VGG16 Notes:

- On first pass, validation is better than training from the start. Something feels wrong about this.
- Shuffling the data still results in the same problems
- No luck with reducing the alterations (rotation, shearing, zoom and so on) either
- Lowering the learning rate and adding momentum - works! Overfitting starts happening around epoch 5, so we'll train for 5 epochs in the final model.

InceptionV3 Notes:

- Overfit right away, even with slow learning rate, slow momentum and lots of training data manipulation (shearing, zoom, crop, and so on).
- Adding dropout makes it diffucult to learn (accuracy below 90%)
- Even allowing a few of the later layers of the inception model to be trainable results in a really awful accuracy + loss curve (see below).
- Since we were able to achieve approx. 95% accuracy with the vgg16-based model, it doesn't seem worth it to continue fine-tuning the inception model, especially at 30 minutes per epoch!

In [11]:

```
# Standard modules
from IPython.display import display
import itertools
import random

# Third-party modules
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from pathlib import Path
import pydot_ng as pydot
import shutil
from sklearn.metrics import confusion_matrix
from tensorflow.keras import optimizers
from tensorflow.keras.applications import VGG16, InceptionV3
from tensorflow.keras.layers import Flatten, Dense, Dropout
from tensorflow.keras.models import Sequential, load_model
from tensorflow.keras.preprocessing.image import ImageDataGenerator, array_to_img
from tensorflow.keras.utils import plot_model
```

In [5]:

```
random.seed(42)
plt.xkcd()
# The following is a very ugly hack to get the plot_model function to work properly
import os
os.environ['PATH'] = os.environ['PATH']+';'+os.environ['CONDA_PREFIX']+r"\Library\bin\graphviz"
```

In [3]:
```
img_attribute_file = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\Independent_Study_AI_ML'
                      r'\Celeb_Photos_20191114\list_attr_celeba_csv_correction_headers.txt')
attributes = pd.read_csv(img_attribute_file).sample(frac=1).reset_index(drop=True)

# Use all images for this binary classification problem.
males = attributes[['FileName']][attributes['Male']==1]
females = attributes[['FileName']][attributes['Male']==-1]

training_count = round(0.6 * len(males)) + round(0.6 * len(females))
val_count = round(0.2 * len(males)) + round(0.2 * len(females))
```

In [4]:
```
src_root = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\Independent_Study_AI_ML'
           r'\Celeb_Photos_20191114\img_align_celeba')

dst_root = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
               r'\Assignment_2\Images')
shutil.rmtree(dst_root)
```

Let's use a 60%, 20%, 20% split for training, validation, and test. That's roughly 120k, 40k, and 40k respectively.

In [5]:
```
train_male_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                      r'\Assignment_2\Images\train\male')
train_male_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(males[:round(0.6 * len(males))]):
    shutil.copy(src_root / img[0], train_male_pth)
```

In [6]:
```
train_female_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                        r'\Assignment_2\Images\train\female')
train_female_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(females[:round(0.6*len(females))]):
    shutil.copy(src_root / img[0], train_female_pth)
```

In [7]:
```
validation_male_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                           r'\Assignment_2\Images\validation\male')
validation_male_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(males[round(0.6 * len(males)):round(0.8 * len(males))]):
    shutil.copy(src_root / img[0], validation_male_pth)
```

In [8]:
```
validation_female_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learnin
g'
                             r'\Assignment_2\Images\validation\female')
validation_female_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(females[round(0.6*len(females)):round(0.8*len(females))]):
    shutil.copy(src_root / img[0], validation_female_pth)
```

In [9]:
```
test_male_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                     r'\Assignment_2\Images\test\male')
test_male_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(males[round(0.8*len(males)):]):
    shutil.copy(src_root / img[0], test_male_pth)
```

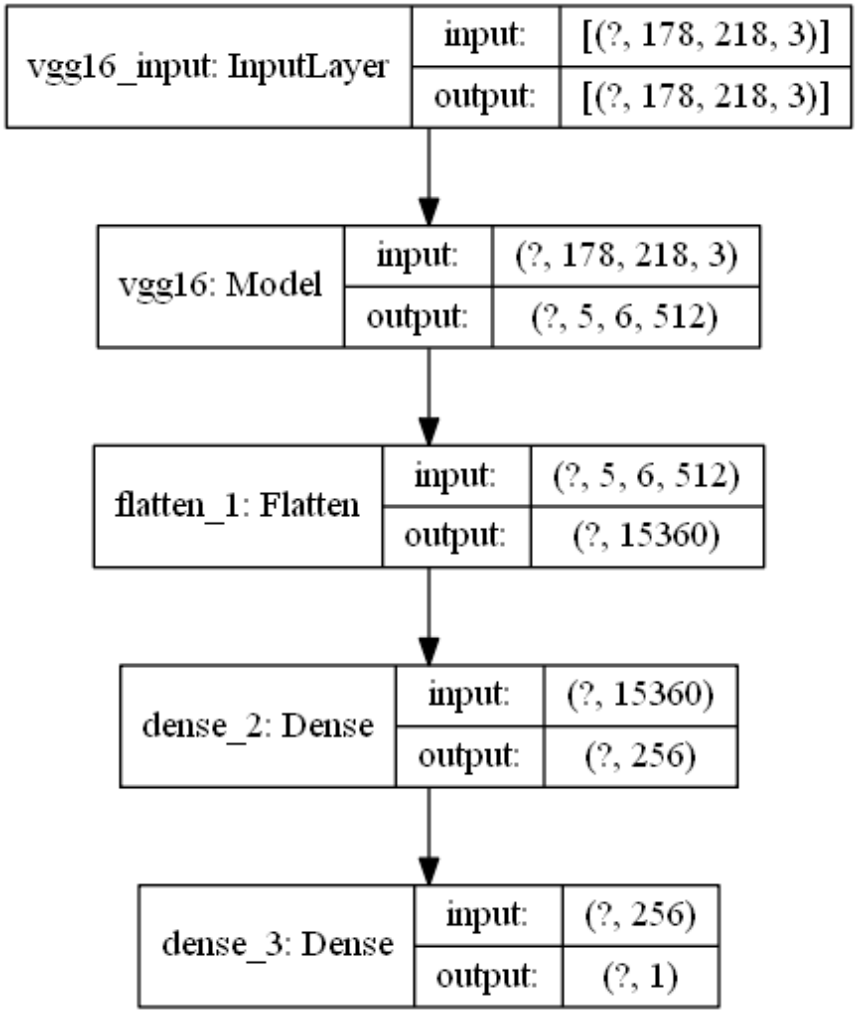
In [10]:
```
test_female_pth = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                       r'\Assignment_2\Images\test\female')
test_female_pth.mkdir(parents=True, exist_ok=True)
for img in np.array(females[round(0.8*len(females)):]):
    shutil.copy(src_root / img[0], test_female_pth)
```

In [6]:
```
vgg16_conv_base = VGG16(weights='imagenet',
include_top=False,
input_shape=(178, 218, 3))

vgg16_mdl = Sequential()
vgg16_mdl.add(vgg16_conv_base)
vgg16_mdl.add(Flatten())
vgg16_mdl.add(Dense(256, activation='relu'))
vgg16_mdl.add(Dense(1, activation='sigmoid'))

vgg16_conv_base.trainable = False
```

In [12]:
```
vgg16_mdl.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Model)                (None, 5, 6, 512)         14714688
_________________________________________________________________
flatten (Flatten)            (None, 15360)             0
_________________________________________________________________
dense (Dense)                (None, 256)               3932416
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 257
=================================================================
Total params: 18,647,361
Trainable params: 3,932,673
Non-trainable params: 14,714,688
_________________________________________________________________
```

In [10]:
```
plot_model(vgg16_mdl, to_file='model_plot.png', show_shapes=True, show_layer_names=True)
```



In [13]:

```
train_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
             r'\Assignment_2\Images\train')
validation_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                  r'\Assignment_2\Images\validation')


train_datagen = ImageDataGenerator(
```

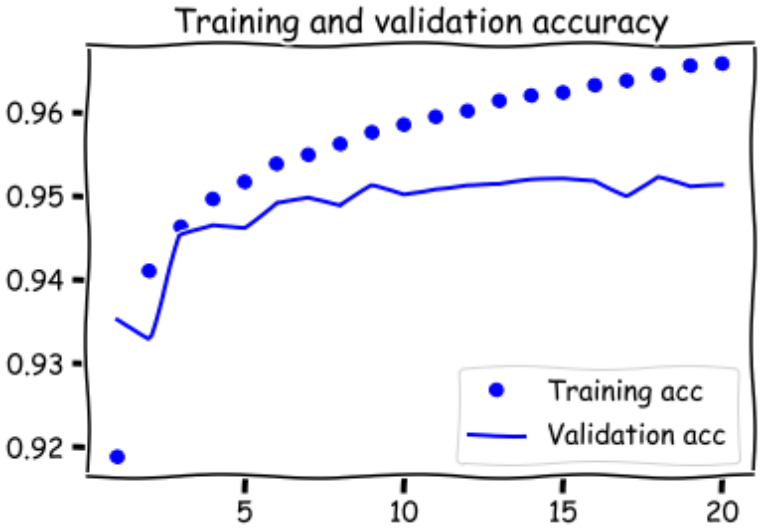
```
    rescale=1./255,
    #rotation_range=40,
    #width_shift_range=0.2,
    #height_shift_range=0.2,
    #shear_range=0.2,
    #zoom_range=0.2,
    #horizontal_flip=True,
    fill_mode='nearest')

val_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=(178, 218),
    batch_size=20,
    class_mode='binary')

validation_generator = val_datagen.flow_from_directory(
    validation_dir,
    target_size=(178, 218),
    batch_size=20,
    class_mode='binary')

vgg16_mdl.compile(loss='binary_crossentropy',
    optimizer=optimizers.RMSprop(learning_rate=0.000005, rho=0.9),
    metrics=['acc'])

history = vgg16_mdl.fit_generator(
    train_generator,
    steps_per_epoch=round(training_count/20),
    epochs=20,
    validation_data=validation_generator,
    validation_steps= round(val_count/20))
```

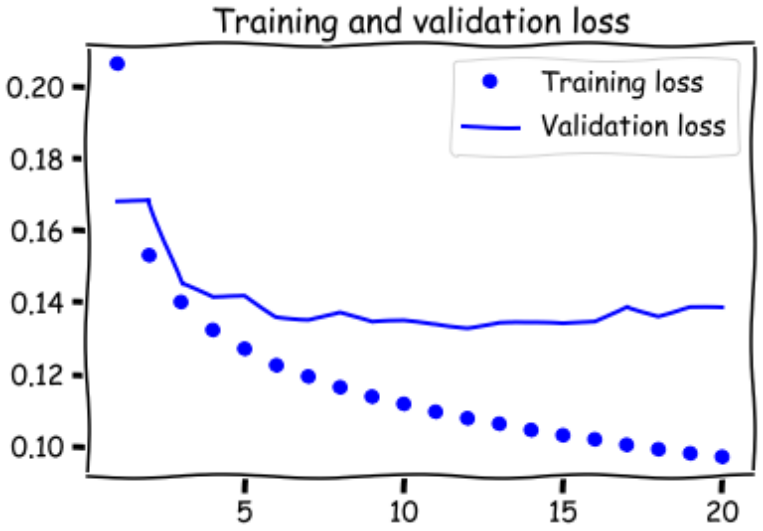
```
Found 121559 images belonging to 2 classes.
Found 40520 images belonging to 2 classes.
WARNING:tensorflow:From <ipython-input-13-be1cb70322cd>:39: Model.fit_generator (from tensorflow.python.keras.engine.training) is deprecated and will be removed in a future version.
Instructions for updating:
Please use Model.fit, which supports generators.
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
Train for 6078 steps, validate for 2026 steps
Epoch 1/20
6078/6078 [==============================] - 2644s 435ms/step - loss: 0.2062 - acc: 0.9188 - val_loss: 0.1680 - val_acc: 0.9352
Epoch 2/20
6078/6078 [==============================] - 1890s 311ms/step - loss: 0.1529 - acc: 0.9409 - val_loss: 0.1689 - val_acc: 0.9331
Epoch 3/20
6078/6078 [==============================] - 1891s 311ms/step - loss: 0.1399 - acc: 0.9462 - val_loss: 0.1449 - val_acc: 0.9451
Epoch 4/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1321 - acc: 0.9495 - val_loss: 0.1411 - val_acc: 0.9464
Epoch 5/20
6078/6078 [==============================] - 1890s 311ms/step - loss: 0.1269 - acc: 0.9516 - val_loss: 0.1419 - val_acc: 0.9463
Epoch 6/20
6078/6078 [==============================] - 1887s 311ms/step - loss: 0.1223 - acc: 0.9537 - val_loss: 0.1364 - val_acc: 0.9493
Epoch 7/20
6078/6078 [==============================] - 1887s 311ms/step - loss: 0.1192 - acc: 0.9548 - val_loss: 0.1354 - val_acc: 0.9498
Epoch 8/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1162 - acc: 0.9561 - val_loss: 0.1370 - val_acc: 0.9486
Epoch 9/20
6078/6078 [==============================] - 1889s 311ms/step - loss: 0.1136 - acc: 0.9575 - val_loss: 0.1341 - val_acc: 0.9510
Epoch 10/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1116 - acc: 0.9584 - val_loss: 0.1345 - val_acc: 0.9501
Epoch 11/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1094 - acc: 0.9593 - val_loss: 0.1341 - val_acc: 0.9510
Epoch 12/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1076 - acc: 0.9600 - val_loss: 0.1333 - val_acc: 0.9514
Epoch 13/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1060 - acc: 0.9612 - val_loss: 0.1345 - val_acc: 0.9513
Epoch 14/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1043 - acc: 0.9619 - val_loss: 0.1340 - val_acc: 0.9517
```

```
Epoch 15/20
6078/6078 [==============================] - 1888s 311ms/step - loss: 0.1029 - acc: 0.9622 - val_loss: 0.1336 - val_acc: 0.9520
Epoch 16/20
6078/6078 [==============================] - 1887s 310ms/step - loss: 0.1017 - acc: 0.9631 - val_loss: 0.1346 - val_acc: 0.9519
Epoch 17/20
6078/6078 [==============================] - 1886s 310ms/step - loss: 0.1002 - acc: 0.9636 - val_loss: 0.1392 - val_acc: 0.9501
Epoch 18/20
6078/6078 [==============================] - 1886s 310ms/step - loss: 0.0989 - acc: 0.9644 - val_loss: 0.1363 - val_acc: 0.9521
Epoch 19/20
6078/6078 [==============================] - 1885s 310ms/step - loss: 0.0978 - acc: 0.9654 - val_loss: 0.1383 - val_acc: 0.9508
Epoch 20/20
6078/6078 [==============================] - 1884s 310ms/step - loss: 0.0969 - acc: 0.9657 - val_loss: 0.1380 - val_acc: 0.9512
```

