object-detection-yolo

April 2, 2020

Object detection and classification with YOLOv2

Project created during the Deep Learning Specialization course on www.coursera.org

[1]:
```
import warnings
warnings.filterwarnings(action='ignore')
import os
import matplotlib.pyplot as plt
from matplotlib.pyplot import imshow
import numpy as np
import imageio
import tensorflow as tf
from PIL import Image, ImageDraw, ImageFont
from keras import backend as K
import colorsys
import random
from io import BytesIO
from keras.models import load_model

%matplotlib inline
```

```
Using TensorFlow backend.
```

Input image preprocessing

[2]:
```
# Preprocess input images to match model input size

def preprocess_image(img_path, model_image_size):

    image = Image.open(img_path)

    # Retrieve image shape (necessary to scale predicted bounding boxes later on)
    image_shape = image.size[::-1]

    # Resize image to correspond to model image size with BICUBIC interpolation␣
↪mode (cubic spline interpolation)
    resized_image = image.resize(model_image_size, Image.BICUBIC)
```

```
    # Convert image to a numpy array
    image_data = np.array(resized_image, dtype='float32')

    # Normalize image
    image_data /= 255.

    # Add batch dimension
    image_data = np.expand_dims(image_data, 0)

    # Display the image
    plt.show()

    return image, image_data, image_shape
```

Defining anchor boxes

[3]:
```
# Load anchor boxes dimensions (predefined)

def read_anchors(anchors_path):
    with open(anchors_path) as f:
        anchors = f.readline()
        anchors = [float(x) for x in anchors.split(',')]
        anchors = np.array(anchors).reshape(-1, 2)
    return anchors
```

[4]:
```
anchors = read_anchors('./yad2k/model_data/yolo_anchors.txt')
anchors
```

[4]:
```
array([[0.57273 , 0.677385],
       [1.87446 , 2.06253 ],
       [3.33843 , 5.47434 ],
       [7.88282 , 3.52778 ],
       [9.77052 , 9.16828 ]])
```

Defining labels

[5]:
```
# Load labels from COCO dataset

def read_classes(classes_path):
    with open(classes_path) as f:
        class_names = f.readlines()
    class_names = [c.strip() for c in class_names]
    return class_names
```

[6]:
```
class_names = read_classes('./yad2k/model_data/coco_classes.txt')
class_names[:10]
```

[6]:
```
['person',
 'bicycle',
 'car',
 'motorbike',
 'aeroplane',
 'bus',
 'train',
 'truck',
 'boat',
 'traffic light']
```

[7]:
```
# Generate colors to represent classes on the image (for drawing bounding boxes)

def generate_colors(class_names):

    hsv_tuples = [(x / len(class_names), 1., 1.) for x in␣
 ↪range(len(class_names))]
    colors = list(map(lambda x: colorsys.hsv_to_rgb(*x), hsv_tuples))
    colors = list(map(lambda x: (int(x[0] * 255), int(x[1] * 255), int(x[2] *␣
 ↪255)), colors))

    # Fixed seed for consistent colors across runs
    random.seed(10101)

    # Shuffle colors to decorrelate adjacent classes
    random.shuffle(colors)

    # Reset seed to default
    random.seed(None)

    return colors
```

Loading pretrained YOLOv2

[8]:
```
sess = K.get_session()
```

[9]:
```
# Load pre-trained model from the official YOLO site, according to instructions␣
 ↪in this repo:
# https://github.com/allanzelener/YAD2K
model = load_model('./yad2k/model_data/yolo.h5')
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/site-
packages/keras/backend/tensorflow_backend.py:4070: The name tf.nn.max_pool is
deprecated. Please use tf.nn.max_pool2d instead.
```

```
WARNING:tensorflow:From /Users/alicjamazur/Desktop/dl/keras/utils_yolo/yad2k/yad
2k/models/keras_yolo.py:32: The name tf.space_to_depth is deprecated. Please use
tf.compat.v1.space_to_depth instead.
```

[10]:
```
# Show model summary
model.summary()
```

```
Model: "model_1"
________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            (None, 608, 608, 3)  0
________________________________________________________________________________
__________________
conv2d_1 (Conv2D)               (None, 608, 608, 32) 864         input_1[0][0]
________________________________________________________________________________
__________________
batch_normalization_1 (BatchNor (None, 608, 608, 32) 128         conv2d_1[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_1 (LeakyReLU)       (None, 608, 608, 32) 0
batch_normalization_1[0][0]
________________________________________________________________________________
__________________
max_pooling2d_1 (MaxPooling2D)  (None, 304, 304, 32) 0
leaky_re_lu_1[0][0]
________________________________________________________________________________
__________________
conv2d_2 (Conv2D)               (None, 304, 304, 64) 18432
max_pooling2d_1[0][0]
________________________________________________________________________________
__________________
batch_normalization_2 (BatchNor (None, 304, 304, 64) 256         conv2d_2[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_2 (LeakyReLU)       (None, 304, 304, 64) 0
batch_normalization_2[0][0]
________________________________________________________________________________
__________________
max_pooling2d_2 (MaxPooling2D)  (None, 152, 152, 64) 0
leaky_re_lu_2[0][0]
________________________________________________________________________________
__________________
conv2d_3 (Conv2D)               (None, 152, 152, 128 73728
```

```
max_pooling2d_2[0][0]
________________________________________________________________________________
__________________
batch_normalization_3 (BatchNor (None, 152, 152, 128 512         conv2d_3[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_3 (LeakyReLU)       (None, 152, 152, 128 0
batch_normalization_3[0][0]
________________________________________________________________________________
__________________
conv2d_4 (Conv2D)               (None, 152, 152, 64) 8192
leaky_re_lu_3[0][0]
________________________________________________________________________________
__________________
batch_normalization_4 (BatchNor (None, 152, 152, 64) 256         conv2d_4[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_4 (LeakyReLU)       (None, 152, 152, 64) 0
batch_normalization_4[0][0]
________________________________________________________________________________
__________________
conv2d_5 (Conv2D)               (None, 152, 152, 128 73728
leaky_re_lu_4[0][0]
________________________________________________________________________________
__________________
batch_normalization_5 (BatchNor (None, 152, 152, 128 512         conv2d_5[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_5 (LeakyReLU)       (None, 152, 152, 128 0
batch_normalization_5[0][0]
________________________________________________________________________________
__________________
max_pooling2d_3 (MaxPooling2D)  (None, 76, 76, 128)  0
leaky_re_lu_5[0][0]
________________________________________________________________________________
__________________
conv2d_6 (Conv2D)               (None, 76, 76, 256)  294912
max_pooling2d_3[0][0]
________________________________________________________________________________
__________________
batch_normalization_6 (BatchNor (None, 76, 76, 256)  1024        conv2d_6[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_6 (LeakyReLU)       (None, 76, 76, 256)  0
batch_normalization_6[0][0]
________________________________________________________________________________
__________________
conv2d_7 (Conv2D)               (None, 76, 76, 128)  32768
```

```
leaky_re_lu_6[0][0]
__________________________________________________________________________________________________
batch_normalization_7 (BatchNor (None, 76, 76, 128)  512         conv2d_7[0][0]
__________________________________________________________________________________________________
leaky_re_lu_7 (LeakyReLU)       (None, 76, 76, 128)  0
batch_normalization_7[0][0]
__________________________________________________________________________________________________
conv2d_8 (Conv2D)               (None, 76, 76, 256)  294912
leaky_re_lu_7[0][0]
__________________________________________________________________________________________________
batch_normalization_8 (BatchNor (None, 76, 76, 256)  1024        conv2d_8[0][0]
__________________________________________________________________________________________________
leaky_re_lu_8 (LeakyReLU)       (None, 76, 76, 256)  0
batch_normalization_8[0][0]
__________________________________________________________________________________________________
max_pooling2d_4 (MaxPooling2D)  (None, 38, 38, 256)  0
leaky_re_lu_8[0][0]
__________________________________________________________________________________________________
conv2d_9 (Conv2D)               (None, 38, 38, 512)  1179648
max_pooling2d_4[0][0]
__________________________________________________________________________________________________
batch_normalization_9 (BatchNor (None, 38, 38, 512)  2048        conv2d_9[0][0]
__________________________________________________________________________________________________
leaky_re_lu_9 (LeakyReLU)       (None, 38, 38, 512)  0
batch_normalization_9[0][0]
__________________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 38, 38, 256)  131072
leaky_re_lu_9[0][0]
__________________________________________________________________________________________________
batch_normalization_10 (BatchNo (None, 38, 38, 256)  1024        conv2d_10[0][0]
__________________________________________________________________________________________________
leaky_re_lu_10 (LeakyReLU)      (None, 38, 38, 256)  0
batch_normalization_10[0][0]
__________________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 38, 38, 512)  1179648
```

```
leaky_re_lu_10[0][0]
__________________________________________________________________________________________________
batch_normalization_11 (BatchNo (None, 38, 38, 512)  2048        conv2d_11[0][0]
__________________________________________________________________________________________________
leaky_re_lu_11 (LeakyReLU)      (None, 38, 38, 512)  0
batch_normalization_11[0][0]
__________________________________________________________________________________________________
conv2d_12 (Conv2D)              (None, 38, 38, 256)  131072
leaky_re_lu_11[0][0]
__________________________________________________________________________________________________
batch_normalization_12 (BatchNo (None, 38, 38, 256)  1024        conv2d_12[0][0]
__________________________________________________________________________________________________
leaky_re_lu_12 (LeakyReLU)      (None, 38, 38, 256)  0
batch_normalization_12[0][0]
__________________________________________________________________________________________________
conv2d_13 (Conv2D)              (None, 38, 38, 512)  1179648
leaky_re_lu_12[0][0]
__________________________________________________________________________________________________
batch_normalization_13 (BatchNo (None, 38, 38, 512)  2048        conv2d_13[0][0]
__________________________________________________________________________________________________
leaky_re_lu_13 (LeakyReLU)      (None, 38, 38, 512)  0
batch_normalization_13[0][0]
__________________________________________________________________________________________________
max_pooling2d_5 (MaxPooling2D)  (None, 19, 19, 512)  0
leaky_re_lu_13[0][0]
__________________________________________________________________________________________________
conv2d_14 (Conv2D)              (None, 19, 19, 1024) 4718592
max_pooling2d_5[0][0]
__________________________________________________________________________________________________
batch_normalization_14 (BatchNo (None, 19, 19, 1024) 4096        conv2d_14[0][0]
__________________________________________________________________________________________________
leaky_re_lu_14 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_14[0][0]
__________________________________________________________________________________________________
conv2d_15 (Conv2D)              (None, 19, 19, 512)  524288
```

```
leaky_re_lu_14[0][0]
__________________________________________________________________________________________________
batch_normalization_15 (BatchNo (None, 19, 19, 512)  2048        conv2d_15[0][0]
__________________________________________________________________________________________________
leaky_re_lu_15 (LeakyReLU)      (None, 19, 19, 512)  0
batch_normalization_15[0][0]
__________________________________________________________________________________________________
conv2d_16 (Conv2D)              (None, 19, 19, 1024) 4718592
leaky_re_lu_15[0][0]
__________________________________________________________________________________________________
batch_normalization_16 (BatchNo (None, 19, 19, 1024) 4096        conv2d_16[0][0]
__________________________________________________________________________________________________
leaky_re_lu_16 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_16[0][0]
__________________________________________________________________________________________________
conv2d_17 (Conv2D)              (None, 19, 19, 512)  524288
leaky_re_lu_16[0][0]
__________________________________________________________________________________________________
batch_normalization_17 (BatchNo (None, 19, 19, 512)  2048        conv2d_17[0][0]
__________________________________________________________________________________________________
leaky_re_lu_17 (LeakyReLU)      (None, 19, 19, 512)  0
batch_normalization_17[0][0]
__________________________________________________________________________________________________
conv2d_18 (Conv2D)              (None, 19, 19, 1024) 4718592
leaky_re_lu_17[0][0]
__________________________________________________________________________________________________
batch_normalization_18 (BatchNo (None, 19, 19, 1024) 4096        conv2d_18[0][0]
__________________________________________________________________________________________________
leaky_re_lu_18 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_18[0][0]
__________________________________________________________________________________________________
conv2d_19 (Conv2D)              (None, 19, 19, 1024) 9437184
leaky_re_lu_18[0][0]
__________________________________________________________________________________________________
batch_normalization_19 (BatchNo (None, 19, 19, 1024) 4096        conv2d_19[0][0]
```

```
________________________________________________________________________________
__________________
conv2d_21 (Conv2D)              (None, 38, 38, 64)   32768
leaky_re_lu_13[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_19 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_19[0][0]
________________________________________________________________________________
__________________
batch_normalization_21 (BatchNo (None, 38, 38, 64)   256         conv2d_21[0][0]
________________________________________________________________________________
__________________
conv2d_20 (Conv2D)              (None, 19, 19, 1024) 9437184
leaky_re_lu_19[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_21 (LeakyReLU)      (None, 38, 38, 64)   0
batch_normalization_21[0][0]
________________________________________________________________________________
__________________
batch_normalization_20 (BatchNo (None, 19, 19, 1024) 4096        conv2d_20[0][0]
________________________________________________________________________________
__________________
space_to_depth_x2 (Lambda)      (None, 19, 19, 256)  0
leaky_re_lu_21[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_20 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_20[0][0]
________________________________________________________________________________
__________________
concatenate_1 (Concatenate)     (None, 19, 19, 1280) 0
space_to_depth_x2[0][0]
leaky_re_lu_20[0][0]
________________________________________________________________________________
__________________
conv2d_22 (Conv2D)              (None, 19, 19, 1024) 11796480
concatenate_1[0][0]
________________________________________________________________________________
__________________
batch_normalization_22 (BatchNo (None, 19, 19, 1024) 4096        conv2d_22[0][0]
________________________________________________________________________________
__________________
leaky_re_lu_22 (LeakyReLU)      (None, 19, 19, 1024) 0
batch_normalization_22[0][0]
________________________________________________________________________________
__________________
```

```
conv2d_23 (Conv2D)              (None, 19, 19, 425)  435625
leaky_re_lu_22[0][0]
================================================================================
==================
Total params: 50,983,561
Trainable params: 50,962,889
Non-trainable params: 20,672
--------------------------------------------------------------------------------
------------------
```

Feature extraction and conversion to bounding box params

[11]:
```python
# Retrieve features from the final layer of the model
features = model.output
```

[12]:
```python
# Convert model features to bounding box parameters

def features_to_boxes(features, anchors, num_classes):

    num_anchors = len(anchors)

    # Reshape to batch, height, width, num_anchors, box_params
    anchors_tensor = K.reshape(K.variable(anchors), [1, 1, 1, num_anchors, 2])

    # Dynamic implementation of conv dims for fully convolutional model
    conv_dims = K.shape(features)[1:3]  # assuming channels last
    # In YOLO the height index is the inner most iteration
    conv_height_index = K.arange(0, stop=conv_dims[0])
    conv_width_index = K.arange(0, stop=conv_dims[1])
    conv_height_index = K.tile(conv_height_index, [conv_dims[1]])

    conv_width_index = K.tile(
        K.expand_dims(conv_width_index, 0), [conv_dims[0], 1])
    conv_width_index = K.flatten(K.transpose(conv_width_index))
    conv_index = K.transpose(K.stack([conv_height_index, conv_width_index]))
    conv_index = K.reshape(conv_index, [1, conv_dims[0], conv_dims[1], 1, 2])
    conv_index = K.cast(conv_index, K.dtype(features))

    features = K.reshape(
        features, [-1, conv_dims[0], conv_dims[1], num_anchors, num_classes + 5])
    conv_dims = K.cast(K.reshape(conv_dims, [1, 1, 1, 1, 2]), K.dtype(features))

    box_xy = K.sigmoid(features[..., :2])
    box_wh = K.exp(features[..., 2:4])
    box_confidence = K.sigmoid(features[..., 4:5])
    box_class_probs = K.softmax(features[..., 5:])
```

```
    # Adjust preditions to each spatial grid point and anchor size.
    # Note: YOLO iterates over height index before width index.
    box_xy = (box_xy + conv_index) / conv_dims
    box_wh = box_wh * anchors_tensor / conv_dims

    return box_xy, box_wh, box_confidence, box_class_probs
```

[13]:
```
yolo_outputs = features_to_boxes(features, anchors, len(class_names))
```

Evaluation of detected objects

Selection of most probable bounding boxes

[14]:
```
# Evaluate detected objects

def yolo_evaluate(yolo_outputs, image_shape=(720., 1280.), max_output_size=10,␣
↪score_threshold=.6, iou_threshold=.5):

    # Unpack bounding box params
    xy, wh, confidence, class_probs = yolo_outputs

    # Convert boxes information from (middle-point-coordinates, width-height) to␣
↪corners coordinates
    boxes = boxes_to_corners(xy, wh)

    # Step 1: eliminate boxes with low probabilities - filter boxes with scores␣
↪lower than the threshold
    scores, boxes, classes = filter_boxes(confidence, boxes, class_probs,␣
↪score_threshold)

    # Step 2: eliminate boxes with non-max scores and high overlap - filter␣
↪boxes with IoU lower than the threshold
    scores, boxes, classes = non_max_suppression(scores, boxes, classes,␣
↪max_output_size, iou_threshold)

    # Scale boxes to match input image size
    boxes = scale_boxes(boxes, image_shape)

    return scores, boxes, classes
```

[15]:
```
# Helper function: convert boxes to corners

def boxes_to_corners(box_xy, box_wh):

    box_mins = box_xy - (box_wh / 2.)
    box_maxes = box_xy + (box_wh / 2.)
```

```
    return K.concatenate([
        box_mins[..., 1:2],  # y_min
        box_mins[..., 0:1],  # x_min
        box_maxes[..., 1:2],  # y_max
        box_maxes[..., 0:1]])  # x_max
```

[16]:
```
# Helper function: eliminate boxes data with low predicted probability

def filter_boxes(confidence, boxes, class_probs, threshold = 0.6):

    # Compute the score for each box (object probability multiplied by class␣
 ↪probability)
    scores = confidence * class_probs

    # Find class with maximum score for each box and respective score
    classes_with_max_score = K.argmax(scores, axis=-1)
    max_scores = K.max(scores, axis=-1)

    # Define a mask (binary filter) to discard boxes with score lower than the␣
 ↪set threshold
    mask = (max_scores >= threshold)

    # Apply the mask to discard boxes data with the score lower than the set␣
 ↪threshold
    scores = tf.boolean_mask(max_scores, mask)
    boxes =  tf.boolean_mask(boxes, mask)
    classes = tf.boolean_mask(classes_with_max_score, mask)

    return scores, boxes, classes
```

[17]:
```
'''
Calculate intersection over union ratio. This function is not used in this␣
 ↪implementation.
Here just as an exercise.
'''

def iou(box1, box2):

    # Unpack vertices information
    (x1_1, y1_1, x2_1, y2_1) = box1
    (x1_2, y1_2, x2_2, y2_2) = box2

    # Find area of intersection
    width = min(x2_1, x2_2) - max(x1_1, x1_2)
    height = min(y2_1, y2_2) - max(y1_1, y1_2)
    intersection = max(width, 0) * max(height, 0)
```

```
    # Find union area
    area_1 = (x2_1 - x1_1) * (y2_1 - y1_1)
    area_2 = (x2_2 - x1_2) * (y2_2 - y1_2)
    union = area_1 + area_2 - intersection

    # Compute IoU
    iou = intersection / union

    return iou
```

[18]:
```
# Helper function: perform non-max suppression to make sure algorithm detects␣
↪objects only once

def non_max_suppression(scores, boxes, classes, max_output_size = 10,␣
↪iou_threshold = 0.5):

    # Initialize max_output_size variable (we need it later to perform tf.image.
↪non_max_suppression)
    max_output_size_tensor = K.variable(max_output_size, dtype='int32')
    K.get_session().run(tf.variables_initializer([max_output_size_tensor]))

    # Return indices from the boxes data to keep: eliminate non-max scores with␣
↪a significant overlap with the max score
    remaining_indices = tf.image.non_max_suppression(boxes, scores,␣
↪max_output_size_tensor, iou_threshold=0.5)

    # Get rid of bounding box data with non-max scores and significant overlap␣
↪with max score
    scores = K.gather(scores, remaining_indices)
    boxes = K.gather(boxes, remaining_indices)
    classes = K.gather(classes, remaining_indices)

    return scores, boxes, classes
```

[19]:
```
# Helper function: Scale predicted boxes to make them drawble on the image␣
↪(normalize boxes by image dimensions)

def scale_boxes(boxes, image_shape):

    # Retrieve image dimensions
    height = image_shape[0]
    width = image_shape[1]

    # Stack and reshape image dimensions to correspond to boxes coordinates␣
↪(b_x, b_y, b_h, b_w)
```

```
    image_dims = K.stack([height, width, height, width])
    image_dims = K.reshape(image_dims, [1, 4])
    image_dims = K.cast(image_dims, 'float32')
    # Normalize boxes by image dimensions
    boxes = boxes * image_dims

    return boxes
```

Testing

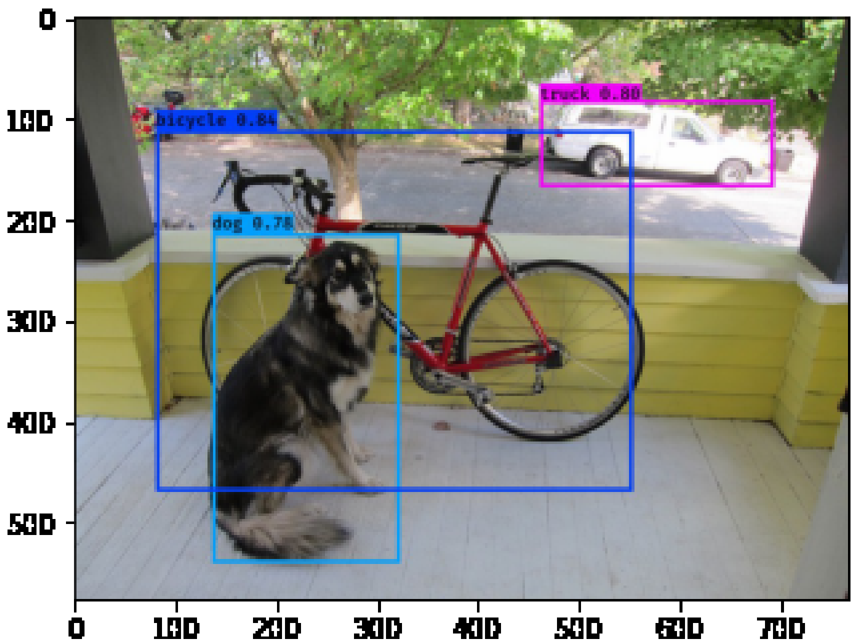
[20]:
```
# Make predictions and draw predicted bounding boxes on the input image

def predict(sess, img_path):

    # Preprocess input images to match model input size
    image, image_data, image_shape = preprocess_image(img_path, model_image_size␣
 ↪= (608, 608))

    # Optimize: perform forward propagation
    out_scores, out_boxes, out_classes = sess.run(yolo_evaluate(yolo_outputs,␣
 ↪image_shape), feed_dict={model.input: image_data,
                                                                               ␣
 ↪                      K.learning_phase(): 0})
    # Draw bounding boxes on the input image
    draw_boxes(image, out_scores, out_boxes, out_classes, class_names)

    # Save edited image
    path, filename = os.path.split(img_path)
    image.save(os.path.join('./out', filename), quality=90)

    # Display the image
    output_image = imageio.imread(os.path.join('out/', filename))
    imshow(output_image)

    return out_scores, out_boxes, out_classes
```

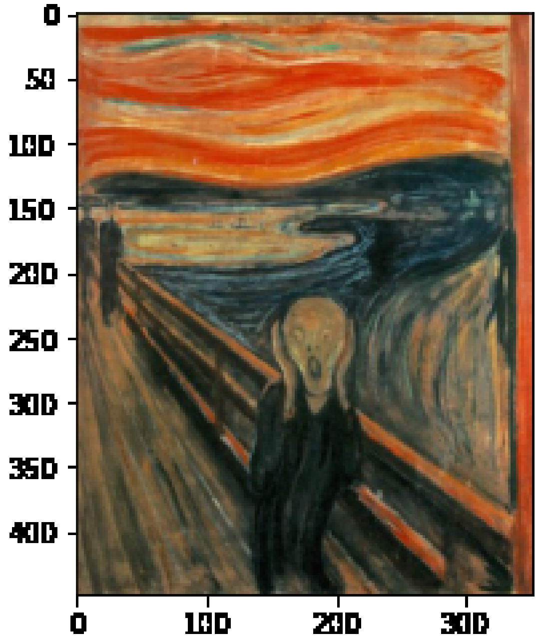
[21]:
```
# Helper function: draw selected bounding boxes on the image

def draw_boxes(image, out_scores, out_boxes, out_classes, class_names):

    # Generate colors for drawing predicted bounding boxes
    colors = generate_colors(class_names)

    # Load a font - workaround for ImageFont.truetype OSError
    file = open("./font/FiraMono-Medium.otf", "rb")
    bytes_font = BytesIO(file.read())
```

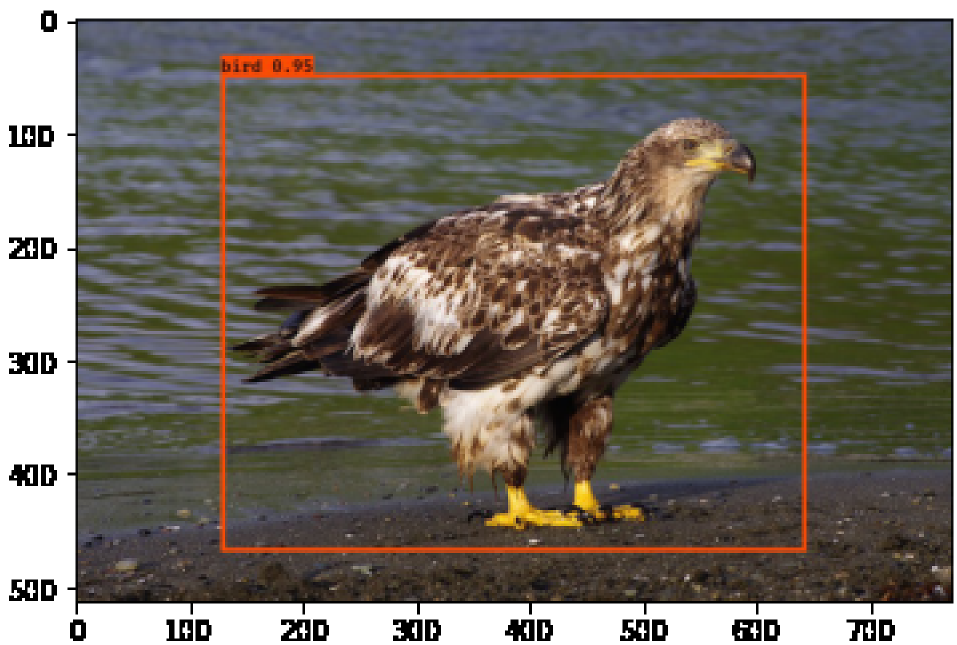
```
    font = ImageFont.truetype(bytes_font, size=np.floor(3e-2 * image.size[1] + 0.
↪5).astype('int32'))
    file.close()

    # Set bounding box line thickness
    thickness = (image.size[0] + image.size[1]) // 300

    for i, c in reversed(list(enumerate(out_classes))):

        # Retrieve box parameters
        predicted_class = class_names[c]
        box = out_boxes[i]
        score = out_scores[i]

        # Create output label
        label = '{} {:.2f}'.format(predicted_class, score)

        # Draw the bounding box on the image
        draw = ImageDraw.Draw(image)
        label_size = draw.textsize(label, font)

        # Retrieve box coordinates
        top, left, bottom, right = box

        # Limit bounding box coordinates to the image dimensions
        top = max(0, np.floor(top + 0.5).astype('int32'))
        left = max(0, np.floor(left + 0.5).astype('int32'))
        bottom = min(image.size[1], np.floor(bottom + 0.5).astype('int32'))
        right = min(image.size[0], np.floor(right + 0.5).astype('int32'))

        # Set origin for the label text
        if top - label_size[1] >= 0:
            text_origin = np.array([left, top - label_size[1]])
        else:
            text_origin = np.array([left, top + 1])

        # My kingdom for a good redistributable image drawing library.
        for i in range(thickness):
            draw.rectangle([left + i, top + i, right - i, bottom - i],␣
↪outline=colors[c])
        draw.rectangle([tuple(text_origin), tuple(text_origin + label_size)],␣
↪fill=colors[c])
        draw.text(text_origin, label, fill=(0, 0, 0), font=font)
        del draw
```

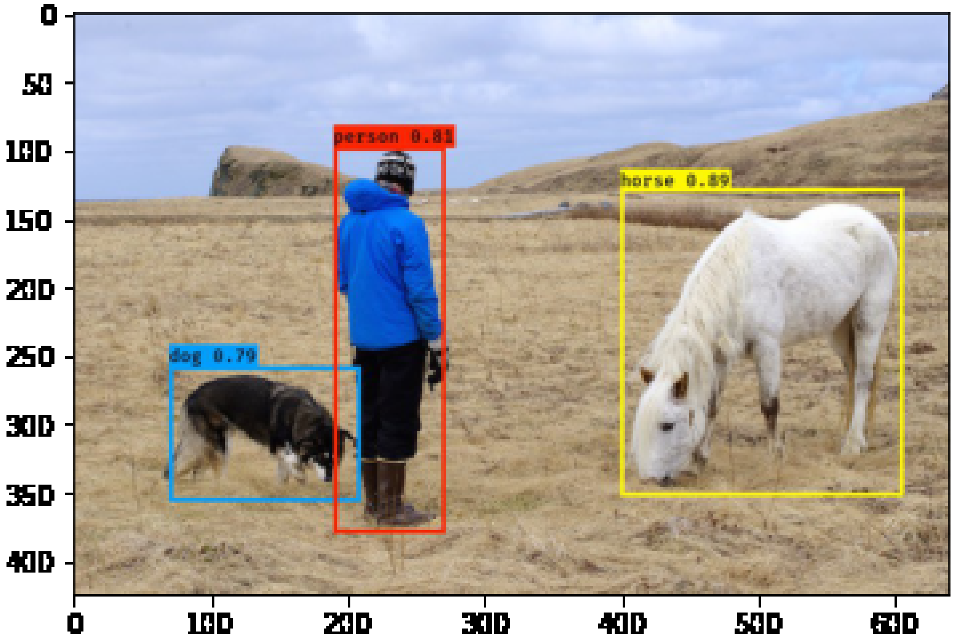
[22]:
```
for filename in os.listdir('./yad2k/images'):
    if filename.endswith('.jpg'):
        predict(sess, './yad2k/images/' + str(filename))
```

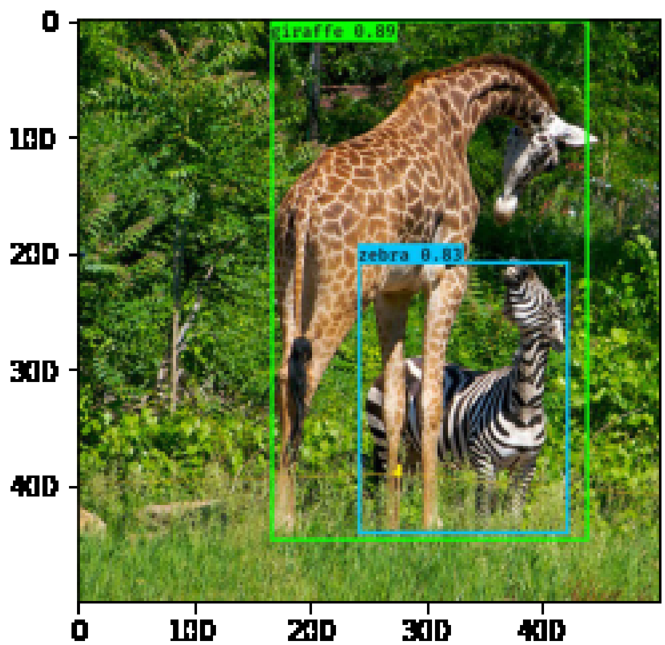
```
WARNING:tensorflow:From /usr/local/lib/python3.6/site-
packages/tensorflow/python/ops/array_ops.py:1354:
add_dispatch_support.<locals>.wrapper (from tensorflow.python.ops.array_ops) is
deprecated and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
```

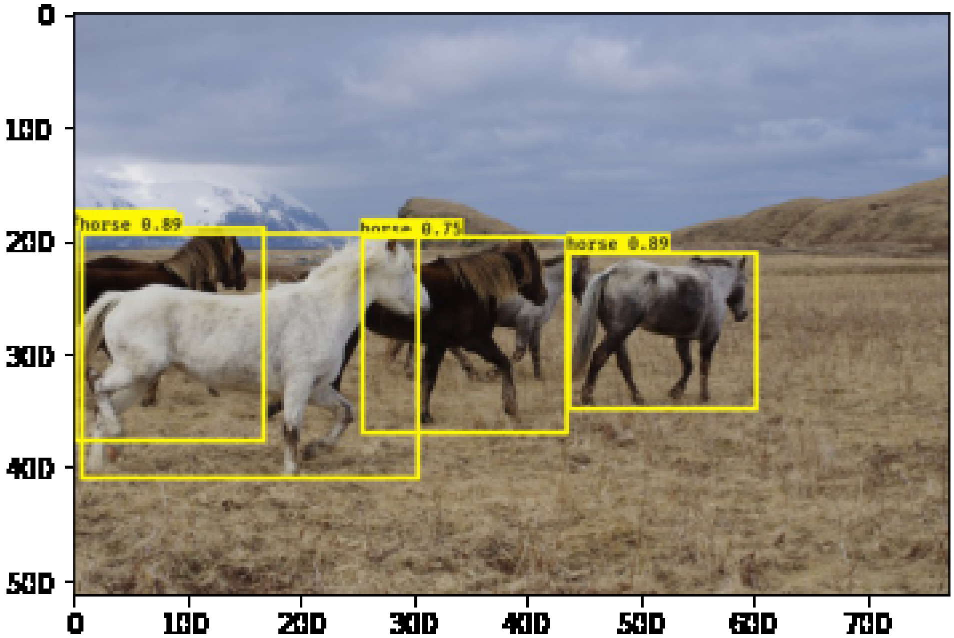



0
50
100
150
200
250
300
350
400
0
100
200
300

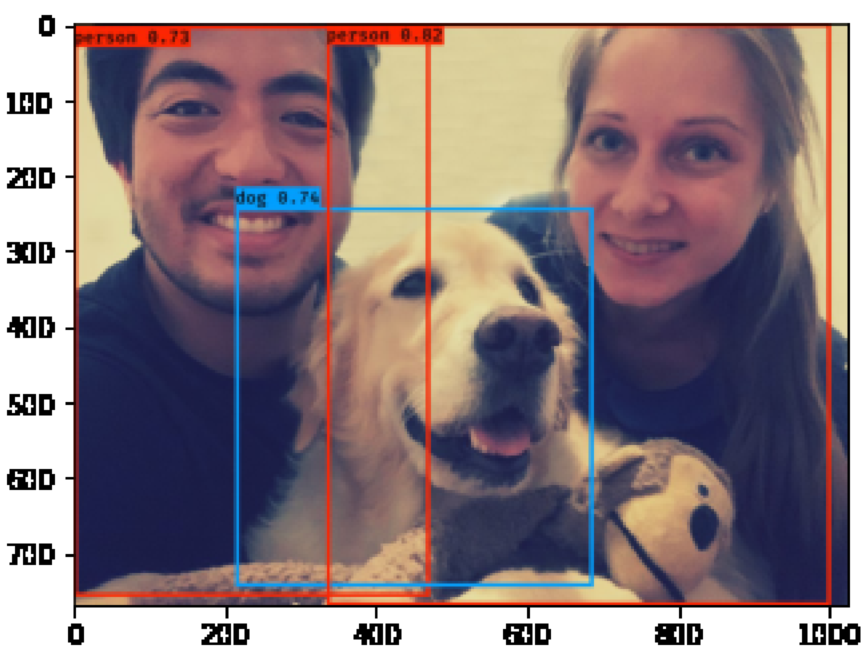

bird 0.95
0
100
200
300
400
500
0
100
200
300
400
500
600
700

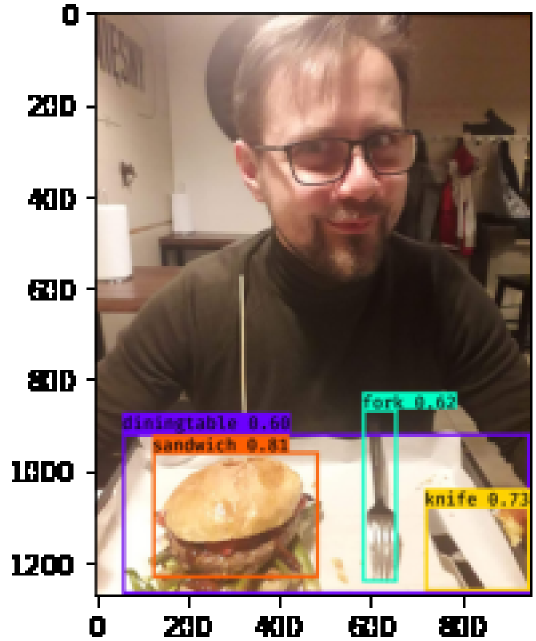

person 0.81
horse 0.89
dog 0.79
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
600

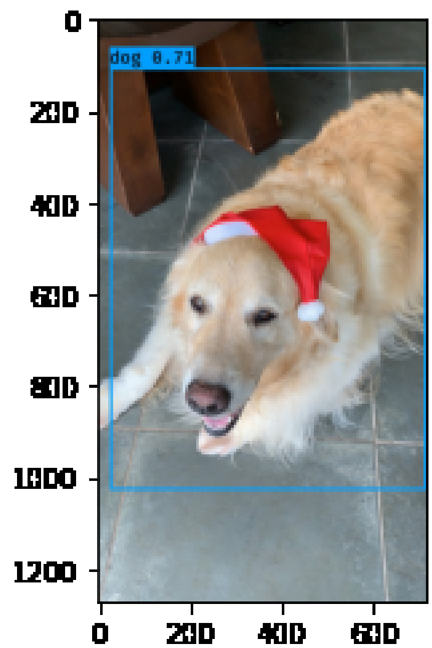

giraffe 0.89
zebra 0.83
0
100
200
300
400
0
100
200
300
400

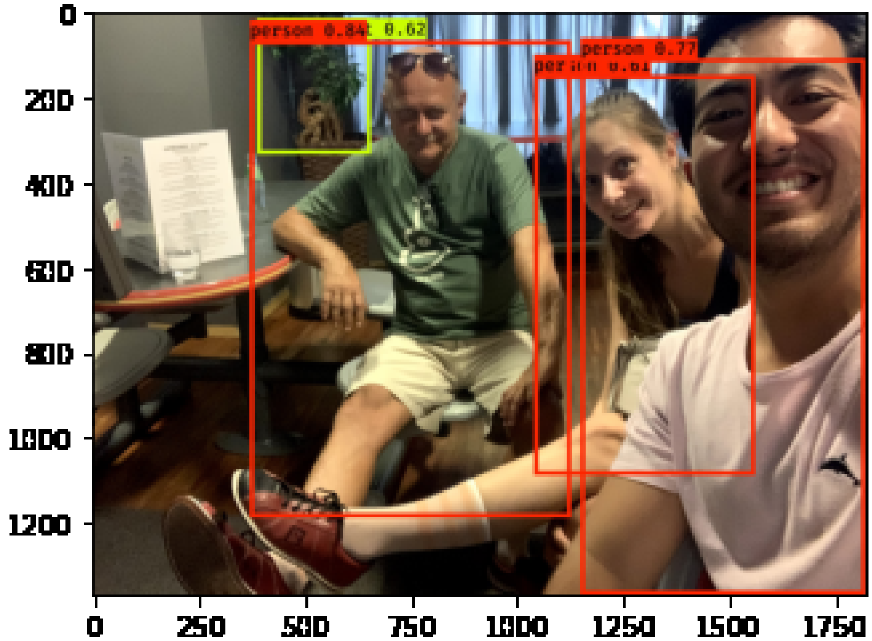



```
[23]: for filename in os.listdir('./images'):
          if filename.endswith('.jpg'):
              predict(sess, './images/' + str(filename))
```




diningtable 0.60
sandwich 0.81
fork 0.62
knife 0.73
0
200
400
600
800
1000
1200
0
200
400
600
800


dog 0.71
0
200
400
600
800
1000
1200
0
200
400
600


person 0.84
person 0.77
0
200
400
600
800
1000
1200
0
250
500
750
1000
1250
1500
1750

[ ]: