Import Libaries

```
In [1]:
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, Flatten, Dropout, MaxPooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
```

Clone Dataset

```
In [ ]:
# Cloning Dataset on Colab
! git clone https://github.com/source-droid/Covid-19-CXR-Dataset.git
```

```
In [2]:
import os
base_dir = 'dataset'
train_dir = os.path.join(base_dir, 'train')
test_dir = os.path.join(base_dir, 'test')
train_covid_dir = os.path.join(train_dir, 'Covid')
train_normal_dir = os.path.join(train_dir, 'Normal')
test_covid_dir = os.path.join(test_dir, 'Covid')
test_normal_dir = os.path.join(test_dir, 'Normal')
```

```
In [3]:
train_covid_names = os.listdir(train_covid_dir)
print(train_covid_names[:3])

train_normal_names = os.listdir(train_normal_dir)
print(train_normal_names[:3])

test_covid_names = os.listdir(test_covid_dir)
print(test_covid_names[:3])

test_normal_names = os.listdir(test_normal_dir)
print(test_normal_names[:3])
```

```
['00870a9c.jpg', '01E392EE-69F9-4E33-BFCE-E5C968654078.jpeg', '03BF7561-A9BA-4C3C-B8A0-D3E585F73F3C.jpeg']
['NORMAL (1).png', 'NORMAL (100).png', 'NORMAL (1001).png']
['08ed451c576ee00935ee178ec85c57_jumbo-1.jpeg', '1-s2.0-S0085253820303616-gr1_lrg-a.png', '1-s2.0-S0735675720302746-gr1_lrg.jpg']
['NORMAL (10).png', 'NORMAL (1000).png', 'NORMAL (101).png']
```

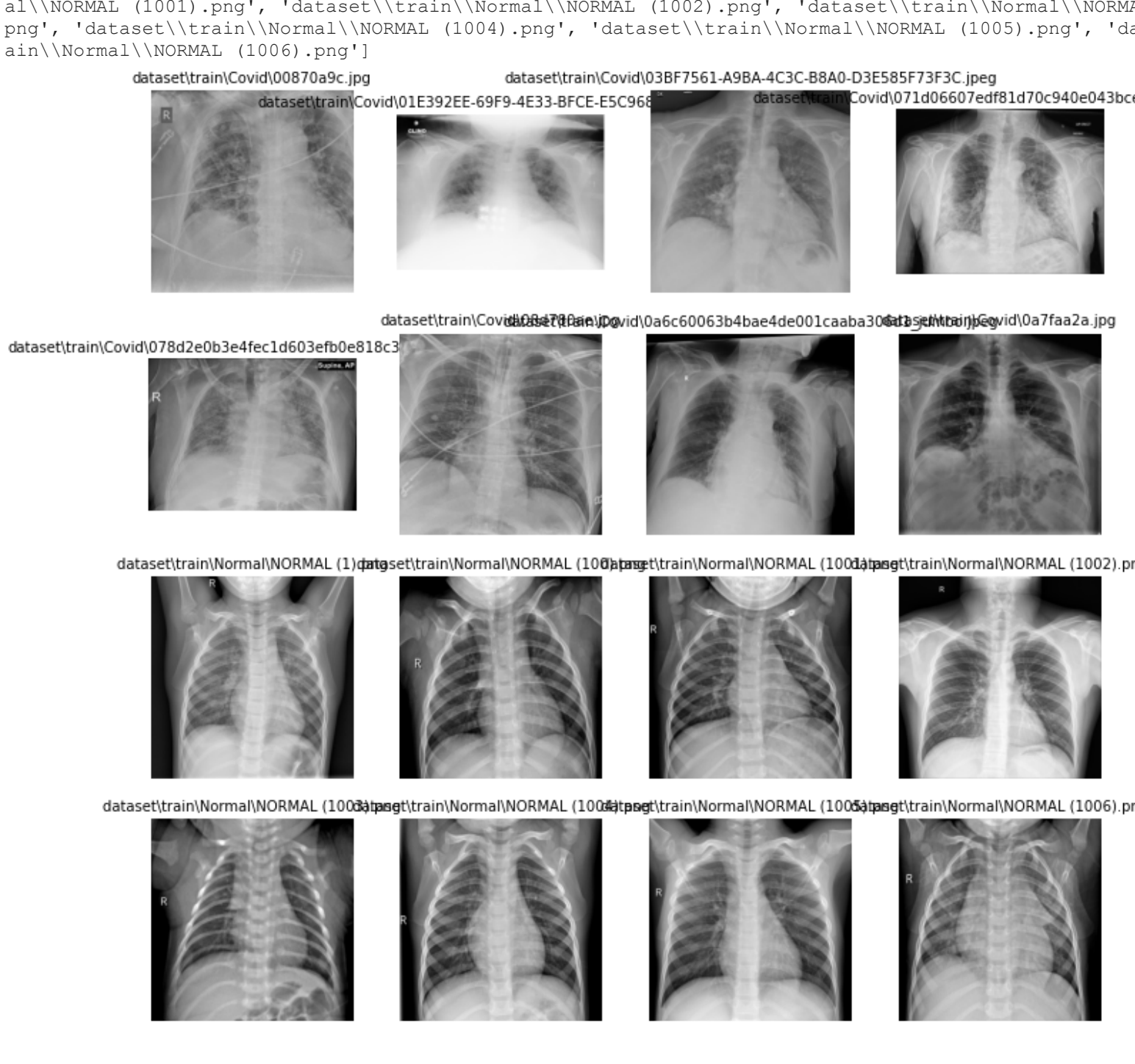
```
In [4]:
print("train dataset covid images: ", len(train_covid_names))
print("train dataset normal images: ", len(train_normal_names))
print("test dataset covid images: ", len(test_covid_names))
print("test dataset normal images: ", len(test_normal_names))

print("total train images: ", len(train_covid_names+train_normal_names))
print("total test images: ", len(test_covid_names+test_normal_names))
```

```
train dataset covid images:  1330
train dataset normal images:  1072
test dataset covid images:  333
test dataset normal images:  269
total train images:  2402
total test images:  602
```

Data Visualization

```
In [5]:
import matplotlib.image as mpimg

#set the number of colums and rows
nrows = 4
ncols = 4

#set the figure size
fig = plt.gcf()
fig.set_size_inches(12,12)

#get the filesnames from the covid & normal dir of the train dataset
next_covid_pic = [os.path.join(train_covid_dir,fname)for fname in train_covid_names[0:8]]
next_normal_pic = [os.path.join(train_normal_dir,fname)for fname in train_normal_names[0:8]]

# print the list
print(next_covid_pic)
print(next_normal_pic)

for i , img_path in enumerate(next_covid_pic+next_normal_pic):
  data = img_path.split('/',6)[0]
  sp = plt.subplot(nrows, ncols, i+1)
  sp.axis('off')
  img = mpimg.imread(img_path)
  sp.set_title(data, fontsize = 10)
  plt.imshow(img, cmap = 'gray')

plt.show()
```

```
['dataset\\train\\Covid\\00870a9c.jpg', 'dataset\\train\\Covid\\01E392EE-69F9-4E33-BFCE-E5C968654078.jpeg', 'dataset\\train\\Covid\\03BF7561-A9BA-4C3C-B8A0-D3E585F73F3C.jpeg', 'dataset\\train\\Covid\\071d06607edf81d70c940e043bce34_jumbo.jpeg', 'dataset\\train\\Covid\\078d2e0b3e4fec1d603efb0e818c31_jumbo.jpeg', 'dataset\\train\\Covid\\08d780ae.jpg', 'dataset\\train\\Covid\\0a6c60063b4bae4de001caaba306d1_jumbo.jpeg', 'dataset\\train\\Covid\\0a7faa2a.jpg']
['dataset\\train\\Normal\\NORMAL (1).png', 'dataset\\train\\Normal\\NORMAL (100).png', 'dataset\\train\\Normal\\NORMAL (1001).png', 'dataset\\train\\Normal\\NORMAL (1002).png', 'dataset\\train\\Normal\\NORMAL (1003).png', 'dataset\\train\\Normal\\NORMAL (1004).png', 'dataset\\train\\Normal\\NORMAL (1005).png', 'dataset\\train\\Normal\\NORMAL (1006).png']
```



Generating Training, Validation & testing Batches

```
In [6]:
# Generator for our training data
train_datagen = ImageDataGenerator(rescale = 1./255,
                                   validation_split = 0.2,
                                   zoom_range = 0.2,
                                   horizontal_flip = True)

#Generator for our Validation data
validation_datagen = ImageDataGenerator(rescale = 1./255)

#Generator for our test data
test_datagen = ImageDataGenerator(rescale = 1./255)

train_generator = train_datagen.flow_from_directory(train_dir,
                                                    target_size = (150,150),
                                                    subset = 'training',
                                                    batch_size = 32,
                                                    class_mode = 'binary')

validation_generator = train_datagen.flow_from_directory(train_dir,
                                                    target_size = (150,150),
                                                    subset = 'validation',
                                                    batch_size = 32,
                                                    class_mode = 'binary')

test_generator = test_datagen.flow_from_directory(test_dir,
                                                    target_size = (150,150),
                                                    batch_size = 32,
                                                    class_mode = 'binary')
```

```
Found 1922 images belonging to 2 classes.
Found 480 images belonging to 2 classes.
Found 602 images belonging to 2 classes.
```

```
In [7]: train_generator.class_indices
Out[7]: {'Covid': 0, 'Normal': 1}
```

```
In [8]: train_generator.image_shape
Out[8]: (150, 150, 3)
```

Dataset

Credits and Links

1. Covid Chest X Ray Dataset

520 Covid-19 images are taken from above dataset

1. COVID-19 Radiography Database

1341 normal and 1143 Covid-19 images are taken from above dataset

`Our Dataset`

Split	Normal	Covid19	Total
Train	1072	1330	1922
Test	269	333	602
Total	**1341**	**1663**	**3004**

Build CNN Model

```
In [18]:
# Model With Dropout Layer


model = Sequential()

# add the convolutional layer
# filters, size of filters, padding, activation_function, inout_shape
model.add(Conv2D(32,(5,5), padding = 'SAME', activation = 'relu', input_shape = (150,150,3)))

# pooling layer
model.add(MaxPooling2D(pool_size = (2,2)))

# place a dropout layer
model.add(Dropout(0.5)) ## Minimizes the overfitting

# add another convolutional layer
model.add(Conv2D(64,(5,5), padding = 'SAME', activation = 'relu'))

# pooling layer
model.add(MaxPooling2D(pool_size = (2,2)))

# place a dropout layer
model.add(Dropout(0.5))

# Flatten the image to 1 dimensional array
model.add(Flatten())

# add a dense layer : amount of nodes, activation
model.add(Dense(256, activation = 'relu'))

# place a dropout layer
# 0.5 drop out rate is recommended, half input will be dropped at each update
model.add(Dropout(0.5))
model.add(Dense(1, activation = 'sigmoid'))
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_22 (Conv2D)           (None, 150, 150, 32)      2432
_________________________________________________________________
max_pooling2d_13 (MaxPooling (None, 75, 75, 32)        0
_________________________________________________________________
dropout_6 (Dropout)          (None, 75, 75, 32)        0
_________________________________________________________________
conv2d_23 (Conv2D)           (None, 75, 75, 64)        51264
_________________________________________________________________
max_pooling2d_14 (MaxPooling (None, 37, 37, 64)        0
_________________________________________________________________
dropout_7 (Dropout)          (None, 37, 37, 64)        0
_________________________________________________________________
flatten_5 (Flatten)          (None, 87616)             0
_________________________________________________________________
dense_10 (Dense)             (None, 256)               22429952
_________________________________________________________________
dropout_8 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_11 (Dense)             (None, 1)                 257
=================================================================
Total params: 22,483,905
Trainable params: 22,483,905
Non-trainable params: 0
_________________________________________________________________
```

```
In [10]:
# Model Without Dropout Layer


model2 = Sequential()

# add the convolutional layer
# filters, size of filters, padding, activation_function, inout_shape
model2.add(Conv2D(32,(5,5), padding = 'SAME', activation = 'relu', input_shape = (150,150,3)))

# pooling layer
model2.add(MaxPooling2D(pool_size = (2,2)))

# place a dropout layer
#model2.add(Dropout(0.5)) ## Minimizes the overfitting

# add another convolutional layer
model2.add(Conv2D(64,(5,5), padding = 'SAME', activation = 'relu'))

# pooling layer
model2.add(MaxPooling2D(pool_size = (2,2)))

# place a dropout layer
#model2.add(Dropout(0.5))

# Flatten the image to 1 dimensional array
model2.add(Flatten())

# add a dense layer : amount of nodes, activation
model2.add(Dense(256, activation = 'relu'))

# place a dropout layer
# 0.5 drop out rate is recommended, half input will be dropped at each update
#model2.add(Dropout(0.5))
model2.add(Dense(1, activation = 'sigmoid'))
model2.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_2 (Conv2D)            (None, 150, 150, 32)      2432
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 75, 75, 32)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 75, 75, 64)        51264
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 37, 37, 64)        0
_________________________________________________________________
flatten_1 (Flatten)          (None, 87616)             0
_________________________________________________________________
dense_2 (Dense)              (None, 256)               22429952
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 257
=================================================================
Total params: 22,483,905
Trainable params: 22,483,905
Non-trainable params: 0
_________________________________________________________________
```

```
In [13]:
# Model with batch Normalization layer

from keras.models import Sequential
from keras.layers import Dense, Conv2D, MaxPool2D, Dropout, Flatten, BatchNormalization


model3 = Sequential()

model3.add(Conv2D(filters=32, kernel_size=(3, 3), input_shape=(150, 150, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(Conv2D(filters=32, kernel_size=(3, 3), input_shape=(150, 150, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(MaxPool2D(pool_size=(2, 2)))

model3.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(MaxPool2D(pool_size=(2, 2)))

model3.add(Conv2D(filters=128, kernel_size=(3, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(Conv2D(filters=128, kernel_size=(3, 3), activation='relu'))
model3.add(BatchNormalization())
model3.add(MaxPool2D(pool_size=(2, 2)))

model3.add(Flatten())
model3.add(Dense(128, activation='relu'))
model3.add(Dropout(0.5))

model3.add(Dense(1, activation='sigmoid'))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 150, 150, 32)      2432
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 75, 75, 32)        0
_________________________________________________________________
dropout (Dropout)            (None, 75, 75, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 75, 75, 64)        51264
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 37, 37, 64)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 37, 37, 64)        0
_________________________________________________________________
flatten (Flatten)            (None, 87616)             0
_________________________________________________________________
dense (Dense)                (None, 256)               22429952
_________________________________________________________________
dropout_2 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 257
=================================================================
Total params: 22,483,905
Trainable params: 22,483,905
Non-trainable params: 0
_________________________________________________________________
```

