National University of Sciences & Technology
School of Electrical Engineering and Computer Science
Department of Computing

CS867 Computer Vision

Assignment 2			
Maximum Marks:		Instructor: Dr. Muhammad Moazam Fraz	
Submission Date: 18/11/2021		Type: Code Report	
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Chest-Xray Dataset

ResNet50

Parameter

Epochs = 10 Batch size = 12 Learning Rate = 0.0001

Total params: 23,591,810
Trainable params: 23,538,690
Non-trainable params: 53,120

Dataset split

Before validation Split

Training data = 5,233 images [NORMAL = 1349, PNEUMONIA = 3884]

Testing data = 624 images [NORMAL = 234, PNEUMONIA = 390]

After validation Split

Training data = 4709 images [NORMAL = 1202, PNEUMONIA = 3507]

Validation data = 524 images [NORMAL = 147, PNEUMONIA = 377]

Testing data = 624 images [NORMAL = 234, PNEUMONIA = 390]

Transfer Learning

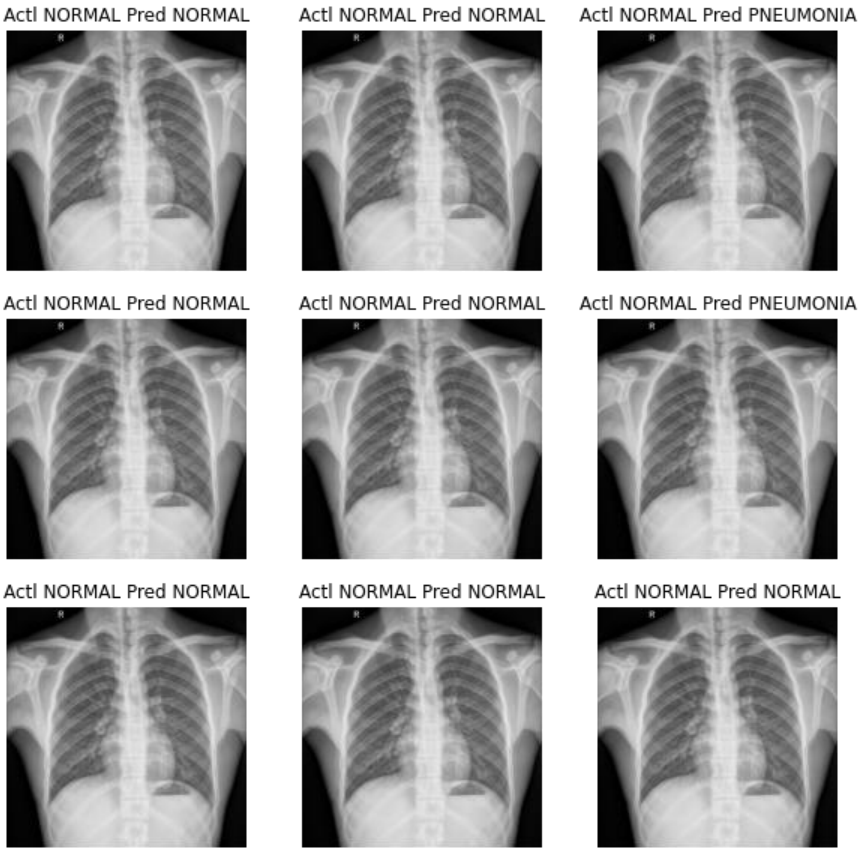
I used ResNet50 model as base model with none weights. Then add global average pooling layer Dropout layer and Dense (prediction softmax layer) after the output of base model ResNet50. Model weights are none no pre-trained imagenet weights are used in our ResNet50 model.

Inference Time

Best inference time for 100 images are 16.6 secs out of 5 loops.

```
5 loops, best of 1: 16.6 s per loop
```