In [14]:

```
acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(1, len(acc) + 1)
plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()
plt.figure()
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()
plt.show()
```





In [20]:
```
inception_conv_base = InceptionV3(weights='imagenet',
include_top=False,
input_shape=(178, 218, 3))
```

In [21]:
```
inception_conv_base.summary()
```

```
Model: "inception_v3"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_5 (InputLayer)            [(None, 178, 218, 3) 0
__________________________________________________________________________________________________
conv2d_376 (Conv2D)             (None, 88, 108, 32)  864         input_5[0][0]
__________________________________________________________________________________________________
batch_normalization_376 (BatchN (None, 88, 108, 32)  96          conv2d_376[0][0]
__________________________________________________________________________________________________
activation_376 (Activation)     (None, 88, 108, 32)  0           batch_normalization_376[0][0]
__________________________________________________________________________________________________
conv2d_377 (Conv2D)             (None, 86, 106, 32)  9216        activation_376[0][0]
__________________________________________________________________________________________________
batch_normalization_377 (BatchN (None, 86, 106, 32)  96          conv2d_377[0][0]
__________________________________________________________________________________________________
activation_377 (Activation)     (None, 86, 106, 32)  0           batch_normalization_377[0][0]
__________________________________________________________________________________________________
conv2d_378 (Conv2D)             (None, 86, 106, 64)  18432       activation_377[0][0]
__________________________________________________________________________________________________
batch_normalization_378 (BatchN (None, 86, 106, 64)  192         conv2d_378[0][0]
__________________________________________________________________________________________________
activation_378 (Activation)     (None, 86, 106, 64)  0           batch_normalization_378[0][0]
__________________________________________________________________________________________________
max_pooling2d_16 (MaxPooling2D) (None, 42, 52, 64)   0           activation_378[0][0]
__________________________________________________________________________________________________
conv2d_379 (Conv2D)             (None, 42, 52, 80)   5120        max_pooling2d_16[0][0]
__________________________________________________________________________________________________
batch_normalization_379 (BatchN (None, 42, 52, 80)   240         conv2d_379[0][0]
__________________________________________________________________________________________________
activation_379 (Activation)     (None, 42, 52, 80)   0           batch_normalization_379[0][0]
__________________________________________________________________________________________________
conv2d_380 (Conv2D)             (None, 40, 50, 192)  138240      activation_379[0][0]
__________________________________________________________________________________________________
batch_normalization_380 (BatchN (None, 40, 50, 192)  576         conv2d_380[0][0]
__________________________________________________________________________________________________
activation_380 (Activation)     (None, 40, 50, 192)  0           batch_normalization_380[0][0]
__________________________________________________________________________________________________
max_pooling2d_17 (MaxPooling2D) (None, 19, 24, 192)  0           activation_380[0][0]
__________________________________________________________________________________________________
conv2d_384 (Conv2D)             (None, 19, 24, 64)   12288       max_pooling2d_17[0][0]
__________________________________________________________________________________________________
batch_normalization_384 (BatchN (None, 19, 24, 64)   192         conv2d_384[0][0]
```

activation_384 (Activation)	(None, 19, 24, 64)	0	batch_normalization_384[0][0]
conv2d_382 (Conv2D)	(None, 19, 24, 48)	9216	max_pooling2d_17[0][0]
conv2d_385 (Conv2D)	(None, 19, 24, 96)	55296	activation_384[0][0]
batch_normalization_382 (BatchN	(None, 19, 24, 48)	144	conv2d_382[0][0]
batch_normalization_385 (BatchN	(None, 19, 24, 96)	288	conv2d_385[0][0]
activation_382 (Activation)	(None, 19, 24, 48)	0	batch_normalization_382[0][0]
activation_385 (Activation)	(None, 19, 24, 96)	0	batch_normalization_385[0][0]
average_pooling2d_36 (AveragePo	(None, 19, 24, 192)	0	max_pooling2d_17[0][0]
conv2d_381 (Conv2D)	(None, 19, 24, 64)	12288	max_pooling2d_17[0][0]
conv2d_383 (Conv2D)	(None, 19, 24, 64)	76800	activation_382[0][0]
conv2d_386 (Conv2D)	(None, 19, 24, 96)	82944	activation_385[0][0]
conv2d_387 (Conv2D)	(None, 19, 24, 32)	6144	average_pooling2d_36[0][0]
batch_normalization_381 (BatchN	(None, 19, 24, 64)	192	conv2d_381[0][0]
batch_normalization_383 (BatchN	(None, 19, 24, 64)	192	conv2d_383[0][0]
batch_normalization_386 (BatchN	(None, 19, 24, 96)	288	conv2d_386[0][0]
batch_normalization_387 (BatchN	(None, 19, 24, 32)	96	conv2d_387[0][0]
activation_381 (Activation)	(None, 19, 24, 64)	0	batch_normalization_381[0][0]
activation_383 (Activation)	(None, 19, 24, 64)	0	batch_normalization_383[0][0]
activation_386 (Activation)	(None, 19, 24, 96)	0	batch_normalization_386[0][0]
activation_387 (Activation)	(None, 19, 24, 32)	0	batch_normalization_387[0][0]
mixed0 (Concatenate)	(None, 19, 24, 256)	0	activation_381[0][0] activation_383[0][0]

			activation_386[0][0] activation_387[0][0]
conv2d_391 (Conv2D)	(None, 19, 24, 64)	16384	mixed0[0][0]
batch_normalization_391 (BatchN	(None, 19, 24, 64)	192	conv2d_391[0][0]
activation_391 (Activation)	(None, 19, 24, 64)	0	batch_normalization_391[0][0]
conv2d_389 (Conv2D)	(None, 19, 24, 48)	12288	mixed0[0][0]
conv2d_392 (Conv2D)	(None, 19, 24, 96)	55296	activation_391[0][0]
batch_normalization_389 (BatchN	(None, 19, 24, 48)	144	conv2d_389[0][0]
batch_normalization_392 (BatchN	(None, 19, 24, 96)	288	conv2d_392[0][0]
activation_389 (Activation)	(None, 19, 24, 48)	0	batch_normalization_389[0][0]
activation_392 (Activation)	(None, 19, 24, 96)	0	batch_normalization_392[0][0]
average_pooling2d_37 (AveragePo	(None, 19, 24, 256)	0	mixed0[0][0]
conv2d_388 (Conv2D)	(None, 19, 24, 64)	16384	mixed0[0][0]
conv2d_390 (Conv2D)	(None, 19, 24, 64)	76800	activation_389[0][0]
conv2d_393 (Conv2D)	(None, 19, 24, 96)	82944	activation_392[0][0]
conv2d_394 (Conv2D)	(None, 19, 24, 64)	16384	average_pooling2d_37[0][0]
batch_normalization_388 (BatchN	(None, 19, 24, 64)	192	conv2d_388[0][0]
batch_normalization_390 (BatchN	(None, 19, 24, 64)	192	conv2d_390[0][0]
batch_normalization_393 (BatchN	(None, 19, 24, 96)	288	conv2d_393[0][0]
batch_normalization_394 (BatchN	(None, 19, 24, 64)	192	conv2d_394[0][0]
activation_388 (Activation)	(None, 19, 24, 64)	0	batch_normalization_388[0][0]
activation_390 (Activation)	(None, 19, 24, 64)	0	batch_normalization_390[0][0]

```
activation_393 (Activation)     (None, 19, 24, 96)   0          batch_normalization_393[0][0]
__________________________________________________________________________________________
activation_394 (Activation)     (None, 19, 24, 64)   0          batch_normalization_394[0][0]
__________________________________________________________________________________________
mixed1 (Concatenate)            (None, 19, 24, 288)  0          activation_388[0][0]
                                                                activation_390[0][0]
                                                                activation_393[0][0]
                                                                activation_394[0][0]
__________________________________________________________________________________________
conv2d_398 (Conv2D)             (None, 19, 24, 64)   18432      mixed1[0][0]
__________________________________________________________________________________________
batch_normalization_398 (BatchN (None, 19, 24, 64)   192        conv2d_398[0][0]
__________________________________________________________________________________________
activation_398 (Activation)     (None, 19, 24, 64)   0          batch_normalization_398[0][0]
__________________________________________________________________________________________
conv2d_396 (Conv2D)             (None, 19, 24, 48)   13824      mixed1[0][0]
__________________________________________________________________________________________
conv2d_399 (Conv2D)             (None, 19, 24, 96)   55296      activation_398[0][0]
__________________________________________________________________________________________
batch_normalization_396 (BatchN (None, 19, 24, 48)   144        conv2d_396[0][0]
__________________________________________________________________________________________
batch_normalization_399 (BatchN (None, 19, 24, 96)   288        conv2d_399[0][0]
__________________________________________________________________________________________
activation_396 (Activation)     (None, 19, 24, 48)   0          batch_normalization_396[0][0]
__________________________________________________________________________________________
activation_399 (Activation)     (None, 19, 24, 96)   0          batch_normalization_399[0][0]
__________________________________________________________________________________________
average_pooling2d_38 (AveragePo (None, 19, 24, 288)  0          mixed1[0][0]
__________________________________________________________________________________________
conv2d_395 (Conv2D)             (None, 19, 24, 64)   18432      mixed1[0][0]
__________________________________________________________________________________________
conv2d_397 (Conv2D)             (None, 19, 24, 64)   76800      activation_396[0][0]
__________________________________________________________________________________________
conv2d_400 (Conv2D)             (None, 19, 24, 96)   82944      activation_399[0][0]
__________________________________________________________________________________________
conv2d_401 (Conv2D)             (None, 19, 24, 64)   18432      average_pooling2d_38[0][0]
__________________________________________________________________________________________
batch_normalization_395 (BatchN (None, 19, 24, 64)   192        conv2d_395[0][0]
__________________________________________________________________________________________
batch_normalization_397 (BatchN (None, 19, 24, 64)   192        conv2d_397[0][0]
__________________________________________________________________________________________
batch_normalization_400 (BatchN (None, 19, 24, 96)   288        conv2d_400[0][0]
__________________________________________________________________________________________
```

```
batch_normalization_401 (BatchN (None, 19, 24, 64)   192         conv2d_401[0][0]
__________________________________________________________________________________________________
activation_395 (Activation)     (None, 19, 24, 64)   0           batch_normalization_395[0][0]
__________________________________________________________________________________________________
activation_397 (Activation)     (None, 19, 24, 64)   0           batch_normalization_397[0][0]
__________________________________________________________________________________________________
activation_400 (Activation)     (None, 19, 24, 96)   0           batch_normalization_400[0][0]
__________________________________________________________________________________________________
activation_401 (Activation)     (None, 19, 24, 64)   0           batch_normalization_401[0][0]
__________________________________________________________________________________________________
mixed2 (Concatenate)            (None, 19, 24, 288)  0           activation_395[0][0]
                                                                 activation_397[0][0]
                                                                 activation_400[0][0]
                                                                 activation_401[0][0]
__________________________________________________________________________________________________
conv2d_403 (Conv2D)             (None, 19, 24, 64)   18432       mixed2[0][0]
__________________________________________________________________________________________________
batch_normalization_403 (BatchN (None, 19, 24, 64)   192         conv2d_403[0][0]
__________________________________________________________________________________________________
activation_403 (Activation)     (None, 19, 24, 64)   0           batch_normalization_403[0][0]
__________________________________________________________________________________________________
conv2d_404 (Conv2D)             (None, 19, 24, 96)   55296       activation_403[0][0]
__________________________________________________________________________________________________
batch_normalization_404 (BatchN (None, 19, 24, 96)   288         conv2d_404[0][0]
__________________________________________________________________________________________________
activation_404 (Activation)     (None, 19, 24, 96)   0           batch_normalization_404[0][0]
__________________________________________________________________________________________________
conv2d_402 (Conv2D)             (None, 9, 11, 384)   995328      mixed2[0][0]
__________________________________________________________________________________________________
conv2d_405 (Conv2D)             (None, 9, 11, 96)    82944       activation_404[0][0]
__________________________________________________________________________________________________
batch_normalization_402 (BatchN (None, 9, 11, 384)   1152        conv2d_402[0][0]
__________________________________________________________________________________________________
batch_normalization_405 (BatchN (None, 9, 11, 96)    288         conv2d_405[0][0]
__________________________________________________________________________________________________
activation_402 (Activation)     (None, 9, 11, 384)   0           batch_normalization_402[0][0]
__________________________________________________________________________________________________
activation_405 (Activation)     (None, 9, 11, 96)    0           batch_normalization_405[0][0]
__________________________________________________________________________________________________
max_pooling2d_18 (MaxPooling2D) (None, 9, 11, 288)   0           mixed2[0][0]
__________________________________________________________________________________________________
mixed3 (Concatenate)            (None, 9, 11, 768)   0           activation_402[0][0]
                                                                 activation_405[0][0]
```