Compile & Train Model

```
In [19]:
# compile model
from tensorflow.keras.optimizers import Adam # Adam is optimizer
# Loss function definition
model.compile(Adam(lr = 0.001),loss = 'binary_crossentropy', metrics = ['accuracy'])
```

```
In [20]:
# compile model
from tensorflow.keras.optimizers import Adam # Adam is optimizer
# Loss function definition
model2.compile(Adam(lr = 0.001),loss = 'binary_crossentropy', metrics = ['accuracy'])
```

```
In [21]:
# compile model
from tensorflow.keras.optimizers import Adam # Adam is optimizer
# Loss function definition
model3.compile(Adam(lr = 0.001),
               loss='binary_crossentropy',
               metrics=['accuracy'])
```

```
In [22]:
# train the model
history1 = model.fit(train_generator,
                     epochs=20,
                     validation_data = validation_generator,
                     validation_steps = 10)
```

```
Epoch 1/20
61/61 [==============================] - 108s 2s/step - loss: 0.9385 - accuracy: 0.7383 - val_loss: 0.2480 - val_accuracy: 0.9094
Epoch 2/20
61/61 [==============================] - 90s 1s/step - loss: 0.1879 - accuracy: 0.9344 - val_loss: 0.1596 - val_accuracy: 0.9750
Epoch 3/20
61/61 [==============================] - 108s 2s/step - loss: 0.1641 - accuracy: 0.9542 - val_loss: 0.1067 - val_accuracy: 0.9719
Epoch 4/20
61/61 [==============================] - 102s 2s/step - loss: 0.1432 - accuracy: 0.9516 - val_loss: 0.1750 - val_accuracy: 0.9625
Epoch 5/20
61/61 [==============================] - 99s 2s/step - loss: 0.1247 - accuracy: 0.9579 - val_loss: 0.1114 - val_accuracy: 0.9750
Epoch 6/20
61/61 [==============================] - 107s 2s/step - loss: 0.1599 - accuracy: 0.9480 - val_loss: 0.1375 - val_accuracy: 0.9500
Epoch 7/20
61/61 [==============================] - 93s 2s/step - loss: 0.1303 - accuracy: 0.9584 - val_loss: 0.0989 - val_accuracy: 0.9688
Epoch 8/20
61/61 [==============================] - 94s 2s/step - loss: 0.1182 - accuracy: 0.9636 - val_loss: 0.0844 - val_accuracy: 0.9750
Epoch 9/20
61/61 [==============================] - 116s 2s/step - loss: 0.1118 - accuracy: 0.9636 - val_loss: 0.1046 - val_accuracy: 0.9656
Epoch 10/20
61/61 [==============================] - 134s 2s/step - loss: 0.1105 - accuracy: 0.9657 - val_loss: 0.0700 - val_accuracy: 0.9812
Epoch 11/20
61/61 [==============================] - 140s 2s/step - loss: 0.1398 - accuracy: 0.9553 - val_loss: 0.1279 - val_accuracy: 0.9563
Epoch 12/20
61/61 [==============================] - 121s 2s/step - loss: 0.0951 - accuracy: 0.9714 - val_loss: 0.0677 - val_accuracy: 0.9719
Epoch 13/20
61/61 [==============================] - 86s 1s/step - loss: 0.0989 - accuracy: 0.9683 - val_loss: 0.0686 - val_accuracy: 0.9688
Epoch 14/20
61/61 [==============================] - 81s 1s/step - loss: 0.1011 - accuracy: 0.9719 - val_loss: 0.0523 - val_accuracy: 0.9781
Epoch 15/20
61/61 [==============================] - 81s 1s/step - loss: 0.1049 - accuracy: 0.9698 - val_loss: 0.0858 - val_accuracy: 0.9781
Epoch 16/20
61/61 [==============================] - 79s 1s/step - loss: 0.0904 - accuracy: 0.9724 - val_loss: 0.0764 - val_accuracy: 0.9719
Epoch 17/20
61/61 [==============================] - 77s 1s/step - loss: 0.0881 - accuracy: 0.9761 - val_loss: 0.0904 - val_accuracy: 0.9688
Epoch 18/20
61/61 [==============================] - 78s 1s/step - loss: 0.0924 - accuracy: 0.9688 - val_loss: 0.0813 - val_accuracy: 0.9750
Epoch 19/20
61/61 [==============================] - 76s 1s/step - loss: 0.0945 - accuracy: 0.9709 - val_loss: 0.0626 - val_accuracy: 0.9719
Epoch 20/20
61/61 [==============================] - 77s 1s/step - loss: 0.0880 - accuracy: 0.9761 - val_loss: 0.1028 - val_accuracy: 0.9719
```

```
In [23]:
# train the model
history2 = model2.fit(train_generator,
                     epochs=20,
                     validation_data = validation_generator,
                     validation_steps = 10)
```

```
Epoch 1/20
61/61 [==============================] - 75s 1s/step - loss: 0.4722 - accuracy: 0.8424 - val_loss: 0.1599 - val_accuracy: 0.9406
Epoch 2/20
61/61 [==============================] - 74s 1s/step - loss: 0.1193 - accuracy: 0.9563 - val_loss: 0.0910 - val_accuracy: 0.9625
Epoch 3/20
61/61 [==============================] - 73s 1s/step - loss: 0.0937 - accuracy: 0.9709 - val_loss: 0.0567 - val_accuracy: 0.9844
Epoch 4/20
61/61 [==============================] - 73s 1s/step - loss: 0.1591 - accuracy: 0.9495 - val_loss: 0.0962 - val_accuracy: 0.9719
Epoch 5/20
61/61 [==============================] - 73s 1s/step - loss: 0.1041 - accuracy: 0.9625 - val_loss: 0.0816 - val_accuracy: 0.9750
Epoch 6/20
61/61 [==============================] - 74s 1s/step - loss: 0.0910 - accuracy: 0.9693 - val_loss: 0.1120 - val_accuracy: 0.9625
Epoch 7/20
61/61 [==============================] - 73s 1s/step - loss: 0.0990 - accuracy: 0.9698 - val_loss: 0.0680 - val_accuracy: 0.9812
Epoch 8/20
61/61 [==============================] - 72s 1s/step - loss: 0.0744 - accuracy: 0.9802 - val_loss: 0.0272 - val_accuracy: 0.9969
Epoch 9/20
61/61 [==============================] - 73s 1s/step - loss: 0.0731 - accuracy: 0.9761 - val_loss: 0.0698 - val_accuracy: 0.9781
Epoch 10/20
61/61 [==============================] - 74s 1s/step - loss: 0.0797 - accuracy: 0.9709 - val_loss: 0.0309 - val_accuracy: 0.9937
Epoch 11/20
61/61 [==============================] - 73s 1s/step - loss: 0.0702 - accuracy: 0.9813 - val_loss: 0.0446 - val_accuracy: 0.9875
Epoch 12/20
61/61 [==============================] - 72s 1s/step - loss: 0.0499 - accuracy: 0.9813 - val_loss: 0.0977 - val_accuracy: 0.9625
Epoch 13/20
61/61 [==============================] - 72s 1s/step - loss: 0.0655 - accuracy: 0.9802 - val_loss: 0.0484 - val_accuracy: 0.9875
Epoch 14/20
61/61 [==============================] - 73s 1s/step - loss: 0.0722 - accuracy: 0.9766 - val_loss: 0.0744 - val_accuracy: 0.9812
Epoch 15/20
61/61 [==============================] - 72s 1s/step - loss: 0.0650 - accuracy: 0.9781 - val_loss: 0.0523 - val_accuracy: 0.9875
Epoch 16/20
61/61 [==============================] - 72s 1s/step - loss: 0.0476 - accuracy: 0.9860 - val_loss: 0.0486 - val_accuracy: 0.9844
Epoch 17/20
61/61 [==============================] - 73s 1s/step - loss: 0.0498 - accuracy: 0.9860 - val_loss: 0.0513 - val_accuracy: 0.9781
Epoch 18/20
61/61 [==============================] - 73s 1s/step - loss: 0.0476 - accuracy: 0.9849 - val_loss: 0.0434 - val_accuracy: 0.9844
Epoch 19/20
61/61 [==============================] - 72s 1s/step - loss: 0.0489 - accuracy: 0.9860 - val_loss: 0.0255 - val_accuracy: 0.9969
Epoch 20/20
61/61 [==============================] - 72s 1s/step - loss: 0.0471 - accuracy: 0.9860 - val_loss: 0.0527 - val_accuracy: 0.9875
```

```
In [24]:
# train the model
history3 = model3.fit(
    train_generator,
    epochs=20,
    validation_data=validation_generator,
    validation_steps=10,
)
```

```
Epoch 1/20
61/61 [==============================] - 170s 3s/step - loss: 0.6567 - accuracy: 0.9324 - val_loss: 4.4261 - val_accuracy: 0.5344
Epoch 2/20
61/61 [==============================] - 169s 3s/step - loss: 0.2197 - accuracy: 0.9594 - val_loss: 40.8538 - val_accuracy: 0.5437
Epoch 3/20
61/61 [==============================] - 184s 3s/step - loss: 0.2033 - accuracy: 0.9610 - val_loss: 47.5902 - val_accuracy: 0.5250
Epoch 4/20
61/61 [==============================] - 188s 3s/step - loss: 0.1433 - accuracy: 0.9683 - val_loss: 46.0743 - val_accuracy: 0.5531
Epoch 5/20
61/61 [==============================] - 183s 3s/step - loss: 0.0654 - accuracy: 0.9745 - val_loss: 45.1863 - val_accuracy: 0.5437
Epoch 6/20
61/61 [==============================] - 181s 3s/step - loss: 0.0975 - accuracy: 0.9735 - val_loss: 59.5538 - val_accuracy: 0.5625
Epoch 7/20
61/61 [==============================] - 179s 3s/step - loss: 0.2141 - accuracy: 0.9625 - val_loss: 31.4265 - val_accuracy: 0.5281
Epoch 8/20
61/61 [==============================] - 178s 3s/step - loss: 0.2358 - accuracy: 0.9651 - val_loss: 1.1158 - val_accuracy: 0.8969
Epoch 9/20
61/61 [==============================] - 178s 3s/step - loss: 0.1180 - accuracy: 0.9703 - val_loss: 2.6413 - val_accuracy: 0.8656
Epoch 10/20
61/61 [==============================] - 177s 3s/step - loss: 0.0803 - accuracy: 0.9787 - val_loss: 0.1005 - val_accuracy: 0.9781
Epoch 11/20
61/61 [==============================] - 179s 3s/step - loss: 0.1057 - accuracy: 0.9781 - val_loss: 0.0716 - val_accuracy: 0.9844
Epoch 12/20
61/61 [==============================] - 177s 3s/step - loss: 0.0850 - accuracy: 0.9771 - val_loss: 0.0579 - val_accuracy: 0.9781
Epoch 13/20
61/61 [==============================] - 177s 3s/step - loss: 0.0610 - accuracy: 0.9834 - val_loss: 0.0320 - val_accuracy: 0.9875
Epoch 14/20
61/61 [==============================] - 176s 3s/step - loss: 0.0661 - accuracy: 0.9807 - val_loss: 0.0636 - val_accuracy: 0.9719
Epoch 15/20
61/61 [==============================] - 176s 3s/step - loss: 0.0576 - accuracy: 0.9797 - val_loss: 0.0304 - val_accuracy: 0.9937
Epoch 16/20
61/61 [==============================] - 178s 3s/step - loss: 0.0493 - accuracy: 0.9807 - val_loss: 0.0188 - val_accuracy: 0.9969
Epoch 17/20
61/61 [==============================] - 178s 3s/step - loss: 0.2190 - accuracy: 0.9553 - val_loss: 9.8865 - val_accuracy: 0.6281
Epoch 18/20
61/61 [==============================] - 178s 3s/step - loss: 0.1107 - accuracy: 0.9709 - val_loss: 0.3137 - val_accuracy: 0.9125
Epoch 19/20
61/61 [==============================] - 177s 3s/step - loss: 0.0806 - accuracy: 0.9755 - val_loss: 0.3221 - val_accuracy: 0.8406
Epoch 20/20
61/61 [==============================] - 177s 3s/step - loss: 0.0819 - accuracy: 0.9761 - val_loss: 0.0545 - val_accuracy: 0.9875
```

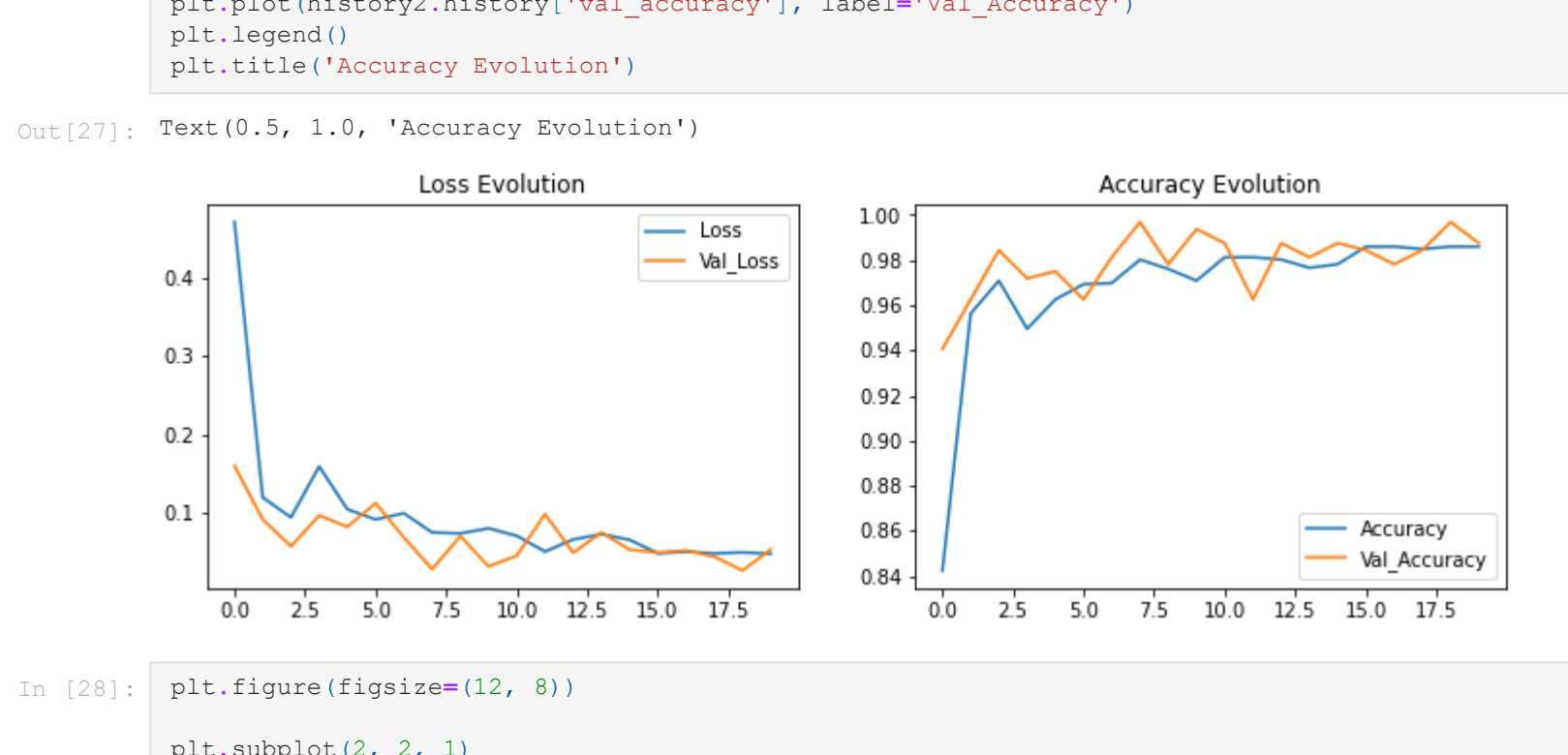
Plotting Loss and Accuracy Graph

```
In [26]:
plt.figure(figsize=(12, 8))

plt.subplot(2, 2, 1)
plt.plot(history1.history['loss'], label='Loss')
plt.plot(history1.history['val_loss'], label='Val_Loss')
plt.legend()
plt.title('Loss Evolution')

plt.subplot(2, 2, 2)
plt.plot(history1.history['accuracy'], label='Accuracy')
plt.plot(history1.history['val_accuracy'], label='Val_Accuracy')
plt.legend()
plt.title('Accuracy Evolution')
```

```
Out[26]: Text(0.5, 1.0, 'Accuracy Evolution')
```


```
In [27]:
plt.figure(figsize=(12, 8))

plt.subplot(2, 2, 1)
plt.plot(history2.history['loss'], label='Loss')
plt.plot(history2.history['val_loss'], label='Val_Loss')
plt.legend()
plt.title('Loss Evolution')

plt.subplot(2, 2, 2)
plt.plot(history2.history['accuracy'], label='Accuracy')
plt.plot(history2.history['val_accuracy'], label='Val_Accuracy')
plt.legend()
plt.title('Accuracy Evolution')
```

```
Out[27]: Text(0.5, 1.0, 'Accuracy Evolution')
```




```
In [28]:
plt.figure(figsize=(12, 8))

plt.subplot(2, 2, 1)
plt.plot(history3.history['loss'], label='Loss')
plt.plot(history3.history['val_loss'], label='Val_Loss')
plt.legend()
plt.title('Loss Evolution')

plt.subplot(2, 2, 2)
plt.plot(history3.history['accuracy'], label='Accuracy')
plt.plot(history3.history['val_accuracy'], label='Val_Accuracy')
plt.legend()
plt.title('Accuracy Evolution')
```

```
Out[28]: Text(0.5, 1.0, 'Accuracy Evolution')
```

Evaluation of Model

```
In [ ]:
test_loss, test_acc = model.evaluate(test_generator )
print('test acc: {} test loss: {}'.format(test_acc,test_loss))
```

```
In [ ]:
test_loss2, test_acc2 = model2.evaluate(test_generator )
print('test acc: {} test loss: {}'.format(test_acc2,test_loss2))
```

```
In [29]:
evaluation = model.evaluate(test_generator)
print(f"Test Accuracy: {evaluation[1] * 100:.2f}%")

evaluation = model.evaluate(train_generator)
print(f"Train Accuracy: {evaluation[1] * 100:.2f}%")
```

```
19/19 [==============================] - 21s 1s/step - loss: 0.1490 - accuracy: 0.9585
Test Accuracy: 95.85%
61/61 [==============================] - 36s 589ms/step - loss: 0.0994 - accuracy: 0.9755
Train Accuracy: 97.55%
```

```
In [30]:
evaluation = model2.evaluate(test_generator)
print(f"Test Accuracy: {evaluation[1] * 100:.2f}%")

evaluation = model2.evaluate(train_generator)
print(f"Train Accuracy: {evaluation[1] * 100:.2f}%")
```

```
19/19 [==============================] - 10s 515ms/step - loss: 0.0328 - accuracy: 0.9867
Test Accuracy: 98.67%
61/61 [==============================] - 36s 596ms/step - loss: 0.0353 - accuracy: 0.9870
Train Accuracy: 98.70%
```

```
In [31]:
evaluation = model3.evaluate(test_generator)
print(f"Test Accuracy: {evaluation[1] * 100:.2f}%")

evaluation = model3.evaluate(train_generator)
print(f"Train Accuracy: {evaluation[1] * 100:.2f}%")
```

```
19/19 [==============================] - 11s 592ms/step - loss: 0.0658 - accuracy: 0.9850
Test Accuracy: 98.50%
61/61 [==============================] - 41s 677ms/step - loss: 0.0593 - accuracy: 0.9834
Train Accuracy: 98.34%
```

Confusion Matrics

```
In [33]:
from sklearn.metrics import confusion_matrix, classification_report
import pandas as pd
pred = model.predict(test_generator)

print(confusion_matrix(test_generator.classes, pred > 0.5))
pd.DataFrame(classification_report(test_generator.classes, pred > 0.5, output_dict=True))
```

```
[[163 170]
 [147 122]]
```

Out[33]:

	0	1	accuracy	macro avg	weighted avg
precision	0.525806	0.417808	0.473422	0.471807	0.477548
recall	0.489489	0.453532	0.473422	0.471511	0.473422
f1-score	0.506998	0.434938	0.473422	0.470968	0.474799
support	333.000000	269.000000	0.473422	602.000000	602.000000

```
In [36]:
pred = model2.predict(test_generator)

print(confusion_matrix(test_generator.classes, pred > 0.5))
pd.DataFrame(classification_report(test_generator.classes, pred > 0.5, output_dict=True))
```

```
[[183 150]
 [148 121]]
```

Out[36]:

	0	1	accuracy	macro avg	weighted avg
precision	0.552870	0.446494	0.504983	0.499682	0.505337
recall	0.549550	0.449814	0.504983	0.499682	0.504983
f1-score	0.551205	0.448148	0.504983	0.499676	0.505155
support	333.000000	269.000000	0.504983	602.000000	602.000000

```
In [37]:
pred = model3.predict(test_generator)

print(confusion_matrix(test_generator.classes, pred > 0.5))
pd.DataFrame(classification_report(test_generator.classes, pred > 0.5, output_dict=True))
```

```
[[184 149]
 [144 125]]
```

Out[37]:

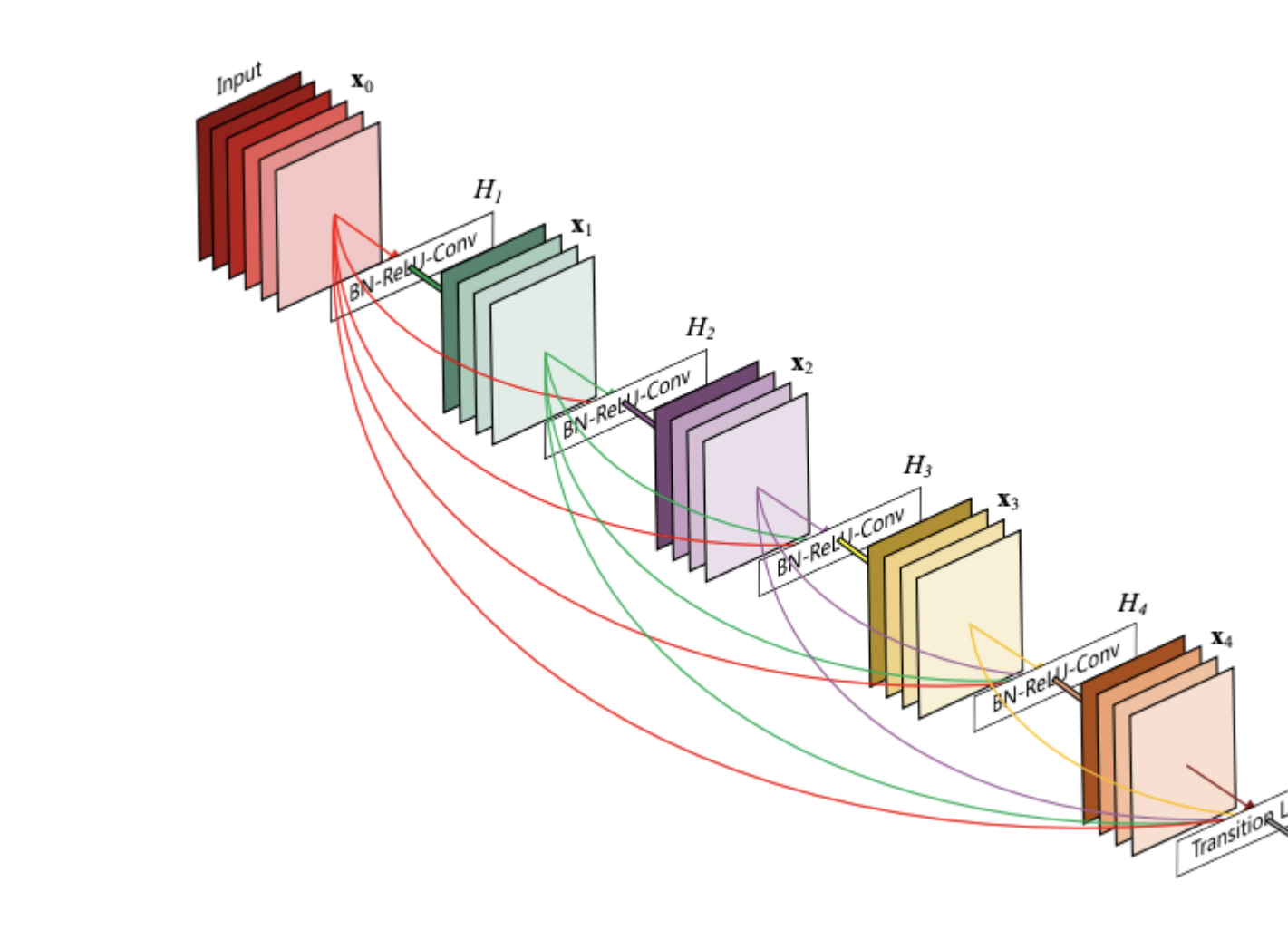
	0	1	accuracy	macro avg	weighted avg
precision	0.560976	0.456204	0.513289	0.508590	0.514159
recall	0.552553	0.464684	0.513289	0.508618	0.513289
f1-score	0.556732	0.460405	0.513289	0.508569	0.513689
support	333.000000	269.000000	0.513289	602.000000	602.000000

Transfer Learning

DenseNet

Densenet is a convolutional network where each layer is connected to all other layers that are deeper in the network:

- The first layer is connected to the 2nd, 3rd, 4th etc.
- The second layer is conected to the 3rd, 4th, 5th etc.



for more information about the DenseNet Architecture visit this website : https://keras.io/api/applications/densenet/

```
In [38]:
from keras.applications.densenet import DenseNet121
from keras.layers import Dense, GlobalAveragePooling2D
from keras.models import Model
from keras import backend as K
```

```
In [39]:
densedet121 = DenseNet121(input_shape=(150, 150, 3), include_top=False, weights='imagenet', pooling='avg')

densedet121.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/densenet/densenet121_weights_tf_dim_ordering_tf_kernels_notop.h5
29089792/29084464 [==============================] - 3s 0us/step
Model: "densenet121"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 150, 150, 3) 0
__________________________________________________________________________________________________
zero_padding2d (ZeroPadding2D)  (None, 156, 156, 3)  0           input_1[0][0]
__________________________________________________________________________________________________
conv1/conv (Conv2D)             (None, 75, 75, 64)   9408        zero_padding2d[0][0]
__________________________________________________________________________________________________
conv1/bn (BatchNormalization)   (None, 75, 75, 64)   256         conv1/conv[0][0]
__________________________________________________________________________________________________
conv1/relu (Activation)         (None, 75, 75, 64)   0           conv1/bn[0][0]
__________________________________________________________________________________________________
zero_padding2d_1 (ZeroPadding2D (None, 77, 77, 64)   0           conv1/relu[0][0]
__________________________________________________________________________________________________
pool1 (MaxPooling2D)            (None, 38, 38, 64)   0           zero_padding2d_1[0][0]
__________________________________________________________________________________________________
conv2_block1_0_bn (BatchNormali (None, 38, 38, 64)   256         pool1[0][0]
__________________________________________________________________________________________________
conv2_block1_0_relu (Activation (None, 38, 38, 64)   0           conv2_block1_0_bn[0][0]
__________________________________________________________________________________________________
conv2_block1_1_conv (Conv2D)    (None, 38, 38, 128)  8192        conv2_block1_0_relu[0][0]
__________________________________________________________________________________________________
conv2_block1_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block1_1_conv[0][0]
__________________________________________________________________________________________________
```

```
conv2_block1_1_relu (Activation (None, 38, 38, 128)  0           conv2_block1_1_bn[0][0]
conv2_block1_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block1_1_relu[0][0]
conv2_block1_concat (Concatenat (None, 38, 38, 96)   0           pool1[0][0]
                                                                 conv2_block1_2_conv[0][0]
conv2_block2_0_bn (BatchNormali (None, 38, 38, 96)   384         conv2_block1_concat[0][0]
conv2_block2_0_relu (Activation (None, 38, 38, 96)   0           conv2_block2_0_bn[0][0]
conv2_block2_1_conv (Conv2D)    (None, 38, 38, 128)  12288       conv2_block2_0_relu[0][0]
conv2_block2_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block2_1_conv[0][0]
conv2_block2_1_relu (Activation (None, 38, 38, 128)  0           conv2_block2_1_bn[0][0]
conv2_block2_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block2_1_relu[0][0]
conv2_block2_concat (Concatenat (None, 38, 38, 128)  0           conv2_block1_concat[0][0]
                                                                 conv2_block2_2_conv[0][0]
conv2_block3_0_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block2_concat[0][0]
conv2_block3_0_relu (Activation (None, 38, 38, 128)  0           conv2_block3_0_bn[0][0]
conv2_block3_1_conv (Conv2D)    (None, 38, 38, 128)  16384       conv2_block3_0_relu[0][0]
conv2_block3_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block3_1_conv[0][0]
conv2_block3_1_relu (Activation (None, 38, 38, 128)  0           conv2_block3_1_bn[0][0]
conv2_block3_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block3_1_relu[0][0]
conv2_block3_concat (Concatenat (None, 38, 38, 160)  0           conv2_block2_concat[0][0]
                                                                 conv2_block3_2_conv[0][0]
conv2_block4_0_bn (BatchNormali (None, 38, 38, 160)  640         conv2_block3_concat[0][0]
conv2_block4_0_relu (Activation (None, 38, 38, 160)  0           conv2_block4_0_bn[0][0]
conv2_block4_1_conv (Conv2D)    (None, 38, 38, 128)  20480       conv2_block4_0_relu[0][0]
conv2_block4_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block4_1_conv[0][0]
conv2_block4_1_relu (Activation (None, 38, 38, 128)  0           conv2_block4_1_bn[0][0]
conv2_block4_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block4_1_relu[0][0]
conv2_block4_concat (Concatenat (None, 38, 38, 192)  0           conv2_block3_concat[0][0]
                                                                 conv2_block4_2_conv[0][0]
conv2_block5_0_bn (BatchNormali (None, 38, 38, 192)  768         conv2_block4_concat[0][0]
conv2_block5_0_relu (Activation (None, 38, 38, 192)  0           conv2_block5_0_bn[0][0]
conv2_block5_1_conv (Conv2D)    (None, 38, 38, 128)  24576       conv2_block5_0_relu[0][0]
conv2_block5_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block5_1_conv[0][0]
conv2_block5_1_relu (Activation (None, 38, 38, 128)  0           conv2_block5_1_bn[0][0]
conv2_block5_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block5_1_relu[0][0]
conv2_block5_concat (Concatenat (None, 38, 38, 224)  0           conv2_block4_concat[0][0]
                                                                 conv2_block5_2_conv[0][0]
conv2_block6_0_bn (BatchNormali (None, 38, 38, 224)  896         conv2_block5_concat[0][0]
conv2_block6_0_relu (Activation (None, 38, 38, 224)  0           conv2_block6_0_bn[0][0]
conv2_block6_1_conv (Conv2D)    (None, 38, 38, 128)  28672       conv2_block6_0_relu[0][0]
conv2_block6_1_bn (BatchNormali (None, 38, 38, 128)  512         conv2_block6_1_conv[0][0]
conv2_block6_1_relu (Activation (None, 38, 38, 128)  0           conv2_block6_1_bn[0][0]
conv2_block6_2_conv (Conv2D)    (None, 38, 38, 32)   36864       conv2_block6_1_relu[0][0]
conv2_block6_concat (Concatenat (None, 38, 38, 256)  0           conv2_block5_concat[0][0]
                                                                 conv2_block6_2_conv[0][0]
pool2_bn (BatchNormalization)   (None, 38, 38, 256)  1024        conv2_block6_concat[0][0]
pool2_relu (Activation)         (None, 38, 38, 256)  0           pool2_bn[0][0]
pool2_conv (Conv2D)             (None, 38, 38, 128)  32768       pool2_relu[0][0]
pool2_pool (AveragePooling2D)   (None, 19, 19, 128)  0           pool2_conv[0][0]
conv3_block1_0_bn (BatchNormali (None, 19, 19, 128)  512         pool2_pool[0][0]
conv3_block1_0_relu (Activation (None, 19, 19, 128)  0           conv3_block1_0_bn[0][0]
conv3_block1_1_conv (Conv2D)    (None, 19, 19, 128)  16384       conv3_block1_0_relu[0][0]
conv3_block1_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block1_1_conv[0][0]
conv3_block1_1_relu (Activation (None, 19, 19, 128)  0           conv3_block1_1_bn[0][0]
conv3_block1_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block1_1_relu[0][0]
conv3_block1_concat (Concatenat (None, 19, 19, 160)  0           pool2_pool[0][0]
                                                                 conv3_block1_2_conv[0][0]
conv3_block2_0_bn (BatchNormali (None, 19, 19, 160)  640         conv3_block1_concat[0][0]
conv3_block2_0_relu (Activation (None, 19, 19, 160)  0           conv3_block2_0_bn[0][0]
conv3_block2_1_conv (Conv2D)    (None, 19, 19, 128)  20480       conv3_block2_0_relu[0][0]
conv3_block2_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block2_1_conv[0][0]
conv3_block2_1_relu (Activation (None, 19, 19, 128)  0           conv3_block2_1_bn[0][0]
conv3_block2_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block2_1_relu[0][0]
conv3_block2_concat (Concatenat (None, 19, 19, 192)  0           conv3_block1_concat[0][0]
                                                                 conv3_block2_2_conv[0][0]
conv3_block3_0_bn (BatchNormali (None, 19, 19, 192)  768         conv3_block2_concat[0][0]
conv3_block3_0_relu (Activation (None, 19, 19, 192)  0           conv3_block3_0_bn[0][0]
conv3_block3_1_conv (Conv2D)    (None, 19, 19, 128)  24576       conv3_block3_0_relu[0][0]
conv3_block3_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block3_1_conv[0][0]
conv3_block3_1_relu (Activation (None, 19, 19, 128)  0           conv3_block3_1_bn[0][0]
conv3_block3_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block3_1_relu[0][0]
conv3_block3_concat (Concatenat (None, 19, 19, 224)  0           conv3_block2_concat[0][0]
                                                                 conv3_block3_2_conv[0][0]
conv3_block4_0_bn (BatchNormali (None, 19, 19, 224)  896         conv3_block3_concat[0][0]
conv3_block4_0_relu (Activation (None, 19, 19, 224)  0           conv3_block4_0_bn[0][0]
conv3_block4_1_conv (Conv2D)    (None, 19, 19, 128)  28672       conv3_block4_0_relu[0][0]
conv3_block4_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block4_1_conv[0][0]
conv3_block4_1_relu (Activation (None, 19, 19, 128)  0           conv3_block4_1_bn[0][0]
conv3_block4_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block4_1_relu[0][0]
conv3_block4_concat (Concatenat (None, 19, 19, 256)  0           conv3_block3_concat[0][0]
                                                                 conv3_block4_2_conv[0][0]
conv3_block5_0_bn (BatchNormali (None, 19, 19, 256)  1024        conv3_block4_concat[0][0]
conv3_block5_0_relu (Activation (None, 19, 19, 256)  0           conv3_block5_0_bn[0][0]
conv3_block5_1_conv (Conv2D)    (None, 19, 19, 128)  32768       conv3_block5_0_relu[0][0]
conv3_block5_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block5_1_conv[0][0]
conv3_block5_1_relu (Activation (None, 19, 19, 128)  0           conv3_block5_1_bn[0][0]
conv3_block5_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block5_1_relu[0][0]
conv3_block5_concat (Concatenat (None, 19, 19, 288)  0           conv3_block4_concat[0][0]
                                                                 conv3_block5_2_conv[0][0]
conv3_block6_0_bn (BatchNormali (None, 19, 19, 288)  1152        conv3_block5_concat[0][0]
conv3_block6_0_relu (Activation (None, 19, 19, 288)  0           conv3_block6_0_bn[0][0]
conv3_block6_1_conv (Conv2D)    (None, 19, 19, 128)  36864       conv3_block6_0_relu[0][0]
conv3_block6_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block6_1_conv[0][0]
conv3_block6_1_relu (Activation (None, 19, 19, 128)  0           conv3_block6_1_bn[0][0]
conv3_block6_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block6_1_relu[0][0]
conv3_block6_concat (Concatenat (None, 19, 19, 320)  0           conv3_block5_concat[0][0]
                                                                 conv3_block6_2_conv[0][0]
conv3_block7_0_bn (BatchNormali (None, 19, 19, 320)  1280        conv3_block6_concat[0][0]
conv3_block7_0_relu (Activation (None, 19, 19, 320)  0           conv3_block7_0_bn[0][0]
conv3_block7_1_conv (Conv2D)    (None, 19, 19, 128)  40960       conv3_block7_0_relu[0][0]
conv3_block7_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block7_1_conv[0][0]
conv3_block7_1_relu (Activation (None, 19, 19, 128)  0           conv3_block7_1_bn[0][0]
conv3_block7_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block7_1_relu[0][0]
conv3_block7_concat (Concatenat (None, 19, 19, 352)  0           conv3_block6_concat[0][0]
                                                                 conv3_block7_2_conv[0][0]
conv3_block8_0_bn (BatchNormali (None, 19, 19, 352)  1408        conv3_block7_concat[0][0]
conv3_block8_0_relu (Activation (None, 19, 19, 352)  0           conv3_block8_0_bn[0][0]
conv3_block8_1_conv (Conv2D)    (None, 19, 19, 128)  45056       conv3_block8_0_relu[0][0]
conv3_block8_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block8_1_conv[0][0]
conv3_block8_1_relu (Activation (None, 19, 19, 128)  0           conv3_block8_1_bn[0][0]
conv3_block8_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block8_1_relu[0][0]
conv3_block8_concat (Concatenat (None, 19, 19, 384)  0           conv3_block7_concat[0][0]
                                                                 conv3_block8_2_conv[0][0]
conv3_block9_0_bn (BatchNormali (None, 19, 19, 384)  1536        conv3_block8_concat[0][0]
conv3_block9_0_relu (Activation (None, 19, 19, 384)  0           conv3_block9_0_bn[0][0]
conv3_block9_1_conv (Conv2D)    (None, 19, 19, 128)  49152       conv3_block9_0_relu[0][0]
conv3_block9_1_bn (BatchNormali (None, 19, 19, 128)  512         conv3_block9_1_conv[0][0]
conv3_block9_1_relu (Activation (None, 19, 19, 128)  0           conv3_block9_1_bn[0][0]
conv3_block9_2_conv (Conv2D)    (None, 19, 19, 32)   36864       conv3_block9_1_relu[0][0]
conv3_block9_concat (Concatenat (None, 19, 19, 416)  0           conv3_block8_concat[0][0]
                                                                 conv3_block9_2_conv[0][0]
conv3_block10_0_bn (BatchNormal (None, 19, 19, 416)  1664        conv3_block9_concat[0][0]
conv3_block10_0_relu (Activatio (None, 19, 19, 416)  0           conv3_block10_0_bn[0][0]
conv3_block10_1_conv (Conv2D)   (None, 19, 19, 128)  53248       conv3_block10_0_relu[0][0]
conv3_block10_1_bn (BatchNormal (None, 19, 19, 128)  512         conv3_block10_1_conv[0][0]
conv3_block10_1_relu (Activatio (None, 19, 19, 128)  0           conv3_block10_1_bn[0][0]
conv3_block10_2_conv (Conv2D)   (None, 19, 19, 32)   36864       conv3_block10_1_relu[0][0]
conv3_block10_concat (Concatena (None, 19, 19, 448)  0           conv3_block9_concat[0][0]
                                                                 conv3_block10_2_conv[0][0]
conv3_block11_0_bn (BatchNormal (None, 19, 19, 448)  1792        conv3_block10_concat[0][0]
conv3_block11_0_relu (Activatio (None, 19, 19, 448)  0           conv3_block11_0_bn[0][0]
conv3_block11_1_conv (Conv2D)   (None, 19, 19, 128)  57344       conv3_block11_0_relu[0][0]
conv3_block11_1_bn (BatchNormal (None, 19, 19, 128)  512         conv3_block11_1_conv[0][0]
conv3_block11_1_relu (Activatio (None, 19, 19, 128)  0           conv3_block11_1_bn[0][0]
conv3_block11_2_conv (Conv2D)   (None, 19, 19, 32)   36864       conv3_block11_1_relu[0][0]
conv3_block11_concat (Concatena (None, 19, 19, 480)  0           conv3_block10_concat[0][0]
                                                                 conv3_block11_2_conv[0][0]
conv3_block12_0_bn (BatchNormal (None, 19, 19, 480)  1920        conv3_block11_concat[0][0]
conv3_block12_0_relu (Activatio (None, 19, 19, 480)  0           conv3_block12_0_bn[0][0]
conv3_block12_1_conv (Conv2D)   (None, 19, 19, 128)  61440       conv3_block12_0_relu[0][0]
conv3_block12_1_bn (BatchNormal (None, 19, 19, 128)  512         conv3_block12_1_conv[0][0]
conv3_block12_1_relu (Activatio (None, 19, 19, 128)  0           conv3_block12_1_bn[0][0]
conv3_block12_2_conv (Conv2D)   (None, 19, 19, 32)   36864       conv3_block12_1_relu[0][0]
conv3_block12_concat (Concatena (None, 19, 19, 512)  0           conv3_block11_concat[0][0]
                                                                 conv3_block12_2_conv[0][0]
pool3_bn (BatchNormalization)   (None, 19, 19, 512)  2048        conv3_block12_concat[0][0]
pool3_relu (Activation)         (None, 19, 19, 512)  0           pool3_bn[0][0]
pool3_conv (Conv2D)             (None, 19, 19, 256)  131072      pool3_relu[0][0]
pool3_pool (AveragePooling2D)   (None, 9, 9, 256)    0           pool3_conv[0][0]
conv4_block1_0_bn (BatchNormali (None, 9, 9, 256)    1024        pool3_pool[0][0]
conv4_block1_0_relu (Activation (None, 9, 9, 256)    0           conv4_block1_0_bn[0][0]
conv4_block1_1_conv (Conv2D)    (None, 9, 9, 128)    32768       conv4_block1_0_relu[0][0]
conv4_block1_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block1_1_conv[0][0]
conv4_block1_1_relu (Activation (None, 9, 9, 128)    0           conv4_block1_1_bn[0][0]
conv4_block1_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block1_1_relu[0][0]
conv4_block1_concat (Concatenat (None, 9, 9, 288)    0           pool3_pool[0][0]
                                                                 conv4_block1_2_conv[0][0]
conv4_block2_0_bn (BatchNormali (None, 9, 9, 288)    1152        conv4_block1_concat[0][0]
conv4_block2_0_relu (Activation (None, 9, 9, 288)    0           conv4_block2_0_bn[0][0]
conv4_block2_1_conv (Conv2D)    (None, 9, 9, 128)    36864       conv4_block2_0_relu[0][0]
conv4_block2_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block2_1_conv[0][0]
conv4_block2_1_relu (Activation (None, 9, 9, 128)    0           conv4_block2_1_bn[0][0]
conv4_block2_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block2_1_relu[0][0]
conv4_block2_concat (Concatenat (None, 9, 9, 320)    0           conv4_block1_concat[0][0]
                                                                 conv4_block2_2_conv[0][0]
conv4_block3_0_bn (BatchNormali (None, 9, 9, 320)    1280        conv4_block2_concat[0][0]
conv4_block3_0_relu (Activation (None, 9, 9, 320)    0           conv4_block3_0_bn[0][0]
conv4_block3_1_conv (Conv2D)    (None, 9, 9, 128)    40960       conv4_block3_0_relu[0][0]
conv4_block3_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block3_1_conv[0][0]
conv4_block3_1_relu (Activation (None, 9, 9, 128)    0           conv4_block3_1_bn[0][0]
conv4_block3_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block3_1_relu[0][0]
conv4_block3_concat (Concatenat (None, 9, 9, 352)    0           conv4_block2_concat[0][0]
                                                                 conv4_block3_2_conv[0][0]
conv4_block4_0_bn (BatchNormali (None, 9, 9, 352)    1408        conv4_block3_concat[0][0]
conv4_block4_0_relu (Activation (None, 9, 9, 352)    0           conv4_block4_0_bn[0][0]
conv4_block4_1_conv (Conv2D)    (None, 9, 9, 128)    45056       conv4_block4_0_relu[0][0]
conv4_block4_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block4_1_conv[0][0]
conv4_block4_1_relu (Activation (None, 9, 9, 128)    0           conv4_block4_1_bn[0][0]
conv4_block4_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block4_1_relu[0][0]
conv4_block4_concat (Concatenat (None, 9, 9, 384)    0           conv4_block3_concat[0][0]
                                                                 conv4_block4_2_conv[0][0]
conv4_block5_0_bn (BatchNormali (None, 9, 9, 384)    1536        conv4_block4_concat[0][0]
conv4_block5_0_relu (Activation (None, 9, 9, 384)    0           conv4_block5_0_bn[0][0]
conv4_block5_1_conv (Conv2D)    (None, 9, 9, 128)    49152       conv4_block5_0_relu[0][0]
conv4_block5_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block5_1_conv[0][0]
conv4_block5_1_relu (Activation (None, 9, 9, 128)    0           conv4_block5_1_bn[0][0]
conv4_block5_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block5_1_relu[0][0]
conv4_block5_concat (Concatenat (None, 9, 9, 416)    0           conv4_block4_concat[0][0]
                                                                 conv4_block5_2_conv[0][0]
conv4_block6_0_bn (BatchNormali (None, 9, 9, 416)    1664        conv4_block5_concat[0][0]
conv4_block6_0_relu (Activation (None, 9, 9, 416)    0           conv4_block6_0_bn[0][0]
conv4_block6_1_conv (Conv2D)    (None, 9, 9, 128)    53248       conv4_block6_0_relu[0][0]
conv4_block6_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block6_1_conv[0][0]
conv4_block6_1_relu (Activation (None, 9, 9, 128)    0           conv4_block6_1_bn[0][0]
conv4_block6_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block6_1_relu[0][0]
conv4_block6_concat (Concatenat (None, 9, 9, 448)    0           conv4_block5_concat[0][0]
                                                                 conv4_block6_2_conv[0][0]
conv4_block7_0_bn (BatchNormali (None, 9, 9, 448)    1792        conv4_block6_concat[0][0]
conv4_block7_0_relu (Activation (None, 9, 9, 448)    0           conv4_block7_0_bn[0][0]
conv4_block7_1_conv (Conv2D)    (None, 9, 9, 128)    57344       conv4_block7_0_relu[0][0]
conv4_block7_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block7_1_conv[0][0]
conv4_block7_1_relu (Activation (None, 9, 9, 128)    0           conv4_block7_1_bn[0][0]
conv4_block7_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block7_1_relu[0][0]
conv4_block7_concat (Concatenat (None, 9, 9, 480)    0           conv4_block6_concat[0][0]
                                                                 conv4_block7_2_conv[0][0]
conv4_block8_0_bn (BatchNormali (None, 9, 9, 480)    1920        conv4_block7_concat[0][0]
conv4_block8_0_relu (Activation (None, 9, 9, 480)    0           conv4_block8_0_bn[0][0]
conv4_block8_1_conv (Conv2D)    (None, 9, 9, 128)    61440       conv4_block8_0_relu[0][0]
conv4_block8_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block8_1_conv[0][0]
conv4_block8_1_relu (Activation (None, 9, 9, 128)    0           conv4_block8_1_bn[0][0]
conv4_block8_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block8_1_relu[0][0]
conv4_block8_concat (Concatenat (None, 9, 9, 512)    0           conv4_block7_concat[0][0]
                                                                 conv4_block8_2_conv[0][0]
conv4_block9_0_bn (BatchNormali (None, 9, 9, 512)    2048        conv4_block8_concat[0][0]
conv4_block9_0_relu (Activation (None, 9, 9, 512)    0           conv4_block9_0_bn[0][0]
conv4_block9_1_conv (Conv2D)    (None, 9, 9, 128)    65536       conv4_block9_0_relu[0][0]
conv4_block9_1_bn (BatchNormali (None, 9, 9, 128)    512         conv4_block9_1_conv[0][0]
conv4_block9_1_relu (Activation (None, 9, 9, 128)    0           conv4_block9_1_bn[0][0]
conv4_block9_2_conv (Conv2D)    (None, 9, 9, 32)     36864       conv4_block9_1_relu[0][0]
conv4_block9_concat (Concatenat (None, 9, 9, 544)    0           conv4_block8_concat[0][0]
                                                                 conv4_block9_2_conv[0][0]
conv4_block10_0_bn (BatchNormal (None, 9, 9, 544)    2176        conv4_block9_concat[0][0]
conv4_block10_0_relu (Activatio (None, 9, 9, 544)    0           conv4_block10_0_bn[0][0]
conv4_block10_1_conv (Conv2D)   (None, 9, 9, 128)    69632       conv4_block10_0_relu[0][0]
conv4_block10_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block10_1_conv[0][0]
conv4_block10_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block10_1_bn[0][0]
conv4_block10_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block10_1_relu[0][0]
conv4_block10_concat (Concatena (None, 9, 9, 576)    0           conv4_block9_concat[0][0]
                                                                 conv4_block10_2_conv[0][0]
conv4_block11_0_bn (BatchNormal (None, 9, 9, 576)    2304        conv4_block10_concat[0][0]
conv4_block11_0_relu (Activatio (None, 9, 9, 576)    0           conv4_block11_0_bn[0][0]
conv4_block11_1_conv (Conv2D)   (None, 9, 9, 128)    73728       conv4_block11_0_relu[0][0]
conv4_block11_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block11_1_conv[0][0]
conv4_block11_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block11_1_bn[0][0]
conv4_block11_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block11_1_relu[0][0]
conv4_block11_concat (Concatena (None, 9, 9, 608)    0           conv4_block10_concat[0][0]
                                                                 conv4_block11_2_conv[0][0]
conv4_block12_0_bn (BatchNormal (None, 9, 9, 608)    2432        conv4_block11_concat[0][0]
conv4_block12_0_relu (Activatio (None, 9, 9, 608)    0           conv4_block12_0_bn[0][0]
conv4_block12_1_conv (Conv2D)   (None, 9, 9, 128)    77824       conv4_block12_0_relu[0][0]
conv4_block12_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block12_1_conv[0][0]
conv4_block12_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block12_1_bn[0][0]
conv4_block12_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block12_1_relu[0][0]
conv4_block12_concat (Concatena (None, 9, 9, 640)    0           conv4_block11_concat[0][0]
                                                                 conv4_block12_2_conv[0][0]
conv4_block13_0_bn (BatchNormal (None, 9, 9, 640)    2560        conv4_block12_concat[0][0]
conv4_block13_0_relu (Activatio (None, 9, 9, 640)    0           conv4_block13_0_bn[0][0]
conv4_block13_1_conv (Conv2D)   (None, 9, 9, 128)    81920       conv4_block13_0_relu[0][0]
conv4_block13_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block13_1_conv[0][0]
conv4_block13_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block13_1_bn[0][0]
conv4_block13_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block13_1_relu[0][0]
conv4_block13_concat (Concatena (None, 9, 9, 672)    0           conv4_block12_concat[0][0]
                                                                 conv4_block13_2_conv[0][0]
conv4_block14_0_bn (BatchNormal (None, 9, 9, 672)    2688        conv4_block13_concat[0][0]
conv4_block14_0_relu (Activatio (None, 9, 9, 672)    0           conv4_block14_0_bn[0][0]
conv4_block14_1_conv (Conv2D)   (None, 9, 9, 128)    86016       conv4_block14_0_relu[0][0]
conv4_block14_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block14_1_conv[0][0]
conv4_block14_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block14_1_bn[0][0]
conv4_block14_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block14_1_relu[0][0]
conv4_block14_concat (Concatena (None, 9, 9, 704)    0           conv4_block13_concat[0][0]
                                                                 conv4_block14_2_conv[0][0]
conv4_block15_0_bn (BatchNormal (None, 9, 9, 704)    2816        conv4_block14_concat[0][0]
conv4_block15_0_relu (Activatio (None, 9, 9, 704)    0           conv4_block15_0_bn[0][0]
conv4_block15_1_conv (Conv2D)   (None, 9, 9, 128)    90112       conv4_block15_0_relu[0][0]
conv4_block15_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block15_1_conv[0][0]
conv4_block15_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block15_1_bn[0][0]
conv4_block15_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block15_1_relu[0][0]
conv4_block15_concat (Concatena (None, 9, 9, 736)    0           conv4_block14_concat[0][0]
                                                                 conv4_block15_2_conv[0][0]
conv4_block16_0_bn (BatchNormal (None, 9, 9, 736)    2944        conv4_block15_concat[0][0]
conv4_block16_0_relu (Activatio (None, 9, 9, 736)    0           conv4_block16_0_bn[0][0]
conv4_block16_1_conv (Conv2D)   (None, 9, 9, 128)    94208       conv4_block16_0_relu[0][0]
conv4_block16_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block16_1_conv[0][0]
conv4_block16_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block16_1_bn[0][0]
conv4_block16_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block16_1_relu[0][0]
conv4_block16_concat (Concatena (None, 9, 9, 768)    0           conv4_block15_concat[0][0]
                                                                 conv4_block16_2_conv[0][0]
conv4_block17_0_bn (BatchNormal (None, 9, 9, 768)    3072        conv4_block16_concat[0][0]
conv4_block17_0_relu (Activatio (None, 9, 9, 768)    0           conv4_block17_0_bn[0][0]
conv4_block17_1_conv (Conv2D)   (None, 9, 9, 128)    98304       conv4_block17_0_relu[0][0]
conv4_block17_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block17_1_conv[0][0]
conv4_block17_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block17_1_bn[0][0]
conv4_block17_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block17_1_relu[0][0]
conv4_block17_concat (Concatena (None, 9, 9, 800)    0           conv4_block16_concat[0][0]
                                                                 conv4_block17_2_conv[0][0]
conv4_block18_0_bn (BatchNormal (None, 9, 9, 800)    3200        conv4_block17_concat[0][0]
conv4_block18_0_relu (Activatio (None, 9, 9, 800)    0           conv4_block18_0_bn[0][0]
conv4_block18_1_conv (Conv2D)   (None, 9, 9, 128)    102400      conv4_block18_0_relu[0][0]
conv4_block18_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block18_1_conv[0][0]
conv4_block18_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block18_1_bn[0][0]
conv4_block18_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block18_1_relu[0][0]
conv4_block18_concat (Concatena (None, 9, 9, 832)    0           conv4_block17_concat[0][0]
                                                                 conv4_block18_2_conv[0][0]
conv4_block19_0_bn (BatchNormal (None, 9, 9, 832)    3328        conv4_block18_concat[0][0]
conv4_block19_0_relu (Activatio (None, 9, 9, 832)    0           conv4_block19_0_bn[0][0]
conv4_block19_1_conv (Conv2D)   (None, 9, 9, 128)    106496      conv4_block19_0_relu[0][0]
conv4_block19_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block19_1_conv[0][0]
conv4_block19_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block19_1_bn[0][0]
conv4_block19_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block19_1_relu[0][0]
conv4_block19_concat (Concatena (None, 9, 9, 864)    0           conv4_block18_concat[0][0]
                                                                 conv4_block19_2_conv[0][0]
conv4_block20_0_bn (BatchNormal (None, 9, 9, 864)    3456        conv4_block19_concat[0][0]
conv4_block20_0_relu (Activatio (None, 9, 9, 864)    0           conv4_block20_0_bn[0][0]
conv4_block20_1_conv (Conv2D)   (None, 9, 9, 128)    110592      conv4_block20_0_relu[0][0]
conv4_block20_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block20_1_conv[0][0]
conv4_block20_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block20_1_bn[0][0]
conv4_block20_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block20_1_relu[0][0]
conv4_block20_concat (Concatena (None, 9, 9, 896)    0           conv4_block19_concat[0][0]
                                                                 conv4_block20_2_conv[0][0]
conv4_block21_0_bn (BatchNormal (None, 9, 9, 896)    3584        conv4_block20_concat[0][0]
conv4_block21_0_relu (Activatio (None, 9, 9, 896)    0           conv4_block21_0_bn[0][0]
conv4_block21_1_conv (Conv2D)   (None, 9, 9, 128)    114688      conv4_block21_0_relu[0][0]
conv4_block21_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block21_1_conv[0][0]
conv4_block21_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block21_1_bn[0][0]
conv4_block21_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block21_1_relu[0][0]
conv4_block21_concat (Concatena (None, 9, 9, 928)    0           conv4_block20_concat[0][0]
                                                                 conv4_block21_2_conv[0][0]
conv4_block22_0_bn (BatchNormal (None, 9, 9, 928)    3712        conv4_block21_concat[0][0]
conv4_block22_0_relu (Activatio (None, 9, 9, 928)    0           conv4_block22_0_bn[0][0]
conv4_block22_1_conv (Conv2D)   (None, 9, 9, 128)    118784      conv4_block22_0_relu[0][0]
conv4_block22_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block22_1_conv[0][0]
conv4_block22_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block22_1_bn[0][0]
conv4_block22_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block22_1_relu[0][0]
conv4_block22_concat (Concatena (None, 9, 9, 960)    0           conv4_block21_concat[0][0]
                                                                 conv4_block22_2_conv[0][0]
conv4_block23_0_bn (BatchNormal (None, 9, 9, 960)    3840        conv4_block22_concat[0][0]
conv4_block23_0_relu (Activatio (None, 9, 9, 960)    0           conv4_block23_0_bn[0][0]
conv4_block23_1_conv (Conv2D)   (None, 9, 9, 128)    122880      conv4_block23_0_relu[0][0]
conv4_block23_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block23_1_conv[0][0]
conv4_block23_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block23_1_bn[0][0]
conv4_block23_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block23_1_relu[0][0]
conv4_block23_concat (Concatena (None, 9, 9, 992)    0           conv4_block22_concat[0][0]
                                                                 conv4_block23_2_conv[0][0]
conv4_block24_0_bn (BatchNormal (None, 9, 9, 992)    3968        conv4_block23_concat[0][0]
conv4_block24_0_relu (Activatio (None, 9, 9, 992)    0           conv4_block24_0_bn[0][0]
conv4_block24_1_conv (Conv2D)   (None, 9, 9, 128)    126976      conv4_block24_0_relu[0][0]
conv4_block24_1_bn (BatchNormal (None, 9, 9, 128)    512         conv4_block24_1_conv[0][0]
conv4_block24_1_relu (Activatio (None, 9, 9, 128)    0           conv4_block24_1_bn[0][0]
conv4_block24_2_conv (Conv2D)   (None, 9, 9, 32)     36864       conv4_block24_1_relu[0][0]
conv4_block24_concat (Concatena (None, 9, 9, 1024)   0           conv4_block23_concat[0][0]
                                                                 conv4_block24_2_conv[0][0]
pool4_bn (BatchNormalization)   (None, 9, 9, 1024)   4096        conv4_block24_concat[0][0]
pool4_relu (Activation)         (None, 9, 9, 1024)   0           pool4_bn[0][0]
pool4_conv (Conv2D)             (None, 9, 9, 512)    524288      pool4_relu[0][0]
pool4_pool (AveragePooling2D)   (None, 4, 4, 512)    0           pool4_conv[0][0]
conv5_block1_0_bn (BatchNormali (None, 4, 4, 512)    2048        pool4_pool[0][0]
conv5_block1_0_relu (Activation (None, 4, 4, 512)    0           conv5_block1_0_bn[0][0]
conv5_block1_1_conv (Conv2D)    (None, 4, 4, 128)    65536       conv5_block1_0_relu[0][0]
conv5_block1_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block1_1_conv[0][0]
conv5_block1_1_relu (Activation (None, 4, 4, 128)    0           conv5_block1_1_bn[0][0]
conv5_block1_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block1_1_relu[0][0]
conv5_block1_concat (Concatenat (None, 4, 4, 544)    0           pool4_pool[0][0]
                                                                 conv5_block1_2_conv[0][0]
conv5_block2_0_bn (BatchNormali (None, 4, 4, 544)    2176        conv5_block1_concat[0][0]
conv5_block2_0_relu (Activation (None, 4, 4, 544)    0           conv5_block2_0_bn[0][0]
conv5_block2_1_conv (Conv2D)    (None, 4, 4, 128)    69632       conv5_block2_0_relu[0][0]
conv5_block2_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block2_1_conv[0][0]
conv5_block2_1_relu (Activation (None, 4, 4, 128)    0           conv5_block2_1_bn[0][0]
conv5_block2_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block2_1_relu[0][0]
conv5_block2_concat (Concatenat (None, 4, 4, 576)    0           conv5_block1_concat[0][0]
                                                                 conv5_block2_2_conv[0][0]
conv5_block3_0_bn (BatchNormali (None, 4, 4, 576)    2304        conv5_block2_concat[0][0]
conv5_block3_0_relu (Activation (None, 4, 4, 576)    0           conv5_block3_0_bn[0][0]
conv5_block3_1_conv (Conv2D)    (None, 4, 4, 128)    73728       conv5_block3_0_relu[0][0]
conv5_block3_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block3_1_conv[0][0]
conv5_block3_1_relu (Activation (None, 4, 4, 128)    0           conv5_block3_1_bn[0][0]
conv5_block3_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block3_1_relu[0][0]
conv5_block3_concat (Concatenat (None, 4, 4, 608)    0           conv5_block2_concat[0][0]
                                                                 conv5_block3_2_conv[0][0]
conv5_block4_0_bn (BatchNormali (None, 4, 4, 608)    2432        conv5_block3_concat[0][0]
conv5_block4_0_relu (Activation (None, 4, 4, 608)    0           conv5_block4_0_bn[0][0]
conv5_block4_1_conv (Conv2D)    (None, 4, 4, 128)    77824       conv5_block4_0_relu[0][0]
conv5_block4_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block4_1_conv[0][0]
conv5_block4_1_relu (Activation (None, 4, 4, 128)    0           conv5_block4_1_bn[0][0]
conv5_block4_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block4_1_relu[0][0]
conv5_block4_concat (Concatenat (None, 4, 4, 640)    0           conv5_block3_concat[0][0]
                                                                 conv5_block4_2_conv[0][0]
conv5_block5_0_bn (BatchNormali (None, 4, 4, 640)    2560        conv5_block4_concat[0][0]
conv5_block5_0_relu (Activation (None, 4, 4, 640)    0           conv5_block5_0_bn[0][0]
conv5_block5_1_conv (Conv2D)    (None, 4, 4, 128)    81920       conv5_block5_0_relu[0][0]
conv5_block5_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block5_1_conv[0][0]
conv5_block5_1_relu (Activation (None, 4, 4, 128)    0           conv5_block5_1_bn[0][0]
conv5_block5_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block5_1_relu[0][0]
conv5_block5_concat (Concatenat (None, 4, 4, 672)    0           conv5_block4_concat[0][0]
                                                                 conv5_block5_2_conv[0][0]
conv5_block6_0_bn (BatchNormali (None, 4, 4, 672)    2688        conv5_block5_concat[0][0]
conv5_block6_0_relu (Activation (None, 4, 4, 672)    0           conv5_block6_0_bn[0][0]
conv5_block6_1_conv (Conv2D)    (None, 4, 4, 128)    86016       conv5_block6_0_relu[0][0]
conv5_block6_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block6_1_conv[0][0]
conv5_block6_1_relu (Activation (None, 4, 4, 128)    0           conv5_block6_1_bn[0][0]
conv5_block6_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block6_1_relu[0][0]
conv5_block6_concat (Concatenat (None, 4, 4, 704)    0           conv5_block5_concat[0][0]
                                                                 conv5_block6_2_conv[0][0]
conv5_block7_0_bn (BatchNormali (None, 4, 4, 704)    2816        conv5_block6_concat[0][0]
conv5_block7_0_relu (Activation (None, 4, 4, 704)    0           conv5_block7_0_bn[0][0]
conv5_block7_1_conv (Conv2D)    (None, 4, 4, 128)    90112       conv5_block7_0_relu[0][0]
conv5_block7_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block7_1_conv[0][0]
conv5_block7_1_relu (Activation (None, 4, 4, 128)    0           conv5_block7_1_bn[0][0]
conv5_block7_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block7_1_relu[0][0]
conv5_block7_concat (Concatenat (None, 4, 4, 736)    0           conv5_block6_concat[0][0]
                                                                 conv5_block7_2_conv[0][0]
conv5_block8_0_bn (BatchNormali (None, 4, 4, 736)    2944        conv5_block7_concat[0][0]
conv5_block8_0_relu (Activation (None, 4, 4, 736)    0           conv5_block8_0_bn[0][0]
conv5_block8_1_conv (Conv2D)    (None, 4, 4, 128)    94208       conv5_block8_0_relu[0][0]
conv5_block8_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block8_1_conv[0][0]
conv5_block8_1_relu (Activation (None, 4, 4, 128)    0           conv5_block8_1_bn[0][0]
conv5_block8_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block8_1_relu[0][0]
conv5_block8_concat (Concatenat (None, 4, 4, 768)    0           conv5_block7_concat[0][0]
                                                                 conv5_block8_2_conv[0][0]
conv5_block9_0_bn (BatchNormali (None, 4, 4, 768)    3072        conv5_block8_concat[0][0]
conv5_block9_0_relu (Activation (None, 4, 4, 768)    0           conv5_block9_0_bn[0][0]
conv5_block9_1_conv (Conv2D)    (None, 4, 4, 128)    98304       conv5_block9_0_relu[0][0]
conv5_block9_1_bn (BatchNormali (None, 4, 4, 128)    512         conv5_block9_1_conv[0][0]
conv5_block9_1_relu (Activation (None, 4, 4, 128)    0           conv5_block9_1_bn[0][0]
conv5_block9_2_conv (Conv2D)    (None, 4, 4, 32)     36864       conv5_block9_1_relu[0][0]
conv5_block9_concat (Concatenat (None, 4, 4, 800)    0           conv5_block8_concat[0][0]
                                                                 conv5_block9_2_conv[0][0]
conv5_block10_0_bn (BatchNormal (None, 4, 4, 800)    3200        conv5_block9_concat[0][0]
conv5_block10_0_relu (Activatio (None, 4, 4, 800)    0           conv5_block10_0_bn[0][0]
conv5_block10_1_conv (Conv2D)   (None, 4, 4, 128)    102400      conv5_block10_0_relu[0][0]
conv5_block10_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block10_1_conv[0][0]
conv5_block10_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block10_1_bn[0][0]
conv5_block10_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block10_1_relu[0][0]
conv5_block10_concat (Concatena (None, 4, 4, 832)    0           conv5_block9_concat[0][0]
                                                                 conv5_block10_2_conv[0][0]
conv5_block11_0_bn (BatchNormal (None, 4, 4, 832)    3328        conv5_block10_concat[0][0]
conv5_block11_0_relu (Activatio (None, 4, 4, 832)    0           conv5_block11_0_bn[0][0]
conv5_block11_1_conv (Conv2D)   (None, 4, 4, 128)    106496      conv5_block11_0_relu[0][0]
conv5_block11_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block11_1_conv[0][0]
conv5_block11_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block11_1_bn[0][0]
conv5_block11_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block11_1_relu[0][0]
conv5_block11_concat (Concatena (None, 4, 4, 864)    0           conv5_block10_concat[0][0]
                                                                 conv5_block11_2_conv[0][0]
conv5_block12_0_bn (BatchNormal (None, 4, 4, 864)    3456        conv5_block11_concat[0][0]
conv5_block12_0_relu (Activatio (None, 4, 4, 864)    0           conv5_block12_0_bn[0][0]
conv5_block12_1_conv (Conv2D)   (None, 4, 4, 128)    110592      conv5_block12_0_relu[0][0]
conv5_block12_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block12_1_conv[0][0]
conv5_block12_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block12_1_bn[0][0]
conv5_block12_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block12_1_relu[0][0]
conv5_block12_concat (Concatena (None, 4, 4, 896)    0           conv5_block11_concat[0][0]
                                                                 conv5_block12_2_conv[0][0]
conv5_block13_0_bn (BatchNormal (None, 4, 4, 896)    3584        conv5_block12_concat[0][0]
conv5_block13_0_relu (Activatio (None, 4, 4, 896)    0           conv5_block13_0_bn[0][0]
conv5_block13_1_conv (Conv2D)   (None, 4, 4, 128)    114688      conv5_block13_0_relu[0][0]
conv5_block13_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block13_1_conv[0][0]
conv5_block13_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block13_1_bn[0][0]
conv5_block13_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block13_1_relu[0][0]
conv5_block13_concat (Concatena (None, 4, 4, 928)    0           conv5_block12_concat[0][0]
                                                                 conv5_block13_2_conv[0][0]
conv5_block14_0_bn (BatchNormal (None, 4, 4, 928)    3712        conv5_block13_concat[0][0]
conv5_block14_0_relu (Activatio (None, 4, 4, 928)    0           conv5_block14_0_bn[0][0]
conv5_block14_1_conv (Conv2D)   (None, 4, 4, 128)    118784      conv5_block14_0_relu[0][0]
conv5_block14_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block14_1_conv[0][0]
conv5_block14_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block14_1_bn[0][0]
conv5_block14_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block14_1_relu[0][0]
conv5_block14_concat (Concatena (None, 4, 4, 960)    0           conv5_block13_concat[0][0]
                                                                 conv5_block14_2_conv[0][0]
conv5_block15_0_bn (BatchNormal (None, 4, 4, 960)    3840        conv5_block14_concat[0][0]
conv5_block15_0_relu (Activatio (None, 4, 4, 960)    0           conv5_block15_0_bn[0][0]
conv5_block15_1_conv (Conv2D)   (None, 4, 4, 128)    122880      conv5_block15_0_relu[0][0]
conv5_block15_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block15_1_conv[0][0]
conv5_block15_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block15_1_bn[0][0]
conv5_block15_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block15_1_relu[0][0]
conv5_block15_concat (Concatena (None, 4, 4, 992)    0           conv5_block14_concat[0][0]
                                                                 conv5_block15_2_conv[0][0]
conv5_block16_0_bn (BatchNormal (None, 4, 4, 992)    3968        conv5_block15_concat[0][0]
conv5_block16_0_relu (Activatio (None, 4, 4, 992)    0           conv5_block16_0_bn[0][0]
conv5_block16_1_conv (Conv2D)   (None, 4, 4, 128)    126976      conv5_block16_0_relu[0][0]
conv5_block16_1_bn (BatchNormal (None, 4, 4, 128)    512         conv5_block16_1_conv[0][0]
conv5_block16_1_relu (Activatio (None, 4, 4, 128)    0           conv5_block16_1_bn[0][0]
conv5_block16_2_conv (Conv2D)   (None, 4, 4, 32)     36864       conv5_block16_1_relu[0][0]
conv5_block16_concat (Concatena (None, 4, 4, 1024)   0           conv5_block15_concat[0][0]
                                                                 conv5_block16_2_conv[0][0]
bn (BatchNormalization)         (None, 4, 4, 1024)   4096        conv5_block16_concat[0][0]
relu (Activation)               (None, 4, 4, 1024)   0           bn[0][0]
avg_pool (GlobalAveragePooling2 (None, 1024)         0           relu[0][0]
==================================================================================================
Total params: 7,037,504
Trainable params: 6,953,856
Non-trainable params: 83,648
```

In [40]:

```
layers = densedet121.layers
print(f"The model has {len(layers)} layers")
```

```
The model has 428 layers
```

In [41]:

```
print(f"The input shape {densedet121.input}")
print(f"The output shape {densedet121.output}")
```

```
The input shape Tensor("input_1:0", shape=(None, 150, 150, 3), dtype=float32)
The output shape Tensor("avg_pool/Mean:0", shape=(None, 1024), dtype=float32)
```

In [48]:

```
#model = Sequential()
densedet121 = DenseNet121(include_top=False, weights='imagenet')
x = densedet121.output

x = GlobalAveragePooling2D()(x)

predictions = Dense(1, activation="sigmoid")(x)

model4 = Model(inputs=densedet121.input, outputs=predictions)
#model.add(densedet121)
#model.add(GlobalAveragePooling2D())
#model.add(Dense(1, activation='sigmoid'))


model4.compile(
               loss='binary_crossentropy',
               optimizer='adam',
               metrics=['accuracy'])
```

In [49]:

```
history4 = model4.fit(
    train_generator,
    epochs=20,
    validation_data=validation_generator,
    validation_steps=10,
)
```

```
Epoch 1/20
61/61 [==============================] - 613s 10s/step - loss: 0.1322 - accuracy: 0.9542 - val_loss: 0.9519
- val_accuracy: 0.8188
Epoch 2/20
61/61 [==============================] - 619s 10s/step - loss: 0.0407 - accuracy: 0.9860 - val_loss: 0.0148
- val_accuracy: 0.9937
Epoch 3/20
61/61 [==============================] - 551s 9s/step - loss: 0.0278 - accuracy: 0.9891 - val_loss: 1.3600 -
val_accuracy: 0.8469
Epoch 4/20
61/61 [==============================] - 518s 8s/step - loss: 0.0210 - accuracy: 0.9922 - val_loss: 0.0613 -
val_accuracy: 0.9844
Epoch 5/20
61/61 [==============================] - 524s 9s/step - loss: 0.0145 - accuracy: 0.9948 - val_loss: 2.4321 -
val_accuracy: 0.5813
Epoch 6/20
61/61 [==============================] - 520s 9s/step - loss: 0.0809 - accuracy: 0.9750 - val_loss: 1.1067 -
val_accuracy: 0.8562
Epoch 7/20
61/61 [==============================] - 524s 9s/step - loss: 0.1328 - accuracy: 0.9579 - val_loss: 4.8409 -
val_accuracy: 0.7312
Epoch 8/20
61/61 [==============================] - 516s 8s/step - loss: 0.0873 - accuracy: 0.9745 - val_loss: 63.9815
```

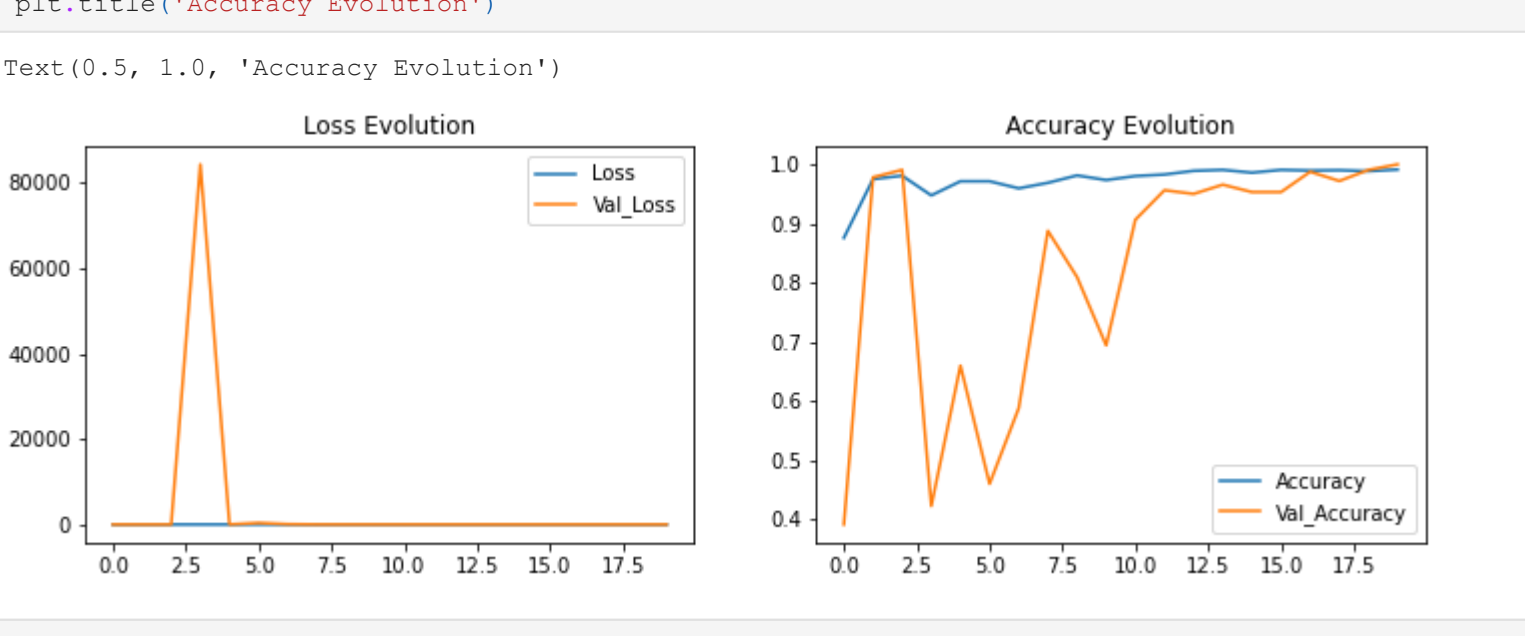
```
Epoch 4/20
61/61 [==============================] - 237s 4s/step - loss: 0.1794 - accuracy: 0.9475 - precision: 0.9555 - recall: 0.9254 - val_loss: 84364.6250 - val_accuracy: 0.4219 - val_precision: 0.4219 - val_recall: 1.0000
Epoch 5/20
61/61 [==============================] - 232s 4s/step - loss: 0.1104 - accuracy: 0.9714 - precision: 0.9674 - recall: 0.9685 - val_loss: 24.0196 - val_accuracy: 0.6594 - val_precision: 0.5737 - val_recall: 0.9863
Epoch 6/20
61/61 [==============================] - 229s 4s/step - loss: 0.0925 - accuracy: 0.9714 - precision: 0.9785 - recall: 0.9569 - val_loss: 361.3386 - val_accuracy: 0.4594 - val_precision: 0.4577 - val_recall: 1.0000
Epoch 7/20
61/61 [==============================] - 221s 4s/step - loss: 0.1354 - accuracy: 0.9594 - precision: 0.9610 - recall: 0.9476 - val_loss: 73.0375 - val_accuracy: 0.5875 - val_precision: 0.5166 - val_recall: 0.9929
Epoch 8/20
61/61 [==============================] - 223s 4s/step - loss: 0.1014 - accuracy: 0.9688 - precision: 0.9694 - recall: 0.9604 - val_loss: 8.9960 - val_accuracy: 0.8875 - val_precision: 0.8057 - val_recall: 0.9860
Epoch 9/20
61/61 [==============================] - 225s 4s/step - loss: 0.0620 - accuracy: 0.9813 - precision: 0.9813 - recall: 0.9767 - val_loss: 2.3987 - val_accuracy: 0.8094 - val_precision: 0.8559 - val_recall: 0.6966
Epoch 10/20
61/61 [==============================] - 221s 4s/step - loss: 0.0850 - accuracy: 0.9735 - precision: 0.9764 - recall: 0.9639 - val_loss: 0.9961 - val_accuracy: 0.6938 - val_precision: 0.8333 - val_recall: 0.4110
Epoch 11/20
61/61 [==============================] - 231s 4s/step - loss: 0.0749 - accuracy: 0.9802 - precision: 0.9812 - recall: 0.9744 - val_loss: 1.4631 - val_accuracy: 0.9062 - val_precision: 0.8544 - val_recall: 0.9507
Epoch 12/20
61/61 [==============================] - 227s 4s/step - loss: 0.0726 - accuracy: 0.9828 - precision: 0.9825 - recall: 0.9790 - val_loss: 2.3520 - val_accuracy: 0.9563 - val_precision: 0.9085 - val_recall: 1.0000
Epoch 13/20
61/61 [==============================] - 228s 4s/step - loss: 0.0432 - accuracy: 0.9891 - precision: 0.9883 - recall: 0.9872 - val_loss: 2.8533 - val_accuracy: 0.9500 - val_precision: 0.9000 - val_recall: 1.0000
Epoch 14/20
61/61 [==============================] - 216s 4s/step - loss: 0.0444 - accuracy: 0.9906 - precision: 0.9884 - recall: 0.9907 - val_loss: 0.8346 - val_accuracy: 0.9656 - val_precision: 0.9276 - val_recall: 1.0000
Epoch 15/20
61/61 [==============================] - 222s 4s/step - loss: 0.0500 - accuracy: 0.9860 - precision: 0.9860 - recall: 0.9825 - val_loss: 0.8447 - val_accuracy: 0.9531 - val_precision: 0.9051 - val_recall: 1.0000
Epoch 16/20
61/61 [==============================] - 218s 4s/step - loss: 0.0340 - accuracy: 0.9906 - precision: 0.9884 - recall: 0.9907 - val_loss: 0.5005 - val_accuracy: 0.9531 - val_precision: 0.9324 - val_recall: 0.9650
Epoch 17/20
61/61 [==============================] - 216s 4s/step - loss: 0.0408 - accuracy: 0.9896 - precision: 0.9883 - recall: 0.9883 - val_loss: 0.0459 - val_accuracy: 0.9875 - val_precision: 0.9929 - val_recall: 0.9789
Epoch 18/20
61/61 [==============================] - 214s 4s/step - loss: 0.0462 - accuracy: 0.9901 - precision: 0.9918 - recall: 0.9860 - val_loss: 0.1310 - val_accuracy: 0.9719 - val_precision: 0.9650 - val_recall: 0.9718
Epoch 19/20
61/61 [==============================] - 213s 3s/step - loss: 0.0412 - accuracy: 0.9886 - precision: 0.9895 - recall: 0.9848 - val_loss: 0.0472 - val_accuracy: 0.9906 - val_precision: 0.9787 - val_recall: 1.0000
Epoch 20/20
61/61 [==============================] - 212s 3s/step - loss: 0.0352 - accuracy: 0.9912 - precision: 0.9918 - recall: 0.9883 - val_loss: 0.0097 - val_accuracy: 1.0000 - val_precision: 1.0000 - val_recall: 1.0000
```

In [69]:

```
plt.figure(figsize=(12, 8))

plt.subplot(2, 2, 1)
plt.plot(history7.history['loss'], label='Loss')
plt.plot(history7.history['val_loss'], label='Val_Loss')
plt.legend()
plt.title('Loss Evolution')

plt.subplot(2, 2, 2)
plt.plot(history7.history['accuracy'], label='Accuracy')
plt.plot(history7.history['val_accuracy'], label='Val_Accuracy')
plt.legend()
plt.title('Accuracy Evolution')
```

Out[69]:

```
Text(0.5, 1.0, 'Accuracy Evolution')
```



In [70]:

```
evaluation =inception_model.evaluate(test_generator)
print(f"Test Accuracy: {evaluation[1] * 100:.2f}%")

evaluation = inception_model.evaluate(train_generator)
print(f"Train Accuracy: {evaluation[1] * 100:.2f}%")
```

```
19/19 [==============================] - 25s 1s/step - loss: 0.0440 - accuracy: 0.9834 - precision: 0.9814 - recall: 0.9814
Test Accuracy: 98.34%
61/61 [==============================] - 44s 716ms/step - loss: 0.0419 - accuracy: 0.9938 - precision: 0.9907 - recall: 0.9953
Train Accuracy: 99.38%
```

In [ ]:

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In [ ]:

In [ ]:

In [ ]:

In [ ]:

```
# test your model with some images from your local computer to predict whether a patient is affected by Covi
import numpy as np
from google.colab import files
from keras.preprocessing import image

uploaded = files.upload()
for fn in uploaded.keys():
  path = '/content/'+fn
  print(path)
  img = image.load_img(path, target_size = (150,150))
  x = image.img_to_array(img)
  x = np.expand_dims(x, axis = 0)
  images = np.vstack([x])
  classes = model.predict(images, batch_size=10)
  print(fn)
  if classes == 0:
    print('Covid19')
  else:
    print('Normal')
```

In [ ]:

```
from google.colab import drive
drive.mount('/content/gdrive')
```

In [ ]:

```
model_save_name = 'colab_with_dropout.h5'
path = F"/content/gdrive/My Drive/Temp/{model_save_name}"
model.save(path)
```

In [ ]:

```
model_save_name = 'colab_without_dropout.h5'
path = F"/content/gdrive/My Drive/Temp/{model_save_name}"
model2.save(path)
```

In [ ]: