YOLO object detection using Keras

Original Source: https://www.kaggle.com/code/mirzamujtaba/yolo-object-detection-using-keras/notebook

Modified by: Dr. Salha Alzahrani

Step 1: Download the necessary data

Data for Yolo v3 kernel : https://www.kaggle.com/datasets/aruchomu/data-for-yolo-v3-kernel

In [1]:
```
import struct
import numpy as np
from numpy import expand_dims
from keras.layers import Conv2D
from keras.layers import Input
from keras.layers import BatchNormalization
from keras.layers import LeakyReLU
from keras.layers import ZeroPadding2D
from keras.layers import UpSampling2D
from keras.layers.merge import add, concatenate
from keras.models import Model
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from matplotlib import pyplot
from matplotlib.patches import Rectangle
```

Step 2: Create an isntance of YOLOv3 model

In [2]:
```
#This function is used to create convolutional layers
def _conv_block(inp, convs, skip=True):
    x = inp
    count = 0
    for conv in convs:
        if count == (len(convs) - 2) and skip:
            skip_connection = x
        count += 1
        if conv['stride'] > 1: x = ZeroPadding2D(((1,0),(1,0)))(x) # peculiar padding as darknet prefer l
        x = Conv2D(conv['filter'],
                   conv['kernel'],
                   strides=conv['stride'],
                   padding='valid' if conv['stride'] > 1 else 'same', # peculiar padding as darknet prefe
                   name='conv_' + str(conv['layer_idx']),
                   use_bias=False if conv['bnorm'] else True)(x)
        if conv['bnorm']: x = BatchNormalization(epsilon=0.001, name='bnorm_' + str(conv['layer_idx']))(x
        if conv['leaky']: x = LeakyReLU(alpha=0.1, name='leaky_' + str(conv['layer_idx']))(x)
    return add([skip_connection, x]) if skip else x
```

In [3]:

```
#This function define the Keras model for YOLOv3
def make_yolov3_model():
    input_image = Input(shape=(None, None, 3))
    # Layer  0 => 4
    x = _conv_block(input_image, [{'filter': 32, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True,
                                  {'filter': 64, 'kernel': 3, 'stride': 2, 'bnorm': True, 'leaky': True,
                                  {'filter': 32, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True,
                                  {'filter': 64, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True,
    # Layer  5 => 8
    x = _conv_block(x, [{'filter': 128, 'kernel': 3, 'stride': 2, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter':  64, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 128, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    # Layer  9 => 11
    x = _conv_block(x, [{'filter':  64, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 128, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    # Layer 12 => 15
    x = _conv_block(x, [{'filter': 256, 'kernel': 3, 'stride': 2, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    # Layer 16 => 36
    for i in range(7):
        x = _conv_block(x, [{'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'laye
                            {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'laye
    skip_36 = x
    # Layer 37 => 40
    x = _conv_block(x, [{'filter': 512, 'kernel': 3, 'stride': 2, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    # Layer 41 => 61
    for i in range(7):
        x = _conv_block(x, [{'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'laye
                            {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'laye
    skip_61 = x
    # Layer 62 => 65
    x = _conv_block(x, [{'filter': 1024, 'kernel': 3, 'stride': 2, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
    # Layer 66 => 74
    for i in range(3):
        x = _conv_block(x, [{'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'lay
                            {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'lay
    # Layer 75 => 79
    x = _conv_block(x, [{'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_i
    # Layer 80 => 82
    yolo_82 = _conv_block(x, [{'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm': True,  'leaky': True,
                              {'filter':  255, 'kernel': 1, 'stride': 1, 'bnorm': False, 'leaky': False,
    # Layer 83 => 86
    x = _conv_block(x, [{'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    x = UpSampling2D(2)(x)
    x = concatenate([x, skip_61])
    # Layer 87 => 91
    x = _conv_block(x, [{'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
                        {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True, 'layer_id
    # Layer 92 => 94
    yolo_94 = _conv_block(x, [{'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm': True,  'leaky': True,  '
                              {'filter': 255, 'kernel': 1, 'stride': 1, 'bnorm': False, 'leaky': False, '
    # Layer 95 => 98
    x = _conv_block(x, [{'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True, 'leaky': True,   'layer_
    x = UpSampling2D(2)(x)
    x = concatenate([x, skip_36])
    # Layer 99 => 106
    yolo_106 = _conv_block(x, [{'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm': True,  'leaky': True,
                               {'filter': 255, 'kernel': 1, 'stride': 1, 'bnorm': False, 'leaky': False,
    model = Model(input_image, [yolo_82, yolo_94, yolo_106])
    return model
```

In [4]:

```
#This class reads and weights from file and rather manually
#decoding the weights from yolo weights file than we can use it.
class WeightReader:
    def __init__(self, weight_file):
        with open(weight_file, 'rb') as w_f:
            major,    = struct.unpack('i', w_f.read(4))
            minor,    = struct.unpack('i', w_f.read(4))
            revision, = struct.unpack('i', w_f.read(4))
            if (major*10 + minor) >= 2 and major < 1000 and minor < 1000:
                w_f.read(8)
            else:
                w_f.read(4)
            transpose = (major > 1000) or (minor > 1000)
            binary = w_f.read()
        self.offset = 0
        self.all_weights = np.frombuffer(binary, dtype='float32')

    def read_bytes(self, size):
        self.offset = self.offset + size
        return self.all_weights[self.offset-size:self.offset]

    def load_weights(self, model):
        for i in range(106):
            try:
                conv_layer = model.get_layer('conv_' + str(i))
                print("loading weights of convolution #" + str(i))
                if i not in [81, 93, 105]:
                    norm_layer = model.get_layer('bnorm_' + str(i))
                    size = np.prod(norm_layer.get_weights()[0].shape)
                    beta  = self.read_bytes(size) # bias
                    gamma = self.read_bytes(size) # scale
                    mean  = self.read_bytes(size) # mean
                    var   = self.read_bytes(size) # variance
                    weights = norm_layer.set_weights([gamma, beta, mean, var])
                if len(conv_layer.get_weights()) > 1:
                    bias   = self.read_bytes(np.prod(conv_layer.get_weights()[1].shape))
                    kernel = self.read_bytes(np.prod(conv_layer.get_weights()[0].shape))
                    kernel = kernel.reshape(list(reversed(conv_layer.get_weights()[0].shape)))
                    kernel = kernel.transpose([2,3,1,0])
                    conv_layer.set_weights([kernel, bias])
                else:
                    kernel = self.read_bytes(np.prod(conv_layer.get_weights()[0].shape))
                    kernel = kernel.reshape(list(reversed(conv_layer.get_weights()[0].shape)))
                    kernel = kernel.transpose([2,3,1,0])
                    conv_layer.set_weights([kernel])
            except ValueError:
                print("no convolution #" + str(i))

    def reset(self):
        self.offset = 0
```

Step 3: Define the Bound Boxes Operations

If we use the above model and try to make predictions, we'll get an encoded output which is encoded candidate bounding boxes from different grid sizes, and the boxes are defined the context of anchor boxes, carefully chosen based on an analysis of the size of objects in the MSCOCO dataset. The function decode_netout() is defined that will take each one of the NumPy arrays, one at a time, and decode the candidate bounding boxes and class predictions. Further, any bounding boxes that don't confidently describe an object (e.g. all class probabilities are below a threshold) are ignored.The function returns a list of BoundBox instances that define the corners of each bounding box in the context of the input image shape and class probabilities.

In [5]:

```
class BoundBox:
    def __init__(self, xmin, ymin, xmax, ymax, objness = None, classes = None):
        self.xmin = xmin
        self.ymin = ymin
        self.xmax = xmax
        self.ymax = ymax
        self.objness = objness
        self.classes = classes
        self.label = -1
        self.score = -1

    def get_label(self):
        if self.label == -1:
            self.label = np.argmax(self.classes)

        return self.label

    def get_score(self):
        if self.score == -1:
            self.score = self.classes[self.get_label()]

        return self.score



def _sigmoid(x):
    return 1. / (1. + np.exp(-x))

def decode_netout(netout, anchors, obj_thresh, net_h, net_w):
    grid_h, grid_w = netout.shape[:2]
    nb_box = 3
    netout = netout.reshape((grid_h, grid_w, nb_box, -1))
    nb_class = netout.shape[-1] - 5
    boxes = []
    netout[..., :2]  = _sigmoid(netout[..., :2])
    netout[..., 4:]  = _sigmoid(netout[..., 4:])
    netout[..., 5:]  = netout[..., 4][..., np.newaxis] * netout[..., 5:]
    netout[..., 5:] *= netout[..., 5:] > obj_thresh

    for i in range(grid_h*grid_w):
        row = i / grid_w
        col = i % grid_w
        for b in range(nb_box):
            # 4th element is objectness score
            objectness = netout[int(row)][int(col)][b][4]
            if(objectness.all() <= obj_thresh): continue
            # first 4 elements are x, y, w, and h
            x, y, w, h = netout[int(row)][int(col)][b][:4]
            x = (col + x) / grid_w # center position, unit: image width
            y = (row + y) / grid_h # center position, unit: image height
            w = anchors[2 * b + 0] * np.exp(w) / net_w # unit: image width
            h = anchors[2 * b + 1] * np.exp(h) / net_h # unit: image height
            # last elements are class probabilities
            classes = netout[int(row)][col][b][5:]
            box = BoundBox(x-w/2, y-h/2, x+w/2, y+h/2, objectness, classes)
            boxes.append(box)
    return boxes
```

