Competitions

Dataset	Images	Classes
Pascal VOC 2012	11,530 images with 27,450 ROI annotated objects	20
COCO	330,000 images with 1.5 million object instances	80
ImageNet	150,000 images	1000/200

Image Credit - http://host.robots.ox.ac.uk/pascal/VOC/voc2012/examples/index.html#bicycle

ImageNet Samples

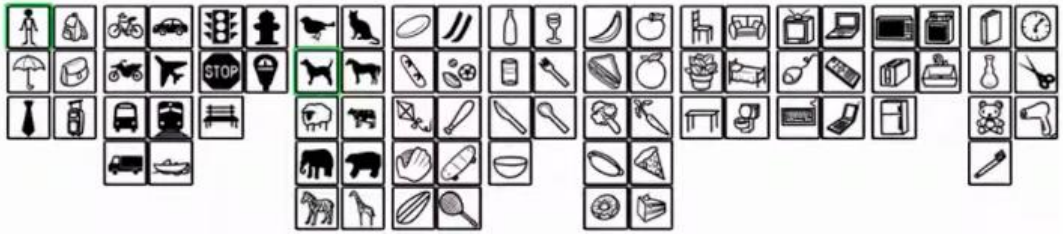
Pascal VOC Samples

Dining tables - *all images contain at least one dining table.*

COCO

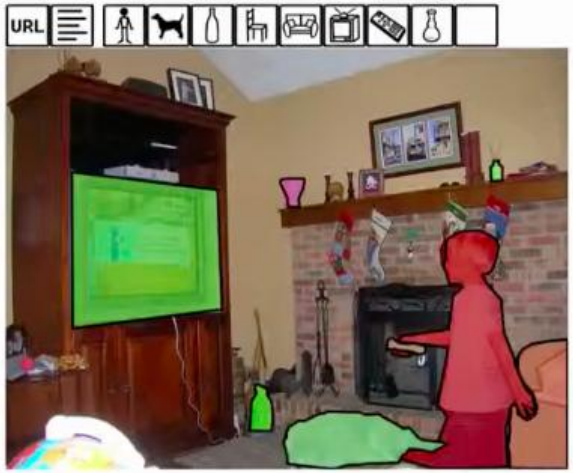
COCO Explorer http://cocodataset.org/#explore

COCO 2017 train/val browser (123,287 images, 886,284 instances). Crowd labels not shown.

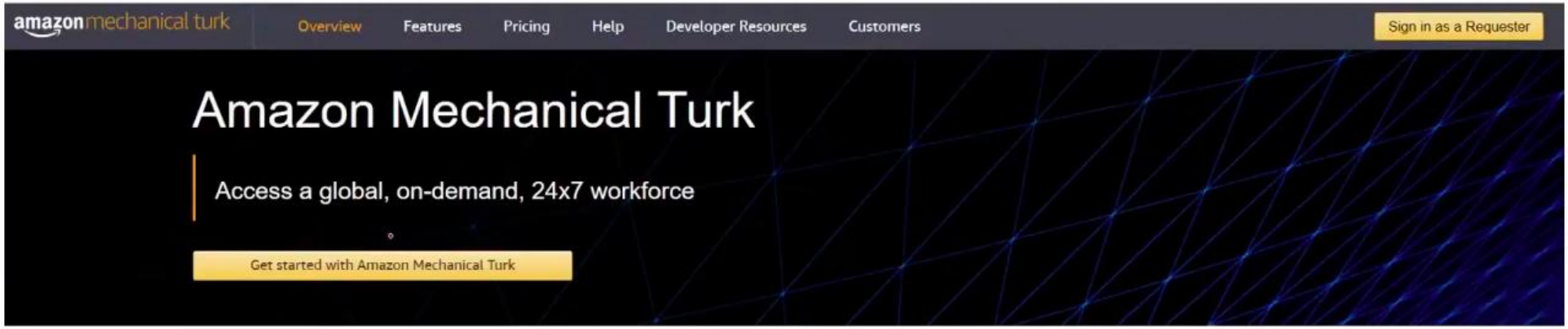


person × dog × search

2125 results



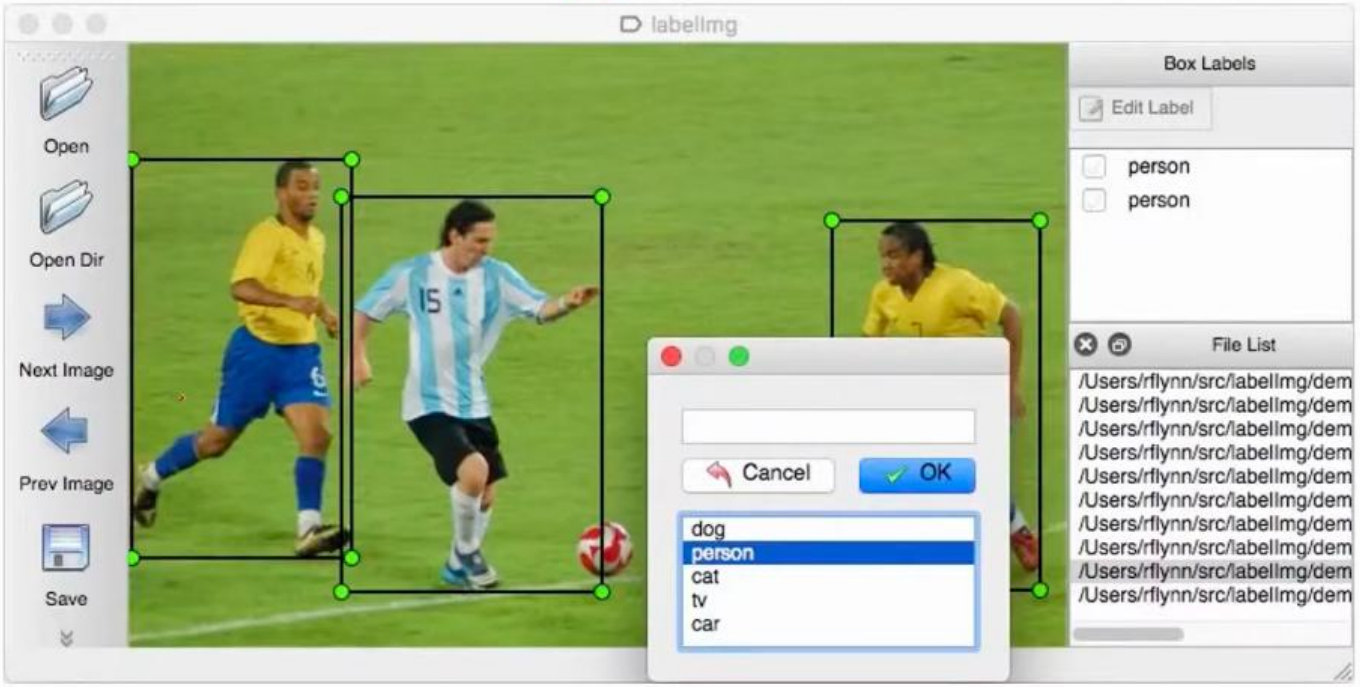
Amazon Mechanical Turk



Amazon Mechanical Turk (MTurk) is a crowdsourcing marketplace that makes it easier for individuals and businesses to outsource their processes and jobs to a distributed workforce who can perform these tasks virtually. This could include anything from conducting simple data validation and research to more subjective tasks like survey participation, content moderation, and more. MTurk enables companies to harness the collective intelligence, skills, and insights from a global workforce to streamline business processes, augment data collection and analysis, and accelerate machine learning development.

While technology continues to improve, there are still many things that human beings can do much more effectively than computers, such as moderating content, performing data deduplication, or research. Traditionally, tasks like this have been accomplished by hiring a large temporary workforce, which is time consuming, expensive and difficult to scale, or have gone undone. Crowdsourcing is a good way to break down a manual, time-consuming project into smaller, more manageable tasks to be completed by distributed workers over the Internet (also known as 'microtasks').

Annotation Tools



How to find out TP and FP

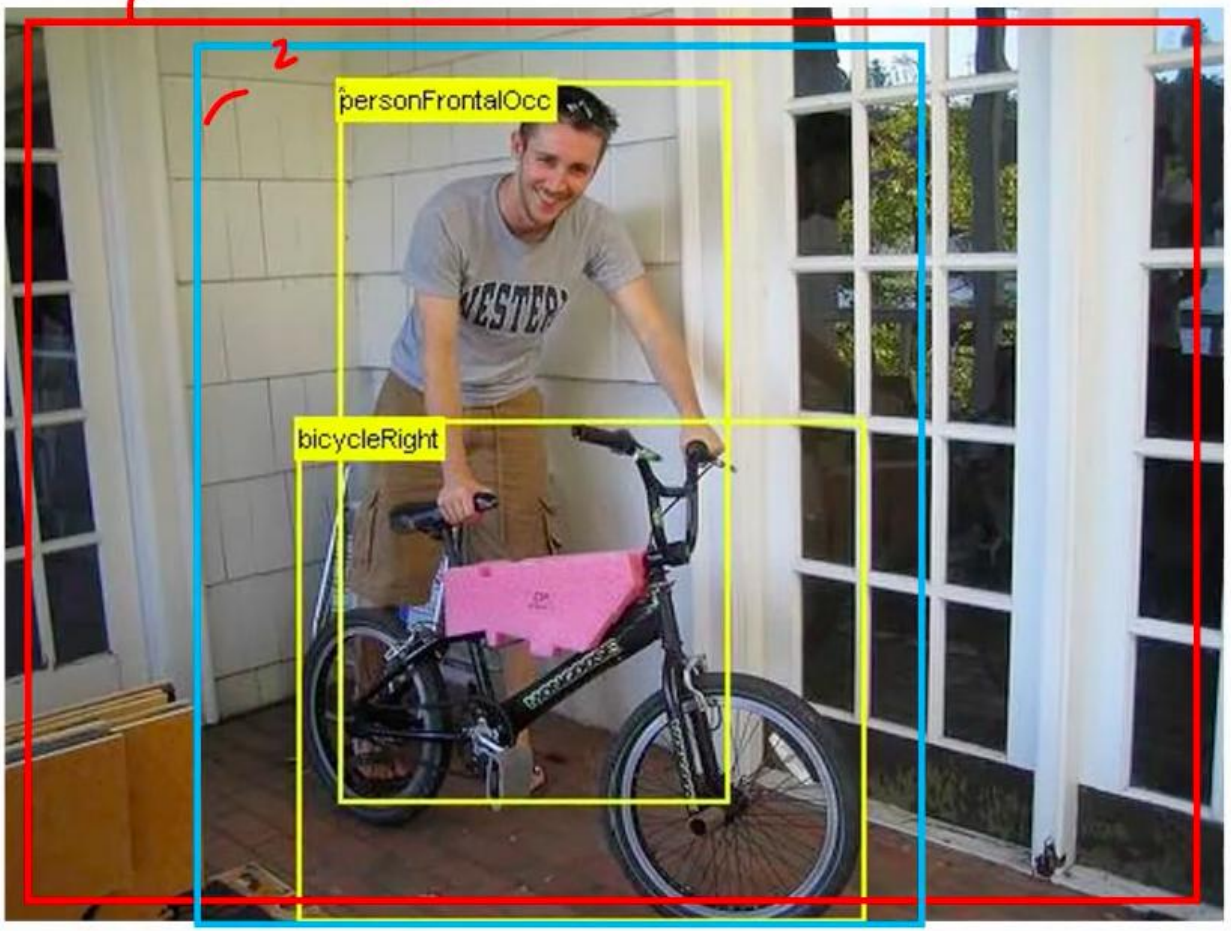
TP FP

How to find out TP and FP

TP FP

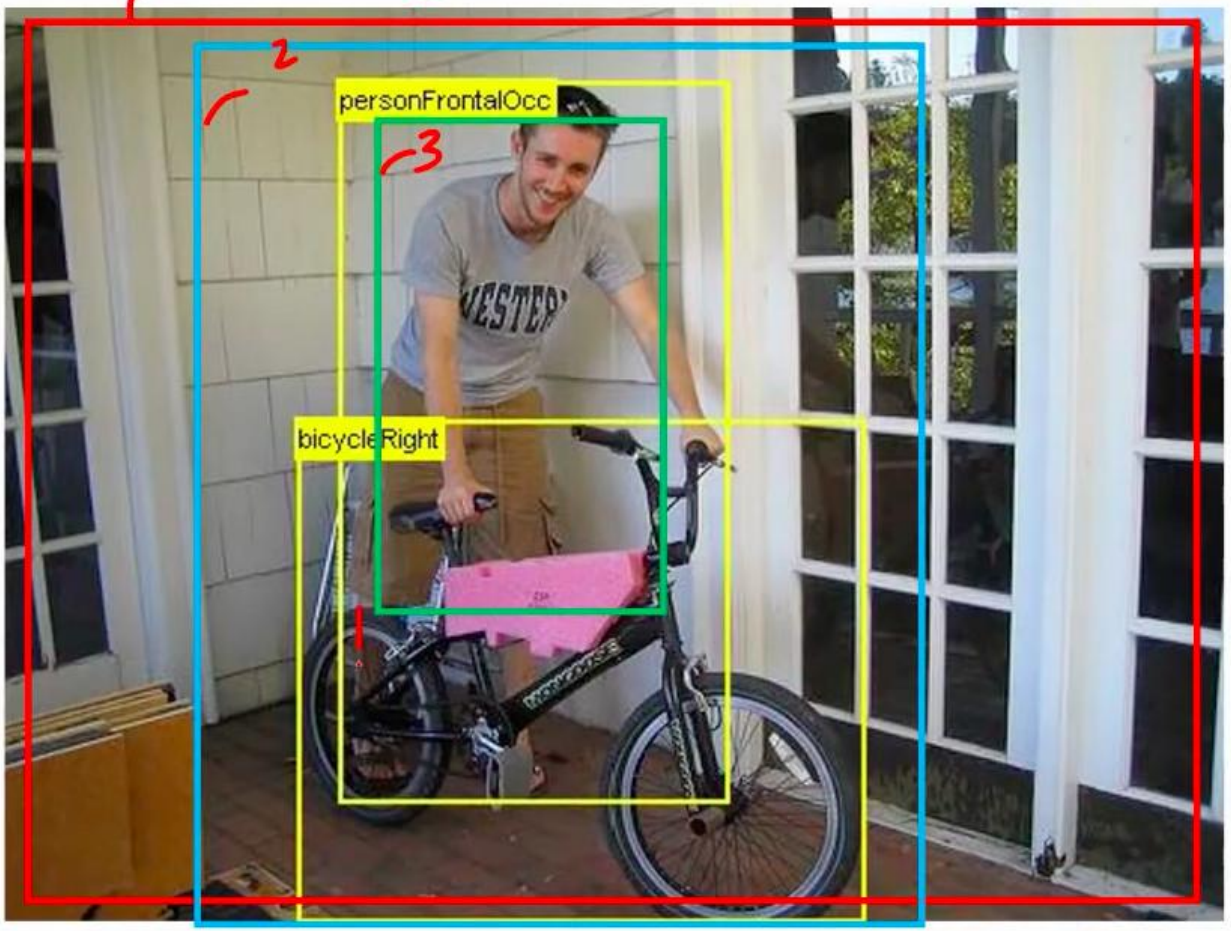
How to find out TP and FP

TP FP



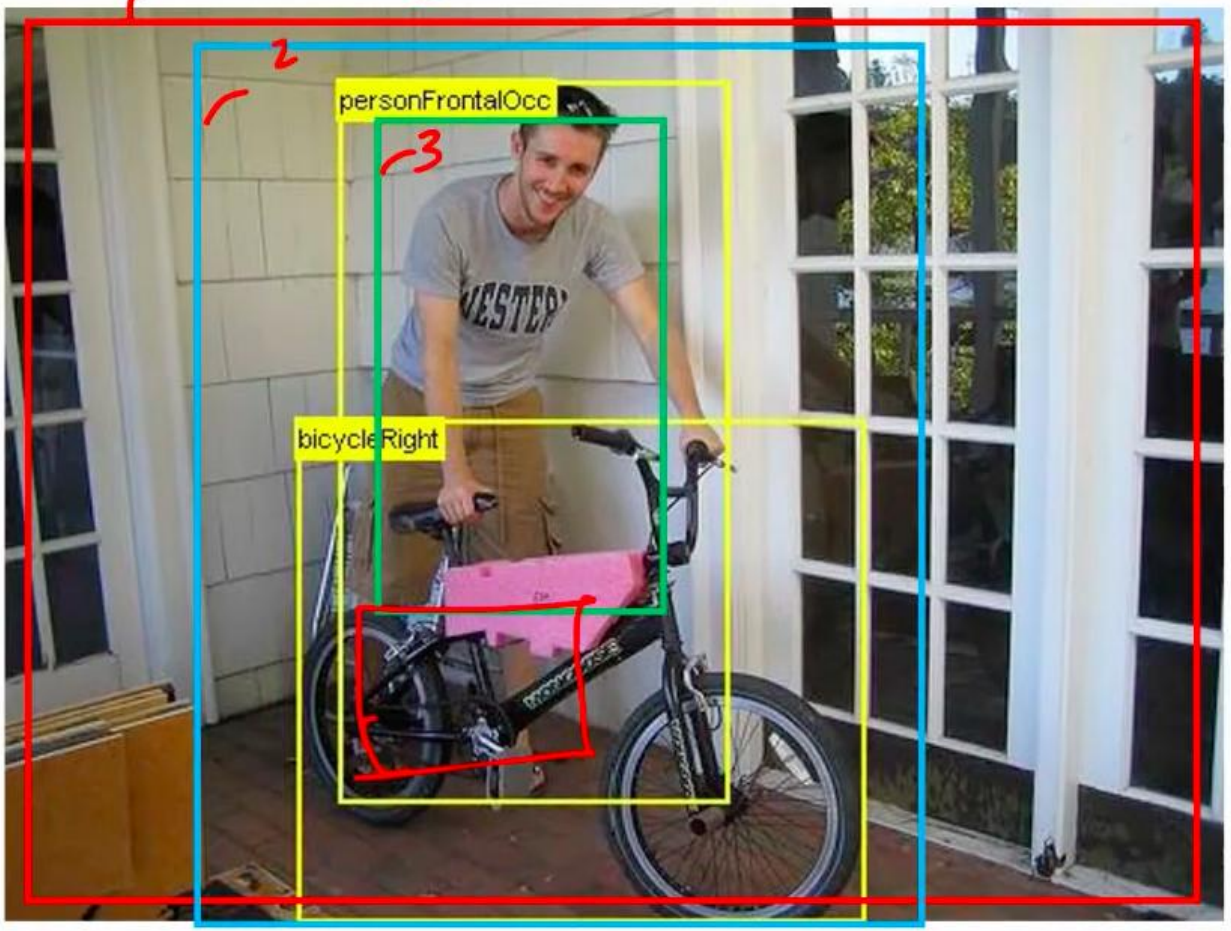
How to find out TP and FP

TP FP



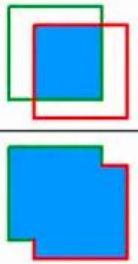
How to find out TP and FP

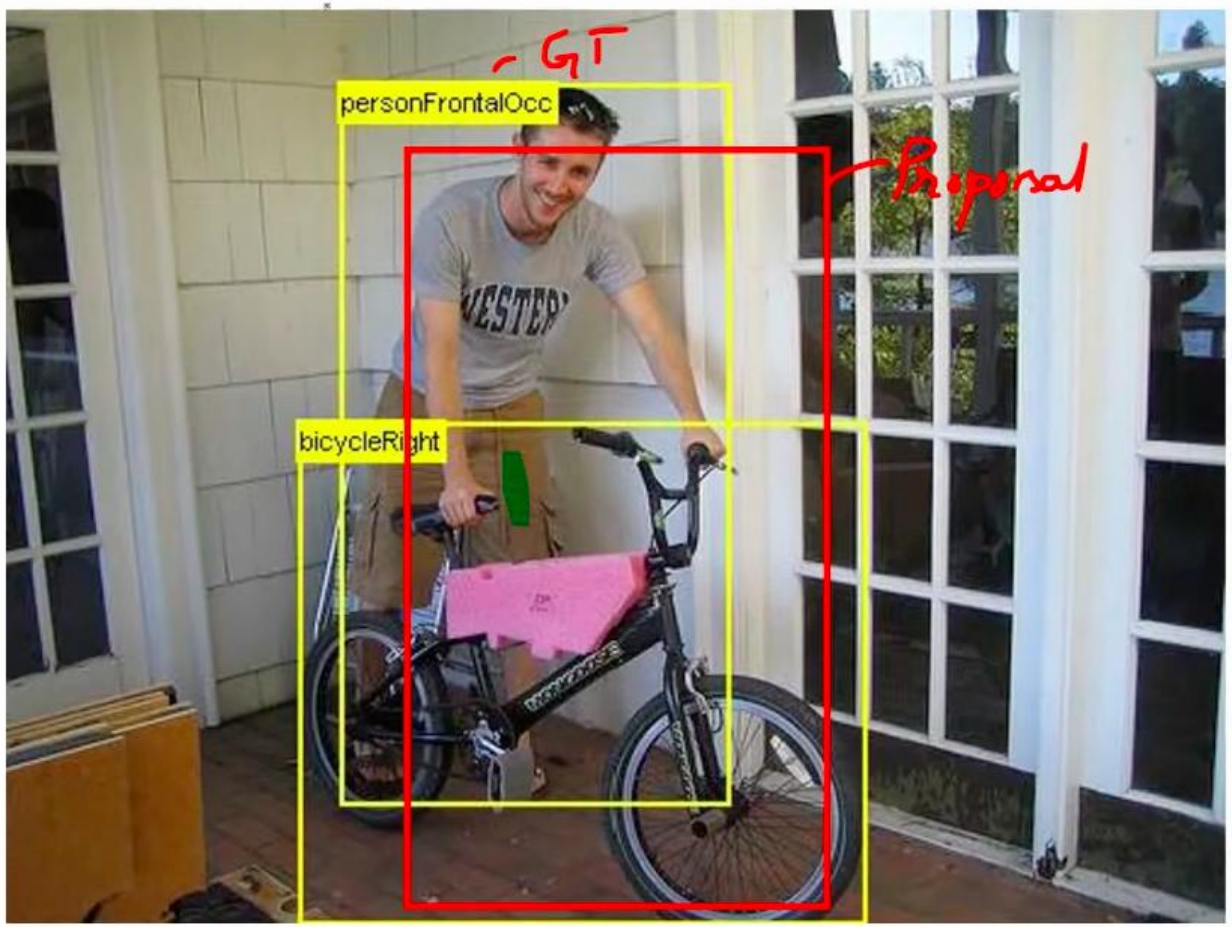
TP FP



IoU

$$IOU = \frac{\text{area of overlap}}{\text{area of union}} = \frac{\text{}}{\text{}}$$





IoU

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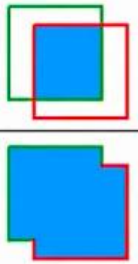
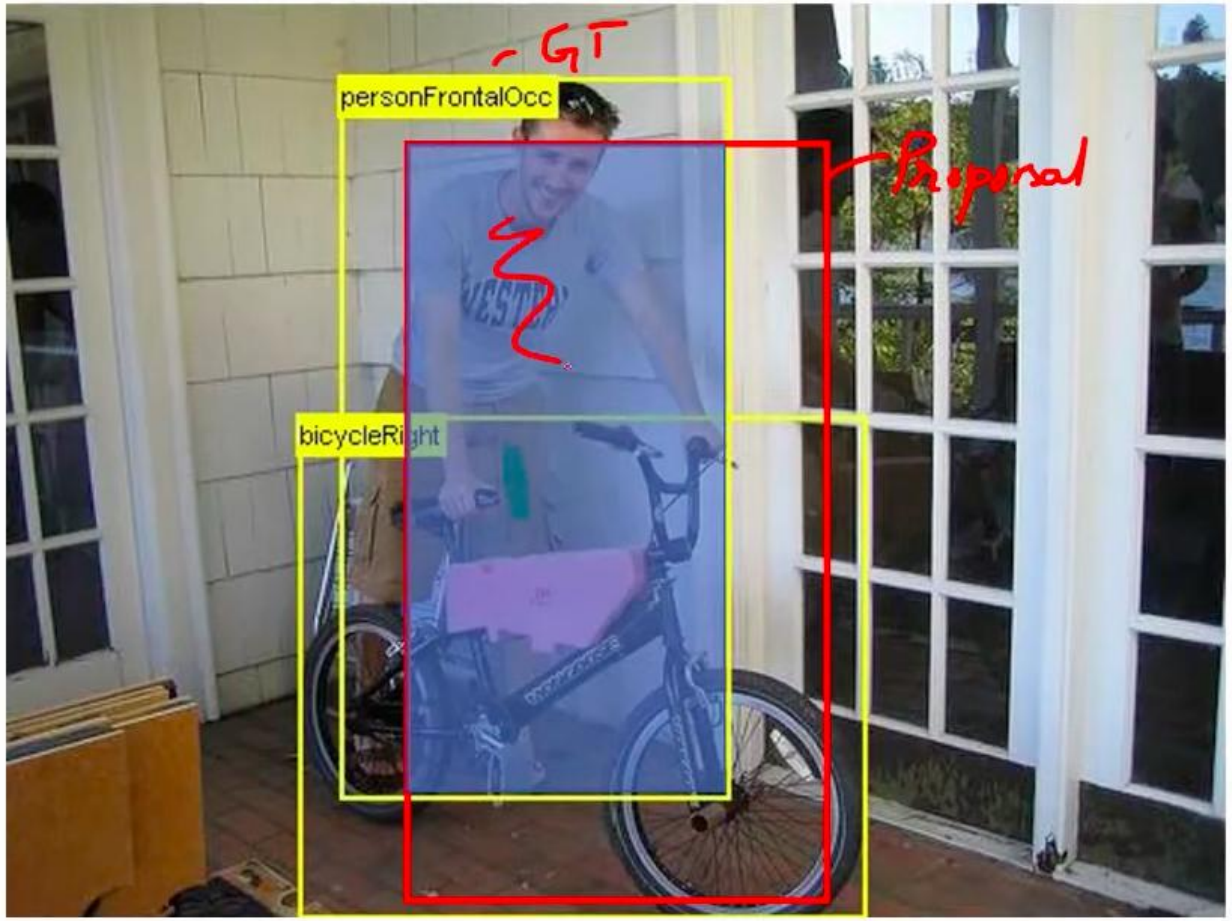
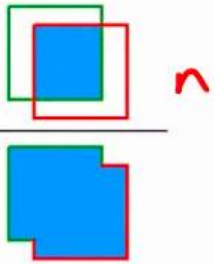
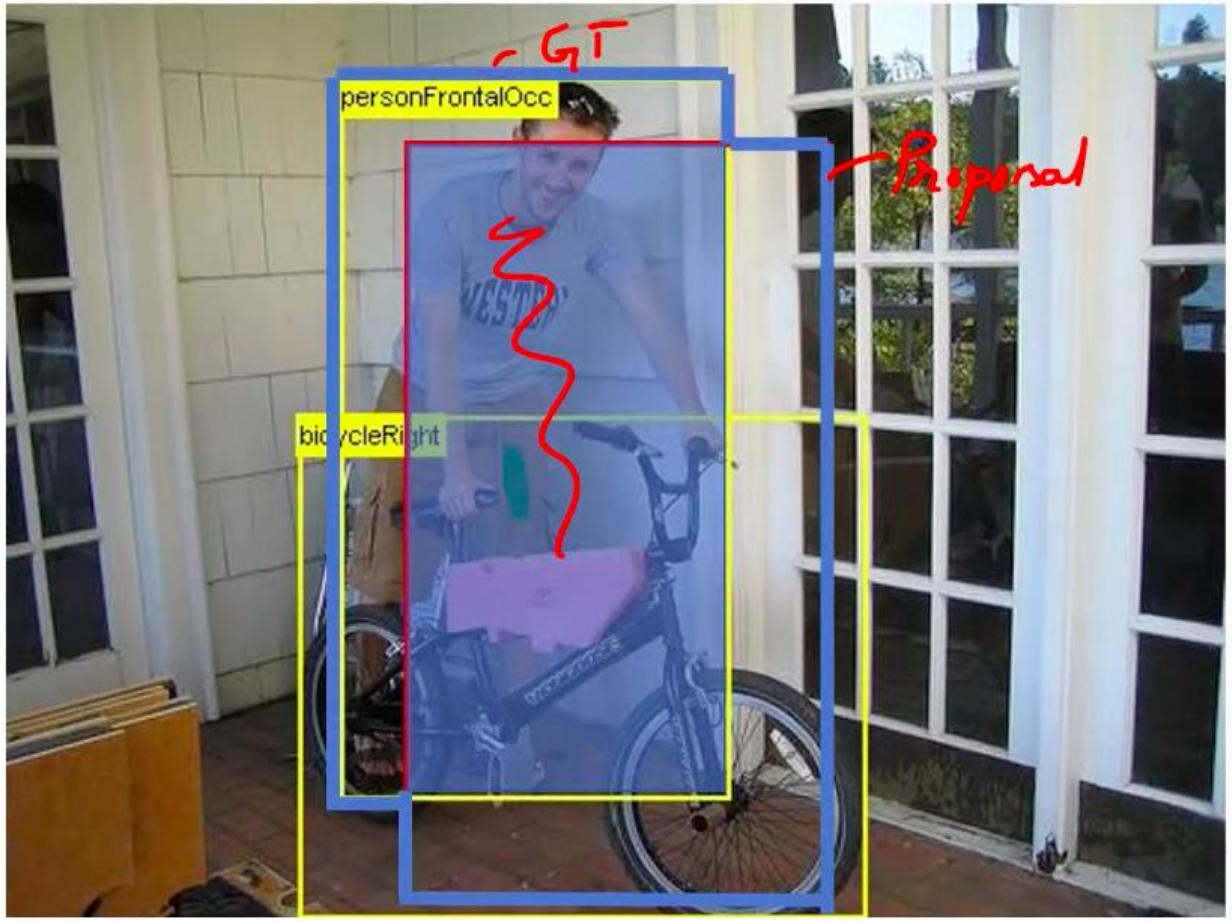




IoU

$$IOU = \frac{\text{area of overlap}}{\text{area of union}} = \frac{\cap}{\cup}$$

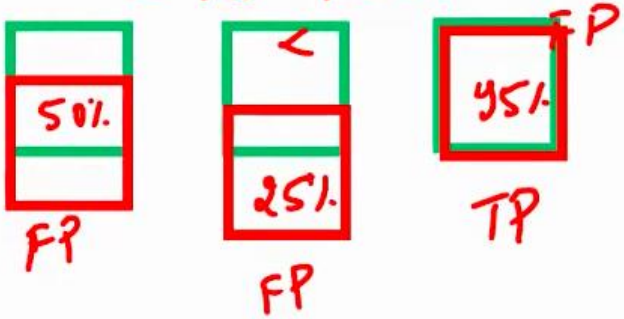


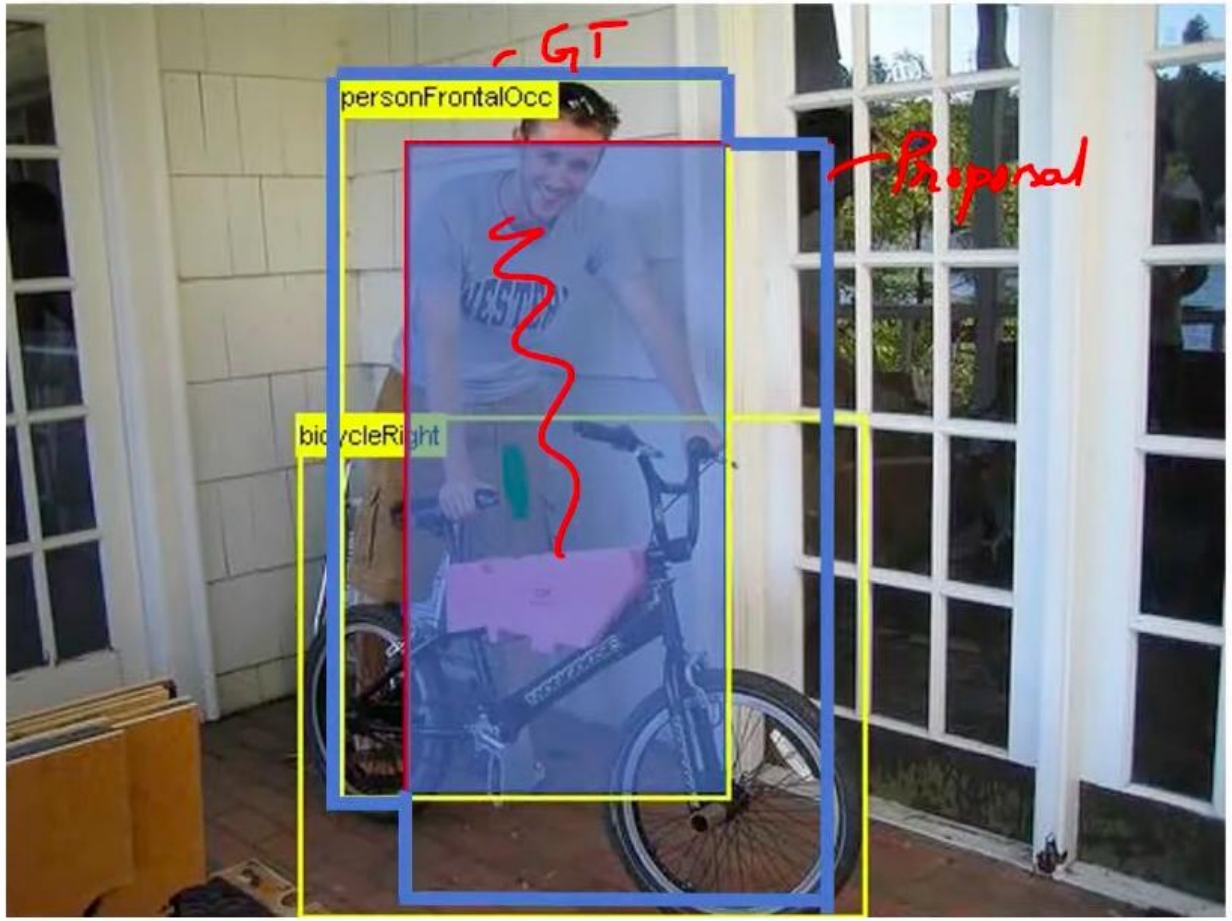


IoU

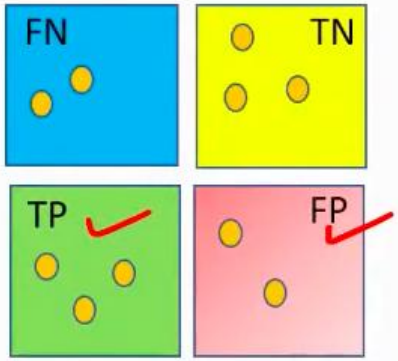
$$IOU = \frac{\text{area of overlap}}{\text{area of union}} = \frac{\cap}{\cup}$$

= X 75%. TP

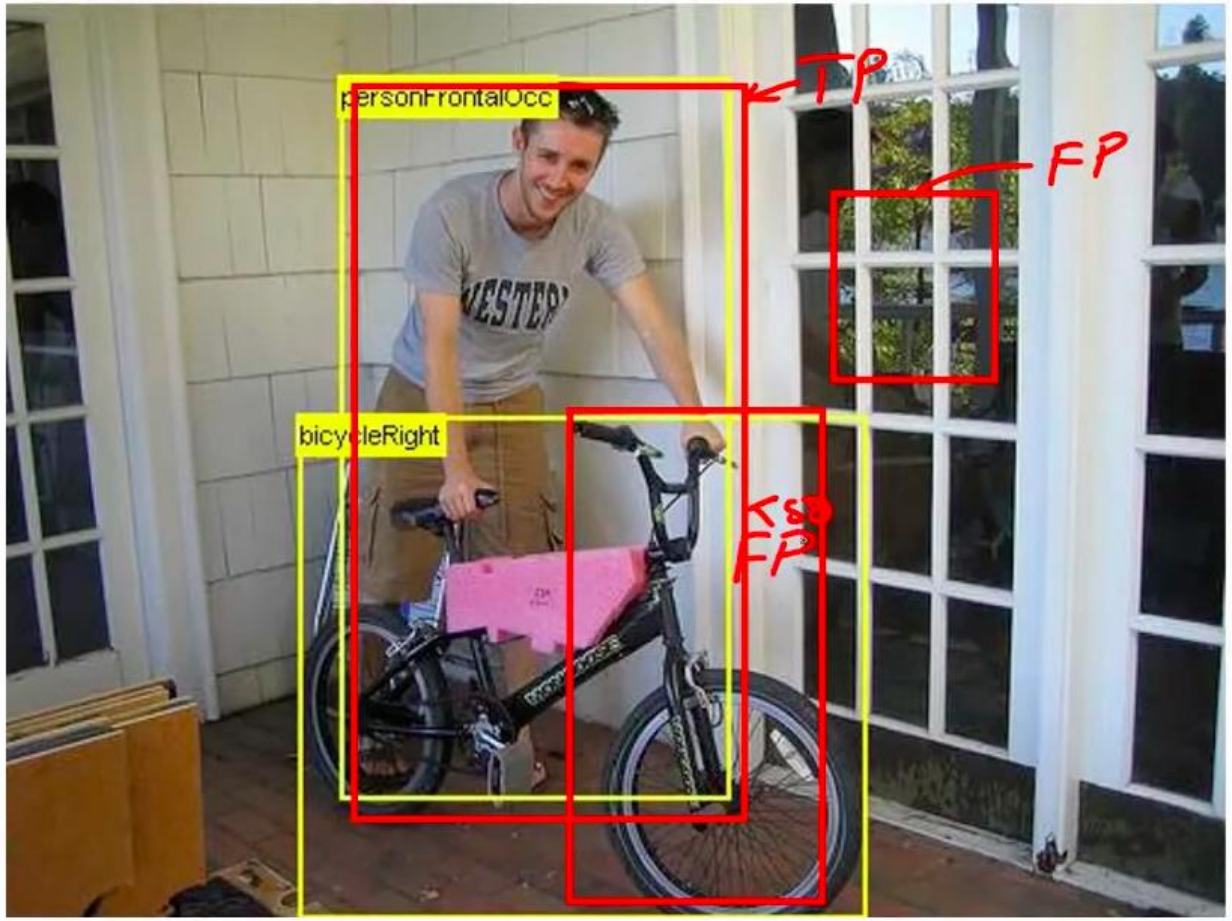




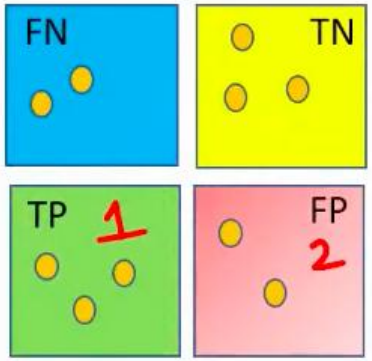
How to find Calculate Precision and Recall



