Computer Vision Knife Detection

April 20, 2018

0.1 Computer Vision Knife Detection

In [2]:
```
import matplotlib.pyplot as plt
from urllib.request import urlretrieve
from os.path import isfile, isdir, getsize
from os import mkdir, makedirs, remove, listdir
from tqdm import tqdm

import zipfile
import tarfile
import imageio
import glob
import shutil
import pickle
import numpy as np

from keras.models import Sequential, Model
from keras import optimizers
from keras.layers import Dense, Activation, Conv2D, MaxPool2D, Flatten, BatchNormaliza
from keras.preprocessing.image import ImageDataGenerator
```

0.1.1 Webcam Initialization

In [3]:
```
import cv2

camera = cv2.VideoCapture(0)

def get_image():
    re, im = camera.read()
    return im
```

0.1.2 Dataset Initialization

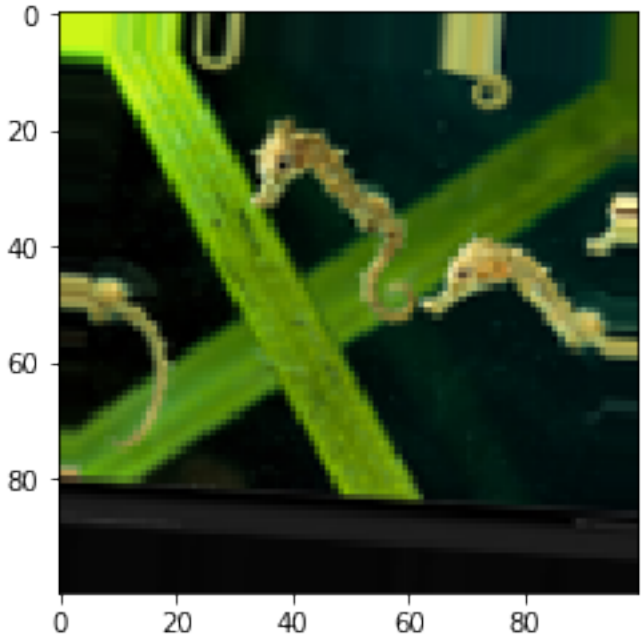
In [4]:
```
datasetfolderpath = "/Users/kevin/desktop/Datas/knives"
files = glob.glob(datasetfolderpath + "/data/**/*.bmp")

labels = np.array([0]*3560 + [1]*9341)
```

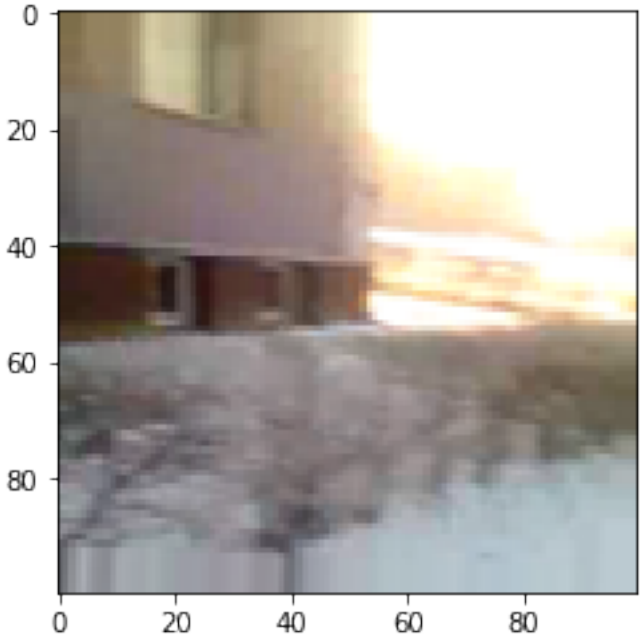
In [5]:
```
len_data = len(files)
train_examples = 10000
test_examples = len_data - train_examples

permutation = np.random.permutation(len_data)
train_set = [files[i] for i in permutation[:train_examples]]
test_set = [files[i] for i in permutation[-test_examples:]]
train_labels = labels[permutation[:train_examples]]
test_labels = labels[permutation[-test_examples:]]

train_folder = datasetfolderpath + '/train'
test_folder = datasetfolderpath + '/test'

if isdir(train_folder):
    shutil.rmtree(train_folder)
if isdir(test_folder):
    shutil.rmtree(test_folder)

makedirs(train_folder + '/positive/')
makedirs(train_folder + '/negative/')
makedirs(test_folder + '/positive/')
makedirs(test_folder + '/negative/')

for f,i in zip(train_set, train_labels):
    if i == 0:
        shutil.copy2(f, train_folder+'/positive/')
    else:
        shutil.copy2(f, train_folder+'/negative/')

for f,i in zip(test_set, test_labels):
    if i == 0:
        shutil.copy2(f, test_folder+'/positive/')
    else:
        shutil.copy2(f, test_folder+'/negative/')
```