			max_pooling2d_18[0][0]
conv2d_410 (Conv2D)	(None, 9, 11, 128)	98304	mixed3[0][0]
batch_normalization_410 (BatchN	(None, 9, 11, 128)	384	conv2d_410[0][0]
activation_410 (Activation)	(None, 9, 11, 128)	0	batch_normalization_410[0][0]
conv2d_411 (Conv2D)	(None, 9, 11, 128)	114688	activation_410[0][0]
batch_normalization_411 (BatchN	(None, 9, 11, 128)	384	conv2d_411[0][0]
activation_411 (Activation)	(None, 9, 11, 128)	0	batch_normalization_411[0][0]
conv2d_407 (Conv2D)	(None, 9, 11, 128)	98304	mixed3[0][0]
conv2d_412 (Conv2D)	(None, 9, 11, 128)	114688	activation_411[0][0]
batch_normalization_407 (BatchN	(None, 9, 11, 128)	384	conv2d_407[0][0]
batch_normalization_412 (BatchN	(None, 9, 11, 128)	384	conv2d_412[0][0]
activation_407 (Activation)	(None, 9, 11, 128)	0	batch_normalization_407[0][0]
activation_412 (Activation)	(None, 9, 11, 128)	0	batch_normalization_412[0][0]
conv2d_408 (Conv2D)	(None, 9, 11, 128)	114688	activation_407[0][0]
conv2d_413 (Conv2D)	(None, 9, 11, 128)	114688	activation_412[0][0]
batch_normalization_408 (BatchN	(None, 9, 11, 128)	384	conv2d_408[0][0]
batch_normalization_413 (BatchN	(None, 9, 11, 128)	384	conv2d_413[0][0]
activation_408 (Activation)	(None, 9, 11, 128)	0	batch_normalization_408[0][0]
activation_413 (Activation)	(None, 9, 11, 128)	0	batch_normalization_413[0][0]
average_pooling2d_39 (AveragePo	(None, 9, 11, 768)	0	mixed3[0][0]
conv2d_406 (Conv2D)	(None, 9, 11, 192)	147456	mixed3[0][0]
conv2d_409 (Conv2D)	(None, 9, 11, 192)	172032	activation_408[0][0]

conv2d_414 (Conv2D)	(None, 9, 11, 192)	172032	activation_413[0][0]
conv2d_415 (Conv2D)	(None, 9, 11, 192)	147456	average_pooling2d_39[0][0]
batch_normalization_406 (BatchN	(None, 9, 11, 192)	576	conv2d_406[0][0]
batch_normalization_409 (BatchN	(None, 9, 11, 192)	576	conv2d_409[0][0]
batch_normalization_414 (BatchN	(None, 9, 11, 192)	576	conv2d_414[0][0]
batch_normalization_415 (BatchN	(None, 9, 11, 192)	576	conv2d_415[0][0]
activation_406 (Activation)	(None, 9, 11, 192)	0	batch_normalization_406[0][0]
activation_409 (Activation)	(None, 9, 11, 192)	0	batch_normalization_409[0][0]
activation_414 (Activation)	(None, 9, 11, 192)	0	batch_normalization_414[0][0]
activation_415 (Activation)	(None, 9, 11, 192)	0	batch_normalization_415[0][0]
mixed4 (Concatenate)	(None, 9, 11, 768)	0	activation_406[0][0] activation_409[0][0] activation_414[0][0] activation_415[0][0]
conv2d_420 (Conv2D)	(None, 9, 11, 160)	122880	mixed4[0][0]
batch_normalization_420 (BatchN	(None, 9, 11, 160)	480	conv2d_420[0][0]
activation_420 (Activation)	(None, 9, 11, 160)	0	batch_normalization_420[0][0]
conv2d_421 (Conv2D)	(None, 9, 11, 160)	179200	activation_420[0][0]
batch_normalization_421 (BatchN	(None, 9, 11, 160)	480	conv2d_421[0][0]
activation_421 (Activation)	(None, 9, 11, 160)	0	batch_normalization_421[0][0]
conv2d_417 (Conv2D)	(None, 9, 11, 160)	122880	mixed4[0][0]
conv2d_422 (Conv2D)	(None, 9, 11, 160)	179200	activation_421[0][0]
batch_normalization_417 (BatchN	(None, 9, 11, 160)	480	conv2d_417[0][0]

batch_normalization_422 (BatchN	(None, 9, 11, 160)	480	conv2d_422[0][0]
activation_417 (Activation)	(None, 9, 11, 160)	0	batch_normalization_417[0][0]
activation_422 (Activation)	(None, 9, 11, 160)	0	batch_normalization_422[0][0]
conv2d_418 (Conv2D)	(None, 9, 11, 160)	179200	activation_417[0][0]
conv2d_423 (Conv2D)	(None, 9, 11, 160)	179200	activation_422[0][0]
batch_normalization_418 (BatchN	(None, 9, 11, 160)	480	conv2d_418[0][0]
batch_normalization_423 (BatchN	(None, 9, 11, 160)	480	conv2d_423[0][0]
activation_418 (Activation)	(None, 9, 11, 160)	0	batch_normalization_418[0][0]
activation_423 (Activation)	(None, 9, 11, 160)	0	batch_normalization_423[0][0]
average_pooling2d_40 (AveragePo	(None, 9, 11, 768)	0	mixed4[0][0]
conv2d_416 (Conv2D)	(None, 9, 11, 192)	147456	mixed4[0][0]
conv2d_419 (Conv2D)	(None, 9, 11, 192)	215040	activation_418[0][0]
conv2d_424 (Conv2D)	(None, 9, 11, 192)	215040	activation_423[0][0]
conv2d_425 (Conv2D)	(None, 9, 11, 192)	147456	average_pooling2d_40[0][0]
batch_normalization_416 (BatchN	(None, 9, 11, 192)	576	conv2d_416[0][0]
batch_normalization_419 (BatchN	(None, 9, 11, 192)	576	conv2d_419[0][0]
batch_normalization_424 (BatchN	(None, 9, 11, 192)	576	conv2d_424[0][0]
batch_normalization_425 (BatchN	(None, 9, 11, 192)	576	conv2d_425[0][0]
activation_416 (Activation)	(None, 9, 11, 192)	0	batch_normalization_416[0][0]
activation_419 (Activation)	(None, 9, 11, 192)	0	batch_normalization_419[0][0]
activation_424 (Activation)	(None, 9, 11, 192)	0	batch_normalization_424[0][0]

```
activation_425 (Activation)     (None, 9, 11, 192)   0          batch_normalization_425[0][0]
__________________________________________________________________________________________
mixed5 (Concatenate)            (None, 9, 11, 768)   0          activation_416[0][0]
                                                                activation_419[0][0]
                                                                activation_424[0][0]
                                                                activation_425[0][0]
__________________________________________________________________________________________
conv2d_430 (Conv2D)             (None, 9, 11, 160)   122880     mixed5[0][0]
__________________________________________________________________________________________
batch_normalization_430 (BatchN (None, 9, 11, 160)   480        conv2d_430[0][0]
__________________________________________________________________________________________
activation_430 (Activation)     (None, 9, 11, 160)   0          batch_normalization_430[0][0]
__________________________________________________________________________________________
conv2d_431 (Conv2D)             (None, 9, 11, 160)   179200     activation_430[0][0]
__________________________________________________________________________________________
batch_normalization_431 (BatchN (None, 9, 11, 160)   480        conv2d_431[0][0]
__________________________________________________________________________________________
activation_431 (Activation)     (None, 9, 11, 160)   0          batch_normalization_431[0][0]
__________________________________________________________________________________________
conv2d_427 (Conv2D)             (None, 9, 11, 160)   122880     mixed5[0][0]
__________________________________________________________________________________________
conv2d_432 (Conv2D)             (None, 9, 11, 160)   179200     activation_431[0][0]
__________________________________________________________________________________________
batch_normalization_427 (BatchN (None, 9, 11, 160)   480        conv2d_427[0][0]
__________________________________________________________________________________________
batch_normalization_432 (BatchN (None, 9, 11, 160)   480        conv2d_432[0][0]
__________________________________________________________________________________________
activation_427 (Activation)     (None, 9, 11, 160)   0          batch_normalization_427[0][0]
__________________________________________________________________________________________
activation_432 (Activation)     (None, 9, 11, 160)   0          batch_normalization_432[0][0]
__________________________________________________________________________________________
conv2d_428 (Conv2D)             (None, 9, 11, 160)   179200     activation_427[0][0]
__________________________________________________________________________________________
conv2d_433 (Conv2D)             (None, 9, 11, 160)   179200     activation_432[0][0]
__________________________________________________________________________________________
batch_normalization_428 (BatchN (None, 9, 11, 160)   480        conv2d_428[0][0]
__________________________________________________________________________________________
batch_normalization_433 (BatchN (None, 9, 11, 160)   480        conv2d_433[0][0]
__________________________________________________________________________________________
activation_428 (Activation)     (None, 9, 11, 160)   0          batch_normalization_428[0][0]
__________________________________________________________________________________________
activation_433 (Activation)     (None, 9, 11, 160)   0          batch_normalization_433[0][0]
__________________________________________________________________________________________
```

```
average_pooling2d_41 (AveragePo (None, 9, 11, 768)   0           mixed5[0][0]
__________________________________________________________________________________________________
conv2d_426 (Conv2D)             (None, 9, 11, 192)   147456      mixed5[0][0]
__________________________________________________________________________________________________
conv2d_429 (Conv2D)             (None, 9, 11, 192)   215040      activation_428[0][0]
__________________________________________________________________________________________________
conv2d_434 (Conv2D)             (None, 9, 11, 192)   215040      activation_433[0][0]
__________________________________________________________________________________________________
conv2d_435 (Conv2D)             (None, 9, 11, 192)   147456      average_pooling2d_41[0][0]
__________________________________________________________________________________________________
batch_normalization_426 (BatchN (None, 9, 11, 192)   576         conv2d_426[0][0]
__________________________________________________________________________________________________
batch_normalization_429 (BatchN (None, 9, 11, 192)   576         conv2d_429[0][0]
__________________________________________________________________________________________________
batch_normalization_434 (BatchN (None, 9, 11, 192)   576         conv2d_434[0][0]
__________________________________________________________________________________________________
batch_normalization_435 (BatchN (None, 9, 11, 192)   576         conv2d_435[0][0]
__________________________________________________________________________________________________
activation_426 (Activation)     (None, 9, 11, 192)   0           batch_normalization_426[0][0]
__________________________________________________________________________________________________
activation_429 (Activation)     (None, 9, 11, 192)   0           batch_normalization_429[0][0]
__________________________________________________________________________________________________
activation_434 (Activation)     (None, 9, 11, 192)   0           batch_normalization_434[0][0]
__________________________________________________________________________________________________
activation_435 (Activation)     (None, 9, 11, 192)   0           batch_normalization_435[0][0]
__________________________________________________________________________________________________
mixed6 (Concatenate)            (None, 9, 11, 768)   0           activation_426[0][0]
                                                                 activation_429[0][0]
                                                                 activation_434[0][0]
                                                                 activation_435[0][0]
__________________________________________________________________________________________________
conv2d_440 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
batch_normalization_440 (BatchN (None, 9, 11, 192)   576         conv2d_440[0][0]
__________________________________________________________________________________________________
activation_440 (Activation)     (None, 9, 11, 192)   0           batch_normalization_440[0][0]
__________________________________________________________________________________________________
conv2d_441 (Conv2D)             (None, 9, 11, 192)   258048      activation_440[0][0]
__________________________________________________________________________________________________
batch_normalization_441 (BatchN (None, 9, 11, 192)   576         conv2d_441[0][0]
__________________________________________________________________________________________________
activation_441 (Activation)     (None, 9, 11, 192)   0           batch_normalization_441[0][0]
__________________________________________________________________________________________________
```

```
conv2d_437 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_442 (Conv2D)             (None, 9, 11, 192)   258048      activation_441[0][0]
__________________________________________________________________________________________________
batch_normalization_437 (BatchN (None, 9, 11, 192)   576         conv2d_437[0][0]
__________________________________________________________________________________________________
batch_normalization_442 (BatchN (None, 9, 11, 192)   576         conv2d_442[0][0]
__________________________________________________________________________________________________
activation_437 (Activation)     (None, 9, 11, 192)   0           batch_normalization_437[0][0]
__________________________________________________________________________________________________
activation_442 (Activation)     (None, 9, 11, 192)   0           batch_normalization_442[0][0]
__________________________________________________________________________________________________
conv2d_438 (Conv2D)             (None, 9, 11, 192)   258048      activation_437[0][0]
__________________________________________________________________________________________________
conv2d_443 (Conv2D)             (None, 9, 11, 192)   258048      activation_442[0][0]
__________________________________________________________________________________________________
batch_normalization_438 (BatchN (None, 9, 11, 192)   576         conv2d_438[0][0]
__________________________________________________________________________________________________
batch_normalization_443 (BatchN (None, 9, 11, 192)   576         conv2d_443[0][0]
__________________________________________________________________________________________________
activation_438 (Activation)     (None, 9, 11, 192)   0           batch_normalization_438[0][0]
__________________________________________________________________________________________________
activation_443 (Activation)     (None, 9, 11, 192)   0           batch_normalization_443[0][0]
__________________________________________________________________________________________________
average_pooling2d_42 (AveragePo (None, 9, 11, 768)   0           mixed6[0][0]
__________________________________________________________________________________________________
conv2d_436 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_439 (Conv2D)             (None, 9, 11, 192)   258048      activation_438[0][0]
__________________________________________________________________________________________________
conv2d_444 (Conv2D)             (None, 9, 11, 192)   258048      activation_443[0][0]
__________________________________________________________________________________________________
conv2d_445 (Conv2D)             (None, 9, 11, 192)   147456      average_pooling2d_42[0][0]
__________________________________________________________________________________________________
batch_normalization_436 (BatchN (None, 9, 11, 192)   576         conv2d_436[0][0]
__________________________________________________________________________________________________
batch_normalization_439 (BatchN (None, 9, 11, 192)   576         conv2d_439[0][0]
__________________________________________________________________________________________________
batch_normalization_444 (BatchN (None, 9, 11, 192)   576         conv2d_444[0][0]
__________________________________________________________________________________________________
batch_normalization_445 (BatchN (None, 9, 11, 192)   576         conv2d_445[0][0]
__________________________________________________________________________________________________
activation_436 (Activation)     (None, 9, 11, 192)   0           batch_normalization_436[0][0]
```

activation_439 (Activation)	(None, 9, 11, 192)	0	batch_normalization_439[0][0]
activation_444 (Activation)	(None, 9, 11, 192)	0	batch_normalization_444[0][0]
activation_445 (Activation)	(None, 9, 11, 192)	0	batch_normalization_445[0][0]
mixed7 (Concatenate)	(None, 9, 11, 768)	0	activation_436[0][0] activation_439[0][0] activation_444[0][0] activation_445[0][0]
conv2d_448 (Conv2D)	(None, 9, 11, 192)	147456	mixed7[0][0]
batch_normalization_448 (BatchN	(None, 9, 11, 192)	576	conv2d_448[0][0]
activation_448 (Activation)	(None, 9, 11, 192)	0	batch_normalization_448[0][0]
conv2d_449 (Conv2D)	(None, 9, 11, 192)	258048	activation_448[0][0]
batch_normalization_449 (BatchN	(None, 9, 11, 192)	576	conv2d_449[0][0]
activation_449 (Activation)	(None, 9, 11, 192)	0	batch_normalization_449[0][0]
conv2d_446 (Conv2D)	(None, 9, 11, 192)	147456	mixed7[0][0]
conv2d_450 (Conv2D)	(None, 9, 11, 192)	258048	activation_449[0][0]
batch_normalization_446 (BatchN	(None, 9, 11, 192)	576	conv2d_446[0][0]
batch_normalization_450 (BatchN	(None, 9, 11, 192)	576	conv2d_450[0][0]
activation_446 (Activation)	(None, 9, 11, 192)	0	batch_normalization_446[0][0]
activation_450 (Activation)	(None, 9, 11, 192)	0	batch_normalization_450[0][0]
conv2d_447 (Conv2D)	(None, 4, 5, 320)	552960	activation_446[0][0]
conv2d_451 (Conv2D)	(None, 4, 5, 192)	331776	activation_450[0][0]
batch_normalization_447 (BatchN	(None, 4, 5, 320)	960	conv2d_447[0][0]
batch_normalization_451 (BatchN	(None, 4, 5, 192)	576	conv2d_451[0][0]

activation_447 (Activation)	(None, 4, 5, 320)	0	batch_normalization_447[0][0]
activation_451 (Activation)	(None, 4, 5, 192)	0	batch_normalization_451[0][0]
max_pooling2d_19 (MaxPooling2D)	(None, 4, 5, 768)	0	mixed7[0][0]
mixed8 (Concatenate)	(None, 4, 5, 1280)	0	activation_447[0][0] activation_451[0][0] max_pooling2d_19[0][0]
conv2d_456 (Conv2D)	(None, 4, 5, 448)	573440	mixed8[0][0]
batch_normalization_456 (BatchN	(None, 4, 5, 448)	1344	conv2d_456[0][0]
activation_456 (Activation)	(None, 4, 5, 448)	0	batch_normalization_456[0][0]
conv2d_453 (Conv2D)	(None, 4, 5, 384)	491520	mixed8[0][0]
conv2d_457 (Conv2D)	(None, 4, 5, 384)	1548288	activation_456[0][0]
batch_normalization_453 (BatchN	(None, 4, 5, 384)	1152	conv2d_453[0][0]
batch_normalization_457 (BatchN	(None, 4, 5, 384)	1152	conv2d_457[0][0]
activation_453 (Activation)	(None, 4, 5, 384)	0	batch_normalization_453[0][0]
activation_457 (Activation)	(None, 4, 5, 384)	0	batch_normalization_457[0][0]
conv2d_454 (Conv2D)	(None, 4, 5, 384)	442368	activation_453[0][0]
conv2d_455 (Conv2D)	(None, 4, 5, 384)	442368	activation_453[0][0]
conv2d_458 (Conv2D)	(None, 4, 5, 384)	442368	activation_457[0][0]
conv2d_459 (Conv2D)	(None, 4, 5, 384)	442368	activation_457[0][0]
average_pooling2d_43 (AveragePo	(None, 4, 5, 1280)	0	mixed8[0][0]
conv2d_452 (Conv2D)	(None, 4, 5, 320)	409600	mixed8[0][0]
batch_normalization_454 (BatchN	(None, 4, 5, 384)	1152	conv2d_454[0][0]

```
batch_normalization_455 (BatchN (None, 4, 5, 384)    1152        conv2d_455[0][0]
__________________________________________________________________________________________
batch_normalization_458 (BatchN (None, 4, 5, 384)    1152        conv2d_458[0][0]
__________________________________________________________________________________________
batch_normalization_459 (BatchN (None, 4, 5, 384)    1152        conv2d_459[0][0]
__________________________________________________________________________________________
conv2d_460 (Conv2D)             (None, 4, 5, 192)    245760      average_pooling2d_43[0][0]
__________________________________________________________________________________________
batch_normalization_452 (BatchN (None, 4, 5, 320)    960         conv2d_452[0][0]
__________________________________________________________________________________________
activation_454 (Activation)     (None, 4, 5, 384)    0           batch_normalization_454[0][0]
__________________________________________________________________________________________
activation_455 (Activation)     (None, 4, 5, 384)    0           batch_normalization_455[0][0]
__________________________________________________________________________________________
activation_458 (Activation)     (None, 4, 5, 384)    0           batch_normalization_458[0][0]
__________________________________________________________________________________________
activation_459 (Activation)     (None, 4, 5, 384)    0           batch_normalization_459[0][0]
__________________________________________________________________________________________
batch_normalization_460 (BatchN (None, 4, 5, 192)    576         conv2d_460[0][0]
__________________________________________________________________________________________
activation_452 (Activation)     (None, 4, 5, 320)    0           batch_normalization_452[0][0]
__________________________________________________________________________________________
mixed9_0 (Concatenate)          (None, 4, 5, 768)    0           activation_454[0][0]
                                                                 activation_455[0][0]
__________________________________________________________________________________________
concatenate_8 (Concatenate)     (None, 4, 5, 768)    0           activation_458[0][0]
                                                                 activation_459[0][0]
__________________________________________________________________________________________
activation_460 (Activation)     (None, 4, 5, 192)    0           batch_normalization_460[0][0]
__________________________________________________________________________________________
mixed9 (Concatenate)            (None, 4, 5, 2048)   0           activation_452[0][0]
                                                                 mixed9_0[0][0]
                                                                 concatenate_8[0][0]
                                                                 activation_460[0][0]
__________________________________________________________________________________________
conv2d_465 (Conv2D)             (None, 4, 5, 448)    917504      mixed9[0][0]
__________________________________________________________________________________________
batch_normalization_465 (BatchN (None, 4, 5, 448)    1344        conv2d_465[0][0]
__________________________________________________________________________________________
activation_465 (Activation)     (None, 4, 5, 448)    0           batch_normalization_465[0][0]
__________________________________________________________________________________________
conv2d_462 (Conv2D)             (None, 4, 5, 384)    786432      mixed9[0][0]
__________________________________________________________________________________________
```

```
conv2d_466 (Conv2D)             (None, 4, 5, 384)    1548288     activation_465[0][0]
__________________________________________________________________________________________________
batch_normalization_462 (BatchN (None, 4, 5, 384)    1152        conv2d_462[0][0]
__________________________________________________________________________________________________
batch_normalization_466 (BatchN (None, 4, 5, 384)    1152        conv2d_466[0][0]
__________________________________________________________________________________________________
activation_462 (Activation)     (None, 4, 5, 384)    0           batch_normalization_462[0][0]
__________________________________________________________________________________________________
activation_466 (Activation)     (None, 4, 5, 384)    0           batch_normalization_466[0][0]
__________________________________________________________________________________________________
conv2d_463 (Conv2D)             (None, 4, 5, 384)    442368      activation_462[0][0]
__________________________________________________________________________________________________
conv2d_464 (Conv2D)             (None, 4, 5, 384)    442368      activation_462[0][0]
__________________________________________________________________________________________________
conv2d_467 (Conv2D)             (None, 4, 5, 384)    442368      activation_466[0][0]
__________________________________________________________________________________________________
conv2d_468 (Conv2D)             (None, 4, 5, 384)    442368      activation_466[0][0]
__________________________________________________________________________________________________
average_pooling2d_44 (AveragePo (None, 4, 5, 2048)   0           mixed9[0][0]
__________________________________________________________________________________________________
conv2d_461 (Conv2D)             (None, 4, 5, 320)    655360      mixed9[0][0]
__________________________________________________________________________________________________
batch_normalization_463 (BatchN (None, 4, 5, 384)    1152        conv2d_463[0][0]
__________________________________________________________________________________________________
batch_normalization_464 (BatchN (None, 4, 5, 384)    1152        conv2d_464[0][0]
__________________________________________________________________________________________________
batch_normalization_467 (BatchN (None, 4, 5, 384)    1152        conv2d_467[0][0]
__________________________________________________________________________________________________
batch_normalization_468 (BatchN (None, 4, 5, 384)    1152        conv2d_468[0][0]
__________________________________________________________________________________________________
conv2d_469 (Conv2D)             (None, 4, 5, 192)    393216      average_pooling2d_44[0][0]
__________________________________________________________________________________________________
batch_normalization_461 (BatchN (None, 4, 5, 320)    960         conv2d_461[0][0]
__________________________________________________________________________________________________
activation_463 (Activation)     (None, 4, 5, 384)    0           batch_normalization_463[0][0]
__________________________________________________________________________________________________
activation_464 (Activation)     (None, 4, 5, 384)    0           batch_normalization_464[0][0]
__________________________________________________________________________________________________
activation_467 (Activation)     (None, 4, 5, 384)    0           batch_normalization_467[0][0]
__________________________________________________________________________________________________
activation_468 (Activation)     (None, 4, 5, 384)    0           batch_normalization_468[0][0]
__________________________________________________________________________________________________
batch_normalization_469 (BatchN (None, 4, 5, 192)    576         conv2d_469[0][0]
```

```
activation_461 (Activation)     (None, 4, 5, 320)    0           batch_normalization_461[0][0]
__________________________________________________________________________________________________
mixed9_1 (Concatenate)          (None, 4, 5, 768)    0           activation_463[0][0]
                                                                 activation_464[0][0]
__________________________________________________________________________________________________
concatenate_9 (Concatenate)     (None, 4, 5, 768)    0           activation_467[0][0]
                                                                 activation_468[0][0]
__________________________________________________________________________________________________
activation_469 (Activation)     (None, 4, 5, 192)    0           batch_normalization_469[0][0]
__________________________________________________________________________________________________
mixed10 (Concatenate)           (None, 4, 5, 2048)   0           activation_461[0][0]
                                                                 mixed9_1[0][0]
                                                                 concatenate_9[0][0]
                                                                 activation_469[0][0]
==================================================================================================
Total params: 21,802,784
Trainable params: 21,768,352
Non-trainable params: 34,432
__________________________________________________________________________________________________
```

In [27]:

```
inception_conv_base.trainable = True
set_trainable = False
for layer in inception_conv_base.layers:
    if layer.name == 'conv2d_461':
        print('Found it!')
        set_trainable = True
    if set_trainable:
        layer.trainable = True
    else:
        layer.trainable = False
```

```
Found it!
```

In [28]:

```
inception_mdl = Sequential()
inception_mdl.add(inception_conv_base)
inception_mdl.add(Flatten())
inception_mdl.add(Dense(256, activation='relu'))
inception_mdl.add(Dropout(0.5))
inception_mdl.add(Dense(1, activation='sigmoid'))
```

In [26]:
```
inception_conv_base.summary()
```

```
Model: "inception_v3"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_5 (InputLayer)            [(None, 178, 218, 3) 0
__________________________________________________________________________________________________
conv2d_376 (Conv2D)             (None, 88, 108, 32)  864         input_5[0][0]
__________________________________________________________________________________________________
batch_normalization_376 (BatchN (None, 88, 108, 32)  96          conv2d_376[0][0]
__________________________________________________________________________________________________
activation_376 (Activation)     (None, 88, 108, 32)  0           batch_normalization_376[0][0]
__________________________________________________________________________________________________
conv2d_377 (Conv2D)             (None, 86, 106, 32)  9216        activation_376[0][0]
__________________________________________________________________________________________________
batch_normalization_377 (BatchN (None, 86, 106, 32)  96          conv2d_377[0][0]
__________________________________________________________________________________________________
activation_377 (Activation)     (None, 86, 106, 32)  0           batch_normalization_377[0][0]
__________________________________________________________________________________________________
conv2d_378 (Conv2D)             (None, 86, 106, 64)  18432       activation_377[0][0]
__________________________________________________________________________________________________
batch_normalization_378 (BatchN (None, 86, 106, 64)  192         conv2d_378[0][0]
__________________________________________________________________________________________________
activation_378 (Activation)     (None, 86, 106, 64)  0           batch_normalization_378[0][0]
__________________________________________________________________________________________________
max_pooling2d_16 (MaxPooling2D) (None, 42, 52, 64)   0           activation_378[0][0]
__________________________________________________________________________________________________
conv2d_379 (Conv2D)             (None, 42, 52, 80)   5120        max_pooling2d_16[0][0]
__________________________________________________________________________________________________
batch_normalization_379 (BatchN (None, 42, 52, 80)   240         conv2d_379[0][0]
__________________________________________________________________________________________________
activation_379 (Activation)     (None, 42, 52, 80)   0           batch_normalization_379[0][0]
__________________________________________________________________________________________________
conv2d_380 (Conv2D)             (None, 40, 50, 192)  138240      activation_379[0][0]
__________________________________________________________________________________________________
batch_normalization_380 (BatchN (None, 40, 50, 192)  576         conv2d_380[0][0]
__________________________________________________________________________________________________
activation_380 (Activation)     (None, 40, 50, 192)  0           batch_normalization_380[0][0]
__________________________________________________________________________________________________
max_pooling2d_17 (MaxPooling2D) (None, 19, 24, 192)  0           activation_380[0][0]
__________________________________________________________________________________________________
conv2d_384 (Conv2D)             (None, 19, 24, 64)   12288       max_pooling2d_17[0][0]
__________________________________________________________________________________________________
batch_normalization_384 (BatchN (None, 19, 24, 64)   192         conv2d_384[0][0]
```

activation_384 (Activation)	(None, 19, 24, 64)	0	batch_normalization_384[0][0]
conv2d_382 (Conv2D)	(None, 19, 24, 48)	9216	max_pooling2d_17[0][0]
conv2d_385 (Conv2D)	(None, 19, 24, 96)	55296	activation_384[0][0]
batch_normalization_382 (BatchN	(None, 19, 24, 48)	144	conv2d_382[0][0]
batch_normalization_385 (BatchN	(None, 19, 24, 96)	288	conv2d_385[0][0]
activation_382 (Activation)	(None, 19, 24, 48)	0	batch_normalization_382[0][0]
activation_385 (Activation)	(None, 19, 24, 96)	0	batch_normalization_385[0][0]
average_pooling2d_36 (AveragePo	(None, 19, 24, 192)	0	max_pooling2d_17[0][0]
conv2d_381 (Conv2D)	(None, 19, 24, 64)	12288	max_pooling2d_17[0][0]
conv2d_383 (Conv2D)	(None, 19, 24, 64)	76800	activation_382[0][0]
conv2d_386 (Conv2D)	(None, 19, 24, 96)	82944	activation_385[0][0]
conv2d_387 (Conv2D)	(None, 19, 24, 32)	6144	average_pooling2d_36[0][0]
batch_normalization_381 (BatchN	(None, 19, 24, 64)	192	conv2d_381[0][0]
batch_normalization_383 (BatchN	(None, 19, 24, 64)	192	conv2d_383[0][0]
batch_normalization_386 (BatchN	(None, 19, 24, 96)	288	conv2d_386[0][0]
batch_normalization_387 (BatchN	(None, 19, 24, 32)	96	conv2d_387[0][0]
activation_381 (Activation)	(None, 19, 24, 64)	0	batch_normalization_381[0][0]
activation_383 (Activation)	(None, 19, 24, 64)	0	batch_normalization_383[0][0]
activation_386 (Activation)	(None, 19, 24, 96)	0	batch_normalization_386[0][0]
activation_387 (Activation)	(None, 19, 24, 32)	0	batch_normalization_387[0][0]
mixed0 (Concatenate)	(None, 19, 24, 256)	0	activation_381[0][0] activation_383[0][0]

			activation_386[0][0] activation_387[0][0]
conv2d_391 (Conv2D)	(None, 19, 24, 64)	16384	mixed0[0][0]
batch_normalization_391 (BatchN	(None, 19, 24, 64)	192	conv2d_391[0][0]
activation_391 (Activation)	(None, 19, 24, 64)	0	batch_normalization_391[0][0]
conv2d_389 (Conv2D)	(None, 19, 24, 48)	12288	mixed0[0][0]
conv2d_392 (Conv2D)	(None, 19, 24, 96)	55296	activation_391[0][0]
batch_normalization_389 (BatchN	(None, 19, 24, 48)	144	conv2d_389[0][0]
batch_normalization_392 (BatchN	(None, 19, 24, 96)	288	conv2d_392[0][0]
activation_389 (Activation)	(None, 19, 24, 48)	0	batch_normalization_389[0][0]
activation_392 (Activation)	(None, 19, 24, 96)	0	batch_normalization_392[0][0]
average_pooling2d_37 (AveragePo	(None, 19, 24, 256)	0	mixed0[0][0]
conv2d_388 (Conv2D)	(None, 19, 24, 64)	16384	mixed0[0][0]
conv2d_390 (Conv2D)	(None, 19, 24, 64)	76800	activation_389[0][0]
conv2d_393 (Conv2D)	(None, 19, 24, 96)	82944	activation_392[0][0]
conv2d_394 (Conv2D)	(None, 19, 24, 64)	16384	average_pooling2d_37[0][0]
batch_normalization_388 (BatchN	(None, 19, 24, 64)	192	conv2d_388[0][0]
batch_normalization_390 (BatchN	(None, 19, 24, 64)	192	conv2d_390[0][0]
batch_normalization_393 (BatchN	(None, 19, 24, 96)	288	conv2d_393[0][0]
batch_normalization_394 (BatchN	(None, 19, 24, 64)	192	conv2d_394[0][0]
activation_388 (Activation)	(None, 19, 24, 64)	0	batch_normalization_388[0][0]
activation_390 (Activation)	(None, 19, 24, 64)	0	batch_normalization_390[0][0]

```
activation_393 (Activation)     (None, 19, 24, 96)   0          batch_normalization_393[0][0]
__________________________________________________________________________________________
activation_394 (Activation)     (None, 19, 24, 64)   0          batch_normalization_394[0][0]
__________________________________________________________________________________________
mixed1 (Concatenate)            (None, 19, 24, 288)  0          activation_388[0][0]
                                                                activation_390[0][0]
                                                                activation_393[0][0]
                                                                activation_394[0][0]
__________________________________________________________________________________________
conv2d_398 (Conv2D)             (None, 19, 24, 64)   18432      mixed1[0][0]
__________________________________________________________________________________________
batch_normalization_398 (BatchN (None, 19, 24, 64)   192        conv2d_398[0][0]
__________________________________________________________________________________________
activation_398 (Activation)     (None, 19, 24, 64)   0          batch_normalization_398[0][0]
__________________________________________________________________________________________
conv2d_396 (Conv2D)             (None, 19, 24, 48)   13824      mixed1[0][0]
__________________________________________________________________________________________
conv2d_399 (Conv2D)             (None, 19, 24, 96)   55296      activation_398[0][0]
__________________________________________________________________________________________
batch_normalization_396 (BatchN (None, 19, 24, 48)   144        conv2d_396[0][0]
__________________________________________________________________________________________
batch_normalization_399 (BatchN (None, 19, 24, 96)   288        conv2d_399[0][0]
__________________________________________________________________________________________
activation_396 (Activation)     (None, 19, 24, 48)   0          batch_normalization_396[0][0]
__________________________________________________________________________________________
activation_399 (Activation)     (None, 19, 24, 96)   0          batch_normalization_399[0][0]
__________________________________________________________________________________________
average_pooling2d_38 (AveragePo (None, 19, 24, 288)  0          mixed1[0][0]
__________________________________________________________________________________________
conv2d_395 (Conv2D)             (None, 19, 24, 64)   18432      mixed1[0][0]
__________________________________________________________________________________________
conv2d_397 (Conv2D)             (None, 19, 24, 64)   76800      activation_396[0][0]
__________________________________________________________________________________________
conv2d_400 (Conv2D)             (None, 19, 24, 96)   82944      activation_399[0][0]
__________________________________________________________________________________________
conv2d_401 (Conv2D)             (None, 19, 24, 64)   18432      average_pooling2d_38[0][0]
__________________________________________________________________________________________
batch_normalization_395 (BatchN (None, 19, 24, 64)   192        conv2d_395[0][0]
__________________________________________________________________________________________
batch_normalization_397 (BatchN (None, 19, 24, 64)   192        conv2d_397[0][0]
__________________________________________________________________________________________
batch_normalization_400 (BatchN (None, 19, 24, 96)   288        conv2d_400[0][0]
__________________________________________________________________________________________
```

```
batch_normalization_401 (BatchN (None, 19, 24, 64)   192         conv2d_401[0][0]
__________________________________________________________________________________________________
activation_395 (Activation)     (None, 19, 24, 64)   0           batch_normalization_395[0][0]
__________________________________________________________________________________________________
activation_397 (Activation)     (None, 19, 24, 64)   0           batch_normalization_397[0][0]
__________________________________________________________________________________________________
activation_400 (Activation)     (None, 19, 24, 96)   0           batch_normalization_400[0][0]
__________________________________________________________________________________________________
activation_401 (Activation)     (None, 19, 24, 64)   0           batch_normalization_401[0][0]
__________________________________________________________________________________________________
mixed2 (Concatenate)            (None, 19, 24, 288)  0           activation_395[0][0]
                                                                 activation_397[0][0]
                                                                 activation_400[0][0]
                                                                 activation_401[0][0]
__________________________________________________________________________________________________
conv2d_403 (Conv2D)             (None, 19, 24, 64)   18432       mixed2[0][0]
__________________________________________________________________________________________________
batch_normalization_403 (BatchN (None, 19, 24, 64)   192         conv2d_403[0][0]
__________________________________________________________________________________________________
activation_403 (Activation)     (None, 19, 24, 64)   0           batch_normalization_403[0][0]
__________________________________________________________________________________________________
conv2d_404 (Conv2D)             (None, 19, 24, 96)   55296       activation_403[0][0]
__________________________________________________________________________________________________
batch_normalization_404 (BatchN (None, 19, 24, 96)   288         conv2d_404[0][0]
__________________________________________________________________________________________________
activation_404 (Activation)     (None, 19, 24, 96)   0           batch_normalization_404[0][0]
__________________________________________________________________________________________________
conv2d_402 (Conv2D)             (None, 9, 11, 384)   995328      mixed2[0][0]
__________________________________________________________________________________________________
conv2d_405 (Conv2D)             (None, 9, 11, 96)    82944       activation_404[0][0]
__________________________________________________________________________________________________
batch_normalization_402 (BatchN (None, 9, 11, 384)   1152        conv2d_402[0][0]
__________________________________________________________________________________________________
batch_normalization_405 (BatchN (None, 9, 11, 96)    288         conv2d_405[0][0]
__________________________________________________________________________________________________
activation_402 (Activation)     (None, 9, 11, 384)   0           batch_normalization_402[0][0]
__________________________________________________________________________________________________
activation_405 (Activation)     (None, 9, 11, 96)    0           batch_normalization_405[0][0]
__________________________________________________________________________________________________
max_pooling2d_18 (MaxPooling2D) (None, 9, 11, 288)   0           mixed2[0][0]
__________________________________________________________________________________________________
mixed3 (Concatenate)            (None, 9, 11, 768)   0           activation_402[0][0]
                                                                 activation_405[0][0]
```

			max_pooling2d_18[0][0]
conv2d_410 (Conv2D)	(None, 9, 11, 128)	98304	mixed3[0][0]
batch_normalization_410 (BatchN	(None, 9, 11, 128)	384	conv2d_410[0][0]
activation_410 (Activation)	(None, 9, 11, 128)	0	batch_normalization_410[0][0]
conv2d_411 (Conv2D)	(None, 9, 11, 128)	114688	activation_410[0][0]
batch_normalization_411 (BatchN	(None, 9, 11, 128)	384	conv2d_411[0][0]
activation_411 (Activation)	(None, 9, 11, 128)	0	batch_normalization_411[0][0]
conv2d_407 (Conv2D)	(None, 9, 11, 128)	98304	mixed3[0][0]
conv2d_412 (Conv2D)	(None, 9, 11, 128)	114688	activation_411[0][0]
batch_normalization_407 (BatchN	(None, 9, 11, 128)	384	conv2d_407[0][0]
batch_normalization_412 (BatchN	(None, 9, 11, 128)	384	conv2d_412[0][0]
activation_407 (Activation)	(None, 9, 11, 128)	0	batch_normalization_407[0][0]
activation_412 (Activation)	(None, 9, 11, 128)	0	batch_normalization_412[0][0]
conv2d_408 (Conv2D)	(None, 9, 11, 128)	114688	activation_407[0][0]
conv2d_413 (Conv2D)	(None, 9, 11, 128)	114688	activation_412[0][0]
batch_normalization_408 (BatchN	(None, 9, 11, 128)	384	conv2d_408[0][0]
batch_normalization_413 (BatchN	(None, 9, 11, 128)	384	conv2d_413[0][0]
activation_408 (Activation)	(None, 9, 11, 128)	0	batch_normalization_408[0][0]
activation_413 (Activation)	(None, 9, 11, 128)	0	batch_normalization_413[0][0]
average_pooling2d_39 (AveragePo	(None, 9, 11, 768)	0	mixed3[0][0]
conv2d_406 (Conv2D)	(None, 9, 11, 192)	147456	mixed3[0][0]
conv2d_409 (Conv2D)	(None, 9, 11, 192)	172032	activation_408[0][0]

conv2d_414 (Conv2D)	(None, 9, 11, 192)	172032	activation_413[0][0]
conv2d_415 (Conv2D)	(None, 9, 11, 192)	147456	average_pooling2d_39[0][0]
batch_normalization_406 (BatchN	(None, 9, 11, 192)	576	conv2d_406[0][0]
batch_normalization_409 (BatchN	(None, 9, 11, 192)	576	conv2d_409[0][0]
batch_normalization_414 (BatchN	(None, 9, 11, 192)	576	conv2d_414[0][0]
batch_normalization_415 (BatchN	(None, 9, 11, 192)	576	conv2d_415[0][0]
activation_406 (Activation)	(None, 9, 11, 192)	0	batch_normalization_406[0][0]
activation_409 (Activation)	(None, 9, 11, 192)	0	batch_normalization_409[0][0]
activation_414 (Activation)	(None, 9, 11, 192)	0	batch_normalization_414[0][0]
activation_415 (Activation)	(None, 9, 11, 192)	0	batch_normalization_415[0][0]
mixed4 (Concatenate)	(None, 9, 11, 768)	0	activation_406[0][0] activation_409[0][0] activation_414[0][0] activation_415[0][0]
conv2d_420 (Conv2D)	(None, 9, 11, 160)	122880	mixed4[0][0]
batch_normalization_420 (BatchN	(None, 9, 11, 160)	480	conv2d_420[0][0]
activation_420 (Activation)	(None, 9, 11, 160)	0	batch_normalization_420[0][0]
conv2d_421 (Conv2D)	(None, 9, 11, 160)	179200	activation_420[0][0]
batch_normalization_421 (BatchN	(None, 9, 11, 160)	480	conv2d_421[0][0]
activation_421 (Activation)	(None, 9, 11, 160)	0	batch_normalization_421[0][0]
conv2d_417 (Conv2D)	(None, 9, 11, 160)	122880	mixed4[0][0]
conv2d_422 (Conv2D)	(None, 9, 11, 160)	179200	activation_421[0][0]
batch_normalization_417 (BatchN	(None, 9, 11, 160)	480	conv2d_417[0][0]

