Keras-YOLOv3

April 4, 2020

1 Part1: Build YOLOv3

[1]:
```
# create a YOLOv3 Keras model and save it to file
# based on https://github.com/experiencor/keras-yolo3
import struct
import numpy as np
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
```

```
Using TensorFlow backend.
```

[2]:
```
def _conv_block(inp, convs, skip=True):
    '''
    inp: input
    convs: array of sets of configurations
    '''
    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 left and top
        x = Conv2D(conv['filter'],
                   conv['kernel'],
                   strides  = conv['stride'],
                   padding  = 'valid' if conv['stride'] > 1 else 'same', #␣
 ↪peculiar padding as darknet prefer left and top
                   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

def make_yolov3_model():
    '''
    yolo_82  = layer81
    yolo_94  = layer84 + skip61 + Upsampling + concatenate + _conv_block5
    yolo_106 = layer96 + skip36 + Upsampling + concatenate + _conv_block7
    '''
    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, 'layer_idx': 0},
                                  {'filter': 64, 'kernel': 3, 'stride': 2,␣
↪'bnorm': True, 'leaky': True, 'layer_idx': 1},
                                  {'filter': 32, 'kernel': 1, 'stride': 1,␣
↪'bnorm': True, 'leaky': True, 'layer_idx': 2},
                                  {'filter': 64, 'kernel': 3, 'stride': 1,␣
↪'bnorm': True, 'leaky': True, 'layer_idx': 3}])
    # Layer  5 => 8
    x = _conv_block(x, [{'filter': 128, 'kernel': 3, 'stride': 2, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 5},
                        {'filter':  64, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 6},
                        {'filter': 128, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 7}])
    # Layer  9 => 11
    x = _conv_block(x, [{'filter':  64, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 9},
                        {'filter': 128, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 10}])
    # Layer 12 => 15
    x = _conv_block(x, [{'filter': 256, 'kernel': 3, 'stride': 2, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 12},
                        {'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 13},
                        {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 14}])
    # Layer 16 => 36
    for i in range(7):
```

```
        x = _conv_block(x, [{'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 16+i*3},
                            {'filter': 256, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 17+i*3}])
    skip_36 = x
    # Layer 37 => 40
    x = _conv_block(x, [{'filter': 512, 'kernel': 3, 'stride': 2, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 37},
                        {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 38},
                        {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 39}])
    # Layer 41 => 61
    for i in range(7):
        x = _conv_block(x, [{'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 41+i*3},
                            {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 42+i*3}])
    skip_61 = x
    # Layer 62 => 65
    x = _conv_block(x, [{'filter': 1024, 'kernel': 3, 'stride': 2, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 62},
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 63},
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 64}])
    # Layer 66 => 74
    for i in range(3):
        x = _conv_block(x, [{'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 66+i*3},
                            {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 67+i*3}])
    # Layer 75 => 79
    x = _conv_block(x, [{'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 75},
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 76},
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 77},
                        {'filter': 1024, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 78},
                        {'filter':  512, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 79}], skip=False)
    # Layer 80 => 82
    yolo_82 = _conv_block(x, [{'filter': 1024, 'kernel': 3, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 80},
```

```
                              {'filter':  255, 'kernel': 1, 'stride': 1,␣
↪'bnorm': False, 'leaky': False, 'layer_idx': 81}], skip=False)
   # Layer 83 => 86
   x = _conv_block(x, [{'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 84}], skip=False)
   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_idx': 87},
                       {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 88},
                       {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 89},
                       {'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 90},
                       {'filter': 256, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 91}], skip=False)
   # Layer 92 => 94
   yolo_94 = _conv_block(x, [{'filter': 512, 'kernel': 3, 'stride': 1, 'bnorm':
↪ True,  'leaky': True,  'layer_idx': 92},
                             {'filter': 255, 'kernel': 1, 'stride': 1, 'bnorm':
↪ False, 'leaky': False, 'layer_idx': 93}], skip=False)
   # Layer 95 => 98
   x = _conv_block(x, [{'filter': 128, 'kernel': 1, 'stride': 1, 'bnorm':␣
↪True, 'leaky': True, 'layer_idx': 96}], skip=False)
   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,  'layer_idx': 99},
                              {'filter': 256, 'kernel': 3, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 100},
                              {'filter': 128, 'kernel': 1, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 101},
                              {'filter': 256, 'kernel': 3, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 102},
                              {'filter': 128, 'kernel': 1, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 103},
                              {'filter': 256, 'kernel': 3, 'stride': 1,␣
↪'bnorm': True,  'leaky': True,  'layer_idx': 104},
                              {'filter': 255, 'kernel': 1, 'stride': 1,␣
↪'bnorm': False, 'leaky': False, 'layer_idx': 105}], skip=False)
   model = Model(input_image, [yolo_82, yolo_94, yolo_106])
   return model
```

```
class WeightReader:
    def __init__(self, weight_file):
        with open(weight_file, 'rb') as w_f:
            # i: int
            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
```

[3]:
```
# define the model
model = make_yolov3_model()
# load the model weights
weight_reader = WeightReader('yolov3.weights')
# set the model weights into the model
weight_reader.load_weights(model)
# save the model to file
model.save('model.h5')
```

```
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
loading weights of convolution #19
loading weights of convolution #20
no convolution #21
loading weights of convolution #22
loading weights of convolution #23
no convolution #24
loading weights of convolution #25
loading weights of convolution #26
no convolution #27
loading weights of convolution #28
loading weights of convolution #29
```

```
no convolution #30
loading weights of convolution #31
loading weights of convolution #32
no convolution #33
loading weights of convolution #34
loading weights of convolution #35
no convolution #36
loading weights of convolution #37
loading weights of convolution #38
loading weights of convolution #39
no convolution #40
loading weights of convolution #41
loading weights of convolution #42
no convolution #43
loading weights of convolution #44
loading weights of convolution #45
no convolution #46
loading weights of convolution #47
loading weights of convolution #48
no convolution #49
loading weights of convolution #50
loading weights of convolution #51
no convolution #52
loading weights of convolution #53
loading weights of convolution #54
no convolution #55
loading weights of convolution #56
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no convolution #58
loading weights of convolution #59
loading weights of convolution #60
no convolution #61
loading weights of convolution #62
loading weights of convolution #63
loading weights of convolution #64
no convolution #65
loading weights of convolution #66
loading weights of convolution #67
no convolution #68
loading weights of convolution #69
loading weights of convolution #70
no convolution #71
loading weights of convolution #72
loading weights of convolution #73
no convolution #74
loading weights of convolution #75
loading weights of convolution #76
loading weights of convolution #77
```

```
loading weights of convolution #78
loading weights of convolution #79
loading weights of convolution #80
loading weights of convolution #81
no convolution #82
no convolution #83
loading weights of convolution #84
no convolution #85
no convolution #86
loading weights of convolution #87
loading weights of convolution #88
loading weights of convolution #89
loading weights of convolution #90
loading weights of convolution #91
loading weights of convolution #92
loading weights of convolution #93
no convolution #94
no convolution #95
loading weights of convolution #96
no convolution #97
no convolution #98
loading weights of convolution #99
loading weights of convolution #100
loading weights of convolution #101
loading weights of convolution #102
loading weights of convolution #103
loading weights of convolution #104
loading weights of convolution #105
```

2 Part2: Make a prediction

[4]:
```
# load yolov3 model and perform object detection
# based on https://github.com/experiencor/keras-yolo3
from numpy import expand_dims
from keras.models import load_model
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
```

[5]:
```
# 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
```

[6]:
```
# load yolov3 model
model = load_model('model.h5')
# define the expected input shape for the model
input_w, input_h = 416, 416
# define our new photo
photo_filename = 'img/zebra.png'
# 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])
```

```
/Users/chanho/miniconda3/envs/kd/lib/python3.5/site-
packages/keras/engine/saving.py:269: UserWarning: No training configuration
found in save file: the model was *not* compiled. Compile it manually.
  warnings.warn('No training configuration found in save file: '

[(1, 13, 13, 255), (1, 26, 26, 255), (1, 52, 52, 255)]
```

3 Part3: Make a Prediction and Interpret Result

[7]:
```
# load yolov3 model and perform object detection
# based on https://github.com/experiencor/keras-yolo3
import numpy as np
from numpy import expand_dims
from keras.models import load_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
```

[8]:
```
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))

# [(1, 13, 13, 255), (1, 26, 26, 255), (1, 52, 52, 255)]
def decode_netout(netout, anchors, obj_thresh, net_h, net_w):
    grid_h, grid_w = netout.shape[:2] # (13, 13)
    nb_box = 3
    netout = netout.reshape((grid_h, grid_w, nb_box, -1)) # (13, 13, 3, 1)
    nb_class = netout.shape[-1] - 5 # 85 - 5 = 80, this is the number of labels
    boxes = []
    # : means as many as needed
    netout[..., :2]  = _sigmoid(netout[..., :2])
    netout[..., 4:]  = _sigmoid(netout[..., 4:])
    # np.newaxis: increase the dimension
    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

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

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

# 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

# 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):
    # load the image
    data = pyplot.imread(filename)
    # plot the image
    pyplot.imshow(data)
    # get the context for drawing boxes
```

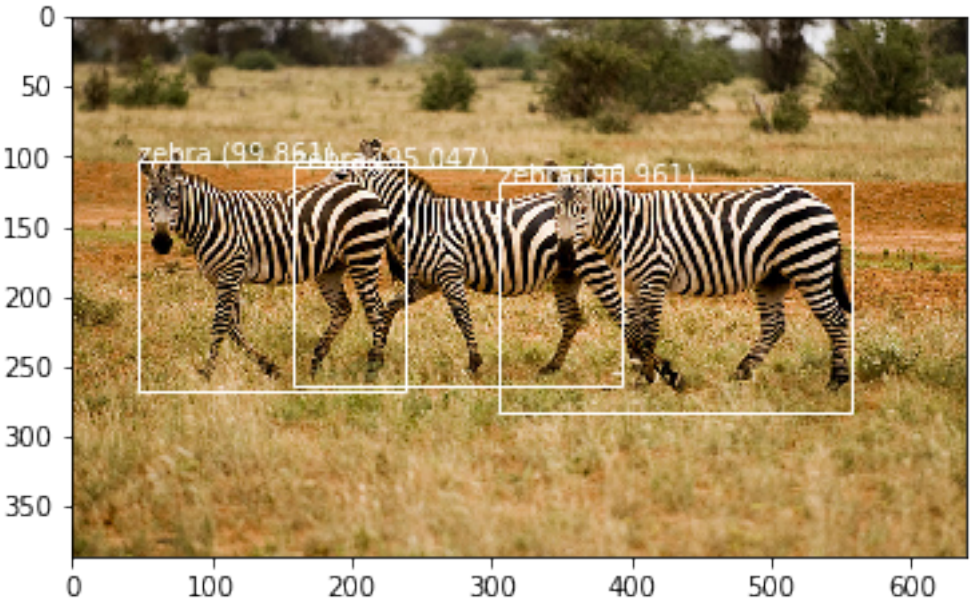
```
    ax = pyplot.gca()
    # plot each box
    for i in range(len(v_boxes)):
        box = v_boxes[i]
        # get coordinates
        y1, x1, y2, x2 = box.ymin, box.xmin, box.ymax, box.xmax
        # calculate width and height of the box
        width, height = x2 - x1, y2 - y1
        # create the shape
        rect = Rectangle((x1, y1), width, height, fill=False, color='white')
        # 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, y1, label, color='white')
    # show the plot
    pyplot.show()
```

[9]:
```
# load yolov3 model
model = load_model('model.h5')
# define the expected input shape for the model
input_w, input_h = 416, 416
# define our new photo
photo_filename = 'img/zebra.png'
# 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])
# 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 = 0.6
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, 0.5)
# define the labels
labels = ["person", "bicycle", "car", "motorbike", "aeroplane", "bus", "train",␣
↪"truck",
```

```
    "boat", "traffic light", "fire hydrant", "stop sign", "parking meter",␣
 ↪"bench",
    "bird", "cat", "dog", "horse", "sheep", "cow", "elephant", "bear", "zebra",␣
 ↪"giraffe",
    "backpack", "umbrella", "handbag", "tie", "suitcase", "frisbee", "skis",␣
 ↪"snowboard",
    "sports ball", "kite", "baseball bat", "baseball glove", "skateboard",␣
 ↪"surfboard",
    "tennis racket", "bottle", "wine glass", "cup", "fork", "knife", "spoon",␣
 ↪"bowl", "banana",
    "apple", "sandwich", "orange", "broccoli", "carrot", "hot dog", "pizza",␣
 ↪"donut", "cake",
    "chair", "sofa", "pottedplant", "bed", "diningtable", "toilet",␣
 ↪"tvmonitor", "laptop", "mouse",
    "remote", "keyboard", "cell phone", "microwave", "oven", "toaster", "sink",␣
 ↪"refrigerator",
    "book", "clock", "vase", "scissors", "teddy bear", "hair drier",␣
 ↪"toothbrush"]
# get the details of the detected objects
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)
```

```
/Users/chanho/miniconda3/envs/kd/lib/python3.5/site-
packages/keras/engine/saving.py:269: UserWarning: No training configuration
found in save file: the model was *not* compiled. Compile it manually.
  warnings.warn('No training configuration found in save file: '
```

```
[(1, 13, 13, 255), (1, 26, 26, 255), (1, 52, 52, 255)]
zebra 95.04725933074951
zebra 99.86120462417603
zebra 96.96118235588074
```


0
50
100
150
200
250
300
350
0
100
200
300
400
500
600