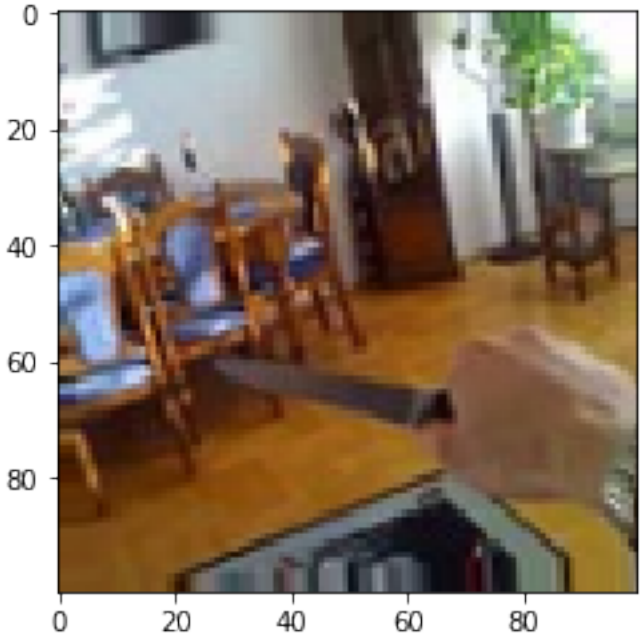
In [7]:
```
datagen = ImageDataGenerator(
    rescale = 1./255,
    rotation_range = 5,
    zoom_range = 0.2,
    horizontal_flip = True
)

img_height = img_width = 100

channels = 3
train_generator = datagen.flow_from_directory(
    train_folder,
    color_mode = 'rgb',
```

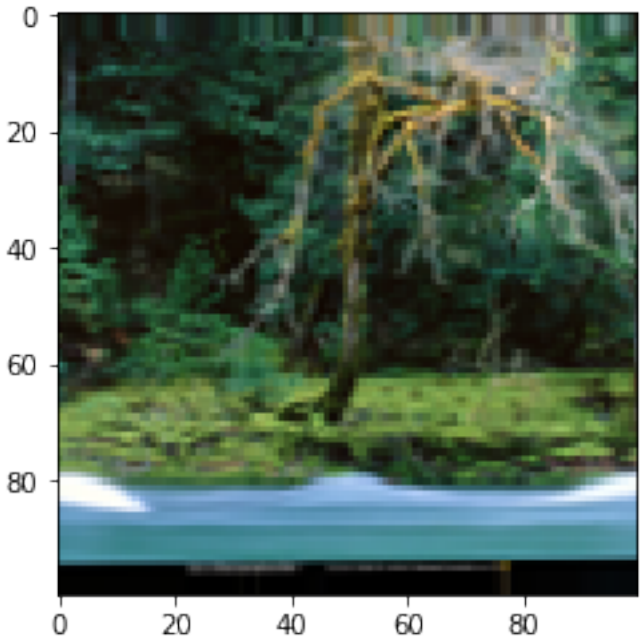
```
        target_size = (img_height, img_width),
        batch_size = 1,
        class_mode = None
    )

    i = 0
    img_list = []

    for batch in train_generator:
        img_list.append(batch)
        i += 1

        if i > 5:
            break

    for img in img_list:
        plt.imshow(np.squeeze(img))
        plt.show()
```

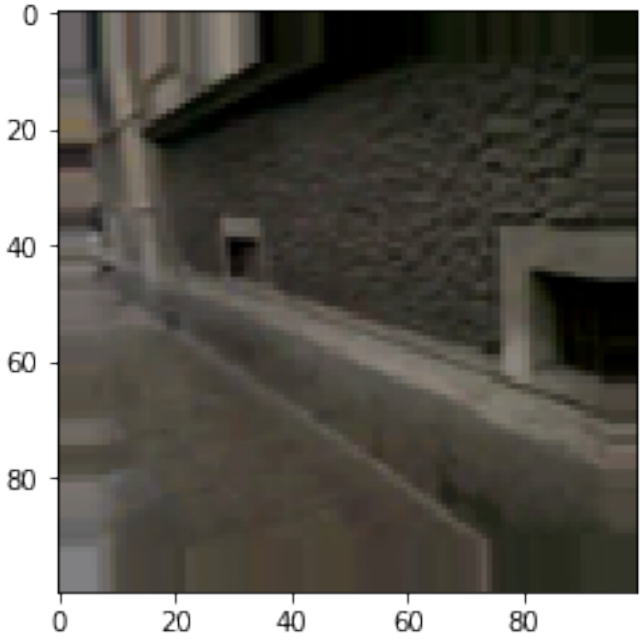
```
Found 10000 images belonging to 2 classes.
```

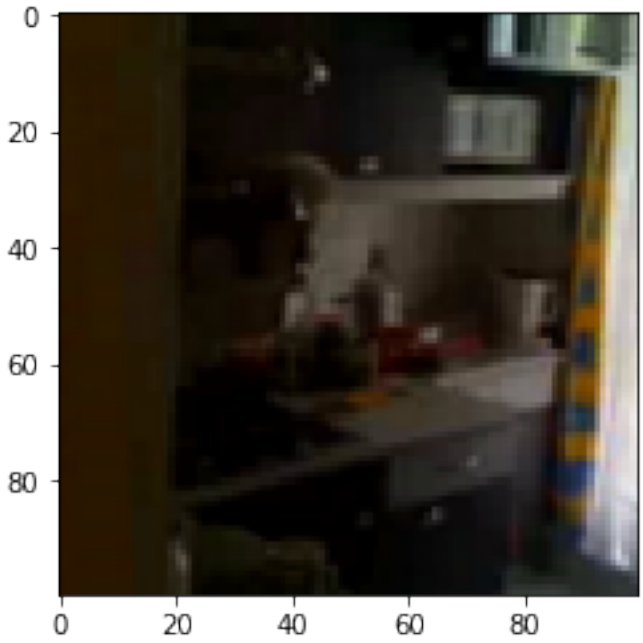



0
20
40
60
80
0
20
40
60
80


0
20
40
60
80
0
20
40
60
80


0
20
40
60
80
0
20
40
60
80


0
20
40
60
80
0
20
40
60
80



0.1.3 Logistic Regression

```
In [8]: batch_size = 1000
        train_generator = datagen.flow_from_directory(
            train_folder,
            color_mode = "rgb",
            target_size = (img_height, img_width),
            batch_size = batch_size,
            class_mode = 'binary'
        )
```

```
Found 10000 images belonging to 2 classes.
```

```
In [9]: x_train, y_train = next(train_generator)
        x_test, y_test = next(train_generator)
```

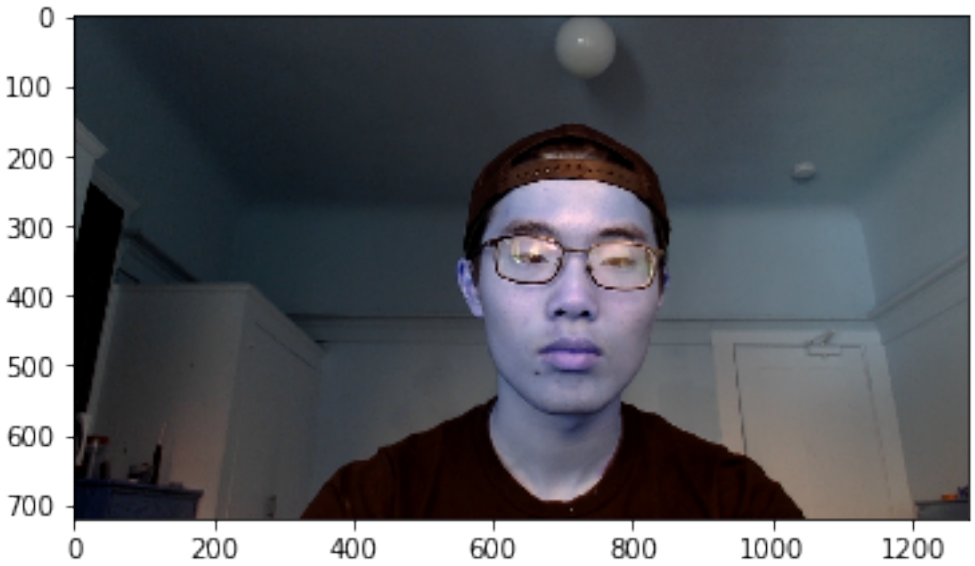
```
In [10]: from sklearn.linear_model import LogisticRegression

         logistic = LogisticRegression()
         logistic.fit(x_train.reshape(batch_size,-1), y_train)
```

```
Out[10]: LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                    intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
                    penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
                    verbose=0, warm_start=False)
```

In [11]:
```
y_pred = logistic.predict(x_test.reshape(len(x_test), -1))
y_pred[:10]
```

Out[11]:
```
array([0., 0., 0., 0., 1., 0., 1., 1., 0., 0.], dtype=float32)
```

In [12]:
```
plt.imshow(get_image())
plt.show()
```



In [13]:
```
image = get_image()
cv2.imwrite('test.png', image)
```

Out[13]:
```
True
```

In [14]:
```
from PIL import Image

img = Image.open('test.png')
input_shape = (3,3)

img_resized = img.resize(input_shape, Image.ANTIALIAS)
img = np.asarray(img.resize((img_height, img_width), Image.ANTIALIAS))/255
```

In [15]:
```
p = logistic.predict([img.reshape(-1)])
if p[0] == 0.00:
    print("This is a knife")
else:
    print("This is not a knife")
```

```
This is a knife
```

In [16]:
```
np.count_nonzero(y_pred == y_test) / len(y_test)
```

Out[16]:
```
0.708
```

0.1.4 Convolutional Neural Networks (CNN)

```
In [17]: CNN_model = Sequential()

         CNN_model.add(Conv2D(8, kernel_size=(3,3),padding='same',input_shape = (img_width, img
         CNN_model.add(Activation('relu'))
         CNN_model.add(MaxPool2D(pool_size=(3,3)))

         CNN_model.add(Conv2D(16, kernel_size=(3,3),padding='same'))
         CNN_model.add(BatchNormalization())
         CNN_model.add(Activation('relu'))
         CNN_model.add(MaxPool2D(pool_size=(2,2)))

         CNN_model.add(Conv2D(32, kernel_size=(3,3),padding='same'))
         CNN_model.add(BatchNormalization())
         CNN_model.add(Activation('relu'))
         CNN_model.add(MaxPool2D(pool_size=(2,2)))

         CNN_model.add(Conv2D(32, kernel_size=(3,3),padding='same'))
         CNN_model.add(BatchNormalization())
         CNN_model.add(Activation('relu'))
         CNN_model.add(MaxPool2D(pool_size=(2,2)))

         CNN_model.add(Flatten())
         CNN_model.add(Dense(1, activation='sigmoid'))
         CNN_model.compile(optimizer='adadelta',loss='binary_crossentropy',metrics=['accuracy']
```

```
In [18]: CNN_model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 100, 100, 8)       224
_________________________________________________________________
activation_1 (Activation)    (None, 100, 100, 8)       0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 33, 33, 8)         0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 33, 33, 16)        1168
_________________________________________________________________
batch_normalization_1 (Batch (None, 33, 33, 16)        64
_________________________________________________________________
activation_2 (Activation)    (None, 33, 33, 16)        0
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 16, 16, 16)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 16, 16, 32)        4640
_________________________________________________________________
batch_normalization_2 (Batch (None, 16, 16, 32)        128
```

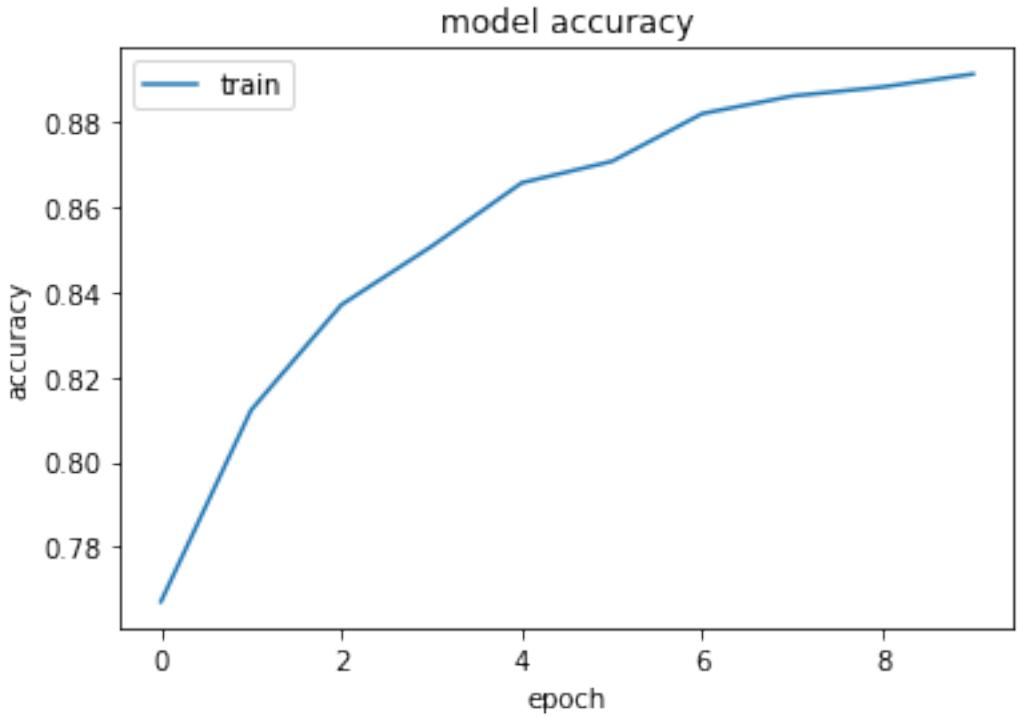
```
_________________________________________________________________
activation_3 (Activation)    (None, 16, 16, 32)        0
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 8, 8, 32)          0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 8, 8, 32)          9248
_________________________________________________________________
batch_normalization_3 (Batch (None, 8, 8, 32)          128
_________________________________________________________________
activation_4 (Activation)    (None, 8, 8, 32)          0
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 4, 4, 32)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 512)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 513
=================================================================
Total params: 16,113
Trainable params: 15,953
Non-trainable params: 160
_________________________________________________________________
```

```
In [19]: batch_size = 128
         train_generator = datagen.flow_from_directory(
             train_folder,
             color_mode = "rgb",
             target_size=(img_height, img_width),
             batch_size=batch_size,
             class_mode='binary')
         history = CNN_model.fit_generator(train_generator, train_examples//batch_size, epochs=
```

```
Found 10000 images belonging to 2 classes.
Epoch 1/10
78/78 [==============================] - 144s 2s/step - loss: 0.4953 - acc: 0.7682
Epoch 2/10
78/78 [==============================] - 128s 2s/step - loss: 0.4041 - acc: 0.8122
Epoch 3/10
78/78 [==============================] - 150s 2s/step - loss: 0.3695 - acc: 0.8333
Epoch 4/10
78/78 [==============================] - 133s 2s/step - loss: 0.3384 - acc: 0.8511
Epoch 5/10
78/78 [==============================] - 141s 2s/step - loss: 0.3228 - acc: 0.8638
Epoch 6/10
78/78 [==============================] - 99s 1s/step - loss: 0.3019 - acc: 0.8716
Epoch 7/10
78/78 [==============================] - 79s 1s/step - loss: 0.2817 - acc: 0.8820
Epoch 8/10
```

```
78/78 [==============================] - 78s 1s/step - loss: 0.2708 - acc: 0.8868
Epoch 9/10
78/78 [==============================] - 86s 1s/step - loss: 0.2642 - acc: 0.8896
Epoch 10/10
78/78 [==============================] - 85s 1s/step - loss: 0.2631 - acc: 0.8905
```

```
In [21]: plt.plot(history.history['acc'])
         plt.title('model accuracy')
         plt.ylabel('accuracy')
         plt.xlabel('epoch')
         plt.legend(['train', 'test'], loc='upper left')
         plt.show()
```




```
In [22]: batch_size = 1
         test_generator = datagen.flow_from_directory(
             test_folder,
             color_mode = "rgb",
             target_size=(img_height, img_width),
             batch_size=batch_size,
             class_mode='binary',
             shuffle=False)
         y_pred = CNN_model.predict_generator(test_generator, test_examples//batch_size, worke
         # model.predict_classes(test_x)
         # np.count_nonzero(y_pred == test_y)/len(test_y)
```

```
Found 2899 images belonging to 2 classes.
```

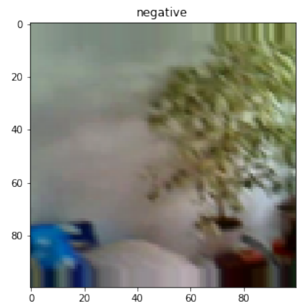
```
In [23]: correct = 0
         true_correct = 0
         for i, f in enumerate(test_generator.filenames):
             if f.startswith('negative') and y_pred[i]<0.5:
                 correct +=1
             if f.startswith('positive') and y_pred[i]>=0.5:
                 correct +=1

         print('Correct predictions: '+str(correct/len(test_generator.filenames)))
```

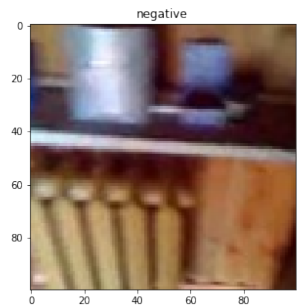
```
Correct predictions: 0.8720248361503967
```

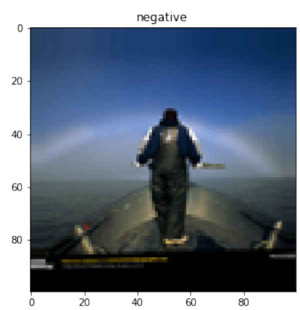
```
In [25]: batch_size = 6
         test_generator = datagen.flow_from_directory(
             test_folder,
             color_mode = "rgb",
             target_size=(img_height, img_width),
             batch_size=batch_size,
             class_mode='binary',
             shuffle=True)
         x_test, y_test = next(test_generator)

         p = CNN_model.predict(x_test)
         label_dict = {0: 'negative', 1: 'positive'}
```

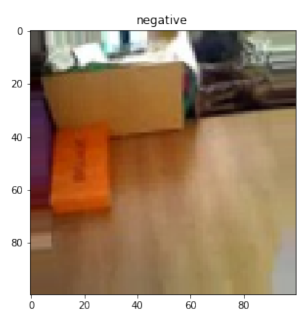
```
Found 2899 images belonging to 2 classes.
```

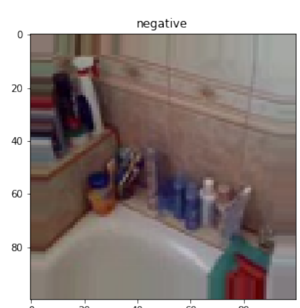
```
In [26]: plt.figure(figsize=(35,35))

         for i in range(batch_size):
             plt.subplot(batch_size,2,2*i+1)
             plt.imshow(x_test[i])
             plt.title(label_dict[y_test[i]])

         plt.show()
```

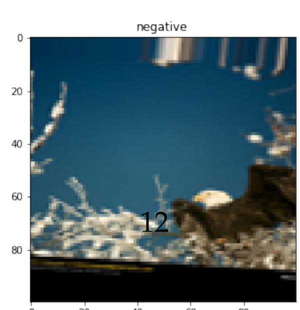

negative


negative


negative


negative

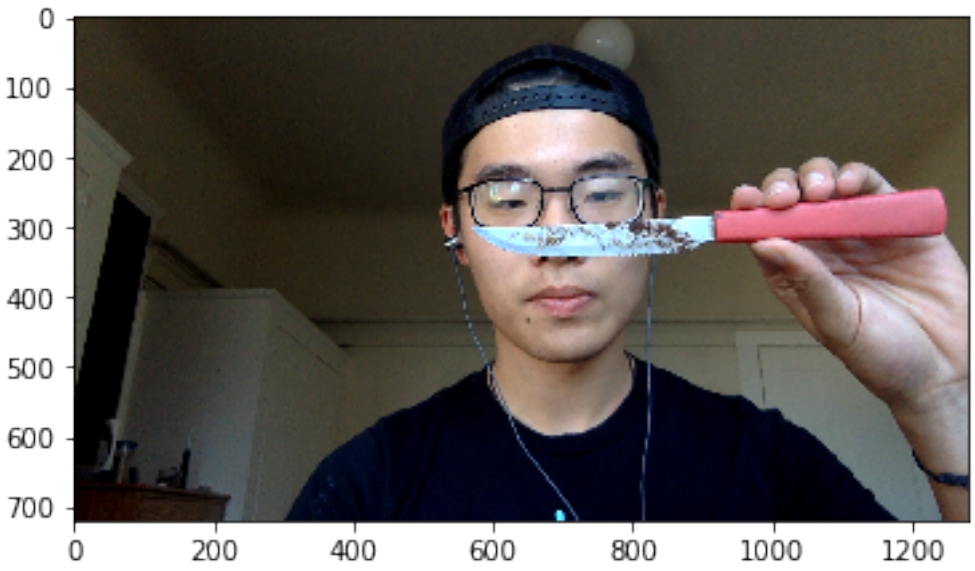

negative


negative

```
In [48]: image = get_image()
         cv2.imwrite('test.png', image)

         img = Image.open('test.png')

         img = np.asarray(img.resize((img_height, img_width), Image.ANTIALIAS))/255

         r = CNN_model.predict(np.array([img]))
```

```
In [49]: plt.imshow(Image.open('test.png'))
         if r[0][0] < 0.5:
             print("This is not a knife")
             print("Confidence: ", 1 - r[0][0])

         else:
             print("This is a knife")
             print("Confidence: ", r[0][0])
```

```
This is a knife
Confidence:  0.8787047
```



0.1.5 Transfer Learning (VGG-16)

```
In [71]: from keras import applications
```

```
        datagen = ImageDataGenerator(rescale=1.0/255)
        VGG_model = applications.VGG16(include_top=False, input_shape=(img_width, img_height,
```

In [184]:
```
batch_size = 128
generator = datagen.flow_from_directory(
    train_folder,
    target_size=(img_width, img_height),
    batch_size=batch_size,
    class_mode=None,
    shuffle=False)
#bottleneck_features_train = VGG_model.predict_generator(generator, train_examples//
#pickle.dump(bottleneck_features_train, open('bottleneck_features_train.npy', 'wb'))
#bottleneck_features_train.shape
```

```
Found 10000 images belonging to 2 classes.
```

In [185]:
```
batch_size = 128
valid_generator = datagen.flow_from_directory(
    test_folder,
    target_size=(img_width, img_height),
    batch_size=batch_size,
    class_mode=None,
    shuffle=False)
#bottleneck_features_valid = VGG_model.predict_generator(generator, test_examples//b
#with open('bottleneck_features_valid.npy', 'wb') as f:
#    pickle.dump(bottleneck_features_valid, f)
#bottleneck_features_valid.shape
```

```
Found 2899 images belonging to 2 classes.
```

In [186]:
```
with open('bottleneck_features_train.npy','rb') as f:
    bottleneck_features_train = pickle.load(f)

VGG_model = Sequential()
VGG_model.add(Flatten(input_shape = bottleneck_features_train.shape[1:]))
VGG_model.add(Dense(256, activation='relu'))
VGG_model.add(Dropout(0.5))
VGG_model.add(Dense(1, activation='sigmoid'))

VGG_model.compile(optimizer='rmsprop',loss='binary_crossentropy',metrics=['accuracy'
VGG_model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
flatten_5 (Flatten)          (None, 4608)              0
_________________________________________________________________
```

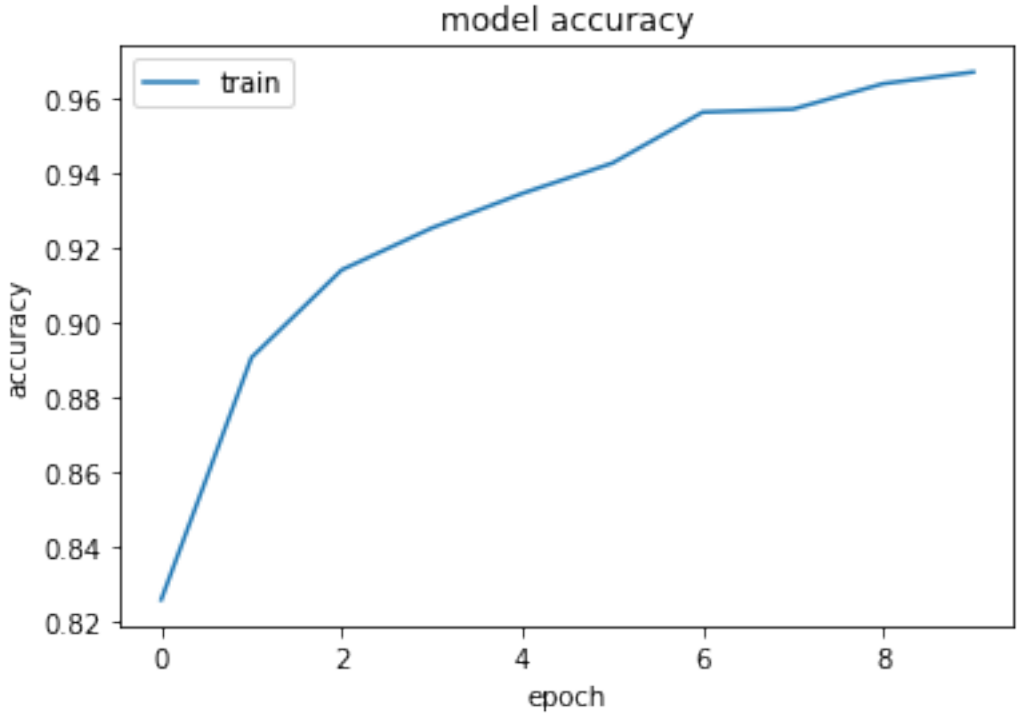
```
dense_5 (Dense)              (None, 256)               1179904
_________________________________________________________________
dropout_1 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 257
=================================================================
Total params: 1,180,161
Trainable params: 1,180,161
Non-trainable params: 0
_________________________________________________________________
```

```
In [187]: batch_size = 128
          generator = datagen.flow_from_directory(
              train_folder,
              target_size=(img_width, img_height),
              batch_size=batch_size,
              class_mode=None,
              shuffle=False)

          labels = np.array([0 if f.startswith('negative') else 1 for f in generator.filenames]
          VGG_history = VGG_model.fit(bottleneck_features_train, labels, epochs=10, batch_size=
```

```
Found 10000 images belonging to 2 classes.
Epoch 1/10
9984/9984 [==============================] - 3s 346us/step - loss: 0.4904 - acc: 0.8258
Epoch 2/10
9984/9984 [==============================] - 3s 289us/step - loss: 0.2528 - acc: 0.8905
Epoch 3/10
9984/9984 [==============================] - 3s 287us/step - loss: 0.2085 - acc: 0.9140
Epoch 4/10
9984/9984 [==============================] - 3s 272us/step - loss: 0.1723 - acc: 0.9252
Epoch 5/10
9984/9984 [==============================] - 3s 317us/step - loss: 0.1607 - acc: 0.9344
Epoch 6/10
9984/9984 [==============================] - 3s 269us/step - loss: 0.1422 - acc: 0.9425
Epoch 7/10
9984/9984 [==============================] - 3s 261us/step - loss: 0.1197 - acc: 0.9561
Epoch 8/10
9984/9984 [==============================] - 3s 271us/step - loss: 0.1104 - acc: 0.9569
Epoch 9/10
9984/9984 [==============================] - 3s 273us/step - loss: 0.0939 - acc: 0.9637
Epoch 10/10
9984/9984 [==============================] - 4s 388us/step - loss: 0.0902 - acc: 0.9668
```

```
In [188]: plt.plot(VGG_history.history['acc'])
          plt.title('model accuracy')
```

```
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```




```
In [189]: with open('bottleneck_features_valid.npy','rb') as f:
              bottleneck_features_valid = pickle.load(f)

          valid_labels = np.array([0 if f.startswith('negative') else 1 for f in valid_generat
          y_valid_pred = VGG_model.predict_classes(bottleneck_features_valid)
          accuracy = np.count_nonzero(valid_labels == y_valid_pred.ravel())/len(valid_labels)

          print('\nThe accuracy is: '+str(accuracy))
```

```
The accuracy is: 0.7574573863636364
```

```
In [190]: vgg16 = applications.VGG16(include_top=False, weights='imagenet', input_shape=(img_w
          combinedModel = Model(inputs= vgg16.input, outputs= VGG_model(vgg16.output))

          for layer in combinedModel.layers[:-3]:
              layer.trainable = False
```

```
In [191]: combinedModel.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_3 (InputLayer)         (None, 100, 100, 3)       0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 100, 100, 64)      1792
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 100, 100, 64)      36928
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 50, 50, 64)        0
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 50, 50, 128)       73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 50, 50, 128)       147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 25, 25, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 25, 25, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 25, 25, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 25, 25, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 12, 12, 256)       0
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 12, 12, 512)       1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 12, 12, 512)       2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 12, 12, 512)       2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 6, 6, 512)         0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 6, 6, 512)         2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 6, 6, 512)         2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 6, 6, 512)         2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 3, 3, 512)         0
_________________________________________________________________
sequential_5 (Sequential)    (None, 1)                 1180161
=================================================================
Total params: 15,894,849
Trainable params: 3,539,969
Non-trainable params: 12,354,880
_________________________________________________________________
```

0.1.6 Fine-tuning (This may take one to two hours)

```
In [101]: VGG_model.save_weights('fc_model.h5')

In [102]: combinedModel.compile(loss='binary_crossentropy',
                        optimizer = optimizers.RMSprop(lr=1e-4, decay=0.9), # optimizers.SGD(l
                        metrics=['accuracy'])

          # prepare data augmentation configuration
          train_datagen = ImageDataGenerator(
              rescale=1. / 255,
              shear_range=0.2,
              zoom_range=0.2,
              horizontal_flip=True)

          test_datagen = ImageDataGenerator(rescale=1. / 255)

          train_generator = train_datagen.flow_from_directory(
              train_folder,
              target_size=(img_height, img_width),
              batch_size=batch_size,
              class_mode='binary')

          validation_generator = test_datagen.flow_from_directory(
              test_folder,
              target_size=(img_height, img_width),
              batch_size=batch_size,
              class_mode='binary')

Found 10000 images belonging to 2 classes.
Found 2899 images belonging to 2 classes.


In [103]: # fine-tune the model
          combinedModel.fit_generator(
              train_generator,
              steps_per_epoch=train_examples//batch_size,
              epochs=5,
              validation_data=validation_generator,
              validation_steps=test_examples//batch_size) # len(valid_generator.filenames)

WARNING:tensorflow:Variable *= will be deprecated. Use variable.assign_mul if you want assignme
Epoch 1/5
78/78 [==============================] - 2334s 30s/step - loss: 1.2813 - acc: 0.4110 - val_loss
Epoch 2/5
78/78 [==============================] - 4183s 54s/step - loss: 0.8882 - acc: 0.5181 - val_loss
Epoch 3/5
78/78 [==============================] - 1626s 21s/step - loss: 0.8141 - acc: 0.5469 - val_loss
Epoch 4/5
```

```
78/78 [==============================] - 1796s 23s/step - loss: 0.7804 - acc: 0.5663 - val_loss
Epoch 5/5
78/78 [==============================] - 1873s 24s/step - loss: 0.7629 - acc: 0.5818 - val_loss
```

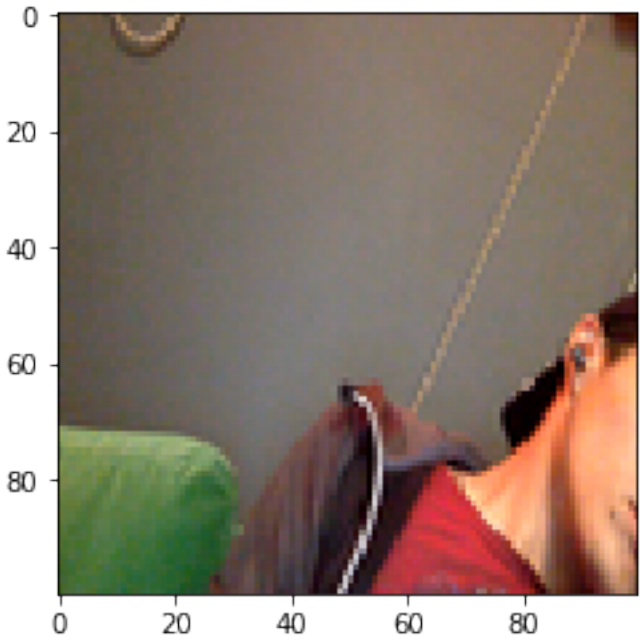
```
Out[103]: <keras.callbacks.History at 0x1a30c5cb00>
```

```
In [199]: image = get_image()
          cv2.imwrite('test.png', image)
```

```
Out[199]: True
```

```
In [200]: img = Image.open('test.png')
          input_shape = (3,3)

          img_resized = img.resize(input_shape, Image.ANTIALIAS)
```

```
In [201]: img = Image.open('test.png')
          img = np.asarray(img.resize((img_height, img_width), Image.ANTIALIAS))/255
          plt.imshow(img)
          plt.show()
          p = combinedModel.predict(np.array([img]))
          if p[0][0] < 0.5:
              print("This is not a knife")
              print("Confidence: ", 1-p[0][0])
          else:
              print("This is a knife")
              print("Confidence: ", p[0][0])
```



```
This is a knife
Confidence:  0.97202975
```

```
In [5]: path = "/anaconda3/lib/python3.6/site-packages/cv2/data/"
        cam = cv2.VideoCapture(0)
        detector=cv2.CascadeClassifier(path + 'haarcascade_frontalface_default.xml')
```

```
In [ ]: while(True):
            ret, img = cam.read()
            gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
            faces = detector.detectMultiScale(gray, 1.3, 5)
            for (x,y,w,h) in faces:
                cv2.rectangle(img,(x,y),(x+w,y+h),(255,0,0),2)

            cv2.imshow('frame',img)
            if cv2.waitKey(1) & 0xFF == ord('q'):
                break
```