Insight to computer vision

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Overview – What is CV?

Classification

Object detection

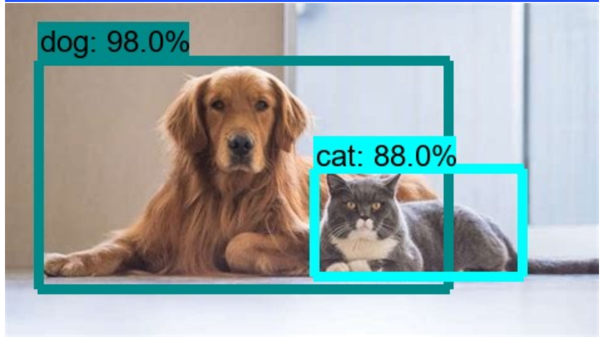


Image Segmentation (panoptic)

Keypoint detection

and many more...

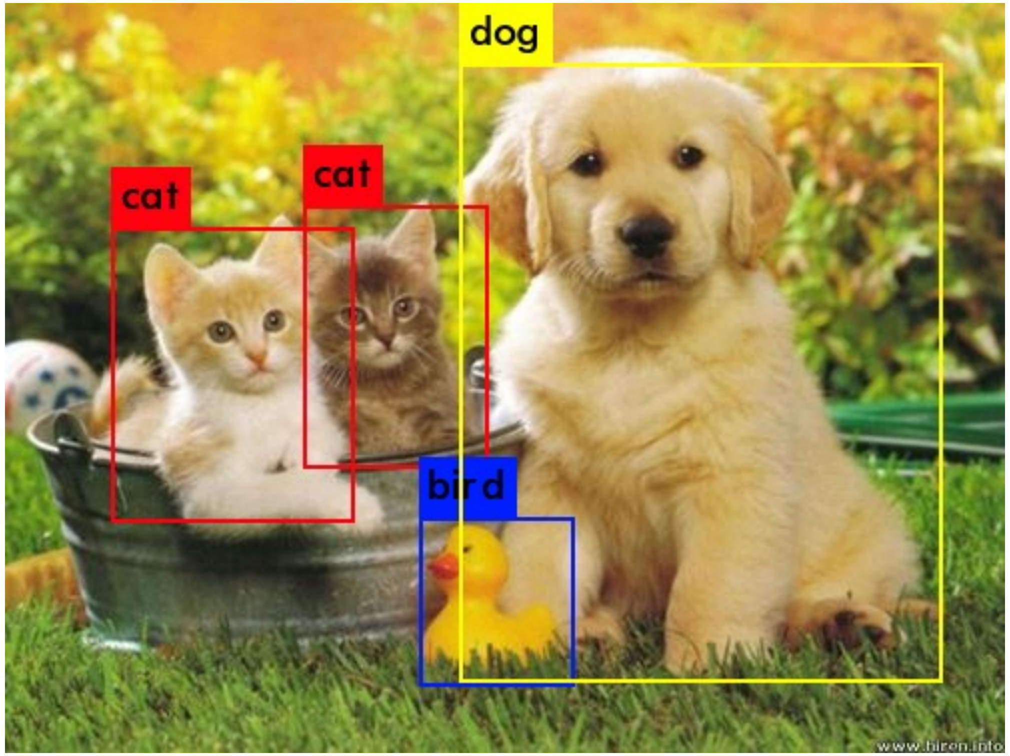
Object Detection Task

Localization (regression)

- Localized the subject in the image
- Done by drawing bounding boxes (bbox) around the subject
- Bbox described as (x1, y1, x2, y2) or (x, y, w, h)

Classification

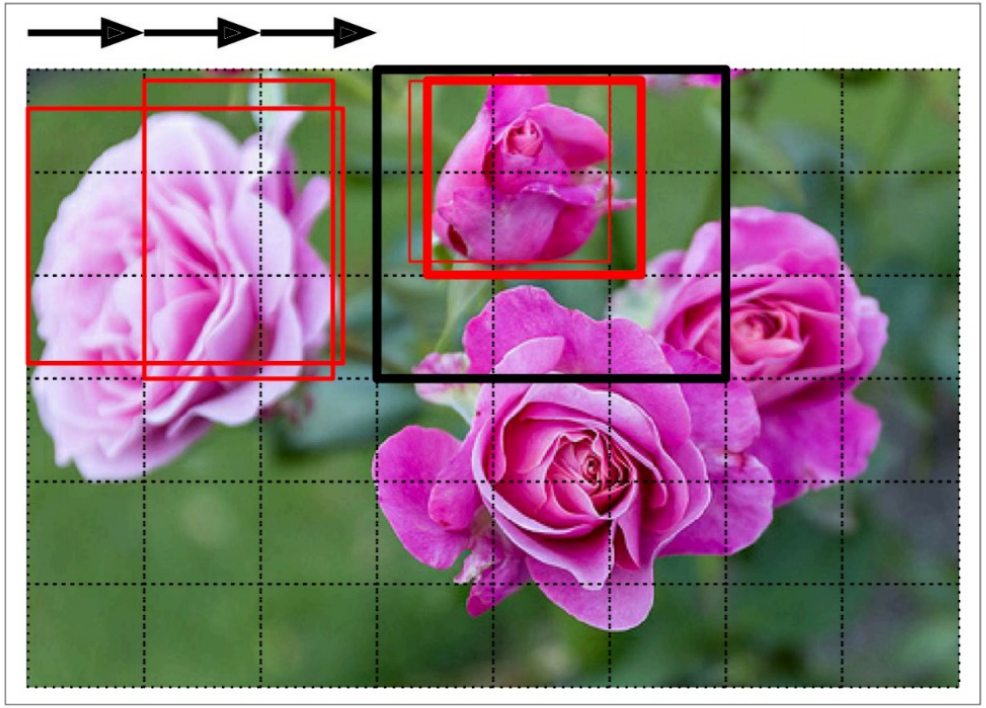
- Classify subject correctly (e.g. cat or dog)



Object detection models

<u>Two-stage models</u>

- Region-based CNN Family Models
  - R-CNN (2014), Fast R-CNN (2015), Faster R-CNN (2016), Mask R-CNN (2017)
- More accurate but are typically slower.



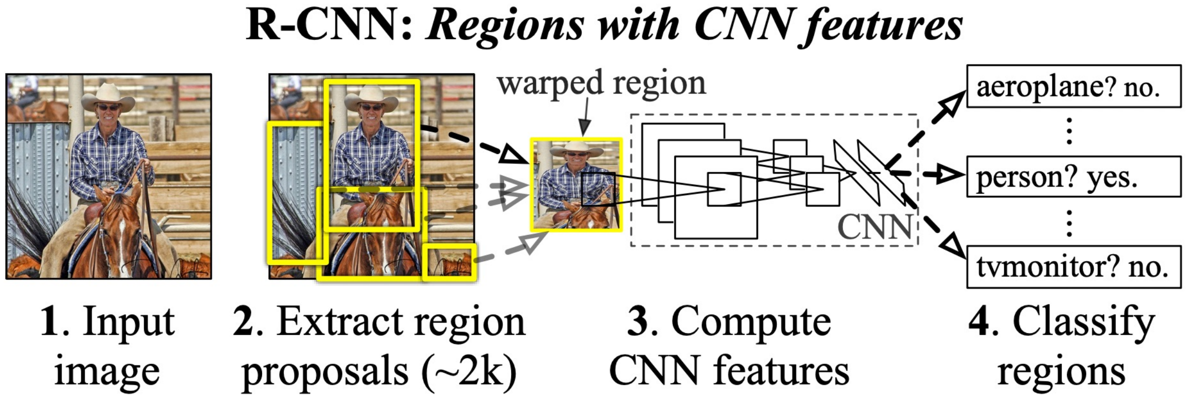


Figure 1: Object detection system overview. Our system (1) takes an input image, (2) extracts around 2000 bottom-up region proposals, (3) computes features for each proposal using a large convolutional neural network (CNN), and then (4) classifies each region using class-specific linear SVMs.

Sliding window technique

Region proposal technique

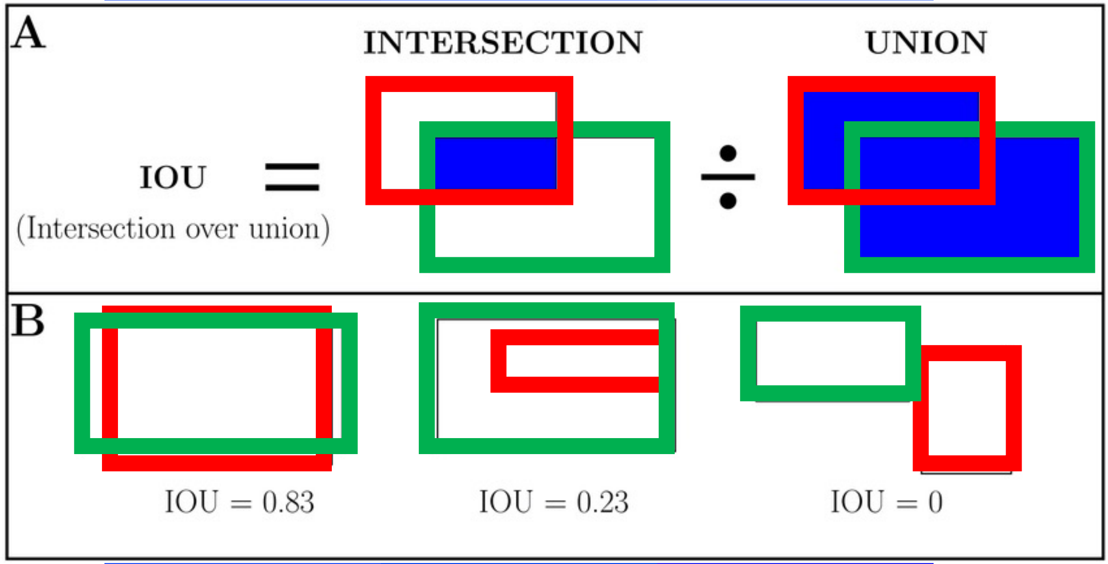
object detection models

One-stage models

- YOLO Family Models
  - YOLO (2015), YOLOv2 (2016), YOLOv3 (2018), YOLOv4 (2020), YOLOv5 (2021)
- SSD (2016)
- Fast inference speed, but not as good at recognizing a group of small objects

Evaluation metric: Intersection over Union (IoU)

- IoU quantify the amount of overlap area between predicted bbox overlapped with ground-truth bbox
- Range from 0 (prediction totally off) to 1 (prefect prediction)
- If prediction has IoU > 0.5, correct classification -> TP
- If prediction has IoU < 0.5, correct classification -> FP
- If no prediction when there is a target -> FN
  (0.5 is an arbitrary threshold)

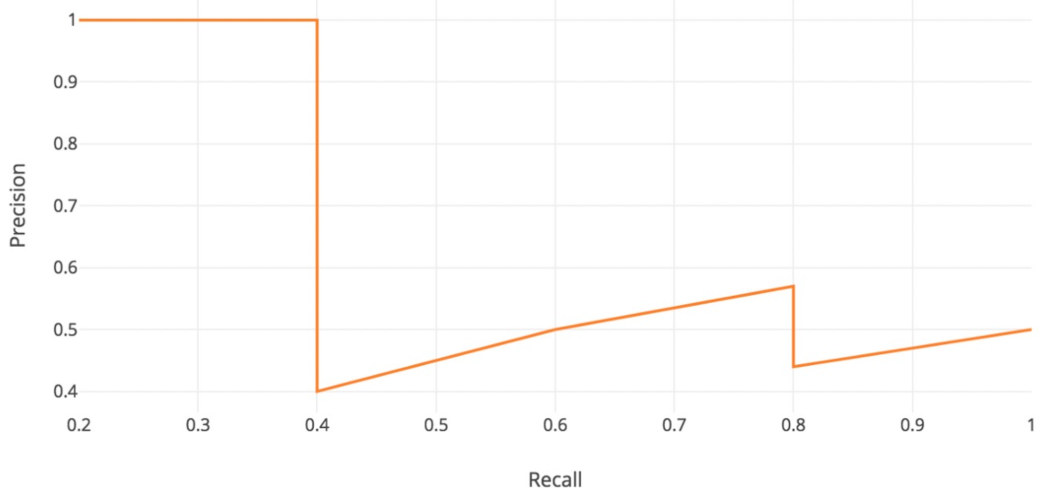


Evaluation metric: Mean Average Precision (mAP)

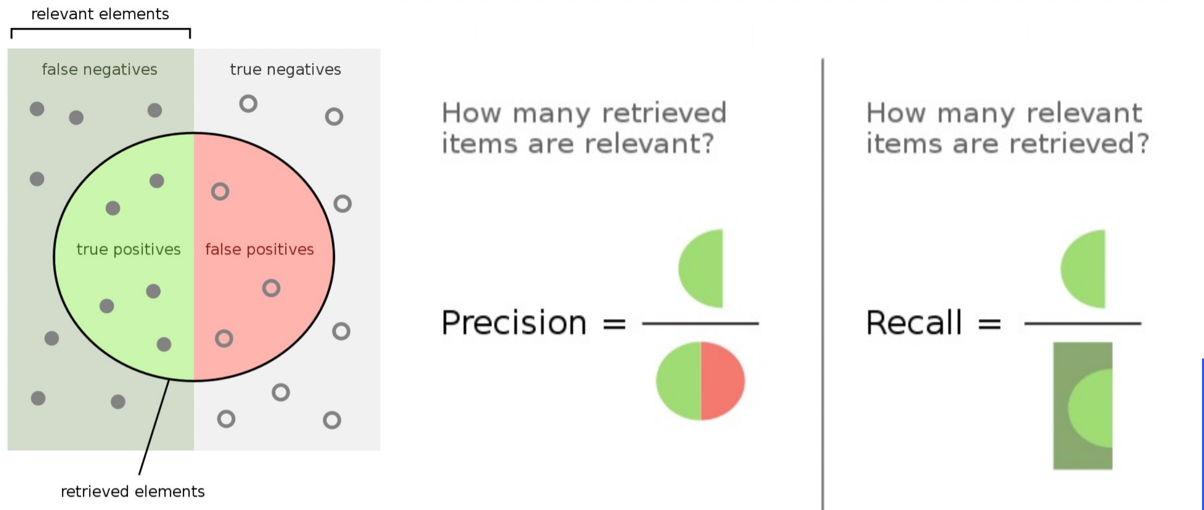
- Based on the concept of IoU, calculate TP, FP, FN to built a precision –recall curve
- STEPS :
  - Sort the predictions by confidence level
  - Compute the precision and recall for each row sequentially
  - Plot graph
- Calculate area under graph and you get AP!
- Repeat this for diff classes and average them e.g. AP_{CAT} , AP_{DOG}
- Hence mean AP

5 total cases in this e.g.

Rank	Correct?	Precision	Recall
1	True	1.0 1 / 1	0.2 1 / 5
2	True	1.0 2 / 2	0.4 2 / 5
3	False	0.67 2 / 3	0.4 2 / 5
4	False	0.5 2 / 4	0.4 2 / 5
5	False	0.4	0.4
6	True	0.5	0.6
7	True	0.57	0.8
8	False	0.5	0.8
9	False	0.44	0.8
10	True	0.5	1.0



Precision-recall curve



Evaluation metric: Mean Average Precision (mAP)

COCO Object Detection Challenge

Average Precision (AP):

AP	% AP at IoU=.50:.05:.95 **(primary challenge metric)**
$AP^{IoU=.50}$	% AP at IoU=.50 (PASCAL VOC metric)
$AP^{IoU=.75}$	% AP at IoU=.75 (strict metric)

AP Across Scales:

AP^{small}	% AP for small objects: area < 32^2
AP^{medium}	% AP for medium objects: 32^2 < area < 96^2
AP^{large}	% AP for large objects: area > 96^2

Average Recall (AR):

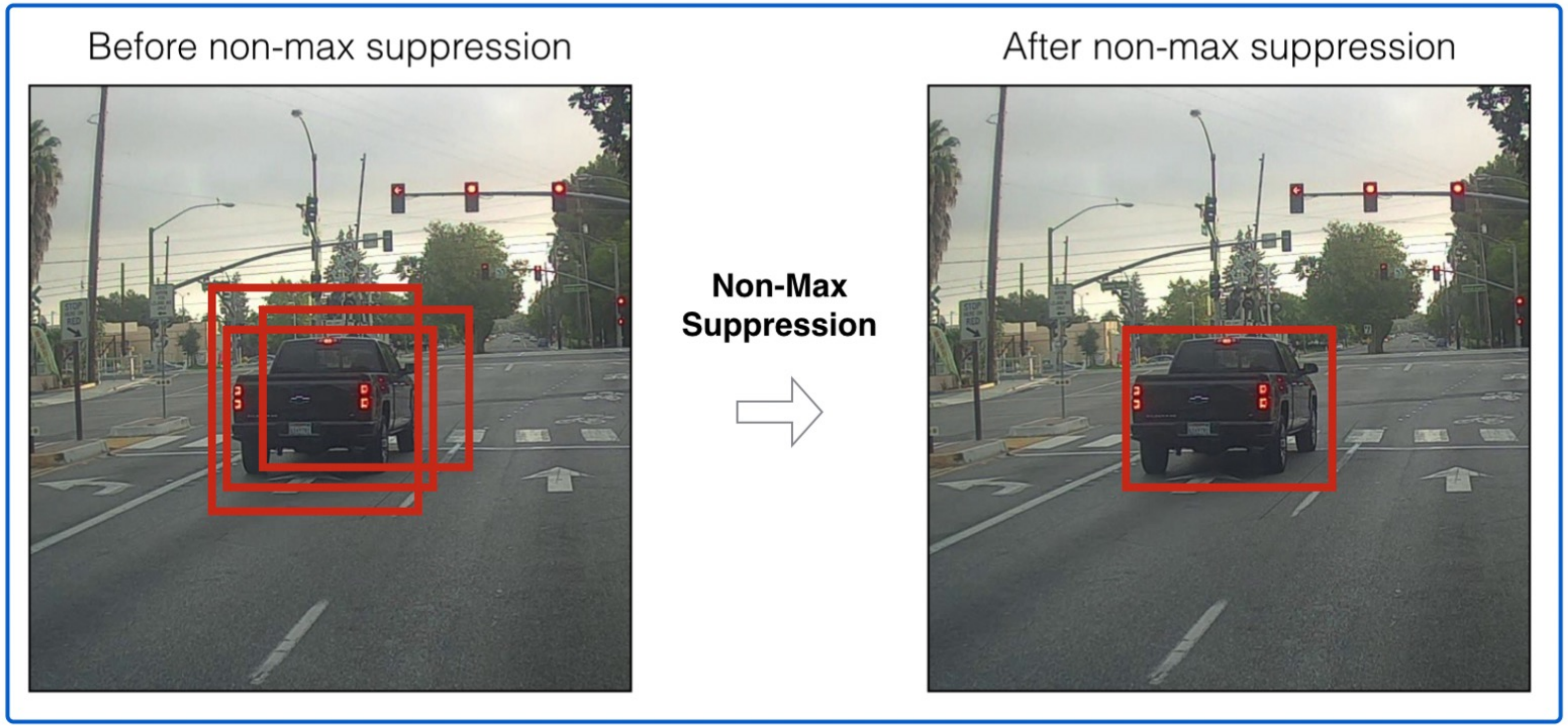
$AR^{max=1}$	% AR given 1 detection per image
$AR^{max=10}$	% AR given 10 detections per image
$AR^{max=100}$	% AR given 100 detections per image

AR Across Scales:

AR^{small}	% AR for small objects: area < 32^2
AR^{medium}	% AR for medium objects: 32^2 < area < 96^2
AR^{large}	% AR for large objects: area > 96^2

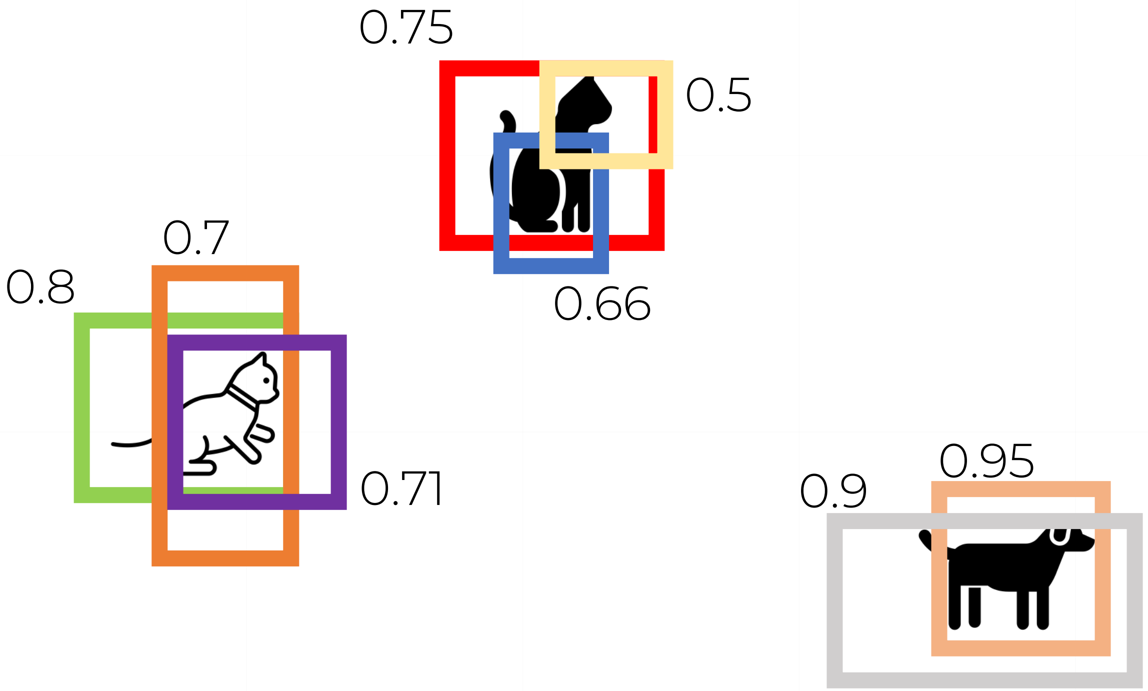
Non-max suppression (NMS)

- Most obj detection models proposed multiple bbox around the target.
- NMS is a technique to remove all except one bbox proposal



Steps:

1. Start from one class
2. Select the bbox with the highest conf idence score.
3. Check the IOU score of other bboxes.
4. Discard the bbox if IOU > 0.7 (arbitrar y threshold
5. Select the second highest confidence score and repeat step 3 and 4.
6. Repeat step 1 to 5 for other classes.



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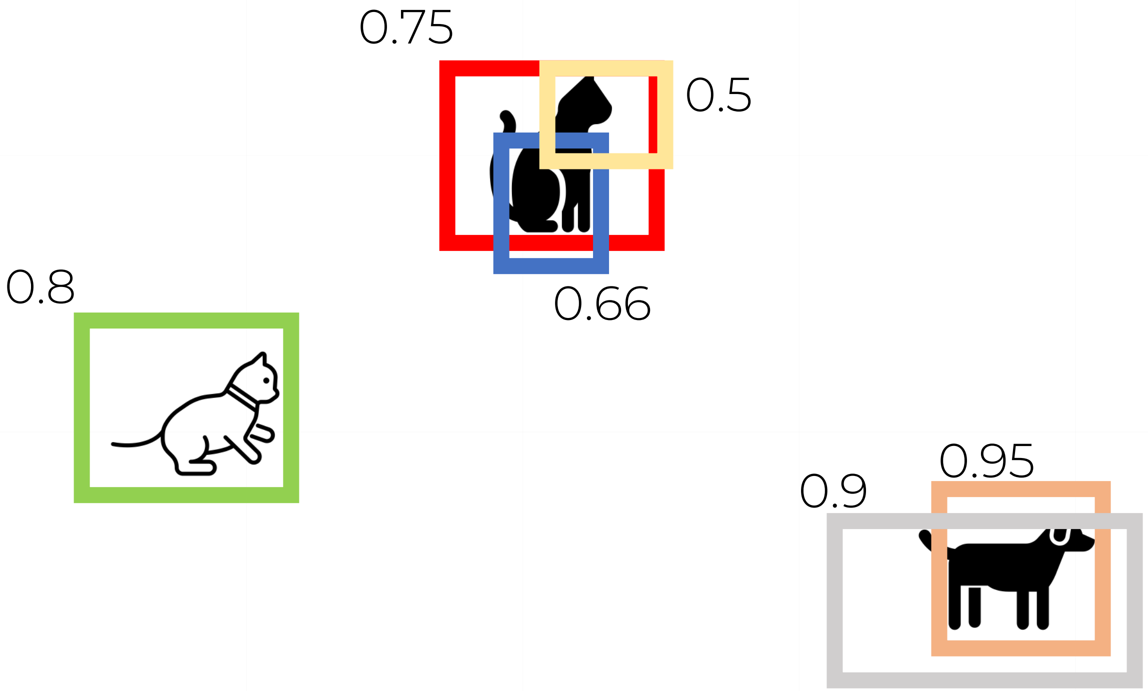

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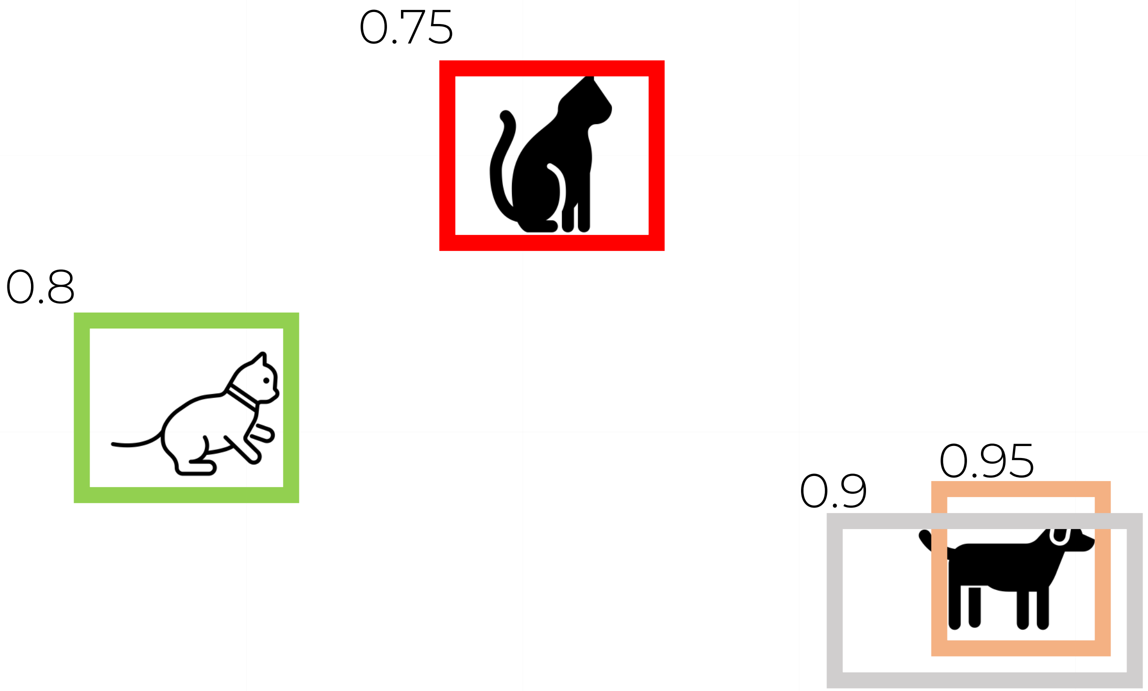

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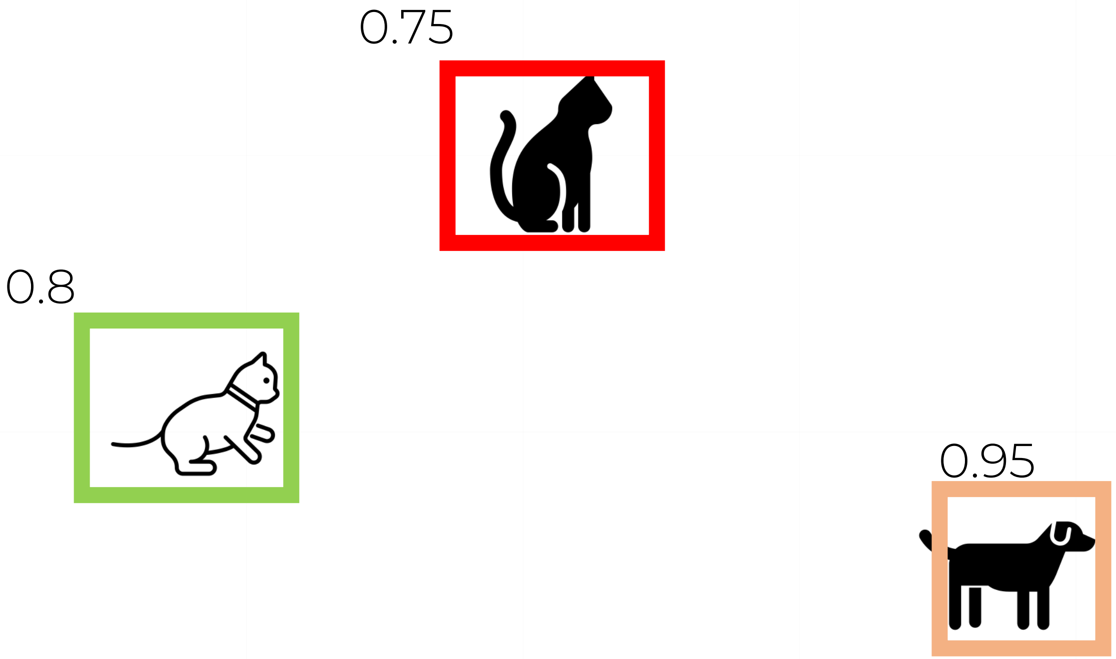

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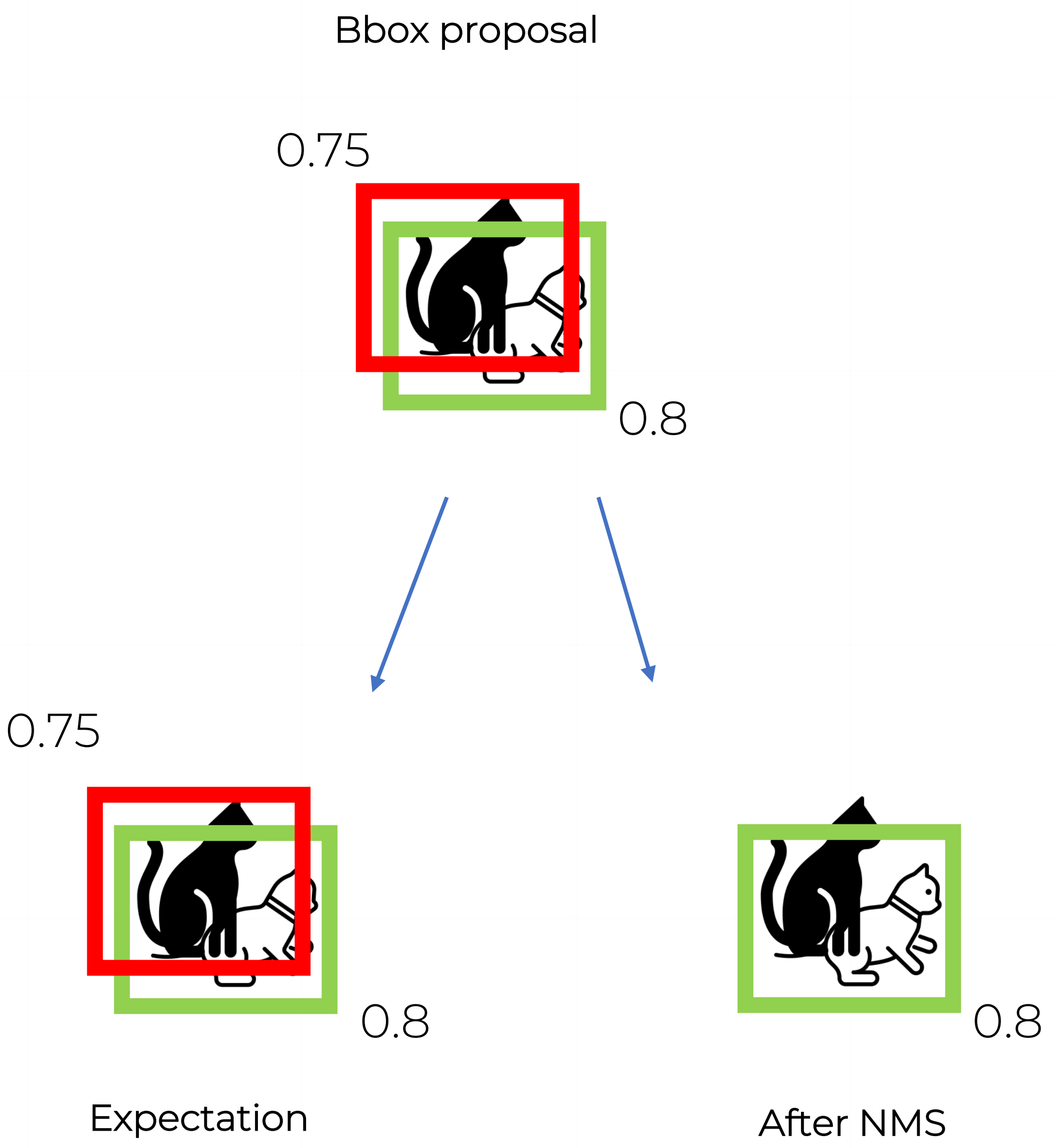

Problem?

NMS performed poorly if targets are close

Thanks !