batch_normalization_422 (BatchN	(None, 9, 11, 160)	480	conv2d_422[0][0]
activation_417 (Activation)	(None, 9, 11, 160)	0	batch_normalization_417[0][0]
activation_422 (Activation)	(None, 9, 11, 160)	0	batch_normalization_422[0][0]
conv2d_418 (Conv2D)	(None, 9, 11, 160)	179200	activation_417[0][0]
conv2d_423 (Conv2D)	(None, 9, 11, 160)	179200	activation_422[0][0]
batch_normalization_418 (BatchN	(None, 9, 11, 160)	480	conv2d_418[0][0]
batch_normalization_423 (BatchN	(None, 9, 11, 160)	480	conv2d_423[0][0]
activation_418 (Activation)	(None, 9, 11, 160)	0	batch_normalization_418[0][0]
activation_423 (Activation)	(None, 9, 11, 160)	0	batch_normalization_423[0][0]
average_pooling2d_40 (AveragePo	(None, 9, 11, 768)	0	mixed4[0][0]
conv2d_416 (Conv2D)	(None, 9, 11, 192)	147456	mixed4[0][0]
conv2d_419 (Conv2D)	(None, 9, 11, 192)	215040	activation_418[0][0]
conv2d_424 (Conv2D)	(None, 9, 11, 192)	215040	activation_423[0][0]
conv2d_425 (Conv2D)	(None, 9, 11, 192)	147456	average_pooling2d_40[0][0]
batch_normalization_416 (BatchN	(None, 9, 11, 192)	576	conv2d_416[0][0]
batch_normalization_419 (BatchN	(None, 9, 11, 192)	576	conv2d_419[0][0]
batch_normalization_424 (BatchN	(None, 9, 11, 192)	576	conv2d_424[0][0]
batch_normalization_425 (BatchN	(None, 9, 11, 192)	576	conv2d_425[0][0]
activation_416 (Activation)	(None, 9, 11, 192)	0	batch_normalization_416[0][0]
activation_419 (Activation)	(None, 9, 11, 192)	0	batch_normalization_419[0][0]
activation_424 (Activation)	(None, 9, 11, 192)	0	batch_normalization_424[0][0]

```
activation_425 (Activation)     (None, 9, 11, 192)   0          batch_normalization_425[0][0]
__________________________________________________________________________________________
mixed5 (Concatenate)            (None, 9, 11, 768)   0          activation_416[0][0]
                                                                activation_419[0][0]
                                                                activation_424[0][0]
                                                                activation_425[0][0]
__________________________________________________________________________________________
conv2d_430 (Conv2D)             (None, 9, 11, 160)   122880     mixed5[0][0]
__________________________________________________________________________________________
batch_normalization_430 (BatchN (None, 9, 11, 160)   480        conv2d_430[0][0]
__________________________________________________________________________________________
activation_430 (Activation)     (None, 9, 11, 160)   0          batch_normalization_430[0][0]
__________________________________________________________________________________________
conv2d_431 (Conv2D)             (None, 9, 11, 160)   179200     activation_430[0][0]
__________________________________________________________________________________________
batch_normalization_431 (BatchN (None, 9, 11, 160)   480        conv2d_431[0][0]
__________________________________________________________________________________________
activation_431 (Activation)     (None, 9, 11, 160)   0          batch_normalization_431[0][0]
__________________________________________________________________________________________
conv2d_427 (Conv2D)             (None, 9, 11, 160)   122880     mixed5[0][0]
__________________________________________________________________________________________
conv2d_432 (Conv2D)             (None, 9, 11, 160)   179200     activation_431[0][0]
__________________________________________________________________________________________
batch_normalization_427 (BatchN (None, 9, 11, 160)   480        conv2d_427[0][0]
__________________________________________________________________________________________
batch_normalization_432 (BatchN (None, 9, 11, 160)   480        conv2d_432[0][0]
__________________________________________________________________________________________
activation_427 (Activation)     (None, 9, 11, 160)   0          batch_normalization_427[0][0]
__________________________________________________________________________________________
activation_432 (Activation)     (None, 9, 11, 160)   0          batch_normalization_432[0][0]
__________________________________________________________________________________________
conv2d_428 (Conv2D)             (None, 9, 11, 160)   179200     activation_427[0][0]
__________________________________________________________________________________________
conv2d_433 (Conv2D)             (None, 9, 11, 160)   179200     activation_432[0][0]
__________________________________________________________________________________________
batch_normalization_428 (BatchN (None, 9, 11, 160)   480        conv2d_428[0][0]
__________________________________________________________________________________________
batch_normalization_433 (BatchN (None, 9, 11, 160)   480        conv2d_433[0][0]
__________________________________________________________________________________________
activation_428 (Activation)     (None, 9, 11, 160)   0          batch_normalization_428[0][0]
__________________________________________________________________________________________
activation_433 (Activation)     (None, 9, 11, 160)   0          batch_normalization_433[0][0]
__________________________________________________________________________________________
```

```
average_pooling2d_41 (AveragePo (None, 9, 11, 768)   0           mixed5[0][0]
__________________________________________________________________________________________________
conv2d_426 (Conv2D)             (None, 9, 11, 192)   147456      mixed5[0][0]
__________________________________________________________________________________________________
conv2d_429 (Conv2D)             (None, 9, 11, 192)   215040      activation_428[0][0]
__________________________________________________________________________________________________
conv2d_434 (Conv2D)             (None, 9, 11, 192)   215040      activation_433[0][0]
__________________________________________________________________________________________________
conv2d_435 (Conv2D)             (None, 9, 11, 192)   147456      average_pooling2d_41[0][0]
__________________________________________________________________________________________________
batch_normalization_426 (BatchN (None, 9, 11, 192)   576         conv2d_426[0][0]
__________________________________________________________________________________________________
batch_normalization_429 (BatchN (None, 9, 11, 192)   576         conv2d_429[0][0]
__________________________________________________________________________________________________
batch_normalization_434 (BatchN (None, 9, 11, 192)   576         conv2d_434[0][0]
__________________________________________________________________________________________________
batch_normalization_435 (BatchN (None, 9, 11, 192)   576         conv2d_435[0][0]
__________________________________________________________________________________________________
activation_426 (Activation)     (None, 9, 11, 192)   0           batch_normalization_426[0][0]
__________________________________________________________________________________________________
activation_429 (Activation)     (None, 9, 11, 192)   0           batch_normalization_429[0][0]
__________________________________________________________________________________________________
activation_434 (Activation)     (None, 9, 11, 192)   0           batch_normalization_434[0][0]
__________________________________________________________________________________________________
activation_435 (Activation)     (None, 9, 11, 192)   0           batch_normalization_435[0][0]
__________________________________________________________________________________________________
mixed6 (Concatenate)            (None, 9, 11, 768)   0           activation_426[0][0]
                                                                 activation_429[0][0]
                                                                 activation_434[0][0]
                                                                 activation_435[0][0]
__________________________________________________________________________________________________
conv2d_440 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
batch_normalization_440 (BatchN (None, 9, 11, 192)   576         conv2d_440[0][0]
__________________________________________________________________________________________________
activation_440 (Activation)     (None, 9, 11, 192)   0           batch_normalization_440[0][0]
__________________________________________________________________________________________________
conv2d_441 (Conv2D)             (None, 9, 11, 192)   258048      activation_440[0][0]
__________________________________________________________________________________________________
batch_normalization_441 (BatchN (None, 9, 11, 192)   576         conv2d_441[0][0]
__________________________________________________________________________________________________
activation_441 (Activation)     (None, 9, 11, 192)   0           batch_normalization_441[0][0]
__________________________________________________________________________________________________
```

```
conv2d_437 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_442 (Conv2D)             (None, 9, 11, 192)   258048      activation_441[0][0]
__________________________________________________________________________________________________
batch_normalization_437 (BatchN (None, 9, 11, 192)   576         conv2d_437[0][0]
__________________________________________________________________________________________________
batch_normalization_442 (BatchN (None, 9, 11, 192)   576         conv2d_442[0][0]
__________________________________________________________________________________________________
activation_437 (Activation)     (None, 9, 11, 192)   0           batch_normalization_437[0][0]
__________________________________________________________________________________________________
activation_442 (Activation)     (None, 9, 11, 192)   0           batch_normalization_442[0][0]
__________________________________________________________________________________________________
conv2d_438 (Conv2D)             (None, 9, 11, 192)   258048      activation_437[0][0]
__________________________________________________________________________________________________
conv2d_443 (Conv2D)             (None, 9, 11, 192)   258048      activation_442[0][0]
__________________________________________________________________________________________________
batch_normalization_438 (BatchN (None, 9, 11, 192)   576         conv2d_438[0][0]
__________________________________________________________________________________________________
batch_normalization_443 (BatchN (None, 9, 11, 192)   576         conv2d_443[0][0]
__________________________________________________________________________________________________
activation_438 (Activation)     (None, 9, 11, 192)   0           batch_normalization_438[0][0]
__________________________________________________________________________________________________
activation_443 (Activation)     (None, 9, 11, 192)   0           batch_normalization_443[0][0]
__________________________________________________________________________________________________
average_pooling2d_42 (AveragePo (None, 9, 11, 768)   0           mixed6[0][0]
__________________________________________________________________________________________________
conv2d_436 (Conv2D)             (None, 9, 11, 192)   147456      mixed6[0][0]
__________________________________________________________________________________________________
conv2d_439 (Conv2D)             (None, 9, 11, 192)   258048      activation_438[0][0]
__________________________________________________________________________________________________
conv2d_444 (Conv2D)             (None, 9, 11, 192)   258048      activation_443[0][0]
__________________________________________________________________________________________________
conv2d_445 (Conv2D)             (None, 9, 11, 192)   147456      average_pooling2d_42[0][0]
__________________________________________________________________________________________________
batch_normalization_436 (BatchN (None, 9, 11, 192)   576         conv2d_436[0][0]
__________________________________________________________________________________________________
batch_normalization_439 (BatchN (None, 9, 11, 192)   576         conv2d_439[0][0]
__________________________________________________________________________________________________
batch_normalization_444 (BatchN (None, 9, 11, 192)   576         conv2d_444[0][0]
__________________________________________________________________________________________________
batch_normalization_445 (BatchN (None, 9, 11, 192)   576         conv2d_445[0][0]
__________________________________________________________________________________________________
activation_436 (Activation)     (None, 9, 11, 192)   0           batch_normalization_436[0][0]
```

activation_439 (Activation)	(None, 9, 11, 192)	0	batch_normalization_439[0][0]
activation_444 (Activation)	(None, 9, 11, 192)	0	batch_normalization_444[0][0]
activation_445 (Activation)	(None, 9, 11, 192)	0	batch_normalization_445[0][0]
mixed7 (Concatenate)	(None, 9, 11, 768)	0	activation_436[0][0] activation_439[0][0] activation_444[0][0] activation_445[0][0]
conv2d_448 (Conv2D)	(None, 9, 11, 192)	147456	mixed7[0][0]
batch_normalization_448 (BatchN	(None, 9, 11, 192)	576	conv2d_448[0][0]
activation_448 (Activation)	(None, 9, 11, 192)	0	batch_normalization_448[0][0]
conv2d_449 (Conv2D)	(None, 9, 11, 192)	258048	activation_448[0][0]
batch_normalization_449 (BatchN	(None, 9, 11, 192)	576	conv2d_449[0][0]
activation_449 (Activation)	(None, 9, 11, 192)	0	batch_normalization_449[0][0]
conv2d_446 (Conv2D)	(None, 9, 11, 192)	147456	mixed7[0][0]
conv2d_450 (Conv2D)	(None, 9, 11, 192)	258048	activation_449[0][0]
batch_normalization_446 (BatchN	(None, 9, 11, 192)	576	conv2d_446[0][0]
batch_normalization_450 (BatchN	(None, 9, 11, 192)	576	conv2d_450[0][0]
activation_446 (Activation)	(None, 9, 11, 192)	0	batch_normalization_446[0][0]
activation_450 (Activation)	(None, 9, 11, 192)	0	batch_normalization_450[0][0]
conv2d_447 (Conv2D)	(None, 4, 5, 320)	552960	activation_446[0][0]
conv2d_451 (Conv2D)	(None, 4, 5, 192)	331776	activation_450[0][0]
batch_normalization_447 (BatchN	(None, 4, 5, 320)	960	conv2d_447[0][0]
batch_normalization_451 (BatchN	(None, 4, 5, 192)	576	conv2d_451[0][0]

activation_447 (Activation)	(None, 4, 5, 320)	0	batch_normalization_447[0][0]
activation_451 (Activation)	(None, 4, 5, 192)	0	batch_normalization_451[0][0]
max_pooling2d_19 (MaxPooling2D)	(None, 4, 5, 768)	0	mixed7[0][0]
mixed8 (Concatenate)	(None, 4, 5, 1280)	0	activation_447[0][0] activation_451[0][0] max_pooling2d_19[0][0]
conv2d_456 (Conv2D)	(None, 4, 5, 448)	573440	mixed8[0][0]
batch_normalization_456 (BatchN	(None, 4, 5, 448)	1344	conv2d_456[0][0]
activation_456 (Activation)	(None, 4, 5, 448)	0	batch_normalization_456[0][0]
conv2d_453 (Conv2D)	(None, 4, 5, 384)	491520	mixed8[0][0]
conv2d_457 (Conv2D)	(None, 4, 5, 384)	1548288	activation_456[0][0]
batch_normalization_453 (BatchN	(None, 4, 5, 384)	1152	conv2d_453[0][0]
batch_normalization_457 (BatchN	(None, 4, 5, 384)	1152	conv2d_457[0][0]
activation_453 (Activation)	(None, 4, 5, 384)	0	batch_normalization_453[0][0]
activation_457 (Activation)	(None, 4, 5, 384)	0	batch_normalization_457[0][0]
conv2d_454 (Conv2D)	(None, 4, 5, 384)	442368	activation_453[0][0]
conv2d_455 (Conv2D)	(None, 4, 5, 384)	442368	activation_453[0][0]
conv2d_458 (Conv2D)	(None, 4, 5, 384)	442368	activation_457[0][0]
conv2d_459 (Conv2D)	(None, 4, 5, 384)	442368	activation_457[0][0]
average_pooling2d_43 (AveragePo	(None, 4, 5, 1280)	0	mixed8[0][0]
conv2d_452 (Conv2D)	(None, 4, 5, 320)	409600	mixed8[0][0]
batch_normalization_454 (BatchN	(None, 4, 5, 384)	1152	conv2d_454[0][0]

```
batch_normalization_455 (BatchN (None, 4, 5, 384)    1152        conv2d_455[0][0]
__________________________________________________________________________________________
batch_normalization_458 (BatchN (None, 4, 5, 384)    1152        conv2d_458[0][0]
__________________________________________________________________________________________
batch_normalization_459 (BatchN (None, 4, 5, 384)    1152        conv2d_459[0][0]
__________________________________________________________________________________________
conv2d_460 (Conv2D)             (None, 4, 5, 192)    245760      average_pooling2d_43[0][0]
__________________________________________________________________________________________
batch_normalization_452 (BatchN (None, 4, 5, 320)    960         conv2d_452[0][0]
__________________________________________________________________________________________
activation_454 (Activation)     (None, 4, 5, 384)    0           batch_normalization_454[0][0]
__________________________________________________________________________________________
activation_455 (Activation)     (None, 4, 5, 384)    0           batch_normalization_455[0][0]
__________________________________________________________________________________________
activation_458 (Activation)     (None, 4, 5, 384)    0           batch_normalization_458[0][0]
__________________________________________________________________________________________
activation_459 (Activation)     (None, 4, 5, 384)    0           batch_normalization_459[0][0]
__________________________________________________________________________________________
batch_normalization_460 (BatchN (None, 4, 5, 192)    576         conv2d_460[0][0]
__________________________________________________________________________________________
activation_452 (Activation)     (None, 4, 5, 320)    0           batch_normalization_452[0][0]
__________________________________________________________________________________________
mixed9_0 (Concatenate)          (None, 4, 5, 768)    0           activation_454[0][0]
                                                                 activation_455[0][0]
__________________________________________________________________________________________
concatenate_8 (Concatenate)     (None, 4, 5, 768)    0           activation_458[0][0]
                                                                 activation_459[0][0]
__________________________________________________________________________________________
activation_460 (Activation)     (None, 4, 5, 192)    0           batch_normalization_460[0][0]
__________________________________________________________________________________________
mixed9 (Concatenate)            (None, 4, 5, 2048)   0           activation_452[0][0]
                                                                 mixed9_0[0][0]
                                                                 concatenate_8[0][0]
                                                                 activation_460[0][0]
__________________________________________________________________________________________
conv2d_465 (Conv2D)             (None, 4, 5, 448)    917504      mixed9[0][0]
__________________________________________________________________________________________
batch_normalization_465 (BatchN (None, 4, 5, 448)    1344        conv2d_465[0][0]
__________________________________________________________________________________________
activation_465 (Activation)     (None, 4, 5, 448)    0           batch_normalization_465[0][0]
__________________________________________________________________________________________
conv2d_462 (Conv2D)             (None, 4, 5, 384)    786432      mixed9[0][0]
__________________________________________________________________________________________
```

```
conv2d_466 (Conv2D)             (None, 4, 5, 384)    1548288     activation_465[0][0]
__________________________________________________________________________________________________
batch_normalization_462 (BatchN (None, 4, 5, 384)    1152        conv2d_462[0][0]
__________________________________________________________________________________________________
batch_normalization_466 (BatchN (None, 4, 5, 384)    1152        conv2d_466[0][0]
__________________________________________________________________________________________________
activation_462 (Activation)     (None, 4, 5, 384)    0           batch_normalization_462[0][0]
__________________________________________________________________________________________________
activation_466 (Activation)     (None, 4, 5, 384)    0           batch_normalization_466[0][0]
__________________________________________________________________________________________________
conv2d_463 (Conv2D)             (None, 4, 5, 384)    442368      activation_462[0][0]
__________________________________________________________________________________________________
conv2d_464 (Conv2D)             (None, 4, 5, 384)    442368      activation_462[0][0]
__________________________________________________________________________________________________
conv2d_467 (Conv2D)             (None, 4, 5, 384)    442368      activation_466[0][0]
__________________________________________________________________________________________________
conv2d_468 (Conv2D)             (None, 4, 5, 384)    442368      activation_466[0][0]
__________________________________________________________________________________________________
average_pooling2d_44 (AveragePo (None, 4, 5, 2048)   0           mixed9[0][0]
__________________________________________________________________________________________________
conv2d_461 (Conv2D)             (None, 4, 5, 320)    655360      mixed9[0][0]
__________________________________________________________________________________________________
batch_normalization_463 (BatchN (None, 4, 5, 384)    1152        conv2d_463[0][0]
__________________________________________________________________________________________________
batch_normalization_464 (BatchN (None, 4, 5, 384)    1152        conv2d_464[0][0]
__________________________________________________________________________________________________
batch_normalization_467 (BatchN (None, 4, 5, 384)    1152        conv2d_467[0][0]
__________________________________________________________________________________________________
batch_normalization_468 (BatchN (None, 4, 5, 384)    1152        conv2d_468[0][0]
__________________________________________________________________________________________________
conv2d_469 (Conv2D)             (None, 4, 5, 192)    393216      average_pooling2d_44[0][0]
__________________________________________________________________________________________________
batch_normalization_461 (BatchN (None, 4, 5, 320)    960         conv2d_461[0][0]
__________________________________________________________________________________________________
activation_463 (Activation)     (None, 4, 5, 384)    0           batch_normalization_463[0][0]
__________________________________________________________________________________________________
activation_464 (Activation)     (None, 4, 5, 384)    0           batch_normalization_464[0][0]
__________________________________________________________________________________________________
activation_467 (Activation)     (None, 4, 5, 384)    0           batch_normalization_467[0][0]
__________________________________________________________________________________________________
activation_468 (Activation)     (None, 4, 5, 384)    0           batch_normalization_468[0][0]
__________________________________________________________________________________________________
batch_normalization_469 (BatchN (None, 4, 5, 192)    576         conv2d_469[0][0]
```

```
activation_461 (Activation)     (None, 4, 5, 320)    0           batch_normalization_461[0][0]
__________________________________________________________________________________________________
mixed9_1 (Concatenate)          (None, 4, 5, 768)    0           activation_463[0][0]
                                                                 activation_464[0][0]
__________________________________________________________________________________________________
concatenate_9 (Concatenate)     (None, 4, 5, 768)    0           activation_467[0][0]
                                                                 activation_468[0][0]
__________________________________________________________________________________________________
activation_469 (Activation)     (None, 4, 5, 192)    0           batch_normalization_469[0][0]
__________________________________________________________________________________________________
mixed10 (Concatenate)           (None, 4, 5, 2048)   0           activation_461[0][0]
                                                                 mixed9_1[0][0]
                                                                 concatenate_9[0][0]
                                                                 activation_469[0][0]
==================================================================================================
Total params: 21,802,784
Trainable params: 192
Non-trainable params: 21,802,592
__________________________________________________________________________________________________
```

In [29]:
```
inception_mdl.summary()
```

```
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Model)         (None, 4, 5, 2048)        21802784
_________________________________________________________________
flatten_6 (Flatten)          (None, 40960)             0
_________________________________________________________________
dense_13 (Dense)             (None, 256)               10486016
_________________________________________________________________
dropout_7 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_14 (Dense)             (None, 1)                 257
=================================================================
Total params: 32,289,057
Trainable params: 11,536,897
Non-trainable params: 20,752,160
_________________________________________________________________
```

In [33]:

```
train_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
             r'\Assignment_2\Images\train')
validation_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                  r'\Assignment_2\Images\validation')

train_datagen = ImageDataGenerator(
    rescale=1./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,
    fill_mode='nearest')

train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=(178, 218),
    batch_size=20,
    class_mode='binary')

val_datagen = ImageDataGenerator(rescale=1./255)
validation_generator = val_datagen.flow_from_directory(
    validation_dir,
    target_size=(178, 218),
    batch_size=20,
    class_mode='binary')

inception_mdl.compile(loss='binary_crossentropy',
    optimizer=optimizers.RMSprop(learning_rate=0.000005, rho=0.9),
    metrics=['acc'])

history = inception_mdl.fit_generator(
```

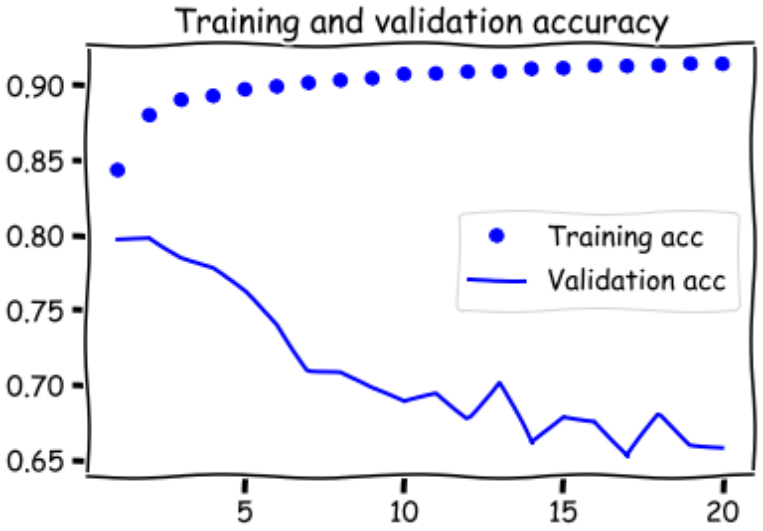
```
    train_generator,
    steps_per_epoch=round(training_count/20),
    epochs=20,
    validation_data=validation_generator,
    validation_steps=round(val_count/20))
```

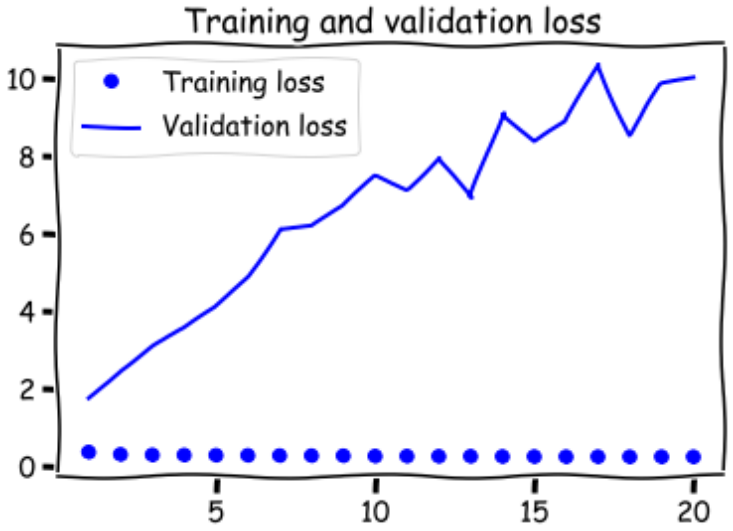
```
Found 121559 images belonging to 2 classes.
Found 40520 images belonging to 2 classes.
WARNING:tensorflow:From <ipython-input-33-c0b1d441167d>:38: Model.fit_generator (from tensorflow.python.keras.engine.training) is deprecat
ed and will be removed in a future version.
Instructions for updating:
Please use Model.fit, which supports generators.
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
Train for 6078 steps, validate for 2026 steps
Epoch 1/20
6078/6078 [==============================] - 1452s 239ms/step - loss: 0.3544 - acc: 0.8432 - val_loss: 1.7566 - val_acc: 0.7972
Epoch 2/20
6078/6078 [==============================] - 1419s 233ms/step - loss: 0.2946 - acc: 0.8799 - val_loss: 2.5109 - val_acc: 0.7993
Epoch 3/20
6078/6078 [==============================] - 1379s 227ms/step - loss: 0.2817 - acc: 0.8901 - val_loss: 3.1236 - val_acc: 0.7859
Epoch 4/20
6078/6078 [==============================] - 1399s 230ms/step - loss: 0.2782 - acc: 0.8927 - val_loss: 3.5366 - val_acc: 0.7776
Epoch 5/20
6078/6078 [==============================] - 1403s 231ms/step - loss: 0.2722 - acc: 0.8971 - val_loss: 4.0775 - val_acc: 0.7614
Epoch 6/20
6078/6078 [==============================] - 1401s 231ms/step - loss: 0.2693 - acc: 0.8990 - val_loss: 4.9030 - val_acc: 0.7404
Epoch 7/20
6078/6078 [==============================] - 1428s 235ms/step - loss: 0.2640 - acc: 0.9015 - val_loss: 6.1425 - val_acc: 0.7106
Epoch 8/20
6078/6078 [==============================] - 1420s 234ms/step - loss: 0.2618 - acc: 0.9031 - val_loss: 6.2003 - val_acc: 0.7088
Epoch 9/20
6078/6078 [==============================] - 1414s 233ms/step - loss: 0.2593 - acc: 0.9044 - val_loss: 6.6808 - val_acc: 0.6973
Epoch 10/20
6078/6078 [==============================] - 1519s 250ms/step - loss: 0.2502 - acc: 0.9072 - val_loss: 7.4777 - val_acc: 0.6880
Epoch 11/20
6078/6078 [==============================] - 1761s 290ms/step - loss: 0.2494 - acc: 0.9077 - val_loss: 7.1592 - val_acc: 0.6945
Epoch 12/20
6078/6078 [==============================] - 1375s 226ms/step - loss: 0.2456 - acc: 0.9088 - val_loss: 7.9718 - val_acc: 0.6788
Epoch 13/20
6078/6078 [==============================] - 1369s 225ms/step - loss: 0.2458 - acc: 0.9090 - val_loss: 6.8948 - val_acc: 0.7016
Epoch 14/20
6078/6078 [==============================] - 1369s 225ms/step - loss: 0.2401 - acc: 0.9108 - val_loss: 9.1274 - val_acc: 0.6609
```

```
Epoch 15/20
6078/6078 [==============================] - 1366s 225ms/step - loss: 0.2384 - acc: 0.9111 - val_loss: 8.3881 - val_acc: 0.6797
Epoch 16/20
6078/6078 [==============================] - 1368s 225ms/step - loss: 0.2350 - acc: 0.9129 - val_loss: 8.8567 - val_acc: 0.6768
Epoch 17/20
6078/6078 [==============================] - 1363s 224ms/step - loss: 0.2359 - acc: 0.9126 - val_loss: 10.3694 - val_acc: 0.6518
Epoch 18/20
6078/6078 [==============================] - 1362s 224ms/step - loss: 0.2331 - acc: 0.9130 - val_loss: 8.5357 - val_acc: 0.6800
Epoch 19/20
6078/6078 [==============================] - 1383s 228ms/step - loss: 0.2335 - acc: 0.9142 - val_loss: 9.8357 - val_acc: 0.6606
Epoch 20/20
6078/6078 [==============================] - 1539s 253ms/step - loss: 0.2323 - acc: 0.9141 - val_loss: 10.0375 - val_acc: 0.6594
```

In [34]:

```
acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(1, len(acc) + 1)
plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()
plt.figure()
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()
plt.show()
```


Training and validation accuracy
0.90
0.85
0.80
0.75
0.70
0.65
5
10
15
20
Training acc
Validation acc


Training and validation loss
10
8
6
4
2
0
5
10
15
20
Training loss
Validation loss

In [15]:

```
vgg16_conv_base = VGG16(weights='imagenet',
include_top=False,
input_shape=(178, 218, 3))

vgg16_mdl = Sequential()
vgg16_mdl.add(vgg16_conv_base)
vgg16_mdl.add(Flatten())
vgg16_mdl.add(Dense(256, activation='relu'))
vgg16_mdl.add(Dense(1, activation='sigmoid'))

vgg16_conv_base.trainable = False
```

In [16]:

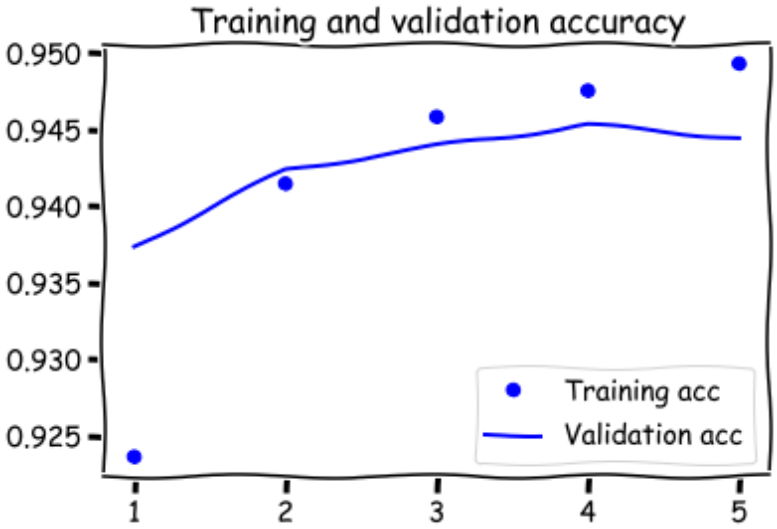
```
train_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
             r'\Assignment_2\Images\train')
validation_dir = (r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                  r'\Assignment_2\Images\validation')

train_datagen = ImageDataGenerator(
    rescale=1./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,
    fill_mode='nearest')

val_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
    train_dir,
    target_size=(178, 218),
```

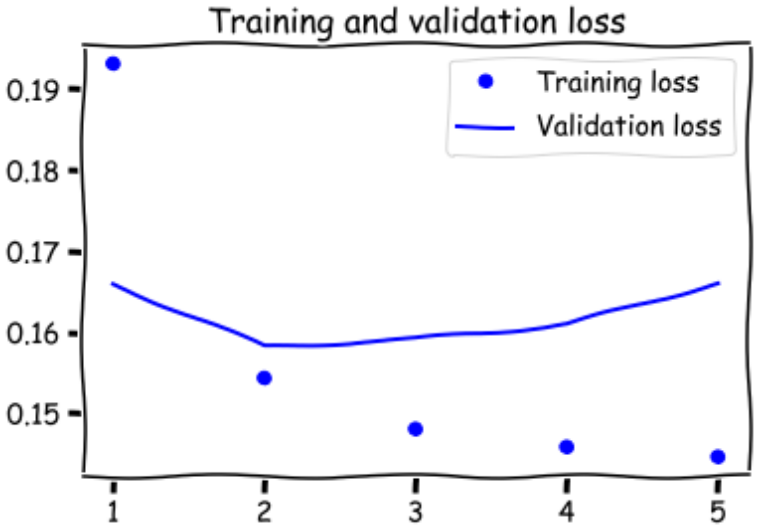
```
    batch_size=5,
    class_mode='binary')

validation_generator = val_datagen.flow_from_directory(
    validation_dir,
    target_size=(178, 218),
    batch_size=5,
    class_mode='binary')

vgg16_mdl.compile(loss='binary_crossentropy',
    optimizer=optimizers.RMSprop(learning_rate=0.000005, rho=0.9),
    metrics=['acc'])

history = vgg16_mdl.fit_generator(
    train_generator,
    steps_per_epoch=round(training_count/5),
    epochs=5,
    validation_data=validation_generator,
    validation_steps= round(val_count/5))
```

```
Found 121559 images belonging to 2 classes.
Found 40520 images belonging to 2 classes.
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
WARNING:tensorflow:sample_weight modes were coerced from
  ...
    to
  ['...']
Train for 24312 steps, validate for 8104 steps
Epoch 1/5
24312/24312 [==============================] - 2451s 101ms/step - loss: 0.1931 - acc: 0.9236 - val_loss: 0.1660 - val_acc: 0.9374
Epoch 2/5
24312/24312 [==============================] - 2460s 101ms/step - loss: 0.1543 - acc: 0.9414 - val_loss: 0.1582 - val_acc: 0.9424
Epoch 3/5
24312/24312 [==============================] - 2460s 101ms/step - loss: 0.1480 - acc: 0.9458 - val_loss: 0.1591 - val_acc: 0.9439
Epoch 4/5
24312/24312 [==============================] - 2469s 102ms/step - loss: 0.1458 - acc: 0.9475 - val_loss: 0.1610 - val_acc: 0.9453
Epoch 5/5
24312/24312 [==============================] - 2470s 102ms/step - loss: 0.1446 - acc: 0.9493 - val_loss: 0.1661 - val_acc: 0.9445
```

In [17]:

```
acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(1, len(acc) + 1)
plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()
plt.figure()
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()
plt.show()
```





In [18]:
```
vgg16_mdl.save('male_female_classification.h5')
```

In [12]:
```
mdl = load_model('male_female_classification.h5')
```

In [28]:

```
test_dir = Path(r'D:\Google_Drive_Sync\Data\Documents\School\UL\CECS590_Deep_Learning'
                r'\Assignment_2\Images\test')
test_datagen = ImageDataGenerator(rescale=1./255)
test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=(178, 218),
    batch_size=1,
    class_mode='binary')
```

```
Found 40520 images belonging to 2 classes.
```

In [29]:

```
test_truth = []
test_pred = []
for idx, x in enumerate(test_generator):
    if idx == 40520: break
    img_array = x[0]
    arr = img_array[0]
    img_class = mdl.predict_classes(img_array)

    test_truth.append(x[1][0])
    test_pred.append(img_class[0][0])
    #img = array_to_img(arr)
    #display(img)
    #if img_class[0][0]:
    #    print("Male")
    #else:
    #    print("Female")
    if (1 + idx) % 1000 == 0:
        print('Processed %i images...' % (1 + idx))
```

```
Processed 1000 images...
Processed 2000 images...
Processed 3000 images...
Processed 4000 images...
Processed 5000 images...
Processed 6000 images...
Processed 7000 images...
Processed 8000 images...
Processed 9000 images...
Processed 10000 images...
Processed 11000 images...
Processed 12000 images...
Processed 13000 images...
Processed 14000 images...
Processed 15000 images...
Processed 16000 images...
Processed 17000 images...
Processed 18000 images...
Processed 19000 images...
Processed 20000 images...
Processed 21000 images...
Processed 22000 images...
Processed 23000 images...
Processed 24000 images...
Processed 25000 images...
Processed 26000 images...
Processed 27000 images...
Processed 28000 images...
Processed 29000 images...
Processed 30000 images...
Processed 31000 images...
Processed 32000 images...
Processed 33000 images...
Processed 34000 images...
Processed 35000 images...
Processed 36000 images...
Processed 37000 images...
Processed 38000 images...
Processed 39000 images...
Processed 40000 images...
```

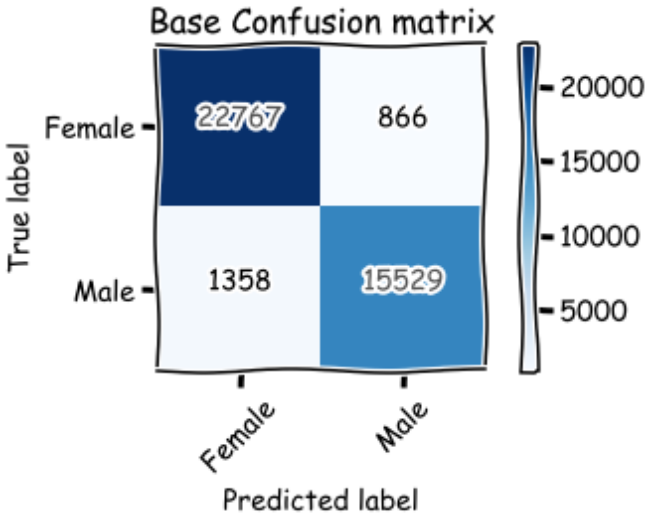
In [30]:
```
class_names = ['Female','Male']
```

```
def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    print(cm)

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="#555555" if cm[i, j] > thresh else "black")

    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.tight_layout()
```

In [31]:
```
cnf = confusion_matrix(test_truth, test_pred)
```

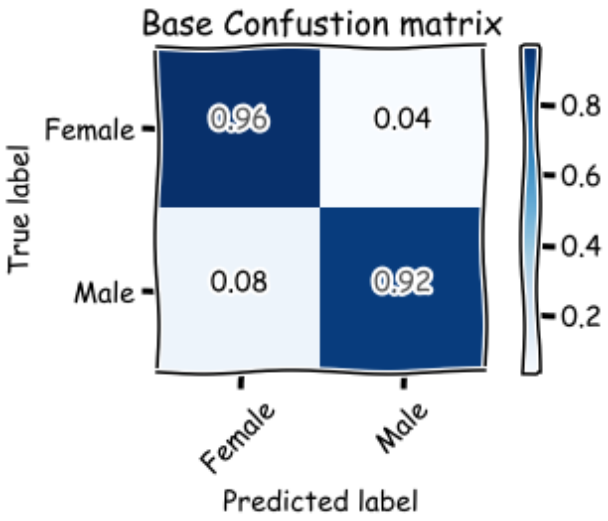
In [34]:
```
plot_confusion_matrix(cnf, classes=class_names, title='Base Confusion matrix')
```

```
Confusion matrix, without normalization
[[22767   866]
 [ 1358 15529]]
```



In [35]:
```
plot_confusion_matrix(cnf, normalize=True, classes=class_names, title='Base Confustion matrix')
```

```
Normalized confusion matrix
[[0.96335632 0.03664368]
 [0.08041689 0.91958311]]
```



In [37]:

```
for idx, x in enumerate(test_generator):
    if idx == 1000: break
    img_array = x[0]
    arr = img_array[0]
    img_class = mdl.predict_classes(img_array)
    img = array_to_img(arr)
    if x[1][0] != img_class[0][0]:
        display(img)
        if img_class[0][0]:
            print("Male")
        else:
            print("Female")
    if (1 + idx) % 1000 == 0:
        print('Processed %i images...' % (1 + idx))
```

Male

Male

Female

Male

Female

Male

Male

Female

Female

Female

Female

Female

Male

Male

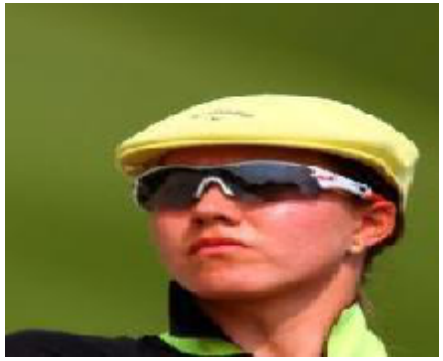
Female

Male

Male

Male

Female



Male

Male

Female

Female

Male

Female

Female

Female

Female

Female

Male

Female

Female

Female

Male

Female

Male

Male

Male

Male

Female

Female

Female

Female

Male

Female

Female

Male

Female

Female

Male

Female

Female

Male

Female

```
Female
Processed 1000 images...
```

In [ ]: