In [1]:
```
#Justin McAllister
import keras
import numpy as np
import pandas as pd
from keras.models import Sequential
```

```
Using TensorFlow backend.
```

In [2]:
```
from google.colab import drive
drive.mount('/gdrive')
```

```
Drive already mounted at /gdrive; to attempt to forcibly remount, call drive.
mount("/gdrive", force_remount=True).
```

In [3]:
```
import os, shutil
os.listdir('/gdrive/My Drive/Surgical-Instrument-Dataset')
```

Out[3]:
```
['instrument_recognition_dataset',
 '.git',
 'instrument_segmentation_dataset',
 '.gitattributes',
 '.gitignore',
 'LICENSE',
 'train',
 'validation',
 'models',
 'TestImages']
```

Setup Environment

Run Once

In [4]:
```
BaseDir = '/gdrive/My Drive/Surgical-Instrument-Dataset'

OriginalRecognitionDataset = '/gdrive/My Drive/Surgical-Instrument-Dataset/ins
trument_recognition_dataset/images'

OriginalSegmentationDataset = '/gdrive/My Drive/Surgical-Instrument-Dataset/in
strument_segmentation_dataset'

#Setup Training directories
TrainDir = os.path.join(BaseDir, 'train')
os.mkdir(TrainDir)

TrainScalpelDir = os.path.join(TrainDir, 'scalpel')
os.mkdir(TrainScalpelDir)

TrainRetractorDir = os.path.join(TrainDir, 'retractor')
os.mkdir(TrainRetractorDir)

TrainScissorsDir = os.path.join(TrainDir, 'scissors')
os.mkdir(TrainScissorsDir)

TrainBabcockForcepsDir = os.path.join(TrainDir, 'babcock_forceps')
os.mkdir(TrainBabcockForcepsDir)

TrainHemostatDir = os.path.join(TrainDir, 'hemostat')
os.mkdir(TrainHemostatDir)




#Setup Validation directories
ValidationDir = os.path.join(BaseDir, 'validation')
os.mkdir(ValidationDir)

ValidationScalpelDir = os.path.join(ValidationDir, 'scalpel')
os.mkdir(ValidationScalpelDir)

ValidationRetractorDir = os.path.join(ValidationDir, 'retractor')
os.mkdir(ValidationRetractorDir)

ValidationScissorsDir = os.path.join(ValidationDir, 'scissors')
os.mkdir(ValidationScissorsDir)

ValidationBabcockForcepsDir = os.path.join(ValidationDir, 'babcock_forceps')
os.mkdir(ValidationBabcockForcepsDir)

ValidationHemostatDir = os.path.join(ValidationDir, 'hemostat')
os.mkdir(ValidationHemostatDir)



#Copy first 512 image to scalpel
fnames = ['0_{}.jpg'.format(i) for i in range(512)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(TrainScalpelDir, fname)
```

```
    shutil.copyfile(src, dst)

#Copy first 512 image to retractor
fnames = ['1_{}.jpg'.format(i) for i in range(512)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(TrainRetractorDir, fname)
    shutil.copyfile(src, dst)

#Copy first 512 image to scissors
fnames = ['2_{}.jpg'.format(i) for i in range(512)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(TrainScissorsDir, fname)
    shutil.copyfile(src, dst)

#Copy first 512 image to Babcock Forceps
fnames = ['3_{}.jpg'.format(i) for i in range(512)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(TrainBabcockForcepsDir, fname)
    shutil.copyfile(src, dst)

#Copy first 512 image to Hemostat
fnames = ['4_{}.jpg'.format(i) for i in range(512)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(TrainHemostatDir, fname)
    shutil.copyfile(src, dst)




#Copy next 128 image to scalpel
fnames = ['0_{}.jpg'.format(i) for i in range(512, 640)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(ValidationScalpelDir, fname)
    shutil.copyfile(src, dst)

#Copy next 128 image to retractor
fnames = ['1_{}.jpg'.format(i) for i in range(512, 640)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(ValidationRetractorDir, fname)
    shutil.copyfile(src, dst)

#Copy next 128 image to scissors
fnames = ['2_{}.jpg'.format(i) for i in range(512, 640)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(ValidationScissorsDir, fname)
    shutil.copyfile(src, dst)

#Copy next 128 image to Babcock Forceps
fnames = ['3_{}.jpg'.format(i) for i in range(512, 640)]
for fname in fnames:
```

```
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(ValidationBabcockForcepsDir, fname)
    shutil.copyfile(src, dst)

#Copy next 128 image to Hemostat
fnames = ['4_{}.jpg'.format(i) for i in range(512, 640)]
for fname in fnames:
    src = os.path.join(OriginalRecognitionDataset, fname)
    dst = os.path.join(ValidationHemostatDir, fname)
    shutil.copyfile(src, dst)
```

```
---------------------------------------------------------------------------
FileExistsError                           Traceback (most recent call last)
<ipython-input-4-80e09c386754> in <module>()
      7 #Setup Training directories
      8 TrainDir = os.path.join(BaseDir, 'train')
----> 9 os.mkdir(TrainDir)
     10
     11 TrainScalpelDir = os.path.join(TrainDir, 'scalpel')

FileExistsError: [Errno 17] File exists: '/gdrive/My Drive/Surgical-Instrumen
t-Dataset/train'
```

In [0]:
```
BaseDir = '/gdrive/My Drive/Surgical-Instrument-Dataset'

OriginalRecognitionDataset = '/gdrive/My Drive/Surgical-Instrument-Dataset/ins
trument_recognition_dataset/images'

OriginalSegmentationDataset = '/gdrive/My Drive/Surgical-Instrument-Dataset/in
strument_segmentation_dataset'

#Setup Training directories
TrainDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train'

TrainScalpelDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train/scalpel'


TrainRetractorDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retrac
tor'

TrainScissorsDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train/scissor
s'

TrainBabcockForcepsDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train/b
abcock_forceps'

TrainHemostatDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/train/hemosta
t'




#Setup Validation directories
ValidationDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/validation'

ValidationScalpelDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/validatio
n/scalpel'

ValidationRetractorDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/validat
ion/retractor'

ValidationScissorsDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/validati
on/scissors'

ValidationBabcockForcepsDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/va
lidation/babcock_forceps'

ValidationHemostatDir = '/gdrive/My Drive/Surgical-Instrument-Dataset/validati
on/hemostat'
```

Sanity Check

In [6]:
```
print('total training scalpel images:', len(os.listdir(TrainScalpelDir)))
```

```
total training scalpel images: 512
```

In [7]:
```
print('total training Retractor images:', len(os.listdir(TrainRetractorDir)))
```

```
total training Retractor images: 512
```

In [8]:
```
print('total training Scissors images:', len(os.listdir(TrainScissorsDir)))
```

```
total training Scissors images: 512
```

In [9]:
```
print('total training BabcockForceps images:', len(os.listdir(TrainBabcockForc
epsDir)))
```

```
total training BabcockForceps images: 512
```

In [10]:
```
print('total training Hemostat images:', len(os.listdir(TrainHemostatDir)))
```

```
total training Hemostat images: 512
```

In [11]:
```
print('total Validation scalpel images:', len(os.listdir(ValidationScalpelDir
)))
```

```
total Validation scalpel images: 128
```

In [12]:
```
print('total Validation Retractor images:', len(os.listdir(ValidationRetractor
Dir)))
```

```
total Validation Retractor images: 128
```

In [13]:
```
print('total Validation Scissors images:', len(os.listdir(ValidationScissorsDi
r)))
```

```
total Validation Scissors images: 128
```

In [14]:
```
print('total Validation BabcockForceps images:', len(os.listdir(ValidationBabc
ockForcepsDir)))
```

```
total Validation BabcockForceps images: 128
```

In [15]:
```
print('total Validation Hemostat images:', len(os.listdir(ValidationHemostatDi
r)))
```

```
total Validation Hemostat images: 128
```

In [0]:
```
from keras import layers
from keras import models
from keras import optimizers
from keras.preprocessing.image import ImageDataGenerator
```

In [0]:
```
import matplotlib.pyplot as plt
```

Modify images

In [0]:
```
datagen = ImageDataGenerator(
      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')
```

In [19]:
```
# This is module with image preprocessing utilities
from keras.preprocessing import image

# Colab Server lists reverselt. "cat.999.jpg" file first
fnames = [os.path.join(TrainRetractorDir, fname) for fname in os.listdir(Train
RetractorDir)]
fnames
```

```
Out[19]: ['/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_0.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_1.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_2.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_3.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_4.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_5.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_6.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_7.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_8.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_9.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_10.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_11.jpg',
          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_12.jpg',
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          '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_15.jpg',
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'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_151.jpg',
'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_152.jpg',
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'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_449.jpg',
'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_450.jpg',
'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_451.jpg',
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'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_454.jpg',
'/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_455.jpg',
```

```
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_456.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_457.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_458.jpg',
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 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_475.jpg',
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 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_503.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_504.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_505.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_506.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_507.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_508.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_509.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_510.jpg',
 '/gdrive/My Drive/Surgical-Instrument-Dataset/train/retractor/1_511.jpg']
```
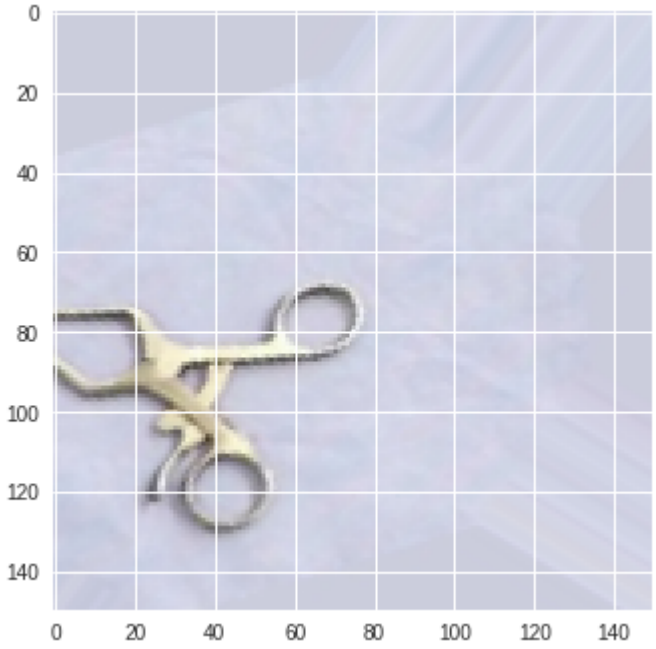
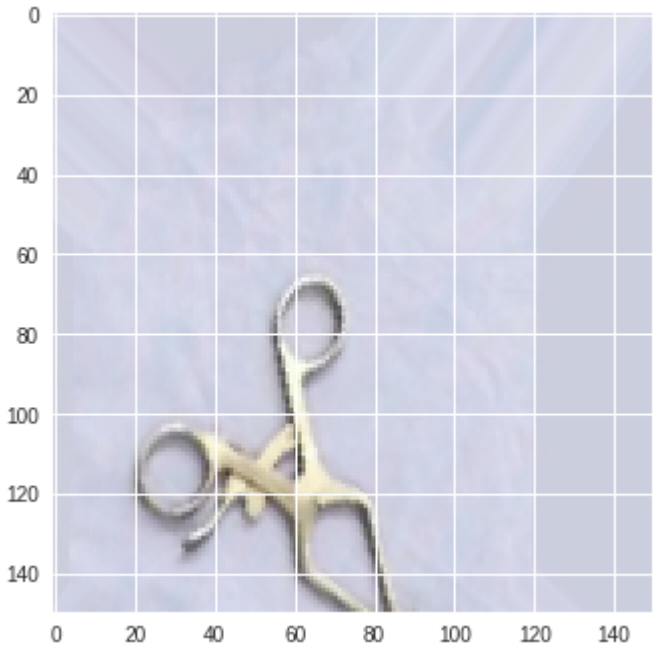
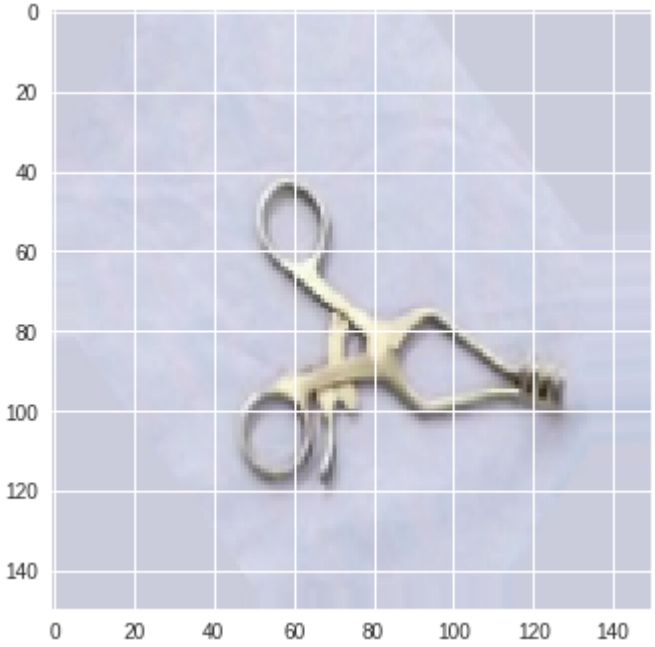
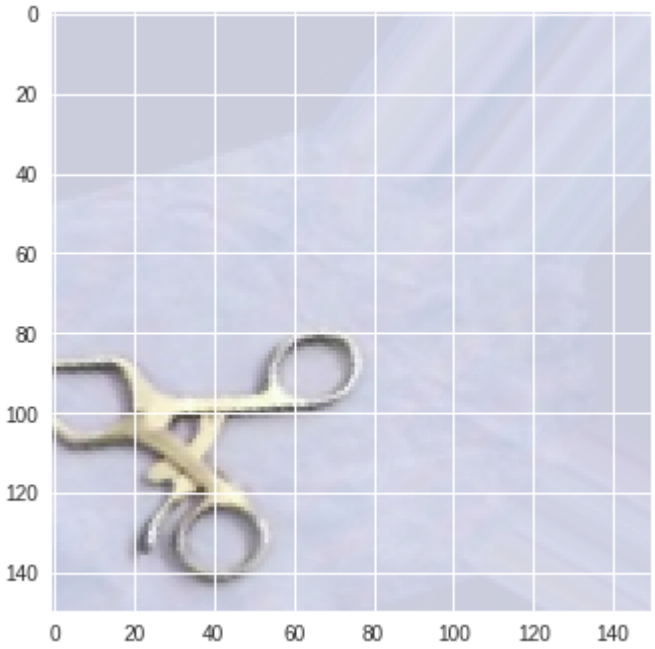

In [20]:
```
# We pick one image to "augment"
img_path = fnames[-1]

# Read the image and resize it
img = image.load_img(img_path, target_size=(150,150, 1))

# Convert it to a Numpy array with shape (150, 150, 3)
x = image.img_to_array(img)

print(x.shape)

# Reshape it to (1, 150, 150, 3)
x = x.reshape((1,) + x.shape)

# The .flow() command below generates batches of randomly transformed images.
# It will loop indefinitely, so we need to `break` the loop at some point!
i = 0
for batch in datagen.flow(x, batch_size=1):
    plt.figure(i)
    #imgplot =
    plt.imshow(image.array_to_img(batch[0]))
    i += 1
    if i % 4 == 0:
        break

#plt.show()
```

```
(150, 150, 3)
```


0
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140


0
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140


0
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140


0
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140

In [21]:
```
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,)

# Note that the validation data should not be augmented!
test_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
        # This is the target directory
        TrainDir,
        # All images will be resized to 150x150
        target_size=(150, 150),
        batch_size=32,
        # Since we use binary_crossentropy loss, we need binary labels
        class_mode='categorical')

validation_generator = test_datagen.flow_from_directory(
        ValidationDir,
        target_size=(150, 150),
        batch_size=32,
        class_mode='categorical')
```

```
Found 2560 images belonging to 5 classes.
Found 640 images belonging to 5 classes.
```

In [0]:
```
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu',
                        input_shape=(150, 150, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(256, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Flatten())
model.add(layers.Dense(512, activation='relu'))
model.add(layers.Dense(5, activation='softmax'))

#model.compile(loss='categorical_crossentropy',
#              optimizer=optimizers.RMSprop(lr=1e-4),
#              metrics=['acc'])

#from keras.callbacks import EarlyStopping
#early_stopping = EarlyStopping(monitor='val_loss', patience=2)
#model.fit(x, y, validation_split=0.2, callbacks=[early_stopping])


model.compile(loss='categorical_crossentropy',
              optimizer=keras.optimizers.Adamax(lr=0.002, beta_1=0.9, beta_2=
0.999, epsilon=None, decay=0.0),
              metrics=['acc'])
```

In [23]:
```
for data_batch, labels_batch in train_generator:
    print('data batch shape:', data_batch.shape)
    print('labels batch shape:', labels_batch.shape)
    break
```

```
data batch shape: (32, 150, 150, 3)
labels batch shape: (32, 5)
```

In [0]:
```
history = model.fit_generator(
      train_generator,
      steps_per_epoch=100,
      epochs=100,
      validation_data=validation_generator,
      validation_steps=50)
```

```
Epoch 1/100
100/100 [==============================] - 848s 8s/step - loss: 1.6107 - acc:
0.2106 - val_loss: 1.6102 - val_acc: 0.2013
Epoch 2/100
 56/100 [===============>..............] - ETA: 17s - loss: 1.5548 - acc: 0.2
980
```

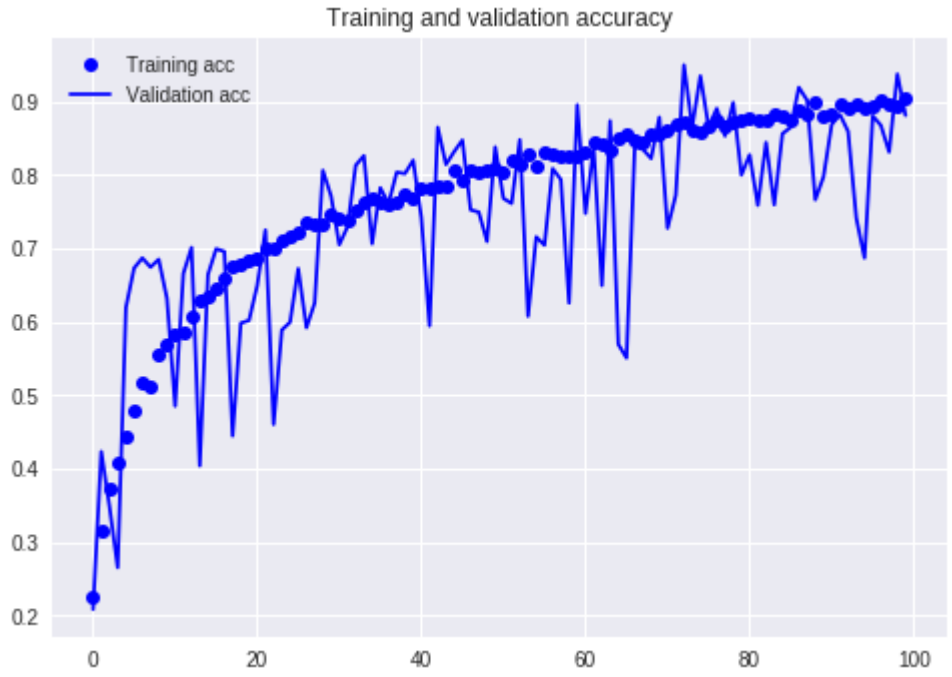
In [0]:
```
model.save('/gdrive/My Drive/Surgical-Instrument-Dataset/models/SurgicalInstru
mentation_2.csv')
model.save_weights('/gdrive/My Drive/Surgical-Instrument-Dataset/models/Surgic
alInstrumentation_Weights.csv')
```

In [0]:
```
acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(len(acc))

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()
```

loss='categorical_crossentropy'

4 Layers (32, 64, 64, 128)

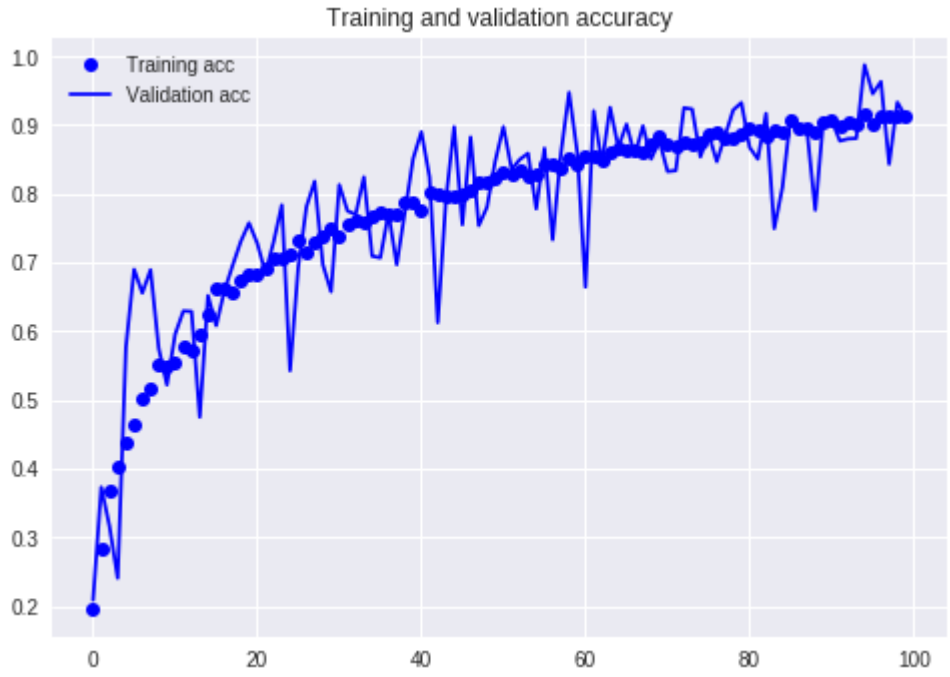
dense (512)



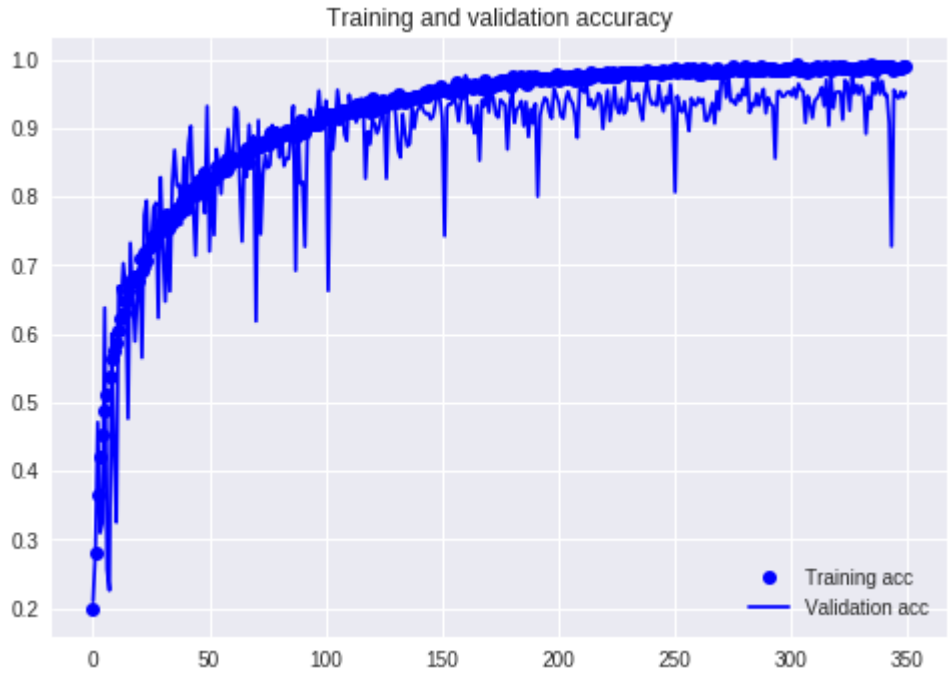
loss='categorical_crossentropy'

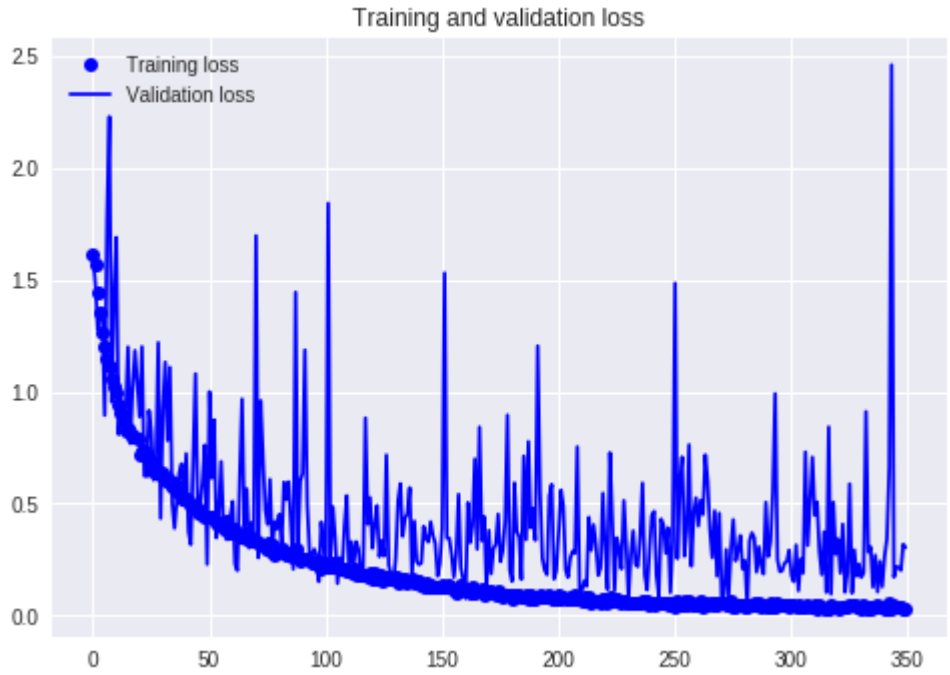
4 Layers (32, 64, 128, 128)

dense (512)



350 epochs


Training and validation accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
50
100
150
200
250
300
350
Training acc
Validation acc


Training and validation loss
2.5
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
350
Training loss
Validation loss

tf.keras

adam Optimization