In [6]:

```
#The correct_yolo_boxes() function to perform the translation of bounding box
#coordinates, taking the list of bounding boxes, the original shape of our
#loaded photograph, and the shape of the input to the network as arguments.
#The coordinates of the bounding boxes are updated directly.

def correct_yolo_boxes(boxes, image_h, image_w, net_h, net_w):
    new_w, new_h = net_w, net_h
    for i in range(len(boxes)):
        x_offset, x_scale = (net_w - new_w)/2./net_w, float(new_w)/net_w
        y_offset, y_scale = (net_h - new_h)/2./net_h, float(new_h)/net_h
        boxes[i].xmin = int((boxes[i].xmin - x_offset) / x_scale * image_w)
        boxes[i].xmax = int((boxes[i].xmax - x_offset) / x_scale * image_w)
        boxes[i].ymin = int((boxes[i].ymin - y_offset) / y_scale * image_h)
        boxes[i].ymax = int((boxes[i].ymax - y_offset) / y_scale * image_h)

def _interval_overlap(interval_a, interval_b):
    x1, x2 = interval_a
    x3, x4 = interval_b
    if x3 < x1:
        if x4 < x1:
            return 0
        else:
            return min(x2,x4) - x1
    else:
        if x2 < x3:
             return 0
        else:
            return min(x2,x4) - x3

def bbox_iou(box1, box2):
    intersect_w = _interval_overlap([box1.xmin, box1.xmax], [box2.xmin, box2.xmax])
    intersect_h = _interval_overlap([box1.ymin, box1.ymax], [box2.ymin, box2.ymax])
    intersect = intersect_w * intersect_h
    w1, h1 = box1.xmax-box1.xmin, box1.ymax-box1.ymin
    w2, h2 = box2.xmax-box2.xmin, box2.ymax-box2.ymin
    union = w1*h1 + w2*h2 - intersect
    return float(intersect) / union
```

In [7]:

```
def do_nms(boxes, nms_thresh):
    if len(boxes) > 0:
        nb_class = len(boxes[0].classes)
    else:
        return
    for c in range(nb_class):
        sorted_indices = np.argsort([-box.classes[c] for box in boxes])
        for i in range(len(sorted_indices)):
            index_i = sorted_indices[i]
            if boxes[index_i].classes[c] == 0: continue
            for j in range(i+1, len(sorted_indices)):
                index_j = sorted_indices[j]
                if bbox_iou(boxes[index_i], boxes[index_j]) >= nms_thresh:
                    boxes[index_j].classes[c] = 0
```

In [8]:
```
# get_boxes() function takes the list of boxes, known labels, and our classification threshold as argumen
# returns parallel lists of boxes, labels, and scores
# get all of the results above a threshold
def get_boxes(boxes, labels, thresh):
    v_boxes, v_labels, v_scores = list(), list(), list()
    # enumerate all boxes
    for box in boxes:
        # enumerate all possible labels
        for i in range(len(labels)):
            # check if the threshold for this label is high enough
            if box.classes[i] > thresh:
                v_boxes.append(box)
                v_labels.append(labels[i])
                v_scores.append(box.classes[i]*100)
                # don't break, many labels may trigger for one box
    return v_boxes, v_labels, v_scores

# draw all results
def draw_boxes(filename, v_boxes, v_labels, v_scores):
    pyplot.figure(figsize=(20,10))
    # load the image
    data = pyplot.imread(filename)
    # plot the image
    pyplot.imshow(data)
    # get the context for drawing boxes
    ax = pyplot.gca()
    # plot each box
    for i in range(len(v_boxes)):
        box = v_boxes[i]
        # get coordinates
        y1, x1, y2, x2 = box.ymin, box.xmin, box.ymax, box.xmax
        # calculate width and height of the box
        width, height = x2 - x1, y2 - y1
        # create the shape
        rect = Rectangle((x1, y1), width, height, fill=False, color='blue',lw=3)
        # draw the box
        ax.add_patch(rect)
        # draw text and score in top left corner
        label = "%s (%.3f)" % (v_labels[i], v_scores[i])
        pyplot.text(x1-20, y1-20, label, color='red',fontsize=16)
    # show the plot
    pyplot.show()
```

Step 4: Create Load Image Function

In [9]:
```
# load and prepare an image
def load_image_pixels(filename, shape):
    # load the image to get its shape
    image = load_img(filename)
    width, height = image.size
    # load the image with the required size
    image = load_img(filename, target_size=shape)
    # convert to numpy array
    image = img_to_array(image)
    # scale pixel values to [0, 1]
    image = image.astype('float32')
    image /= 255.0
    # add a dimension so that we have one sample
    image = expand_dims(image, 0)
    return image, width, height
```

Step 5: Create Model and Load Weights

Now let us use all the above defined functions to detect objects in an image.First we define a model and load weights in it.Then we start loading the picture and preproceesing it.

In [10]:
```
# define the model
model = make_yolov3_model()
```

In [15]:
```
#read weights from yolov3 weights file provided in the data
weight_reader = WeightReader('data-for-yolo-v3-kernel/yolov3.weights')
```

In [16]:

```
# set the model weights into the model
weight_reader.load_weights(model)
```

```
loading weights of convolution #0
loading weights of convolution #1
loading weights of convolution #2
loading weights of convolution #3
no convolution #4
loading weights of convolution #5
loading weights of convolution #6
loading weights of convolution #7
no convolution #8
loading weights of convolution #9
loading weights of convolution #10
no convolution #11
loading weights of convolution #12
loading weights of convolution #13
loading weights of convolution #14
no convolution #15
loading weights of convolution #16
loading weights of convolution #17
no convolution #18
```

Step 6: Use YOLO to Detect Objects in New Images

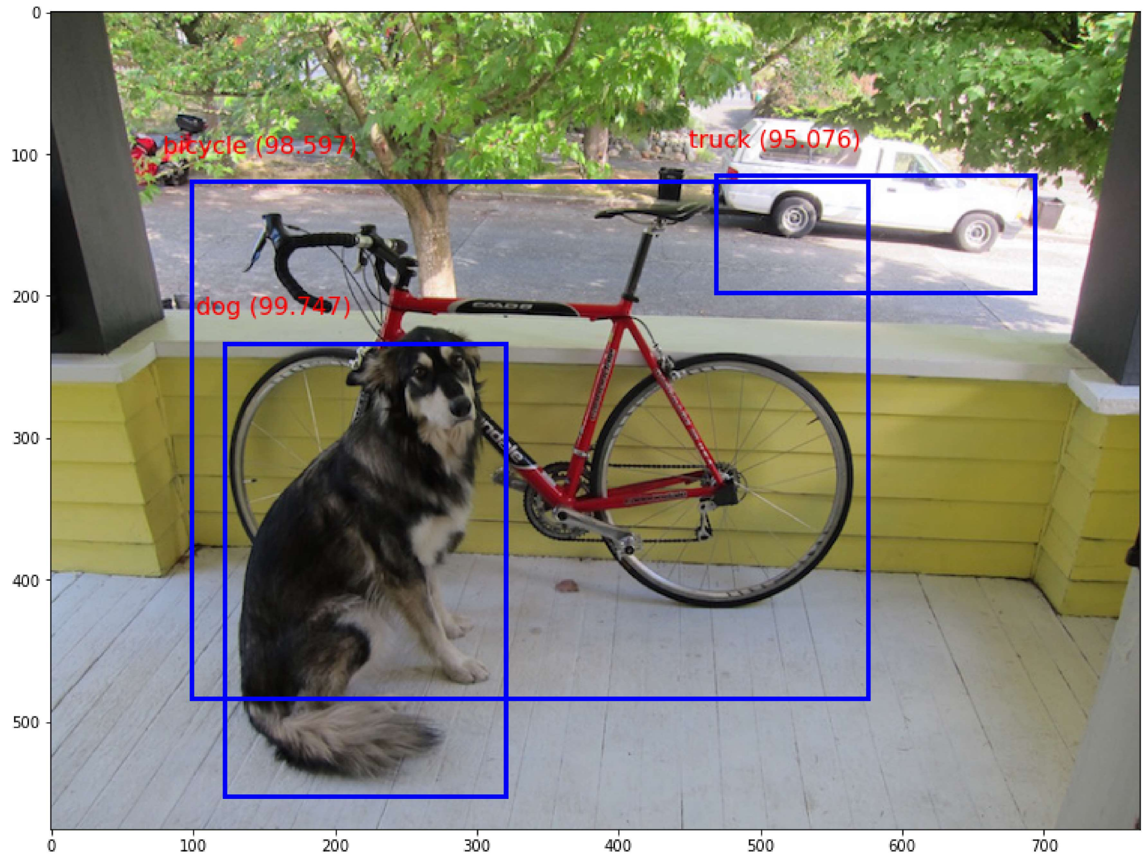
In [20]:

```
# define the labels
labels = []
with open("data-for-yolo-v3-kernel/coco.names", "r") as f:
    labels = [line.strip() for line in f.readlines()]

# define the anchors
anchors = [[116,90, 156,198, 373,326], [30,61, 62,45, 59,119], [10,13, 16,30, 33,23]]

# define the probability threshold for detected objects
class_threshold = 0.7
```

In [21]:

```
# define the expected input shape for the model
input_w, input_h = 416, 416

# define our new photo
photo_filename = 'data-for-yolo-v3-kernel/dog.jpg'

# load and prepare image
image, image_w, image_h = load_image_pixels(photo_filename, (input_w, input_h))

# make prediction
yhat = model.predict(image)

# summarize the shape of the list of arrays
print([a.shape for a in yhat])

boxes = list()
for i in range(len(yhat)):
    # decode the output of the network
    boxes += decode_netout(yhat[i][0], anchors[i], class_threshold, input_h, input_w)

# correct the sizes of the bounding boxes for the shape of the image
correct_yolo_boxes(boxes, image_h, image_w, input_h, input_w)

# suppress non-maximal boxes
do_nms(boxes, 0.4)

v_boxes, v_labels, v_scores = get_boxes(boxes, labels, class_threshold)

# summarize what we found
for i in range(len(v_boxes)):
    print(v_labels[i], v_scores[i])

# draw what we found
draw_boxes(photo_filename, v_boxes, v_labels, v_scores)
```

```
[(1, 13, 13, 255), (1, 26, 26, 255), (1, 52, 52, 255)]
truck 95.0762391090393
bicycle 98.59656095504761
dog 99.74659085273743
```



In [22]:

```python
# define our new photo
photo_filename = 'data-for-yolo-v3-kernel/office.jpg'

# load and prepare image
image, image_w, image_h = load_image_pixels(photo_filename, (input_w, input_h))

# make prediction
yhat = model.predict(image)

# summarize the shape of the list of arrays
print([a.shape for a in yhat])

boxes = list()
for i in range(len(yhat)):
    # decode the output of the network
    boxes += decode_netout(yhat[i][0], anchors[i], class_threshold, input_h, input_w)

# correct the sizes of the bounding boxes for the shape of the image
correct_yolo_boxes(boxes, image_h, image_w, input_h, input_w)

# suppress non-maximal boxes
do_nms(boxes, 0.4)

v_boxes, v_labels, v_scores = get_boxes(boxes, labels, class_threshold)

# summarize what we found
for i in range(len(v_boxes)):
    print(v_labels[i], v_scores[i])

# draw what we found
draw_boxes(photo_filename, v_boxes, v_labels, v_scores)
```

```
[(1, 13, 13, 255), (1, 26, 26, 255), (1, 52, 52, 255)]
person 97.65632748603821
tvmonitor 92.88041591644287
person 84.24031138420105
person 99.7834324836731
person 97.21069931983948
chair 74.42909479141235
chair 84.44295525550842
chair 99.31058883666992
```