In [1]:
```
from keras.models import Sequential
from keras.layers import Convolution2D
from keras.layers import MaxPool2D
from keras.layers import Flatten
from keras.layers import Dense

from keras.preprocessing.image import ImageDataGenerator

import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
train_path = "C:\\Users\\aswin\\OneDrive\\Desktop\\Imarticus\\00_Capstone Projects_Imarticus\\Capstone_2_Facial_Recognition\\Imag
```

In [3]:
```
ion_path= "C:\\Users\\aswin\\OneDrive\\Desktop\\Imarticus\\00_Capstone Projects_Imarticus\\Capstone_2_Facial_Recognition\\Images\
```

In [4]:
```
from keras.preprocessing.image import ImageDataGenerator
```

In [5]:
```
train_data_gen = ImageDataGenerator(rescale = 1./225)
validation_data_gen = ImageDataGenerator(rescale = 1./225)
```

Train Set

In [6]:
```
train_set = train_data_gen.flow_from_directory(train_path,
                                               target_size = (64,64),
                                               batch_size = 20,
                                               class_mode = 'categorical')
```

```
Found 320 images belonging to 40 classes.
```

Validation Set

In [7]:
```
validation_set = validation_data_gen.flow_from_directory(validation_path,
                                                         target_size = (64,64),
                                                         batch_size = 20,
                                                         class_mode = 'categorical')
```

```
Found 80 images belonging to 40 classes.
```

BASE MODEL

In [8]:
```
classifier = Sequential()
classifier.add(Convolution2D(32, kernel_size=(3,3),input_shape=(64,64,3), activation ='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Convolution2D(64, kernel_size=(3,3), activation='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Convolution2D(64, kernel_size=(3,3), activation='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Flatten())
classifier.add(Dense(64, activation='relu'))
classifier.add(Dense(40, activation='softmax'))
```

In [9]:
```
classifier.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 62, 62, 32)        896

 max_pooling2d (MaxPooling2D  (None, 31, 31, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 29, 29, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 14, 14, 64)       0
 2D)

 conv2d_2 (Conv2D)           (None, 12, 12, 64)        36928

 max_pooling2d_2 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 flatten (Flatten)           (None, 2304)              0

 dense (Dense)               (None, 64)                147520

 dense_1 (Dense)             (None, 40)                2600

=================================================================
Total params: 206,440
Trainable params: 206,440
Non-trainable params: 0
_________________________________________________________________
```

Compiler

In [10]:
```
classifier.compile(loss='categorical_crossentropy', optimizer = 'adam', metrics =['accuracy'])
```

Execution of model

In [11]:
```
model = classifier.fit_generator(train_set, epochs =20, validation_data = validation_set)
```

```
Epoch 1/20
16/16 [==============================] - 14s 829ms/step - loss: 3.7081 - accuracy: 0.0250 - val_loss: 3.6844 - val_accuracy: 0.
0250
Epoch 2/20
16/16 [==============================] - 9s 545ms/step - loss: 3.6694 - accuracy: 0.0500 - val_loss: 3.6141 - val_accuracy: 0.0
500
Epoch 3/20
16/16 [==============================] - 9s 559ms/step - loss: 3.5173 - accuracy: 0.0938 - val_loss: 3.3385 - val_accuracy: 0.1
250
Epoch 4/20
16/16 [==============================] - 9s 542ms/step - loss: 3.0704 - accuracy: 0.1906 - val_loss: 2.7549 - val_accuracy: 0.2
750
Epoch 5/20
16/16 [==============================] - 8s 533ms/step - loss: 2.4080 - accuracy: 0.4219 - val_loss: 2.2888 - val_accuracy: 0.4
250
Epoch 6/20
16/16 [==============================] - 9s 539ms/step - loss: 1.9825 - accuracy: 0.5437 - val_loss: 2.1775 - val_accuracy: 0.4
875
Epoch 7/20
16/16 [==============================] - 9s 536ms/step - loss: 1.4466 - accuracy: 0.6375 - val_loss: 1.7911 - val_accuracy: 0.5
375
Epoch 8/20
16/16 [==============================] - 8s 526ms/step - loss: 1.0516 - accuracy: 0.7312 - val_loss: 1.8086 - val_accuracy: 0.5
625
Epoch 9/20
16/16 [==============================] - 10s 603ms/step - loss: 0.7800 - accuracy: 0.7969 - val_loss: 1.6275 - val_accuracy: 0.
6375
Epoch 10/20
16/16 [==============================] - 8s 530ms/step - loss: 0.5735 - accuracy: 0.8250 - val_loss: 1.6421 - val_accuracy: 0.5
875
Epoch 11/20
16/16 [==============================] - 9s 579ms/step - loss: 0.4175 - accuracy: 0.8750 - val_loss: 1.7955 - val_accuracy: 0.6
125
Epoch 12/20
16/16 [==============================] - 8s 530ms/step - loss: 0.2709 - accuracy: 0.9250 - val_loss: 1.8633 - val_accuracy: 0.6
375
Epoch 13/20
16/16 [==============================] - 8s 521ms/step - loss: 0.1731 - accuracy: 0.9531 - val_loss: 1.8599 - val_accuracy: 0.6
250
Epoch 14/20
16/16 [==============================] - 8s 519ms/step - loss: 0.1322 - accuracy: 0.9688 - val_loss: 2.0776 - val_accuracy: 0.6
500
Epoch 15/20
16/16 [==============================] - 8s 530ms/step - loss: 0.0672 - accuracy: 0.9937 - val_loss: 2.3227 - val_accuracy: 0.6
250
Epoch 16/20
16/16 [==============================] - 8s 528ms/step - loss: 0.0305 - accuracy: 1.0000 - val_loss: 2.0496 - val_accuracy: 0.6
750
Epoch 17/20
16/16 [==============================] - 9s 539ms/step - loss: 0.0434 - accuracy: 0.9937 - val_loss: 2.2389 - val_accuracy: 0.6
625
Epoch 18/20
16/16 [==============================] - 8s 530ms/step - loss: 0.0407 - accuracy: 0.9969 - val_loss: 2.5099 - val_accuracy: 0.6
125
Epoch 19/20
16/16 [==============================] - 8s 534ms/step - loss: 0.0212 - accuracy: 1.0000 - val_loss: 2.4115 - val_accuracy: 0.6
375
Epoch 20/20
16/16 [==============================] - 8s 537ms/step - loss: 0.0073 - accuracy: 1.0000 - val_loss: 2.3833 - val_accuracy: 0.6
750
```

Accuracy

In [12]:
```
import matplotlib.pyplot as plt
```

In [13]:
```
acc = model.history['accuracy']
```

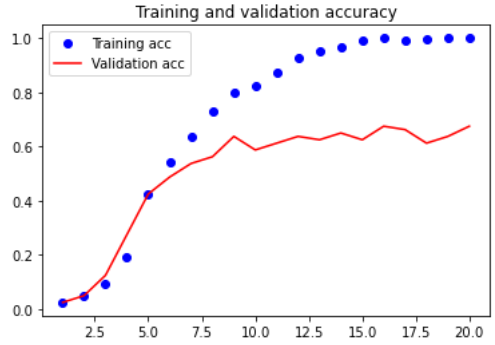
In [14]:
```
val_acc = model.history['val_accuracy']
```

In [15]:
```
loss = model.history['loss']
```

In [16]:
```
val_loss = model.history['val_loss']
```

In [17]:
```
epochs = range(1, len(acc) + 1)
```

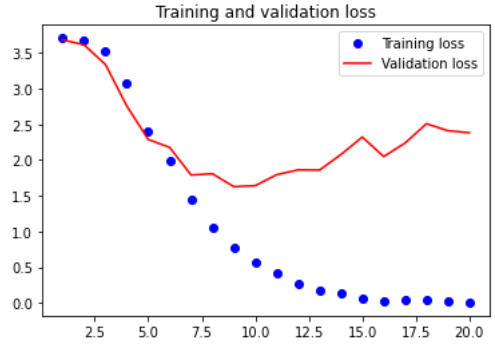
In [18]:
```
plt.plot(epochs, acc, 'bo', label='Training acc');
plt.plot(epochs, val_acc, 'r', label='Validation acc');
plt.title('Training and validation accuracy');
plt.legend();
plt.figure();
```




```
<Figure size 432x288 with 0 Axes>
```

Loss

In [19]:
```
plt.plot(epochs, loss, 'bo', label='Training loss');
plt.plot(epochs, val_loss, 'r', label='Validation loss');
plt.title('Training and validation loss');
plt.legend();
plt.figure();
```




```
<Figure size 432x288 with 0 Axes>
```

MODEL 2

In [20]:
```
train_data_gen = ImageDataGenerator(rescale=1./225,
                                    shear_range=0.5,
                                    zoom_range=0.5,
                                    width_shift_range=0.2,
                                    height_shift_range=0.2)
```

In [21]:
```
validation_data_gen = ImageDataGenerator(rescale=1./225)
```

Training Set

In [22]:
```
train_set = train_data_gen.flow_from_directory(train_path,
                                               target_size=(64,64),
                                               batch_size=20,
                                               class_mode='categorical')
```

```
Found 320 images belonging to 40 classes.
```

Validation Set

In [23]:
```
validation_set = validation_data_gen.flow_from_directory(validation_path,
                                                         target_size=(64,64),
                                                         batch_size=20,
                                                         class_mode='categorical')
```

```
Found 80 images belonging to 40 classes.
```

MODEL

In [24]:
```
classifier = Sequential()
classifier.add(Convolution2D(32, kernel_size=(3,3),input_shape=(64,64,3), activation ='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Convolution2D(64, kernel_size=(3,3), activation='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Convolution2D(64, kernel_size=(3,3), activation='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Convolution2D(64, kernel_size=(3,3), activation='relu'))
classifier.add(MaxPool2D(pool_size=(2,2)))
classifier.add(Flatten())
classifier.add(Dense(64, activation='relu'))
classifier.add(Dense(40, activation='softmax'))
```

In [25]:
```
classifier.summary()
```

```
 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_6 (Conv2D)           (None, 4, 4, 64)          36928

 max_pooling2d_6 (MaxPooling  (None, 2, 2, 64)         0
 2D)

 flatten_1 (Flatten)         (None, 256)               0

 dense_2 (Dense)             (None, 64)                16448

 dense_3 (Dense)             (None, 40)                2600

=================================================================
Total params: 112,296
Trainable params: 112,296
Non-trainable params: 0
_________________________________________________________________
```

Compiler

In [26]:
```
classifier.compile(loss='categorical_crossentropy',optimizer='adam', metrics=['accuracy'])
```

Execution of model

In [27]:
```
model2 = classifier.fit_generator(train_set, epochs = 150,validation_data=validation_set)
```

```
Epoch 1/150
16/16 [==============================] - 10s 575ms/step - loss: 3.6985 - accuracy: 0.0188 - val_loss: 3.6902 - val_accuracy: 0.
0250
Epoch 2/150
16/16 [==============================] - 9s 541ms/step - loss: 3.6913 - accuracy: 0.0250 - val_loss: 3.6870 - val_accuracy: 0.0
125
Epoch 3/150
16/16 [==============================] - 10s 606ms/step - loss: 3.6884 - accuracy: 0.0188 - val_loss: 3.6837 - val_accuracy: 0.
0625
Epoch 4/150
16/16 [==============================] - 9s 549ms/step - loss: 3.6850 - accuracy: 0.0375 - val_loss: 3.6693 - val_accuracy: 0.0
500
Epoch 5/150
16/16 [==============================] - 9s 580ms/step - loss: 3.6588 - accuracy: 0.0500 - val_loss: 3.5845 - val_accuracy: 0.0
750
Epoch 6/150
16/16 [==============================] - 9s 571ms/step - loss: 3.5852 - accuracy: 0.0500 - val_loss: 3.4374 - val_accuracy: 0.1
000
Epoch 7/150
16/16 [==============================] - 11s 685ms/step - loss: 3.4652 - accuracy: 0.0750 - val_loss: 3.2110 - val_accuracy: 0.
1375
Epoch 8/150
16/16 [==============================] - 9s 591ms/step - loss: 3.3737 - accuracy: 0.0906 - val_loss: 3.5702 - val_accuracy: 0.0
875
Epoch 9/150
16/16 [==============================] - 9s 591ms/step - loss: 3.3303 - accuracy: 0.1031 - val_loss: 3.0797 - val_accuracy: 0.1
250
Epoch 10/150
16/16 [==============================] - 9s 597ms/step - loss: 3.1996 - accuracy: 0.1250 - val_loss: 2.9891 - val_accuracy: 0.1
500
Epoch 11/150
16/16 [==============================] - 9s 575ms/step - loss: 3.0904 - accuracy: 0.1344 - val_loss: 2.7340 - val_accuracy: 0.1
625
Epoch 12/150
16/16 [==============================] - 9s 559ms/step - loss: 2.9410 - accuracy: 0.1562 - val_loss: 2.5516 - val_accuracy: 0.2
125
Epoch 13/150
16/16 [==============================] - 9s 544ms/step - loss: 2.8420 - accuracy: 0.1844 - val_loss: 2.5553 - val_accuracy: 0.2
750
Epoch 14/150
16/16 [==============================] - 9s 544ms/step - loss: 2.7731 - accuracy: 0.2438 - val_loss: 2.4220 - val_accuracy: 0.3
500
Epoch 15/150
16/16 [==============================] - 10s 620ms/step - loss: 2.7121 - accuracy: 0.2062 - val_loss: 2.5132 - val_accuracy: 0.
2750
Epoch 16/150
16/16 [==============================] - 9s 564ms/step - loss: 2.6002 - accuracy: 0.2531 - val_loss: 2.3016 - val_accuracy: 0.3
250
Epoch 17/150
16/16 [==============================] - 9s 560ms/step - loss: 2.5973 - accuracy: 0.2562 - val_loss: 2.3104 - val_accuracy: 0.3
500
Epoch 18/150
16/16 [==============================] - 10s 604ms/step - loss: 2.4763 - accuracy: 0.2969 - val_loss: 2.1465 - val_accuracy: 0.
3500
Epoch 19/150
16/16 [==============================] - 9s 582ms/step - loss: 2.4698 - accuracy: 0.2875 - val_loss: 2.1221 - val_accuracy: 0.4
000
Epoch 20/150
16/16 [==============================] - 9s 551ms/step - loss: 2.4653 - accuracy: 0.3250 - val_loss: 2.1726 - val_accuracy: 0.3
875
Epoch 21/150
16/16 [==============================] - 9s 554ms/step - loss: 2.4538 - accuracy: 0.3063 - val_loss: 2.1224 - val_accuracy: 0.4
375
Epoch 22/150
16/16 [==============================] - 9s 553ms/step - loss: 2.3242 - accuracy: 0.3406 - val_loss: 2.0215 - val_accuracy: 0.4
500
Epoch 23/150
16/16 [==============================] - 9s 552ms/step - loss: 2.2804 - accuracy: 0.3406 - val_loss: 2.0001 - val_accuracy: 0.5
375
Epoch 24/150
16/16 [==============================] - 9s 544ms/step - loss: 2.3409 - accuracy: 0.3531 - val_loss: 2.1579 - val_accuracy: 0.4
375
Epoch 25/150
16/16 [==============================] - 9s 556ms/step - loss: 2.2934 - accuracy: 0.3781 - val_loss: 1.9247 - val_accuracy: 0.4
750
Epoch 26/150
16/16 [==============================] - 9s 572ms/step - loss: 2.1381 - accuracy: 0.3719 - val_loss: 1.8530 - val_accuracy: 0.4
875
Epoch 27/150
16/16 [==============================] - 9s 559ms/step - loss: 2.1139 - accuracy: 0.3969 - val_loss: 2.2395 - val_accuracy: 0.3
750
Epoch 28/150
16/16 [==============================] - 9s 576ms/step - loss: 2.1428 - accuracy: 0.3844 - val_loss: 1.8350 - val_accuracy: 0.5
375
Epoch 29/150
16/16 [==============================] - 9s 604ms/step - loss: 2.1506 - accuracy: 0.3938 - val_loss: 1.9054 - val_accuracy: 0.4
```

```
625
Epoch 30/150
16/16 [==============================] - 9s 544ms/step - loss: 2.1061 - accuracy: 0.3438 - val_loss: 2.0290 - val_accuracy: 0.3
500
Epoch 31/150
16/16 [==============================] - 9s 559ms/step - loss: 2.1060 - accuracy: 0.3812 - val_loss: 1.7485 - val_accuracy: 0.5
500
Epoch 32/150
16/16 [==============================] - 9s 564ms/step - loss: 1.9382 - accuracy: 0.4156 - val_loss: 1.6950 - val_accuracy: 0.4
750
Epoch 33/150
16/16 [==============================] - 9s 568ms/step - loss: 1.9568 - accuracy: 0.4406 - val_loss: 1.6952 - val_accuracy: 0.5
000
Epoch 34/150
16/16 [==============================] - 9s 564ms/step - loss: 1.9452 - accuracy: 0.4688 - val_loss: 1.7851 - val_accuracy: 0.4
625
Epoch 35/150
16/16 [==============================] - 9s 549ms/step - loss: 1.8600 - accuracy: 0.4344 - val_loss: 1.6738 - val_accuracy: 0.5
000
Epoch 36/150
16/16 [==============================] - 9s 575ms/step - loss: 1.8600 - accuracy: 0.4594 - val_loss: 1.7129 - val_accuracy: 0.5
250
Epoch 37/150
16/16 [==============================] - 9s 579ms/step - loss: 1.7499 - accuracy: 0.4875 - val_loss: 1.6318 - val_accuracy: 0.5
125
Epoch 38/150
16/16 [==============================] - 9s 583ms/step - loss: 1.7787 - accuracy: 0.4563 - val_loss: 1.6277 - val_accuracy: 0.5
500
Epoch 39/150
16/16 [==============================] - 9s 581ms/step - loss: 1.6739 - accuracy: 0.5156 - val_loss: 1.6780 - val_accuracy: 0.5
250
Epoch 40/150
16/16 [==============================] - 9s 569ms/step - loss: 1.5856 - accuracy: 0.5625 - val_loss: 1.5113 - val_accuracy: 0.5
625
Epoch 41/150
16/16 [==============================] - 9s 562ms/step - loss: 1.7098 - accuracy: 0.5094 - val_loss: 1.8807 - val_accuracy: 0.4
625
Epoch 42/150
16/16 [==============================] - 9s 552ms/step - loss: 1.6110 - accuracy: 0.5594 - val_loss: 1.5674 - val_accuracy: 0.5
875
Epoch 43/150
16/16 [==============================] - 9s 575ms/step - loss: 1.5430 - accuracy: 0.5469 - val_loss: 1.9915 - val_accuracy: 0.4
250
Epoch 44/150
16/16 [==============================] - 10s 629ms/step - loss: 1.6065 - accuracy: 0.5562 - val_loss: 1.4890 - val_accuracy: 0.
5750
Epoch 45/150
16/16 [==============================] - 10s 625ms/step - loss: 1.5792 - accuracy: 0.5344 - val_loss: 1.3943 - val_accuracy: 0.
6000
Epoch 46/150
16/16 [==============================] - 9s 574ms/step - loss: 1.5564 - accuracy: 0.5562 - val_loss: 1.5746 - val_accuracy: 0.5
625
Epoch 47/150
16/16 [==============================] - 9s 577ms/step - loss: 1.4618 - accuracy: 0.5844 - val_loss: 1.5130 - val_accuracy: 0.5
750
Epoch 48/150
16/16 [==============================] - 10s 586ms/step - loss: 1.3974 - accuracy: 0.5969 - val_loss: 1.4434 - val_accuracy: 0.
6375
Epoch 49/150
16/16 [==============================] - 9s 580ms/step - loss: 1.4301 - accuracy: 0.5625 - val_loss: 1.6493 - val_accuracy: 0.5
375
Epoch 50/150
16/16 [==============================] - 9s 573ms/step - loss: 1.2608 - accuracy: 0.6313 - val_loss: 1.4298 - val_accuracy: 0.5
875
Epoch 51/150
16/16 [==============================] - 9s 555ms/step - loss: 1.2913 - accuracy: 0.5906 - val_loss: 1.3948 - val_accuracy: 0.6
000
Epoch 52/150
16/16 [==============================] - 10s 599ms/step - loss: 1.4061 - accuracy: 0.5813 - val_loss: 1.4210 - val_accuracy: 0.
6000
Epoch 53/150
16/16 [==============================] - 10s 602ms/step - loss: 1.3725 - accuracy: 0.5875 - val_loss: 1.4136 - val_accuracy: 0.
6000
Epoch 54/150
16/16 [==============================] - 9s 563ms/step - loss: 1.1899 - accuracy: 0.6531 - val_loss: 1.6785 - val_accuracy: 0.6
125
Epoch 55/150
16/16 [==============================] - 9s 570ms/step - loss: 1.2582 - accuracy: 0.6313 - val_loss: 1.4782 - val_accuracy: 0.5
875
Epoch 56/150
16/16 [==============================] - 9s 567ms/step - loss: 1.2341 - accuracy: 0.6344 - val_loss: 1.2466 - val_accuracy: 0.6
250
Epoch 57/150
16/16 [==============================] - 9s 560ms/step - loss: 1.1521 - accuracy: 0.6656 - val_loss: 1.3665 - val_accuracy: 0.6
250
```

```
Epoch 58/150
16/16 [==============================] - 9s 563ms/step - loss: 1.1676 - accuracy: 0.6406 - val_loss: 1.6148 - val_accuracy: 0.5
500
Epoch 59/150
16/16 [==============================] - 10s 626ms/step - loss: 1.1772 - accuracy: 0.6594 - val_loss: 1.4657 - val_accuracy: 0.
6250
Epoch 60/150
16/16 [==============================] - 9s 584ms/step - loss: 1.2169 - accuracy: 0.6187 - val_loss: 1.2535 - val_accuracy: 0.6
875
Epoch 61/150
16/16 [==============================] - 9s 567ms/step - loss: 1.0410 - accuracy: 0.6687 - val_loss: 1.8967 - val_accuracy: 0.5
250
Epoch 62/150
16/16 [==============================] - 9s 573ms/step - loss: 1.1048 - accuracy: 0.6687 - val_loss: 1.3309 - val_accuracy: 0.6
375
Epoch 63/150
16/16 [==============================] - 9s 575ms/step - loss: 1.1957 - accuracy: 0.6594 - val_loss: 1.5899 - val_accuracy: 0.5
875
Epoch 64/150
16/16 [==============================] - 9s 568ms/step - loss: 1.1585 - accuracy: 0.6562 - val_loss: 1.2882 - val_accuracy: 0.6
500
Epoch 65/150
16/16 [==============================] - 9s 589ms/step - loss: 1.1681 - accuracy: 0.6219 - val_loss: 1.5731 - val_accuracy: 0.6
000
Epoch 66/150
16/16 [==============================] - 9s 587ms/step - loss: 1.1045 - accuracy: 0.6687 - val_loss: 1.4277 - val_accuracy: 0.6
125
Epoch 67/150
16/16 [==============================] - 9s 577ms/step - loss: 1.0636 - accuracy: 0.6656 - val_loss: 1.3899 - val_accuracy: 0.6
625
Epoch 68/150
16/16 [==============================] - 9s 576ms/step - loss: 0.9445 - accuracy: 0.7375 - val_loss: 1.2616 - val_accuracy: 0.7
000
Epoch 69/150
16/16 [==============================] - 9s 570ms/step - loss: 1.1446 - accuracy: 0.6812 - val_loss: 1.1281 - val_accuracy: 0.7
250
Epoch 70/150
16/16 [==============================] - 10s 626ms/step - loss: 0.9573 - accuracy: 0.7344 - val_loss: 1.3730 - val_accuracy: 0.
6250
Epoch 71/150
16/16 [==============================] - 11s 695ms/step - loss: 0.8929 - accuracy: 0.7250 - val_loss: 1.3273 - val_accuracy: 0.
6500
Epoch 72/150
16/16 [==============================] - 9s 594ms/step - loss: 0.9684 - accuracy: 0.7219 - val_loss: 1.2864 - val_accuracy: 0.6
250
Epoch 73/150
16/16 [==============================] - 9s 601ms/step - loss: 1.1382 - accuracy: 0.6438 - val_loss: 1.4695 - val_accuracy: 0.6
250
Epoch 74/150
16/16 [==============================] - 9s 597ms/step - loss: 0.9628 - accuracy: 0.7000 - val_loss: 1.4162 - val_accuracy: 0.6
375
Epoch 75/150
16/16 [==============================] - 9s 567ms/step - loss: 0.8838 - accuracy: 0.7312 - val_loss: 1.2836 - val_accuracy: 0.7
000
Epoch 76/150
16/16 [==============================] - 9s 574ms/step - loss: 0.8986 - accuracy: 0.7469 - val_loss: 1.3196 - val_accuracy: 0.6
500
Epoch 77/150
16/16 [==============================] - 9s 582ms/step - loss: 0.9330 - accuracy: 0.7688 - val_loss: 1.4532 - val_accuracy: 0.6
625
Epoch 78/150
16/16 [==============================] - 9s 583ms/step - loss: 1.0140 - accuracy: 0.7031 - val_loss: 1.1587 - val_accuracy: 0.6
625
Epoch 79/150
16/16 [==============================] - 9s 562ms/step - loss: 0.7790 - accuracy: 0.7656 - val_loss: 1.4037 - val_accuracy: 0.6
500
Epoch 80/150
16/16 [==============================] - 9s 581ms/step - loss: 0.8314 - accuracy: 0.7531 - val_loss: 1.4469 - val_accuracy: 0.6
250
Epoch 81/150
16/16 [==============================] - 9s 573ms/step - loss: 0.7528 - accuracy: 0.7750 - val_loss: 1.5419 - val_accuracy: 0.6
250
Epoch 82/150
16/16 [==============================] - 10s 617ms/step - loss: 1.0623 - accuracy: 0.6812 - val_loss: 2.1326 - val_accuracy: 0.
5125
Epoch 83/150
16/16 [==============================] - 9s 589ms/step - loss: 0.8790 - accuracy: 0.7312 - val_loss: 1.4923 - val_accuracy: 0.6
500
Epoch 84/150
16/16 [==============================] - 9s 592ms/step - loss: 0.7988 - accuracy: 0.7844 - val_loss: 1.2543 - val_accuracy: 0.6
875
Epoch 85/150
16/16 [==============================] - 9s 567ms/step - loss: 0.7720 - accuracy: 0.7563 - val_loss: 1.6192 - val_accuracy: 0.5
875
Epoch 86/150
16/16 [==============================] - 9s 581ms/step - loss: 0.7096 - accuracy: 0.7688 - val_loss: 1.5231 - val_accuracy: 0.6
```

```
500
Epoch 87/150
16/16 [==============================] - 9s 563ms/step - loss: 0.8277 - accuracy: 0.7406 - val_loss: 1.5986 - val_accuracy: 0.6
375
Epoch 88/150
16/16 [==============================] - 9s 585ms/step - loss: 0.7764 - accuracy: 0.7375 - val_loss: 1.2969 - val_accuracy: 0.7
125
Epoch 89/150
16/16 [==============================] - 9s 573ms/step - loss: 0.8038 - accuracy: 0.7375 - val_loss: 1.2751 - val_accuracy: 0.6
375
Epoch 90/150
16/16 [==============================] - 9s 585ms/step - loss: 0.8038 - accuracy: 0.7750 - val_loss: 1.4737 - val_accuracy: 0.6
375
Epoch 91/150
16/16 [==============================] - 9s 586ms/step - loss: 0.7045 - accuracy: 0.8062 - val_loss: 1.4573 - val_accuracy: 0.6
500
Epoch 92/150
16/16 [==============================] - 9s 567ms/step - loss: 0.7335 - accuracy: 0.7688 - val_loss: 1.7661 - val_accuracy: 0.6
125
Epoch 93/150
16/16 [==============================] - 9s 591ms/step - loss: 0.9381 - accuracy: 0.7125 - val_loss: 1.7650 - val_accuracy: 0.6
500
Epoch 94/150
16/16 [==============================] - 11s 712ms/step - loss: 0.7141 - accuracy: 0.7844 - val_loss: 1.6092 - val_accuracy: 0.
6875
Epoch 95/150
16/16 [==============================] - 10s 613ms/step - loss: 0.6026 - accuracy: 0.8156 - val_loss: 1.4940 - val_accuracy: 0.
6500
Epoch 96/150
16/16 [==============================] - 10s 622ms/step - loss: 0.6372 - accuracy: 0.8281 - val_loss: 1.5006 - val_accuracy: 0.
6375
Epoch 97/150
16/16 [==============================] - 11s 689ms/step - loss: 0.7336 - accuracy: 0.7937 - val_loss: 1.5958 - val_accuracy: 0.
6750
Epoch 98/150
16/16 [==============================] - 12s 774ms/step - loss: 0.7433 - accuracy: 0.7812 - val_loss: 1.3604 - val_accuracy: 0.
6375
Epoch 99/150
16/16 [==============================] - 10s 612ms/step - loss: 0.7410 - accuracy: 0.7531 - val_loss: 1.3462 - val_accuracy: 0.
6625
Epoch 100/150
16/16 [==============================] - 10s 608ms/step - loss: 0.7526 - accuracy: 0.7594 - val_loss: 1.3791 - val_accuracy: 0.
6750
Epoch 101/150
16/16 [==============================] - 10s 622ms/step - loss: 0.6611 - accuracy: 0.8125 - val_loss: 1.7618 - val_accuracy: 0.
6250
Epoch 102/150
16/16 [==============================] - 10s 594ms/step - loss: 0.6728 - accuracy: 0.8094 - val_loss: 1.2507 - val_accuracy: 0.
7250
Epoch 103/150
16/16 [==============================] - 9s 599ms/step - loss: 0.7428 - accuracy: 0.7812 - val_loss: 1.2987 - val_accuracy: 0.6
625
Epoch 104/150
16/16 [==============================] - 10s 620ms/step - loss: 0.7054 - accuracy: 0.7875 - val_loss: 1.3410 - val_accuracy: 0.
6875
Epoch 105/150
16/16 [==============================] - 10s 621ms/step - loss: 0.6633 - accuracy: 0.8062 - val_loss: 1.4454 - val_accuracy: 0.
6500
Epoch 106/150
16/16 [==============================] - 10s 585ms/step - loss: 0.5873 - accuracy: 0.8125 - val_loss: 1.4491 - val_accuracy: 0.
6500
Epoch 107/150
16/16 [==============================] - 9s 589ms/step - loss: 0.5818 - accuracy: 0.8313 - val_loss: 1.7472 - val_accuracy: 0.6
000
Epoch 108/150
16/16 [==============================] - 9s 591ms/step - loss: 0.6756 - accuracy: 0.7719 - val_loss: 1.5799 - val_accuracy: 0.6
375
Epoch 109/150
16/16 [==============================] - 9s 594ms/step - loss: 0.7126 - accuracy: 0.7750 - val_loss: 1.2474 - val_accuracy: 0.7
250
Epoch 110/150
16/16 [==============================] - 9s 579ms/step - loss: 0.6338 - accuracy: 0.8188 - val_loss: 1.4924 - val_accuracy: 0.6
750
Epoch 111/150
16/16 [==============================] - 9s 595ms/step - loss: 0.6575 - accuracy: 0.8281 - val_loss: 1.5322 - val_accuracy: 0.6
875
Epoch 112/150
16/16 [==============================] - 9s 584ms/step - loss: 0.5419 - accuracy: 0.8344 - val_loss: 1.3050 - val_accuracy: 0.6
625
Epoch 113/150
16/16 [==============================] - 9s 587ms/step - loss: 0.5631 - accuracy: 0.8469 - val_loss: 1.3945 - val_accuracy: 0.6
750
Epoch 114/150
16/16 [==============================] - 9s 575ms/step - loss: 0.5534 - accuracy: 0.8531 - val_loss: 1.1860 - val_accuracy: 0.7
375
```

```
Epoch 115/150
16/16 [==============================] - 9s 582ms/step - loss: 0.4706 - accuracy: 0.8438 - val_loss: 1.5319 - val_accuracy: 0.6
625
Epoch 116/150
16/16 [==============================] - 9s 598ms/step - loss: 0.5427 - accuracy: 0.8281 - val_loss: 1.6004 - val_accuracy: 0.6
500
Epoch 117/150
16/16 [==============================] - 10s 618ms/step - loss: 0.6205 - accuracy: 0.8156 - val_loss: 1.4417 - val_accuracy: 0.
6875
Epoch 118/150
16/16 [==============================] - 10s 612ms/step - loss: 0.6856 - accuracy: 0.8125 - val_loss: 1.4990 - val_accuracy: 0.
6625
Epoch 119/150
16/16 [==============================] - 9s 583ms/step - loss: 0.6533 - accuracy: 0.7937 - val_loss: 1.4415 - val_accuracy: 0.6
375
Epoch 120/150
16/16 [==============================] - 9s 580ms/step - loss: 0.5880 - accuracy: 0.8219 - val_loss: 1.4934 - val_accuracy: 0.6
375
Epoch 121/150
16/16 [==============================] - 9s 585ms/step - loss: 0.6025 - accuracy: 0.8188 - val_loss: 1.2612 - val_accuracy: 0.6
750
Epoch 122/150
16/16 [==============================] - 9s 586ms/step - loss: 0.5098 - accuracy: 0.8656 - val_loss: 1.5326 - val_accuracy: 0.6
125
Epoch 123/150
16/16 [==============================] - 9s 585ms/step - loss: 0.5244 - accuracy: 0.8219 - val_loss: 1.4304 - val_accuracy: 0.6
250
Epoch 124/150
16/16 [==============================] - 9s 591ms/step - loss: 0.4184 - accuracy: 0.8719 - val_loss: 1.2228 - val_accuracy: 0.7
250
Epoch 125/150
16/16 [==============================] - 9s 579ms/step - loss: 0.5749 - accuracy: 0.8438 - val_loss: 1.2959 - val_accuracy: 0.6
875
Epoch 126/150
16/16 [==============================] - 9s 589ms/step - loss: 0.4745 - accuracy: 0.8375 - val_loss: 1.4060 - val_accuracy: 0.6
750
Epoch 127/150
16/16 [==============================] - 9s 592ms/step - loss: 0.5029 - accuracy: 0.8281 - val_loss: 1.9756 - val_accuracy: 0.6
375
Epoch 128/150
16/16 [==============================] - 9s 594ms/step - loss: 0.5831 - accuracy: 0.8406 - val_loss: 1.5846 - val_accuracy: 0.7
000
Epoch 129/150
16/16 [==============================] - 9s 588ms/step - loss: 0.6118 - accuracy: 0.8000 - val_loss: 1.2757 - val_accuracy: 0.7
375
Epoch 130/150
16/16 [==============================] - 9s 593ms/step - loss: 0.5535 - accuracy: 0.8344 - val_loss: 1.4842 - val_accuracy: 0.6
500
Epoch 131/150
16/16 [==============================] - 9s 583ms/step - loss: 0.4587 - accuracy: 0.8656 - val_loss: 1.3450 - val_accuracy: 0.7
875
Epoch 132/150
16/16 [==============================] - 9s 575ms/step - loss: 0.5011 - accuracy: 0.8438 - val_loss: 1.5937 - val_accuracy: 0.7
000
Epoch 133/150
16/16 [==============================] - 9s 591ms/step - loss: 0.4485 - accuracy: 0.8719 - val_loss: 1.7536 - val_accuracy: 0.6
625
Epoch 134/150
16/16 [==============================] - 9s 596ms/step - loss: 0.4337 - accuracy: 0.8469 - val_loss: 1.8329 - val_accuracy: 0.6
750
Epoch 135/150
16/16 [==============================] - 10s 605ms/step - loss: 0.5071 - accuracy: 0.8531 - val_loss: 1.4983 - val_accuracy: 0.
7125
Epoch 136/150
16/16 [==============================] - 9s 587ms/step - loss: 0.5732 - accuracy: 0.8156 - val_loss: 1.4510 - val_accuracy: 0.6
625
Epoch 137/150
16/16 [==============================] - 9s 577ms/step - loss: 0.5595 - accuracy: 0.8313 - val_loss: 1.2327 - val_accuracy: 0.7
625
Epoch 138/150
16/16 [==============================] - 9s 577ms/step - loss: 0.4917 - accuracy: 0.8562 - val_loss: 1.3891 - val_accuracy: 0.6
875
Epoch 139/150
16/16 [==============================] - 10s 621ms/step - loss: 0.5734 - accuracy: 0.8062 - val_loss: 1.4881 - val_accuracy: 0.
6500
Epoch 140/150
16/16 [==============================] - 9s 592ms/step - loss: 0.5286 - accuracy: 0.8313 - val_loss: 1.6331 - val_accuracy: 0.6
500
Epoch 141/150
16/16 [==============================] - 9s 579ms/step - loss: 0.5252 - accuracy: 0.8344 - val_loss: 1.3823 - val_accuracy: 0.6
875
Epoch 142/150
16/16 [==============================] - 11s 694ms/step - loss: 0.4827 - accuracy: 0.8562 - val_loss: 1.6002 - val_accuracy: 0.
6750
Epoch 143/150
16/16 [==============================] - 10s 616ms/step - loss: 0.4816 - accuracy: 0.8562 - val_loss: 1.6762 - val_accuracy: 0.
```

```
6500
Epoch 144/150
16/16 [==============================] - 11s 678ms/step - loss: 0.4616 - accuracy: 0.8406 - val_loss: 1.3790 - val_accuracy: 0.
6875
Epoch 145/150
16/16 [==============================] - 10s 620ms/step - loss: 0.6060 - accuracy: 0.8188 - val_loss: 1.3876 - val_accuracy: 0.
7000
Epoch 146/150
16/16 [==============================] - 10s 609ms/step - loss: 0.4345 - accuracy: 0.8500 - val_loss: 1.4830 - val_accuracy: 0.
7375
Epoch 147/150
16/16 [==============================] - 9s 593ms/step - loss: 0.4966 - accuracy: 0.8562 - val_loss: 1.2515 - val_accuracy: 0.6
750
Epoch 148/150
16/16 [==============================] - 9s 584ms/step - loss: 0.4873 - accuracy: 0.8438 - val_loss: 1.6998 - val_accuracy: 0.6
250
Epoch 149/150
16/16 [==============================] - 9s 592ms/step - loss: 0.4426 - accuracy: 0.8844 - val_loss: 1.8082 - val_accuracy: 0.6
250
Epoch 150/150
16/16 [==============================] - 9s 595ms/step - loss: 0.4221 - accuracy: 0.8813 - val_loss: 1.4905 - val_accuracy: 0.6
625
```

Accuracy

In [28]:
```
import matplotlib.pyplot as plt
```

In [29]:
```
acc = model2.history['accuracy']
```

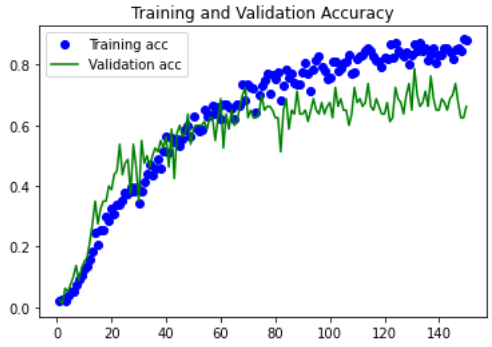
In [30]:
```
val_acc = model2.history['val_accuracy']
```

In [31]:
```
loss = model2.history['loss']
```

In [32]:
```
val_loss = model2.history['val_loss']
```

In [33]:
```
epochs = range(1, len(acc) + 1)
```

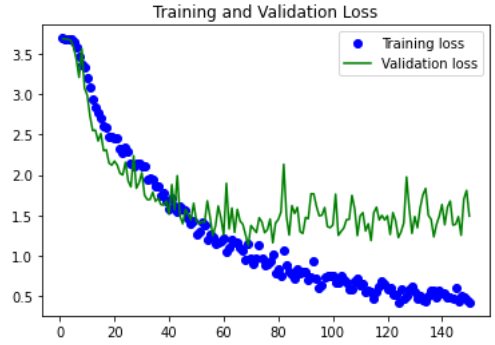
In [34]:
```
plt.plot(epochs, acc, 'bo', label='Training acc');
plt.plot(epochs, val_acc, 'g', label='Validation acc');
plt.title('Training and Validation Accuracy');
plt.legend();
plt.figure();
```




```
<Figure size 432x288 with 0 Axes>
```

Loss

In [35]:
```
plt.plot(epochs, loss, 'bo', label='Training loss');
plt.plot(epochs, val_loss, 'g', label='Validation loss');
plt.title('Training and Validation Loss');
plt.legend();
plt.figure();
```




```
<Figure size 432x288 with 0 Axes>
```