2. Object Detection

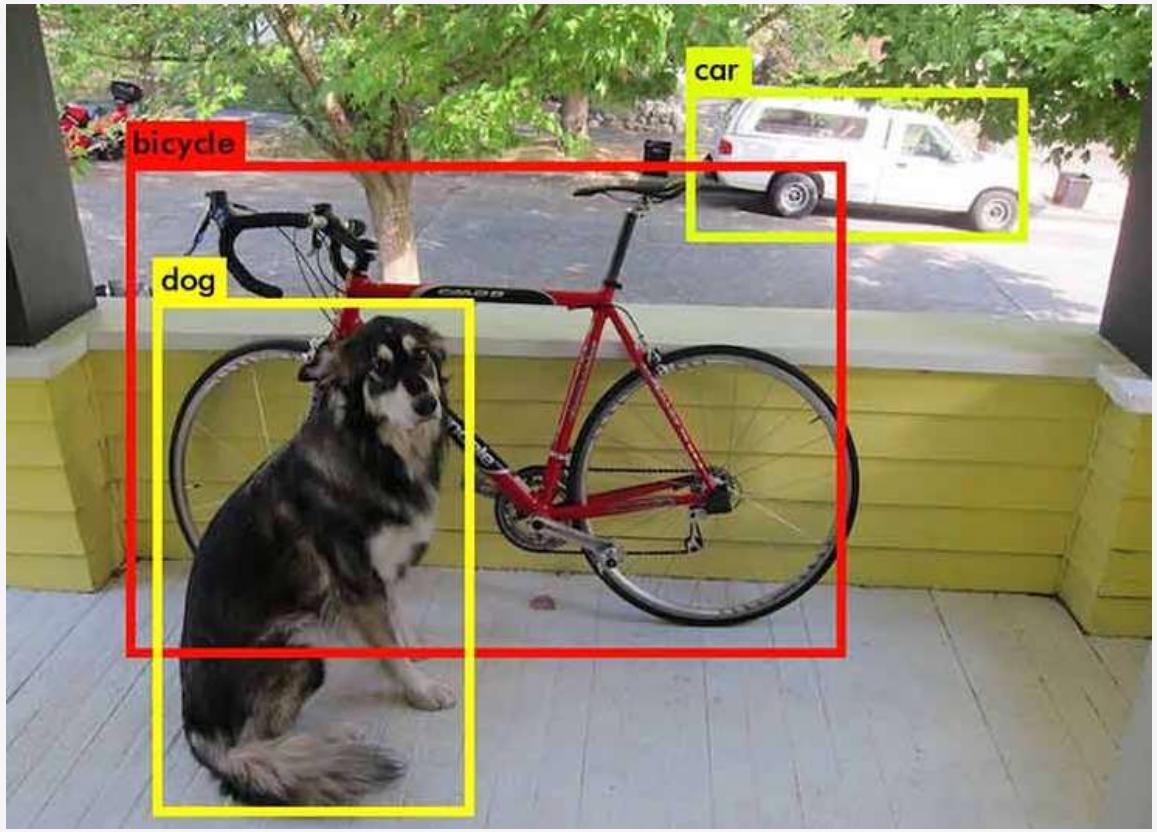
주제	
0. Introduction	강의 커리큘럼 소개
1. Face Recognition	1-1. Face Recognition 이론 소개
	1-2. Face Detection - 대표 모델 및 코드 소개
	1-3. [실습1] Dlib 및 Retina Face 코드 구현
	1-4. Face Alignment - 대표 모델 및 코드 소개
	1-5. [실습2] 황금비율 계산
	1-6. Face Recognition - 대표 모델 및 코드 소개
	1-7. [실습3] 그룹 가수 사진에서 각각 멤버 인식하기
2. Object Detection	2-1. Object Detection 이론 소개
	2-2. 대표 모델 – Yolov8 소개
	2-3. [실습1] 마스크 착용 유무 프로젝트
	2-4. [실습2] Tensor-RT 기반의 Yolov8, 표지판 신호등 검출
	2-5. 대표 모델 - Complex-Yolov4
	2-6. [실습3] Lidar Data 기반의 차량 Detection

CONTENT

Object Detection

Object Detection이란?

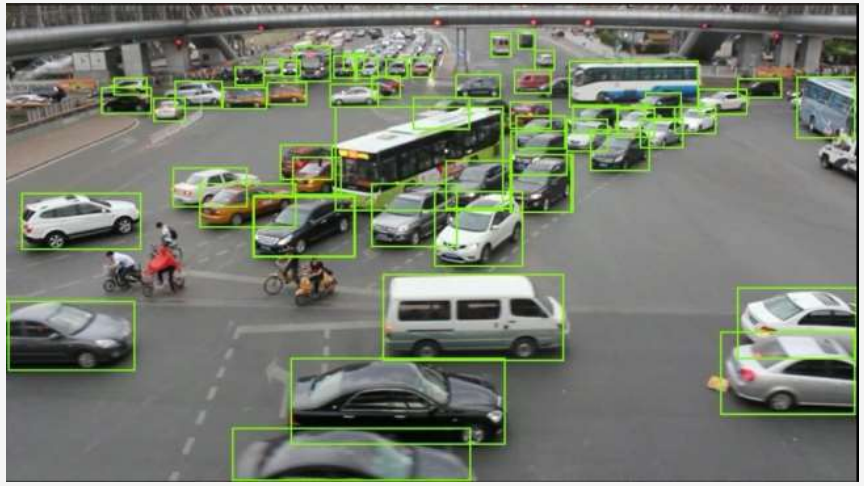
이미지 내의 모든 Object에 대하여 Classification와 Localization을 수행

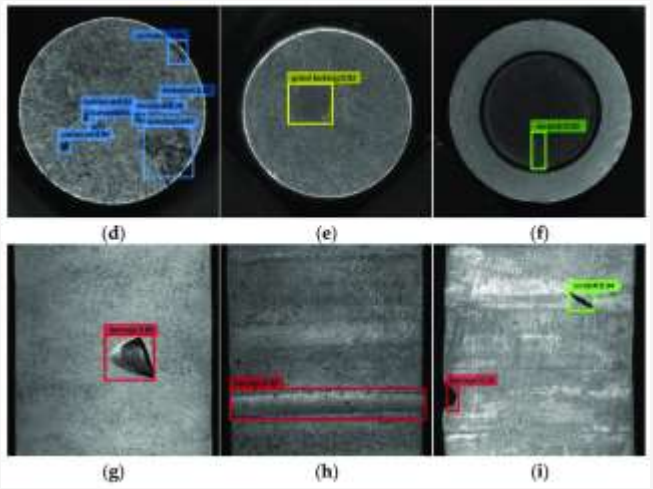


References
https://machinethink.net/blog/object-detection-with-yolo/

Application of Object Detection

Application of Object Detection

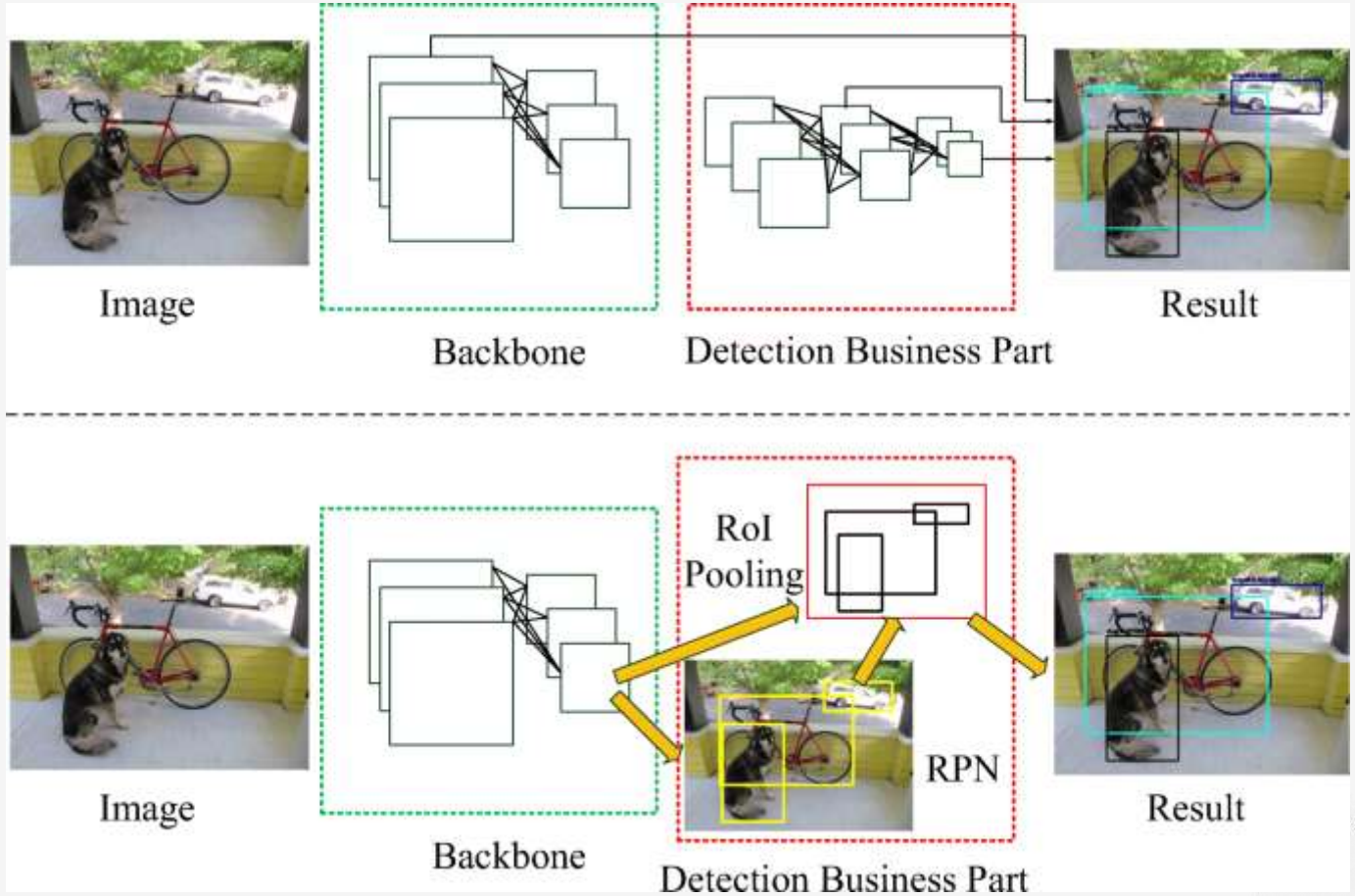




References
(Left, Top) http://mbiz.heraldcorp.com/view.php?ud=20181206000505
(Right, Top) https://www.researchgate.net/figure/Defect-detection-results-a-Corrosion-and-damage-b-grind-lacking-and-damage-c-d_fig2_329600882
(Left, Bottom) https://recruit.si-analytics.ai/77b59190-1ebe-486d-a2bc-54ad589774b0
(Right, Bottom) https://viso.ai/deep-learning/object-detection/

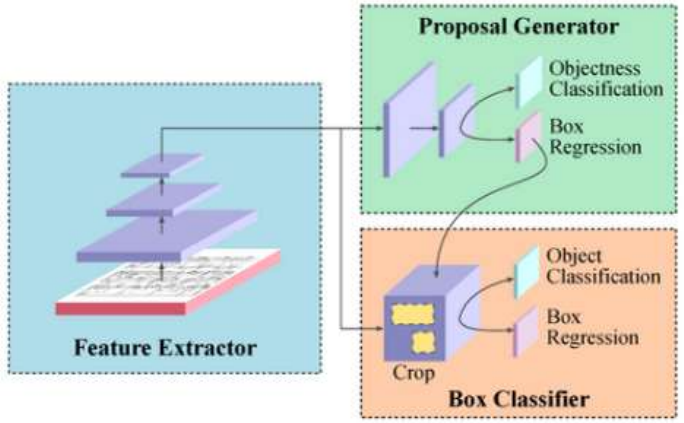
Object Detection의 종류

Object Detection Diagram

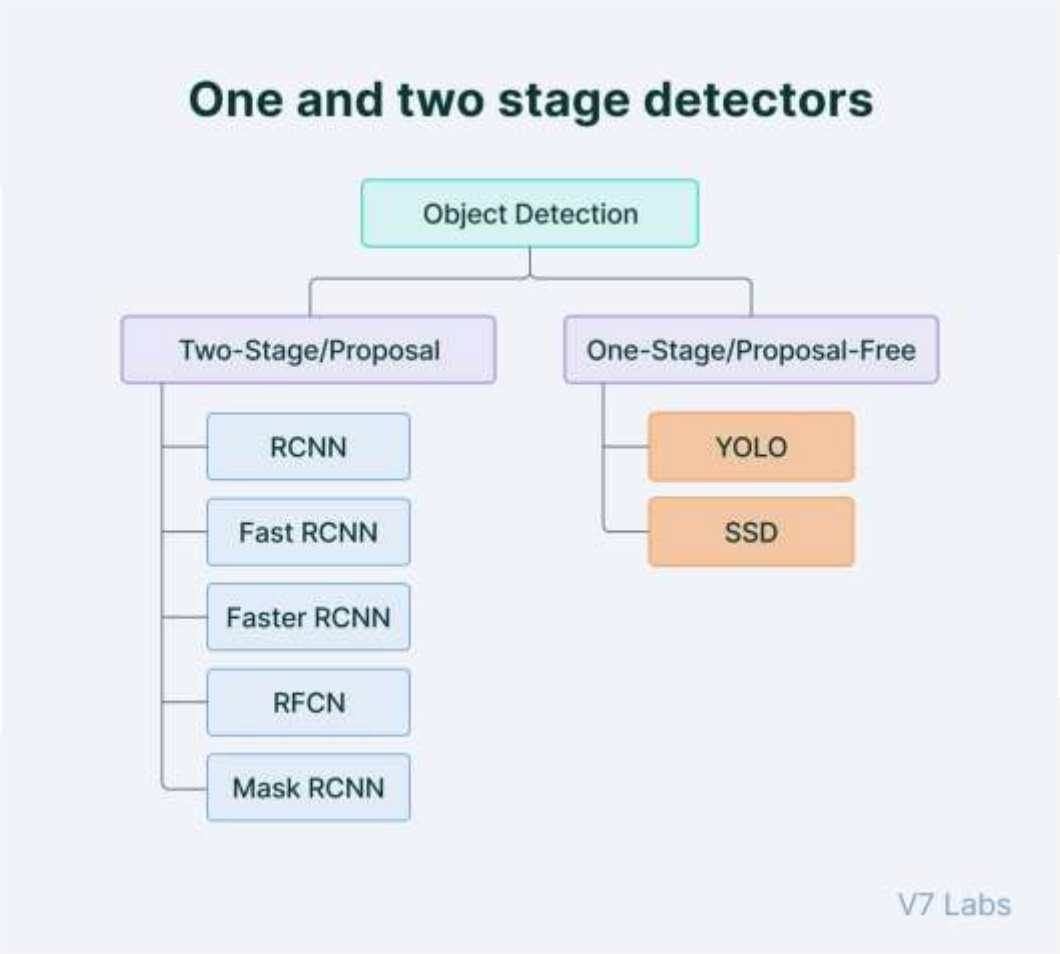


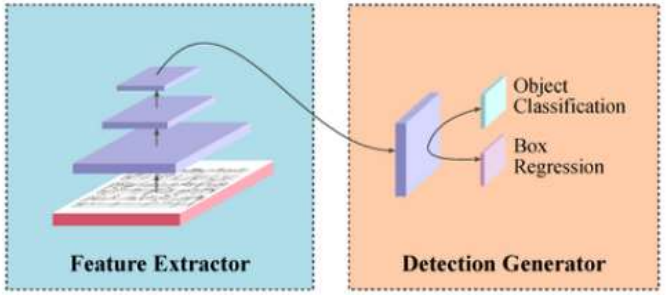
References
https://link.springer.com/article/10.1007/s11042-019-07898-2

One-Stage Detector VS Two-Stage Detector



(b) Basic architecture of a two-stage detector.





(a) Basic architecture of a one-stage detector.

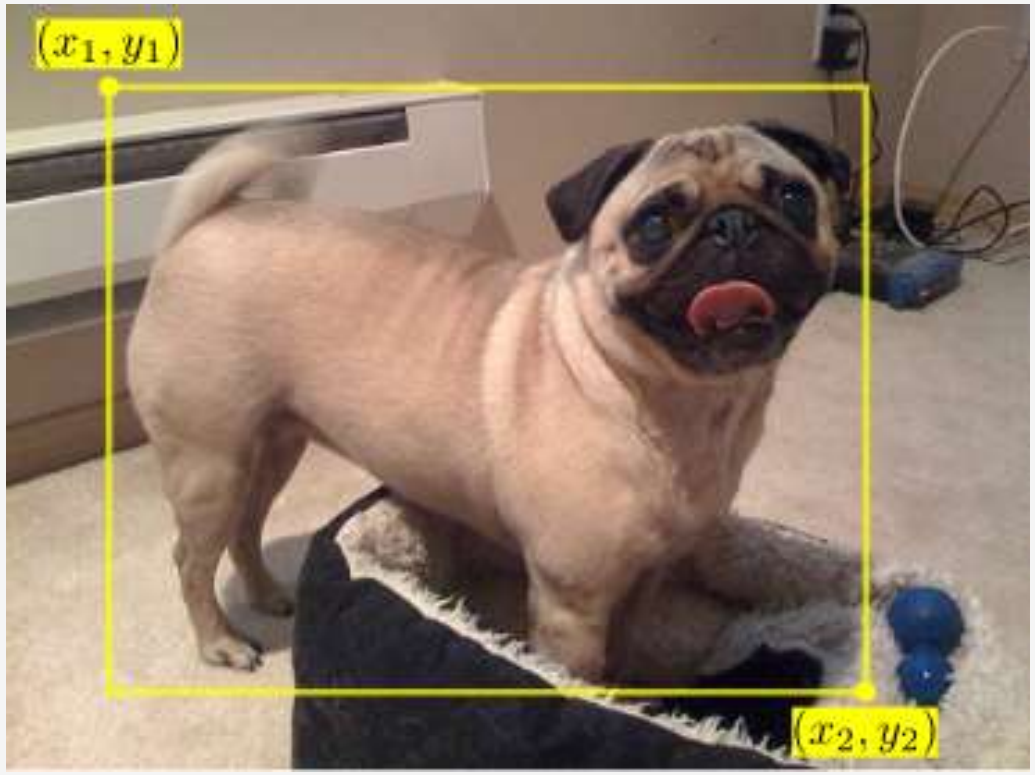
References
(Middle) https://www.v7labs.com/blog/yolo-object-detection
(Left, Right)https://gaussian37.github.io/vision-detection-table

주요 용어 정리

Bounding Box

이미지 내에서 물체 전체를 가득 차게 그린 가장 작은 직사각형을 의미

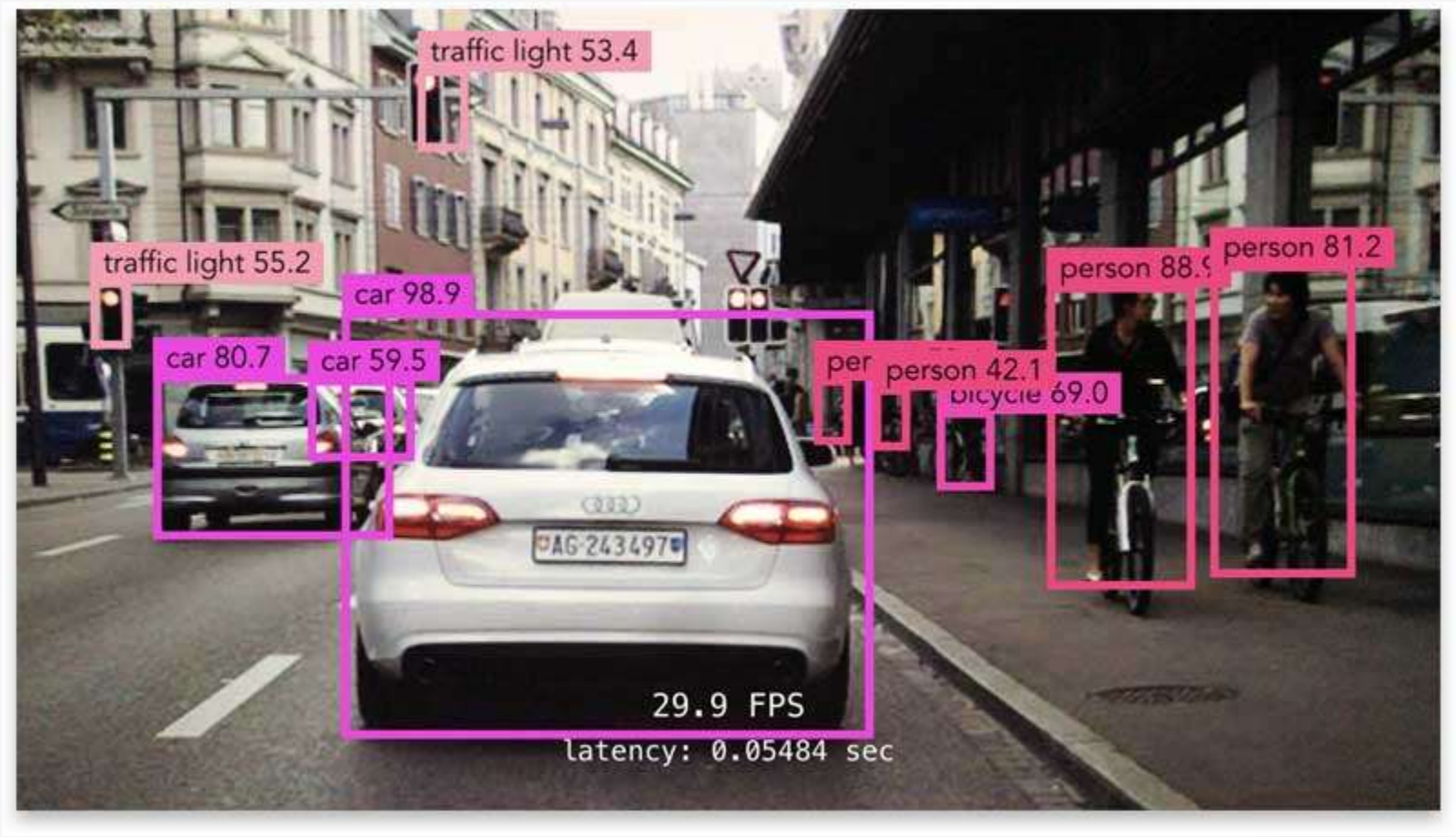
(xmin, ymin, xmax, ymax) or (x_center, y_center, width, height) or (x_min, y_min, width, height)



References
https://oopsys.tistory.com/229

Confidence Score

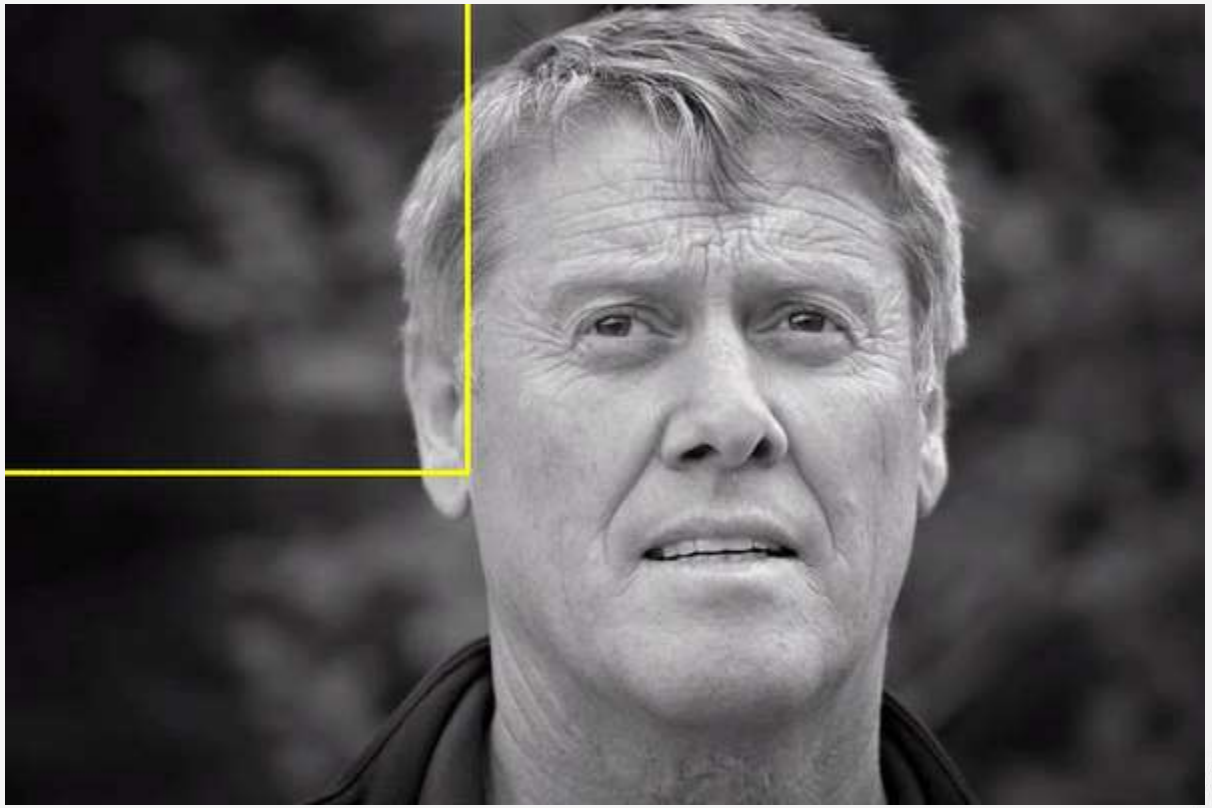
이미지 내에서 찾은 Bounding box 안에 물체가 있을 확률



References
https://machinethink.net/blog/object-detection/

Sliding Window

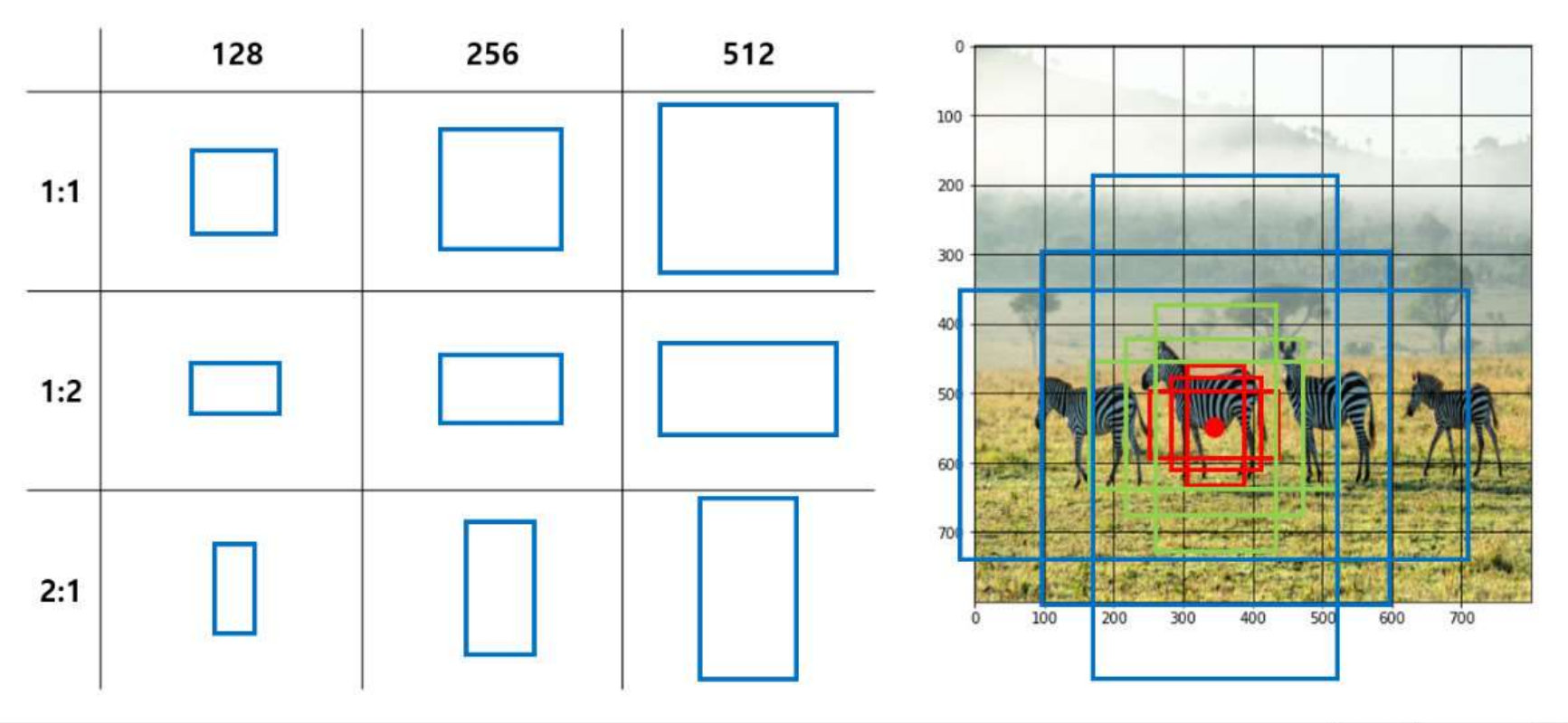
이미지에서 적당한 크기의 영역 (Window)을 정하여, 영역을 이동 (Sliding)시키면서 알고리즘을 적용하는 방식



References
https://learnopencv.com/slicing-aided-hyper-inference/

Anchor Box

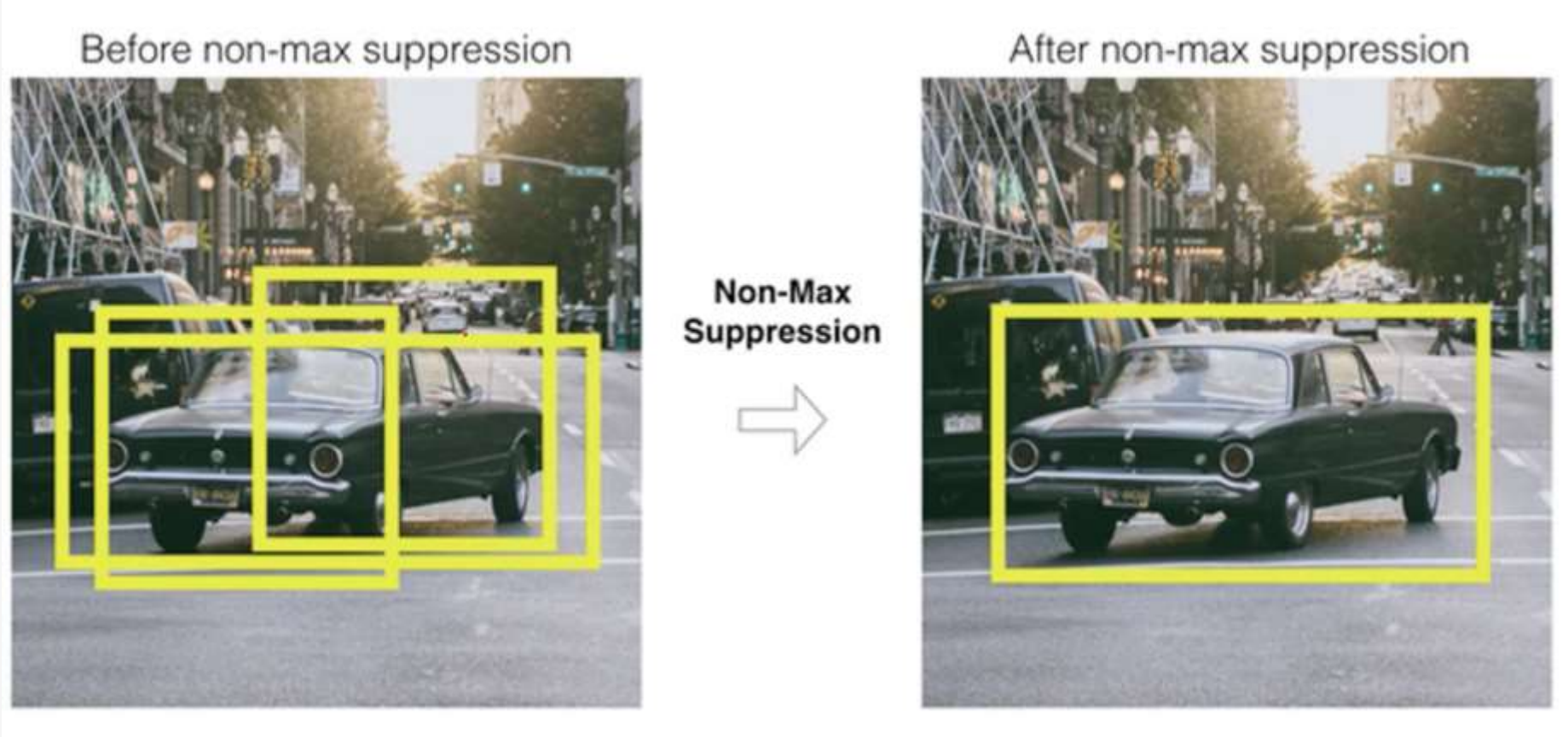
특정 사이즈나 비율로 미리 정의된 Box



References
https://herbwood.tistory.com/10

NMS (Non-Maximum Suppression)

검출된 Bounding box 중에서, 비슷한 위치에 있거나 Object일 확률이 낮은 box들을 제거하고, 가장 적합한 box를 찾는 것



References
https://naknaklee.github.io/etc/2021/03/08/NMS/

Metric

Confusion Matrix

		Actual Class	
		Positive (P)	Negative (N)
Predicted Class	Positive (P)	True Positive (TP)	False Positive (FP)
	Negative (N)	False Negative (FN)	True Negative (TN)

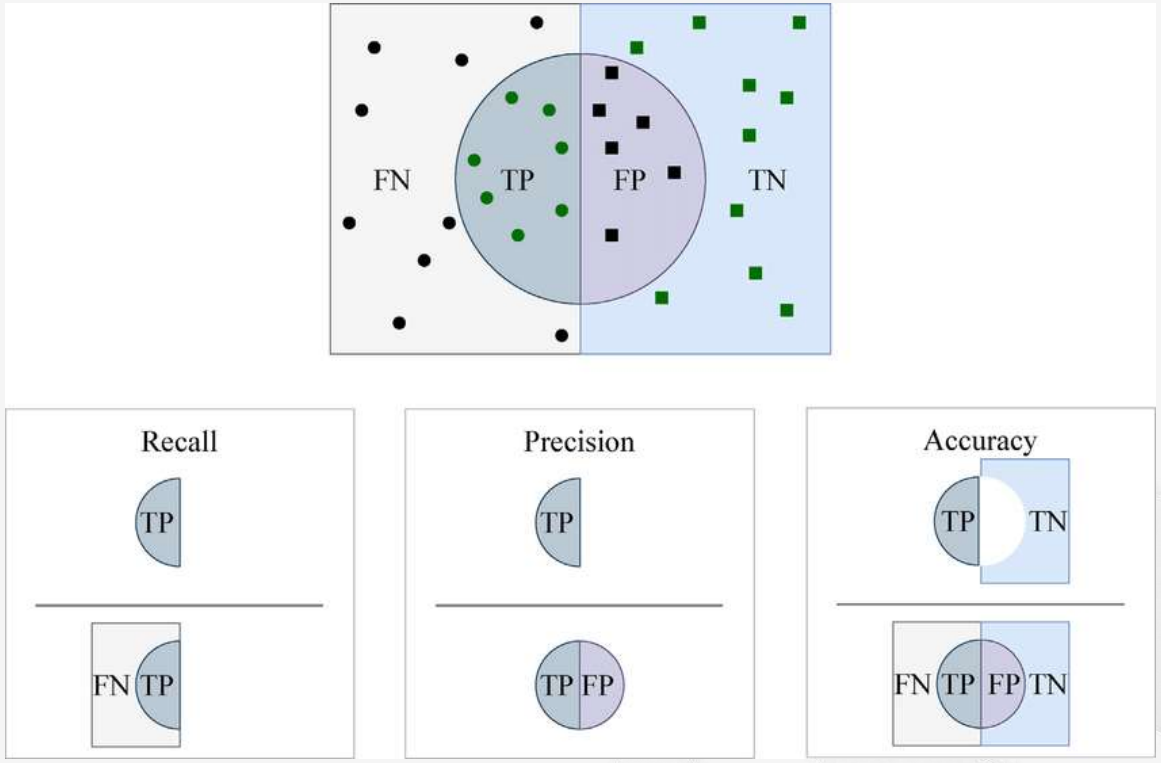
Accuracy, Recall, Precision

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN}$$

$$Recall = \frac{TP}{TP + FN}$$

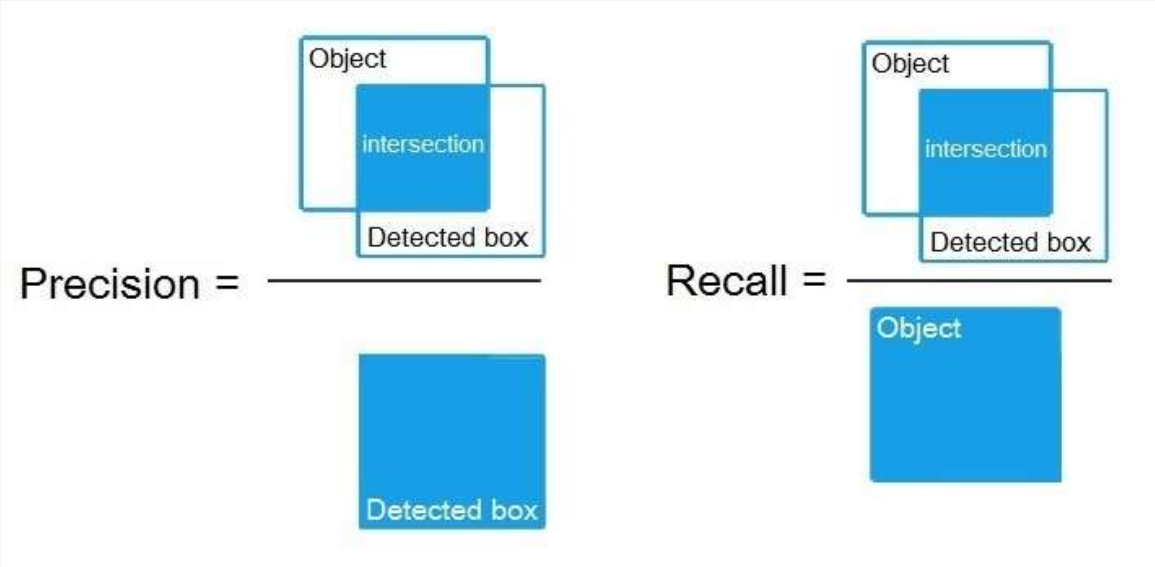
$$Precision = \frac{TP}{TP + FP}$$

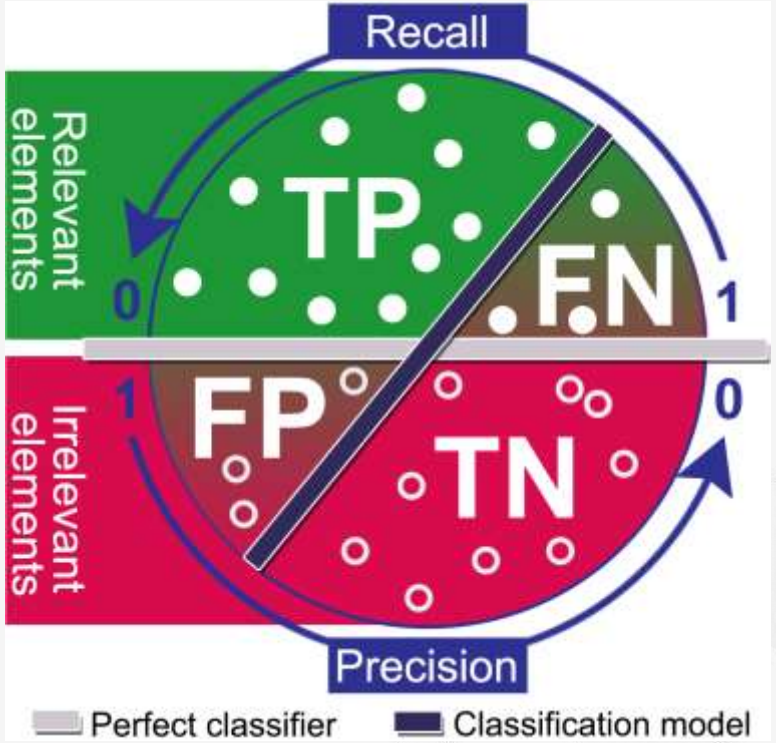
$$F1Score = 2 * \frac{Precision * Recall}{Precision + Recall}$$



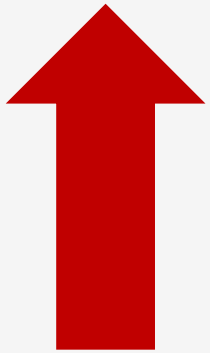
References
https://www.researchgate.net/figure/Visualizing-accuracy-recall-aka-sensitivity-and-precision-which-are-the-common_fig3_346129022

Recall vs Precision





References
(Left) https://i.stack.imgur.com/JlHnn.jpg
(Right) https://commons.wikimedia.org/wiki/File:Precision-Recall_tradeoff.png



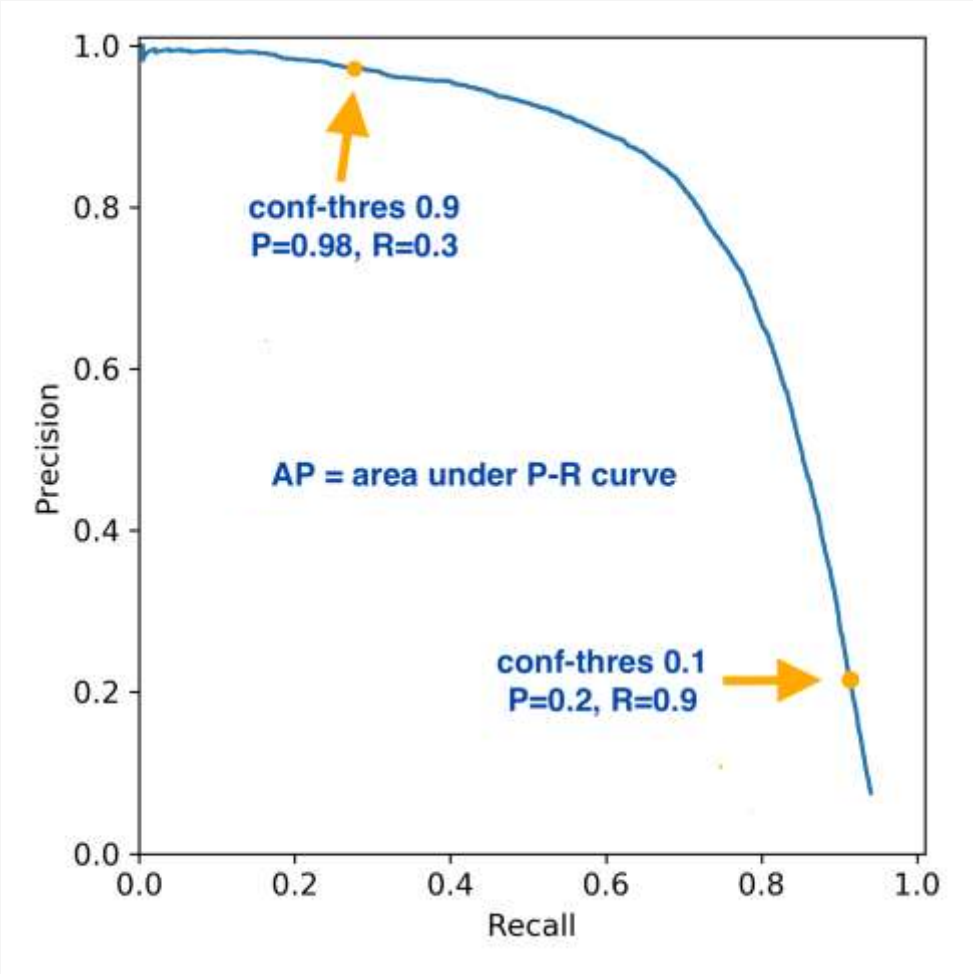
Recall vs Precision

References
(Left) https://medigatenews.com/news/935485369
(Right) http://www.edujin.co.kr/news/articleView.html?idxno=31119

Recall vs Precision

References
https://www.itworld.co.kr/news/214344

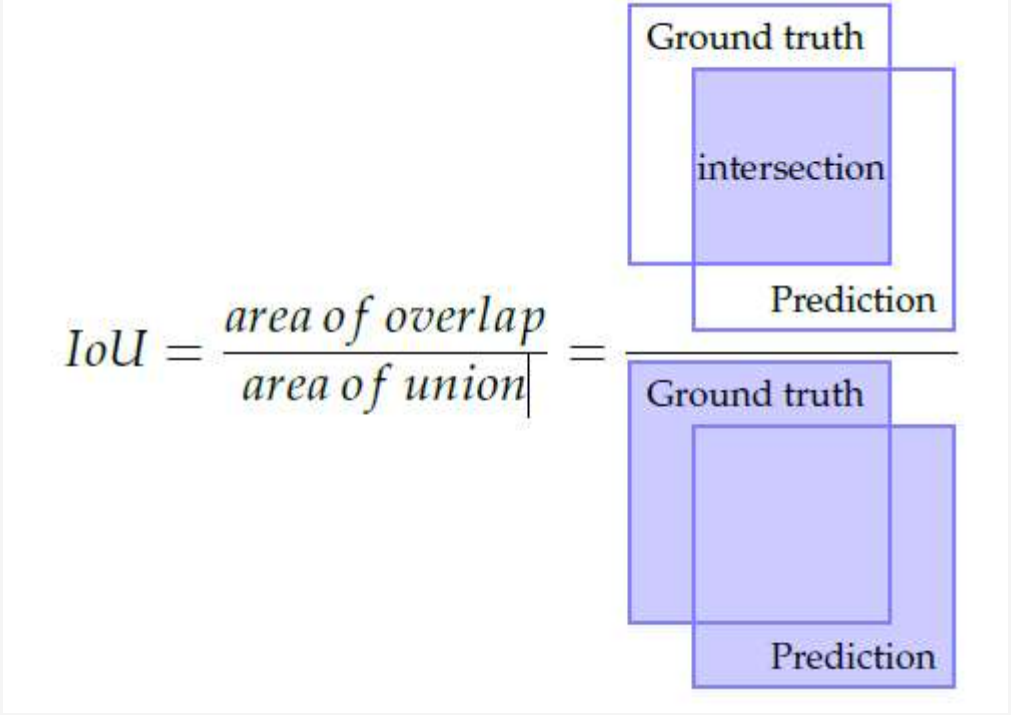
Precision-Recall Curve (PR-Curve) & AP (Average Precision)

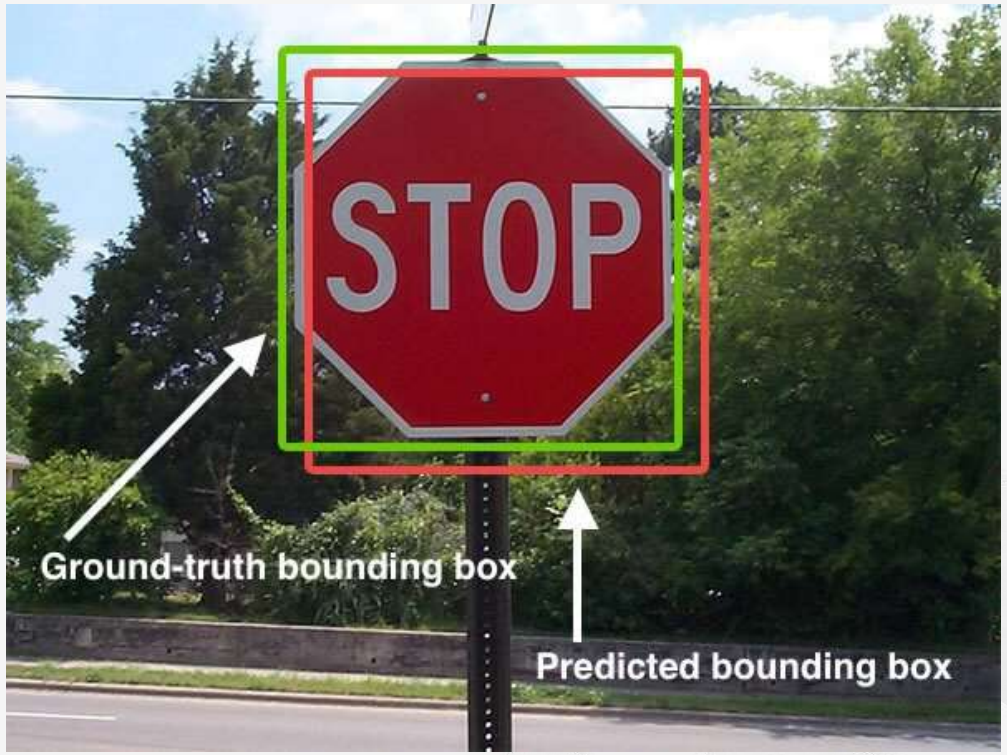


References
https://github.com/ultralytics/yolov3/issues/898

IoU (Intersection over Union)

$$IoU = \frac{area\ of\ overlap}{area\ of\ union} = \frac{\text{Ground truth} \cap \text{Prediction}}{\text{Ground truth} \cup \text{Prediction}}$$





References
(Left) https://tex.stackexchange.com/questions/637812/drawing-intersection-over-union-in-equation
(Right) http://www.gabormelli.com/RKB/Bounding_Box_Intersection_over_Union_%28IoU%29_Measure

IoU (Intersection over Union)

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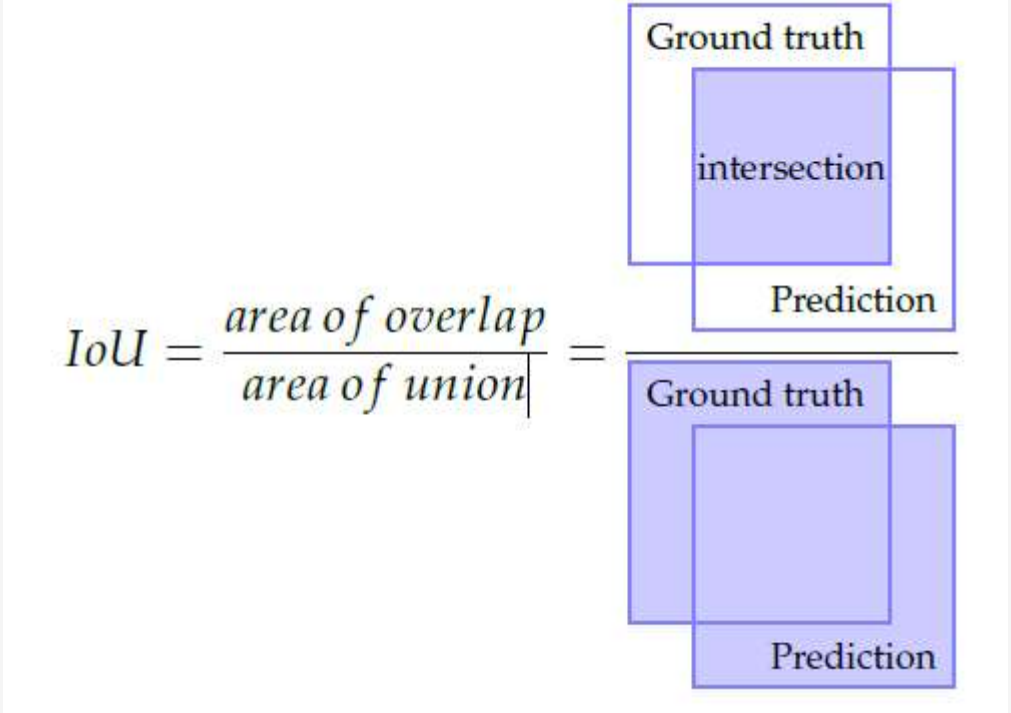
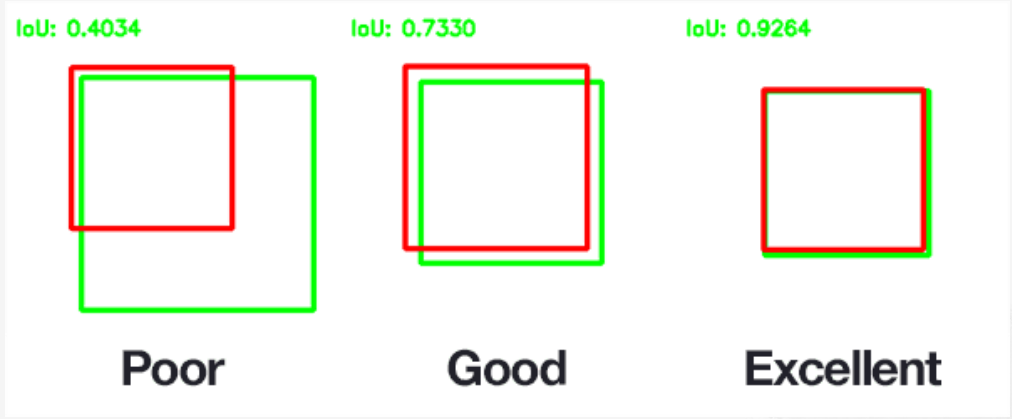




References
(Left) https://tex.stackexchange.com/questions/637812/drawing-intersection-over-union-in-equation
(Right) https://chacha95.github.io/2020-02-10-Object-Detection1/

IoU와 mAP

$$AP@[.5:.05:.95] = \frac{(AP50 \times 0.5 + AP55 \times 0.55 + AP60 \times 0.6 + AP65 \times 0.65 + AP70 \times 0.7 + AP75 \times 0.75 + AP80 \times 0.8 + AP85 \times 0.85 + AP90 \times 0.9 + AP95 \times 0.95)}{0.5 + 0.55 + 0.6 + 0.65 + 0.7 + 0.75 + 0.8 + 0.85 + 0.9 + 0.95}$$

Iou_threshold = 0.50,
IoU >= Iou_threshold : TP
IoU < Iou_threshold : FP

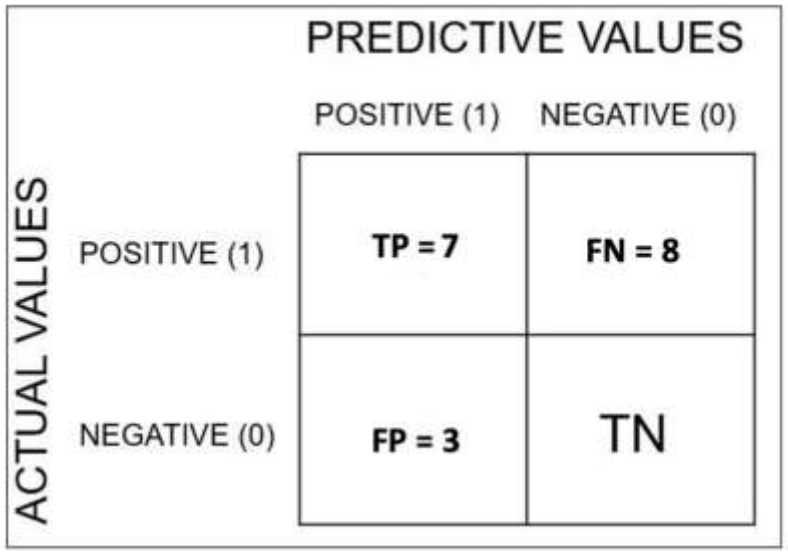
명칭	약어	IoU
AP@IoU=0.50	AP50	0.50
AP@IoU=0.55	AP55	0.55
AP@IoU=0.60	AP60	0.60
AP@IoU=0.65	AP65	0.65
AP@IoU=0.70	AP70	0.70
AP@IoU=0.75	AP75	0.75
AP@IoU=0.80	AP80	0.80
AP@IoU=0.85	AP85	0.85
AP@IoU=0.90	AP90	0.90
AP@IoU=0.95	AP95	0.95

References
https://yunwoong.tistory.com/108

Example

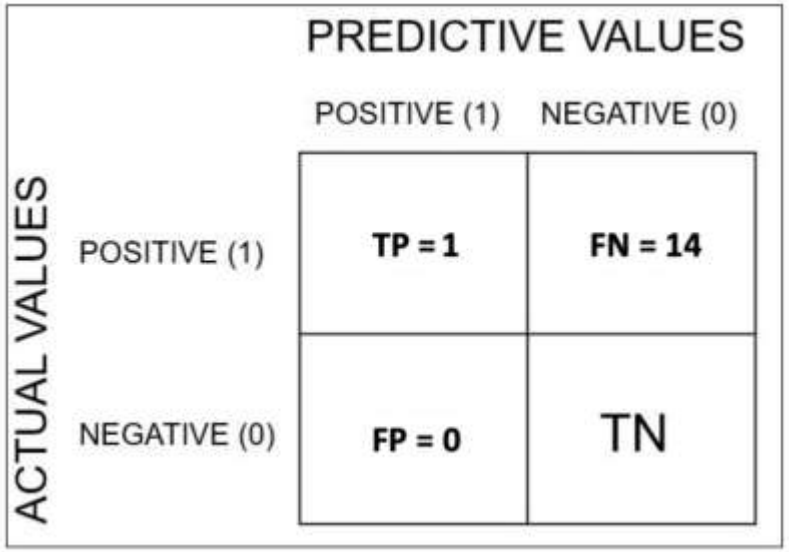
Detections	Confidences	TP or FP
A	57%	TP
B	78%	TP
C	43%	FP
D	85%	TP
E	91%	TP
F	13%	FP
G	45%	TP
H	68%	FP
I	95%	TP
J	81%	TP

Confidence_threshold = 0



Precision = 7/10 = 0.7
Recall = 7/15 = 0.47…

Confidence_threshold = 0.95

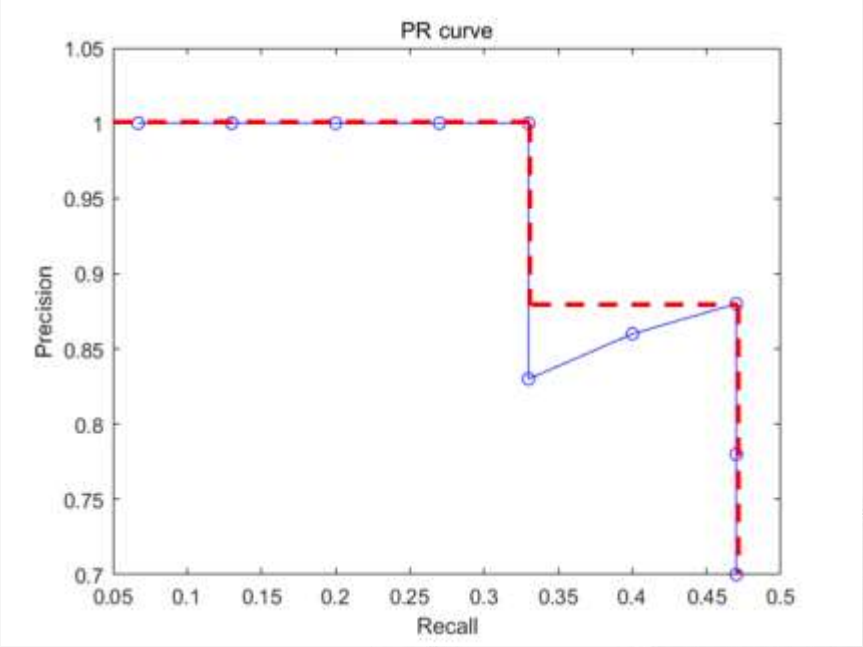


Precision = 1/1 = 1
Recall = 1/15 = 0.067

References
https://lapina.tistory.com/98

Example

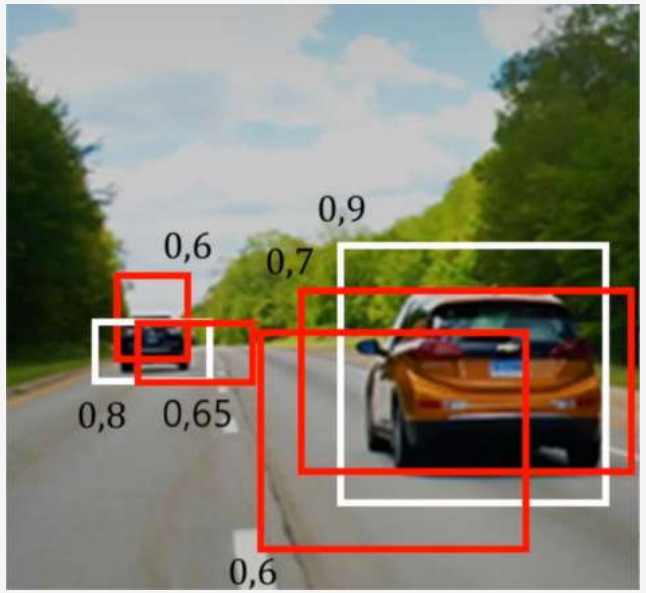
Detections	Confidences	TP or FP	누적 TP	누적 FP	Precision	Recall
I	95%	TP	1	0	1/1 = 1	1/15 = 0.067
E	91%	TP	2	0	2/2 = 1	2/15 = 0.13
D	85%	TP	3	0	3/3 = 1	3/15 = 0.2
J	81%	TP	4	0	4/4 = 1	4/15 = 0.27
B	78%	TP	5	0	5/5 = 1	5/15 = 0.33
H	68%	FP	5	1	5/6 = 0.83	5/15 = 0.33
A	57%	TP	6	1	6/7 = 0.86	6/15 = 0.4
G	45%	TP	7	1	7/8 = 0.88	7/15 = 0.47
C	43%	FP	7	2	7/9 = 0.78	7/15 = 0.47
F	13%	FP	7	3	7/10 = 0.7	7/15 = 0.47



References
https://lapina.tistory.com/98

NMS 알고리즘

NMS (Non-Maximum Suppression) 알고리즘



1. 검출된 Bounding box 중, confidence_threshold 보다 작으면 제거

2. Confidence score를 기준으로 내림차순 정렬

3. 모든 박스에 대하여 순차적으로 시행

가장 높은 Confidence Score의 Bounding box와 동일한 Class면서 iou_threshold 이상인 Bounding bx는 제거

4. 남은 Bounding box 선택

References
https://wikidocs.net/142645

NMS (Non-Maximum Suppression) 알고리즘

Confidence_threshold = 0.4

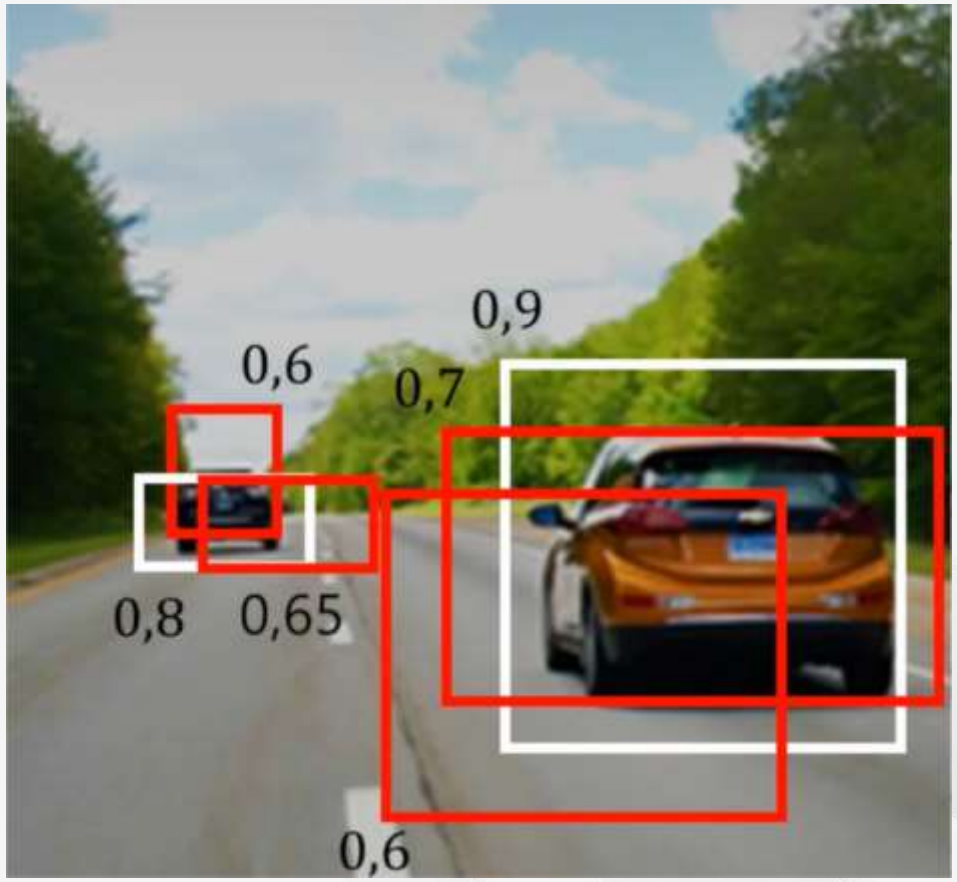
0.6	0.8	0.65	0.9	0.7	0.6

confidence_threshold 보다 작으면 제거

0.6	0.8	0.65	0.9	0.7	0.6

Confidence score 기준으로 내림차순

0.9	0.8	0.7	0.65	0.6	0.6



References
https://wikidocs.net/142645

NMS (Non-Maximum Suppression) 알고리즘

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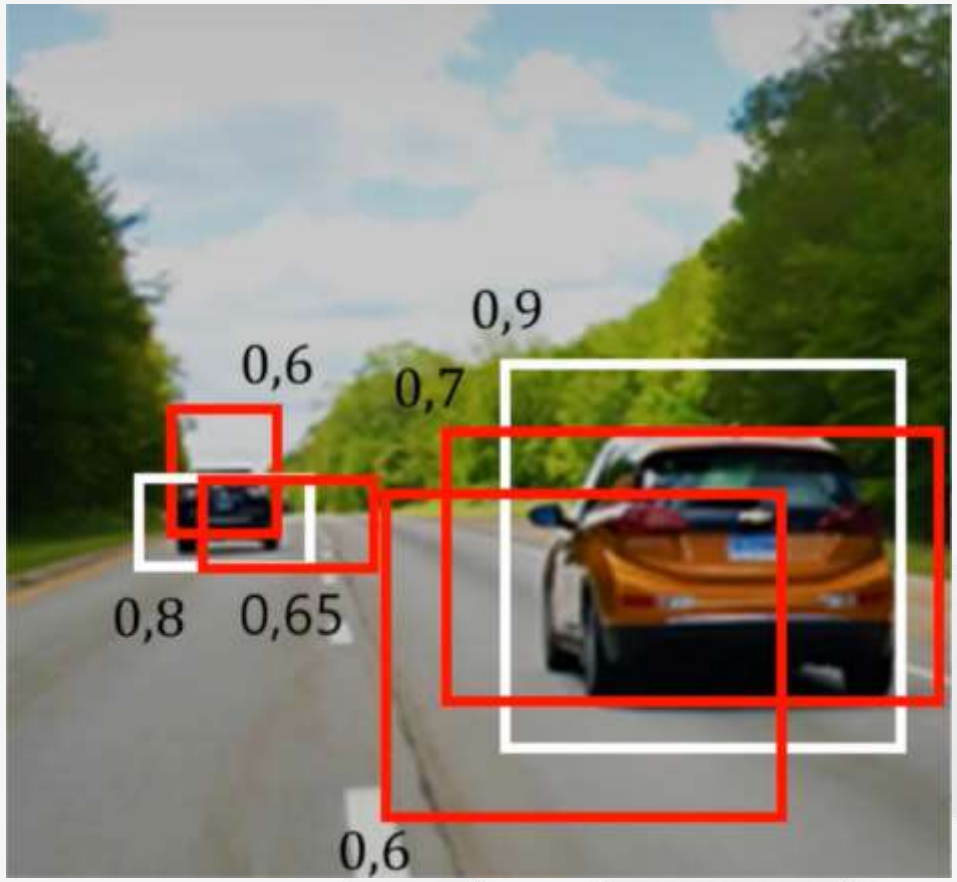

References
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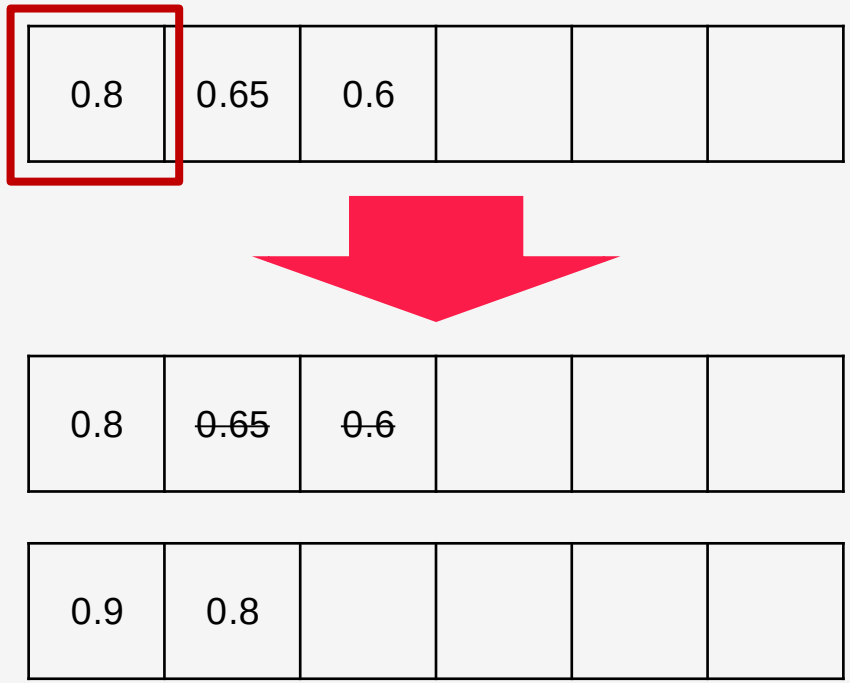
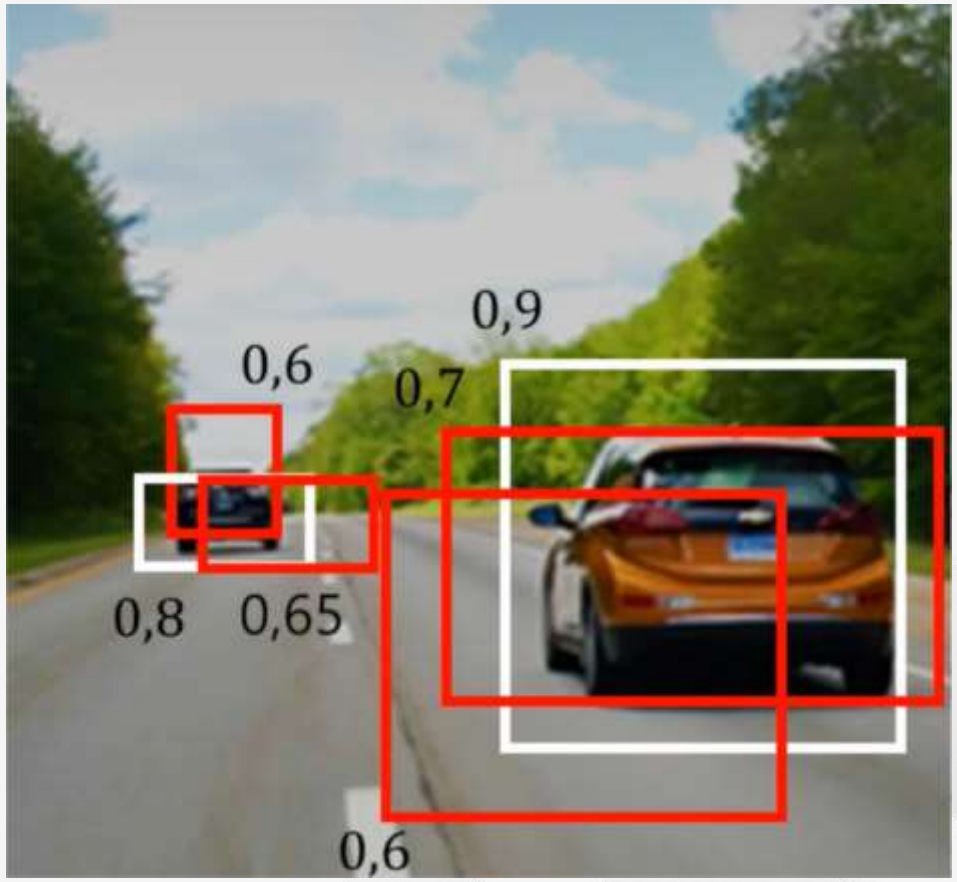


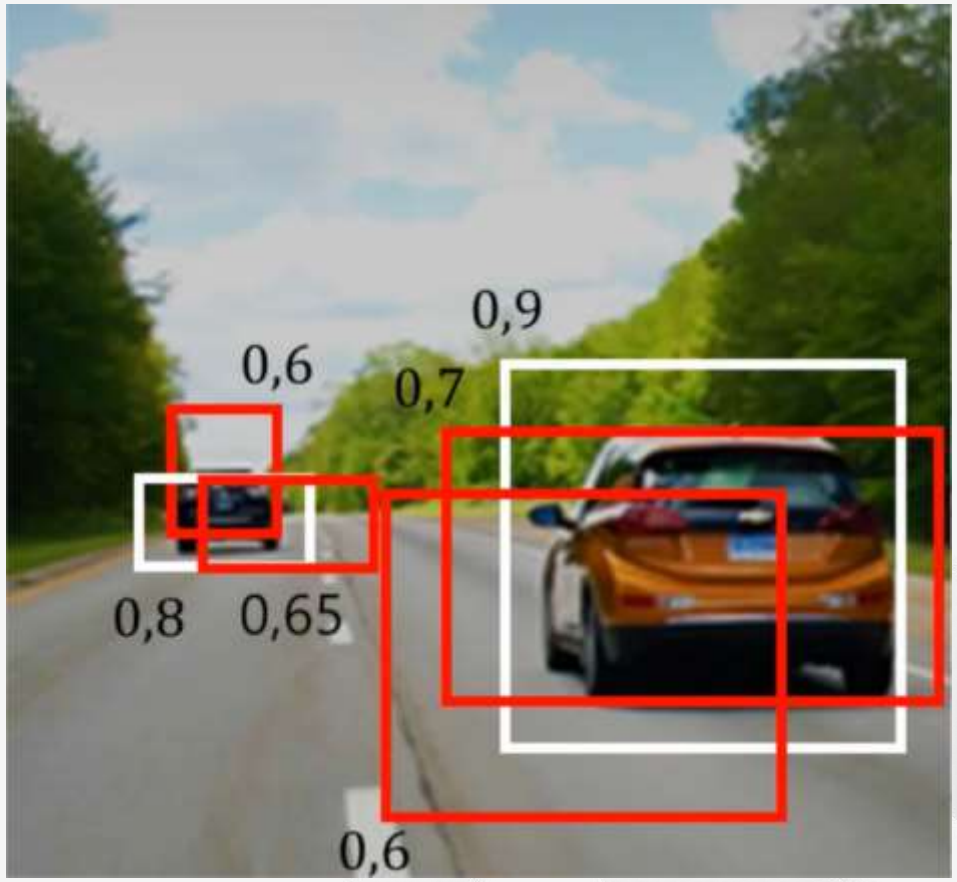


References
https://wikidocs.net/142645

NMS (Non-Maximum Suppression) 알고리즘

Confidence_threshold = 0.4

0.9	0.8				



References
https://wikidocs.net/142645

NMS (Non-Maximum Suppression) 알고리즘 코드 예시

```
box = [class, confidence_score, xmin, ymin, xmax, ymax]
```

```
nms_result = []

boxes = [box for box in boxes if box[1] > confidence_threshold]

boxes = sorted(boxes, key = lambda x:x[1], reverse = True)

while boxes:
    present_box = boxes.pop(0)
    boxes = [box for box in boxes if box[0] != present_box[0] or calc_IoU(present_box, box) < iou_threshold]
    nms_result.append(present_box)
```

1. 검출된 Bounding box 중, confidence_threshold 보다 작으면 제거

2. Confidence score를 기준으로 내림차순 정렬

3. 모든 박스에 대하여 순차적으로 시행

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4. 남은 Bounding box 선택

Object Detection Dataset

Object Detection Dataset

PASCAL2
Pattern Analysis, Statistical Modelling and Computational Learning

COCO
Common Objects in Context

References
https://deepbaksuvision.github.io/Modu_ObjectDetection/posts/02_00_Datasets_for_Object_Detection.html

Thank You