In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
import os
os.environ['KMP_DUPLICATE_LIB_OK'] = 'True'
```

In [3]:
```
import tensorflow as tf
from tensorflow import keras
```

In [4]:
```
train_dir = r'C:\Users\shant\OneDrive\Documents\bones\Osteoarthritis_Assignment_dataset\train'

test_dir = r'C:\Users\shant\OneDrive\Documents\bones\Osteoarthritis_Assignment_dataset\test'

validation_dir = r'C:\Users\shant\OneDrive\Documents\bones\Osteoarthritis_Assignment_dataset\Valid'
```

Data Preprocessing

In [5]:
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

In [6]:
```
train_datagen = ImageDataGenerator(rescale = 1.0/255,
                                   rotation_range = 40,
                                   width_shift_range = 0.2,
                                   height_shift_range = 0.2,
                                   shear_range = 0.2,
                                   zoom_range = 0.2,
                                  horizontal_flip = True)

test_datagen = ImageDataGenerator(rescale = 1.0/255)
```

Going through directory where images held

In [7]:
```
train_generator = train_datagen.flow_from_directory(train_dir,
                                                    target_size = (150,150),
                                                    batch_size = 20,
                                                    class_mode = 'binary')
validation_generator = train_datagen.flow_from_directory(validation_dir,
                                                    target_size = (150,150),
                                                    batch_size = 20,
                                                    class_mode = 'binary')
```

```
Found 2350 images belonging to 2 classes.
Found 641 images belonging to 2 classes.
```

Building googleNet layer before our model(convolutional base)

In [8]:
```
from tensorflow.keras.applications import InceptionV3
```

In [9]:
```
conv_base = InceptionV3(weights = 'imagenet',
                 include_top = False,
                 input_shape = (150,150,3))
```

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

```
Model: "inception_v3"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 150, 150, 3  0           []
                                )]

 conv2d (Conv2D)                (None, 74, 74, 32)   864         ['input_1[0][0]']

 batch_normalization (BatchNorm  (None, 74, 74, 32)  96          ['conv2d[0][0]']
 alization)

 activation (Activation)        (None, 74, 74, 32)   0           ['batch_normalization[0][0]']

 conv2d_1 (Conv2D)              (None, 72, 72, 32)   9216        ['activation[0][0]']

 batch_normalization_1 (BatchNo  (None, 72, 72, 32)  96          ['conv2d_1[0][0]']
 rmalization)

 activation_1 (Activation)      (None, 72, 72, 32)   0           ['batch_normalization_1[0][0]']

 conv2d_2 (Conv2D)              (None, 72, 72, 64)   18432       ['activation_1[0][0]']

 batch_normalization_2 (BatchNo  (None, 72, 72, 64)  192         ['conv2d_2[0][0]']
 rmalization)

 activation_2 (Activation)      (None, 72, 72, 64)   0           ['batch_normalization_2[0][0]']
```

```
max_pooling2d (MaxPooling2D)   (None, 35, 35, 64)   0           ['activation_2[0][0]']

conv2d_3 (Conv2D)              (None, 35, 35, 80)   5120        ['max_pooling2d[0][0]']

batch_normalization_3 (BatchNo  (None, 35, 35, 80)  240         ['conv2d_3[0][0]']
rmalization)

activation_3 (Activation)      (None, 35, 35, 80)   0           ['batch_normalization_3[0][0]']

conv2d_4 (Conv2D)              (None, 33, 33, 192)  138240      ['activation_3[0][0]']

batch_normalization_4 (BatchNo  (None, 33, 33, 192)  576        ['conv2d_4[0][0]']
rmalization)

activation_4 (Activation)      (None, 33, 33, 192)  0           ['batch_normalization_4[0][0]']

max_pooling2d_1 (MaxPooling2D)  (None, 16, 16, 192)  0          ['activation_4[0][0]']

conv2d_8 (Conv2D)              (None, 16, 16, 64)   12288       ['max_pooling2d_1[0][0]']

batch_normalization_8 (BatchNo  (None, 16, 16, 64)  192         ['conv2d_8[0][0]']
rmalization)

activation_8 (Activation)      (None, 16, 16, 64)   0           ['batch_normalization_8[0][0]']

conv2d_6 (Conv2D)              (None, 16, 16, 48)   9216        ['max_pooling2d_1[0][0]']

conv2d_9 (Conv2D)              (None, 16, 16, 96)   55296       ['activation_8[0][0]']

batch_normalization_6 (BatchNo  (None, 16, 16, 48)  144         ['conv2d_6[0][0]']
rmalization)

batch_normalization_9 (BatchNo  (None, 16, 16, 96)  288         ['conv2d_9[0][0]']
rmalization)

activation_6 (Activation)      (None, 16, 16, 48)   0           ['batch_normalization_6[0][0]']

activation_9 (Activation)      (None, 16, 16, 96)   0           ['batch_normalization_9[0][0]']

average_pooling2d (AveragePool  (None, 16, 16, 192)  0         ['max_pooling2d_1[0][0]']
ing2D)

conv2d_5 (Conv2D)              (None, 16, 16, 64)   12288       ['max_pooling2d_1[0][0]']

conv2d_7 (Conv2D)              (None, 16, 16, 64)   76800       ['activation_6[0][0]']

conv2d_10 (Conv2D)             (None, 16, 16, 96)   82944       ['activation_9[0][0]']

conv2d_11 (Conv2D)             (None, 16, 16, 32)   6144        ['average_pooling2d[0][0]']

batch_normalization_5 (BatchNo  (None, 16, 16, 64)  192         ['conv2d_5[0][0]']
rmalization)

batch_normalization_7 (BatchNo  (None, 16, 16, 64)  192         ['conv2d_7[0][0]']
rmalization)

batch_normalization_10 (BatchN  (None, 16, 16, 96)  288         ['conv2d_10[0][0]']
ormalization)

batch_normalization_11 (BatchN  (None, 16, 16, 32)  96          ['conv2d_11[0][0]']
ormalization)

activation_5 (Activation)      (None, 16, 16, 64)   0           ['batch_normalization_5[0][0]']

activation_7 (Activation)      (None, 16, 16, 64)   0           ['batch_normalization_7[0][0]']

activation_10 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_10[0][0]']

activation_11 (Activation)     (None, 16, 16, 32)   0           ['batch_normalization_11[0][0]']

mixed0 (Concatenate)           (None, 16, 16, 256)  0           ['activation_5[0][0]',
                                                                 'activation_7[0][0]',
                                                                 'activation_10[0][0]',
                                                                 'activation_11[0][0]']

conv2d_15 (Conv2D)             (None, 16, 16, 64)   16384       ['mixed0[0][0]']

batch_normalization_15 (BatchN  (None, 16, 16, 64)  192         ['conv2d_15[0][0]']
ormalization)

activation_15 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_15[0][0]']

conv2d_13 (Conv2D)             (None, 16, 16, 48)   12288       ['mixed0[0][0]']

conv2d_16 (Conv2D)             (None, 16, 16, 96)   55296       ['activation_15[0][0]']

batch_normalization_13 (BatchN  (None, 16, 16, 48)  144         ['conv2d_13[0][0]']
ormalization)
```

```
batch_normalization_16 (BatchN  (None, 16, 16, 96)  288         ['conv2d_16[0][0]']
ormalization)

activation_13 (Activation)     (None, 16, 16, 48)   0           ['batch_normalization_13[0][0]']

activation_16 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_16[0][0]']

average_pooling2d_1 (AveragePo  (None, 16, 16, 256)  0         ['mixed0[0][0]']
oling2D)

conv2d_12 (Conv2D)             (None, 16, 16, 64)   16384       ['mixed0[0][0]']

conv2d_14 (Conv2D)             (None, 16, 16, 64)   76800       ['activation_13[0][0]']

conv2d_17 (Conv2D)             (None, 16, 16, 96)   82944       ['activation_16[0][0]']

conv2d_18 (Conv2D)             (None, 16, 16, 64)   16384       ['average_pooling2d_1[0][0]']

batch_normalization_12 (BatchN  (None, 16, 16, 64)  192         ['conv2d_12[0][0]']
ormalization)

batch_normalization_14 (BatchN  (None, 16, 16, 64)  192         ['conv2d_14[0][0]']
ormalization)

batch_normalization_17 (BatchN  (None, 16, 16, 96)  288         ['conv2d_17[0][0]']
ormalization)

batch_normalization_18 (BatchN  (None, 16, 16, 64)  192         ['conv2d_18[0][0]']
ormalization)

activation_12 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_12[0][0]']

activation_14 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_14[0][0]']

activation_17 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_17[0][0]']

activation_18 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_18[0][0]']

mixed1 (Concatenate)           (None, 16, 16, 288)  0           ['activation_12[0][0]',
                                                                 'activation_14[0][0]',
                                                                 'activation_17[0][0]',
                                                                 'activation_18[0][0]']

conv2d_22 (Conv2D)             (None, 16, 16, 64)   18432       ['mixed1[0][0]']

batch_normalization_22 (BatchN  (None, 16, 16, 64)  192         ['conv2d_22[0][0]']
ormalization)

activation_22 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_22[0][0]']

conv2d_20 (Conv2D)             (None, 16, 16, 48)   13824       ['mixed1[0][0]']

conv2d_23 (Conv2D)             (None, 16, 16, 96)   55296       ['activation_22[0][0]']

batch_normalization_20 (BatchN  (None, 16, 16, 48)  144         ['conv2d_20[0][0]']
ormalization)

batch_normalization_23 (BatchN  (None, 16, 16, 96)  288         ['conv2d_23[0][0]']
ormalization)

activation_20 (Activation)     (None, 16, 16, 48)   0           ['batch_normalization_20[0][0]']

activation_23 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_23[0][0]']

average_pooling2d_2 (AveragePo  (None, 16, 16, 288)  0         ['mixed1[0][0]']
oling2D)

conv2d_19 (Conv2D)             (None, 16, 16, 64)   18432       ['mixed1[0][0]']

conv2d_21 (Conv2D)             (None, 16, 16, 64)   76800       ['activation_20[0][0]']

conv2d_24 (Conv2D)             (None, 16, 16, 96)   82944       ['activation_23[0][0]']

conv2d_25 (Conv2D)             (None, 16, 16, 64)   18432       ['average_pooling2d_2[0][0]']

batch_normalization_19 (BatchN  (None, 16, 16, 64)  192         ['conv2d_19[0][0]']
ormalization)

batch_normalization_21 (BatchN  (None, 16, 16, 64)  192         ['conv2d_21[0][0]']
ormalization)

batch_normalization_24 (BatchN  (None, 16, 16, 96)  288         ['conv2d_24[0][0]']
ormalization)

batch_normalization_25 (BatchN  (None, 16, 16, 64)  192         ['conv2d_25[0][0]']
ormalization)

activation_19 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_19[0][0]']
```

```
activation_21 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_21[0][0]']

activation_24 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_24[0][0]']

activation_25 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_25[0][0]']

mixed2 (Concatenate)           (None, 16, 16, 288)  0           ['activation_19[0][0]',
                                                                 'activation_21[0][0]',
                                                                 'activation_24[0][0]',
                                                                 'activation_25[0][0]']

conv2d_27 (Conv2D)             (None, 16, 16, 64)   18432       ['mixed2[0][0]']

batch_normalization_27 (BatchN  (None, 16, 16, 64)  192         ['conv2d_27[0][0]']
ormalization)

activation_27 (Activation)     (None, 16, 16, 64)   0           ['batch_normalization_27[0][0]']

conv2d_28 (Conv2D)             (None, 16, 16, 96)   55296       ['activation_27[0][0]']

batch_normalization_28 (BatchN  (None, 16, 16, 96)  288         ['conv2d_28[0][0]']
ormalization)

activation_28 (Activation)     (None, 16, 16, 96)   0           ['batch_normalization_28[0][0]']

conv2d_26 (Conv2D)             (None, 7, 7, 384)    995328      ['mixed2[0][0]']

conv2d_29 (Conv2D)             (None, 7, 7, 96)     82944       ['activation_28[0][0]']

batch_normalization_26 (BatchN  (None, 7, 7, 384)   1152        ['conv2d_26[0][0]']
ormalization)

batch_normalization_29 (BatchN  (None, 7, 7, 96)    288         ['conv2d_29[0][0]']
ormalization)

activation_26 (Activation)     (None, 7, 7, 384)    0           ['batch_normalization_26[0][0]']

activation_29 (Activation)     (None, 7, 7, 96)     0           ['batch_normalization_29[0][0]']

max_pooling2d_2 (MaxPooling2D)  (None, 7, 7, 288)   0           ['mixed2[0][0]']

mixed3 (Concatenate)           (None, 7, 7, 768)    0           ['activation_26[0][0]',
                                                                 'activation_29[0][0]',
                                                                 'max_pooling2d_2[0][0]']

conv2d_34 (Conv2D)             (None, 7, 7, 128)    98304       ['mixed3[0][0]']

batch_normalization_34 (BatchN  (None, 7, 7, 128)   384         ['conv2d_34[0][0]']
ormalization)

activation_34 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_34[0][0]']

conv2d_35 (Conv2D)             (None, 7, 7, 128)    114688      ['activation_34[0][0]']

batch_normalization_35 (BatchN  (None, 7, 7, 128)   384         ['conv2d_35[0][0]']
ormalization)

activation_35 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_35[0][0]']

conv2d_31 (Conv2D)             (None, 7, 7, 128)    98304       ['mixed3[0][0]']

conv2d_36 (Conv2D)             (None, 7, 7, 128)    114688      ['activation_35[0][0]']

batch_normalization_31 (BatchN  (None, 7, 7, 128)   384         ['conv2d_31[0][0]']
ormalization)

batch_normalization_36 (BatchN  (None, 7, 7, 128)   384         ['conv2d_36[0][0]']
ormalization)

activation_31 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_31[0][0]']

activation_36 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_36[0][0]']

conv2d_32 (Conv2D)             (None, 7, 7, 128)    114688      ['activation_31[0][0]']

conv2d_37 (Conv2D)             (None, 7, 7, 128)    114688      ['activation_36[0][0]']

batch_normalization_32 (BatchN  (None, 7, 7, 128)   384         ['conv2d_32[0][0]']
ormalization)

batch_normalization_37 (BatchN  (None, 7, 7, 128)   384         ['conv2d_37[0][0]']
ormalization)

activation_32 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_32[0][0]']

activation_37 (Activation)     (None, 7, 7, 128)    0           ['batch_normalization_37[0][0]']

average_pooling2d_3 (AveragePo  (None, 7, 7, 768)   0           ['mixed3[0][0]']
oling2D)
```

```
conv2d_30 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed3[0][0]']

conv2d_33 (Conv2D)             (None, 7, 7, 192)    172032      ['activation_32[0][0]']

conv2d_38 (Conv2D)             (None, 7, 7, 192)    172032      ['activation_37[0][0]']

conv2d_39 (Conv2D)             (None, 7, 7, 192)    147456      ['average_pooling2d_3[0][0]']

batch_normalization_30 (BatchN  (None, 7, 7, 192)   576         ['conv2d_30[0][0]']
ormalization)

batch_normalization_33 (BatchN  (None, 7, 7, 192)   576         ['conv2d_33[0][0]']
ormalization)

batch_normalization_38 (BatchN  (None, 7, 7, 192)   576         ['conv2d_38[0][0]']
ormalization)

batch_normalization_39 (BatchN  (None, 7, 7, 192)   576         ['conv2d_39[0][0]']
ormalization)

activation_30 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_30[0][0]']

activation_33 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_33[0][0]']

activation_38 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_38[0][0]']

activation_39 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_39[0][0]']

mixed4 (Concatenate)           (None, 7, 7, 768)    0           ['activation_30[0][0]',
                                                                 'activation_33[0][0]',
                                                                 'activation_38[0][0]',
                                                                 'activation_39[0][0]']

conv2d_44 (Conv2D)             (None, 7, 7, 160)    122880      ['mixed4[0][0]']

batch_normalization_44 (BatchN  (None, 7, 7, 160)   480         ['conv2d_44[0][0]']
ormalization)

activation_44 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_44[0][0]']

conv2d_45 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_44[0][0]']

batch_normalization_45 (BatchN  (None, 7, 7, 160)   480         ['conv2d_45[0][0]']
ormalization)

activation_45 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_45[0][0]']

conv2d_41 (Conv2D)             (None, 7, 7, 160)    122880      ['mixed4[0][0]']

conv2d_46 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_45[0][0]']

batch_normalization_41 (BatchN  (None, 7, 7, 160)   480         ['conv2d_41[0][0]']
ormalization)

batch_normalization_46 (BatchN  (None, 7, 7, 160)   480         ['conv2d_46[0][0]']
ormalization)

activation_41 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_41[0][0]']

activation_46 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_46[0][0]']

conv2d_42 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_41[0][0]']

conv2d_47 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_46[0][0]']

batch_normalization_42 (BatchN  (None, 7, 7, 160)   480         ['conv2d_42[0][0]']
ormalization)

batch_normalization_47 (BatchN  (None, 7, 7, 160)   480         ['conv2d_47[0][0]']
ormalization)

activation_42 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_42[0][0]']

activation_47 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_47[0][0]']

average_pooling2d_4 (AveragePo  (None, 7, 7, 768)   0           ['mixed4[0][0]']
oling2D)

conv2d_40 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed4[0][0]']

conv2d_43 (Conv2D)             (None, 7, 7, 192)    215040      ['activation_42[0][0]']

conv2d_48 (Conv2D)             (None, 7, 7, 192)    215040      ['activation_47[0][0]']

conv2d_49 (Conv2D)             (None, 7, 7, 192)    147456      ['average_pooling2d_4[0][0]']

batch_normalization_40 (BatchN  (None, 7, 7, 192)   576         ['conv2d_40[0][0]']
ormalization)
```

```
batch_normalization_43 (BatchN  (None, 7, 7, 192)   576         ['conv2d_43[0][0]']
ormalization)

batch_normalization_48 (BatchN  (None, 7, 7, 192)   576         ['conv2d_48[0][0]']
ormalization)

batch_normalization_49 (BatchN  (None, 7, 7, 192)   576         ['conv2d_49[0][0]']
ormalization)

activation_40 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_40[0][0]']

activation_43 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_43[0][0]']

activation_48 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_48[0][0]']

activation_49 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_49[0][0]']

mixed5 (Concatenate)           (None, 7, 7, 768)    0           ['activation_40[0][0]',
                                                                 'activation_43[0][0]',
                                                                 'activation_48[0][0]',
                                                                 'activation_49[0][0]']

conv2d_54 (Conv2D)             (None, 7, 7, 160)    122880      ['mixed5[0][0]']

batch_normalization_54 (BatchN  (None, 7, 7, 160)   480         ['conv2d_54[0][0]']
ormalization)

activation_54 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_54[0][0]']

conv2d_55 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_54[0][0]']

batch_normalization_55 (BatchN  (None, 7, 7, 160)   480         ['conv2d_55[0][0]']
ormalization)

activation_55 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_55[0][0]']

conv2d_51 (Conv2D)             (None, 7, 7, 160)    122880      ['mixed5[0][0]']

conv2d_56 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_55[0][0]']

batch_normalization_51 (BatchN  (None, 7, 7, 160)   480         ['conv2d_51[0][0]']
ormalization)

batch_normalization_56 (BatchN  (None, 7, 7, 160)   480         ['conv2d_56[0][0]']
ormalization)

activation_51 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_51[0][0]']

activation_56 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_56[0][0]']

conv2d_52 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_51[0][0]']

conv2d_57 (Conv2D)             (None, 7, 7, 160)    179200      ['activation_56[0][0]']

batch_normalization_52 (BatchN  (None, 7, 7, 160)   480         ['conv2d_52[0][0]']
ormalization)

batch_normalization_57 (BatchN  (None, 7, 7, 160)   480         ['conv2d_57[0][0]']
ormalization)

activation_52 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_52[0][0]']

activation_57 (Activation)     (None, 7, 7, 160)    0           ['batch_normalization_57[0][0]']

average_pooling2d_5 (AveragePo  (None, 7, 7, 768)   0           ['mixed5[0][0]']
oling2D)

conv2d_50 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed5[0][0]']

conv2d_53 (Conv2D)             (None, 7, 7, 192)    215040      ['activation_52[0][0]']

conv2d_58 (Conv2D)             (None, 7, 7, 192)    215040      ['activation_57[0][0]']

conv2d_59 (Conv2D)             (None, 7, 7, 192)    147456      ['average_pooling2d_5[0][0]']

batch_normalization_50 (BatchN  (None, 7, 7, 192)   576         ['conv2d_50[0][0]']
ormalization)

batch_normalization_53 (BatchN  (None, 7, 7, 192)   576         ['conv2d_53[0][0]']
ormalization)

batch_normalization_58 (BatchN  (None, 7, 7, 192)   576         ['conv2d_58[0][0]']
ormalization)

batch_normalization_59 (BatchN  (None, 7, 7, 192)   576         ['conv2d_59[0][0]']
ormalization)

activation_50 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_50[0][0]']
```

```
activation_53 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_53[0][0]']

activation_58 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_58[0][0]']

activation_59 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_59[0][0]']

mixed6 (Concatenate)           (None, 7, 7, 768)    0           ['activation_50[0][0]',
                                                                 'activation_53[0][0]',
                                                                 'activation_58[0][0]',
                                                                 'activation_59[0][0]']

conv2d_64 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed6[0][0]']

batch_normalization_64 (BatchN  (None, 7, 7, 192)   576         ['conv2d_64[0][0]']
ormalization)

activation_64 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_64[0][0]']

conv2d_65 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_64[0][0]']

batch_normalization_65 (BatchN  (None, 7, 7, 192)   576         ['conv2d_65[0][0]']
ormalization)

activation_65 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_65[0][0]']

conv2d_61 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed6[0][0]']

conv2d_66 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_65[0][0]']

batch_normalization_61 (BatchN  (None, 7, 7, 192)   576         ['conv2d_61[0][0]']
ormalization)

batch_normalization_66 (BatchN  (None, 7, 7, 192)   576         ['conv2d_66[0][0]']
ormalization)

activation_61 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_61[0][0]']

activation_66 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_66[0][0]']

conv2d_62 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_61[0][0]']

conv2d_67 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_66[0][0]']

batch_normalization_62 (BatchN  (None, 7, 7, 192)   576         ['conv2d_62[0][0]']
ormalization)

batch_normalization_67 (BatchN  (None, 7, 7, 192)   576         ['conv2d_67[0][0]']
ormalization)

activation_62 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_62[0][0]']

activation_67 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_67[0][0]']

average_pooling2d_6 (AveragePo  (None, 7, 7, 768)   0           ['mixed6[0][0]']
oling2D)

conv2d_60 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed6[0][0]']

conv2d_63 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_62[0][0]']

conv2d_68 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_67[0][0]']

conv2d_69 (Conv2D)             (None, 7, 7, 192)    147456      ['average_pooling2d_6[0][0]']

batch_normalization_60 (BatchN  (None, 7, 7, 192)   576         ['conv2d_60[0][0]']
ormalization)

batch_normalization_63 (BatchN  (None, 7, 7, 192)   576         ['conv2d_63[0][0]']
ormalization)

batch_normalization_68 (BatchN  (None, 7, 7, 192)   576         ['conv2d_68[0][0]']
ormalization)

batch_normalization_69 (BatchN  (None, 7, 7, 192)   576         ['conv2d_69[0][0]']
ormalization)

activation_60 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_60[0][0]']

activation_63 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_63[0][0]']

activation_68 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_68[0][0]']

activation_69 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_69[0][0]']

mixed7 (Concatenate)           (None, 7, 7, 768)    0           ['activation_60[0][0]',
                                                                 'activation_63[0][0]',
                                                                 'activation_68[0][0]',
                                                                 'activation_69[0][0]']
```

```
conv2d_72 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed7[0][0]']

batch_normalization_72 (BatchN  (None, 7, 7, 192)   576         ['conv2d_72[0][0]']
ormalization)

activation_72 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_72[0][0]']

conv2d_73 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_72[0][0]']

batch_normalization_73 (BatchN  (None, 7, 7, 192)   576         ['conv2d_73[0][0]']
ormalization)

activation_73 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_73[0][0]']

conv2d_70 (Conv2D)             (None, 7, 7, 192)    147456      ['mixed7[0][0]']

conv2d_74 (Conv2D)             (None, 7, 7, 192)    258048      ['activation_73[0][0]']

batch_normalization_70 (BatchN  (None, 7, 7, 192)   576         ['conv2d_70[0][0]']
ormalization)

