotlib.pyplot as plt

plt.imshow(img_tensor[0])
plt.show()
```



[ ]:
```
# layers = model.layers
# # for layer in layers:
# #     print(layer.name)
# # filters, biases = model.layers[2]._get_trainable_state
# layers_to_visualize = [model.get_layer('conv1'), model.
 ↪get_layer('conv2c_branch2b'), model.get_layer('conv5c_branch2c')]

# layers_to_visualize = [model.get_layer('conv1_relu'),
#                        model.get_layer('conv3_block2_2_relu'),
#                        model.get_layer('conv5_block3_2_relu')]

layers_to_visualize = [model.get_layer('conv1'),
                       model.get_layer('conv3a_branch2b'),
                       model.get_layer('conv5c_branch2c')]
# # print(layers[2].name, filters.shape)
# for layer in model.layers:
#     print(layer.name)
for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1
conv3a_branch2b
```

conv5c_branch2c

[ ]:
```
act_input = model.input
# Extracts the outputs of the top 50 layers:
# layer_outputs = [layer.output for layer in model.layers[1:51]]
layer_outputs = [layer.output for layer in layers_to_visualize]

# First block :  conv1
# Middle block:  conv2c_branch2b
# Last block:    conv5c_branch2c

# layer_outputs = [layer.output for layer in layers_to_visualize]
# Creates a model that will return these outputs, given the model input:
activation_model = Model(inputs=act_input, outputs=layer_outputs)
```

[ ]:
```
activation_model.summary()
```

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

 zero_padding2d (ZeroPaddin  (None, 230, 230, 3)       0
['input_1[0][0]']
 g2D)

 conv1 (Conv2D)              (None, 112, 112, 64)      9472
['zero_padding2d[0][0]']

 bn_conv1 (BatchNormalizati  (None, 112, 112, 64)      256
['conv1[0][0]']
 on)

 activation (Activation)     (None, 112, 112, 64)      0
['bn_conv1[0][0]']

 max_pooling2d (MaxPooling2  (None, 55, 55, 64)        0
['activation[0][0]']
 D)

 conv2a_branch2a (Conv2D)    (None, 55, 55, 64)        4160
['max_pooling2d[0][0]']

 bn2a_branch2a (BatchNormal  (None, 55, 55, 64)        256
['conv2a_branch2a[0][0]']
```

```
 ization)

 activation_1 (Activation)   (None, 55, 55, 64)          0
['bn2a_branch2a[0][0]']

 conv2a_branch2b (Conv2D)    (None, 55, 55, 64)          36928
['activation_1[0][0]']

 bn2a_branch2b (BatchNormal  (None, 55, 55, 64)          256
['conv2a_branch2b[0][0]']
 ization)

 activation_2 (Activation)   (None, 55, 55, 64)          0
['bn2a_branch2b[0][0]']

 conv2a_branch2c (Conv2D)    (None, 55, 55, 256)         16640
['activation_2[0][0]']

 conv2a_branch1 (Conv2D)     (None, 55, 55, 256)         16640
['max_pooling2d[0][0]']

 bn2a_branch2c (BatchNormal  (None, 55, 55, 256)         1024
['conv2a_branch2c[0][0]']
 ization)

 bn2a_branch1 (BatchNormali  (None, 55, 55, 256)         1024
['conv2a_branch1[0][0]']
 zation)

 add (Add)                   (None, 55, 55, 256)         0
['bn2a_branch2c[0][0]',
'bn2a_branch1[0][0]']

 activation_3 (Activation)   (None, 55, 55, 256)         0
['add[0][0]']

 conv2b_branch2a (Conv2D)    (None, 55, 55, 64)          16448
['activation_3[0][0]']

 bn2b_branch2a (BatchNormal  (None, 55, 55, 64)          256
['conv2b_branch2a[0][0]']
 ization)

 activation_4 (Activation)   (None, 55, 55, 64)          0
['bn2b_branch2a[0][0]']

 conv2b_branch2b (Conv2D)    (None, 55, 55, 64)          36928
['activation_4[0][0]']
```

```
 bn2b_branch2b (BatchNormal  (None, 55, 55, 64)          256
['conv2b_branch2b[0][0]']
 ization)

 activation_5 (Activation)   (None, 55, 55, 64)          0
['bn2b_branch2b[0][0]']

 conv2b_branch2c (Conv2D)    (None, 55, 55, 256)         16640
['activation_5[0][0]']

 bn2b_branch2c (BatchNormal  (None, 55, 55, 256)         1024
['conv2b_branch2c[0][0]']
 ization)

 add_1 (Add)                 (None, 55, 55, 256)         0
['bn2b_branch2c[0][0]',
'activation_3[0][0]']

 activation_6 (Activation)   (None, 55, 55, 256)         0
['add_1[0][0]']

 conv2c_branch2a (Conv2D)    (None, 55, 55, 64)          16448
['activation_6[0][0]']

 bn2c_branch2a (BatchNormal  (None, 55, 55, 64)          256
['conv2c_branch2a[0][0]']
 ization)

 activation_7 (Activation)   (None, 55, 55, 64)          0
['bn2c_branch2a[0][0]']

 conv2c_branch2b (Conv2D)    (None, 55, 55, 64)          36928
['activation_7[0][0]']

 bn2c_branch2b (BatchNormal  (None, 55, 55, 64)          256
['conv2c_branch2b[0][0]']
 ization)

 activation_8 (Activation)   (None, 55, 55, 64)          0
['bn2c_branch2b[0][0]']

 conv2c_branch2c (Conv2D)    (None, 55, 55, 256)         16640
['activation_8[0][0]']

 bn2c_branch2c (BatchNormal  (None, 55, 55, 256)         1024
['conv2c_branch2c[0][0]']
 ization)
```

```
 add_2 (Add)                 (None, 55, 55, 256)          0
['bn2c_branch2c[0][0]',
'activation_6[0][0]']

 activation_9 (Activation)   (None, 55, 55, 256)          0
['add_2[0][0]']

 conv3a_branch2a (Conv2D)    (None, 28, 28, 128)          32896
['activation_9[0][0]']

 bn3a_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3a_branch2a[0][0]']
 ization)

 activation_10 (Activation)  (None, 28, 28, 128)          0
['bn3a_branch2a[0][0]']

 conv3a_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_10[0][0]']

 bn3a_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3a_branch2b[0][0]']
 ization)

 activation_11 (Activation)  (None, 28, 28, 128)          0
['bn3a_branch2b[0][0]']

 conv3a_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_11[0][0]']

 conv3a_branch1 (Conv2D)     (None, 28, 28, 512)          131584
['activation_9[0][0]']

 bn3a_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3a_branch2c[0][0]']
 ization)

 bn3a_branch1 (BatchNormali  (None, 28, 28, 512)          2048
['conv3a_branch1[0][0]']
 zation)

 add_3 (Add)                 (None, 28, 28, 512)          0
['bn3a_branch2c[0][0]',
'bn3a_branch1[0][0]']

 activation_12 (Activation)  (None, 28, 28, 512)          0
['add_3[0][0]']
```

```
 conv3b_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_12[0][0]']

 bn3b_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3b_branch2a[0][0]']
 ization)

 activation_13 (Activation)  (None, 28, 28, 128)          0
['bn3b_branch2a[0][0]']

 conv3b_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_13[0][0]']

 bn3b_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3b_branch2b[0][0]']
 ization)

 activation_14 (Activation)  (None, 28, 28, 128)          0
['bn3b_branch2b[0][0]']

 conv3b_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_14[0][0]']

 bn3b_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3b_branch2c[0][0]']
 ization)

 add_4 (Add)                 (None, 28, 28, 512)          0
['bn3b_branch2c[0][0]',
'activation_12[0][0]']

 activation_15 (Activation)  (None, 28, 28, 512)          0
['add_4[0][0]']

 conv3c_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_15[0][0]']

 bn3c_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3c_branch2a[0][0]']
 ization)

 activation_16 (Activation)  (None, 28, 28, 128)          0
['bn3c_branch2a[0][0]']

 conv3c_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_16[0][0]']
```

```
 bn3c_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3c_branch2b[0][0]']
 ization)

 activation_17 (Activation)  (None, 28, 28, 128)          0
['bn3c_branch2b[0][0]']

 conv3c_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_17[0][0]']

 bn3c_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3c_branch2c[0][0]']
 ization)

 add_5 (Add)                 (None, 28, 28, 512)          0
['bn3c_branch2c[0][0]',
'activation_15[0][0]']

 activation_18 (Activation)  (None, 28, 28, 512)          0
['add_5[0][0]']

 conv3d_branch2a (Conv2D)    (None, 28, 28, 128)          65664
['activation_18[0][0]']

 bn3d_branch2a (BatchNormal  (None, 28, 28, 128)          512
['conv3d_branch2a[0][0]']
 ization)

 activation_19 (Activation)  (None, 28, 28, 128)          0
['bn3d_branch2a[0][0]']

 conv3d_branch2b (Conv2D)    (None, 28, 28, 128)          147584
['activation_19[0][0]']

 bn3d_branch2b (BatchNormal  (None, 28, 28, 128)          512
['conv3d_branch2b[0][0]']
 ization)

 activation_20 (Activation)  (None, 28, 28, 128)          0
['bn3d_branch2b[0][0]']

 conv3d_branch2c (Conv2D)    (None, 28, 28, 512)          66048
['activation_20[0][0]']

 bn3d_branch2c (BatchNormal  (None, 28, 28, 512)          2048
['conv3d_branch2c[0][0]']
 ization)
```

```
 add_6 (Add)                 (None, 28, 28, 512)          0
['bn3d_branch2c[0][0]',
'activation_18[0][0]']

 activation_21 (Activation)  (None, 28, 28, 512)          0
['add_6[0][0]']

 conv4a_branch2a (Conv2D)    (None, 14, 14, 256)          131328
['activation_21[0][0]']

 bn4a_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4a_branch2a[0][0]']
 ization)

 activation_22 (Activation)  (None, 14, 14, 256)          0
['bn4a_branch2a[0][0]']

 conv4a_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_22[0][0]']

 bn4a_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4a_branch2b[0][0]']
 ization)

 activation_23 (Activation)  (None, 14, 14, 256)          0
['bn4a_branch2b[0][0]']

 conv4a_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_23[0][0]']

 conv4a_branch1 (Conv2D)     (None, 14, 14, 1024)         525312
['activation_21[0][0]']

 bn4a_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4a_branch2c[0][0]']
 ization)

 bn4a_branch1 (BatchNormali  (None, 14, 14, 1024)         4096
['conv4a_branch1[0][0]']
 zation)

 add_7 (Add)                 (None, 14, 14, 1024)         0
['bn4a_branch2c[0][0]',
'bn4a_branch1[0][0]']

 activation_24 (Activation)  (None, 14, 14, 1024)         0
['add_7[0][0]']
```

```
 conv4b_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_24[0][0]']

 bn4b_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4b_branch2a[0][0]']
 ization)

 activation_25 (Activation)  (None, 14, 14, 256)          0
['bn4b_branch2a[0][0]']

 conv4b_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_25[0][0]']

 bn4b_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4b_branch2b[0][0]']
 ization)

 activation_26 (Activation)  (None, 14, 14, 256)          0
['bn4b_branch2b[0][0]']

 conv4b_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_26[0][0]']

 bn4b_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4b_branch2c[0][0]']
 ization)

 add_8 (Add)                 (None, 14, 14, 1024)         0
['bn4b_branch2c[0][0]',
'activation_24[0][0]']

 activation_27 (Activation)  (None, 14, 14, 1024)         0
['add_8[0][0]']

 conv4c_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_27[0][0]']

 bn4c_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4c_branch2a[0][0]']
 ization)

 activation_28 (Activation)  (None, 14, 14, 256)          0
['bn4c_branch2a[0][0]']

 conv4c_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_28[0][0]']

 bn4c_branch2b (BatchNormal  (None, 14, 14, 256)          1024
```

```
['conv4c_branch2b[0][0]']
 ization)

 activation_29 (Activation)  (None, 14, 14, 256)          0
['bn4c_branch2b[0][0]']

 conv4c_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_29[0][0]']

 bn4c_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4c_branch2c[0][0]']
 ization)

 add_9 (Add)                 (None, 14, 14, 1024)         0
['bn4c_branch2c[0][0]',
'activation_27[0][0]']

 activation_30 (Activation)  (None, 14, 14, 1024)         0
['add_9[0][0]']

 conv4d_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_30[0][0]']

 bn4d_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4d_branch2a[0][0]']
 ization)

 activation_31 (Activation)  (None, 14, 14, 256)          0
['bn4d_branch2a[0][0]']

 conv4d_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_31[0][0]']

 bn4d_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4d_branch2b[0][0]']
 ization)

 activation_32 (Activation)  (None, 14, 14, 256)          0
['bn4d_branch2b[0][0]']

 conv4d_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_32[0][0]']

 bn4d_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4d_branch2c[0][0]']
 ization)

 add_10 (Add)                (None, 14, 14, 1024)         0
```

```
['bn4d_branch2c[0][0]',
'activation_30[0][0]']

 activation_33 (Activation)  (None, 14, 14, 1024)         0
['add_10[0][0]']

 conv4e_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_33[0][0]']

 bn4e_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4e_branch2a[0][0]']
 ization)

 activation_34 (Activation)  (None, 14, 14, 256)          0
['bn4e_branch2a[0][0]']

 conv4e_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_34[0][0]']

 bn4e_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4e_branch2b[0][0]']
 ization)

 activation_35 (Activation)  (None, 14, 14, 256)          0
['bn4e_branch2b[0][0]']

 conv4e_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_35[0][0]']

 bn4e_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4e_branch2c[0][0]']
 ization)

 add_11 (Add)                (None, 14, 14, 1024)         0
['bn4e_branch2c[0][0]',
'activation_33[0][0]']

 activation_36 (Activation)  (None, 14, 14, 1024)         0
['add_11[0][0]']

 conv4f_branch2a (Conv2D)    (None, 14, 14, 256)          262400
['activation_36[0][0]']

 bn4f_branch2a (BatchNormal  (None, 14, 14, 256)          1024
['conv4f_branch2a[0][0]']
 ization)

 activation_37 (Activation)  (None, 14, 14, 256)          0
```

```
['bn4f_branch2a[0][0]']

 conv4f_branch2b (Conv2D)    (None, 14, 14, 256)          590080
['activation_37[0][0]']

 bn4f_branch2b (BatchNormal  (None, 14, 14, 256)          1024
['conv4f_branch2b[0][0]']
 ization)

 activation_38 (Activation)  (None, 14, 14, 256)          0
['bn4f_branch2b[0][0]']

 conv4f_branch2c (Conv2D)    (None, 14, 14, 1024)         263168
['activation_38[0][0]']

 bn4f_branch2c (BatchNormal  (None, 14, 14, 1024)         4096
['conv4f_branch2c[0][0]']
 ization)

 add_12 (Add)                (None, 14, 14, 1024)         0
['bn4f_branch2c[0][0]',
'activation_36[0][0]']

 activation_39 (Activation)  (None, 14, 14, 1024)         0
['add_12[0][0]']

 conv5a_branch2a (Conv2D)    (None, 7, 7, 512)            524800
['activation_39[0][0]']

 bn5a_branch2a (BatchNormal  (None, 7, 7, 512)            2048
['conv5a_branch2a[0][0]']
 ization)

 activation_40 (Activation)  (None, 7, 7, 512)            0
['bn5a_branch2a[0][0]']

 conv5a_branch2b (Conv2D)    (None, 7, 7, 512)            2359808
['activation_40[0][0]']

 bn5a_branch2b (BatchNormal  (None, 7, 7, 512)            2048
['conv5a_branch2b[0][0]']
 ization)

 activation_41 (Activation)  (None, 7, 7, 512)            0
['bn5a_branch2b[0][0]']

 conv5a_branch2c (Conv2D)    (None, 7, 7, 2048)           1050624
['activation_41[0][0]']
```

```
 conv5a_branch1 (Conv2D)     (None, 7, 7, 2048)           2099200
['activation_39[0][0]']

 bn5a_branch2c (BatchNormal  (None, 7, 7, 2048)           8192
['conv5a_branch2c[0][0]']
 ization)

 bn5a_branch1 (BatchNormali  (None, 7, 7, 2048)           8192
['conv5a_branch1[0][0]']
 zation)

 add_13 (Add)                (None, 7, 7, 2048)           0
['bn5a_branch2c[0][0]',
'bn5a_branch1[0][0]']

 activation_42 (Activation)  (None, 7, 7, 2048)           0
['add_13[0][0]']

 conv5b_branch2a (Conv2D)    (None, 7, 7, 512)            1049088
['activation_42[0][0]']

 bn5b_branch2a (BatchNormal  (None, 7, 7, 512)            2048
['conv5b_branch2a[0][0]']
 ization)

 activation_43 (Activation)  (None, 7, 7, 512)            0
['bn5b_branch2a[0][0]']

 conv5b_branch2b (Conv2D)    (None, 7, 7, 512)            2359808
['activation_43[0][0]']

 bn5b_branch2b (BatchNormal  (None, 7, 7, 512)            2048
['conv5b_branch2b[0][0]']
 ization)

 activation_44 (Activation)  (None, 7, 7, 512)            0
['bn5b_branch2b[0][0]']

 conv5b_branch2c (Conv2D)    (None, 7, 7, 2048)           1050624
['activation_44[0][0]']

 bn5b_branch2c (BatchNormal  (None, 7, 7, 2048)           8192
['conv5b_branch2c[0][0]']
 ization)

 add_14 (Add)                (None, 7, 7, 2048)           0
['bn5b_branch2c[0][0]',
```

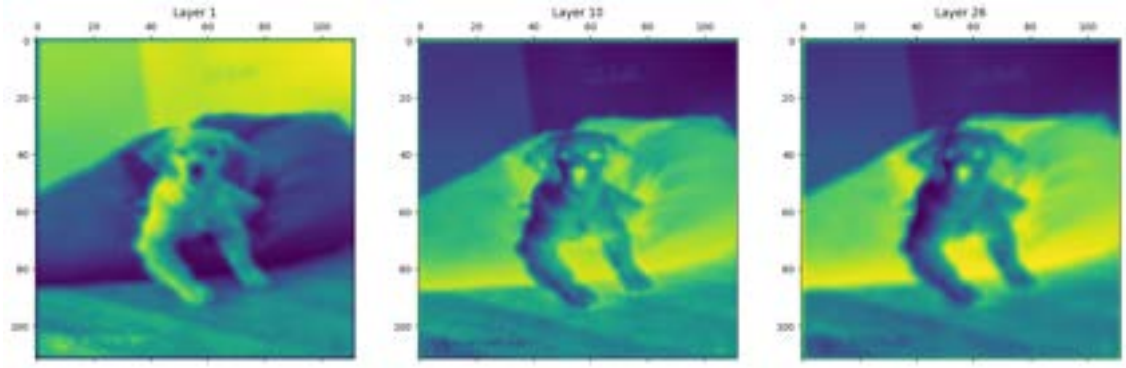
```
'activation_42[0][0]']

 activation_45 (Activation)  (None, 7, 7, 2048)          0
['add_14[0][0]']

 conv5c_branch2a (Conv2D)    (None, 7, 7, 512)           1049088
['activation_45[0][0]']

 bn5c_branch2a (BatchNormal  (None, 7, 7, 512)           2048
['conv5c_branch2a[0][0]']
 ization)

 activation_46 (Activation)  (None, 7, 7, 512)           0
['bn5c_branch2a[0][0]']

 conv5c_branch2b (Conv2D)    (None, 7, 7, 512)           2359808
['activation_46[0][0]']

 bn5c_branch2b (BatchNormal  (None, 7, 7, 512)           2048
['conv5c_branch2b[0][0]']
 ization)

 activation_47 (Activation)  (None, 7, 7, 512)           0
['bn5c_branch2b[0][0]']

 conv5c_branch2c (Conv2D)    (None, 7, 7, 2048)          1050624
['activation_47[0][0]']

==================================================================================
==================
Total params: 23579520 (89.95 MB)
Trainable params: 23530496 (89.76 MB)
Non-trainable params: 49024 (191.50 KB)
----------------------------------------------------------------------------------
------------------
```

First Layer activation

[ ]:
```python
# This will return a list of 5 Numpy arrays:
# one array per layer activation

activations = activation_model.predict([img_tensor])

first_layer_activation = activations[0]
print(first_layer_activation.shape)

for activation in activations:
    print(activation.shape)
```

```
# for i in range(3):  # Loop through the channels
#     plt.matshow(first_layer_activation[0, :, :, i], cmap='viridis')
#     plt.show()
# plt.matshow(first_layer_activation[0, :, :, 0], cmap='viridis')
# plt.show()
# plt.matshow(first_layer_activation[0, :, :, 3], cmap='viridis')
# plt.show()

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(first_layer_activation[0, :, :, 4], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(first_layer_activation[0, :, :, 13], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(first_layer_activation[0, :, :, 49], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 49ms/step
(1, 112, 112, 64)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 2048)
```



[ ]:
```
# for i in range(64):
```

```
#     plt.matshow(first_layer_activation[0, :, :, i], cmap='viridis')
#     plt.show()
```

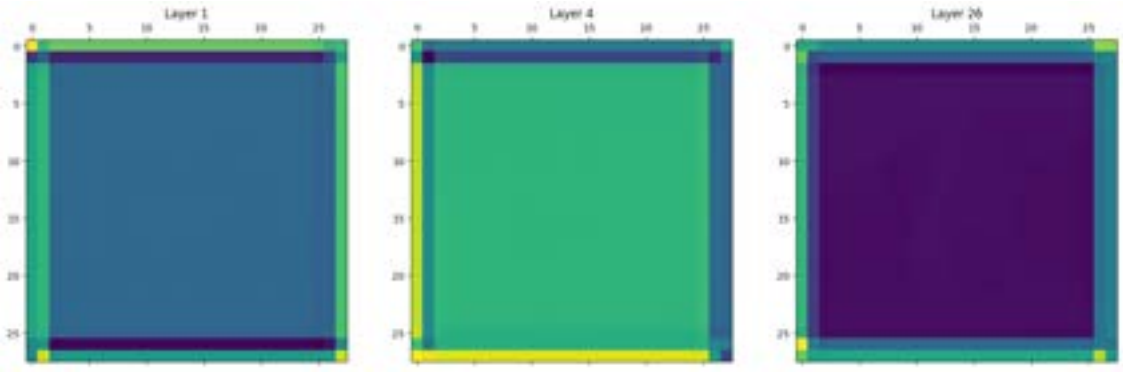
This one looks like a “bright green dot” detector, useful to encode dog eyes and nose.

At this point, let’s go and plot a complete visualization of all the activations in the network.

Middle Layer activation

[ ]:
```
activations = activation_model.predict([img_tensor])

middle_layer_activation = activations[1]
print(middle_layer_activation.shape)

# for activation in activations:
#     print(activation.shape)

# plt.matshow(middle_layer_activation[0, :, :, 1], cmap='viridis')
# plt.show()

fig, axes = plt.subplots(1, 3, figsize=(20, 8))

# Display the first activation
axes[0].matshow(middle_layer_activation[0, :, :, 1], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(middle_layer_activation[0, :, :, 4], cmap='viridis')
axes[1].set_title('Layer 4')

# Display the second activation
axes[2].matshow(middle_layer_activation[0, :, :, 26], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

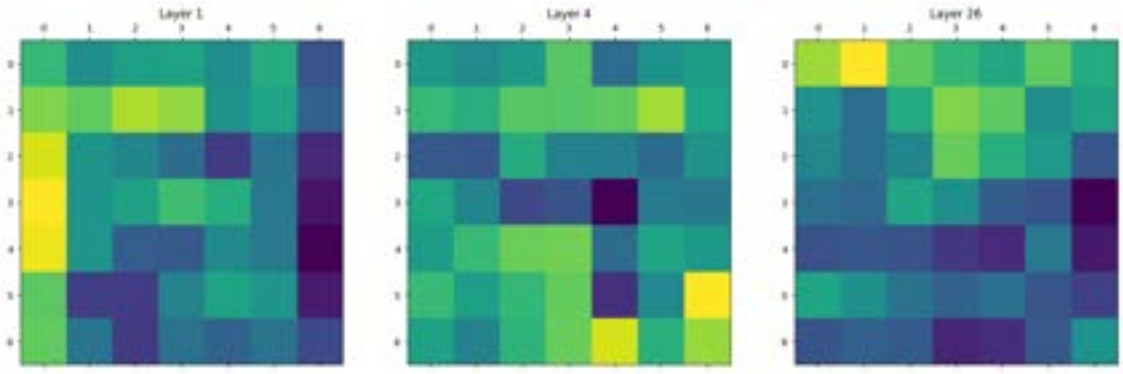
```
1/1 [==============================] - 0s 86ms/step
(1, 28, 28, 128)
```



Last Layer activation

[ ]:
```
activations = activation_model.predict([img_tensor])

last_layer_activation = activations[2]
print(last_layer_activation.shape)

# plt.matshow(last_layer_activation[0, :, :, 1], cmap='viridis')
# plt.show()
# plt.matshow(last_layer_activation[0, :, :, 26], cmap='viridis')
# plt.show()

fig, axes = plt.subplots(1, 3, figsize=(20, 8))

# Display the first activation
axes[0].matshow(last_layer_activation[0, :, :, 1], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(last_layer_activation[0, :, :, 4], cmap='viridis')
axes[1].set_title('Layer 4')

# Display the second activation
axes[2].matshow(last_layer_activation[0, :, :, 26], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

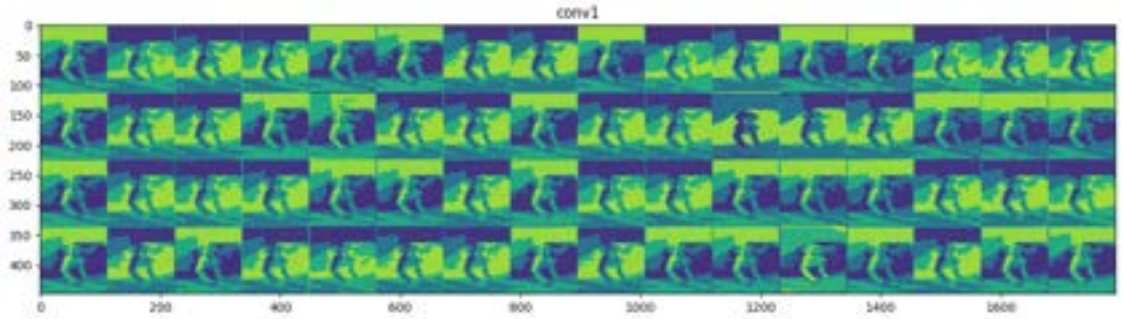
```
1/1 [==============================] - 0s 54ms/step
(1, 7, 7, 2048)
```

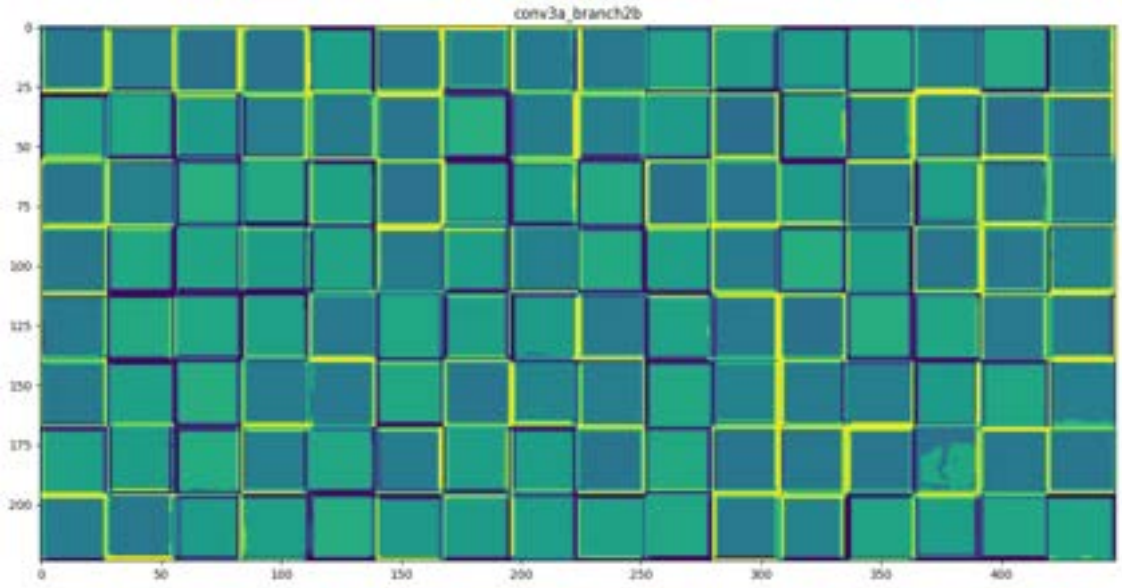


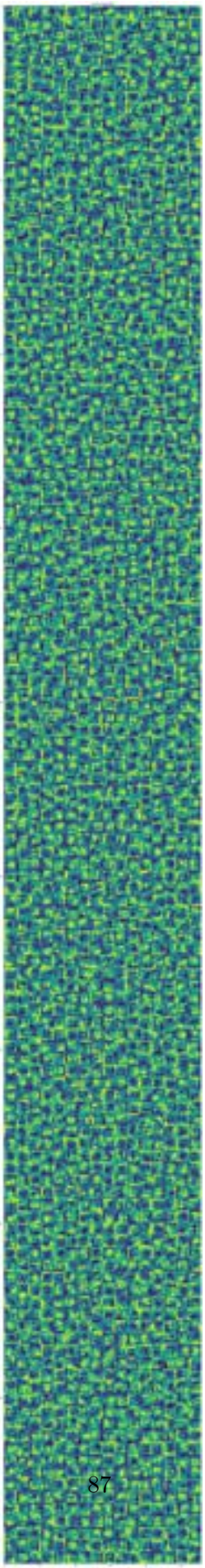
[ ]:
```
# These are the names of the layers, so can have them as part of our plot
layer_names = []
# layer_names = layers_to_visualize
# for layer in model.layers[:50]:
#     layer_names.append(layer.name)
for layer in layers_to_visualize:
    print(layer.name)
    layer_names.append(layer.name)

images_per_row = 16

# Now let's display our feature maps
for layer_name, layer_activation in zip(layer_names, activations):
    # This is the number of features in the feature map
    n_features = layer_activation.shape[-1]

    # The feature map has shape (1, size, size, n_features)
    size = layer_activation.shape[1]

    # We will tile the activation channels in this matrix
    n_cols = n_features // images_per_row
    display_grid = np.zeros((size * n_cols, images_per_row * size))

    # We'll tile each filter into this big horizontal grid
    for col in range(n_cols):
        for row in range(images_per_row):
            channel_image = layer_activation[0,
                                             :, :,
                                             col * images_per_row + row]
            # Post-process the feature to make it visually palatable
            channel_image -= channel_image.mean()
            channel_image /= channel_image.std()
            channel_image *= 64
            channel_image += 128
```

```
            channel_image = np.clip(channel_image, 0, 255).astype('uint8')
            display_grid[col * size : (col + 1) * size,
                         row * size : (row + 1) * size] = channel_image

    # Display the grid
    scale = 1. / size
    plt.figure(figsize=(scale * display_grid.shape[1],
                        scale * display_grid.shape[0]))
    plt.title(layer_name)
    plt.grid(False)
    plt.imshow(display_grid, aspect='auto', cmap='viridis')

plt.show()
```

```
conv1
conv3a_branch2b
conv5c_branch2c
```







1.1.7 PS1.A - Visualizing convnet filters

Chosen blocks/ layers

[ ]:
```
model = load_model('model_resnet50_aug4.h5')
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

[ ]:
```
layers_to_visualize = [model.get_layer('conv1_conv'),
                       model.get_layer('conv3_block2_2_conv'),
                       model.get_layer('conv5_block3_3_conv')]

for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_conv
conv3_block2_2_conv
conv5_block3_3_conv
```

[ ]:
```
def deprocess_image(x):
    # normalize tensor: center on 0., ensure std is 0.1
    x -= x.mean()
    x /= (x.std() + 1e-5)
    x *= 0.1

    # clip to [0, 1]
    x += 0.5
    x = np.clip(x, 0, 1)

    # convert to RGB array
    x *= 255
    x = np.clip(x, 0, 255).astype('uint8')
    return x
```

[ ]:
```
# Disable eager execution
tf.compat.v1.disable_eager_execution()
```

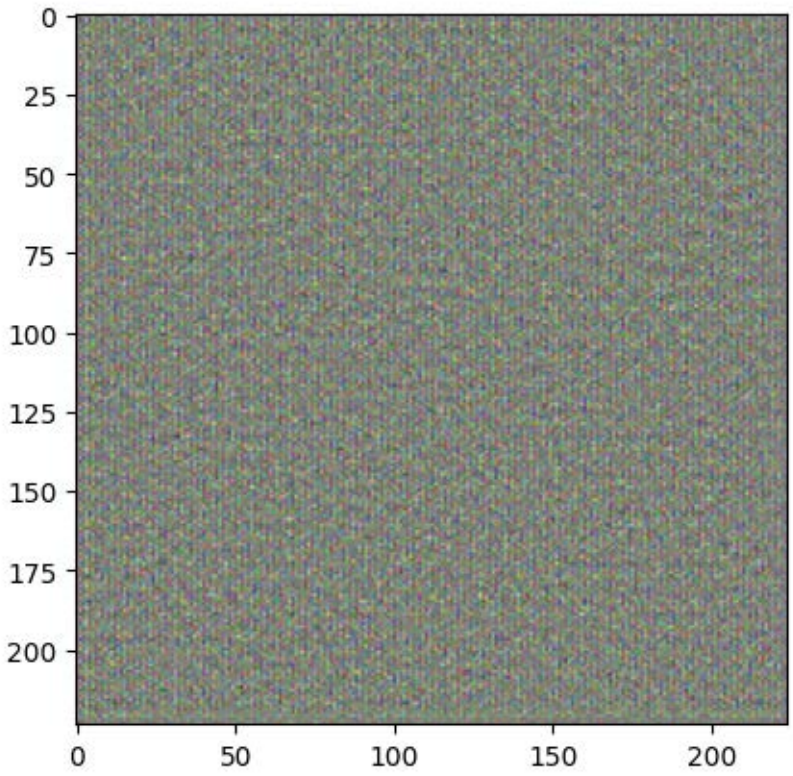
[ ]:
```
# Modify your deprocess_image function as follows
def deprocess_image(x):
    x = x - x.mean()
    x = x / (x.std() + 1e-5)
    x = x * 0.1 + 0.5
    x = np.clip(x, 0, 1)
    x = x * 255
```

```
    x = np.clip(x, 0, 255).astype('uint8')
    return x
```

[ ]:
```
def generate_pattern(layer_name, filter_index, size=224):

    # Load ResNet50 without top layers
    # model1 = ResNet50(weights=None, include_top=False)

    layer = model.get_layer(layer_name)
    input_img = model.input

    loss = K.mean(layer.output[:, :, :, filter_index])
    grads = K.gradients(loss, input_img)[0]
    grads /= (K.sqrt(K.mean(K.square(grads))) + 1e-5)

    iterate = K.function([input_img], [loss, grads])

    input_img_data = np.random.random((1, size, size, 3)) * 20 + 128.

    step = 1.
    for i in range(40):
        loss_value, grads_value = iterate([input_img_data])
        input_img_data += grads_value * step

    img = input_img_data[0]
    return deprocess_image(img)
```

[ ]:
```
# Now you can use generate_pattern function
layer_name = 'conv2_block1_1_conv'
filter_index = 0

pattern = generate_pattern(layer_name, filter_index)
plt.imshow(pattern)
plt.show()
```

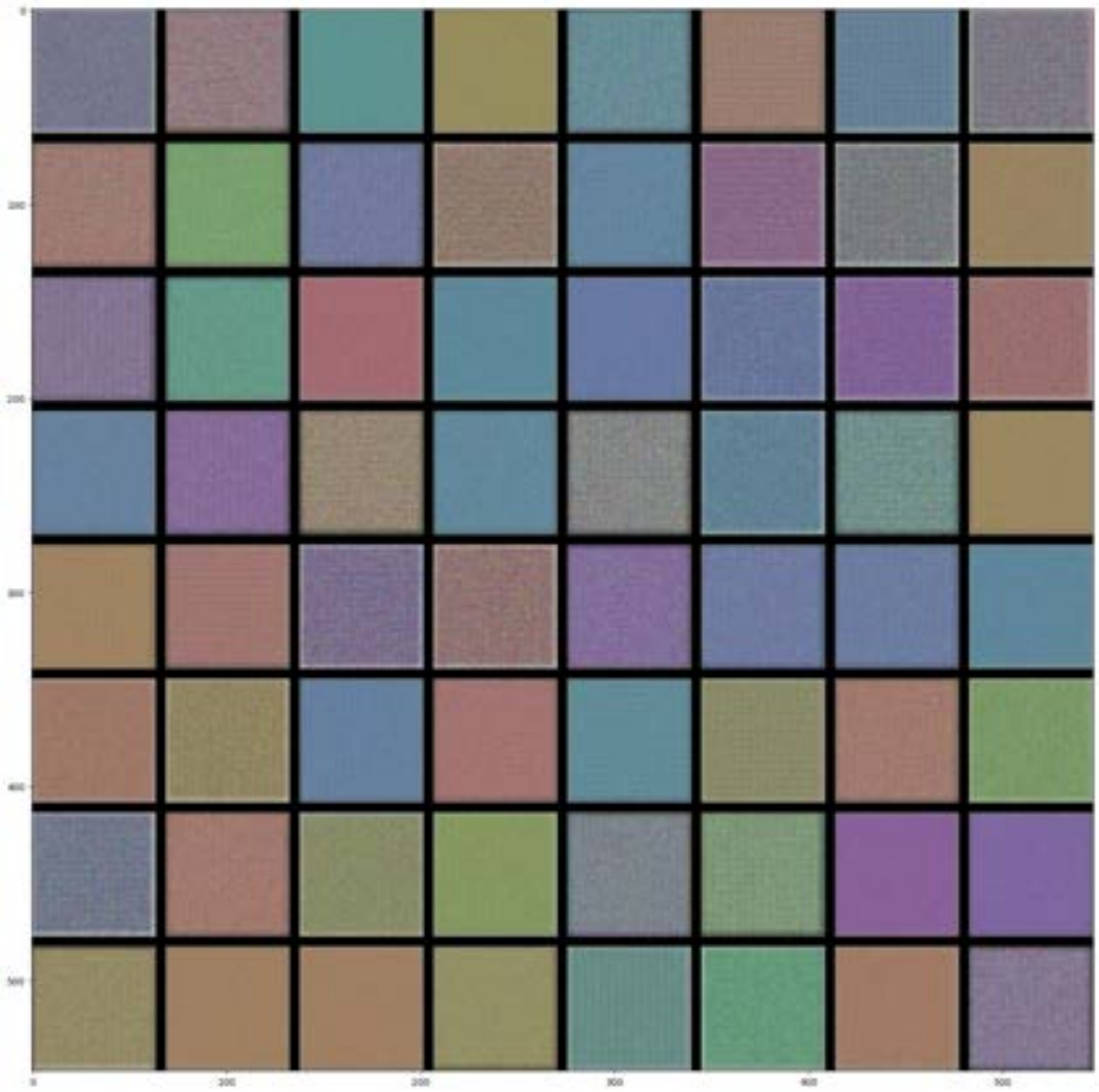
```
2023-10-25 22:11:58.001917: W tensorflow/c/c_api.cc:305] Operation
'{name:'conv5_block2_1_conv_6/kernel/Assign' id:32615 op device:{requested: '',
assigned: ''} def:{{{node conv5_block2_1_conv_6/kernel/Assign}} =
AssignVariableOp[_has_manual_control_dependencies=true, dtype=DT_FLOAT,
validate_shape=false](conv5_block2_1_conv_6/kernel,
conv5_block2_1_conv_6/kernel/Initializer/stateless_random_uniform)}}' was
changed by setting attribute after it was run by a session. This mutation will
have no effect, and will trigger an error in the future. Either don't modify
nodes after running them or create a new session.
```

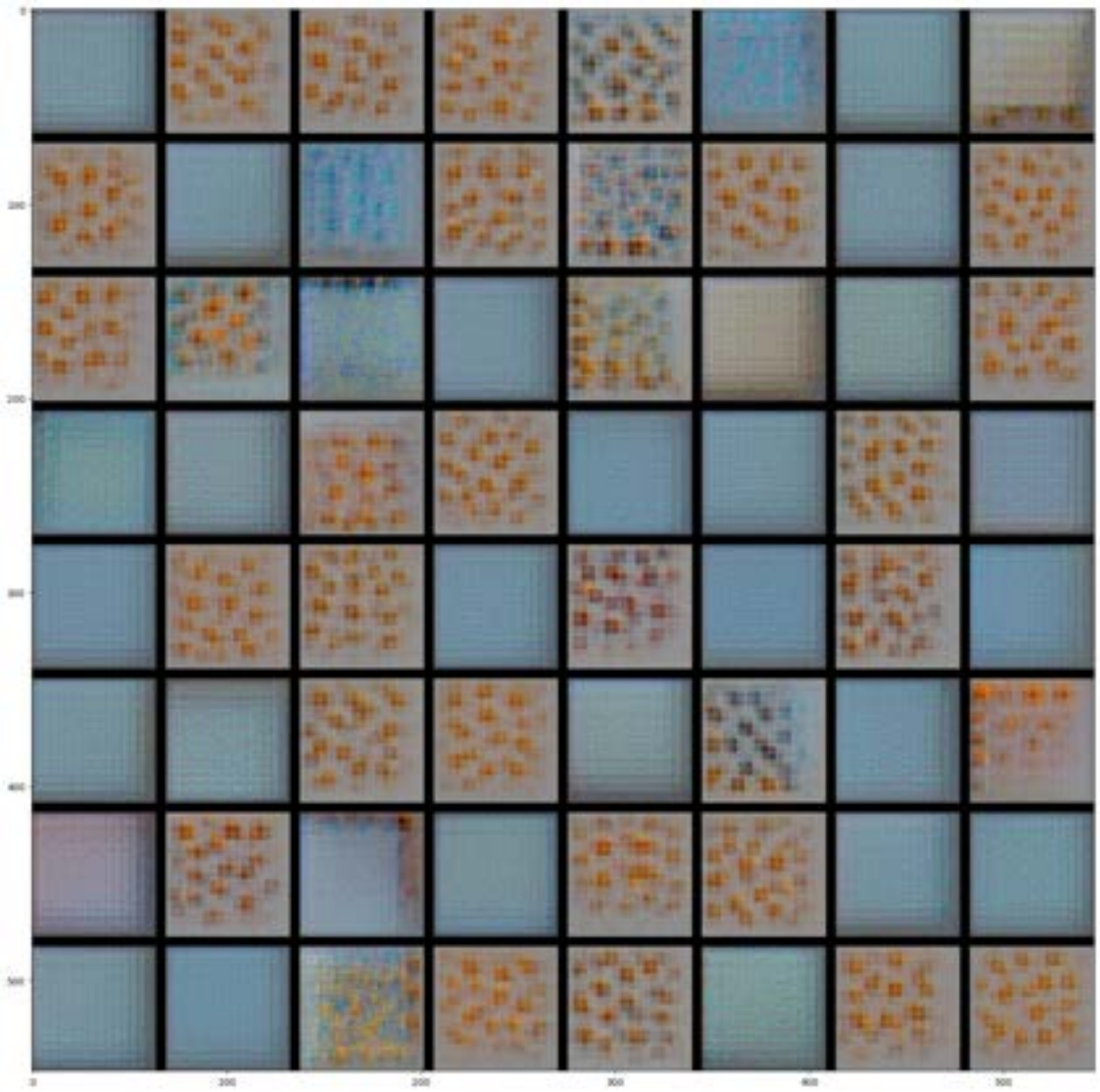


First and Middle Conv Blocks Scroll for both the images

[ ]:
```
for layer_name in ['conv1_conv', 'conv3_block2_2_conv', 'conv5_block3_3_conv']:
    size = 64
    margin = 5

    # This a empty (black) image where we will store our results.
    results = np.zeros((8 * size + 7 * margin, 8 * size + 7 * margin, 3))

    for i in range(8):  # iterate over the rows of our results grid
        for j in range(8):  # iterate over the columns of our results grid
            # Generate the pattern for filter `i + (j * 8)` in `layer_name`
            filter_img = generate_pattern(layer_name, i + (j * 8), size=size)

            # Put the result in the square `(i, j)` of the results grid
            horizontal_start = i * size + i * margin
            horizontal_end = horizontal_start + size
            vertical_start = j * size + j * margin
            vertical_end = vertical_start + size
            results[horizontal_start: horizontal_end, vertical_start:␣
↪vertical_end, :] = filter_img
```

```
# Display the results grid
plt.figure(figsize=(20, 20))
plt.imshow((results * 255).astype(np.uint8))
plt.show()
```





The Kernel crashed while executing code in the the current cell or a previous␣
↪cell. Please review the code in the cell(s) to identify a possible cause of␣
↪the failure. Click here␣
↪for more info. View Jupyter log for␣
↪further details.

[ ]:
```
model = load_model('model_resnet50_aug4.h5')
model.summary()
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.

Model: "model"
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)       0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)      9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)      256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)      0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)      0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)        0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)        4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)        256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)        0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)        36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)        256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)        0
['conv2_block1_2_bn[0][0]']
```

```
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
```

```
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
```

```
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
```

```
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
```

```
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
```

```
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
```

```
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
```

```
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
```

```
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
```

```
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
```

```
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
```

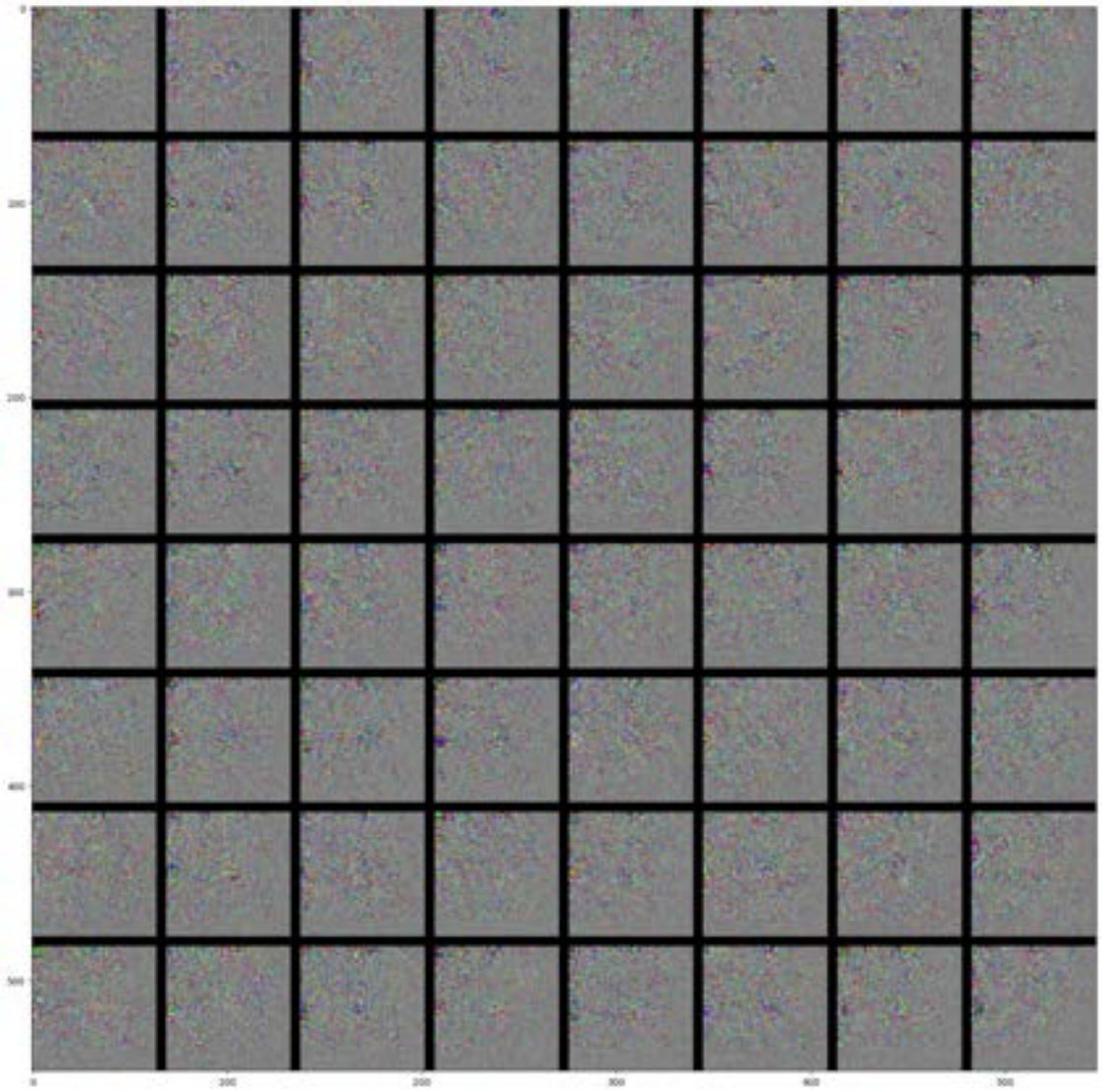
```
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)          2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
```

```
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)          0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
```

```
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)           0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)                0
['average_pooling2d[0][0]']

 dense (Dense)               (None, 9)                    165897
['flatten[0][0]']

==================================================================================
==================
Total params: 23753609 (90.61 MB)
Trainable params: 23700489 (90.41 MB)
Non-trainable params: 53120 (207.50 KB)
----------------------------------------------------------------------------------
------------------
```

Last Conv Block Plotted the last layer separately to "avoid kernel crash"

[ ]:
```
for layer_name in ['conv5_block3_3_conv']:
    size = 64
    margin = 5

    # This a empty (black) image where we will store our results.
    results = np.zeros((8 * size + 7 * margin, 8 * size + 7 * margin, 3))

    for i in range(8):  # iterate over the rows of our results grid
        for j in range(8):  # iterate over the columns of our results grid
            # Generate the pattern for filter `i + (j * 8)` in `layer_name`
            filter_img = generate_pattern(layer_name, i + (j * 8), size=size)

            # Put the result in the square `(i, j)` of the results grid
            horizontal_start = i * size + i * margin
            horizontal_end = horizontal_start + size
            vertical_start = j * size + j * margin
            vertical_end = vertical_start + size
            results[horizontal_start: horizontal_end, vertical_start:␣
↪vertical_end, :] = filter_img

    # Display the results grid
    plt.figure(figsize=(20, 20))
    plt.imshow((results * 255).astype(np.uint8))
    plt.show()
```



1.1.8 PS1A. Visualizing heatmaps of class activation

[ ]:
```
model = load_model('model_resnet50_aug4.h5')
```

```
2023-10-25 23:21:25.936815: W tensorflow/c/c_api.cc:305] Operation
'{name:'conv3_block4_2_bn_1/beta/Assign' id:9217 op device:{requested: '',
assigned: ''} def:{{{node conv3_block4_2_bn_1/beta/Assign}} =
AssignVariableOp[_has_manual_control_dependencies=true, dtype=DT_FLOAT,
validate_shape=false](conv3_block4_2_bn_1/beta,
conv3_block4_2_bn_1/beta/Initializer/zeros)}}' was changed by setting attribute
after it was run by a session. This mutation will have no effect, and will
trigger an error in the future. Either don't modify nodes after running them or
create a new session.
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

[ ]:
```python
import numpy as np

# The local path to our target image
#img_path = 'creative_commons_elephant.jpg'
img_path = 'refs/dog_1.jpg'

im_size = 224

# `img` is a PIL image of size 224x224
img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))

# `x` is a float32 Numpy array of shape (224, 224, 3)
img_tensor = tf.keras.utils.img_to_array(img)

# We add a dimension to transform our array into a "batch"
# of size (1, 224, 224, 3)
img_tensor = np.expand_dims(img_tensor, axis=0)

img_tensor /= 255.

# # Its shape is (1, 224, 224, 3)
print(img_tensor.shape)
```

```
(1, 224, 224, 3)
```

[ ]:
```python
preds = model.predict(img_tensor)
def custom_decode_predictions(predictions, top=5, class_names=None):
    if class_names is None:
        class_names = [str(i) for i in range(predictions.shape[-1])]

    results = []
    for pred in predictions:
        top_indices = pred.argsort()[-top:][::-1]
        decoded_preds = [(class_names[i], pred[i]) for i in top_indices]
        results.append(decoded_preds)

    return results

classes = ['airplane', 'automobile', 'bird', 'cat', 'dog', 'deer', 'frog',␣
 ↪'horse', 'truck']

print('Predicted:', custom_decode_predictions(preds, top=5,␣
 ↪class_names=classes))
```

```
/Users/banani/Library/Python/3.9/lib/python/site-
packages/keras/src/engine/training_v1.py:2359: UserWarning:
`Model.state_updates` will be removed in a future version. This property should
not be used in TensorFlow 2.0, as `updates` are applied automatically.
  updates=self.state_updates,
2023-10-25 23:21:32.224473: W tensorflow/c/c_api.cc:305] Operation
'{name:'dense_1/Softmax' id:11531 op device:{requested: '', assigned: ''}
def:{{{node dense_1/Softmax}} = Softmax[T=DT_FLOAT,
_has_manual_control_dependencies=true](dense_1/BiasAdd)}}' was changed by
setting attribute after it was run by a session. This mutation will have no
effect, and will trigger an error in the future. Either don't modify nodes after
running them or create a new session.
2023-10-25 23:21:32.709967: W tensorflow/c/c_api.cc:305] Operation
'{name:'total_1/Assign' id:12826 op device:{requested: '', assigned: ''}
def:{{{node total_1/Assign}} =
AssignVariableOp[_has_manual_control_dependencies=true, dtype=DT_FLOAT,
validate_shape=false](total_1, total_1/Initializer/zeros)}}' was changed by
setting attribute after it was run by a session. This mutation will have no
effect, and will trigger an error in the future. Either don't modify nodes after
running them or create a new session.

Predicted: [[('dog', 0.16175188), ('frog', 0.15776682), ('horse', 0.15381174),
('deer', 0.12696117), ('cat', 0.10170399)]]
```

Chosen Layers or blocks

[ ]:
```
layers_to_visualize = [model.get_layer('conv1_relu'),
                       model.get_layer('conv3_block2_2_relu'),
                       model.get_layer('conv5_block3_2_relu')]

for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

[ ]:
```
model.summary()
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)       0
['input_1[0][0]']
```

```
 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)
```

```
 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)
```

```
 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)
```

```
 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)
```

```
 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)
```

```
 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)
```

```
 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)
```

```
 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)
```

```
 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)
```

```
 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)
```

```
 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)
```

```
 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)
```

```
 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)          2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)
```

```
 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)          0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_2_bn[0][0]']
 ation)
```

```
 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)           0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)                0
['average_pooling2d[0][0]']

 dense (Dense)               (None, 9)                    165897
['flatten[0][0]']

==================================================================================
==================
Total params: 23753609 (90.61 MB)
Trainable params: 23700489 (90.41 MB)
Non-trainable params: 53120 (207.50 KB)
----------------------------------------------------------------------------------
------------------
```

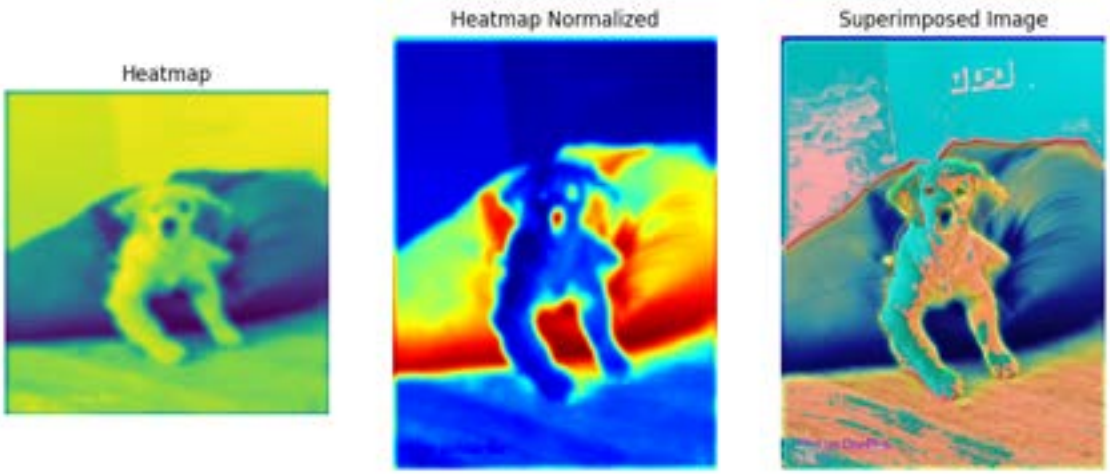
[ ]:
```python
import cv2

def overlay_heatmap(heatmap, img_path, alpha=0.4):
    img = cv2.imread(img_path)

    hmap = heatmap

    # Resize the heatmap to the size of the original image
    heatmap = cv2.resize(heatmap, (img.shape[1], img.shape[0]))

    # Normalize the heatmap
    heatmap = (heatmap - np.min(heatmap)) / (np.max(heatmap) - np.min(heatmap))
```

```
    # Apply a colormap to the heatmap
    heatmap = cv2.applyColorMap(np.uint8(255 * heatmap), cv2.COLORMAP_JET)

    # Superimpose the heatmap on the original image
    superimposed_img = heatmap * alpha + img


    fig, axes = plt.subplots(1, 3, figsize=(12, 8))


    # Display the heatmap in the second subplot
    axes[0].imshow(hmap)
    axes[0].set_title('Heatmap')
    axes[0].axis('off')

    # Display the heatmap in the second subplot
    axes[1].imshow(heatmap, cmap='jet')
    axes[1].set_title('Heatmap Normalized')
    axes[1].axis('off')


    # Display the superimposed image in the first subplot
    axes[2].imshow(cv2.cvtColor(np.uint8(superimposed_img), cv2.COLOR_BGR2RGB))
    axes[2].set_title('Superimposed Image')
    axes[2].axis('off')


    plt.show()


    # plt.imshow(cv2.cvtColor(np.uint8(superimposed_img), cv2.COLOR_BGR2RGB))
    # plt.axis('off')
    # plt.show()
```

First Layer Heatmap

[ ]:
```
# This is the "dog" entry in the prediction vector
dog_output = model.output[:, 4]

# The is the output feature map of the `conv3_block2_2_relu` layer,
# the first convolutional layer in ResNet50
first_conv_layer = model.get_layer('conv1_relu')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(dog_output, first_conv_layer.output)[0]
```

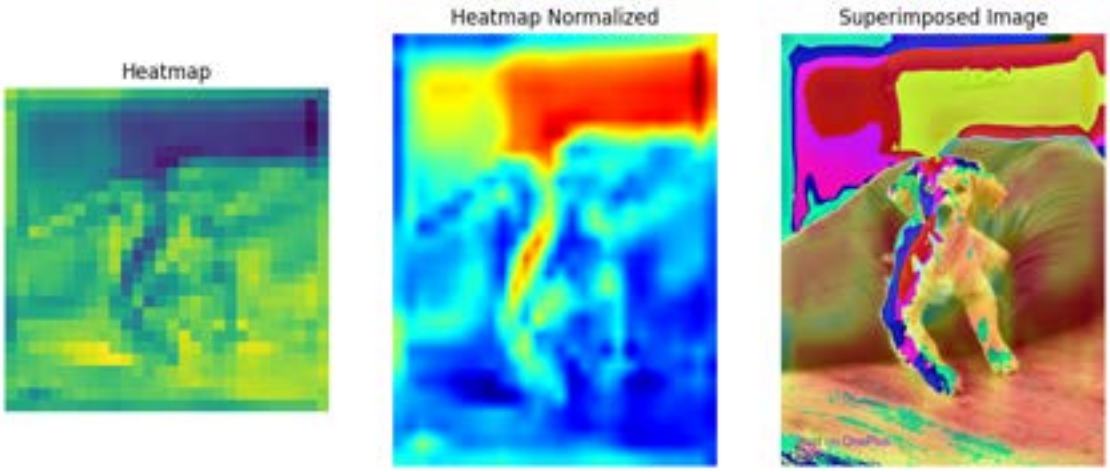
```
# This is a vector of shape (512,), where each entry
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
 ↪defined:
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([model.input], [pooled_grads, first_conv_layer.output[0]])

# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(64):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_first = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_first, img_path)
```



Middle Layer Heatmap

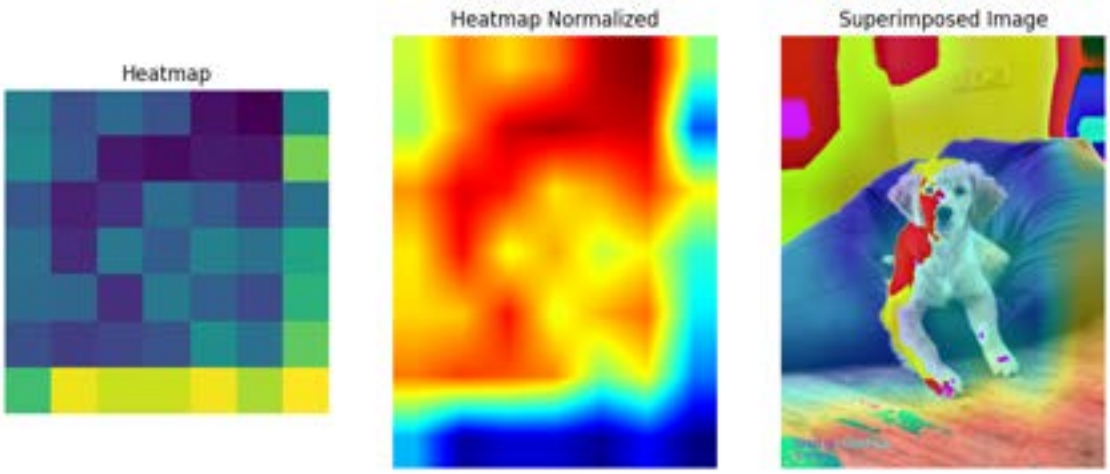
[ ]:
```
# This is the "dog" entry in the prediction vector
dog_output = model.output[:, 4]
```

```
# The is the output feature map of the `conv3_block2_2_relu` layer,
# the middle convolutional layer in ResNet50
middle_conv_layer = model.get_layer('conv3_block2_2_relu')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(dog_output, middle_conv_layer.output)[0]

# This is a vector of shape (512,), where each entry
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
 ↪defined:
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([model.input], [pooled_grads, middle_conv_layer.output[0]])

# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(128):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_middle = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_middle, img_path)
```

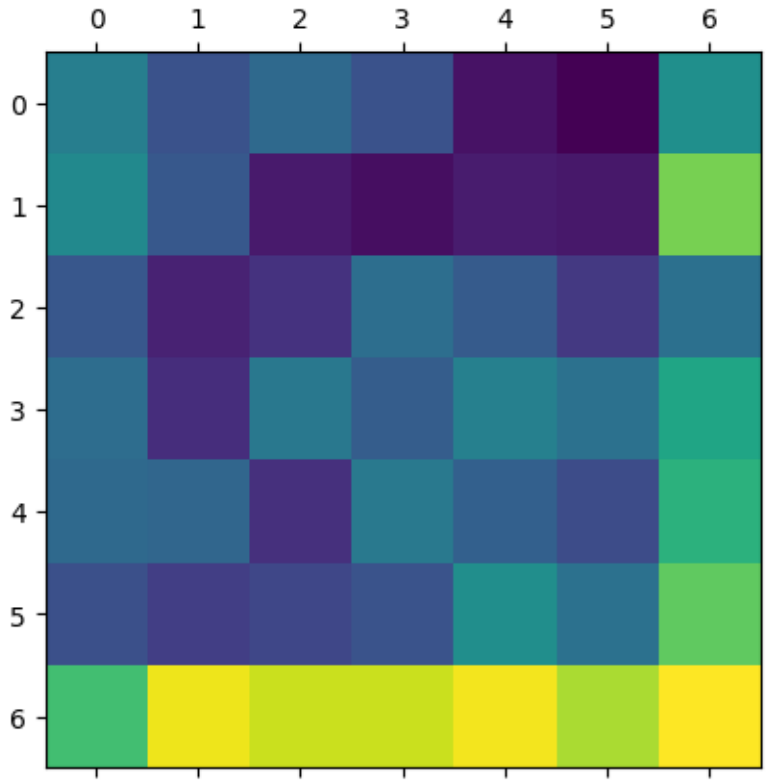


Last layer heatmap

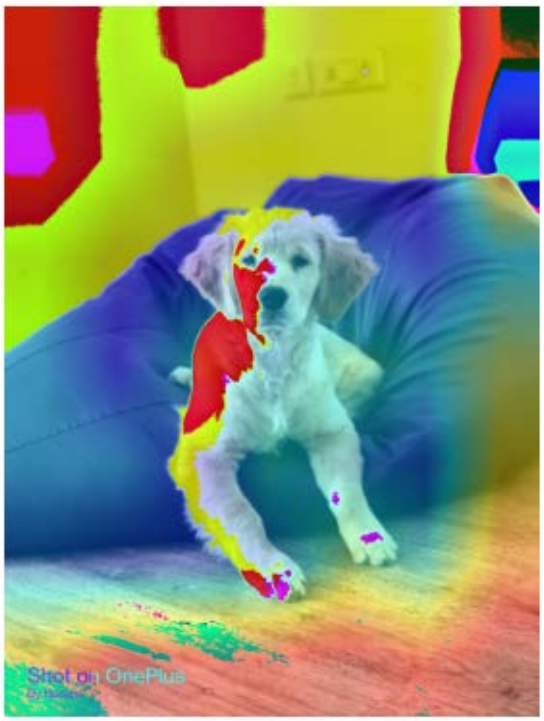
[ ]:
```
# This is the "dog" entry in the prediction vector
dog_output = model.output[:, 4]

# The is the output feature map of the `conv5_block3_3_conv` layer,
# the last convolutional layer in ResNet50
last_conv_layer = model.get_layer('conv5_block3_3_conv')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(dog_output, last_conv_layer.output)[0]

# This is a vector of shape (512,), where each entry
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
 ↪defined:
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([model.input], [pooled_grads, last_conv_layer.output[0]])

# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(512):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_last = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_last, img_path)
```



[ ]:
```
# # print(heatmap)
# heatmap = np.maximum(heatmap, 0)
# heatmap /= np.max(heatmap)
# plt.matshow(heatmap)
# plt.show()
```



[ ]:
```
overlay_heatmap(heatmap, img_path)
```



[ ]:
```

```

[ ]:
```
# # print(heatmap)
# heatmap = np.maximum(heatmap, 0)
# heatmap /= np.max(heatmap)
# plt.matshow(heatmap)
# plt.show()
```

[ ]:
```
# overlay_heatmap(heatmap, img_path)
```

1.2 PS 1.B - 20 points

In this notebook we showcase *transfer learning* using a pre-trained CNN model.

Perform the fine-tunning and feature extraction methods of transfer learning using the same model as in PS-1A, for the class `ship`.

Repeat the visualization of PS-1.A before and after transfer learning and write a conclusive summary as to the relative value of the two methods.

[ ]:
```
# Insert your code here

```

```
#Load base_model from PS 1.A
# base_model = load_model('model_my_custom_resnet50_aug1.h5')
# base_model = tf.keras.models.load_model('model_my_custom_resnet50_1.h5')
base_model = load_model('model_resnet50_aug4.h5')
base_model.summary()
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)
```

```
 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)
```

```
 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)
```

```
 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)
```

```
 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)
```

```
 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']
```

```
 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)
```

```
 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)
```

```
 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)
```

```
 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)
```

```
 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)
```

```
 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']
```

```
 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']
```

```
 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)
```

```
 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)          0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)          0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)          0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)               0
['average_pooling2d[0][0]']

 dense (Dense)               (None, 9)                   165897
['flatten[0][0]']

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

```
==================
Total params: 23753609 (90.61 MB)
Trainable params: 23700489 (90.41 MB)
Non-trainable params: 53120 (207.50 KB)
_________________________________________________________________________________
_________________
```

Here model 2 will get defined using model2b = Model(input = base-model.input, output = base-model.outputs) but update base-model.outputs' s last layer for sigmoid

1.2.1 Freeze the base layer

[ ]:
```
for layer in base_model.layers:
    layer.trainable = False

base_model.summary()
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)
```

```
 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)
```

```
 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)
```

```
 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)
```

```
 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)
```

```
 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)
```

```
 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']
```

```
 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']
```

```
 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)
```

```
 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)
```

```
 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)
```

```
 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)
```

```
 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)
```

```
 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']
```

```
 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)           0
['conv5_block3_out[0][0]']
 Pooling2D)
```

```
 flatten (Flatten)           (None, 18432)                0
['average_pooling2d[0][0]']

 dense (Dense)               (None, 9)                    165897
['flatten[0][0]']

==================================================================================
==================
Total params: 23753609 (90.61 MB)
Trainable params: 0 (0.00 Byte)
Non-trainable params: 23753609 (90.61 MB)
----------------------------------------------------------------------------------
------------------
```

Feature Extraction

[ ]:
```
# Add a new Dense layer with sigmoid activation for binary classification

num_classes = 1  # For binary classification
output_layer = Dense(num_classes, activation='sigmoid',␣
 ↪name='fc9_predictions')(base_model.layers[-2].output)

model_2b = Model(inputs=base_model.input, outputs=output_layer)

model_2b.summary()
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
```

```
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)          0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)          4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)          256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)          0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)          36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)          256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)          0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)         16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)         16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)         0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']
```

```
 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)
```

```
 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)
```

```
 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)
```

```
 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)
```

```
 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)
```

```
 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)
```

```
 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']
```

```
 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)
```

```
 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)
```

```
 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)
```

```
 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)
```

```
 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)           0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block2_2_relu[0][0]']
 D)
```

```
 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)           0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']
```

```
 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)           0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)                0
['average_pooling2d[0][0]']

 fc9_predictions (Dense)     (None, 1)                    18433
['flatten[0][0]']

==================================================================================
==================
Total params: 23606145 (90.05 MB)
Trainable params: 18433 (72.00 KB)
Non-trainable params: 23587712 (89.98 MB)
----------------------------------------------------------------------------------
------------------
```

Fine Tuning

[ ]:
```
# Set hyperparameters
learning_rate = 0.001
beta1 = 0.9
beta2 = 0.999
epsilon = 1e-8
num_iterations = 1000
# optimizer = Adam(learning_rate=learning_rate, beta_1=beta1, beta_2=beta2,␣
 ↪epsilon=1e-8)
optimizer = SGD(learning_rate=learning_rate, momentum=0.9, nesterov=True)
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.
```

[ ]:
```
# Create the final model
transfer_model = Model(inputs=model_2b.input, outputs=model_2b.outputs)

# Compile the model with an appropriate optimizer and loss function
# transfer_model.compile(optimizer='adam', loss='categorical_crossentropy',␣
 ↪metrics=['accuracy'])

transfer_model.compile(optimizer=optimizer, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
```

```
transfer_model.summary()
```

```
Model: "model_2"
__________________________________________________________________________________
__________________
 Layer (type)                Output Shape                 Param #   Connected to
==================================================================================
==================
 input_1 (InputLayer)        [(None, 224, 224, 3)]        0         []

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
```

```
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)          0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)         16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)         16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)         0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)         0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)          16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)          256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)          0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)          36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)          256
```

```
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)          0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)         16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)         0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)         0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)          16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)          256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)          0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)          36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)          256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)          0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)         16640
```

```
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
```

```
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
```

```
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
```

```
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
```

```
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
```

```
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
```

```
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
```

```
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
```

```
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
```

```
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)          2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
```

```
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)          0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
```

```
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)          0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)          0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)          0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)               0
['average_pooling2d[0][0]']

 fc9_predictions (Dense)     (None, 1)                   18433
['flatten[0][0]']

==================================================================================
==================
Total params: 23606145 (90.05 MB)
Trainable params: 18433 (72.00 KB)
Non-trainable params: 23587712 (89.98 MB)
----------------------------------------------------------------------------------
------------------
```

1.2.2 Data pre-processing for 2B

[ ]:
```
(x_train_new, y_train_new), (x_test_new, y_test_new) = cifar10.load_data()

classes = len(np.unique(y_train_new))
classes
```

[ ]:
```
10
```

[ ]:
```
print(x_train_new.shape, y_train_new.shape, x_test_new.shape, y_test_new.shape)
```

```
(50000, 32, 32, 3) (50000, 1) (10000, 32, 32, 3) (10000, 1)
```

[ ]:
```
index = np.where(y_train_new == 8)
# Filter the dataset for 9 out of 10 classes (exclude "ship index 8" class)
ship_class = 8  # Adjust this class to exclude "ship"
x_train_new = x_train_new / 255.0
# y_train_new = y_train_new[y_train_new == ship_class].astype(int)
# Create binary labels (0 for negative, 1 for positive)
y_train_new_norm = np.where(y_train_new == ship_class, 1, 0)
x_test_new = x_test_new / 255.0
y_test_new_norm = np.where(y_test_new == ship_class, 1, 0)
# y_test_new = y_test_new[y_test_new == ship_class].astype(int)


# number of classes K=9
k = 1
```

[ ]:
```
print(x_train_new.shape, y_train_new.shape, x_test_new.shape, y_test_new.shape)
```

```
(50000, 32, 32, 3) (50000, 1) (10000, 32, 32, 3) (10000, 1)
```

[ ]:
```
# visualize data by plotting images
fig, ax = plt.subplots(5, 5)
k = 1

for i in range(5):
    for j in range(5):
        ax[i][j].imshow(x_train_new[k], aspect='auto')
        k += 1

plt.show()
```

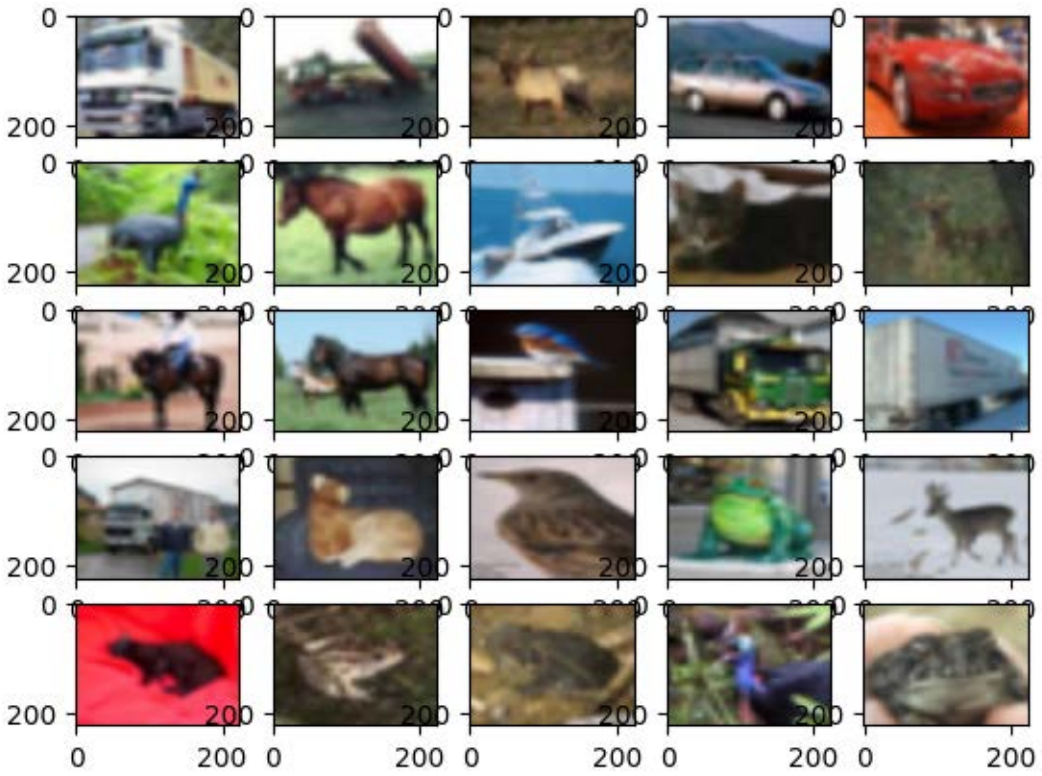
[ ]:
```
# A ResNet-50 model expects 224 × 224-pixel images
im_size = 224

x_train_new_resize = Resizing(height=im_size, width=im_size,␣
 ↪crop_to_aspect_ratio=True)(x_train_new)
x_test_new_resize = Resizing(height=im_size, width=im_size,␣
 ↪crop_to_aspect_ratio=True)(x_test_new)
```

[ ]:
```
print(x_train_new_resize.shape, y_train_new_norm.shape, x_test_new_resize.
 ↪shape, y_test_new_norm.shape)
```

```
(50000, 224, 224, 3) (50000, 1) (10000, 224, 224, 3) (10000, 1)
```

[ ]:
```
# visualize data by plotting images
fig, ax = plt.subplots(5, 5)
k = 1

for i in range(5):
    for j in range(5):
        ax[i][j].imshow(x_train_new_resize[k], aspect='auto')
        k += 1
```

```
plt.show()
```



[ ]:
```
## Data augmentation
batch_size = 32
data_generator = tf.keras.preprocessing.image.ImageDataGenerator(
  width_shift_range=0.1,
  height_shift_range=0.1,
    horizontal_flip=True,)

train_generator_new = data_generator.flow(x_train_new_resize,
                                          y_train_new_norm,
                                          batch_size)
steps_per_epoch = x_train_new_resize.shape[0] // batch_size
```

[ ]:
```
val_loss_callback = ValidationLoss()
lr_scheduler = CustomLRScheduler()


transfer_model.fit_generator(
    train_generator_new,  # Your training labels
    epochs=10,
    steps_per_epoch=10,
```

```
    validation_data=(x_test_new_resize, y_test_new_norm),
    callbacks=[val_loss_callback, lr_scheduler]
    # Other parameters like callbacks, verbose, etc.
)


# transfer_model.fit(
#     x=x_train_new_resize,  # Your training data
#     y=y_train_new_norm,  # Your training labels
#     batch_size=64,
#     epochs=10,
#     steps_per_epoch=10,
#     validation_data=(x_test_new_resize, y_test_new_norm),
#     callbacks=[val_loss_callback, lr_scheduler]
#     # Other parameters like callbacks, verbose, etc.
# )

transfer_model.save('transfer_resnet50_2b_aug1.h5')
```

```
Epoch 1: Learning Rate = 0.001
Epoch 1/10
/var/folders/xy/1x8f1vlx569_ch145p3563j80000gn/T/ipykernel_17264/2315718120.py:1
6: UserWarning: `Model.fit_generator` is deprecated and will be removed in a
future version. Please use `Model.fit`, which supports generators.
  transfer_model.fit_generator(
10/10 [==============================] - 51s 5s/step - loss: 0.0952 - accuracy:
0.9831 - val_loss: 5.3289 - val_accuracy: 0.0000e+00
Epoch 2: Learning Rate = 0.0007071067811865475
Epoch 2/10
10/10 [==============================] - 48s 5s/step - loss: 3.3305e-05 -
accuracy: 1.0000 - val_loss: 7.3087 - val_accuracy: 0.0000e+00
Epoch 3: Learning Rate = 0.0005773502691896258
Epoch 3/10
10/10 [==============================] - 50s 5s/step - loss: 2.7973e-06 -
accuracy: 1.0000 - val_loss: 8.2863 - val_accuracy: 0.0000e+00
Epoch 4: Learning Rate = 0.0005
Epoch 4/10
10/10 [==============================] - 50s 5s/step - loss: 2.1394e-06 -
accuracy: 1.0000 - val_loss: 8.8889 - val_accuracy: 0.0000e+00
Epoch 5: Learning Rate = 0.0004472135954999579
Epoch 5/10
10/10 [==============================] - 48s 5s/step - loss: 2.3662e-06 -
accuracy: 1.0000 - val_loss: 9.2786 - val_accuracy: 0.0000e+00
Epoch 6: Learning Rate = 0.0004082482904638631
Epoch 6/10
10/10 [==============================] - 47s 5s/step - loss: 1.7452e-06 -
```

```
accuracy: 1.0000 - val_loss: 9.6265 - val_accuracy: 0.0000e+00
Epoch 7: Learning Rate = 0.0003779644730092272
Epoch 7/10
10/10 [==============================] - 48s 5s/step - loss: 3.1252e-06 -
accuracy: 1.0000 - val_loss: 9.9620 - val_accuracy: 0.0000e+00
Epoch 8: Learning Rate = 0.00035355339059327376
Epoch 8/10
10/10 [==============================] - 51s 5s/step - loss: 2.1242e-06 -
accuracy: 1.0000 - val_loss: 10.3004 - val_accuracy: 0.0000e+00
Epoch 9: Learning Rate = 0.0003333333333333333
Epoch 9/10
10/10 [==============================] - 49s 5s/step - loss: 3.2146e-06 -
accuracy: 1.0000 - val_loss: 10.6168 - val_accuracy: 0.0000e+00
Epoch 10: Learning Rate = 0.00031622776601683794
Epoch 10/10
10/10 [==============================] - 53s 5s/step - loss: 1.6738e-06 -
accuracy: 1.0000 - val_loss: 11.0166 - val_accuracy: 0.0000e+00

/Users/banani/Library/Python/3.9/lib/python/site-
packages/keras/src/engine/training.py:3079: UserWarning: You are saving your
model as an HDF5 file via `model.save()`. This file format is considered legacy.
We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')`.
  saving_api.save_model(
```

1.2.3 Pre process the test image

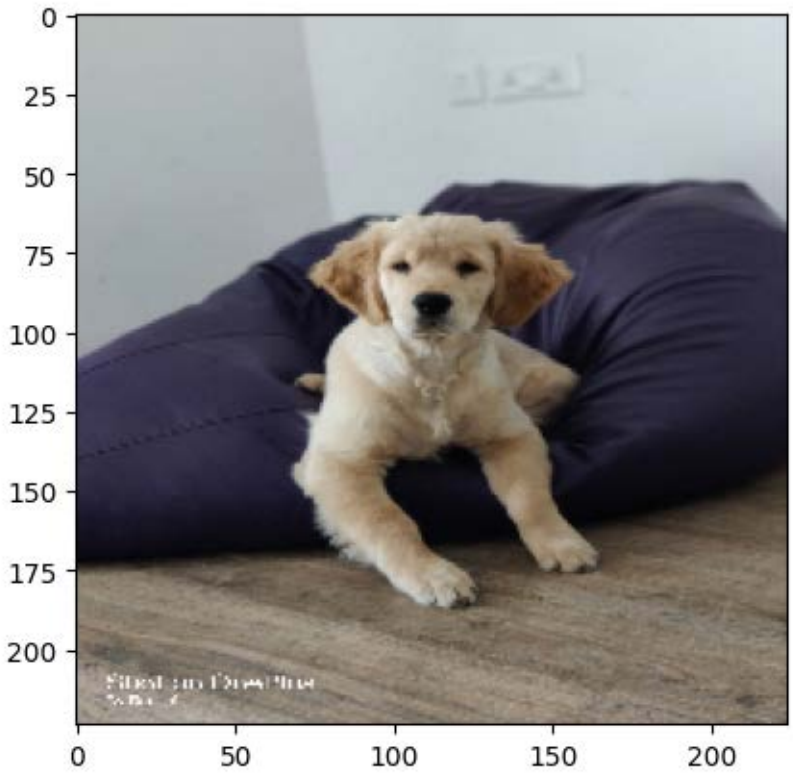
[ ]:
```
layers_to_visualize = [transfer_model.get_layer('conv1_relu'),
                       transfer_model.get_layer('conv3_block2_2_relu'),
                       transfer_model.get_layer('conv5_block3_2_relu')]

for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

[ ]:
```
# img_path = 'dogscats/subset/test/cats/cat.1700.jpg'
img_path='refs/dog_1.jpg'
# img_path='refs/dog.215.jpg'

im_size = 224

img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))
img_tensor = tf.keras.utils.img_to_array(img)
img_tensor = np.expand_dims(img_tensor, axis=0)
```

```
img_tensor /= 255.

# Its shape is (1, 224, 224, 3)
print(img_tensor.shape)

plt.imshow(img_tensor[0])
plt.show()
```

```
(1, 224, 224, 3)
```



1.2.4 Image pre process to visualize

[ ]:
```
# import tensorflow as tf
transfer_model = tf.keras.models.load_model('transfer_resnet50_2b_aug1.h5')
transfer_model.summary()
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.

Model: "model_1"

_________________________________________________________________________________
```

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)
```

```
 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)
```

```
 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)
```

```
 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)
```

```
 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)
```

```
 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)
```

```
 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)
```

```
 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)
```

```
 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)
```

```
 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)
```

```
 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)
```

```
 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)
```

```
 conv5_block1_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)          2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
 rmalization)
```

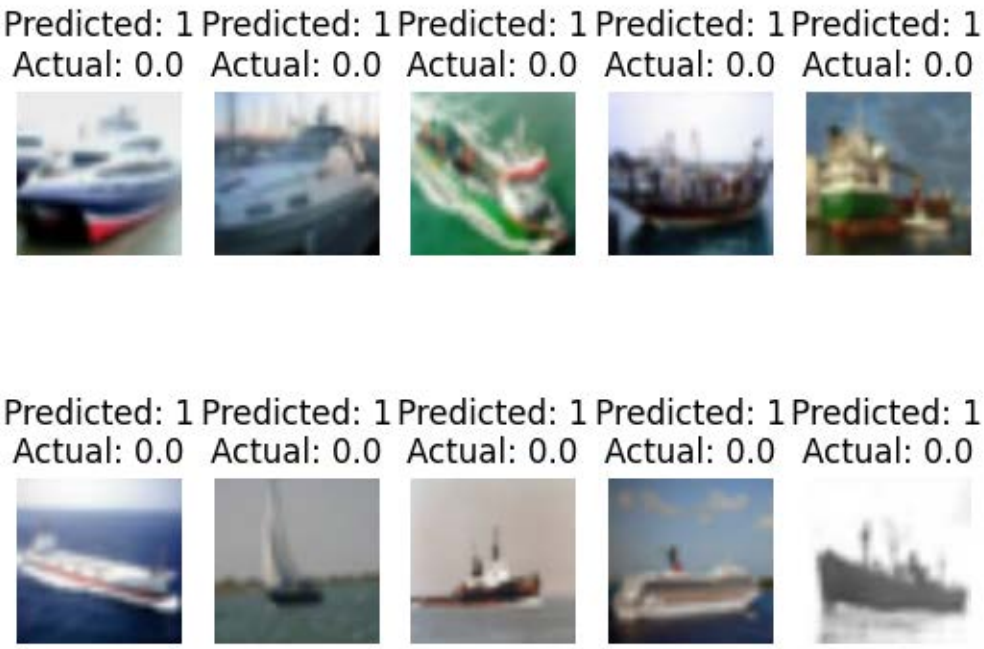
```
 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)          0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
 D)
```

```
 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)           0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)                0
['average_pooling2d[0][0]']

 fc9_predictions (Dense)     (None, 1)                    18433
['flatten[0][0]']

==================================================================================
==================
Total params: 23606145 (90.05 MB)
Trainable params: 23553025 (89.85 MB)
Non-trainable params: 53120 (207.50 KB)
----------------------------------------------------------------------------------
------------------
```

[ ]:
```
# Visualize predictions on test data
predictions = transfer_model.predict(x_test_new_resize)
predicted_labels = (predictions > 0.5).astype(int)
sample_images = x_test_new_resize[:10]
```

```
sample_labels = y_test_new_norm[:10]

for i in range(10):
    plt.subplot(2, 5, i + 1)
    plt.imshow(sample_images[i])
    plt.title(f'Predicted: {predicted_labels[i][0]}\nActual:␣
 ↪{sample_labels[i][0]}')
    plt.axis('off')

plt.show()
```

```
32/32 [==============================] - 21s 637ms/step
```



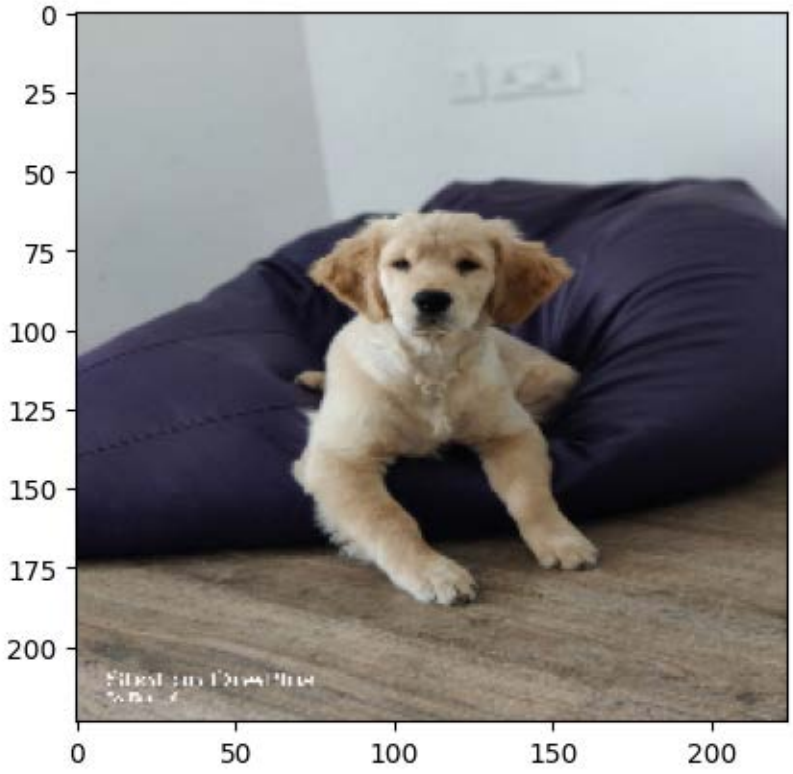
1.2.5 PS1.B Visualize Activation

[ ]:
```
# img_path = 'dogscats/subset/test/cats/cat.1700.jpg'
img_path='refs/dog_1.jpg'
# img_path='refs/dog.215.jpg'

# We preprocess the image into a 4D tensor
from keras.preprocessing import image
import numpy as np

im_size = 224
```

```
img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))
img_tensor = tf.keras.utils.img_to_array(img)
img_tensor = np.expand_dims(img_tensor, axis=0)
# Remember that the model was trained on inputs
# that were preprocessed in the following way:
img_tensor /= 255.

# Its shape is (1, 150, 150, 3)
print(img_tensor.shape)
```

```
(1, 224, 224, 3)
```

[ ]:
```
plt.imshow(img_tensor[0])
plt.show()
```



Chosen layer

[ ]:
```
layers_to_visualize = [transfer_model.get_layer('conv1_relu'),
                       transfer_model.get_layer('conv3_block2_2_relu'),
                       transfer_model.get_layer('conv5_block3_2_relu')]

for layer in layers_to_visualize:
```

```
    print(layer.name)
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

[ ]:
```
act_input1 = transfer_model.input
# Extracts the outputs of the top 50 layers:
# layer_outputs = [layer.output for layer in model.layers[1:51]]
layer_outputs1 = [layer.output for layer in layers_to_visualize]

# First block :  conv1
# Middle block:  conv2c_branch2b
# Last block:    conv5c_branch2c

# layer_outputs = [layer.output for layer in layers_to_visualize]
# Creates a model that will return these outputs, given the model input:
activation_model1 = Model(inputs=act_input1, outputs=layer_outputs1)
activation_model1.summary()
```

```
Model: "model_2"
__________________________________________________________________________________
__________________
 Layer (type)                Output Shape              Param #   Connected to
==================================================================================
==================
 input_1 (InputLayer)        [(None, 224, 224, 3)]     0         []

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)       0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)      9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)      256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)      0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)      0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)        0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)        4160
```

```
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
```

```
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
```

```
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512
```

```
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
```

```
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
```

```
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
```

```
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
```

```
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
```

```
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
```

```
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
```

```
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
```

```
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
```

```
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
```

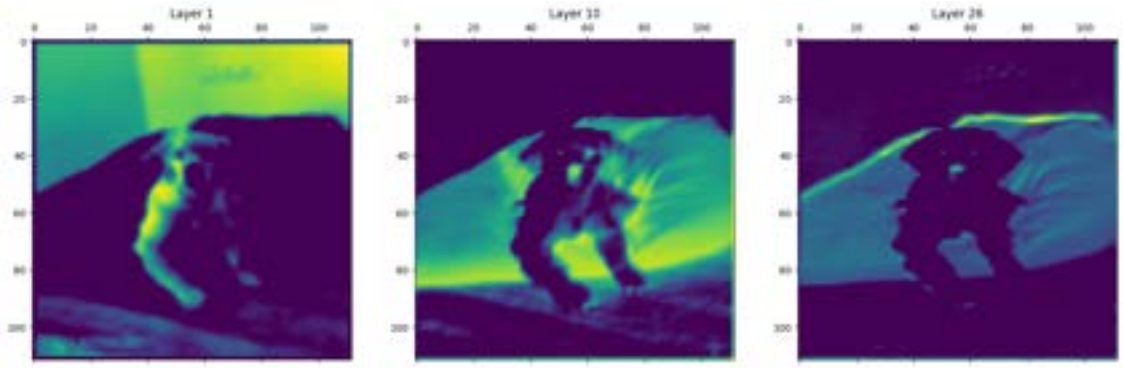
```
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block3_2_bn[0][0]']
 ation)

==================================================================================
==================
Total params: 22528896 (85.94 MB)
Trainable params: 22479872 (85.75 MB)
Non-trainable params: 49024 (191.50 KB)
----------------------------------------------------------------------------------
------------------
```

First Block Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

first_layer_activation = activations[0]
print(first_layer_activation.shape)

for activation in activations:
    print(activation.shape)
```

```
fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(first_layer_activation[0, :, :, 6], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(first_layer_activation[0, :, :, 10], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(first_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 55ms/step
(1, 112, 112, 64)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```



This nose and eyes looks more bright green and is further clear or better to encode dog eyes and nose in the learnt model

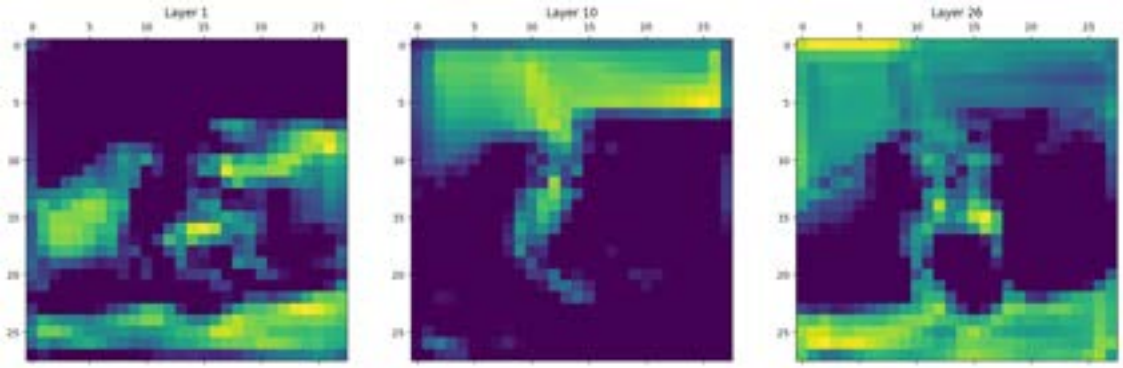
At this point, let's go and plot a complete visualization of all the activations in the network.

Middle Block Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

middle_layer_activation = activations[1]
print(middle_layer_activation.shape)
```

```
for activation in activations:
    print(activation.shape)

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(middle_layer_activation[0, :, :, 6], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(middle_layer_activation[0, :, :, 10], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(middle_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 62ms/step
(1, 28, 28, 128)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```

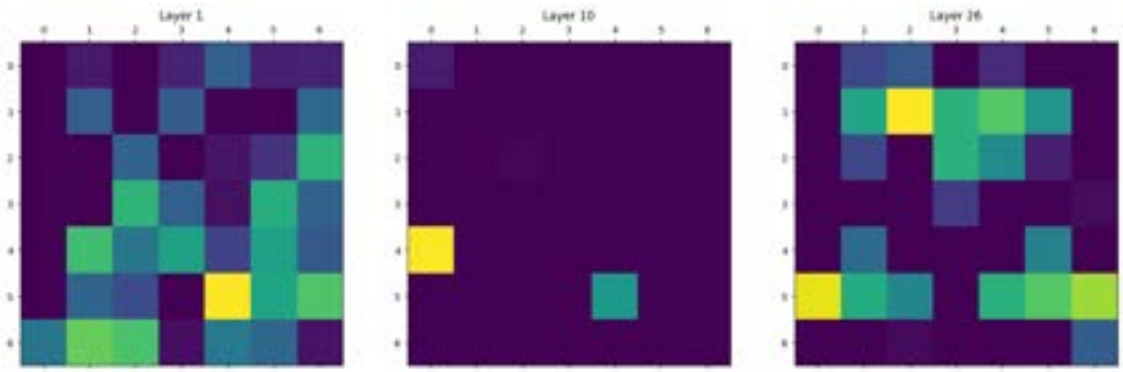


Last Block Activation

[ ]:
```
activations = activation_model1.predict([img_tensor])

last_layer_activation = activations[2]
print(first_layer_activation.shape)
```

```
for activation in activations:
    print(activation.shape)

fig, axes = plt.subplots(1, 3,  figsize=(20, 8))

# Display the first activation
axes[0].matshow(last_layer_activation[0, :, :, 1], cmap='viridis')
axes[0].set_title('Layer 1')

# Display the second activation
axes[1].matshow(last_layer_activation[0, :, :, 11], cmap='viridis')
axes[1].set_title('Layer 10')

# Display the second activation
axes[2].matshow(last_layer_activation[0, :, :, 15], cmap='viridis')
axes[2].set_title('Layer 26')

# Show the subplots
plt.show()
```

```
1/1 [==============================] - 0s 53ms/step
(1, 112, 112, 64)
(1, 112, 112, 64)
(1, 28, 28, 128)
(1, 7, 7, 512)
```



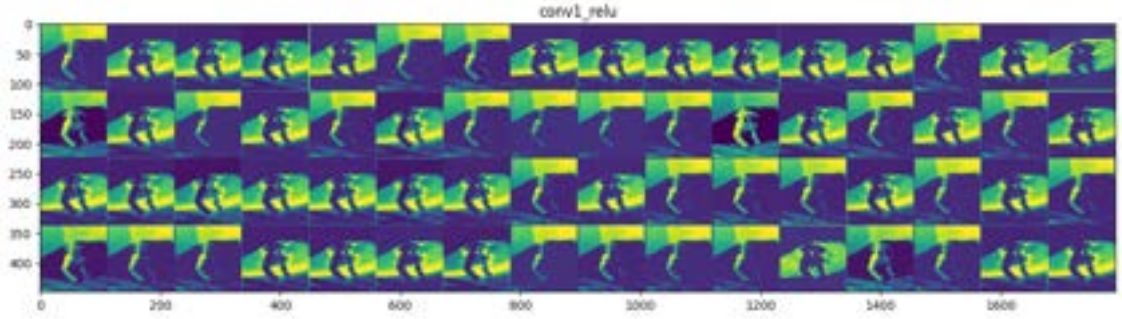
All Block channels

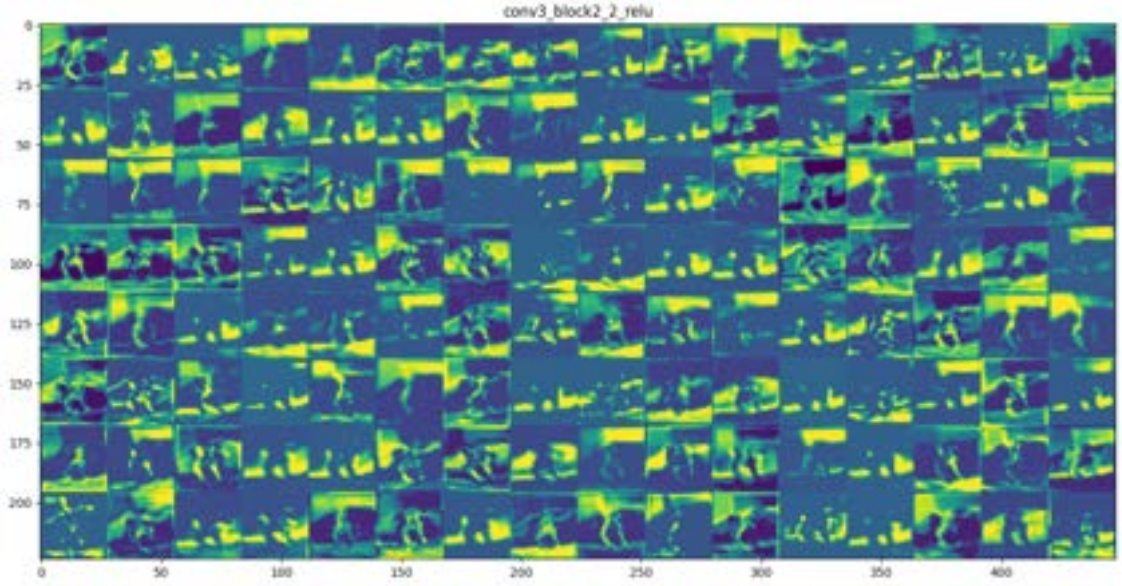
[ ]:
```
# These are the names of the layers, so can have them as part of our plot
layer_names = []
# layer_names = layers_to_visualize
# for layer in model.layers[:50]:
#     layer_names.append(layer.name)
for layer in layers_to_visualize:
```

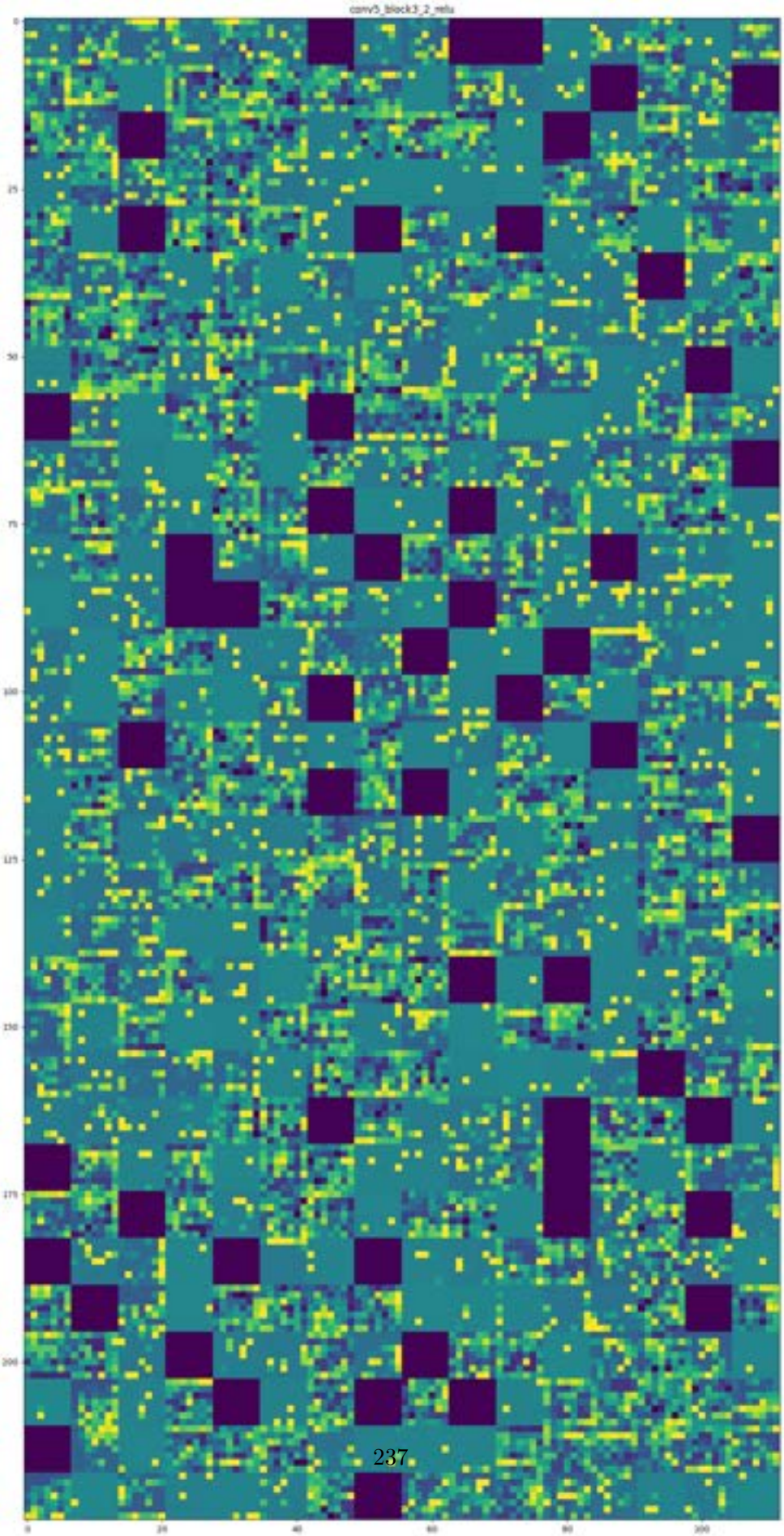
```
    print(layer.name)
    layer_names.append(layer.name)

# layer_names = layers_to_visualize

images_per_row = 16

# Now let's display our feature maps
for layer_name, layer_activation in zip(layer_names, activations):
    # This is the number of features in the feature map
    n_features = layer_activation.shape[-1]

    # The feature map has shape (1, size, size, n_features)
    size = layer_activation.shape[1]

    # We will tile the activation channels in this matrix
    n_cols = n_features // images_per_row
    display_grid = np.zeros((size * n_cols, images_per_row * size))

    # We'll tile each filter into this big horizontal grid
    for col in range(n_cols):
        for row in range(images_per_row):
            channel_image = layer_activation[0,
                                             :, :,
                                             col * images_per_row + row]
            # Post-process the feature to make it visually palatable
            channel_image -= channel_image.mean()
            channel_image /= channel_image.std()
            channel_image *= 64
            channel_image += 128
            channel_image = np.clip(channel_image, 0, 255).astype('uint8')
            display_grid[col * size : (col + 1) * size,
                         row * size : (row + 1) * size] = channel_image

    # Display the grid
    scale = 1. / size
    plt.figure(figsize=(scale * display_grid.shape[1],
                        scale * display_grid.shape[0]))
    plt.title(layer_name)
    plt.grid(False)
    plt.imshow(display_grid, aspect='auto', cmap='viridis')

plt.show()
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

```
/var/folders/xy/1x8f1vlx569_ch145p3563j80000gn/T/ipykernel_17264/1518767542.py:3
7: RuntimeWarning: invalid value encountered in cast
  channel_image = np.clip(channel_image, 0, 255).astype('uint8')
```






conv5_block3_2_relu
0
25
50
75
100
125
150
175
200
0
20
40
60
80
100

Please scroll for all the plots

1.2.6 PS1.B Visualize convnet Filter

[ ]:
```
layers_to_visualize = [transfer_model.get_layer('conv1_conv'),
                       transfer_model.get_layer('conv3_block2_2_conv'),
                       transfer_model.get_layer('conv5_block3_3_conv')]

for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_conv
conv3_block2_2_conv
conv5_block3_3_conv
```

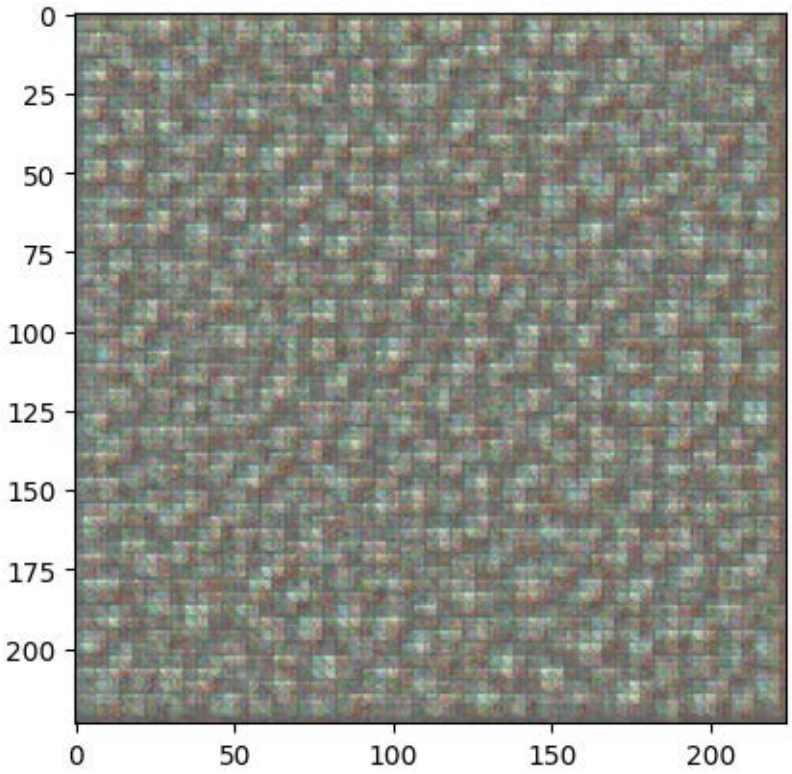
[ ]:
```
def deprocess_image(x):
    # normalize tensor: center on 0., ensure std is 0.1
    x -= x.mean()
    x /= (x.std() + 1e-5)
    x *= 0.1

    # clip to [0, 1]
    x += 0.5
    x = np.clip(x, 0, 1)

    # convert to RGB array
    x *= 255
    x = np.clip(x, 0, 255).astype('uint8')
    return x
```

[ ]:
```
# Disable eager execution
tf.compat.v1.disable_eager_execution()
```

[ ]:
```
def generate_pattern_transfer(layer_name, filter_index, size=224):

    layer = transfer_model.get_layer(layer_name)
    input_img = transfer_model.input

    loss = K.mean(layer.output[:, :, :, filter_index])
    grads = K.gradients(loss, input_img)[0]
    grads /= (K.sqrt(K.mean(K.square(grads))) + 1e-5)

    iterate = K.function([input_img], [loss, grads])

    input_img_data = np.random.random((1, size, size, 3)) * 20 + 128.
```

```
    step = 1.
    for i in range(40):
        loss_value, grads_value = iterate([input_img_data])
        input_img_data += grads_value * step

    img = input_img_data[0]
    return deprocess_image(img)
```

[ ]:
```
# Now you can use generate_pattern function
layer_name = 'conv1_block1_1_conv'
filter_index = 0

pattern = generate_pattern_transfer(layer_name, filter_index)
plt.imshow(pattern)
plt.show()
```



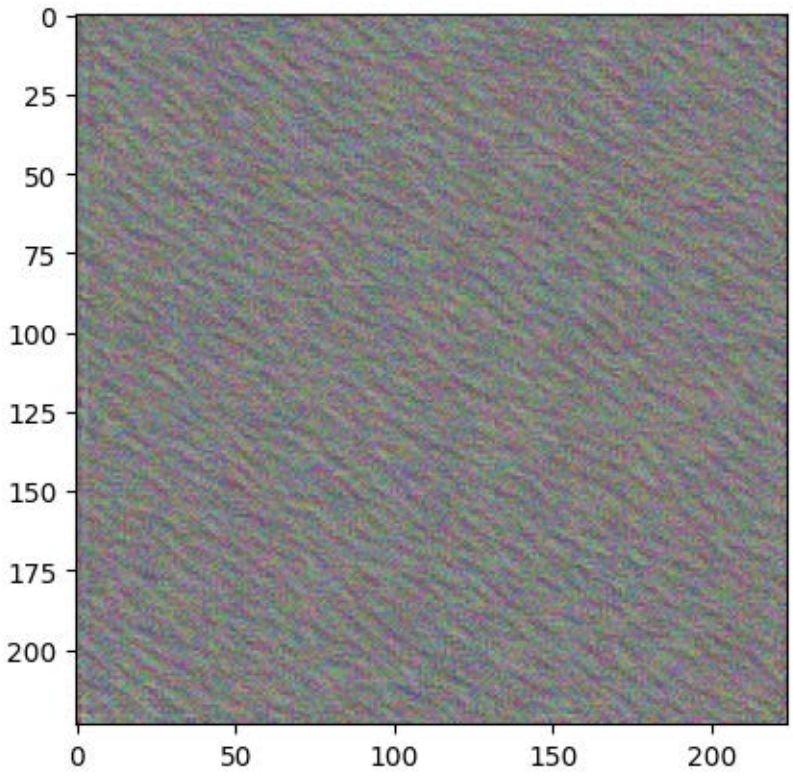
First and Middle Block

[ ]:
```
# Now you can use generate_pattern function
layer_name = 'conv2_block1_1_conv'
filter_index = 0
```

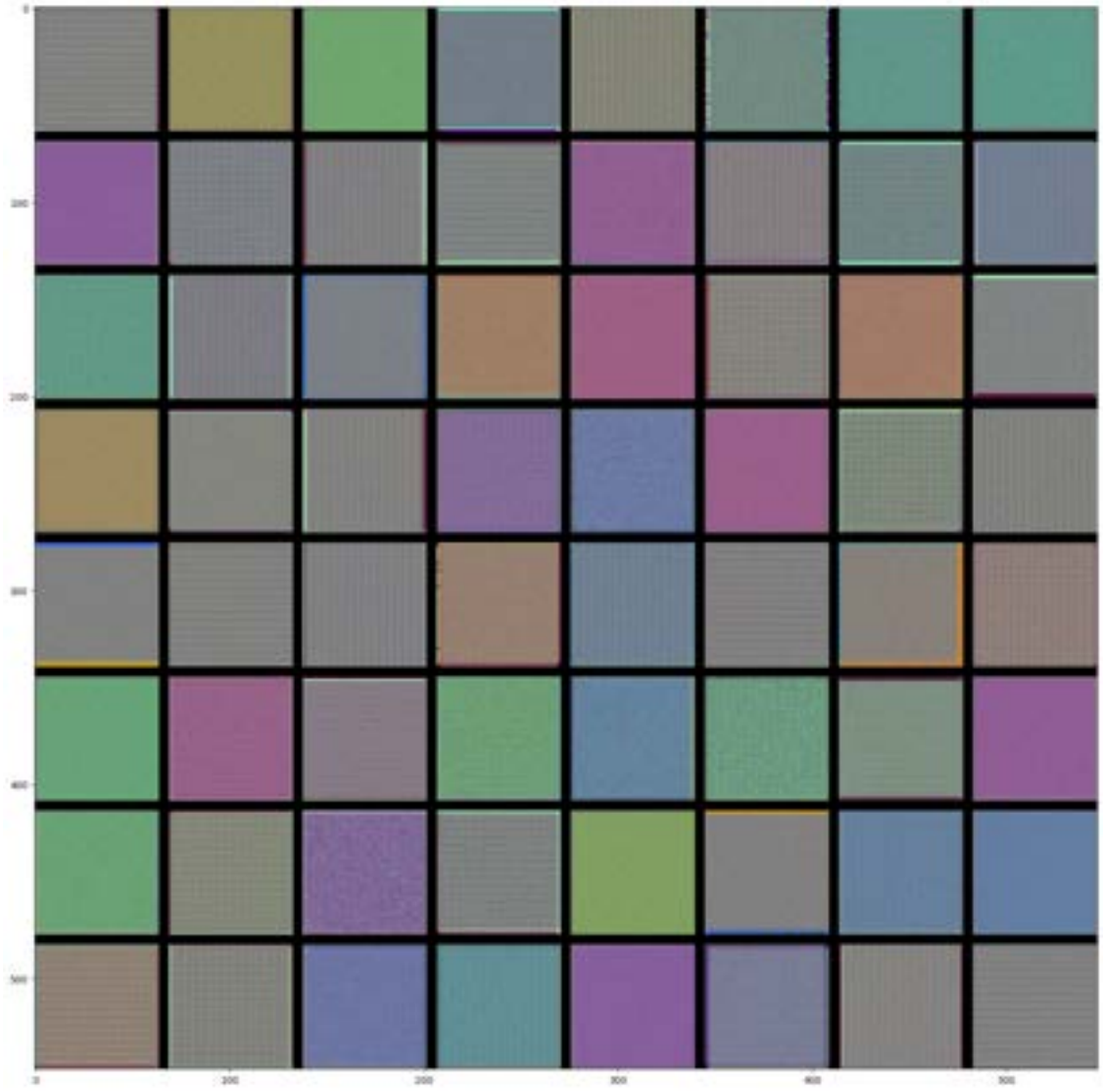
```
pattern = generate_pattern(layer_name, filter_index)
plt.imshow(pattern)
plt.show()
```

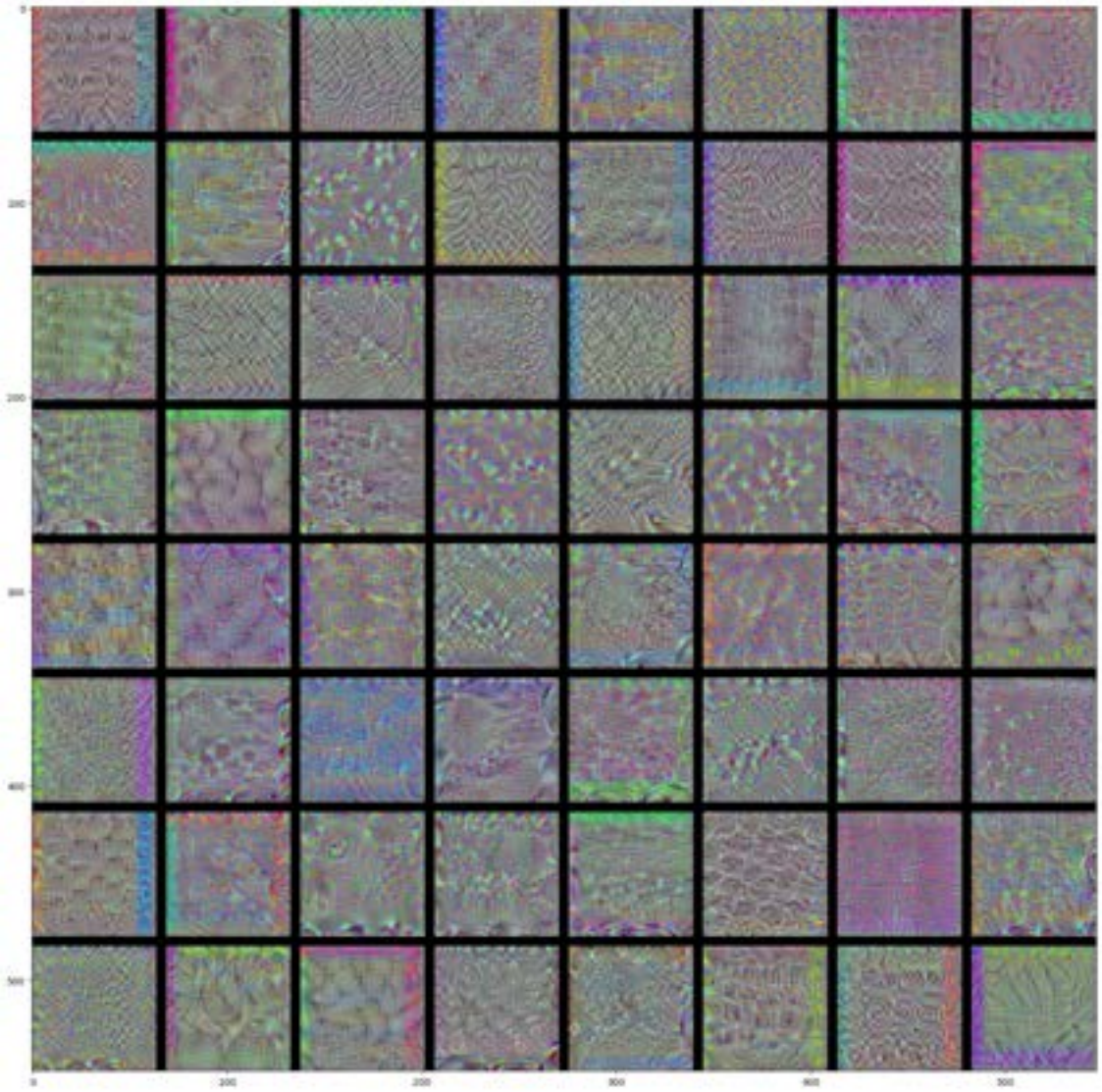
```
WARNING:tensorflow:From /Users/banani/Library/Python/3.9/lib/python/site-
packages/keras/src/layers/normalization/batch_normalization.py:883:
_colocate_with (from tensorflow.python.framework.ops) is deprecated and will be
removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
```

```
WARNING:tensorflow:From /Users/banani/Library/Python/3.9/lib/python/site-
packages/keras/src/layers/normalization/batch_normalization.py:883:
_colocate_with (from tensorflow.python.framework.ops) is deprecated and will be
removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
2023-10-26 03:59:55.775561: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:382] MLIR V1
optimization pass is not enabled
2023-10-26 03:59:55.973099: W tensorflow/c/c_api.cc:305] Operation
'{name:'conv5_block1_3_bn/moving_mean/Assign' id:3409 op device:{requested: '',
assigned: ''} def:{{{node conv5_block1_3_bn/moving_mean/Assign}} =
AssignVariableOp[_has_manual_control_dependencies=true, dtype=DT_FLOAT,
validate_shape=false](conv5_block1_3_bn/moving_mean,
conv5_block1_3_bn/moving_mean/Initializer/zeros)}}' was changed by setting
attribute after it was run by a session. This mutation will have no effect, and
will trigger an error in the future. Either don't modify nodes after running
them or create a new session.
```



[ ]:
```
for layer_name in ['conv1_conv', 'conv3_block3_2_conv']:
    size = 64
    margin = 5

    results = np.zeros((8 * size + 7 * margin, 8 * size + 7 * margin, 3))

    for i in range(8):
        for j in range(8):
            filter_img = generate_pattern(layer_name, i + (j * 8), size=size)

            horizontal_start = i * size + i * margin
            horizontal_end = horizontal_start + size
            vertical_start = j * size + j * margin
            vertical_end = vertical_start + size
            results[horizontal_start: horizontal_end, vertical_start:␣
↪vertical_end, :] = filter_img

    plt.figure(figsize=(20, 20))
    plt.imshow((results * 255).astype(np.uint8))
    plt.show()
```

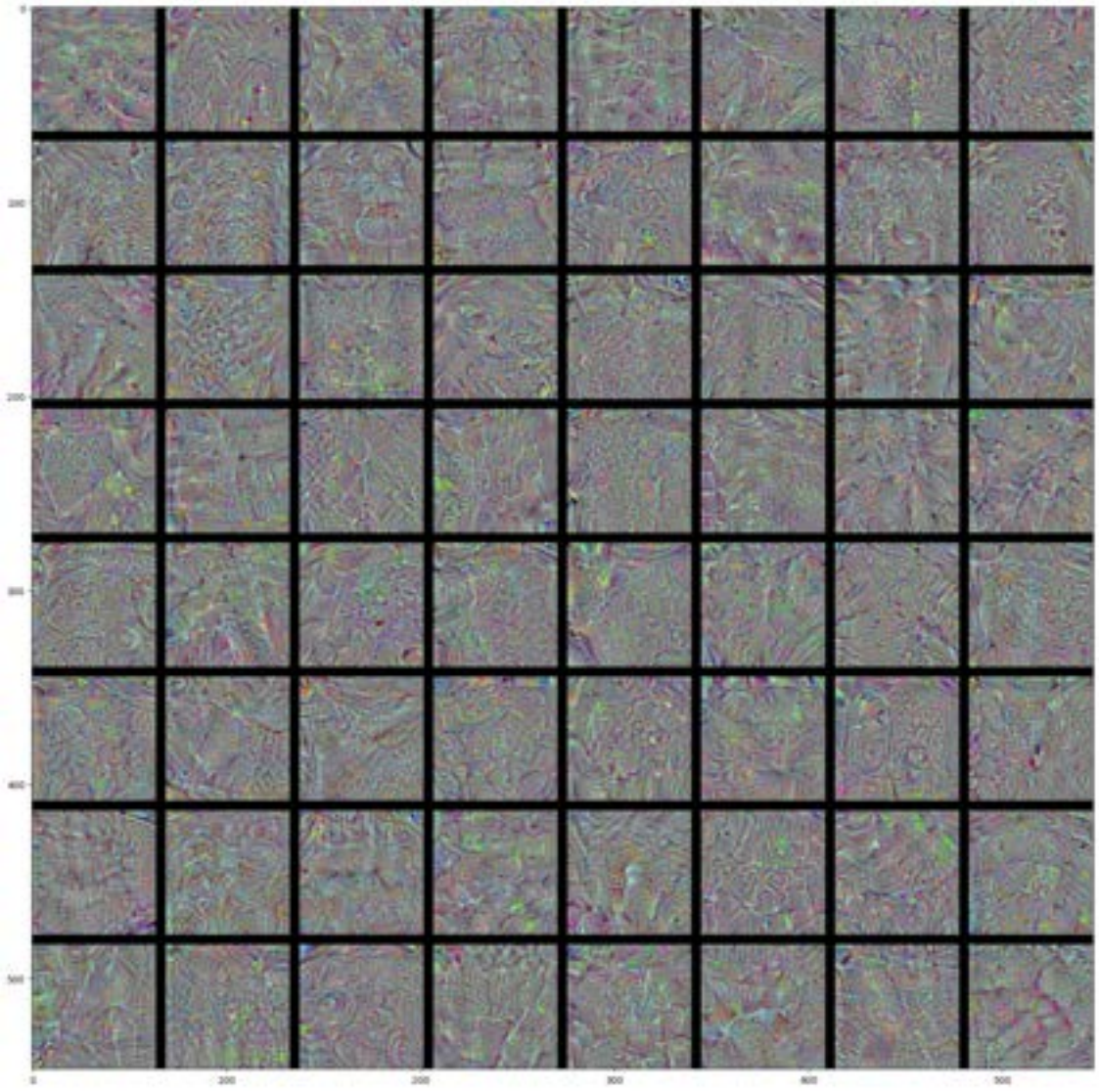




Last Conv Block To avoid kernel crash

[ ]:
```
for layer_name in ['conv5_block3_3_conv']:
    size = 64
    margin = 5

    # This a empty (black) image where we will store our results.
    results = np.zeros((8 * size + 7 * margin, 8 * size + 7 * margin, 3))

    for i in range(8):  # iterate over the rows of our results grid
        for j in range(8):  # iterate over the columns of our results grid
            # Generate the pattern for filter `i + (j * 8)` in `layer_name`
            filter_img = generate_pattern(layer_name, i + (j * 8), size=size)
```

```
            # Put the result in the square `(i, j)` of the results grid
            horizontal_start = i * size + i * margin
            horizontal_end = horizontal_start + size
            vertical_start = j * size + j * margin
            vertical_end = vertical_start + size
            results[horizontal_start: horizontal_end, vertical_start:␣
↪vertical_end, :] = filter_img

    # Display the results grid
    plt.figure(figsize=(20, 20))
    plt.imshow((results * 255).astype(np.uint8))
    plt.show()
```



[ ]:

1.2.7 PS1.B Visualize Heatmaps

[ ]:
```
# import tensorflow as tf
transfer_model = tf.keras.models.load_model('transfer_resnet50_2b_aug1.h5')
transfer_model.summary()
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizers.SGD` runs
slowly on M1/M2 Macs, please use the legacy Keras optimizer instead, located at
`tf.keras.optimizers.legacy.SGD`.

Model: "model_1"

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

 conv1_pad (ZeroPadding2D)   (None, 230, 230, 3)          0
['input_1[0][0]']

 conv1_conv (Conv2D)         (None, 112, 112, 64)         9472
['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati  (None, 112, 112, 64)         256
['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)     (None, 112, 112, 64)         0
['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)   (None, 114, 114, 64)         0
['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)   (None, 56, 56, 64)           0
['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2  (None, 56, 56, 64)           4160
['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ  (None, 56, 56, 64)           0
```

```
['conv2_block1_1_bn[0][0]']
 ation)

 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640
['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_0_bn[0][0]',
'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0
['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0
```

```
['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block2_1_relu[0][0]']
 D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0
['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640
['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024
['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0
['conv2_block1_out[0][0]',
'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0
['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448
['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256
['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0
['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928
['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256
```

```
['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)          0
['conv2_block3_2_bn[0][0]']
 ation)

 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)         16640
['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)         1024
['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)         0
['conv2_block2_out[0][0]',
'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)         0
['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)         32896
['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)         512
['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)         0
['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)         147584
['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)         512
['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)         0
['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)         131584
```

```
['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_0_conv[0][0]']
 rmalization)

 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_0_bn[0][0]',
'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0
['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048
```

```
['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0
['conv3_block1_out[0][0]',
'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0
['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0
```

```
['conv3_block2_out[0][0]',
'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0
['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664
['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_1_conv[0][0]']
 rmalization)

 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584
['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512
['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0
['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048
['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048
['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0
['conv3_block3_out[0][0]',
'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0
['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328
```

```
['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block1_2_conv[0][0]']
 rmalization)

 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312
['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_0_bn[0][0]',
'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0
['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400
```

```
['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0
['conv4_block1_out[0][0]',
'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0
['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0
```

```
['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block3_3_conv[0][0]']
 rmalization)

 conv4_block3_add (Add)      (None, 14, 14, 1024)         0
['conv4_block2_out[0][0]',
'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0
['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024
```

```
['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0
['conv4_block3_out[0][0]',
'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0
['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block4_out[0][0]']
 D)

 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168
```

```
['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0
['conv4_block4_out[0][0]',
'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0
['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400
['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080
['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024
['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0
['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168
['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096
['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0
```

```
['conv4_block5_out[0][0]',
'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0
['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800
['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808
['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048
['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0
['conv5_block1_2_bn[0][0]']
 ation)

 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200
['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624
['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192
['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0
```

```
['conv5_block1_0_bn[0][0]',
'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)          0
['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)           1049088
['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block2_2_relu[0][0]']
 D)

 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)          0
['conv5_block1_out[0][0]',
'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)          0
['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)           1049088
```

```
['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)           2359808
['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)           2048
['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)           0
['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)          1050624
['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)          8192
['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)          0
['conv5_block2_out[0][0]',
'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)          0
['conv5_block3_add[0][0]']
 on)

 average_pooling2d (Average  (None, 3, 3, 2048)          0
['conv5_block3_out[0][0]']
 Pooling2D)

 flatten (Flatten)           (None, 18432)               0
['average_pooling2d[0][0]']

 fc9_predictions (Dense)     (None, 1)                   18433
['flatten[0][0]']
```

```
=================================================================================
==================
Total params: 23606145 (90.05 MB)
Trainable params: 23553025 (89.85 MB)
Non-trainable params: 53120 (207.50 KB)
---------------------------------------------------------------------------------
------------------
```

[ ]:
```python
import numpy as np

# The local path to our target image
#img_path = 'creative_commons_elephant.jpg'
# img_path = 'refs/dog_1.jpg'
img_path = 'refs/ship_1.jpg'

im_size = 224

# `img` is a PIL image of size 224x224
img = tf.keras.utils.load_img(img_path, target_size=(im_size, im_size))

# `x` is a float32 Numpy array of shape (224, 224, 3)
img_tensor = tf.keras.utils.img_to_array(img)

# We add a dimension to transform our array into a "batch"
# of size (1, 224, 224, 3)
img_tensor = np.expand_dims(img_tensor, axis=0)

img_tensor /= 255.

# # Its shape is (1, 224, 224, 3)
print(img_tensor.shape)
```

```
(1, 224, 224, 3)
```

[ ]:
```python
preds = transfer_model.predict(img_tensor)
def custom_decode_predictions(predictions, top=5, class_names=None):
    if class_names is None:
        class_names = [str(i) for i in range(predictions.shape[-1])]

    results = []
    for pred in predictions:
        top_indices = pred.argsort()[-top:][::-1]
        decoded_preds = [(class_names[i], pred[i]) for i in top_indices]
        results.append(decoded_preds)

    return results
```

```
# classes = ['ship']
classes = ['airplane', 'automobile', 'bird', 'cat', 'dog', 'deer', 'frog',␣
 ↪'horse', 'ship', 'truck']

print('Predicted:', custom_decode_predictions(preds, top=5,␣
 ↪class_names=classes))
```

```
Predicted: [[('airplane', 0.9999543)]]
```

Chosen Layers

[ ]:
```
img_path
layers_to_visualize = [transfer_model.get_layer('conv1_relu'),
                       transfer_model.get_layer('conv3_block2_2_relu'),
                       transfer_model.get_layer('conv5_block3_2_relu')]

for layer in layers_to_visualize:
    print(layer.name)
```

```
conv1_relu
conv3_block2_2_relu
conv5_block3_2_relu
```

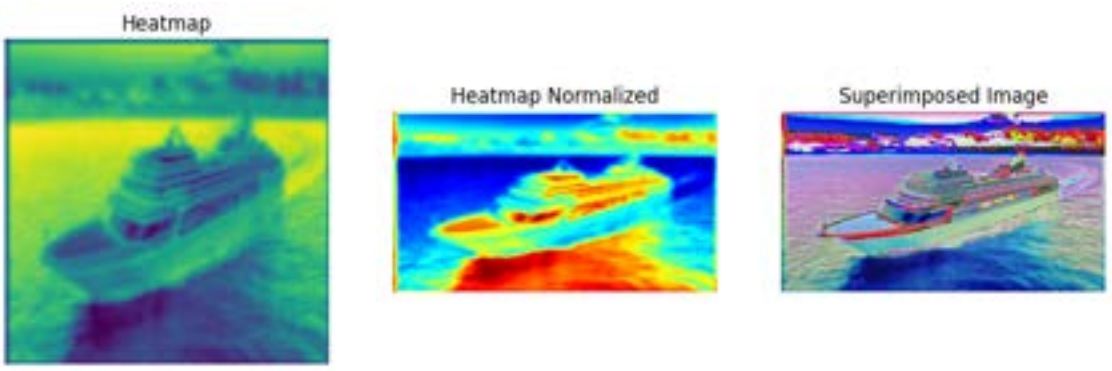
[ ]:
```
import cv2

def overlay_heatmap(heatmap, img_path, alpha=0.4):
    img = cv2.imread(img_path)

    hmap = heatmap

    # Resize the heatmap to the size of the original image
    heatmap = cv2.resize(heatmap, (img.shape[1], img.shape[0]))

    # Normalize the heatmap
    heatmap = (heatmap - np.min(heatmap)) / (np.max(heatmap) - np.min(heatmap))

    # Apply a colormap to the heatmap
    heatmap = cv2.applyColorMap(np.uint8(255 * heatmap), cv2.COLORMAP_JET)

    # Superimpose the heatmap on the original image
    superimposed_img = heatmap * alpha + img


    fig, axes = plt.subplots(1, 3, figsize=(12, 8))


    # Display the heatmap in the second subplot
```

```
    axes[0].imshow(hmap)
    axes[0].set_title('Heatmap')
    axes[0].axis('off')

    # Display the heatmap in the second subplot
    axes[1].imshow(heatmap, cmap='jet')
    axes[1].set_title('Heatmap Normalized')
    axes[1].axis('off')


    # Display the superimposed image in the first subplot
    axes[2].imshow(cv2.cvtColor(np.uint8(superimposed_img), cv2.COLOR_BGR2RGB))
    axes[2].set_title('Superimposed Image')
    axes[2].axis('off')


    plt.show()


    # plt.imshow(cv2.cvtColor(np.uint8(superimposed_img), cv2.COLOR_BGR2RGB))
    # plt.axis('off')
    # plt.show()
```

First Layer Heatmap

[ ]:
```
# This is the "ship" entry in the prediction vector
ship_output = transfer_model.output

# The is the output feature map of the `conv3_block2_2_relu` layer,
# the first convolutional layer in ResNet50
first_conv_layer = transfer_model.get_layer('conv1_relu')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(ship_output, first_conv_layer.output)[0]

# This is a vector of shape (512,), where each entry
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
 ↪defined:
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([transfer_model.input], [pooled_grads, first_conv_layer.
 ↪output[0]])
```

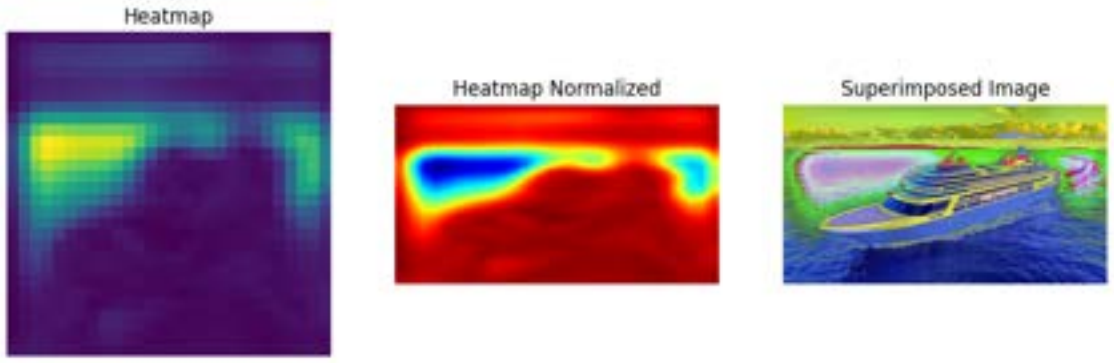
```
# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(64):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_first = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_first, img_path)
```



Middle Layer Heatmap

[ ]:
```
# This is the "ship" entry in the prediction vector
ship_output = transfer_model.output

# The is the output feature map of the `conv3_block2_2_relu` layer,
# the first convolutional layer in ResNet50
middle_conv_layer = transfer_model.get_layer('conv3_block2_2_relu')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(ship_output, middle_conv_layer.output)[0]

# This is a vector of shape (512,), where each entry
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
↪defined:
```

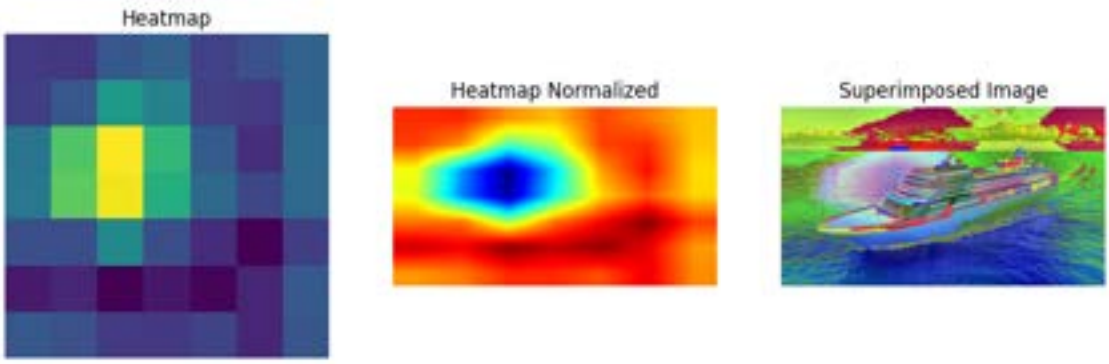
```
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([transfer_model.input], [pooled_grads, middle_conv_layer.
 ↪output[0]])

# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(64):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_middle = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_middle, img_path)
```



Last Layer Heatmap

```
[ ]: # This is the "ship" entry in the prediction vector
ship_output = transfer_model.output

# The is the output feature map of the `conv3_block2_2_relu` layer,
# the first convolutional layer in ResNet50
last_conv_layer = transfer_model.get_layer('conv5_block3_2_relu')

# This is the gradient of the "dog" class with regard to
# the output feature map of `conv5_block3_3_conv`
grads = K.gradients(ship_output, last_conv_layer.output)[0]

# This is a vector of shape (512,), where each entry
```

```
# is the mean intensity of the gradient over a specific feature map channel
pooled_grads = K.mean(grads, axis=(0, 1, 2))

# This function allows us to access the values of the quantities we just␣
 ↪defined:
# `pooled_grads` and the output feature map of `block5_conv3`,
# given a sample image
iterate = K.function([transfer_model.input], [pooled_grads, last_conv_layer.
 ↪output[0]])

# These are the values of these two quantities, as Numpy arrays,
# given our sample image of two elephants
pooled_grads_value, conv_layer_output_value = iterate([img_tensor])

# We multiply each channel in the feature map array
# by "how important this channel is" with regard to the elephant class
for i in range(64):
    conv_layer_output_value[:, :, i] *= pooled_grads_value[i]

# The channel-wise mean of the resulting feature map
# is our heatmap of class activation
heatmap_last = np.mean(conv_layer_output_value, axis=-1)

overlay_heatmap(heatmap_last, img_path)
```



1.3 END