main(1)

April 26, 2018

1 Main

1.1 Part 1 - Face Detection

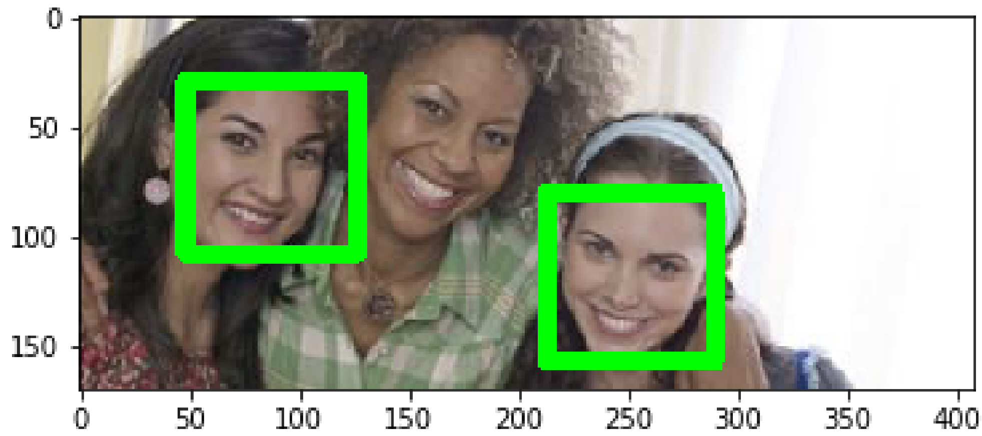
In this project, we aim to construct a face detection model. We used a method haar to extract features. After that, by applying extracted features to cascade method, we were able to dectect people's faces and also count the number of faces through pictures as well as webcam. Pre-trained cascade was used from OpenCV.

1.1.1 Part 1.1 - Face Detection without Rotation on Image

We started off the project with face detection on an image.

```
In [233]: os.chdir('../doc')

          # %load ../lib/count_face.py
          def counting_face():
                  import numpy as np
                  import cv2
                  from matplotlib import pyplot as plt

                  # loading OpenCV cascade for haar method with frontal face
                  face_cascade = cv2.CascadeClassifier('../lib/haarcascade_frontalface_default.x

                  # loading test image
                  img = cv2.imread('../data/test_image/104.jpg')
                  gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
                  faces = face_cascade.detectMultiScale(gray, 1.2, 5)

                  # implementing model
                  for (x,y,w,h) in faces:
                      cv2.rectangle(img,(x,y),(x+w,y+h),(0,255,0),8)

                  # showing image
                  RGB_img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
                  plt.imshow(RGB_img)
                  plt.show()
```

In [234]: counting_face()



1.1.2 Part 1.2 - Face Detection with Rotation

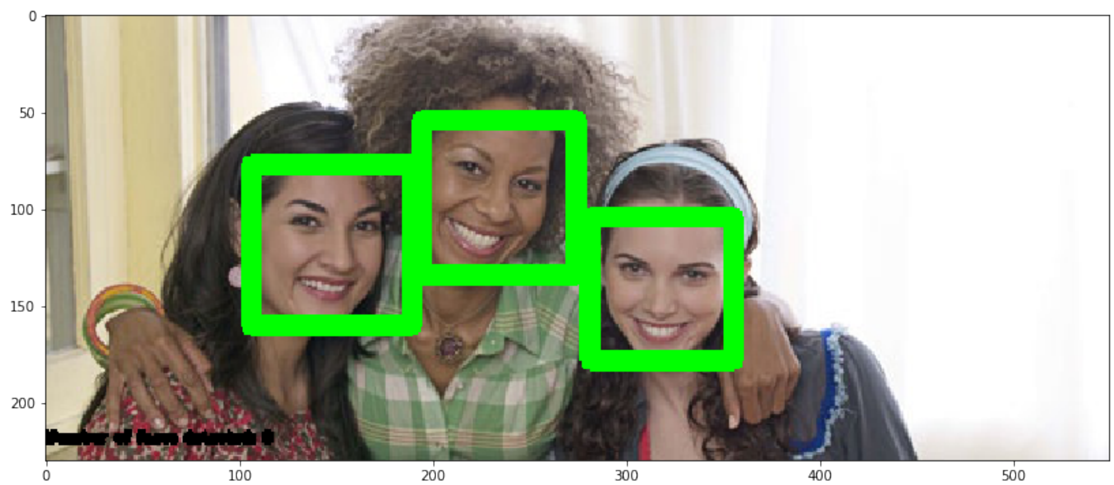
After implementation of Part 1, we realized the OpenCV front face cascade could not detect rotated face. Hence, we made some adjustments and declared additional functions to allow our model to analyze images from different rotation angle.

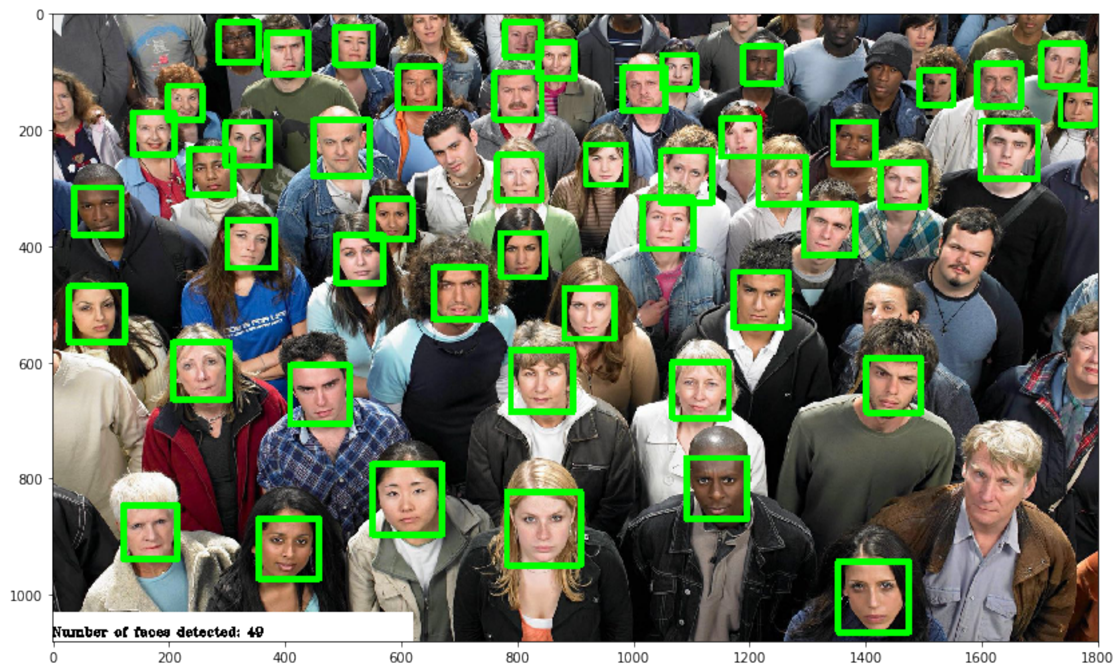
In [241]:
```
# %load ../lib/counting_faces_image.py
#!/usr/bin/env python3
"""
Created on Sat Apr 21 20:24:20 2018

@author: zailchen
"""

def face_dectect_image(directory = '../data/test_image/cascade/', scaleFactor = 1.3, m

    import numpy as np
    import cv2
    import tensorflow
    import os
    from matplotlib import pyplot as plt


      # I followed Harrison Kingsley's work for this
      # Much of the source code is found https://pythonprogramming.net/haar-cascade-fa

    def rotate_image(img, angle):
        if angle == 0: return img
        # print("checked for shape".format(image.shape))
```

```python
    height, width = img.shape[:2]
    rot_mat = cv2.getRotationMatrix2D((width/2, height/2), angle, 0.9)
    result = cv2.warpAffine(img, rot_mat, (width, height), flags=cv2.INTER_LINEAR)
    return result

def rotate_point(pos, img, angle):
    if angle == 0: return pos
    x = pos[:,0] - img.shape[1]*0.4
    y = pos[:,1] - img.shape[0]*0.4
    newx = x*cos(radians(angle)) + y*sin(radians(angle)) + img.shape[1]*0.4
    newy = -x*sin(radians(angle)) + y*cos(radians(angle)) + img.shape[0]*0.4
    return np.array((newx, newy, pos[:,2], pos[:,3]), int).T


face_cascade = cv2.CascadeClassifier('../lib/haarcascade_frontalface_default.xml')


PATH_TO_TEST_IMAGES_DIR = directory
TEST_IMAGES_NAMES = os.listdir(directory)
TEST_IMAGE_PATHS = [os.path.join(PATH_TO_TEST_IMAGES_DIR, TEST_IMAGES_NAMES[i]) fo
n = len(TEST_IMAGE_PATHS)
i = 0

for image in TEST_IMAGE_PATHS:

    img = cv2.imread(image)
    length = int(max(img.shape[0:2]))
    height = int(min(img.shape[0:2]))
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    for angle in [0, -30, 30]:
        rimg = rotate_image(gray, angle)
        faces = face_cascade.detectMultiScale(rimg, scaleFactor, minNeighbors)

        if len(faces):
                faces = rotate_point(faces, img, -angle)
                break


    if len(faces) == 0:
        print("No faces found")

    else:
        for (x,y,w,h) in faces:
            cv2.rectangle(img,(x,y),(x+w,y+h),(0,255,0),10)

        cv2.rectangle(img, ((0,img.shape[0] - 50*int(height/1080))),(620 * int(len
        cv2.putText(img, "Number of faces detected: " + str(faces.shape[0]), (0,im
```

```
            RGB_img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
            plt.figure(figsize=(14,10))
            plt.imshow(RGB_img)
            plt.show()

            cv2.imwrite('../output/processed_{}'.format(TEST_IMAGES_NAMES[i+1]),img)
            i +=1
```

```
In [242]: face_dectect_image('../data/test_image/cascade')
```





1.1.3 Part 1.3 - Real Time Face Detection with WebCam

After we improved our model, we wanted to further develop our model. Therefore, in this part, we implemented real time face detection using WebCam.

In [225]:
```
# %load ../lib/counting_faces_webcam.py
#!/usr/bin/env python3
"""
Created on Sun Apr 22 16:14:00 2018

@author: zailchen
"""

def face_dectect_webcam(scaleFactor = 1.3, minNeighbors = 5):


    import numpy as np
    import cv2
    from math import sin, cos, radians


    def rotate_image(img, angle):
        if angle == 0: return img
        # print("checked for shape".format(image.shape))
        height, width = img.shape[:2]
        rot_mat = cv2.getRotationMatrix2D((width/2, height/2), angle, 0.9)
```

```
        result = cv2.warpAffine(img, rot_mat, (width, height), flags=cv2.INTER_LINEAR)
        return result

    def rotate_point(pos, img, angle):
        if angle == 0: return pos
        x = pos[:,0] - img.shape[1]*0.4
        y = pos[:,1] - img.shape[0]*0.4
        newx = x*cos(radians(angle)) + y*sin(radians(angle)) + img.shape[1]*0.4
        newy = -x*sin(radians(angle)) + y*cos(radians(angle)) + img.shape[0]*0.4
        return np.array((newx, newy, pos[:,2], pos[:,3]), int).T


    face_cascade = cv2.CascadeClassifier('../lib/haarcascade_frontalface_default.xml')
    cap = cv2.VideoCapture(0)

    while 1:
        ret, img = cap.read()
        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

        for angle in [0, -45, 45]:
            rimg = rotate_image(gray, angle)
            faces = face_cascade.detectMultiScale(rimg, scaleFactor, minNeighbors)

            if len(faces):
                    faces = rotate_point(faces, img, -angle)
                    break


        for (x,y,w,h) in faces:
            cv2.rectangle(img,(x,y),(x+w,y+h),(255,0,0),2)

        cv2.rectangle(img, ((0,img.shape[0] -25)),(270, img.shape[0]), (255,255,255),

        if type(faces) == tuple:
            cv2.putText(img, "Number of faces detected: 1" , (0,img.shape[0] -10), cv2
        else:
            cv2.putText(img, "Number of faces detected: " + str(faces.shape[0]), (0,im


        cv2.imshow('img',img)
        if cv2.waitKey(25) & 0xFF == ord('q'):
              cv2.destroyAllWindows()
              cap.release()
              break
```

```
In [226]: '''
```

```
        Press Q to close the camera



        '''

        face_dectect_webcam()
```

1.2 Part 2 - Object Detection API using Tensorflow

After we constructed our model in Part 1, we realized there exist some limitations in cascade model. Cascade model tends to have lower accuracy in side faces or partially showed faces. Also, cascade cannot detect highly rotated faces. To overcome such limitations, a popular and powerful approach is the use of tensorflow. In this section, we implement object detection with a pretrained model, Tensorflow Object Detection API. This model requires intallation of tensorflow. Further instruction of the installation can be referred to https://github.com/tensorflow/models/tree/master/research/object_detection. This model can detect and categorize object, including person, bottle, cellphone, etc. However, cascada model would result better if only faces are showed on an image while this API model would result better if more parts of human body are showed.

1.2.1 Part 2.1 - Object Detection API with Tensorflow on Image

Similar to Part 1.1, we started off with object detection using image.

```
In [227]: # %load ../lib/tensorflowFn.py

          def objectDetection(directory = '../data/test_image/tensorflow'):
              import cv2
              # coding: utf-8
              # # Object Detection Demo
              # Welcome to the object detection inference walkthrough!  This notebook will walk

              # # Imports


              import numpy as np
              import os
              import six.moves.urllib as urllib
              import sys
              import tarfile
              import tensorflow as tf
```

```
import zipfile

from collections import defaultdict
from io import StringIO
from matplotlib import pyplot as plt
from PIL import Image

# This is needed since the notebook is stored in the object_detection folder.
#cwd = os.getcwd()
os.chdir('../lib/object_detection')
#sys.path.append("..")
from object_detection.utils import ops as utils_ops

if tf.__version__ < '1.4.0':
  raise ImportError('Please upgrade your tensorflow installation to v1.4.* or late


# ## Env setup


# This is needed to display the images.
get_ipython().magic('matplotlib inline')


# ## Object detection imports
# Here are the imports from the object detection module.


from utils import label_map_util

from utils import visualization_utils as vis_util


# # Model preparation

# ## Variables
#
# Any model exported using the `export_inference_graph.py` tool can be loaded here
#
# By default we use an "SSD with Mobilenet" model here. See the [detection model z


# What model to download.
MODEL_NAME = 'ssd_mobilenet_v1_coco_2017_11_17'
MODEL_FILE = MODEL_NAME + '.tar.gz'
DOWNLOAD_BASE = 'http://download.tensorflow.org/models/object_detection/'

# Path to frozen detection graph. This is the actual model that is used for the ob
```

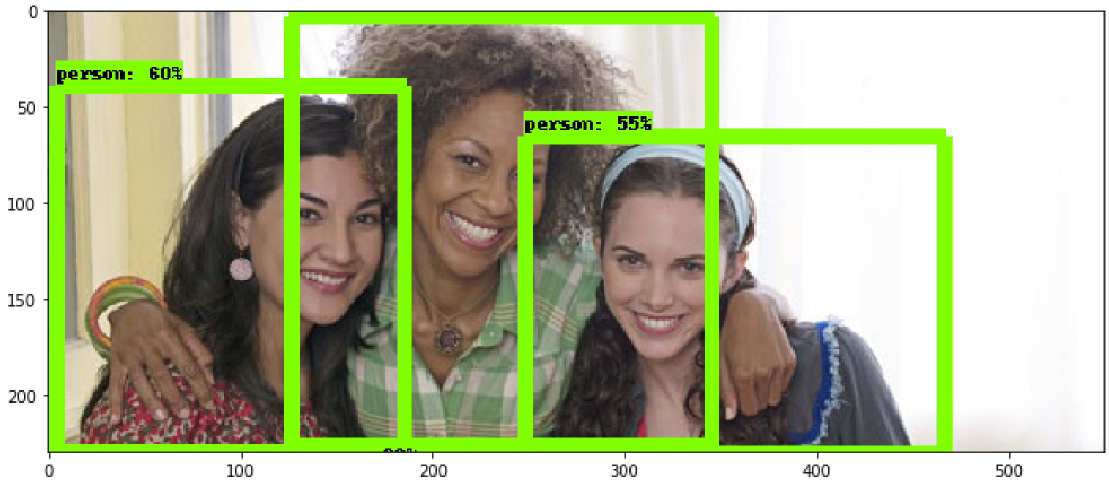
```python
PATH_TO_CKPT = MODEL_NAME + '/frozen_inference_graph.pb'

# List of the strings that is used to add correct label for each box.
PATH_TO_LABELS = os.path.join('data', 'mscoco_label_map.pbtxt')

NUM_CLASSES = 90


# ## Download Model

if False:
    opener = urllib.request.URLopener()
    opener.retrieve(DOWNLOAD_BASE + MODEL_FILE, MODEL_FILE)
    tar_file = tarfile.open(MODEL_FILE)
    for file in tar_file.getmembers():
      file_name = os.path.basename(file.name)
      if 'frozen_inference_graph.pb' in file_name:
        tar_file.extract(file, os.getcwd())


# ## Load a (frozen) Tensorflow model into memory.


detection_graph = tf.Graph()
with detection_graph.as_default():
  od_graph_def = tf.GraphDef()
  with tf.gfile.GFile(PATH_TO_CKPT, 'rb') as fid:
    serialized_graph = fid.read()
    od_graph_def.ParseFromString(serialized_graph)
    tf.import_graph_def(od_graph_def, name='')


# ## Loading label map
# Label maps map indices to category names, so that when our convolution network p


label_map = label_map_util.load_labelmap(PATH_TO_LABELS)
categories = label_map_util.convert_label_map_to_categories(label_map, max_num_cla
category_index = label_map_util.create_category_index(categories)


# ## Helper code


def load_image_into_numpy_array(image):
  (im_width, im_height) = image.size
  return np.array(image.getdata()).reshape(
      (im_height, im_width, 3)).astype(np.uint8)
```

```python
# # Detection

# For the sake of simplicity we will use only 2 images:
# image1.jpg
# image2.jpg
# If you want to test the code with your images, just add path to the images to th
PATH_TO_TEST_IMAGES_DIR = directory
TEST_IMAGES_NAMES = os.listdir(directory)
TEST_IMAGE_PATHS = [os.path.join(PATH_TO_TEST_IMAGES_DIR, TEST_IMAGES_NAMES[i]) fo

# Size, in inches, of the output images.
IMAGE_SIZE = (12, 8)



def run_inference_for_single_image(image, graph):
  with graph.as_default():
    with tf.Session() as sess:
      # Get handles to input and output tensors
      ops = tf.get_default_graph().get_operations()
      all_tensor_names = {output.name for op in ops for output in op.outputs}
      tensor_dict = {}
      for key in [
          'num_detections', 'detection_boxes', 'detection_scores',
          'detection_classes', 'detection_masks'
      ]:
        tensor_name = key + ':0'
        if tensor_name in all_tensor_names:
          tensor_dict[key] = tf.get_default_graph().get_tensor_by_name(
              tensor_name)
      if 'detection_masks' in tensor_dict:
        # The following processing is only for single image
        detection_boxes = tf.squeeze(tensor_dict['detection_boxes'], [0])
        detection_masks = tf.squeeze(tensor_dict['detection_masks'], [0])
        # Reframe is required to translate mask from box coordinates to image coor
        real_num_detection = tf.cast(tensor_dict['num_detections'][0], tf.int32)
        detection_boxes = tf.slice(detection_boxes, [0, 0], [real_num_detection, -
        detection_masks = tf.slice(detection_masks, [0, 0, 0], [real_num_detection
        detection_masks_reframed = utils_ops.reframe_box_masks_to_image_masks(
            detection_masks, detection_boxes, image.shape[0], image.shape[1])
        detection_masks_reframed = tf.cast(
            tf.greater(detection_masks_reframed, 0.5), tf.uint8)
        # Follow the convention by adding back the batch dimension
        tensor_dict['detection_masks'] = tf.expand_dims(
            detection_masks_reframed, 0)
      image_tensor = tf.get_default_graph().get_tensor_by_name('image_tensor:0')
```

```
            # Run inference
            output_dict = sess.run(tensor_dict,
                                   feed_dict={image_tensor: np.expand_dims(image, 0)})

            # all outputs are float32 numpy arrays, so convert types as appropriate
            output_dict['num_detections'] = int(output_dict['num_detections'][0])
            output_dict['detection_classes'] = output_dict[
                'detection_classes'][0].astype(np.uint8)
            output_dict['detection_boxes'] = output_dict['detection_boxes'][0]
            output_dict['detection_scores'] = output_dict['detection_scores'][0]
            if 'detection_masks' in output_dict:
              output_dict['detection_masks'] = output_dict['detection_masks'][0]
        return output_dict



      for image_path in TEST_IMAGE_PATHS:
        image = Image.open(image_path)
        # the array based representation of the image will be used later in order to pre
        # result image with boxes and labels on it.
        image_np = load_image_into_numpy_array(image)
        # Expand dimensions since the model expects images to have shape: [1, None, None
        image_np_expanded = np.expand_dims(image_np, axis=0)
        # Actual detection.
        output_dict = run_inference_for_single_image(image_np, detection_graph)
        # Visualization of the results of a detection.
        vis_util.visualize_boxes_and_labels_on_image_array(
            image_np,
            output_dict['detection_boxes'],
            output_dict['detection_classes'],
            output_dict['detection_scores'],
            category_index,
            instance_masks=output_dict.get('detection_masks'),
            use_normalized_coordinates=True,
            line_thickness=8)
        plt.figure(figsize=IMAGE_SIZE)
        plt.imshow(image_np)

      os.chdir('../../doc')
```

```
In [243]: #os.chdir('../../doc')
          #os.getcwd()
          objectDetection('../../data/test_image/tensorflow')
```


0
50
100
150
200
250
300
350
0
200
400
600
800
1000


person: 60%
person: 55%
0
50
100
150
200
0
100
200
300
400
500

1.2.2 Part 2.2 - Real Time Object Detection API with Tensorflow using WebCam

Part 2.1 resulted in highly accurate result detecting most of the objects into their corresponding categories. We further improved the model by implementing the model using WebCam as an input. The result was again very accurate.

```
In [230]: # %load ../lib/tensorflowFnVideo.py


          def objectDetectionCap():
              import cv2
              import numpy as np
              import os
              import six.moves.urllib as urllib
              import sys
              import tarfile
              import tensorflow as tf
              import zipfile

              from collections import defaultdict
              from io import StringIO
              from matplotlib import pyplot as plt
              from PIL import Image


              # This is needed since the notebook is stored in the object_detection folder.
```

```
#cwd = os.getcwd()
os.chdir('../lib/object_detection')
#sys.path.append("..")
from object_detection.utils import ops as utils_ops

if tf.__version__ < '1.4.0':
  raise ImportError('Please upgrade your tensorflow installation to v1.4.* or late


# ## Env setup


# This is needed to display the images.
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# What model to download.
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# List of the strings that is used to add correct label for each box.
PATH_TO_LABELS = os.path.join('data', 'mscoco_label_map.pbtxt')

NUM_CLASSES = 90
```

```
# ## Download Model

#    opener = urllib.request.URLopener()
#    opener.retrieve(DOWNLOAD_BASE + MODEL_FILE, MODEL_FILE)
#    tar_file = tarfile.open(MODEL_FILE)
#    for file in tar_file.getmembers():
#      file_name = os.path.basename(file.name)
#      if 'frozen_inference_graph.pb' in file_name:
#        tar_file.extract(file, os.getcwd())


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  od_graph_def = tf.GraphDef()
  with tf.gfile.GFile(PATH_TO_CKPT, 'rb') as fid:
    serialized_graph = fid.read()
    od_graph_def.ParseFromString(serialized_graph)
    tf.import_graph_def(od_graph_def, name='')


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categories = label_map_util.convert_label_map_to_categories(label_map, max_num_cla
category_index = label_map_util.create_category_index(categories)


cap = cv2.VideoCapture(0)
with detection_graph.as_default():
  with tf.Session(graph=detection_graph) as sess:
   ret = True
   while (ret):
      ret,image_np = cap.read()
      image_np_expanded = np.expand_dims(image_np, axis=0)
      image_tensor = detection_graph.get_tensor_by_name('image_tensor:0')
      boxes = detection_graph.get_tensor_by_name('detection_boxes:0')
      scores = detection_graph.get_tensor_by_name('detection_scores:0')
      classes = detection_graph.get_tensor_by_name('detection_classes:0')
      num_detections = detection_graph.get_tensor_by_name('num_detections:0')
      (boxes, scores, classes, num_detections) = sess.run(
              [boxes, scores, classes, num_detections],
              feed_dict={image_tensor: image_np_expanded})
      vis_util.visualize_boxes_and_labels_on_image_array(
```

```
                    image_np,
                    np.squeeze(boxes),
                    np.squeeze(classes).astype(np.int32),
                    np.squeeze(scores),
                    category_index,
                    use_normalized_coordinates=True,
                    line_thickness=8)
                cv2.imshow('image', cv2.resize(image_np,(1280,800)))
                if cv2.waitKey(25) & 0xFF == ord('q'):
                    cv2.destroyAllWindows()
                    cap.release()
                    break
        os.chdir('../../doc')
```

In [231]:
```
'''




Press Q to close the camera




'''





objectDetectionCap()
```

In [246]:

Out[246]: '/Users/zailchen/Documents/RWorkplace/ADS_Project/Spring2018-Project5-grp_9/doc'