batch_normalization_74 (BatchN  (None, 7, 7, 192)   576         ['conv2d_74[0][0]']
ormalization)

activation_70 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_70[0][0]']

activation_74 (Activation)     (None, 7, 7, 192)    0           ['batch_normalization_74[0][0]']

conv2d_71 (Conv2D)             (None, 3, 3, 320)    552960      ['activation_70[0][0]']

conv2d_75 (Conv2D)             (None, 3, 3, 192)    331776      ['activation_74[0][0]']

batch_normalization_71 (BatchN  (None, 3, 3, 320)   960         ['conv2d_71[0][0]']
ormalization)

batch_normalization_75 (BatchN  (None, 3, 3, 192)   576         ['conv2d_75[0][0]']
ormalization)

activation_71 (Activation)     (None, 3, 3, 320)    0           ['batch_normalization_71[0][0]']

activation_75 (Activation)     (None, 3, 3, 192)    0           ['batch_normalization_75[0][0]']

max_pooling2d_3 (MaxPooling2D)  (None, 3, 3, 768)   0           ['mixed7[0][0]']

mixed8 (Concatenate)           (None, 3, 3, 1280)   0           ['activation_71[0][0]',
                                                                 'activation_75[0][0]',
                                                                 'max_pooling2d_3[0][0]']

conv2d_80 (Conv2D)             (None, 3, 3, 448)    573440      ['mixed8[0][0]']

batch_normalization_80 (BatchN  (None, 3, 3, 448)   1344        ['conv2d_80[0][0]']
ormalization)

activation_80 (Activation)     (None, 3, 3, 448)    0           ['batch_normalization_80[0][0]']

conv2d_77 (Conv2D)             (None, 3, 3, 384)    491520      ['mixed8[0][0]']

conv2d_81 (Conv2D)             (None, 3, 3, 384)    1548288     ['activation_80[0][0]']

batch_normalization_77 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_77[0][0]']
ormalization)

batch_normalization_81 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_81[0][0]']
ormalization)

activation_77 (Activation)     (None, 3, 3, 384)    0           ['batch_normalization_77[0][0]']

activation_81 (Activation)     (None, 3, 3, 384)    0           ['batch_normalization_81[0][0]']

conv2d_78 (Conv2D)             (None, 3, 3, 384)    442368      ['activation_77[0][0]']

conv2d_79 (Conv2D)             (None, 3, 3, 384)    442368      ['activation_77[0][0]']

conv2d_82 (Conv2D)             (None, 3, 3, 384)    442368      ['activation_81[0][0]']

conv2d_83 (Conv2D)             (None, 3, 3, 384)    442368      ['activation_81[0][0]']

average_pooling2d_7 (AveragePo  (None, 3, 3, 1280)  0           ['mixed8[0][0]']
oling2D)

conv2d_76 (Conv2D)             (None, 3, 3, 320)    409600      ['mixed8[0][0]']

batch_normalization_78 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_78[0][0]']
ormalization)

batch_normalization_79 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_79[0][0]']
ormalization)
```

```
batch_normalization_82 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_82[0][0]']
ormalization)

batch_normalization_83 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_83[0][0]']
ormalization)

conv2d_84 (Conv2D)              (None, 3, 3, 192)    245760      ['average_pooling2d_7[0][0]']

batch_normalization_76 (BatchN  (None, 3, 3, 320)   960         ['conv2d_76[0][0]']
ormalization)

activation_78 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_78[0][0]']

activation_79 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_79[0][0]']

activation_82 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_82[0][0]']

activation_83 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_83[0][0]']

batch_normalization_84 (BatchN  (None, 3, 3, 192)   576         ['conv2d_84[0][0]']
ormalization)

activation_76 (Activation)      (None, 3, 3, 320)    0           ['batch_normalization_76[0][0]']

mixed9_0 (Concatenate)          (None, 3, 3, 768)    0           ['activation_78[0][0]',
                                                                 'activation_79[0][0]']

concatenate (Concatenate)       (None, 3, 3, 768)    0           ['activation_82[0][0]',
                                                                 'activation_83[0][0]']

activation_84 (Activation)      (None, 3, 3, 192)    0           ['batch_normalization_84[0][0]']

mixed9 (Concatenate)            (None, 3, 3, 2048)   0           ['activation_76[0][0]',
                                                                 'mixed9_0[0][0]',
                                                                 'concatenate[0][0]',
                                                                 'activation_84[0][0]']

conv2d_89 (Conv2D)              (None, 3, 3, 448)    917504      ['mixed9[0][0]']

batch_normalization_89 (BatchN  (None, 3, 3, 448)   1344        ['conv2d_89[0][0]']
ormalization)

activation_89 (Activation)      (None, 3, 3, 448)    0           ['batch_normalization_89[0][0]']

conv2d_86 (Conv2D)              (None, 3, 3, 384)    786432      ['mixed9[0][0]']

conv2d_90 (Conv2D)              (None, 3, 3, 384)    1548288     ['activation_89[0][0]']

batch_normalization_86 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_86[0][0]']
ormalization)

batch_normalization_90 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_90[0][0]']
ormalization)

activation_86 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_86[0][0]']

activation_90 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_90[0][0]']

conv2d_87 (Conv2D)              (None, 3, 3, 384)    442368      ['activation_86[0][0]']

conv2d_88 (Conv2D)              (None, 3, 3, 384)    442368      ['activation_86[0][0]']

conv2d_91 (Conv2D)              (None, 3, 3, 384)    442368      ['activation_90[0][0]']

conv2d_92 (Conv2D)              (None, 3, 3, 384)    442368      ['activation_90[0][0]']

average_pooling2d_8 (AveragePo  (None, 3, 3, 2048)  0           ['mixed9[0][0]']
oling2D)

conv2d_85 (Conv2D)              (None, 3, 3, 320)    655360      ['mixed9[0][0]']

batch_normalization_87 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_87[0][0]']
ormalization)

batch_normalization_88 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_88[0][0]']
ormalization)

batch_normalization_91 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_91[0][0]']
ormalization)

batch_normalization_92 (BatchN  (None, 3, 3, 384)   1152        ['conv2d_92[0][0]']
ormalization)

conv2d_93 (Conv2D)              (None, 3, 3, 192)    393216      ['average_pooling2d_8[0][0]']

batch_normalization_85 (BatchN  (None, 3, 3, 320)   960         ['conv2d_85[0][0]']
ormalization)

activation_87 (Activation)      (None, 3, 3, 384)    0           ['batch_normalization_87[0][0]']
```

```
activation_88 (Activation)     (None, 3, 3, 384)    0           ['batch_normalization_88[0][0]']

activation_91 (Activation)     (None, 3, 3, 384)    0           ['batch_normalization_91[0][0]']

activation_92 (Activation)     (None, 3, 3, 384)    0           ['batch_normalization_92[0][0]']

batch_normalization_93 (BatchN  (None, 3, 3, 192)   576         ['conv2d_93[0][0]']
ormalization)

activation_85 (Activation)     (None, 3, 3, 320)    0           ['batch_normalization_85[0][0]']

mixed9_1 (Concatenate)         (None, 3, 3, 768)    0           ['activation_87[0][0]',
                                                                 'activation_88[0][0]']

concatenate_1 (Concatenate)    (None, 3, 3, 768)    0           ['activation_91[0][0]',
                                                                 'activation_92[0][0]']

activation_93 (Activation)     (None, 3, 3, 192)    0           ['batch_normalization_93[0][0]']

mixed10 (Concatenate)          (None, 3, 3, 2048)   0           ['activation_85[0][0]',
                                                                 'mixed9_1[0][0]',
                                                                 'concatenate_1[0][0]',
                                                                 'activation_93[0][0]']

==================================================================================================
Total params: 21,802,784
Trainable params: 21,768,352
Non-trainable params: 34,432
__________________________________________________________________________________________________
```

Constructing fully connected layer

In [11]:
```
from tensorflow.keras import models
from tensorflow.keras import layers
```

In [12]:
```
model = models.Sequential()
```

In [13]:
```
model.add(conv_base)
model.add(layers.Flatten())
model.add(layers.Dense(256,activation = 'relu'))
model.add(layers.Dense(1,activation = 'sigmoid'))
```

In [14]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 inception_v3 (Functional)   (None, 3, 3, 2048)        21802784

 flatten (Flatten)           (None, 18432)             0

 dense (Dense)               (None, 256)               4718848

 dense_1 (Dense)             (None, 1)                 257

=================================================================
Total params: 26,521,889
Trainable params: 26,487,457
Non-trainable params: 34,432
_________________________________________________________________
```

In [15]:
```
conv_base.trainable = False
```

In [16]:
```
from tensorflow.keras import optimizers
```

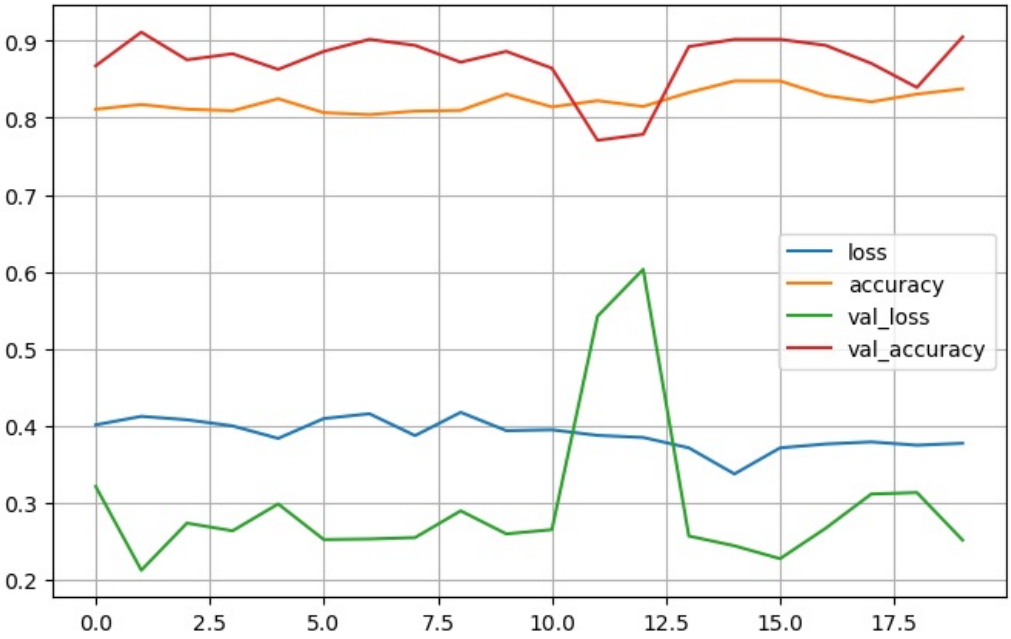
In [17]:
```
model.compile(loss = 'binary_crossentropy',
              optimizer = optimizers.RMSprop(),
              metrics = ['accuracy'])
```

In [21]:
```
history = model.fit(train_generator,
                    steps_per_epoch = 100,
                    epochs = 20,
                    validation_data = validation_generator)
```

```
Epoch 1/20
100/100 [==============================] - 84s 841ms/step - loss: 0.4012 - accuracy: 0.8111 - val_loss: 0.3212
- val_accuracy: 0.8674
Epoch 2/20
100/100 [==============================] - 84s 835ms/step - loss: 0.4123 - accuracy: 0.8171 - val_loss: 0.2125
- val_accuracy: 0.9111
Epoch 3/20
100/100 [==============================] - 84s 840ms/step - loss: 0.4078 - accuracy: 0.8111 - val_loss: 0.2737
- val_accuracy: 0.8752
Epoch 4/20
100/100 [==============================] - 82s 819ms/step - loss: 0.3998 - accuracy: 0.8090 - val_loss: 0.2637
- val_accuracy: 0.8830
Epoch 5/20
100/100 [==============================] - 84s 842ms/step - loss: 0.3837 - accuracy: 0.8246 - val_loss: 0.2985
- val_accuracy: 0.8627
Epoch 6/20
100/100 [==============================] - 84s 840ms/step - loss: 0.4094 - accuracy: 0.8065 - val_loss: 0.2523
- val_accuracy: 0.8861
Epoch 7/20
100/100 [==============================] - 84s 839ms/step - loss: 0.4156 - accuracy: 0.8040 - val_loss: 0.2530
- val_accuracy: 0.9017
Epoch 8/20
100/100 [==============================] - 84s 838ms/step - loss: 0.3873 - accuracy: 0.8085 - val_loss: 0.2549
- val_accuracy: 0.8939
Epoch 9/20
100/100 [==============================] - 159s 2s/step - loss: 0.4175 - accuracy: 0.8095 - val_loss: 0.2896 -
val_accuracy: 0.8721
Epoch 10/20
100/100 [==============================] - 84s 837ms/step - loss: 0.3937 - accuracy: 0.8307 - val_loss: 0.2597
- val_accuracy: 0.8861
Epoch 11/20
100/100 [==============================] - 79s 785ms/step - loss: 0.3948 - accuracy: 0.8140 - val_loss: 0.2652
- val_accuracy: 0.8643
Epoch 12/20
100/100 [==============================] - 84s 838ms/step - loss: 0.3876 - accuracy: 0.8221 - val_loss: 0.5423
- val_accuracy: 0.7707
Epoch 13/20
100/100 [==============================] - 82s 815ms/step - loss: 0.3849 - accuracy: 0.8146 - val_loss: 0.6031
- val_accuracy: 0.7785
Epoch 14/20
100/100 [==============================] - 84s 838ms/step - loss: 0.3714 - accuracy: 0.8327 - val_loss: 0.2569
- val_accuracy: 0.8924
Epoch 15/20
100/100 [==============================] - 84s 835ms/step - loss: 0.3375 - accuracy: 0.8477 - val_loss: 0.2442
- val_accuracy: 0.9017
Epoch 16/20
100/100 [==============================] - 84s 840ms/step - loss: 0.3714 - accuracy: 0.8477 - val_loss: 0.2275
- val_accuracy: 0.9017
Epoch 17/20
100/100 [==============================] - 81s 806ms/step - loss: 0.3764 - accuracy: 0.8286 - val_loss: 0.2670
- val_accuracy: 0.8939
Epoch 18/20
100/100 [==============================] - 84s 840ms/step - loss: 0.3791 - accuracy: 0.8206 - val_loss: 0.3114
- val_accuracy: 0.8705
Epoch 19/20
100/100 [==============================] - 78s 779ms/step - loss: 0.3748 - accuracy: 0.8307 - val_loss: 0.3133
- val_accuracy: 0.8393
Epoch 20/20
100/100 [==============================] - 84s 842ms/step - loss: 0.3773 - accuracy: 0.8375 - val_loss: 0.2516
- val_accuracy: 0.9048
```

In [22]:

```
pd.DataFrame(history.history).plot(figsize = (8,5))
plt.grid()
plt.show()
```



In [ ]: