Yolo

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1 Introduction

You Only Looked Once Suppose three objects are needed to be classified

1. pedestrian
2. car
3. motorcycle

The 4th class is a background class.

Recall Sliding window for object detection and localization

$$y = \begin{pmatrix} \mathrm{P}_c \\ \mathrm{b}_x \\ \mathrm{b}_y \\ \mathrm{b}_w \\ \mathrm{b}_h \\ \mathrm{C}_1 \\ \mathrm{C}_2 \\ \mathrm{C}_3 \end{pmatrix} \tag{1}$$

1.1 Challenges

1. What if there are multiple objects in a sliding window?
2. What if an object spans over multiples windows?
3. What if the object is not a balanced rectangle?

2 Solution:Bounding Box Prediction

1. Divide an image into cells. For instance, 3x3 grid or 19x19 grid.
2. Apply convolution through the sliding window technique.
3. For each cell, get the output for each grid. i.e., equation 1.

4. Upper left corner for each cell would be 0,0 and lower right would be 1,1
5. If an object is in multiple cells then take the cell with center of the object
6. If there are a large number of cells then chances for more than one object in a cell are low
7. b_x and b_y denotes center point of the object within the cell. They will always be between 0 and 1
8. b_w and b_h denotes width and height of the box. Can they be greater than 1 because the bounding box could span over multiple grids.
9. What if an item spans multiple boxes ?

3 Intersection Over Union

IoU (Intersection over Union) measures the accuracy of bounding box prediction. Figure 1 illustrates the difference between predicted vs actual.

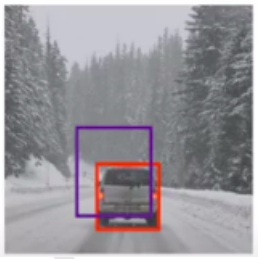


Figure 1: Predicted vs actual output

$$iou = sizeofintersection/sizeofunion \tag{2}$$

if IOU ==1 then same
if IOU >=0.5 then correct
IOU is measure of overlap between two bounding boxes. IOU can also be used to compare two similar bounding boxes.

4 Non max Suppression

Developed to cater the problem of detecting same object multiple times It is possible when we have many cells. Each cell may likely claim to have an object (high probability)

A simplified car detection algorithm

$$y = \begin{pmatrix} \mathrm{P}_c \\ \mathrm{b}_x \\ \mathrm{b}_y \\ \mathrm{b}_w \\ \mathrm{b}_h \end{pmatrix} \tag{3}$$

1. Discard all boxes with $P_c <= 0.6$
2. If there are more boxes
3. Pick the box with largest P_c prediction. Output it as a prediction
4. Discard any remaining box with $IoU >= 0.5$ with the output box in the above mentioned step
5. iterate

5 Anchor box algorithm

Difference between anchor box and bounding box.

Bounding Boxes are predicted by the network. The purpose of the box is to predict the size and location of the object. However, we can only detect one object in a cell.

Anchor Boxes Some pre-assumed shape about the object. Humans will have rectangular shape. Cars will have probably 2:1 aspect ratio in terms of width vs height. They are anchor boxes. These are sent to the network as a pair of width vs height. : Five anchor boxes are shown below: anchors = [1.18, 1.32, 3.23, 4.28, 4.43, 12.38, 7.72, 7.91, 15.31, 11.09]

Designed to detect multiple objects with in a cell

Two anchor boxes. Each reflecting shape of the object Equation is modified

$$y = \begin{pmatrix} \mathrm{P}_c \\ \mathrm{b}_x \\ \mathrm{b}_y \\ \mathrm{b}_w \\ \mathrm{b}_h \\ \mathrm{C}_1 \\ \mathrm{C}_2 \\ \mathrm{C}_3 \\ \mathrm{P}_c \\ \mathrm{b}_x \\ \mathrm{b}_y \\ \mathrm{b}_w \\ \mathrm{b}_h \\ \mathrm{C}_1 \\ \mathrm{C}_2 \\ \mathrm{C}_3 \end{pmatrix} \tag{4}$$

5.1 Previously

Each object in training image is assigned to the grid cell that contains the object's midpoint.

Output y 3x3x8 (Why?)

5.2 Updated - with anchor boxes

Each object in training image is assigned to grid cell that contains object's midpoint and anchor box for the grid cell with the highest IoU.

Objects are assigned to a pair (gridcell,anchorbox) This instance . output = 3x3x2x8

5.3 limitations

cannot detect following:

1. two anchor boxes and 3 objects with in a cell
2. two objects with same anchor box shape with in a cell

These limitations can be addressed if we use a large grid size such as 19x19

5.4 how to select anchor boxes

1. Select by hand 8 to 10 most common shapes, which tend to cover most of the shapes
2. Use unsupervised machine learning (such as K-means) to identify most common shapes within the dataset

How to select size What is the smallest size box I want to detect? If center of bounding box differs with center of anchor box, we may miss the object detection.

5.5 How to detect objects using anchor boxes

1. Create several (may be hundreds) of anchor boxes
2. For each anchor box calculate which objects bounding box has highest overlap w.r.t IoU.
3. If IoU >=50 percent detect the object with highest IoU
4. else if IoU >= $40 and < 50$; percent detection is ambiguous
5. else if <40 percent ; no object

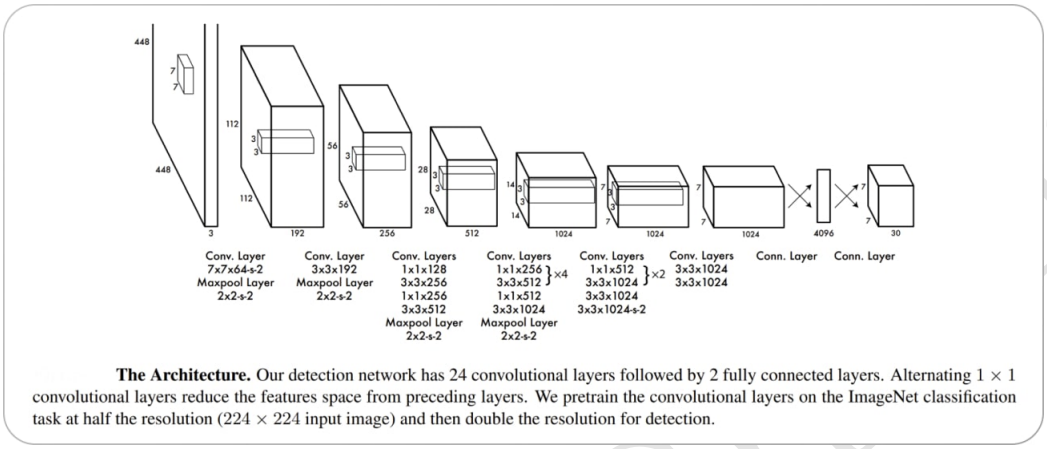
6 Yolo-combined

Suppose two anchor boxes. THree classes 4th class is for background. y=3x3x2x8
For three classes and 3x3 grid size and 2 anchor boxes.
y is 3x3x2x8
Object will be associate with the anchor box with higher IoU.
If we increase anchor boxes to 5? For grids with no object, PC will be zero ; other values will be skipped.
How to run non-max suppression?

1. For each cell get 2 predicted bounding boxes.
2. Remove low probability predictions
3. for each class (P,C,M) independently use non-max suppression to generate final predictions

7 Architecture of YOLO

ImageNet is a large-scale image database designed for use in visual object recognition software research. It was developed by researchers at Stanford University. Yolo uses transfer learning over Imagenet.



The Architecture. Our detection network has 24 convolutional layers followed by 2 fully connected layers. Alternating 1×1 convolutional layers reduce the features space from preceding layers. We pretrain the convolutional layers on the ImageNet classification task at half the resolution (224×224 input image) and then double the resolution for detection.

Figure 2: Yolo Architecure

Figure 2 shows the architecture of Yolo.

8 R-CNN

There are four attributes, which are used to form an object
scales, colors, textures, and enclosure
Regions are identified based on these attributes.
sub segments are generated to identify multiple regions
Similar regions are then combined to form large regions
Regions of Interest (RoI) are identified.