Project_Team1

May 21, 2018

Introduction to Machine Learning (Spring 18) - Team 1
Team Members: Anurag Marwah (Net ID: am8482)

1 Initialize

```
In [1]: import numpy as np
        from scipy import misc
        import time
        import matplotlib.pyplot as plt
        import pandas as pd
        %matplotlib inline
```

2 Step 0: Prepare Data

2.1 Flickr API

```
In [2]: import flickrapi
        import urllib.request
        import skimage.io
        import skimage.transform
        import requests
        import warnings
        import os
        from io import BytesIO
```

```
In [3]: api_key = u'xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx'
        api_secret = u'xxxxxxxxxxxxxxx'
        flickr = flickrapi.FlickrAPI(api_key, api_secret)
```

```
In [4]: def createdir(dir_name):
            dir_exists = os.path.isdir(dir_name)
            if not dir_exists:
                os.mkdir(dir_name)
                print("Making directory %s" % dir_name)
            else:
                print("Directory %s already present!" % dir_name)
```

```
In [5]: def downloadimages(dir_name,keyword,nimage):

            photos = flickr.walk(text=keyword, tag_mode='all', tags=keyword,extras='url_c',\
                                 sort='relevance',per_page=100)
        #     nimage = 10
            i = 0
            nrow = 224
            ncol = 224
            for photo in photos:
                url=photo.get('url_c')
                if not (url is None):

                    # Create a file from the URL
                    # This may only work in Python3
                    response = requests.get(url)
                    file = BytesIO(response.content)

                    # Read image from file
                    im = skimage.io.imread(file)

                    # Resize images
                    im1 = skimage.transform.resize(im,(nrow,ncol),mode='constant')

                    # Convert to uint8, suppress the warning about the precision loss
                    with warnings.catch_warnings():
                        warnings.simplefilter("ignore")
                        im2 = skimage.img_as_ubyte(im1)

                    # Save the image
                    local_name = '{0:s}/{1:s}/{2:s}_{3:04d}.jpg'.format(dir_name,keyword,keywo
                    skimage.io.imsave(local_name, im2)
                    print(local_name)
                    i = i + 1
                if (i >= nimage):
                    break
```

2.2 Creating Directories

```
In [6]: dir1 = 'train'
        dir2 = 'test'
        keyword1 = 'person'
        keyword2 = 'car'
        keyword3 = 'animal'
        keyword4 = 'bird'
        keyword5 = 'building'
        keyword6 = 'tree'
        keyword7 = 'face'
        keyword8 = 'group'
```

```
In [7]: # createdir(dir1)
        # createdir(dir1+'/'+keyword1)
        # createdir(dir1+'/'+keyword2)
        # createdir(dir1+'/'+keyword3)
        # createdir(dir1+'/'+keyword4)
        # createdir(dir1+'/'+keyword5)
        # createdir(dir1+'/'+keyword6)
        # createdir(dir1+'/'+keyword7)
        # createdir(dir2)
        # createdir(dir2+'/'+keyword1)
        # createdir(dir2+'/'+keyword2)
        # createdir(dir2+'/'+keyword3)
        # createdir(dir2+'/'+keyword4)
        # createdir(dir2+'/'+keyword5)
        # createdir(dir2+'/'+keyword6)
        # createdir(dir2+'/'+keyword7)
        # createdir(dir2+'/'+keyword8)
```

2.3 Download Data

```
In [8]: # downloadimages(dir1,keyword1,1000)
        # downloadimages(dir1,keyword2,1000)
        # downloadimages(dir1,keyword3,1000)
        # downloadimages(dir1,keyword4,1000)
        # downloadimages(dir1,keyword5,1000)
        # downloadimages(dir1,keyword6,1000)
        # downloadimages(dir1,keyword7,1000)

        # downloadimages(dir2,keyword1,300)
        # downloadimages(dir2,keyword2,300)
        # downloadimages(dir2,keyword3,300)
        # downloadimages(dir2,keyword4,300)
        # downloadimages(dir2,keyword5,300)
        # downloadimages(dir2,keyword6,300)
        # downloadimages(dir2,keyword7,300)
        # downloadimages(dir2,keyword8,300)
```

3 Step 1: Download Model

```
In [9]: import keras
```

```
/Applications/anaconda/lib/python3.6/site-packages/h5py/__init__.py:34: FutureWarning: Conversi
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

```
In [10]: from keras import applications
         from keras.preprocessing.image import ImageDataGenerator
```

```
        from keras import optimizers
        from keras.models import Sequential
        from keras.layers import Dropout, Flatten, Dense
```

```
In [11]: import keras.backend as K
         K.clear_session()
```

```
In [12]: nrow = 64
         ncol = 64
         nchan = 3
         image_shape = (nrow,ncol,3)
         print(image_shape)
```

```
(64, 64, 3)
```

3.1 Download VGGNet

```
In [13]: from keras.applications.vgg16 import VGG16
         from keras.preprocessing import image
         from keras.applications.vgg16 import decode_predictions, preprocess_input
         base_model = VGG16(include_top=False, weights='imagenet', input_shape=image_shape)
         base_model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 64, 64, 3)         0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 64, 64, 64)        1792
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 64, 64, 64)        36928
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 32, 32, 64)        0
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 32, 32, 128)       73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 32, 32, 128)       147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 16, 16, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 16, 16, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 8, 8, 256)         0
_________________________________________________________________
```

```
block4_conv1 (Conv2D)        (None, 8, 8, 512)         1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 4, 4, 512)         0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 2, 2, 512)         0
=================================================================
Total params: 14,714,688
Trainable params: 14,714,688
Non-trainable params: 0
_________________________________________________________________
```

3.2 Create New Model

```
In [14]: # Create new model
         model = Sequential()

         # Add layers into the new model
         for layer in base_model.layers:
             model.add(layer)

         # Freeze the layers in the new model
         for layer in model.layers:
             layer.trainable=False

         model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 64, 64, 3)         0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 64, 64, 64)        1792
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 64, 64, 64)        36928
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 32, 32, 64)        0
_________________________________________________________________
```

```
block2_conv1 (Conv2D)        (None, 32, 32, 128)       73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 32, 32, 128)       147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 16, 16, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 16, 16, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 8, 8, 256)         0
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 8, 8, 512)         1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 4, 4, 512)         0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 2, 2, 512)         0
=================================================================
Total params: 14,714,688
Trainable params: 0
Non-trainable params: 14,714,688
_________________________________________________________________
```

```
In [15]: model.add(Flatten())
         model.add(Dense(256, activation='relu'))
         model.add(Dense(1, activation='sigmoid'))
         model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         (None, 64, 64, 3)         0
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 64, 64, 64)        1792
_________________________________________________________________
```

```
block1_conv2 (Conv2D)        (None, 64, 64, 64)        36928
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 32, 32, 64)        0
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 32, 32, 128)       73856
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 32, 32, 128)       147584
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 16, 16, 128)       0
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 16, 16, 256)       295168
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 16, 16, 256)       590080
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 8, 8, 256)         0
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 8, 8, 512)         1180160
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 8, 8, 512)         2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 4, 4, 512)         0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 4, 4, 512)         2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 2, 2, 512)         0
_________________________________________________________________
flatten_1 (Flatten)          (None, 2048)              0
_________________________________________________________________
dense_1 (Dense)              (None, 256)               524544
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 257
=================================================================
Total params: 15,239,489
Trainable params: 524,801
Non-trainable params: 14,714,688
_________________________________________________________________
```

4 Step 2: Train Model

4.1 Data Generators

In [16]:
```
train_data_dir = './train'
batch_size = 32
train_datagen = ImageDataGenerator(rescale=1./255,
                                   shear_range=0.2,
                                   zoom_range=0.2,
                                   horizontal_flip=True)
train_generator = train_datagen.flow_from_directory(
                          train_data_dir,
                          target_size=(nrow,ncol),
                          batch_size=batch_size,
                          classes=['notaface','face'],
                          class_mode='binary')
```

```
Found 4000 images belonging to 2 classes.
```

In [17]:
```
test_data_dir = './test'
batch_size = 32
test_datagen = ImageDataGenerator(rescale=1./255,
                                   shear_range=0.2,
                                   zoom_range=0.2,
                                   horizontal_flip=True)
test_generator = test_datagen.flow_from_directory(
                          test_data_dir,
                          target_size=(nrow,ncol),
                          batch_size=batch_size,
                          classes=['notaface','face'],
                          class_mode='binary')
```

```
Found 2000 images belonging to 2 classes.
```

In [18]:
```
# Display the image
def disp_image(im):
    if (len(im.shape) == 2):
        # Gray scale image
        plt.imshow(im, cmap='gray')
    else:
        # Color image.
        im1 = (im-np.min(im))/(np.max(im)-np.min(im))*255
        im1 = im1.astype(np.uint8)
        plt.imshow(im1)

    # Remove axis ticks
    plt.xticks([])
    plt.yticks([])
```

4.2 Sample Train and Test Data

```
In [19]: nplot = 10
         plt.figure(figsize=(20,20))
         minibatch_x,minibatch_y = train_generator.next()
         for i in range(nplot):
             plt.subplot(1,nplot,i+1)
             disp_image(minibatch_x[i])
             plt.title(minibatch_y[i])
```


```
In [20]: nplot = 10
         plt.figure(figsize=(20,20))
         minibatch_x,minibatch_y = test_generator.next()
         for i in range(nplot):
             plt.subplot(1,nplot,i+1)
             disp_image(minibatch_x[i])
             plt.title(minibatch_y[i])
```

4.3 Model Training

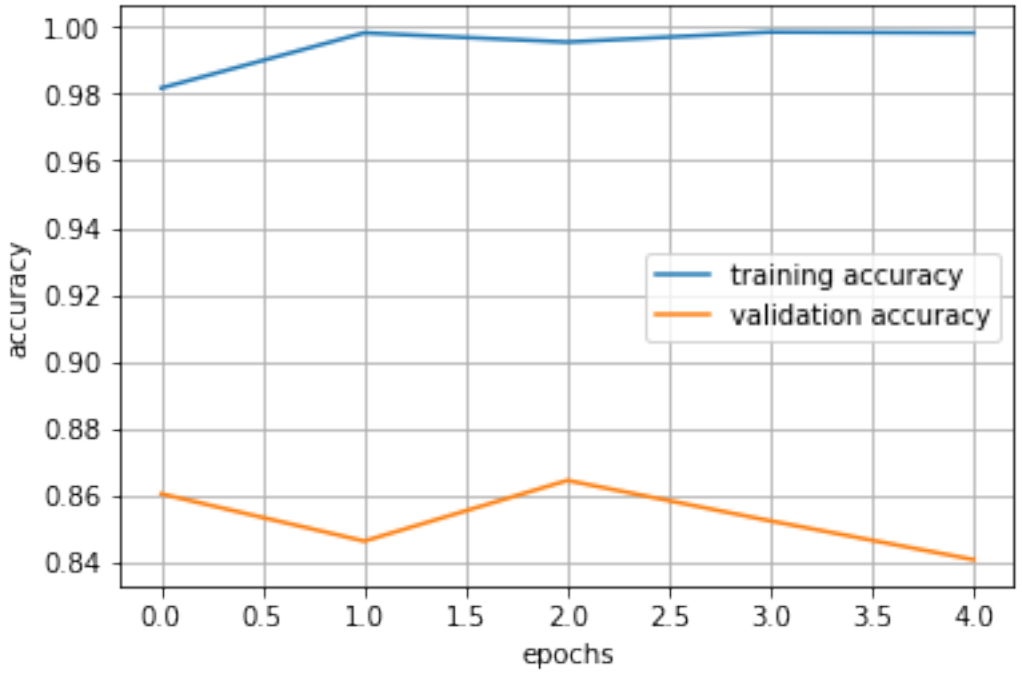
```
In [21]: model.compile(loss='binary_crossentropy',
                       optimizer=optimizers.adam(lr=1e-3),
                       metrics=['accuracy'])

In [22]: steps_per_epoch = train_generator.n // batch_size
         validation_steps = test_generator.n // batch_size

In [23]: nepochs = 5  # Number of epochs

         # Call the fit_generator function
         hist = model.fit_generator(
             train_generator,
             steps_per_epoch=steps_per_epoch,
             epochs=nepochs,
             validation_data=test_generator,
             validation_steps=validation_steps)
```

```
Epoch 1/5
125/125 [==============================] - 320s 3s/step - loss: 0.0447 - acc: 0.9818 - val_loss
Epoch 2/5
125/125 [==============================] - 327s 3s/step - loss: 0.0073 - acc: 0.9982 - val_loss
Epoch 3/5
125/125 [==============================] - 316s 3s/step - loss: 0.0117 - acc: 0.9955 - val_loss
Epoch 4/5
125/125 [==============================] - 324s 3s/step - loss: 0.0033 - acc: 0.9985 - val_loss
Epoch 5/5
125/125 [==============================] - 327s 3s/step - loss: 0.0046 - acc: 0.9982 - val_loss
```

4.4 Training Accuracy vs Validation Accuracy - Plot

In [24]:
```
# Plot the training accuracy and validation accuracy curves on the same figure.
tr_accuracy = hist.history['acc']
val_accuracy = hist.history['val_acc']
plt.plot(tr_accuracy)
plt.plot(val_accuracy)
plt.grid()
plt.xlabel('epochs')
plt.ylabel('accuracy')
plt.legend(['training accuracy', 'validation accuracy'])
```

Out[24]:
```
<matplotlib.legend.Legend at 0x122229f28>
```



5 Step 3: Predict Faces

```
In [25]: from skimage.transform import pyramid_gaussian
```

```
In [26]: import matplotlib.patches as patches
```

5.1 Sliding Window

```
In [27]: def sliding_window(image, stepSize, windowSize):
             # slide a window across the image
             for y in range(0, image.shape[0], stepSize):
                 for x in range(0, image.shape[1], stepSize):
                     # yield the current window
                     yield (x, y, image[y:y + windowSize[1], x:x + windowSize[0]])
```

```
In [28]: # Display the image
         def disp_image2(ax,im):
             if (len(im.shape) == 2):
                 # Gray scale image
                 ax.imshow(im, cmap='gray')
             else:
                 im1 = (im-np.min(im))/(np.max(im)-np.min(im))*255
                 im1 = im1.astype(np.uint8)
                 ax.imshow(im1)

             # Remove axis ticks
             plt.xticks([])
             plt.yticks([])
```

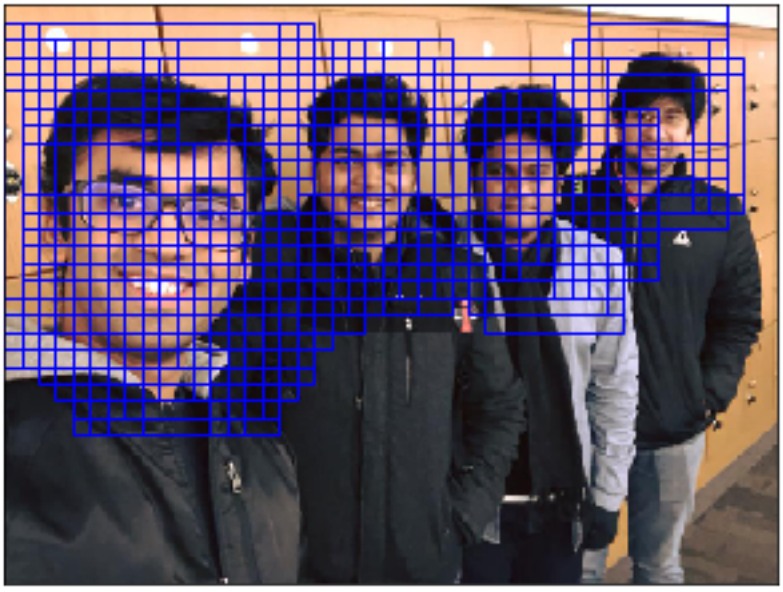
5.2 Face Prediction

```
In [32]: def predict_face(model,im,scale_factor,winW,winH,step,threshold):

             # Build Image Pyramid
             pyramid = tuple(pyramid_gaussian(im, downscale=scale_factor))

             # Calculate the number of images to be used from the image pyramid
             for pyramid_count,p in enumerate(pyramid):
                 # if the image is too small, break from the loop
                 if p.shape[0] < 64 or p.shape[1] < 64:
                     break

             # Build Image Plot
             fig,ax = plt.subplots(1)
             disp_image2(ax,im)

             # Iterate over the Image Pyramid
             for j in range(pyramid_count):
                 p = pyramid[j]
```

```
                # Get windows
                i=0
                x_win = ((int)((p.shape[1]-winW)/step))+1
                y_win = ((int)((p.shape[0]-winH)/step))+1
                num_boxes = x_win * y_win
                box = np.zeros((num_boxes,2))
                win_arr = np.zeros((num_boxes,winW,winH,3))

                # Iterate over the Sliding Windows
                for (x, y, window) in sliding_window(p, stepSize=step, \
                                                     windowSize=(winW, winH)):

                    # if the window does not meet our desired window size, ignore it
                    if window.shape[0] != winH or window.shape[1] != winW:
                        continue

                    # Get windows in an array
                    win_arr[i] = window
                    box[i] = x,y
                    i = i + 1

                # Use VGG-Net for Image Class Prediction
                ntest = win_arr.shape[0]
                yhat = model.predict(win_arr)
                yhat_bin = (yhat>threshold).reshape(ntest).astype(int)

                # Print Boxes
                for k,c in enumerate(box):
                    if yhat_bin[k]==1:
                        rect = patches.Rectangle((box[k,0],box[k,1]),\
                                                 winW*(np.power(scale_factor,j)),\
                                                 winH*(np.power(scale_factor,j)),\
                                                 fill=False,ls='solid',lw=1,color='b')
                        ax.add_patch(rect)
```

In [30]:
```
im_w = 360
im_h = 270
im_shape = (im_h,im_w,3)
im = np.zeros(im_shape)
class_name = 'group'
fn = '{0:s}/{1:s}_{2:04d}.jpg'.format(class_name,class_name,3)
im[:,:,:] = image.load_img(fn, target_size=(im_h, im_w))
disp_image(im)
```

In [33]:
```
predict_face(model,im,scale_factor = 2,winW = 64,winH = 64,step = 8,threshold = 0.5)
```



In [ ]: