C1_W1_Lab_3_densenet

May 2, 2023

1 Densenet

In this week's assignment, you'll be using a pre-trained Densenet model for image classification.

Densenet is a convolutional network where each layer is connected to all other layers that are deeper in the network - The first layer is connected to the 3rd, 4th etc. - The second layer is connected to the 3rd, 4th, 5th etc.

Like this:

For a detailed explanation of Densenet, check out the source of the image above, a paper by Gao Huang et al. 2018 called Densely Connected Convolutional Networks.

The cells below are set up to provide an exploration of the Keras densenet implementation that you'll be using in the assignment. Run these cells to gain some insight into the network architecture.

```python
In [1]: # Import Densenet from Keras
        from keras.applications.densenet import DenseNet121
        from keras.layers import Dense, GlobalAveragePooling2D
        from keras.models import Model
        from keras import backend as K

        import tensorflow as tf
        tf.compat.v1.logging.set_verbosity(tf.compat.v1.logging.ERROR)
```

Using TensorFlow backend.

For your work in the assignment, you'll be loading a set of pre-trained weights to reduce training time.

```python
In [2]: # Create the base pre-trained model
        base_model = DenseNet121(weights='./models/nih/densenet.hdf5', include_top=False);
```

View a summary of the model

```python
In [3]: # Print the model summary
        base_model.summary()
```

Model: "densenet121"

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

_____
zero_padding2d_1 (ZeroPadding2D (None, None, None, 3 0         input_1[0][0]

_____
conv1/conv (Conv2D)           (None, None, None, 6 9408        zero_padding2d_1[0][0]

_____
conv1/bn (BatchNormalization) (None, None, None, 6 256         conv1/conv[0][0]

_____
conv1/relu (Activation)       (None, None, None, 6 0           conv1/bn[0][0]

_____
zero_padding2d_2 (ZeroPadding2D (None, None, None, 6 0         conv1/relu[0][0]

_____
pool1 (MaxPooling2D)          (None, None, None, 6 0           zero_padding2d_2[0][0]

_____
conv2_block1_0_bn (BatchNormali (None, None, None, 6 256       pool1[0][0]

_____
conv2_block1_0_relu (Activation (None, None, None, 6 0         conv2_block1_0_bn[0][0]

_____
conv2_block1_1_conv (Conv2D)  (None, None, None, 1 8192        conv2_block1_0_relu[0][0]

_____
conv2_block1_1_bn (BatchNormali (None, None, None, 1 512       conv2_block1_1_conv[0][0]

_____
conv2_block1_1_relu (Activation (None, None, None, 1 0         conv2_block1_1_bn[0][0]

_____
conv2_block1_2_conv (Conv2D)  (None, None, None, 3 36864       conv2_block1_1_relu[0][0]

_____
conv2_block1_concat (Concatenat (None, None, None, 9 0         pool1[0][0]
                                                               conv2_block1_2_conv[0][0]

_____
conv2_block2_0_bn (BatchNormali (None, None, None, 9 384       conv2_block1_concat[0][0]

_____
conv2_block2_0_relu (Activation (None, None, None, 9 0         conv2_block2_0_bn[0][0]

_____
conv2_block2_1_conv (Conv2D)  (None, None, None, 1 12288       conv2_block2_0_relu[0][0]

_____
conv2_block2_1_bn (BatchNormali (None, None, None, 1 512       conv2_block2_1_conv[0][0]

_____
conv2_block2_1_relu (Activation (None, None, None, 1 0         conv2_block2_1_bn[0][0]

_____
conv2_block2_2_conv (Conv2D)  (None, None, None, 3 36864       conv2_block2_1_relu[0][0]

_____
conv2_block2_concat (Concatenat (None, None, None, 1 0         conv2_block1_concat[0][0]
                                                               conv2_block2_2_conv[0][0]

_____
conv2_block3_0_bn (BatchNormali (None, None, None, 1 512       conv2_block2_concat[0][0]

_____
```

Layer (type)	Output Shape	Param #	Connected to
conv2_block3_0_relu (Activation	(None, None, None, 1	0	conv2_block3_0_bn[0][0]
conv2_block3_1_conv (Conv2D)	(None, None, None, 1	16384	conv2_block3_0_relu[0][0]
conv2_block3_1_bn (BatchNormali	(None, None, None, 1	512	conv2_block3_1_conv[0][0]
conv2_block3_1_relu (Activation	(None, None, None, 1	0	conv2_block3_1_bn[0][0]
conv2_block3_2_conv (Conv2D)	(None, None, None, 3	36864	conv2_block3_1_relu[0][0]
conv2_block3_concat (Concatenat	(None, None, None, 1	0	conv2_block2_concat[0][0] conv2_block3_2_conv[0][0]
conv2_block4_0_bn (BatchNormali	(None, None, None, 1	640	conv2_block3_concat[0][0]
conv2_block4_0_relu (Activation	(None, None, None, 1	0	conv2_block4_0_bn[0][0]
conv2_block4_1_conv (Conv2D)	(None, None, None, 1	20480	conv2_block4_0_relu[0][0]
conv2_block4_1_bn (BatchNormali	(None, None, None, 1	512	conv2_block4_1_conv[0][0]
conv2_block4_1_relu (Activation	(None, None, None, 1	0	conv2_block4_1_bn[0][0]
conv2_block4_2_conv (Conv2D)	(None, None, None, 3	36864	conv2_block4_1_relu[0][0]
conv2_block4_concat (Concatenat	(None, None, None, 1	0	conv2_block3_concat[0][0] conv2_block4_2_conv[0][0]
conv2_block5_0_bn (BatchNormali	(None, None, None, 1	768	conv2_block4_concat[0][0]
conv2_block5_0_relu (Activation	(None, None, None, 1	0	conv2_block5_0_bn[0][0]
conv2_block5_1_conv (Conv2D)	(None, None, None, 1	24576	conv2_block5_0_relu[0][0]
conv2_block5_1_bn (BatchNormali	(None, None, None, 1	512	conv2_block5_1_conv[0][0]
conv2_block5_1_relu (Activation	(None, None, None, 1	0	conv2_block5_1_bn[0][0]
conv2_block5_2_conv (Conv2D)	(None, None, None, 3	36864	conv2_block5_1_relu[0][0]
conv2_block5_concat (Concatenat	(None, None, None, 2	0	conv2_block4_concat[0][0] conv2_block5_2_conv[0][0]
conv2_block6_0_bn (BatchNormali	(None, None, None, 2	896	conv2_block5_concat[0][0]
conv2_block6_0_relu (Activation	(None, None, None, 2	0	conv2_block6_0_bn[0][0]
conv2_block6_1_conv (Conv2D)	(None, None, None, 1	28672	conv2_block6_0_relu[0][0]

```
----------------------------------------------------------------------------------------------------
conv2_block6_1_bn (BatchNormali (None, None, None, 1 512        conv2_block6_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv2_block6_1_relu (Activation (None, None, None, 1 0          conv2_block6_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv2_block6_2_conv (Conv2D)    (None, None, None, 3 36864      conv2_block6_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv2_block6_concat (Concatenat (None, None, None, 2 0          conv2_block5_concat[0][0]
                                                                conv2_block6_2_conv[0][0]
----------------------------------------------------------------------------------------------------
pool2_bn (BatchNormalization)   (None, None, None, 2 1024       conv2_block6_concat[0][0]
----------------------------------------------------------------------------------------------------
pool2_relu (Activation)         (None, None, None, 2 0          pool2_bn[0][0]
----------------------------------------------------------------------------------------------------
pool2_conv (Conv2D)             (None, None, None, 1 32768      pool2_relu[0][0]
----------------------------------------------------------------------------------------------------
pool2_pool (AveragePooling2D)   (None, None, None, 1 0          pool2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_0_bn (BatchNormali (None, None, None, 1 512        pool2_pool[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_0_relu (Activation (None, None, None, 1 0          conv3_block1_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_1_conv (Conv2D)    (None, None, None, 1 16384      conv3_block1_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_1_bn (BatchNormali (None, None, None, 1 512        conv3_block1_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_1_relu (Activation (None, None, None, 1 0          conv3_block1_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_2_conv (Conv2D)    (None, None, None, 3 36864      conv3_block1_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv3_block1_concat (Concatenat (None, None, None, 1 0          pool2_pool[0][0]
                                                                conv3_block1_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_0_bn (BatchNormali (None, None, None, 1 640        conv3_block1_concat[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_0_relu (Activation (None, None, None, 1 0          conv3_block2_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_1_conv (Conv2D)    (None, None, None, 1 20480      conv3_block2_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_1_bn (BatchNormali (None, None, None, 1 512        conv3_block2_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_1_relu (Activation (None, None, None, 1 0          conv3_block2_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_2_conv (Conv2D)    (None, None, None, 3 36864      conv3_block2_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv3_block2_concat (Concatenat (None, None, None, 1 0          conv3_block1_concat[0][0]
                                                                conv3_block2_2_conv[0][0]
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conv3_block3_0_bn (BatchNormali (None, None, None, 1 768         conv3_block2_concat[0][0]
_____
conv3_block3_0_relu (Activation (None, None, None, 1 0           conv3_block3_0_bn[0][0]
_____
conv3_block3_1_conv (Conv2D)    (None, None, None, 1 24576       conv3_block3_0_relu[0][0]
_____
conv3_block3_1_bn (BatchNormali (None, None, None, 1 512         conv3_block3_1_conv[0][0]
_____
conv3_block3_1_relu (Activation (None, None, None, 1 0           conv3_block3_1_bn[0][0]
_____
conv3_block3_2_conv (Conv2D)    (None, None, None, 3 36864       conv3_block3_1_relu[0][0]
_____
conv3_block3_concat (Concatenat (None, None, None, 2 0           conv3_block2_concat[0][0]
                                                                 conv3_block3_2_conv[0][0]
_____
conv3_block4_0_bn (BatchNormali (None, None, None, 2 896         conv3_block3_concat[0][0]
_____
conv3_block4_0_relu (Activation (None, None, None, 2 0           conv3_block4_0_bn[0][0]
_____
conv3_block4_1_conv (Conv2D)    (None, None, None, 1 28672       conv3_block4_0_relu[0][0]
_____
conv3_block4_1_bn (BatchNormali (None, None, None, 1 512         conv3_block4_1_conv[0][0]
_____
conv3_block4_1_relu (Activation (None, None, None, 1 0           conv3_block4_1_bn[0][0]
_____
conv3_block4_2_conv (Conv2D)    (None, None, None, 3 36864       conv3_block4_1_relu[0][0]
_____
conv3_block4_concat (Concatenat (None, None, None, 2 0           conv3_block3_concat[0][0]
                                                                 conv3_block4_2_conv[0][0]
_____
conv3_block5_0_bn (BatchNormali (None, None, None, 2 1024        conv3_block4_concat[0][0]
_____
conv3_block5_0_relu (Activation (None, None, None, 2 0           conv3_block5_0_bn[0][0]
_____
conv3_block5_1_conv (Conv2D)    (None, None, None, 1 32768       conv3_block5_0_relu[0][0]
_____
conv3_block5_1_bn (BatchNormali (None, None, None, 1 512         conv3_block5_1_conv[0][0]
_____
conv3_block5_1_relu (Activation (None, None, None, 1 0           conv3_block5_1_bn[0][0]
_____
conv3_block5_2_conv (Conv2D)    (None, None, None, 3 36864       conv3_block5_1_relu[0][0]
_____
conv3_block5_concat (Concatenat (None, None, None, 2 0           conv3_block4_concat[0][0]
                                                                 conv3_block5_2_conv[0][0]
_____
conv3_block6_0_bn (BatchNormali (None, None, None, 2 1152        conv3_block5_concat[0][0]
_____
conv3_block6_0_relu (Activation (None, None, None, 2 0           conv3_block6_0_bn[0][0]
```

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--------------------------------------------------------------------------------
conv3_block6_1_conv (Conv2D)    (None, None, None, 1 36864    conv3_block6_0_relu[0][0]
--------------------------------------------------------------------------------
conv3_block6_1_bn (BatchNormali (None, None, None, 1 512      conv3_block6_1_conv[0][0]
--------------------------------------------------------------------------------
conv3_block6_1_relu (Activation (None, None, None, 1 0        conv3_block6_1_bn[0][0]
--------------------------------------------------------------------------------
conv3_block6_2_conv (Conv2D)    (None, None, None, 3 36864    conv3_block6_1_relu[0][0]
--------------------------------------------------------------------------------
conv3_block6_concat (Concatenat (None, None, None, 3 0        conv3_block5_concat[0][0]
                                                              conv3_block6_2_conv[0][0]
--------------------------------------------------------------------------------
conv3_block7_0_bn (BatchNormali (None, None, None, 3 1280     conv3_block6_concat[0][0]
--------------------------------------------------------------------------------
conv3_block7_0_relu (Activation (None, None, None, 3 0        conv3_block7_0_bn[0][0]
--------------------------------------------------------------------------------
conv3_block7_1_conv (Conv2D)    (None, None, None, 1 40960    conv3_block7_0_relu[0][0]
--------------------------------------------------------------------------------
conv3_block7_1_bn (BatchNormali (None, None, None, 1 512      conv3_block7_1_conv[0][0]
--------------------------------------------------------------------------------
conv3_block7_1_relu (Activation (None, None, None, 1 0        conv3_block7_1_bn[0][0]
--------------------------------------------------------------------------------
conv3_block7_2_conv (Conv2D)    (None, None, None, 3 36864    conv3_block7_1_relu[0][0]
--------------------------------------------------------------------------------
conv3_block7_concat (Concatenat (None, None, None, 3 0        conv3_block6_concat[0][0]
                                                              conv3_block7_2_conv[0][0]
--------------------------------------------------------------------------------
conv3_block8_0_bn (BatchNormali (None, None, None, 3 1408     conv3_block7_concat[0][0]
--------------------------------------------------------------------------------
conv3_block8_0_relu (Activation (None, None, None, 3 0        conv3_block8_0_bn[0][0]
--------------------------------------------------------------------------------
conv3_block8_1_conv (Conv2D)    (None, None, None, 1 45056    conv3_block8_0_relu[0][0]
--------------------------------------------------------------------------------
conv3_block8_1_bn (BatchNormali (None, None, None, 1 512      conv3_block8_1_conv[0][0]
--------------------------------------------------------------------------------
conv3_block8_1_relu (Activation (None, None, None, 1 0        conv3_block8_1_bn[0][0]
--------------------------------------------------------------------------------
conv3_block8_2_conv (Conv2D)    (None, None, None, 3 36864    conv3_block8_1_relu[0][0]
--------------------------------------------------------------------------------
conv3_block8_concat (Concatenat (None, None, None, 3 0        conv3_block7_concat[0][0]
                                                              conv3_block8_2_conv[0][0]
--------------------------------------------------------------------------------
conv3_block9_0_bn (BatchNormali (None, None, None, 3 1536     conv3_block8_concat[0][0]
--------------------------------------------------------------------------------
conv3_block9_0_relu (Activation (None, None, None, 3 0        conv3_block9_0_bn[0][0]
--------------------------------------------------------------------------------
conv3_block9_1_conv (Conv2D)    (None, None, None, 1 49152    conv3_block9_0_relu[0][0]
--------------------------------------------------------------------------------
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conv3_block9_1_bn (BatchNormali  (None, None, None, 1 512          conv3_block9_1_conv[0][0]
_____
conv3_block9_1_relu (Activation  (None, None, None, 1 0           conv3_block9_1_bn[0][0]
_____
conv3_block9_2_conv (Conv2D)     (None, None, None, 3 36864       conv3_block9_1_relu[0][0]
_____
conv3_block9_concat (Concatenat  (None, None, None, 4 0           conv3_block8_concat[0][0]
                                                                  conv3_block9_2_conv[0][0]
_____
conv3_block10_0_bn (BatchNormal  (None, None, None, 4 1664        conv3_block9_concat[0][0]
_____
conv3_block10_0_relu (Activatio  (None, None, None, 4 0           conv3_block10_0_bn[0][0]
_____
conv3_block10_1_conv (Conv2D)    (None, None, None, 1 53248       conv3_block10_0_relu[0][0]
_____
conv3_block10_1_bn (BatchNormal  (None, None, None, 1 512         conv3_block10_1_conv[0][0]
_____
conv3_block10_1_relu (Activatio  (None, None, None, 1 0           conv3_block10_1_bn[0][0]
_____
conv3_block10_2_conv (Conv2D)    (None, None, None, 3 36864       conv3_block10_1_relu[0][0]
_____
conv3_block10_concat (Concatena  (None, None, None, 4 0           conv3_block9_concat[0][0]
                                                                  conv3_block10_2_conv[0][0]
_____
conv3_block11_0_bn (BatchNormal  (None, None, None, 4 1792        conv3_block10_concat[0][0]
_____
conv3_block11_0_relu (Activatio  (None, None, None, 4 0           conv3_block11_0_bn[0][0]
_____
conv3_block11_1_conv (Conv2D)    (None, None, None, 1 57344       conv3_block11_0_relu[0][0]
_____
conv3_block11_1_bn (BatchNormal  (None, None, None, 1 512         conv3_block11_1_conv[0][0]
_____
conv3_block11_1_relu (Activatio  (None, None, None, 1 0           conv3_block11_1_bn[0][0]
_____
conv3_block11_2_conv (Conv2D)    (None, None, None, 3 36864       conv3_block11_1_relu[0][0]
_____
conv3_block11_concat (Concatena  (None, None, None, 4 0           conv3_block10_concat[0][0]
                                                                  conv3_block11_2_conv[0][0]
_____
conv3_block12_0_bn (BatchNormal  (None, None, None, 4 1920        conv3_block11_concat[0][0]
_____
conv3_block12_0_relu (Activatio  (None, None, None, 4 0           conv3_block12_0_bn[0][0]
_____
conv3_block12_1_conv (Conv2D)    (None, None, None, 1 61440       conv3_block12_0_relu[0][0]
_____
conv3_block12_1_bn (BatchNormal  (None, None, None, 1 512         conv3_block12_1_conv[0][0]
_____
conv3_block12_1_relu (Activatio  (None, None, None, 1 0           conv3_block12_1_bn[0][0]
```

Layer (type)	Output Shape	Param #	Connected to
conv3_block12_2_conv (Conv2D)	(None, None, None, 3	36864	conv3_block12_1_relu[0][0]
conv3_block12_concat (Concatena	(None, None, None, 5	0	conv3_block11_concat[0][0]
			conv3_block12_2_conv[0][0]
pool3_bn (BatchNormalization)	(None, None, None, 5	2048	conv3_block12_concat[0][0]
pool3_relu (Activation)	(None, None, None, 5	0	pool3_bn[0][0]
pool3_conv (Conv2D)	(None, None, None, 2	131072	pool3_relu[0][0]
pool3_pool (AveragePooling2D)	(None, None, None, 2	0	pool3_conv[0][0]
conv4_block1_0_bn (BatchNormali	(None, None, None, 2	1024	pool3_pool[0][0]
conv4_block1_0_relu (Activation	(None, None, None, 2	0	conv4_block1_0_bn[0][0]
conv4_block1_1_conv (Conv2D)	(None, None, None, 1	32768	conv4_block1_0_relu[0][0]
conv4_block1_1_bn (BatchNormali	(None, None, None, 1	512	conv4_block1_1_conv[0][0]
conv4_block1_1_relu (Activation	(None, None, None, 1	0	conv4_block1_1_bn[0][0]
conv4_block1_2_conv (Conv2D)	(None, None, None, 3	36864	conv4_block1_1_relu[0][0]
conv4_block1_concat (Concatenat	(None, None, None, 2	0	pool3_pool[0][0]
			conv4_block1_2_conv[0][0]
conv4_block2_0_bn (BatchNormali	(None, None, None, 2	1152	conv4_block1_concat[0][0]
conv4_block2_0_relu (Activation	(None, None, None, 2	0	conv4_block2_0_bn[0][0]
conv4_block2_1_conv (Conv2D)	(None, None, None, 1	36864	conv4_block2_0_relu[0][0]
conv4_block2_1_bn (BatchNormali	(None, None, None, 1	512	conv4_block2_1_conv[0][0]
conv4_block2_1_relu (Activation	(None, None, None, 1	0	conv4_block2_1_bn[0][0]
conv4_block2_2_conv (Conv2D)	(None, None, None, 3	36864	conv4_block2_1_relu[0][0]
conv4_block2_concat (Concatenat	(None, None, None, 3	0	conv4_block1_concat[0][0]
			conv4_block2_2_conv[0][0]
conv4_block3_0_bn (BatchNormali	(None, None, None, 3	1280	conv4_block2_concat[0][0]
conv4_block3_0_relu (Activation	(None, None, None, 3	0	conv4_block3_0_bn[0][0]

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conv4_block3_1_conv (Conv2D)      (None, None, None, 1 40960    conv4_block3_0_relu[0][0]
_____
conv4_block3_1_bn (BatchNormali (None, None, None, 1 512      conv4_block3_1_conv[0][0]
_____
conv4_block3_1_relu (Activation (None, None, None, 1 0        conv4_block3_1_bn[0][0]
_____
conv4_block3_2_conv (Conv2D)      (None, None, None, 3 36864    conv4_block3_1_relu[0][0]
_____
conv4_block3_concat (Concatenat (None, None, None, 3 0        conv4_block2_concat[0][0]
                                                              conv4_block3_2_conv[0][0]
_____
conv4_block4_0_bn (BatchNormali (None, None, None, 3 1408     conv4_block3_concat[0][0]
_____
conv4_block4_0_relu (Activation (None, None, None, 3 0        conv4_block4_0_bn[0][0]
_____
conv4_block4_1_conv (Conv2D)      (None, None, None, 1 45056    conv4_block4_0_relu[0][0]
_____
conv4_block4_1_bn (BatchNormali (None, None, None, 1 512      conv4_block4_1_conv[0][0]
_____
conv4_block4_1_relu (Activation (None, None, None, 1 0        conv4_block4_1_bn[0][0]
_____
conv4_block4_2_conv (Conv2D)      (None, None, None, 3 36864    conv4_block4_1_relu[0][0]
_____
conv4_block4_concat (Concatenat (None, None, None, 3 0        conv4_block3_concat[0][0]
                                                              conv4_block4_2_conv[0][0]
_____
conv4_block5_0_bn (BatchNormali (None, None, None, 3 1536     conv4_block4_concat[0][0]
_____
conv4_block5_0_relu (Activation (None, None, None, 3 0        conv4_block5_0_bn[0][0]
_____
conv4_block5_1_conv (Conv2D)      (None, None, None, 1 49152    conv4_block5_0_relu[0][0]
_____
conv4_block5_1_bn (BatchNormali (None, None, None, 1 512      conv4_block5_1_conv[0][0]
_____
conv4_block5_1_relu (Activation (None, None, None, 1 0        conv4_block5_1_bn[0][0]
_____
conv4_block5_2_conv (Conv2D)      (None, None, None, 3 36864    conv4_block5_1_relu[0][0]
_____
conv4_block5_concat (Concatenat (None, None, None, 4 0        conv4_block4_concat[0][0]
                                                              conv4_block5_2_conv[0][0]
_____
conv4_block6_0_bn (BatchNormali (None, None, None, 4 1664     conv4_block5_concat[0][0]
_____
conv4_block6_0_relu (Activation (None, None, None, 4 0        conv4_block6_0_bn[0][0]
_____
conv4_block6_1_conv (Conv2D)      (None, None, None, 1 53248    conv4_block6_0_relu[0][0]
_____
conv4_block6_1_bn (BatchNormali (None, None, None, 1 512      conv4_block6_1_conv[0][0]
```

```
----------------------------------------------------------------------------------------------------
conv4_block6_1_relu (Activation (None, None, None, 1 0          conv4_block6_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block6_2_conv (Conv2D)    (None, None, None, 3 36864      conv4_block6_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block6_concat (Concatenat (None, None, None, 4 0          conv4_block5_concat[0][0]
                                                                conv4_block6_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_0_bn (BatchNormali (None, None, None, 4 1792       conv4_block6_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_0_relu (Activation (None, None, None, 4 0          conv4_block7_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_1_conv (Conv2D)    (None, None, None, 1 57344      conv4_block7_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_1_bn (BatchNormali (None, None, None, 1 512        conv4_block7_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_1_relu (Activation (None, None, None, 1 0          conv4_block7_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_2_conv (Conv2D)    (None, None, None, 3 36864      conv4_block7_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block7_concat (Concatenat (None, None, None, 4 0          conv4_block6_concat[0][0]
                                                                conv4_block7_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_0_bn (BatchNormali (None, None, None, 4 1920       conv4_block7_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_0_relu (Activation (None, None, None, 4 0          conv4_block8_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_1_conv (Conv2D)    (None, None, None, 1 61440      conv4_block8_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_1_bn (BatchNormali (None, None, None, 1 512        conv4_block8_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_1_relu (Activation (None, None, None, 1 0          conv4_block8_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_2_conv (Conv2D)    (None, None, None, 3 36864      conv4_block8_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block8_concat (Concatenat (None, None, None, 5 0          conv4_block7_concat[0][0]
                                                                conv4_block8_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block9_0_bn (BatchNormali (None, None, None, 5 2048       conv4_block8_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block9_0_relu (Activation (None, None, None, 5 0          conv4_block9_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block9_1_conv (Conv2D)    (None, None, None, 1 65536      conv4_block9_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block9_1_bn (BatchNormali (None, None, None, 1 512        conv4_block9_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block9_1_relu (Activation (None, None, None, 1 0          conv4_block9_1_bn[0][0]
----------------------------------------------------------------------------------------------------
```

```
conv4_block9_2_conv (Conv2D)     (None, None, None, 3 36864          conv4_block9_1_relu[0][0]
_____
conv4_block9_concat (Concatenat (None, None, None, 5 0              conv4_block8_concat[0][0]
                                                                    conv4_block9_2_conv[0][0]
_____
conv4_block10_0_bn (BatchNormal (None, None, None, 5 2176           conv4_block9_concat[0][0]
_____
conv4_block10_0_relu (Activatio (None, None, None, 5 0              conv4_block10_0_bn[0][0]
_____
conv4_block10_1_conv (Conv2D)   (None, None, None, 1 69632          conv4_block10_0_relu[0][0]
_____
conv4_block10_1_bn (BatchNormal (None, None, None, 1 512            conv4_block10_1_conv[0][0]
_____
conv4_block10_1_relu (Activatio (None, None, None, 1 0              conv4_block10_1_bn[0][0]
_____
conv4_block10_2_conv (Conv2D)   (None, None, None, 3 36864          conv4_block10_1_relu[0][0]
_____
conv4_block10_concat (Concatena (None, None, None, 5 0              conv4_block9_concat[0][0]
                                                                    conv4_block10_2_conv[0][0]
_____
conv4_block11_0_bn (BatchNormal (None, None, None, 5 2304           conv4_block10_concat[0][0]
_____
conv4_block11_0_relu (Activatio (None, None, None, 5 0              conv4_block11_0_bn[0][0]
_____
conv4_block11_1_conv (Conv2D)   (None, None, None, 1 73728          conv4_block11_0_relu[0][0]
_____
conv4_block11_1_bn (BatchNormal (None, None, None, 1 512            conv4_block11_1_conv[0][0]
_____
conv4_block11_1_relu (Activatio (None, None, None, 1 0              conv4_block11_1_bn[0][0]
_____
conv4_block11_2_conv (Conv2D)   (None, None, None, 3 36864          conv4_block11_1_relu[0][0]
_____
conv4_block11_concat (Concatena (None, None, None, 6 0              conv4_block10_concat[0][0]
                                                                    conv4_block11_2_conv[0][0]
_____
conv4_block12_0_bn (BatchNormal (None, None, None, 6 2432           conv4_block11_concat[0][0]
_____
conv4_block12_0_relu (Activatio (None, None, None, 6 0              conv4_block12_0_bn[0][0]
_____
conv4_block12_1_conv (Conv2D)   (None, None, None, 1 77824          conv4_block12_0_relu[0][0]
_____
conv4_block12_1_bn (BatchNormal (None, None, None, 1 512            conv4_block12_1_conv[0][0]
_____
conv4_block12_1_relu (Activatio (None, None, None, 1 0              conv4_block12_1_bn[0][0]
_____
conv4_block12_2_conv (Conv2D)   (None, None, None, 3 36864          conv4_block12_1_relu[0][0]
_____
conv4_block12_concat (Concatena (None, None, None, 6 0              conv4_block11_concat[0][0]
```

```
                                                            conv4_block12_2_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block13_0_bn (BatchNormal (None, None, None, 6 2560   conv4_block12_concat[0][0]
--------------------------------------------------------------------------------------
conv4_block13_0_relu (Activatio (None, None, None, 6 0      conv4_block13_0_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block13_1_conv (Conv2D)   (None, None, None, 1 81920  conv4_block13_0_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block13_1_bn (BatchNormal (None, None, None, 1 512    conv4_block13_1_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block13_1_relu (Activatio (None, None, None, 1 0      conv4_block13_1_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block13_2_conv (Conv2D)   (None, None, None, 3 36864  conv4_block13_1_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block13_concat (Concatena (None, None, None, 6 0      conv4_block12_concat[0][0]
                                                            conv4_block13_2_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block14_0_bn (BatchNormal (None, None, None, 6 2688   conv4_block13_concat[0][0]
--------------------------------------------------------------------------------------
conv4_block14_0_relu (Activatio (None, None, None, 6 0      conv4_block14_0_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block14_1_conv (Conv2D)   (None, None, None, 1 86016  conv4_block14_0_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block14_1_bn (BatchNormal (None, None, None, 1 512    conv4_block14_1_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block14_1_relu (Activatio (None, None, None, 1 0      conv4_block14_1_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block14_2_conv (Conv2D)   (None, None, None, 3 36864  conv4_block14_1_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block14_concat (Concatena (None, None, None, 7 0      conv4_block13_concat[0][0]
                                                            conv4_block14_2_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block15_0_bn (BatchNormal (None, None, None, 7 2816   conv4_block14_concat[0][0]
--------------------------------------------------------------------------------------
conv4_block15_0_relu (Activatio (None, None, None, 7 0      conv4_block15_0_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block15_1_conv (Conv2D)   (None, None, None, 1 90112  conv4_block15_0_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block15_1_bn (BatchNormal (None, None, None, 1 512    conv4_block15_1_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block15_1_relu (Activatio (None, None, None, 1 0      conv4_block15_1_bn[0][0]
--------------------------------------------------------------------------------------
conv4_block15_2_conv (Conv2D)   (None, None, None, 3 36864  conv4_block15_1_relu[0][0]
--------------------------------------------------------------------------------------
conv4_block15_concat (Concatena (None, None, None, 7 0      conv4_block14_concat[0][0]
                                                            conv4_block15_2_conv[0][0]
--------------------------------------------------------------------------------------
conv4_block16_0_bn (BatchNormal (None, None, None, 7 2944   conv4_block15_concat[0][0]
```

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----------------------------------------------------------------------------------------------------
conv4_block16_0_relu (Activatio (None, None, None, 7 0           conv4_block16_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block16_1_conv (Conv2D)   (None, None, None, 1 94208       conv4_block16_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block16_1_bn (BatchNormal (None, None, None, 1 512         conv4_block16_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block16_1_relu (Activatio (None, None, None, 1 0           conv4_block16_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block16_2_conv (Conv2D)   (None, None, None, 3 36864       conv4_block16_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block16_concat (Concatena (None, None, None, 7 0           conv4_block15_concat[0][0]
                                                                 conv4_block16_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_0_bn (BatchNormal (None, None, None, 7 3072        conv4_block16_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_0_relu (Activatio (None, None, None, 7 0           conv4_block17_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_1_conv (Conv2D)   (None, None, None, 1 98304       conv4_block17_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_1_bn (BatchNormal (None, None, None, 1 512         conv4_block17_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_1_relu (Activatio (None, None, None, 1 0           conv4_block17_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_2_conv (Conv2D)   (None, None, None, 3 36864       conv4_block17_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block17_concat (Concatena (None, None, None, 8 0           conv4_block16_concat[0][0]
                                                                 conv4_block17_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_0_bn (BatchNormal (None, None, None, 8 3200        conv4_block17_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_0_relu (Activatio (None, None, None, 8 0           conv4_block18_0_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_1_conv (Conv2D)   (None, None, None, 1 102400      conv4_block18_0_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_1_bn (BatchNormal (None, None, None, 1 512         conv4_block18_1_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_1_relu (Activatio (None, None, None, 1 0           conv4_block18_1_bn[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_2_conv (Conv2D)   (None, None, None, 3 36864       conv4_block18_1_relu[0][0]
----------------------------------------------------------------------------------------------------
conv4_block18_concat (Concatena (None, None, None, 8 0           conv4_block17_concat[0][0]
                                                                 conv4_block18_2_conv[0][0]
----------------------------------------------------------------------------------------------------
conv4_block19_0_bn (BatchNormal (None, None, None, 8 3328        conv4_block18_concat[0][0]
----------------------------------------------------------------------------------------------------
conv4_block19_0_relu (Activatio (None, None, None, 8 0           conv4_block19_0_bn[0][0]
----------------------------------------------------------------------------------------------------
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conv4_block19_1_conv (Conv2D)    (None, None, None, 1 106496      conv4_block19_0_relu[0][0]
_____
conv4_block19_1_bn (BatchNormal  (None, None, None, 1 512         conv4_block19_1_conv[0][0]
_____
conv4_block19_1_relu (Activatio  (None, None, None, 1 0           conv4_block19_1_bn[0][0]
_____
conv4_block19_2_conv (Conv2D)    (None, None, None, 3 36864       conv4_block19_1_relu[0][0]
_____
conv4_block19_concat (Concatena  (None, None, None, 8 0           conv4_block18_concat[0][0]
                                                                  conv4_block19_2_conv[0][0]
_____
conv4_block20_0_bn (BatchNormal  (None, None, None, 8 3456        conv4_block19_concat[0][0]
_____
conv4_block20_0_relu (Activatio  (None, None, None, 8 0           conv4_block20_0_bn[0][0]
_____
conv4_block20_1_conv (Conv2D)    (None, None, None, 1 110592      conv4_block20_0_relu[0][0]
_____
conv4_block20_1_bn (BatchNormal  (None, None, None, 1 512         conv4_block20_1_conv[0][0]
_____
conv4_block20_1_relu (Activatio  (None, None, None, 1 0           conv4_block20_1_bn[0][0]
_____
conv4_block20_2_conv (Conv2D)    (None, None, None, 3 36864       conv4_block20_1_relu[0][0]
_____
conv4_block20_concat (Concatena  (None, None, None, 8 0           conv4_block19_concat[0][0]
                                                                  conv4_block20_2_conv[0][0]
_____
conv4_block21_0_bn (BatchNormal  (None, None, None, 8 3584        conv4_block20_concat[0][0]
_____
conv4_block21_0_relu (Activatio  (None, None, None, 8 0           conv4_block21_0_bn[0][0]
_____
conv4_block21_1_conv (Conv2D)    (None, None, None, 1 114688      conv4_block21_0_relu[0][0]
_____
conv4_block21_1_bn (BatchNormal  (None, None, None, 1 512         conv4_block21_1_conv[0][0]
_____
conv4_block21_1_relu (Activatio  (None, None, None, 1 0           conv4_block21_1_bn[0][0]
_____
conv4_block21_2_conv (Conv2D)    (None, None, None, 3 36864       conv4_block21_1_relu[0][0]
_____
conv4_block21_concat (Concatena  (None, None, None, 9 0           conv4_block20_concat[0][0]
                                                                  conv4_block21_2_conv[0][0]
_____
conv4_block22_0_bn (BatchNormal  (None, None, None, 9 3712        conv4_block21_concat[0][0]
_____
conv4_block22_0_relu (Activatio  (None, None, None, 9 0           conv4_block22_0_bn[0][0]
_____
conv4_block22_1_conv (Conv2D)    (None, None, None, 1 118784      conv4_block22_0_relu[0][0]
_____
conv4_block22_1_bn (BatchNormal  (None, None, None, 1 512         conv4_block22_1_conv[0][0]
```

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--------------------------------------------------------------------------------------------------
conv4_block22_1_relu (Activatio (None, None, None, 1 0          conv4_block22_1_bn[0][0]
--------------------------------------------------------------------------------------------------
conv4_block22_2_conv (Conv2D)   (None, None, None, 3 36864      conv4_block22_1_relu[0][0]
--------------------------------------------------------------------------------------------------
conv4_block22_concat (Concatena (None, None, None, 9 0          conv4_block21_concat[0][0]
                                                                conv4_block22_2_conv[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_0_bn (BatchNormal (None, None, None, 9 3840       conv4_block22_concat[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_0_relu (Activatio (None, None, None, 9 0          conv4_block23_0_bn[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_1_conv (Conv2D)   (None, None, None, 1 122880     conv4_block23_0_relu[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_1_bn (BatchNormal (None, None, None, 1 512        conv4_block23_1_conv[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_1_relu (Activatio (None, None, None, 1 0          conv4_block23_1_bn[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_2_conv (Conv2D)   (None, None, None, 3 36864      conv4_block23_1_relu[0][0]
--------------------------------------------------------------------------------------------------
conv4_block23_concat (Concatena (None, None, None, 9 0          conv4_block22_concat[0][0]
                                                                conv4_block23_2_conv[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_0_bn (BatchNormal (None, None, None, 9 3968       conv4_block23_concat[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_0_relu (Activatio (None, None, None, 9 0          conv4_block24_0_bn[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_1_conv (Conv2D)   (None, None, None, 1 126976     conv4_block24_0_relu[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_1_bn (BatchNormal (None, None, None, 1 512        conv4_block24_1_conv[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_1_relu (Activatio (None, None, None, 1 0          conv4_block24_1_bn[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_2_conv (Conv2D)   (None, None, None, 3 36864      conv4_block24_1_relu[0][0]
--------------------------------------------------------------------------------------------------
conv4_block24_concat (Concatena (None, None, None, 1 0          conv4_block23_concat[0][0]
                                                                conv4_block24_2_conv[0][0]
--------------------------------------------------------------------------------------------------
pool4_bn (BatchNormalization)   (None, None, None, 1 4096       conv4_block24_concat[0][0]
--------------------------------------------------------------------------------------------------
pool4_relu (Activation)         (None, None, None, 1 0          pool4_bn[0][0]
--------------------------------------------------------------------------------------------------
pool4_conv (Conv2D)             (None, None, None, 5 524288     pool4_relu[0][0]
--------------------------------------------------------------------------------------------------
pool4_pool (AveragePooling2D)   (None, None, None, 5 0          pool4_conv[0][0]
--------------------------------------------------------------------------------------------------
conv5_block1_0_bn (BatchNormali (None, None, None, 5 2048       pool4_pool[0][0]
--------------------------------------------------------------------------------------------------
```

```
conv5_block1_0_relu (Activation (None, None, None, 5 0          conv5_block1_0_bn[0][0]
_____
conv5_block1_1_conv (Conv2D)    (None, None, None, 1 65536      conv5_block1_0_relu[0][0]
_____
conv5_block1_1_bn (BatchNormali (None, None, None, 1 512        conv5_block1_1_conv[0][0]
_____
conv5_block1_1_relu (Activation (None, None, None, 1 0          conv5_block1_1_bn[0][0]
_____
conv5_block1_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block1_1_relu[0][0]
_____
conv5_block1_concat (Concatenat (None, None, None, 5 0          pool4_pool[0][0]
                                                                conv5_block1_2_conv[0][0]
_____
conv5_block2_0_bn (BatchNormali (None, None, None, 5 2176       conv5_block1_concat[0][0]
_____
conv5_block2_0_relu (Activation (None, None, None, 5 0          conv5_block2_0_bn[0][0]
_____
conv5_block2_1_conv (Conv2D)    (None, None, None, 1 69632      conv5_block2_0_relu[0][0]
_____
conv5_block2_1_bn (BatchNormali (None, None, None, 1 512        conv5_block2_1_conv[0][0]
_____
conv5_block2_1_relu (Activation (None, None, None, 1 0          conv5_block2_1_bn[0][0]
_____
conv5_block2_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block2_1_relu[0][0]
_____
conv5_block2_concat (Concatenat (None, None, None, 5 0          conv5_block1_concat[0][0]
                                                                conv5_block2_2_conv[0][0]
_____
conv5_block3_0_bn (BatchNormali (None, None, None, 5 2304       conv5_block2_concat[0][0]
_____
conv5_block3_0_relu (Activation (None, None, None, 5 0          conv5_block3_0_bn[0][0]
_____
conv5_block3_1_conv (Conv2D)    (None, None, None, 1 73728      conv5_block3_0_relu[0][0]
_____
conv5_block3_1_bn (BatchNormali (None, None, None, 1 512        conv5_block3_1_conv[0][0]
_____
conv5_block3_1_relu (Activation (None, None, None, 1 0          conv5_block3_1_bn[0][0]
_____
conv5_block3_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block3_1_relu[0][0]
_____
conv5_block3_concat (Concatenat (None, None, None, 6 0          conv5_block2_concat[0][0]
                                                                conv5_block3_2_conv[0][0]
_____
conv5_block4_0_bn (BatchNormali (None, None, None, 6 2432       conv5_block3_concat[0][0]
_____
conv5_block4_0_relu (Activation (None, None, None, 6 0          conv5_block4_0_bn[0][0]
_____
conv5_block4_1_conv (Conv2D)    (None, None, None, 1 77824      conv5_block4_0_relu[0][0]
```

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----------------------------------------------------------------------------------
conv5_block4_1_bn (BatchNormali (None, None, None, 1 512      conv5_block4_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block4_1_relu (Activation (None, None, None, 1 0        conv5_block4_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block4_2_conv (Conv2D)    (None, None, None, 3 36864    conv5_block4_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block4_concat (Concatenat (None, None, None, 6 0        conv5_block3_concat[0][0]
                                                              conv5_block4_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block5_0_bn (BatchNormali (None, None, None, 6 2560     conv5_block4_concat[0][0]
----------------------------------------------------------------------------------
conv5_block5_0_relu (Activation (None, None, None, 6 0        conv5_block5_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block5_1_conv (Conv2D)    (None, None, None, 1 81920    conv5_block5_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block5_1_bn (BatchNormali (None, None, None, 1 512      conv5_block5_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block5_1_relu (Activation (None, None, None, 1 0        conv5_block5_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block5_2_conv (Conv2D)    (None, None, None, 3 36864    conv5_block5_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block5_concat (Concatenat (None, None, None, 6 0        conv5_block4_concat[0][0]
                                                              conv5_block5_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block6_0_bn (BatchNormali (None, None, None, 6 2688     conv5_block5_concat[0][0]
----------------------------------------------------------------------------------
conv5_block6_0_relu (Activation (None, None, None, 6 0        conv5_block6_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block6_1_conv (Conv2D)    (None, None, None, 1 86016    conv5_block6_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block6_1_bn (BatchNormali (None, None, None, 1 512      conv5_block6_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block6_1_relu (Activation (None, None, None, 1 0        conv5_block6_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block6_2_conv (Conv2D)    (None, None, None, 3 36864    conv5_block6_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block6_concat (Concatenat (None, None, None, 7 0        conv5_block5_concat[0][0]
                                                              conv5_block6_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block7_0_bn (BatchNormali (None, None, None, 7 2816     conv5_block6_concat[0][0]
----------------------------------------------------------------------------------
conv5_block7_0_relu (Activation (None, None, None, 7 0        conv5_block7_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block7_1_conv (Conv2D)    (None, None, None, 1 90112    conv5_block7_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block7_1_bn (BatchNormali (None, None, None, 1 512      conv5_block7_1_conv[0][0]
----------------------------------------------------------------------------------
```

```
conv5_block7_1_relu (Activation (None, None, None, 1 0          conv5_block7_1_bn[0][0]
_____
conv5_block7_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block7_1_relu[0][0]
_____
conv5_block7_concat (Concatenat (None, None, None, 7 0          conv5_block6_concat[0][0]
                                                                conv5_block7_2_conv[0][0]
_____
conv5_block8_0_bn (BatchNormali (None, None, None, 7 2944       conv5_block7_concat[0][0]
_____
conv5_block8_0_relu (Activation (None, None, None, 7 0          conv5_block8_0_bn[0][0]
_____
conv5_block8_1_conv (Conv2D)    (None, None, None, 1 94208      conv5_block8_0_relu[0][0]
_____
conv5_block8_1_bn (BatchNormali (None, None, None, 1 512        conv5_block8_1_conv[0][0]
_____
conv5_block8_1_relu (Activation (None, None, None, 1 0          conv5_block8_1_bn[0][0]
_____
conv5_block8_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block8_1_relu[0][0]
_____
conv5_block8_concat (Concatenat (None, None, None, 7 0          conv5_block7_concat[0][0]
                                                                conv5_block8_2_conv[0][0]
_____
conv5_block9_0_bn (BatchNormali (None, None, None, 7 3072       conv5_block8_concat[0][0]
_____
conv5_block9_0_relu (Activation (None, None, None, 7 0          conv5_block9_0_bn[0][0]
_____
conv5_block9_1_conv (Conv2D)    (None, None, None, 1 98304      conv5_block9_0_relu[0][0]
_____
conv5_block9_1_bn (BatchNormali (None, None, None, 1 512        conv5_block9_1_conv[0][0]
_____
conv5_block9_1_relu (Activation (None, None, None, 1 0          conv5_block9_1_bn[0][0]
_____
conv5_block9_2_conv (Conv2D)    (None, None, None, 3 36864      conv5_block9_1_relu[0][0]
_____
conv5_block9_concat (Concatenat (None, None, None, 8 0          conv5_block8_concat[0][0]
                                                                conv5_block9_2_conv[0][0]
_____
conv5_block10_0_bn (BatchNormal (None, None, None, 8 3200       conv5_block9_concat[0][0]
_____
conv5_block10_0_relu (Activatio (None, None, None, 8 0          conv5_block10_0_bn[0][0]
_____
conv5_block10_1_conv (Conv2D)   (None, None, None, 1 102400     conv5_block10_0_relu[0][0]
_____
conv5_block10_1_bn (BatchNormal (None, None, None, 1 512        conv5_block10_1_conv[0][0]
_____
conv5_block10_1_relu (Activatio (None, None, None, 1 0          conv5_block10_1_bn[0][0]
_____
conv5_block10_2_conv (Conv2D)   (None, None, None, 3 36864      conv5_block10_1_relu[0][0]
```

```
----------------------------------------------------------------------------------
conv5_block10_concat (Concatena (None, None, None, 8 0        conv5_block9_concat[0][0]
                                                              conv5_block10_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block11_0_bn (BatchNormal (None, None, None, 8 3328     conv5_block10_concat[0][0]
----------------------------------------------------------------------------------
conv5_block11_0_relu (Activatio (None, None, None, 8 0        conv5_block11_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block11_1_conv (Conv2D)   (None, None, None, 1 106496   conv5_block11_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block11_1_bn (BatchNormal (None, None, None, 1 512      conv5_block11_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block11_1_relu (Activatio (None, None, None, 1 0        conv5_block11_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block11_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block11_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block11_concat (Concatena (None, None, None, 8 0        conv5_block10_concat[0][0]
                                                              conv5_block11_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block12_0_bn (BatchNormal (None, None, None, 8 3456     conv5_block11_concat[0][0]
----------------------------------------------------------------------------------
conv5_block12_0_relu (Activatio (None, None, None, 8 0        conv5_block12_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block12_1_conv (Conv2D)   (None, None, None, 1 110592   conv5_block12_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block12_1_bn (BatchNormal (None, None, None, 1 512      conv5_block12_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block12_1_relu (Activatio (None, None, None, 1 0        conv5_block12_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block12_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block12_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block12_concat (Concatena (None, None, None, 8 0        conv5_block11_concat[0][0]
                                                              conv5_block12_2_conv[0][0]
----------------------------------------------------------------------------------
conv5_block13_0_bn (BatchNormal (None, None, None, 8 3584     conv5_block12_concat[0][0]
----------------------------------------------------------------------------------
conv5_block13_0_relu (Activatio (None, None, None, 8 0        conv5_block13_0_bn[0][0]
----------------------------------------------------------------------------------
conv5_block13_1_conv (Conv2D)   (None, None, None, 1 114688   conv5_block13_0_relu[0][0]
----------------------------------------------------------------------------------
conv5_block13_1_bn (BatchNormal (None, None, None, 1 512      conv5_block13_1_conv[0][0]
----------------------------------------------------------------------------------
conv5_block13_1_relu (Activatio (None, None, None, 1 0        conv5_block13_1_bn[0][0]
----------------------------------------------------------------------------------
conv5_block13_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block13_1_relu[0][0]
----------------------------------------------------------------------------------
conv5_block13_concat (Concatena (None, None, None, 9 0        conv5_block12_concat[0][0]
                                                              conv5_block13_2_conv[0][0]
```

```
--------------------------------------------------------------------------------
conv5_block14_0_bn (BatchNormal (None, None, None, 9 3712      conv5_block13_concat[0][0]
--------------------------------------------------------------------------------
conv5_block14_0_relu (Activatio (None, None, None, 9 0        conv5_block14_0_bn[0][0]
--------------------------------------------------------------------------------
conv5_block14_1_conv (Conv2D)   (None, None, None, 1 118784   conv5_block14_0_relu[0][0]
--------------------------------------------------------------------------------
conv5_block14_1_bn (BatchNormal (None, None, None, 1 512      conv5_block14_1_conv[0][0]
--------------------------------------------------------------------------------
conv5_block14_1_relu (Activatio (None, None, None, 1 0        conv5_block14_1_bn[0][0]
--------------------------------------------------------------------------------
conv5_block14_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block14_1_relu[0][0]
--------------------------------------------------------------------------------
conv5_block14_concat (Concatena (None, None, None, 9 0        conv5_block13_concat[0][0]
                                                              conv5_block14_2_conv[0][0]
--------------------------------------------------------------------------------
conv5_block15_0_bn (BatchNormal (None, None, None, 9 3840      conv5_block14_concat[0][0]
--------------------------------------------------------------------------------
conv5_block15_0_relu (Activatio (None, None, None, 9 0        conv5_block15_0_bn[0][0]
--------------------------------------------------------------------------------
conv5_block15_1_conv (Conv2D)   (None, None, None, 1 122880   conv5_block15_0_relu[0][0]
--------------------------------------------------------------------------------
conv5_block15_1_bn (BatchNormal (None, None, None, 1 512      conv5_block15_1_conv[0][0]
--------------------------------------------------------------------------------
conv5_block15_1_relu (Activatio (None, None, None, 1 0        conv5_block15_1_bn[0][0]
--------------------------------------------------------------------------------
conv5_block15_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block15_1_relu[0][0]
--------------------------------------------------------------------------------
conv5_block15_concat (Concatena (None, None, None, 9 0        conv5_block14_concat[0][0]
                                                              conv5_block15_2_conv[0][0]
--------------------------------------------------------------------------------
conv5_block16_0_bn (BatchNormal (None, None, None, 9 3968      conv5_block15_concat[0][0]
--------------------------------------------------------------------------------
conv5_block16_0_relu (Activatio (None, None, None, 9 0        conv5_block16_0_bn[0][0]
--------------------------------------------------------------------------------
conv5_block16_1_conv (Conv2D)   (None, None, None, 1 126976   conv5_block16_0_relu[0][0]
--------------------------------------------------------------------------------
conv5_block16_1_bn (BatchNormal (None, None, None, 1 512      conv5_block16_1_conv[0][0]
--------------------------------------------------------------------------------
conv5_block16_1_relu (Activatio (None, None, None, 1 0        conv5_block16_1_bn[0][0]
--------------------------------------------------------------------------------
conv5_block16_2_conv (Conv2D)   (None, None, None, 3 36864    conv5_block16_1_relu[0][0]
--------------------------------------------------------------------------------
conv5_block16_concat (Concatena (None, None, None, 1 0        conv5_block15_concat[0][0]
                                                              conv5_block16_2_conv[0][0]
--------------------------------------------------------------------------------
bn (BatchNormalization)         (None, None, None, 1 4096      conv5_block16_concat[0][0]
--------------------------------------------------------------------------------
```

```
relu (Activation)              (None, None, None, 1 0          bn[0][0]
========================================================================
Total params: 7,037,504
Trainable params: 6,953,856
Non-trainable params: 83,648

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

In [4]: *# Print out the first five layers*
        layers_l = base_model.layers

        print("First 5 layers")
        layers_l[0:5]

First 5 layers

Out[4]: [<keras.engine.input_layer.InputLayer at 0x7f7fd031fc18>,
         <keras.layers.convolutional.ZeroPadding2D at 0x7f7fd031fe48>,
         <keras.layers.convolutional.Conv2D at 0x7f7fd031ff98>,
         <keras.layers.normalization.BatchNormalization at 0x7f7fd02bf630>,
         <keras.layers.core.Activation at 0x7f7fd02bf9e8>]

In [5]: *# Print out the last five layers*
        print("Last 5 layers")
        layers_l[-6:-1]

Last 5 layers

Out[5]: [<keras.layers.normalization.BatchNormalization at 0x7f7e7425a320>,
         <keras.layers.core.Activation at 0x7f7e7425a438>,
         <keras.layers.convolutional.Conv2D at 0x7f7e74260fd0>,
         <keras.layers.merge.Concatenate at 0x7f7e7420cfd0>,
         <keras.layers.normalization.BatchNormalization at 0x7f7e74213b70>]

In [6]: *# Get the convolutional layers and print the first 5*
        conv2D_layers = [layer for layer in base_model.layers
                         if str(type(layer)).find('Conv2D') > -1]
        print("The first five conv2D layers")
        conv2D_layers[0:5]

The first five conv2D layers

Out[6]: [<keras.layers.convolutional.Conv2D at 0x7f7fd031ff98>,
         <keras.layers.convolutional.Conv2D at 0x7f7fce020748>,
         <keras.layers.convolutional.Conv2D at 0x7f7fcdfd6668>,
         <keras.layers.convolutional.Conv2D at 0x7f7fce005fd0>,
         <keras.layers.convolutional.Conv2D at 0x7f7fcdfc2ef0>]

```
In [7]:  # Print out the total number of convolutional layers
         print(f"There are {len(conv2D_layers)} convolutional layers")

There are 120 convolutional layers


In [8]:  # Print the number of channels in the input
         print("The input has 3 channels")
         base_model.input

The input has 3 channels


Out[8]:  <tf.Tensor 'input_1:0' shape=(?, ?, ?, 3) dtype=float32>

In [9]:  # Print the number of output channels
         print("The output has 1024 channels")
         x = base_model.output
         x

The output has 1024 channels


Out[9]:  <tf.Tensor 'relu/Relu:0' shape=(?, ?, ?, 1024) dtype=float32>

In [10]: # Add a global spatial average pooling layer
         x_pool = GlobalAveragePooling2D()(x)
         x_pool

Out[10]: <tf.Tensor 'global_average_pooling2d_1/Mean:0' shape=(?, 1024) dtype=float32>

In [11]: # Define a set of five class labels to use as an example
         labels = ['Emphysema',
                   'Hernia',
                   'Mass',
                   'Pneumonia',
                   'Edema']
         n_classes = len(labels)
         print(f"In this example, you want your model to identify {n_classes} classes")

In this example, you want your model to identify 5 classes


In [15]: # Add a logistic layer the same size as the number of classes you're trying to predic
         predictions = Dense(n_classes, activation="softmax")(x_pool)
         print("Predictions have {n_classes} units, one for each class")
         predictions

Predictions have {n_classes} units, one for each class
```

```
Out[15]: <tf.Tensor 'dense_2/Softmax:0' shape=(?, 5) dtype=float32>

In [16]: # Create an updated model
         model = Model(inputs=base_model.input, outputs=predictions)

In [17]: # Compile the model
         model.compile(optimizer='adam',
                       loss='categorical_crossentropy')
         # (You'll customize the loss function in the assignment!)
```

This has been a brief exploration of the Densenet architecture you'll use in this week's graded assignment!