

COVID-19 Identification and Prediction with Computer Vision

```
In [1]: import tensorflow as tf
import cv2, pathlib, splitfolders
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import *
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np

Collecting split-folders
  Downloading split_folders-0.5.1-py3-none-any.whl (8.4 kB)
Installing collected packages: split-folders
Successfully installed split-folders-0.5.1
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It is recommended to use a virtual environment instead: https://pip.pypa.io/warnings/venv
```

```
In [2]: epochs = 50
batch_size = 32
img_height, img_width = 224, 224
input_shape = (img_height, img_width, 3)
```

```
In [3]: def create_data_binary(data_bs):
    data_bs = pathlib.Path(data_bs)
    splitfolders.ratio(data_bs, output='Imgss/', seed=1234, ratio=(0.7, 0.15, 0.15), gr
    data_gen = ImageDataGenerator(
        rescale=1./255,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=True,
        rotation_range = 10,
        width_shift_range = 0.1,
        height_shift_range = 0.1,
        samplewise_center = True,
        samplewise_std_normalization = True
    )
    train_ds = data_gen.flow_from_directory('Imgss/train/', target_size=(img_height, im
        class_mode='binary', batch_size=batch_size)
    test_ds = data_gen.flow_from_directory('Imgss/test/', target_size=(img_height, img_
        class_mode='binary', batch_size=batch_size,
        shuffle=False)

    return train_ds ,test_ds

train_data, test_data = create_data_binary('/kaggle/input/sarscov2-ctscan-dataset/')
```

```
Copying files: 2481 files [00:19, 126.59 files/s]
Found 1736 images belonging to 2 classes.
Found 374 images belonging to 2 classes.
```

```
In [4]: from keras.applications import ResNet50
from keras.models import Sequential
from keras.layers import Dense, Flatten, Conv2D, Dropout, BatchNormalization, GlobalAveragePooling2D
from keras.optimizers import Adam
```

```
import tensorflow as tf

# Load ResNet50
resnet = ResNet50(weights='imagenet', include_top=False, input_shape=input_shape)
```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94765736/94765736 [=====] - 2s 0us/step

```
In [5]: # Add new classifier Layers on top of the pre-trained model
x = tf.keras.layers.GlobalAveragePooling2D()(resnet.output)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.Dropout(0.7)(x)
x = tf.keras.layers.Dense(512, activation = 'LeakyReLU')(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.Dropout(0.4)(x)
x = tf.keras.layers.Dense(64, activation = 'LeakyReLU')(x)
x = tf.keras.layers.BatchNormalization()(x)
x = tf.keras.layers.Dropout(0.4)(x)
x = tf.keras.layers.Dense(1, activation = 'sigmoid')(x)
model_resnet = tf.keras.models.Model(
    inputs = resnet.input,
    outputs = x
)
model_resnet.summary()
```

Model: "model"

Layer (type)	Output Shape	Param #	Connected to
<hr/>			
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 v[0][0]' ization)	(None, 56, 56, 64) 256		['conv2_block1_1_con v[0][0]' ization]
conv2_block1_1_relu (Activatio n[0][0]'	(None, 56, 56, 64) 0		['conv2_block1_1_bn v[0][0]']
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 64) 36928		['conv2_block1_1_rel u[0][0]']
conv2_block1_2_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 64) 256		['conv2_block1_2_con v[0][0]' ization]
conv2_block1_2_relu (Activatio n[0][0]')	(None, 56, 56, 64) 0		['conv2_block1_2_bn v[0][0]']
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_rel u[0][0]']
conv2_block1_0_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 256) 1024		['conv2_block1_0_con v[0][0]' ization]
conv2_block1_3_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 256) 1024		['conv2_block1_3_con v[0][0]' ization]
conv2_block1_add (Add)	(None, 56, 56, 256) 0		['conv2_block1_0_bn v[0][0]']

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[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_con
v[0][0]']
           ziation)

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_rel
u[0][0]']

conv2_block2_2_bn (BatchNormal (None, 56, 56, 64)   256      [ 'conv2_block2_2_con
v[0][0]']
           ziation)

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_rel
u[0][0]']

conv2_block2_3_bn (BatchNormal (None, 56, 56, 256)  1024     [ 'conv2_block2_3_con
v[0][0]']
           ziation)

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_con
v[0][0]']
           ziation)

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_rel
u[0][0]']

conv2_block3_2_bn (BatchNormal (None, 56, 56, 64)   256      [ 'conv2_block3_2_con
v[0][0]']
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ization)

conv2_block3_2_relu (Activation) (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_rel
u[0][0]']

conv2_block3_3_bn (BatchNormal (None, 56, 56, 256) 1024       ['conv2_block3_3_con
v[0][0]']
ization)

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

[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_con
v[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_rel
u[0][0]']

conv3_block1_2_bn (BatchNormal (None, 28, 28, 128) 512        ['conv3_block1_2_con
v[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_rel
u[0][0]']

conv3_block1_0_bn (BatchNormal (None, 28, 28, 512) 2048       ['conv3_block1_0_con
v[0][0]']
ization)

conv3_block1_3_bn (BatchNormal (None, 28, 28, 512) 2048       ['conv3_block1_3_con
v[0][0]']
ization)

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

[0][0]']

conv3_block1_out (Activation) (None, 28, 28, 512) 0           ['conv3_block1_3_bn
[0][0]']
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[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_con
v[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_rel
u[0][0]']

conv3_block2_2_bn (BatchNormal (None, 28, 28, 128)  512       ['conv3_block2_2_con
v[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_rel
u[0][0]']

conv3_block2_3_bn (BatchNormal (None, 28, 28, 512)  2048      ['conv3_block2_3_con
v[0][0]']
   ization)

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

[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_con
v[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_rel
u[0][0]']

conv3_block3_2_bn (BatchNormal (None, 28, 28, 128)  512       ['conv3_block3_2_con
v[0][0]']
   ization)
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conv3_block3_2_relu (Activation) (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_rel  
u[0][0]']  
  
conv3_block3_3_bn (BatchNormal (None, 28, 28, 512) 2048      ['conv3_block3_3_con  
v[0][0]']  
ization)  
  
conv3_block3_add (Add)         (None, 28, 28, 512) 0      ['conv3_block2_out  
[0][0]',  
[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_con  
v[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_rel  
u[0][0]']  
  
conv3_block4_2_bn (BatchNormal (None, 28, 28, 128) 512      ['conv3_block4_2_con  
v[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_rel  
u[0][0]']  
  
conv3_block4_3_bn (BatchNormal (None, 28, 28, 512) 2048      ['conv3_block4_3_con  
v[0][0]']  
ization)  
  
conv3_block4_add (Add)         (None, 28, 28, 512) 0      ['conv3_block3_out  
[0][0]',  
[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_con
```

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v[0][0]']
 ization)

  conv4_block1_1_relu (Activation) (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_rel
u[0][0]']

  conv4_block1_2_bn (BatchNormal (None, 14, 14, 256) 1024      ['conv4_block1_2_con
v[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]']
)
  conv4_block1_3_conv (Conv2D)    (None, 14, 14, 1024 263168      ['conv4_block1_2_rel
u[0][0]']
)
  conv4_block1_0_bn (BatchNormal (None, 14, 14, 1024 4096      ['conv4_block1_0_con
v[0][0]']
 ization)
)
  conv4_block1_3_bn (BatchNormal (None, 14, 14, 1024 4096      ['conv4_block1_3_con
v[0][0]']
 ization)
)
  conv4_block1_add (Add)         (None, 14, 14, 1024 0      ['conv4_block1_0_bn
[0][0]',

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)
  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_con
v[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_rel
u[0][0]']

  conv4_block2_2_bn (BatchNormal (None, 14, 14, 256) 1024      ['conv4_block2_2_con
v[0][0]']
 ization)
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    conv4_block2_2_relu (Activation) (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_rel  
u[0][0]']  
)  
  
    conv4_block2_3_bn (BatchNormal (None, 14, 14, 1024  4096  ['conv4_block2_3_con  
v[0][0]']  
ization) )  
  
    conv4_block2_add (Add)         (None, 14, 14, 1024  0      ['conv4_block1_out  
[0][0]',  
)          )  
[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_con  
v[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_rel  
u[0][0]']  
  
    conv4_block3_2_bn (BatchNormal (None, 14, 14, 256)  1024  ['conv4_block3_2_con  
v[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_rel  
u[0][0]']  
)  
  
    conv4_block3_3_bn (BatchNormal (None, 14, 14, 1024  4096  ['conv4_block3_3_con  
v[0][0]']  
ization) )  
  
    conv4_block3_add (Add)         (None, 14, 14, 1024  0      ['conv4_block2_out  
[0][0]',  
)          )  
[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_con  
v[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_rel  
u[0][0]']  
  
conv4_block4_2_bn (BatchNormal (None, 14, 14, 256)  1024       ['conv4_block4_2_con  
v[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_rel  
u[0][0]']  
    )  
  
conv4_block4_3_bn (BatchNormal (None, 14, 14, 1024  4096       ['conv4_block4_3_con  
v[0][0]']  
    ization)          )  
  
conv4_block4_add (Add)       (None, 14, 14, 1024  0        ['conv4_block3_out  
[0][0]',  
    )  
[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_con  
v[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_rel  
u[0][0]']  
  
conv4_block5_2_bn (BatchNormal (None, 14, 14, 256)  1024       ['conv4_block5_2_con  
v[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 v[0][0])	(None, 7, 7, 512)	2048	['conv5_block1_1_con tination)
conv5_block1_1_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block1_1_bn n)
conv5_block1_2_conv (Conv2D u[0][0])	(None, 7, 7, 512)	2359808	['conv5_block1_1_rel u[0][0])
conv5_block1_2_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block1_2_con tination)
conv5_block1_2_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block1_2_bn n)
conv5_block1_0_conv (Conv2D [0][0])	(None, 7, 7, 2048)	2099200	['conv4_block6_out [0][0])
conv5_block1_3_conv (Conv2D u[0][0])	(None, 7, 7, 2048)	1050624	['conv5_block1_2_rel u[0][0])
conv5_block1_0_bn (BatchNormal v[0][0])	(None, 7, 7, 2048)	8192	['conv5_block1_0_con tination)
conv5_block1_3_bn (BatchNormal v[0][0])	(None, 7, 7, 2048)	8192	['conv5_block1_3_con tination)
conv5_block1_add (Add [0][0], [0][0])	(None, 7, 7, 2048)	0	['conv5_block1_0_bn 'conv5_block1_3_bn [0][0])
conv5_block1_out (Activation) [0][0])	(None, 7, 7, 2048)	0	['conv5_block1_add [0][0])
conv5_block2_1_conv (Conv2D [0][0])	(None, 7, 7, 512)	1049088	['conv5_block1_out [0][0])
conv5_block2_1_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block2_1_con tination)
conv5_block2_1_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block2_1.bn n)
conv5_block2_2_conv (Conv2D u[0][0])	(None, 7, 7, 512)	2359808	['conv5_block2_1_rel u[0][0])
conv5_block2_2_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block2_2_con tination)

conv5_block2_2_relu (Activation) [0][0]'	(None, 7, 7, 512)	0	['conv5_block2_2_bn
conv5_block2_3_conv (Conv2D) u[0][0]'	(None, 7, 7, 2048)	1050624	['conv5_block2_2_rel
conv5_block2_3_bn (BatchNormal v[0][0]'	(None, 7, 7, 2048)	8192	['conv5_block2_3_con
conv5_block2_add (Add) [0][0]',	(None, 7, 7, 2048)	0	['conv5_block1_out
[0][0]'			'conv5_block2_3_bn
conv5_block2_out (Activation) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block2_add
conv5_block3_1_conv (Conv2D) [0][0]'	(None, 7, 7, 512)	1049088	['conv5_block2_out
conv5_block3_1_bn (BatchNormal v[0][0]'	(None, 7, 7, 512)	2048	['conv5_block3_1_con
conv5_block3_1_relu (Activatio n[0][0]'	(None, 7, 7, 512)	0	['conv5_block3_1_bn
n)			
conv5_block3_2_conv (Conv2D) u[0][0]'	(None, 7, 7, 512)	2359808	['conv5_block3_1_rel
conv5_block3_2_bn (BatchNormal v[0][0]'	(None, 7, 7, 512)	2048	['conv5_block3_2_con
ization)			
conv5_block3_2_relu (Activatio n[0][0]'	(None, 7, 7, 512)	0	['conv5_block3_2_bn
n)			
conv5_block3_3_conv (Conv2D) u[0][0]'	(None, 7, 7, 2048)	1050624	['conv5_block3_2_rel
conv5_block3_3_bn (BatchNormal v[0][0]'	(None, 7, 7, 2048)	8192	['conv5_block3_3_con
ization)			
conv5_block3_add (Add) [0][0]',	(None, 7, 7, 2048)	0	['conv5_block2_out
[0][0]'			'conv5_block3_3_bn
conv5_block3_out (Activation) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block3_add
global_average_pooling2d (Glob alAveragePooling2D) [0][0]'	(None, 2048)	0	['conv5_block3_out

```

batch_normalization (BatchNorm (None, 2048)      8192      [ 'global_average_poo
ling2d[0][0]'                                ]]

dropout (Dropout)          (None, 2048)      0      [ 'batch_normalizatio
n[0][0]' ]

dense (Dense)              (None, 512)       1049088   [ 'dropout[0][0]' ]

batch_normalization_1 (BatchNo (None, 512)      2048      [ 'dense[0][0]' ]

dropout_1 (Dropout)        (None, 512)       0      [ 'batch_normalizatio
n_1[0][0]' ]

dense_1 (Dense)            (None, 64)        32832     [ 'dropout_1[0][0]' ]

batch_normalization_2 (BatchNo (None, 64)      256       [ 'dense_1[0][0]' ]

dropout_2 (Dropout)        (None, 64)       0      [ 'batch_normalizatio
n_2[0][0]' ]

dense_2 (Dense)            (None, 1)         65       [ 'dropout_2[0][0]' ]

=====
=====

Total params: 24,680,193
Trainable params: 24,621,825
Non-trainable params: 58,368

```

```
In [7]: for layer in model_resnet.layers[:120]:
    layer.trainable = False
```

```
In [9]: optimizer = Adam(learning_rate= 0.001)
model_resnet.compile(optimizer=optimizer, loss = 'binary_crossentropy' ,metrics=['accu
```

```
In [10]: model_resnet.summary()
```

Model: "model"

Layer (type)	Output Shape	Param #	Connected to
<hr/>			
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 v[0][0]' ization)	(None, 56, 56, 64) 256		['conv2_block1_1_con v[0][0]' ization]
conv2_block1_1_relu (Activatio n[0][0]'	(None, 56, 56, 64) 0		['conv2_block1_1_bn v[0][0]']
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 64) 36928		['conv2_block1_1_rel u[0][0]']
conv2_block1_2_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 64) 256		['conv2_block1_2_con v[0][0]' ization]
conv2_block1_2_relu (Activatio n[0][0]')	(None, 56, 56, 64) 0		['conv2_block1_2.bn [0][0]']
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_rel u[0][0]']
conv2_block1_0_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 256) 1024		['conv2_block1_0.con v[0][0]' ization]
conv2_block1_3_bn (BatchNormal v[0][0]' ization)	(None, 56, 56, 256) 1024		['conv2_block1_3.con v[0][0]' ization]
conv2_block1_add (Add)	(None, 56, 56, 256) 0		['conv2_block1_0.bn [0][0]']

[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 v[0][0]' ization)	['conv2_block2_1_con	
conv2_block2_1_relu (Activatio (None, 56, 56, 64) 0 n)	['conv2_block2_1_bn	
[0][0]']		
conv2_block2_2_conv (Conv2D) (None, 56, 56, 64) 36928	['conv2_block2_1_rel	
u[0][0]']		
conv2_block2_2_bn (BatchNormal (None, 56, 56, 64) 256 v[0][0]' ization)	['conv2_block2_2_con	
conv2_block2_2_relu (Activatio (None, 56, 56, 64) 0 n)	['conv2_block2_2_bn	
[0][0]']		
conv2_block2_3_conv (Conv2D) (None, 56, 56, 256) 16640	['conv2_block2_2_rel	
u[0][0]']		
conv2_block2_3_bn (BatchNormal (None, 56, 56, 256) 1024 v[0][0]' ization)	['conv2_block2_3_con	
conv2_block2_add (Add) (None, 56, 56, 256) 0	['conv2_block1_out	
[0][0]',		
[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 v[0][0]' ization)	['conv2_block3_1_con	
conv2_block3_1_relu (Activatio (None, 56, 56, 64) 0 n)	['conv2_block3_1_bn	
[0][0]']		
conv2_block3_2_conv (Conv2D) (None, 56, 56, 64) 36928	['conv2_block3_1_rel	
u[0][0]']		
conv2_block3_2_bn (BatchNormal (None, 56, 56, 64) 256 v[0][0]' ization)	['conv2_block3_2_con	

```
ization)

conv2_block3_2_relu (Activation) (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_rel
u[0][0]']

conv2_block3_3_bn (BatchNormal (None, 56, 56, 256) 1024       ['conv2_block3_3_con
v[0][0]']
ization)

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

[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_con
v[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_rel
u[0][0]']

conv3_block1_2_bn (BatchNormal (None, 28, 28, 128) 512        ['conv3_block1_2_con
v[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_rel
u[0][0]']

conv3_block1_0_bn (BatchNormal (None, 28, 28, 512) 2048       ['conv3_block1_0_con
v[0][0]']
ization)

conv3_block1_3_bn (BatchNormal (None, 28, 28, 512) 2048       ['conv3_block1_3_con
v[0][0]']
ization)

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

[0][0]']

conv3_block1_out (Activation) (None, 28, 28, 512) 0           ['conv3_block1_3_bn
[0][0]']
```

```
[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_con
v[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_rel
u[0][0]']

conv3_block2_2_bn (BatchNormal (None, 28, 28, 128)  512       ['conv3_block2_2_con
v[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_rel
u[0][0]']

conv3_block2_3_bn (BatchNormal (None, 28, 28, 512)  2048      ['conv3_block2_3_con
v[0][0]']
   ization)

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

[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_con
v[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_rel
u[0][0]']

conv3_block3_2_bn (BatchNormal (None, 28, 28, 128)  512       ['conv3_block3_2_con
v[0][0]']
   ization)
```

```
conv3_block3_2_relu (Activation) (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_rel  
u[0][0]']  
  
conv3_block3_3_bn (BatchNormal (None, 28, 28, 512) 2048      ['conv3_block3_3_con  
v[0][0]']  
ization)  
  
conv3_block3_add (Add)         (None, 28, 28, 512) 0      ['conv3_block2_out  
[0][0]',  
[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_con  
v[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_rel  
u[0][0]']  
  
conv3_block4_2_bn (BatchNormal (None, 28, 28, 128) 512      ['conv3_block4_2_con  
v[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_rel  
u[0][0]']  
  
conv3_block4_3_bn (BatchNormal (None, 28, 28, 512) 2048      ['conv3_block4_3_con  
v[0][0]']  
ization)  
  
conv3_block4_add (Add)         (None, 28, 28, 512) 0      ['conv3_block3_out  
[0][0]',  
[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_con
```

```
v[0][0]']
 ization)

  conv4_block1_1_relu (Activation) (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_rel
u[0][0]']

  conv4_block1_2_bn (BatchNormal (None, 14, 14, 256) 1024      ['conv4_block1_2_con
v[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]']
)
  conv4_block1_3_conv (Conv2D)    (None, 14, 14, 1024 263168      ['conv4_block1_2_rel
u[0][0]']
)
  conv4_block1_0_bn (BatchNormal (None, 14, 14, 1024 4096      ['conv4_block1_0_con
v[0][0]']
 ization)
)
  conv4_block1_3_bn (BatchNormal (None, 14, 14, 1024 4096      ['conv4_block1_3_con
v[0][0]']
 ization)
)
  conv4_block1_add (Add)         (None, 14, 14, 1024 0      ['conv4_block1_0_bn
[0][0]',

[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_con
v[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_rel
u[0][0]']

  conv4_block2_2_bn (BatchNormal (None, 14, 14, 256) 1024      ['conv4_block2_2_con
v[0][0]']
 ization)
```

```
    conv4_block2_2_relu (Activation) (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_rel  
u[0][0]']  
)  
  
    conv4_block2_3_bn (BatchNormal (None, 14, 14, 1024  4096  ['conv4_block2_3_con  
v[0][0]']  
ization) )  
  
    conv4_block2_add (Add)         (None, 14, 14, 1024  0      ['conv4_block1_out  
[0][0]',  
)          )  
[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_con  
v[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_rel  
u[0][0]']  
  
    conv4_block3_2_bn (BatchNormal (None, 14, 14, 256)  1024  ['conv4_block3_2_con  
v[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_rel  
u[0][0]']  
)  
  
    conv4_block3_3_bn (BatchNormal (None, 14, 14, 1024  4096  ['conv4_block3_3_con  
v[0][0]']  
ization) )  
  
    conv4_block3_add (Add)         (None, 14, 14, 1024  0      ['conv4_block2_out  
[0][0]',  
)          )  
[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_con  
v[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_rel  
u[0][0]']  
  
conv4_block4_2_bn (BatchNormal (None, 14, 14, 256)  1024       ['conv4_block4_2_con  
v[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_rel  
u[0][0]']  
    )  
  
conv4_block4_3_bn (BatchNormal (None, 14, 14, 1024  4096       ['conv4_block4_3_con  
v[0][0]']  
    ization)          )  
  
conv4_block4_add (Add)       (None, 14, 14, 1024  0        ['conv4_block3_out  
[0][0]',  
    )  
[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_con  
v[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_rel  
u[0][0]']  
  
conv4_block5_2_bn (BatchNormal (None, 14, 14, 256)  1024       ['conv4_block5_2_con  
v[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 v[0][0])	(None, 7, 7, 512)	2048	['conv5_block1_1_con tination)
conv5_block1_1_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block1_1_bn n)
conv5_block1_2_conv (Conv2D u[0][0])	(None, 7, 7, 512)	2359808	['conv5_block1_1_rel u[0][0])
conv5_block1_2_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block1_2_con tination)
conv5_block1_2_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block1_2_bn n)
conv5_block1_0_conv (Conv2D [0][0])	(None, 7, 7, 2048)	2099200	['conv4_block6_out [0][0])
conv5_block1_3_conv (Conv2D u[0][0])	(None, 7, 7, 2048)	1050624	['conv5_block1_2_rel u[0][0])
conv5_block1_0_bn (BatchNormal v[0][0])	(None, 7, 7, 2048)	8192	['conv5_block1_0_con tination)
conv5_block1_3_bn (BatchNormal v[0][0])	(None, 7, 7, 2048)	8192	['conv5_block1_3_con tination)
conv5_block1_add (Add [0][0], [0][0])	(None, 7, 7, 2048)	0	['conv5_block1_0_bn 'conv5_block1_3_bn [0][0])
conv5_block1_out (Activation) [0][0])	(None, 7, 7, 2048)	0	['conv5_block1_add [0][0])
conv5_block2_1_conv (Conv2D [0][0])	(None, 7, 7, 512)	1049088	['conv5_block1_out [0][0])
conv5_block2_1_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block2_1_con tination)
conv5_block2_1_relu (Activatio n[0][0])	(None, 7, 7, 512)	0	['conv5_block2_1.bn n)
conv5_block2_2_conv (Conv2D u[0][0])	(None, 7, 7, 512)	2359808	['conv5_block2_1_rel u[0][0])
conv5_block2_2_bn (BatchNormal v[0][0])	(None, 7, 7, 512)	2048	['conv5_block2_2_con tination)

conv5_block2_2_relu (Activation) [0][0]'	(None, 7, 7, 512)	0	['conv5_block2_2_bn']
conv5_block2_3_conv (Conv2D) u[0][0]'	(None, 7, 7, 2048)	1050624	['conv5_block2_2_relu']
conv5_block2_3_bn (BatchNormal v[0][0]'	(None, 7, 7, 2048)	8192	['conv5_block2_3_con
ization)			['v[0][0]']
conv5_block2_add (Add) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block1_out']
[0][0]']			['conv5_block2_3_bn']
conv5_block2_out (Activation) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block2_add']
[0][0]']			
conv5_block3_1_conv (Conv2D) [0][0]'	(None, 7, 7, 512)	1049088	['conv5_block2_out']
[0][0]']			
conv5_block3_1_bn (BatchNormal v[0][0]'	(None, 7, 7, 512)	2048	['conv5_block3_1_con
ization)			['v[0][0]']
conv5_block3_1_relu (Activatio n) [0][0]'	(None, 7, 7, 512)	0	['conv5_block3_1_bn']
n)			
conv5_block3_2_conv (Conv2D) u[0][0]'	(None, 7, 7, 512)	2359808	['conv5_block3_1_rel']
u[0][0]']			
conv5_block3_2_bn (BatchNormal v[0][0]'	(None, 7, 7, 512)	2048	['conv5_block3_2_con
ization)			['v[0][0]']
conv5_block3_2_relu (Activatio n) [0][0]'	(None, 7, 7, 512)	0	['conv5_block3_2_bn']
n)			
conv5_block3_3_conv (Conv2D) u[0][0]'	(None, 7, 7, 2048)	1050624	['conv5_block3_2_rel']
u[0][0]']			
conv5_block3_3_bn (BatchNormal v[0][0]'	(None, 7, 7, 2048)	8192	['conv5_block3_3_con
ization)			['v[0][0]']
conv5_block3_add (Add) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block2_out']
[0][0]']			['conv5_block3_3_bn']
conv5_block3_out (Activation) [0][0]'	(None, 7, 7, 2048)	0	['conv5_block3_add']
[0][0]']			
global_average_pooling2d (Glob alAveragePooling2D) [0][0]'	(None, 2048)	0	['conv5_block3_out']

batch_normalization (BatchNorm	(None, 2048)	8192	['global_average_poo
ling2d[0][0]' alization)]
dropout (Dropout)	(None, 2048)	0	['batch_normalizatio
n[0][0]']			
dense (Dense)	(None, 512)	1049088	['dropout[0][0]']
batch_normalization_1 (BatchNo	(None, 512)	2048	['dense[0][0]']
rmalization)			
dropout_1 (Dropout)	(None, 512)	0	['batch_normalizatio
n_1[0][0]']			
dense_1 (Dense)	(None, 64)	32832	['dropout_1[0][0]']
batch_normalization_2 (BatchNo	(None, 64)	256	['dense_1[0][0]']
rmalization)			
dropout_2 (Dropout)	(None, 64)	0	['batch_normalizatio
n_2[0][0]']			
dense_2 (Dense)	(None, 1)	65	['dropout_2[0][0]']
<hr/>			
=====			
=====			
Total params: 24,680,193			
Trainable params: 18,302,721			
Non-trainable params: 6,377,472			

```
In [11]: # Train the models
history_resnet = model_resnet.fit(train_data,
                                    validation_data = test_data,
                                    epochs=epochs,batch_size= 16,
                                    callbacks = [
                                        tf.keras.callbacks.EarlyStopping(
                                            patience = 5, monitor = 'val_loss', mode = 'min',
                                            restore_best_weights = True
                                        ),
                                        tf.keras.callbacks.ReduceLROnPlateau(
                                            patience = 2, monitor = 'val_loss',
                                            mode = 'min', factor = 0.1
                                        )
                                    ])

```

Epoch 1/50
55/55 [=====] - 55s 700ms/step - loss: 0.7336 - accuracy: 0.
6734 - val_loss: 25.2147 - val_accuracy: 0.6123 - lr: 0.0010
Epoch 2/50
55/55 [=====] - 34s 618ms/step - loss: 0.4997 - accuracy: 0.
7840 - val_loss: 1.8071 - val_accuracy: 0.8102 - lr: 0.0010
Epoch 3/50
55/55 [=====] - 34s 623ms/step - loss: 0.4474 - accuracy: 0.
7961 - val_loss: 1.4915 - val_accuracy: 0.7059 - lr: 0.0010
Epoch 4/50
55/55 [=====] - 35s 628ms/step - loss: 0.4055 - accuracy: 0.
8203 - val_loss: 0.4672 - val_accuracy: 0.8449 - lr: 0.0010
Epoch 5/50
55/55 [=====] - 39s 702ms/step - loss: 0.3546 - accuracy: 0.
8312 - val_loss: 0.4920 - val_accuracy: 0.8209 - lr: 0.0010
Epoch 6/50
55/55 [=====] - 34s 618ms/step - loss: 0.3541 - accuracy: 0.
8537 - val_loss: 0.7006 - val_accuracy: 0.7674 - lr: 0.0010
Epoch 7/50
55/55 [=====] - 34s 622ms/step - loss: 0.3339 - accuracy: 0.
8531 - val_loss: 0.3461 - val_accuracy: 0.8422 - lr: 1.0000e-04
Epoch 8/50
55/55 [=====] - 34s 622ms/step - loss: 0.2943 - accuracy: 0.
8710 - val_loss: 0.2962 - val_accuracy: 0.8770 - lr: 1.0000e-04
Epoch 9/50
55/55 [=====] - 34s 624ms/step - loss: 0.2904 - accuracy: 0.
8819 - val_loss: 0.2880 - val_accuracy: 0.8663 - lr: 1.0000e-04
Epoch 10/50
55/55 [=====] - 34s 626ms/step - loss: 0.2684 - accuracy: 0.
8929 - val_loss: 0.2651 - val_accuracy: 0.8797 - lr: 1.0000e-04
Epoch 11/50
55/55 [=====] - 34s 624ms/step - loss: 0.2587 - accuracy: 0.
8975 - val_loss: 0.2370 - val_accuracy: 0.9091 - lr: 1.0000e-04
Epoch 12/50
55/55 [=====] - 34s 620ms/step - loss: 0.2361 - accuracy: 0.
9044 - val_loss: 0.2213 - val_accuracy: 0.9198 - lr: 1.0000e-04
Epoch 13/50
55/55 [=====] - 34s 631ms/step - loss: 0.2145 - accuracy: 0.
9055 - val_loss: 0.2190 - val_accuracy: 0.9118 - lr: 1.0000e-04
Epoch 14/50
55/55 [=====] - 34s 617ms/step - loss: 0.2256 - accuracy: 0.
9096 - val_loss: 0.2226 - val_accuracy: 0.9011 - lr: 1.0000e-04
Epoch 15/50
55/55 [=====] - 34s 620ms/step - loss: 0.1985 - accuracy: 0.
9194 - val_loss: 0.1910 - val_accuracy: 0.9225 - lr: 1.0000e-04
Epoch 16/50
55/55 [=====] - 39s 702ms/step - loss: 0.2057 - accuracy: 0.
9240 - val_loss: 0.2287 - val_accuracy: 0.9037 - lr: 1.0000e-04
Epoch 17/50
55/55 [=====] - 34s 610ms/step - loss: 0.1960 - accuracy: 0.
9286 - val_loss: 0.1974 - val_accuracy: 0.9144 - lr: 1.0000e-04
Epoch 18/50
55/55 [=====] - 34s 620ms/step - loss: 0.1807 - accuracy: 0.
9274 - val_loss: 0.1910 - val_accuracy: 0.9171 - lr: 1.0000e-05
Epoch 19/50
55/55 [=====] - 34s 616ms/step - loss: 0.2067 - accuracy: 0.
9142 - val_loss: 0.1785 - val_accuracy: 0.9385 - lr: 1.0000e-05
Epoch 20/50
55/55 [=====] - 34s 621ms/step - loss: 0.1847 - accuracy: 0.
9286 - val_loss: 0.1751 - val_accuracy: 0.9278 - lr: 1.0000e-05

```
Epoch 21/50
55/55 [=====] - 34s 626ms/step - loss: 0.1815 - accuracy: 0.
9297 - val_loss: 0.1773 - val_accuracy: 0.9412 - lr: 1.0000e-05
Epoch 22/50
55/55 [=====] - 34s 620ms/step - loss: 0.1751 - accuracy: 0.
9332 - val_loss: 0.1775 - val_accuracy: 0.9305 - lr: 1.0000e-05
Epoch 23/50
55/55 [=====] - 34s 624ms/step - loss: 0.1833 - accuracy: 0.
9309 - val_loss: 0.1503 - val_accuracy: 0.9492 - lr: 1.0000e-06
Epoch 24/50
55/55 [=====] - 34s 625ms/step - loss: 0.1809 - accuracy: 0.
9291 - val_loss: 0.1773 - val_accuracy: 0.9225 - lr: 1.0000e-06
Epoch 25/50
55/55 [=====] - 34s 618ms/step - loss: 0.1947 - accuracy: 0.
9217 - val_loss: 0.1688 - val_accuracy: 0.9305 - lr: 1.0000e-06
Epoch 26/50
55/55 [=====] - 34s 614ms/step - loss: 0.1881 - accuracy: 0.
9263 - val_loss: 0.1587 - val_accuracy: 0.9465 - lr: 1.0000e-07
Epoch 27/50
55/55 [=====] - 38s 699ms/step - loss: 0.1633 - accuracy: 0.
9372 - val_loss: 0.1674 - val_accuracy: 0.9332 - lr: 1.0000e-07
Epoch 28/50
55/55 [=====] - 34s 619ms/step - loss: 0.1794 - accuracy: 0.
9384 - val_loss: 0.1705 - val_accuracy: 0.9439 - lr: 1.0000e-08
```

```
In [12]: loss_resnet, acc_resnet = model_resnet.evaluate(test_data)
```

```
12/12 [=====] - 6s 469ms/step - loss: 0.1679 - accuracy: 0.9465
```

```
In [13]: import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score
from sklearn.metrics import auc
```

```
In [15]: def create_charts(cnn, cnn_model):
    ## Define 1: train & validation loss
    train_loss = cnn_model.history['loss']
    val_loss = cnn_model.history['val_loss']

    ## Define 2: train & validation AUC
    train_auc_name = list(cnn_model.history.keys())[3]
    val_auc_name = list(cnn_model.history.keys())[1]
    train_auc = cnn_model.history[train_auc_name]
    val_auc = cnn_model.history[val_auc_name]

    ## Define 3: y_pred & y_true
    y_true = test_data.classes
    Y_pred = cnn.predict_generator(test_data, steps = len(test_data))
    y_pred = (Y_pred > 0.5).T[0]
    y_pred_prob = Y_pred.T[0]

    ## PLOT ##
    fig = plt.figure(figsize=(13, 10))

    ## PLOT 1: TRAIN VS. VALIDATION LOSS
```

```

plt.subplot(2,2,1)
plt.title("Training vs. Validation Loss")
plt.plot(train_loss, label='training loss')
plt.plot(val_loss, label='validation loss')
plt.xlabel("Number of Epochs", size=14)
plt.legend()

## PLOT 2: TRAIN VS. VALIDATION AUC
plt.subplot(2,2,2)
plt.title("Training vs. Validation AUC Score")
plt.plot(train_auc, label='training auc')
plt.plot(val_auc, label='validation auc')
plt.xlabel("Number of Epochs", size=14)
plt.legend()

## PLOT 3: CONFUSION MATRIX
plt.subplot(2,2,3)
    # Set up the Labels for in the confusion matrix
cm = confusion_matrix(y_true, y_pred)
names = ['True Negatives', 'False Positives', 'False Negatives', 'True Positives']
counts = ['{:0.0f}'.format(value) for value in cm.flatten()]
percentages = ['{:0.2%}'.format(value) for value in cm.flatten()/np.sum(cm)]
labels = [f'{v1}\n{v2}' for v1, v2 in zip(names, percentages)]
labels = np.asarray(labels).reshape(2,2)
ticklabels = ['Normal', 'Pneumonia']

    # Create confusion matrix as heatmap
sns.set(font_scale = 1.4)
ax = sns.heatmap(cm, annot=labels, fmt='', cmap='Oranges', xticklabels=ticklabels,
plt.xticks(size=12)
plt.yticks(size=12)
plt.title("Confusion Matrix") #plt.title("Confusion Matrix\n", fontsize=10)
plt.xlabel("Predicted", size=14)
plt.ylabel("Actual", size=14)
#plt.savefig('cm.png', transparent=True)

## PLOT 4: ROC CURVE
plt.subplot(2,2,4)
fpr, tpr, thresholds = roc_curve(y_true, y_pred_prob)
auc = roc_auc_score(y_true, y_pred_prob)
plt.title('ROC Curve')
plt.plot([0, 1], [0, 1], 'k--', label = "Random (AUC = 50%)")
plt.plot(fpr, tpr, label=f'Resnet50 (AUC = {:.2f}%)'.format(auc*100))
plt.xlabel('False Positive Rate', size=14)
plt.ylabel('True Positive Rate', size=14)
plt.legend(loc='best')
#plt.savefig('roc.png', bbox_inches='tight', pad_inches=1)

## END PLOTS
plt.tight_layout()

## Summary Statistics
TN, FP, FN, TP = cm.ravel() # cm[0,0], cm[0, 1], cm[1, 0], cm[1, 1]
accuracy = (TP + TN) / np.sum(cm) # % positive out of all predicted positives
precision = TP / (TP+FP) # % positive out of all predicted positives
recall = TP / (TP+FN) # % positive out of all supposed to be positives
specificity = TN / (TN+FP) # % negative out of all supposed to be negatives
f1 = 2*precision*recall / (precision + recall)

```

```
stats_summary = '[Summary Statistics]\nAccuracy = {:.2%} | Precision = {:.2%} | Re  
print(stats_summary)
```

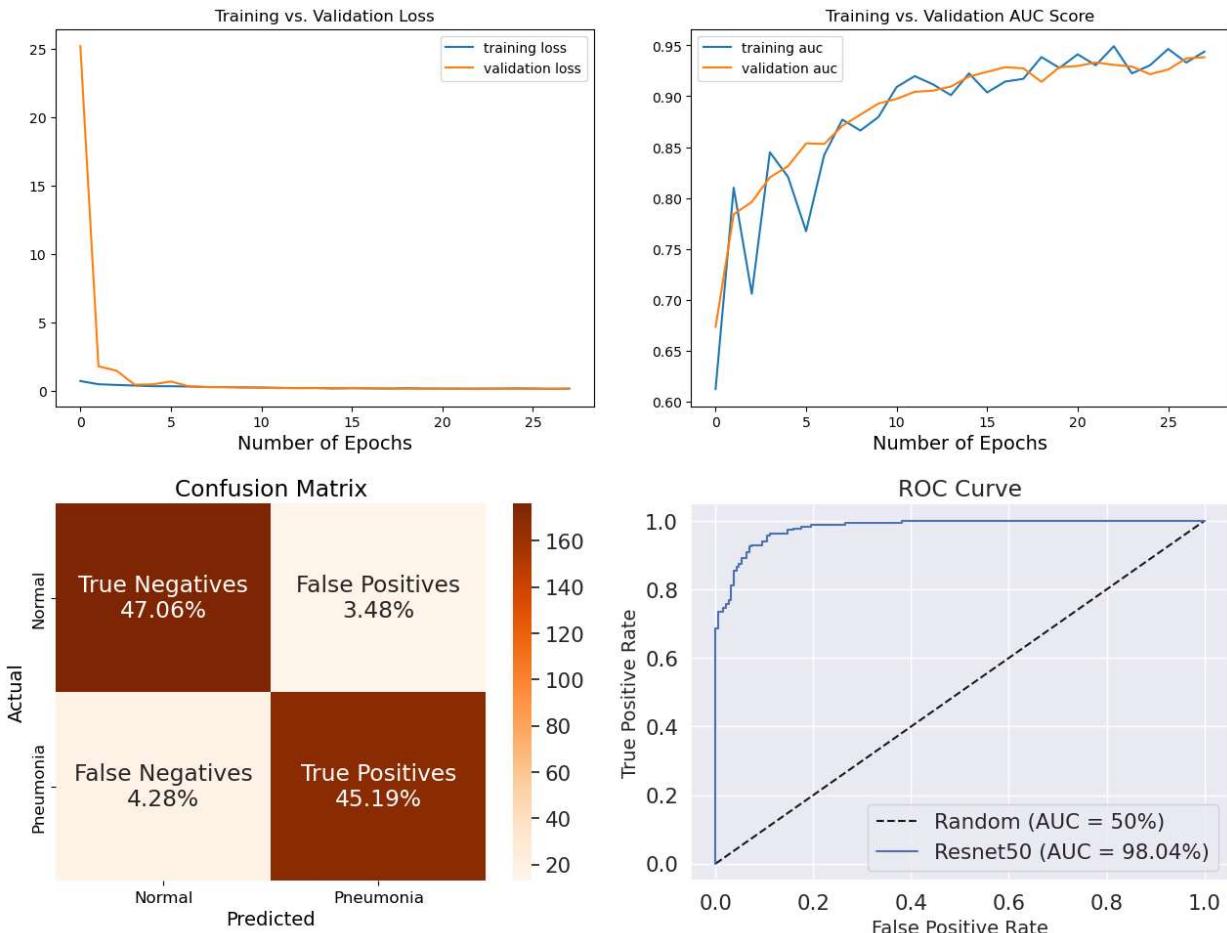
```
In [16]: create_charts(model_resnet, history_resnet)
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:15: UserWarning: `Model.  
predict_generator` is deprecated and will be removed in a future version. Please use  
`Model.predict`, which supports generators.
```

```
from ipykernel import kernelapp as app
```

```
[Summary Statistics]
```

```
Accuracy = 92.25% | Precision = 92.86% | Recall = 91.35% | Specificity = 93.12% | F1  
Score = 92.10%
```



```
In [17]: model_resnet.save('Covid-19_X-ray.h5')
```