Qualitative Results



Training Accuracy Validation Accuracy

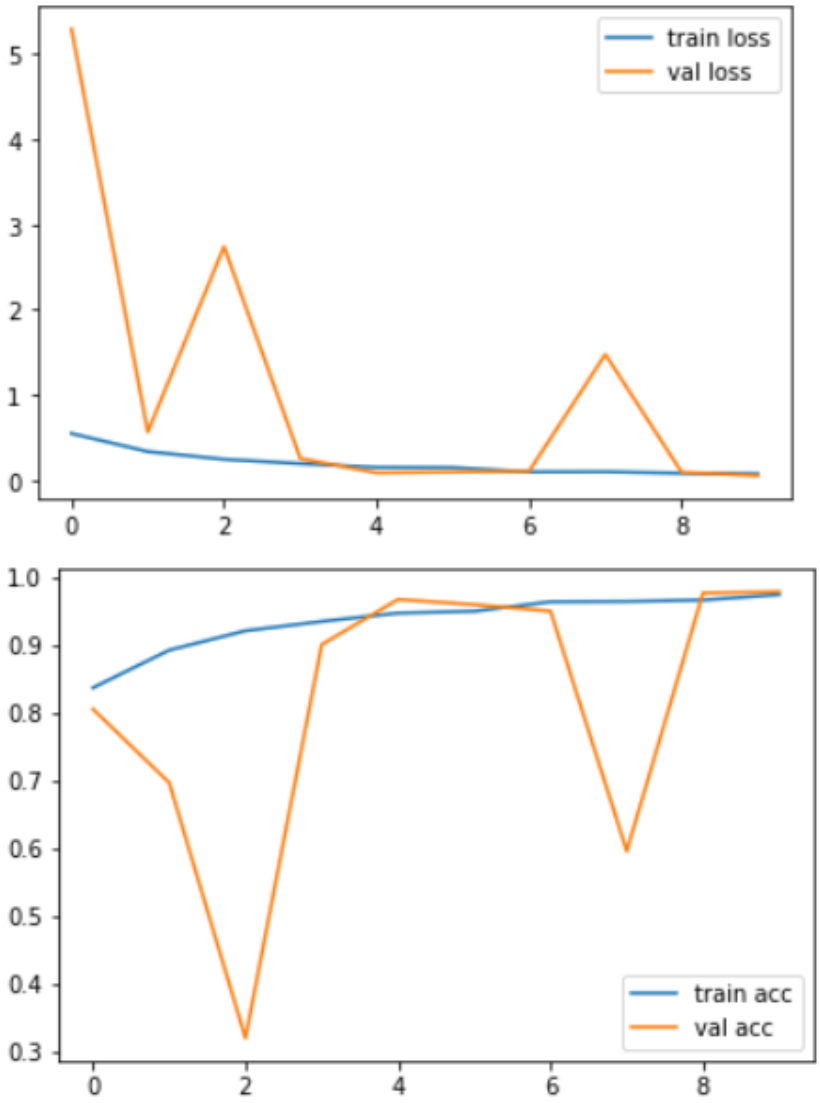
```
Epoch 1/10
393/393 [==============================] - 167s 327ms/step - loss: 0.5492 -
accuracy: 0.8369 - val_loss: 5.2917 - val_accuracy: 0.8053
Epoch 2/10
393/393 [==============================] - 125s 319ms/step - loss: 0.3372 -
accuracy: 0.8925 - val_loss: 0.5670 - val_accuracy: 0.6966
Epoch 3/10
393/393 [==============================] - 125s 318ms/step - loss: 0.2465 -
accuracy: 0.9212 - val_loss: 2.7405 - val_accuracy: 0.3187
Epoch 4/10
393/393 [==============================] - 125s 318ms/step - loss: 0.1965 -
accuracy: 0.9350 - val_loss: 0.2560 - val_accuracy: 0.9008
Epoch 5/10
393/393 [==============================] - 125s 318ms/step - loss: 0.1516 -
accuracy: 0.9473 - val_loss: 0.0882 - val_accuracy: 0.9676
Epoch 6/10
393/393 [==============================] - 126s 320ms/step - loss: 0.1499 -
accuracy: 0.9501 - val_loss: 0.0984 - val_accuracy: 0.9599
Epoch 7/10
393/393 [==============================] - 125s 319ms/step - loss: 0.0990 -
accuracy: 0.9641 - val_loss: 0.1058 - val_accuracy: 0.9504
Epoch 8/10
393/393 [==============================] - 125s 319ms/step - loss: 0.1010 -
accuracy: 0.9645 - val_loss: 1.4767 - val_accuracy: 0.5954
Epoch 9/10
```

```
393/393 [==============================] - 125s 319ms/step - loss: 0.0832 -
accuracy: 0.9667 - val_loss: 0.0954 - val_accuracy: 0.9771
Epoch 10/10
393/393 [==============================] - 125s 319ms/step - loss: 0.0763 -
accuracy: 0.9747 - val_loss: 0.0541 - val_accuracy: 0.9790
```

Testing Accuracy

```
20/20 [==============================] - 6s 245ms/step - loss: 0.8156 - accuracy:
0.8013
Loss = 0.8156483769416809
Test Accuracy = 0.8012820482254028
```

Training loss vs Validation accuracy & Training accuracy vs Validation accuracy



Model Architecture

```
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 (BatchNormalization)  (None, 112, 112, 64  256         ['conv1_conv[0][0]']
                               )

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 (Conv2D)   (None, 56, 56, 64)   4160        ['pool1_pool[0][0]']

conv2_block1_1_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block1_1_conv[0][0]']
ization)

conv2_block1_1_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block1_1_bn[0][0]']
n)

conv2_block1_2_conv (Conv2D)   (None, 56, 56, 64)   36928       ['conv2_block1_1_relu[0][0]']

conv2_block1_2_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block1_2_conv[0][0]']
ization)

conv2_block1_2_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block1_2_bn[0][0]']
n)

conv2_block1_0_conv (Conv2D)   (None, 56, 56, 256)  16640       ['pool1_pool[0][0]']

conv2_block1_3_conv (Conv2D)   (None, 56, 56, 256)  16640       ['conv2_block1_2_relu[0][0]']

conv2_block1_0_bn (BatchNormal  (None, 56, 56, 256)  1024       ['conv2_block1_0_conv[0][0]']
ization)

conv2_block1_3_bn (BatchNormal  (None, 56, 56, 256)  1024       ['conv2_block1_3_conv[0][0]']
ization)

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

conv2_block1_out (Activation)  (None, 56, 56, 256)  0           ['conv2_block1_add[0][0]']

conv2_block2_1_conv (Conv2D)   (None, 56, 56, 64)   16448       ['conv2_block1_out[0][0]']

conv2_block2_1_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block2_1_conv[0][0]']
ization)

conv2_block2_1_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block2_1_bn[0][0]']
n)

conv2_block2_2_conv (Conv2D)   (None, 56, 56, 64)   36928       ['conv2_block2_1_relu[0][0]']

conv2_block2_2_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block2_2_conv[0][0]']
ization)

conv2_block2_2_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block2_2_bn[0][0]']
n)

conv2_block2_3_conv (Conv2D)   (None, 56, 56, 256)  16640       ['conv2_block2_2_relu[0][0]']

conv2_block2_3_bn (BatchNormal  (None, 56, 56, 256)  1024       ['conv2_block2_3_conv[0][0]']
ization)

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

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

conv2_block3_1_conv (Conv2D)   (None, 56, 56, 64)   16448       ['conv2_block2_out[0][0]']
```

```
conv2_block3_1_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block3_1_conv[0][0]']
ization)

conv2_block3_1_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block3_1_bn[0][0]']
n)

conv2_block3_2_conv (Conv2D)   (None, 56, 56, 64)   36928       ['conv2_block3_1_relu[0][0]']

conv2_block3_2_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block3_2_conv[0][0]']
ization)

conv2_block3_2_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block3_2_bn[0][0]']
n)

conv2_block3_3_conv (Conv2D)   (None, 56, 56, 256)  16640       ['conv2_block3_2_relu[0][0]']

conv2_block3_3_bn (BatchNormal  (None, 56, 56, 256)  1024       ['conv2_block3_3_conv[0][0]']
ization)

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

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

conv3_block1_1_conv (Conv2D)   (None, 28, 28, 128)  32896       ['conv2_block3_out[0][0]']

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

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

conv3_block1_2_conv (Conv2D)   (None, 28, 28, 128)  147584      ['conv3_block1_1_relu[0][0]']

conv3_block1_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block1_2_conv[0][0]']
ization)

conv3_block1_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block1_2_bn[0][0]']
n)

conv3_block1_0_conv (Conv2D)   (None, 28, 28, 512)  131584      ['conv2_block3_out[0][0]']

conv3_block1_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block1_2_relu[0][0]']

conv3_block1_0_bn (BatchNormal  (None, 28, 28, 512)  2048       ['conv3_block1_0_conv[0][0]']
ization)

conv3_block1_3_bn (BatchNormal  (None, 28, 28, 512)  2048       ['conv3_block1_3_conv[0][0]']
ization)

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

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

conv3_block2_1_conv (Conv2D)   (None, 28, 28, 128)  65664       ['conv3_block1_out[0][0]']

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

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

conv3_block2_2_conv (Conv2D)   (None, 28, 28, 128)  147584      ['conv3_block2_1_relu[0][0]']

conv3_block2_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block2_2_conv[0][0]']
ization)

conv3_block2_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block2_2_bn[0][0]']
n)

conv3_block2_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block2_2_relu[0][0]']

conv3_block2_3_bn (BatchNormal  (None, 28, 28, 512)  2048       ['conv3_block2_3_conv[0][0]']
ization)
```

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

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

conv3_block3_1_conv (Conv2D)   (None, 28, 28, 128)  65664       ['conv3_block2_out[0][0]']

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

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

conv3_block3_2_conv (Conv2D)   (None, 28, 28, 128)  147584      ['conv3_block3_1_relu[0][0]']

conv3_block3_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block3_2_conv[0][0]']
ization)

conv3_block3_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block3_2_bn[0][0]']
n)

conv3_block3_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block3_2_relu[0][0]']

conv3_block3_3_bn (BatchNormal  (None, 28, 28, 512)  2048       ['conv3_block3_3_conv[0][0]']
ization)

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

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

conv3_block4_1_conv (Conv2D)   (None, 28, 28, 128)  65664       ['conv3_block3_out[0][0]']

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

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

conv3_block4_2_conv (Conv2D)   (None, 28, 28, 128)  147584      ['conv3_block4_1_relu[0][0]']

conv3_block4_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block4_2_conv[0][0]']
ization)

conv3_block4_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block4_2_bn[0][0]']
n)

conv3_block4_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block4_2_relu[0][0]']

conv3_block4_3_bn (BatchNormal  (None, 28, 28, 512)  2048       ['conv3_block4_3_conv[0][0]']
ization)

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

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

conv4_block1_1_conv (Conv2D)   (None, 14, 14, 256)  131328      ['conv3_block4_out[0][0]']

conv4_block1_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block1_1_conv[0][0]']
ization)

conv4_block1_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block1_1_bn[0][0]']
n)

conv4_block1_2_conv (Conv2D)   (None, 14, 14, 256)  590080      ['conv4_block1_1_relu[0][0]']

conv4_block1_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block1_2_conv[0][0]']
ization)

conv4_block1_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block1_2_bn[0][0]']
n)

conv4_block1_0_conv (Conv2D)   (None, 14, 14, 1024  525312      ['conv3_block4_out[0][0]']
```

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                                )

conv4_block1_3_conv (Conv2D)    (None, 14, 14, 1024  263168      ['conv4_block1_2_relu[0][0]']
                                )

conv4_block1_0_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block1_0_conv[0][0]']
ization)                        )

conv4_block1_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block1_3_conv[0][0]']
ization)                        )

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

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

conv4_block2_1_conv (Conv2D)    (None, 14, 14, 256)  262400      ['conv4_block1_out[0][0]']

conv4_block2_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block2_1_conv[0][0]']
ization)

conv4_block2_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block2_1_bn[0][0]']
n)

conv4_block2_2_conv (Conv2D)    (None, 14, 14, 256)  590080      ['conv4_block2_1_relu[0][0]']

conv4_block2_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block2_2_conv[0][0]']
ization)

conv4_block2_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block2_2_bn[0][0]']
n)

conv4_block2_3_conv (Conv2D)    (None, 14, 14, 1024  263168      ['conv4_block2_2_relu[0][0]']
                                )

conv4_block2_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block2_3_conv[0][0]']
ization)                        )

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

conv4_block2_out (Activation)   (None, 14, 14, 1024  0          ['conv4_block2_add[0][0]']
                                )

conv4_block3_1_conv (Conv2D)    (None, 14, 14, 256)  262400      ['conv4_block2_out[0][0]']

conv4_block3_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block3_1_conv[0][0]']
ization)

conv4_block3_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block3_1_bn[0][0]']
n)

conv4_block3_2_conv (Conv2D)    (None, 14, 14, 256)  590080      ['conv4_block3_1_relu[0][0]']

conv4_block3_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block3_2_conv[0][0]']
ization)

conv4_block3_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block3_2_bn[0][0]']
n)

conv4_block3_3_conv (Conv2D)    (None, 14, 14, 1024  263168      ['conv4_block3_2_relu[0][0]']
                                )

conv4_block3_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block3_3_conv[0][0]']
ization)                        )

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

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

conv4_block4_1_conv (Conv2D)    (None, 14, 14, 256)  262400      ['conv4_block3_out[0][0]']
```

```
conv4_block4_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block4_1_conv[0][0]']
ization)

conv4_block4_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block4_1_bn[0][0]']
n)

conv4_block4_2_conv (Conv2D)   (None, 14, 14, 256)  590080     ['conv4_block4_1_relu[0][0]']

conv4_block4_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block4_2_conv[0][0]']
ization)

conv4_block4_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block4_2_bn[0][0]']
n)

conv4_block4_3_conv (Conv2D)   (None, 14, 14, 1024  263168     ['conv4_block4_2_relu[0][0]']
                               )

conv4_block4_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block4_3_conv[0][0]']
ization)                       )

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

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

conv4_block5_1_conv (Conv2D)   (None, 14, 14, 256)  262400     ['conv4_block4_out[0][0]']

conv4_block5_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block5_1_conv[0][0]']
ization)

conv4_block5_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block5_1_bn[0][0]']
n)

conv4_block5_2_conv (Conv2D)   (None, 14, 14, 256)  590080     ['conv4_block5_1_relu[0][0]']

conv4_block5_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block5_2_conv[0][0]']
ization)

conv4_block5_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block5_2_bn[0][0]']
n)

conv4_block5_3_conv (Conv2D)   (None, 14, 14, 1024  263168     ['conv4_block5_2_relu[0][0]']
                               )

conv4_block5_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block5_3_conv[0][0]']
ization)                       )

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

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

conv4_block6_1_conv (Conv2D)   (None, 14, 14, 256)  262400     ['conv4_block5_out[0][0]']

conv4_block6_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block6_1_conv[0][0]']
ization)

conv4_block6_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block6_1_bn[0][0]']
n)

conv4_block6_2_conv (Conv2D)   (None, 14, 14, 256)  590080     ['conv4_block6_1_relu[0][0]']

conv4_block6_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block6_2_conv[0][0]']
ization)

conv4_block6_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block6_2_bn[0][0]']
n)

conv4_block6_3_conv (Conv2D)   (None, 14, 14, 1024  263168     ['conv4_block6_2_relu[0][0]']
                               )

conv4_block6_3_bn (BatchNormal  (None, 14, 14, 1024  4096       ['conv4_block6_3_conv[0][0]']
ization)                       )
```

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

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

conv5_block1_1_conv (Conv2D)   (None, 7, 7, 512)    524800      ['conv4_block6_out[0][0]']

conv5_block1_1_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block1_1_conv[0][0]']
ization)

conv5_block1_1_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block1_1_bn[0][0]']
n)

conv5_block1_2_conv (Conv2D)   (None, 7, 7, 512)    2359808     ['conv5_block1_1_relu[0][0]']

conv5_block1_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block1_2_conv[0][0]']
ization)

conv5_block1_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block1_2_bn[0][0]']
n)

conv5_block1_0_conv (Conv2D)   (None, 7, 7, 2048)   2099200     ['conv4_block6_out[0][0]']

conv5_block1_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block1_2_relu[0][0]']

conv5_block1_0_bn (BatchNormal  (None, 7, 7, 2048)  8192        ['conv5_block1_0_conv[0][0]']
ization)

conv5_block1_3_bn (BatchNormal  (None, 7, 7, 2048)  8192        ['conv5_block1_3_conv[0][0]']
ization)

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

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

conv5_block2_1_conv (Conv2D)   (None, 7, 7, 512)    1049088     ['conv5_block1_out[0][0]']

conv5_block2_1_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block2_1_conv[0][0]']
ization)

conv5_block2_1_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block2_1_bn[0][0]']
n)

conv5_block2_2_conv (Conv2D)   (None, 7, 7, 512)    2359808     ['conv5_block2_1_relu[0][0]']

conv5_block2_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block2_2_conv[0][0]']
ization)

conv5_block2_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block2_2_bn[0][0]']
n)

conv5_block2_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block2_2_relu[0][0]']

conv5_block2_3_bn (BatchNormal  (None, 7, 7, 2048)  8192        ['conv5_block2_3_conv[0][0]']
ization)

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

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

conv5_block3_1_conv (Conv2D)   (None, 7, 7, 512)    1049088     ['conv5_block2_out[0][0]']

conv5_block3_1_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block3_1_conv[0][0]']
ization)

conv5_block3_1_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block3_1_bn[0][0]']
n)

conv5_block3_2_conv (Conv2D)   (None, 7, 7, 512)    2359808     ['conv5_block3_1_relu[0][0]']

conv5_block3_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block3_2_conv[0][0]']
```

```
 ization)

 conv5_block3_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block3_2_bn[0][0]']
 n)

 conv5_block3_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block3_2_relu[0][0]']

 conv5_block3_3_bn (BatchNormal  (None, 7, 7, 2048)  8192        ['conv5_block3_3_conv[0][0]']
 ization)

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

 conv5_block3_out (Activation)  (None, 7, 7, 2048)   0           ['conv5_block3_add[0][0]']

 global_average_pooling2d (Glob  (None, 2048)        0           ['conv5_block3_out[0][0]']
 alAveragePooling2D)

 dropout (Dropout)              (None, 2048)         0           ['global_average_pooling2d[0][0]'
                                                                 ]

 dense (Dense)                  (None, 2)            4098        ['dropout[0][0]']

==================================================================================================
Total params: 23,591,810
Trainable params: 23,538,690
Non-trainable params: 53,120
__________________________________________________________________________________________________
```

VGG16

Parameter

Epochs = 10 Batch size = 12 Learning Rate = $5e^{-5}$

Total params: 27,692,098
Trainable params: 20,056,834
Non-trainable params: 7,635,264

Dataset split

Before validation Split

Training data = 5,233 images [NORMAL = 1349, PNEUMONIA = 3884]

Testing data = 624 images [NORMAL = 234, PNEUMONIA = 390]

After validation Split

Training data = 4709 images [NORMAL = 1202, PNEUMONIA = 3507]

Validation data = 524 images [NORMAL = 147, PNEUMONIA = 377]

Testing data = 624 images [NORMAL = 234, PNEUMONIA = 390]

Transfer Learning

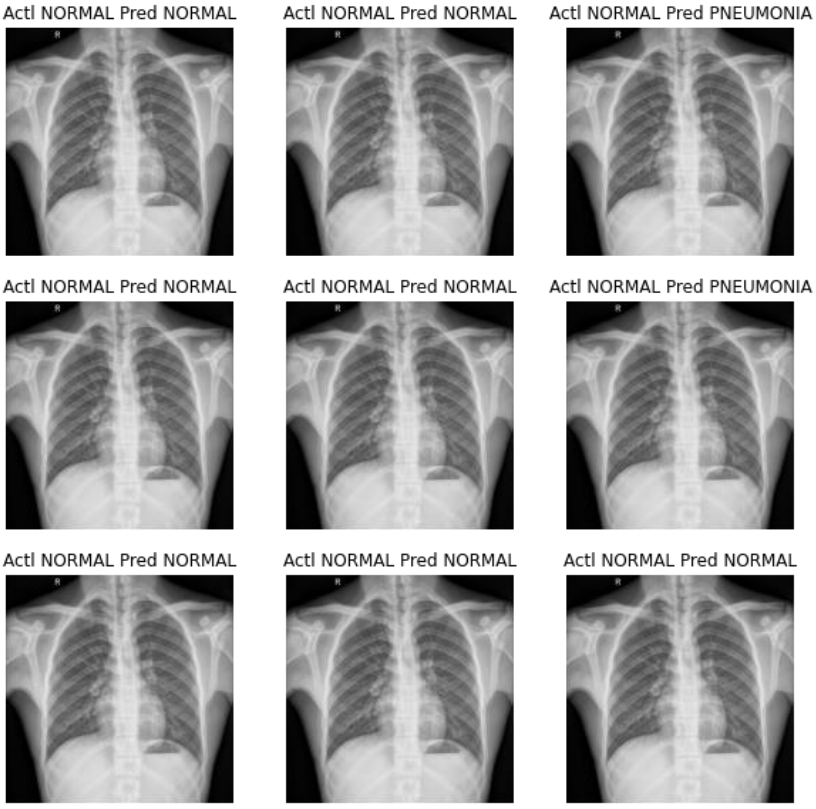
I used VGG16 model as base model with imagenet weights. Then freeze first 15 layers, layers after 15 can be learnable only. After that a fully connected layer Dense layer Dropout layer two Dense layers are added in base model.

Inference Time

Best inference time for 100 images are 49.4 secs out of 5 loops.

```
5 loops, best of 1: 49.4 s per loop
```

Qualitative Results



Training Accuracy Validation Accuracy

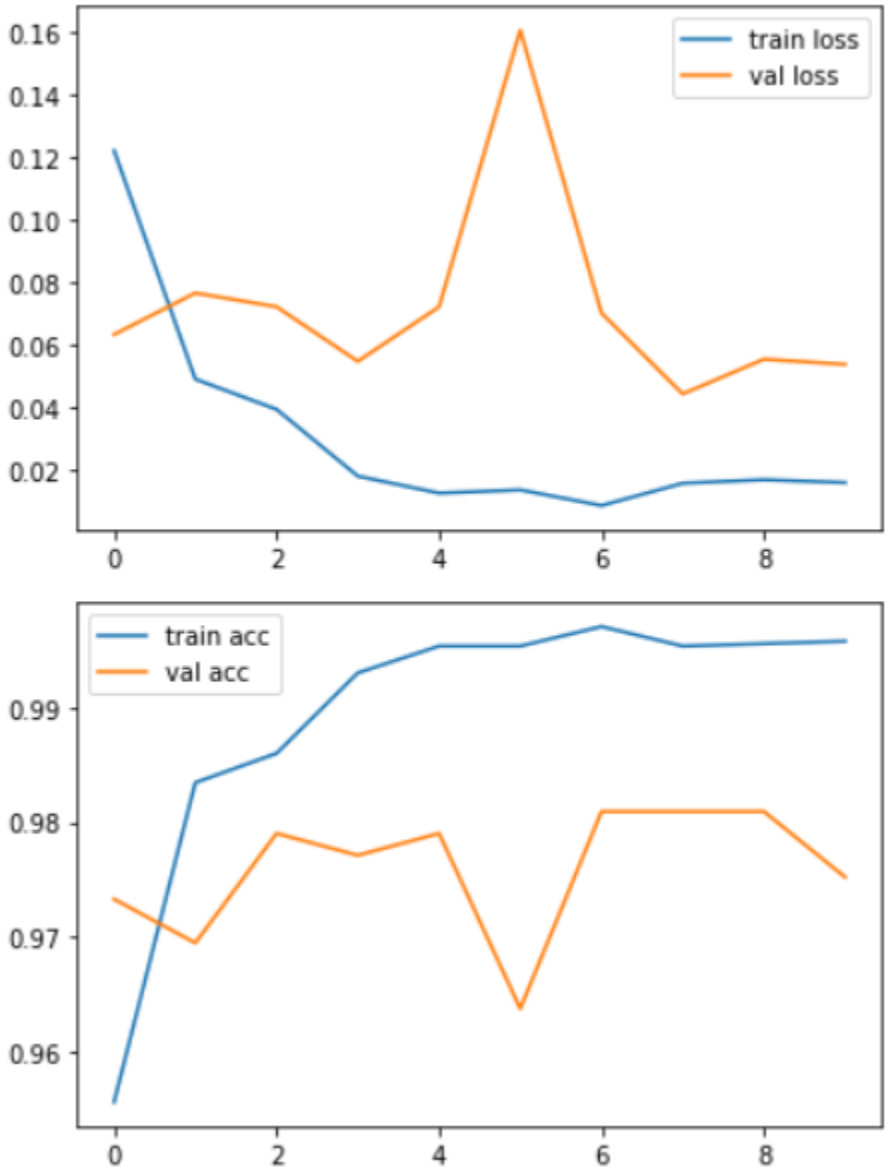
```
Epoch 1/10
393/393 [==============================] - ETA: 0s - loss: 0.1219 - accuracy:
0.9556
Epoch 00001: val_accuracy improved from -inf to 0.97328, saving model to
vgg16_finetune.h15
INFO:tensorflow:Assets written to: vgg16_finetune.h15/assets
393/393 [==============================] - 111s 195ms/step - loss: 0.1219 -
accuracy: 0.9556 - val_loss: 0.0632 - val_accuracy: 0.9733 - lr: 5.0000e-05
Epoch 2/10
393/393 [==============================] - ETA: 0s - loss: 0.0490 - accuracy:
0.9834
Epoch 00002: val_accuracy did not improve from 0.97328
393/393 [==============================] - 62s 159ms/step - loss: 0.0490 -
accuracy: 0.9834 - val_loss: 0.0765 - val_accuracy: 0.9695 - lr: 5.0000e-05
Epoch 3/10
393/393 [==============================] - ETA: 0s - loss: 0.0393 - accuracy:
0.9860
Epoch 00003: val_accuracy improved from 0.97328 to 0.97901, saving model to
vgg16_finetune.h15
INFO:tensorflow:Assets written to: vgg16_finetune.h15/assets
393/393 [==============================] - 70s 179ms/step - loss: 0.0393 -
accuracy: 0.9860 - val_loss: 0.0721 - val_accuracy: 0.9790 - lr: 5.0000e-05
Epoch 4/10
393/393 [==============================] - ETA: 0s - loss: 0.0180 - accuracy:
0.9930
```

```
Epoch 00004: val_accuracy did not improve from 0.97901
393/393 [==============================] - 62s 159ms/step - loss: 0.0180 -
accuracy: 0.9930 - val_loss: 0.0547 - val_accuracy: 0.9771 - lr: 5.0000e-05
Epoch 5/10
393/393 [==============================] - ETA: 0s - loss: 0.0126 - accuracy:
0.9953
Epoch 00005: val_accuracy did not improve from 0.97901
393/393 [==============================] - 62s 159ms/step - loss: 0.0126 -
accuracy: 0.9953 - val_loss: 0.0720 - val_accuracy: 0.9790 - lr: 5.0000e-05
Epoch 6/10
393/393 [==============================] - ETA: 0s - loss: 0.0136 - accuracy:
0.9953
Epoch 00006: val_accuracy did not improve from 0.97901
393/393 [==============================] - 62s 159ms/step - loss: 0.0136 -
accuracy: 0.9953 - val_loss: 0.1604 - val_accuracy: 0.9637 - lr: 5.0000e-05
Epoch 7/10
393/393 [==============================] - ETA: 0s - loss: 0.0086 - accuracy:
0.9970
Epoch 00007: val_accuracy improved from 0.97901 to 0.98092, saving model to
vgg16_finetune.h15
INFO:tensorflow:Assets written to: vgg16_finetune.h15/assets
393/393 [==============================] - 71s 180ms/step - loss: 0.0086 -
accuracy: 0.9970 - val_loss: 0.0701 - val_accuracy: 0.9809 - lr: 5.0000e-05
Epoch 8/10
393/393 [==============================] - ETA: 0s - loss: 0.0157 - accuracy:
0.9953
Epoch 00008: val_accuracy did not improve from 0.98092
393/393 [==============================] - 62s 158ms/step - loss: 0.0157 -
accuracy: 0.9953 - val_loss: 0.0443 - val_accuracy: 0.9809 - lr: 5.0000e-05
Epoch 9/10
393/393 [==============================] - ETA: 0s - loss: 0.0169 - accuracy:
0.9955
Epoch 00009: val_accuracy did not improve from 0.98092
393/393 [==============================] - 62s 159ms/step - loss: 0.0169 -
accuracy: 0.9955 - val_loss: 0.0553 - val_accuracy: 0.9809 - lr: 5.0000e-05
Epoch 10/10
393/393 [==============================] - ETA: 0s - loss: 0.0159 - accuracy:
0.9958
Epoch 00010: val_accuracy did not improve from 0.98092
393/393 [==============================] - 62s 159ms/step - loss: 0.0159 -
accuracy: 0.9958 - val_loss: 0.0537 - val_accuracy: 0.9752 - lr: 5.0000e-05
```

Testing Accuracy

```
20/20 [==============================] - 19s 487ms/step - loss: 0.7982 - accuracy:
0.8510
Loss = 0.7981559634208679
Test Accuracy = 0.8509615659713745
```

Training loss vs Validation accuracy & Training accuracy vs Validation accuracy



Model Architecture

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

 block1_conv1 (Conv2D)       (None, 224, 224, 64)      1792

 block1_conv2 (Conv2D)       (None, 224, 224, 64)      36928
```

```
 block1_pool (MaxPooling2D)  (None, 112, 112, 64)      0

 block2_conv1 (Conv2D)       (None, 112, 112, 128)     73856

 block2_conv2 (Conv2D)       (None, 112, 112, 128)     147584

 block2_pool (MaxPooling2D)  (None, 56, 56, 128)       0

 block3_conv1 (Conv2D)       (None, 56, 56, 256)       295168

 block3_conv2 (Conv2D)       (None, 56, 56, 256)       590080

 block3_conv3 (Conv2D)       (None, 56, 56, 256)       590080

 block3_pool (MaxPooling2D)  (None, 28, 28, 256)       0

 block4_conv1 (Conv2D)       (None, 28, 28, 512)       1180160

 block4_conv2 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_conv3 (Conv2D)       (None, 28, 28, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 14, 14, 512)       0

 block5_conv1 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv2 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_conv3 (Conv2D)       (None, 14, 14, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 7, 7, 512)         0

 flatten (Flatten)           (None, 25088)             0

 dense (Dense)               (None, 512)               12845568

 dropout (Dropout)           (None, 512)               0

 dense_1 (Dense)             (None, 256)               131328

 dense_2 (Dense)             (None, 2)                 514

=================================================================
Total params: 27,692,098
Trainable params: 20,056,834
Non-trainable params: 7,635,264
```

315_Birds_Species

ResNet50 and VGG16 are being trained on this dataset. Due to lack of parallel computing power models are not trained yet. I will push updated report pdf file after training on github. And comparison between models.

Trained Model H5 Files

Click https://drive.google.com/drive/folders/1r0l1Y6gRV5e-5qHYWaCF7_uqkdbHRlsB?usp=sharing