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

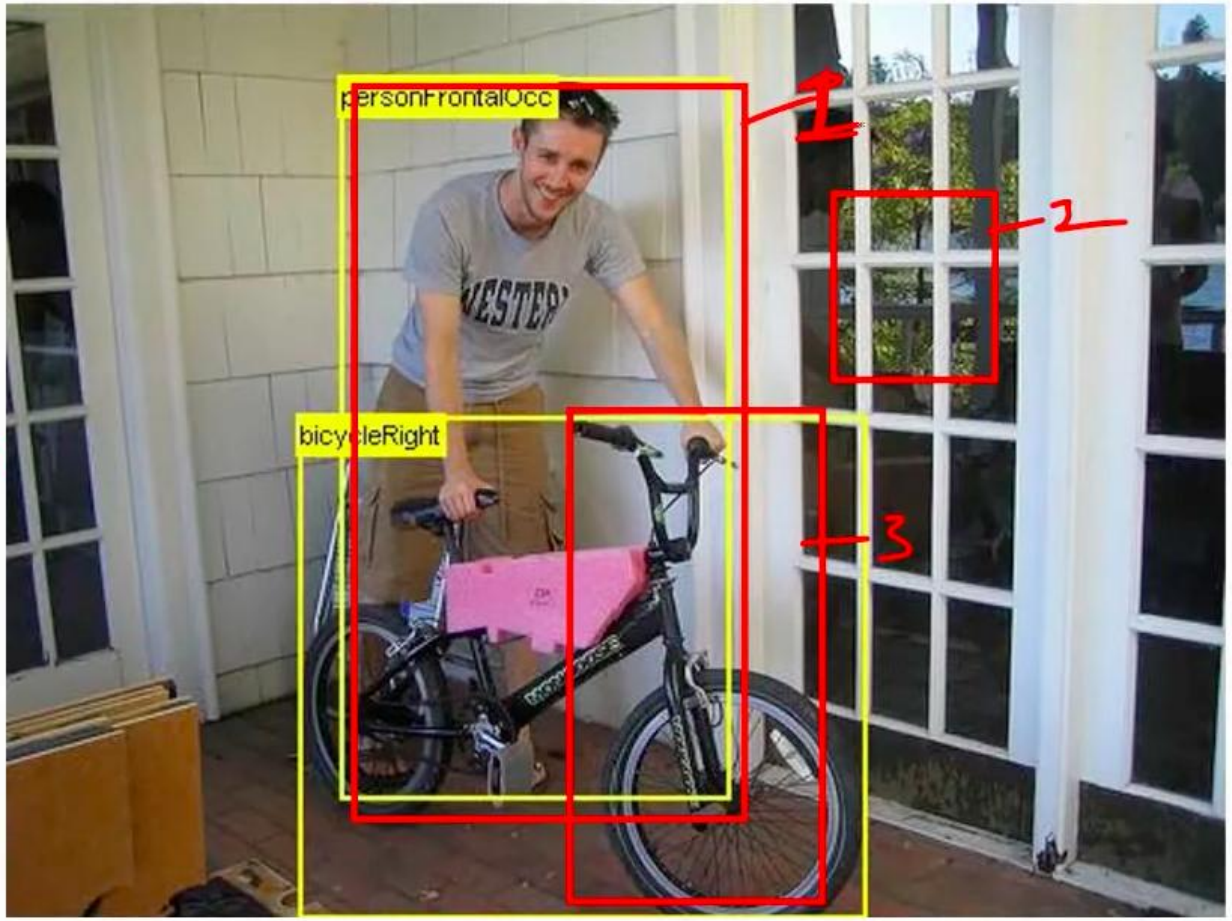


How to find Calculate Precision and Recall

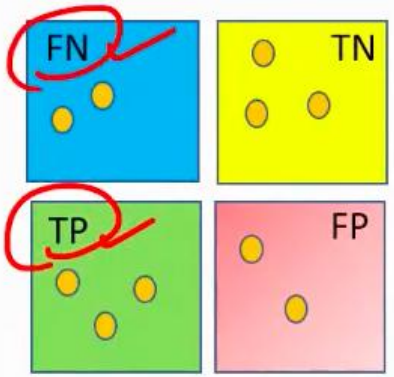


$$P = \frac{TP}{TP+FP} = \frac{1}{3} = 33\%$$

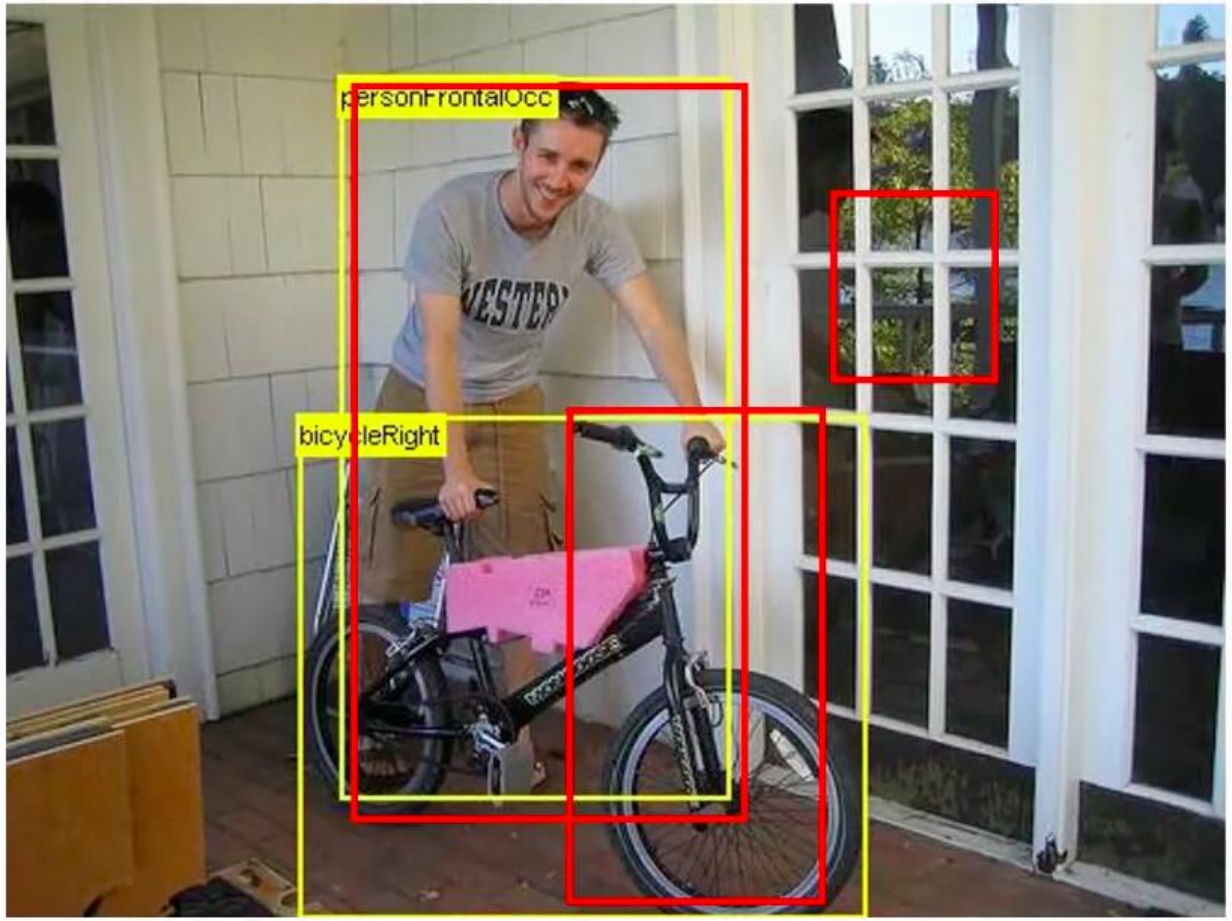
$TP+FP \rightarrow \#RoI$



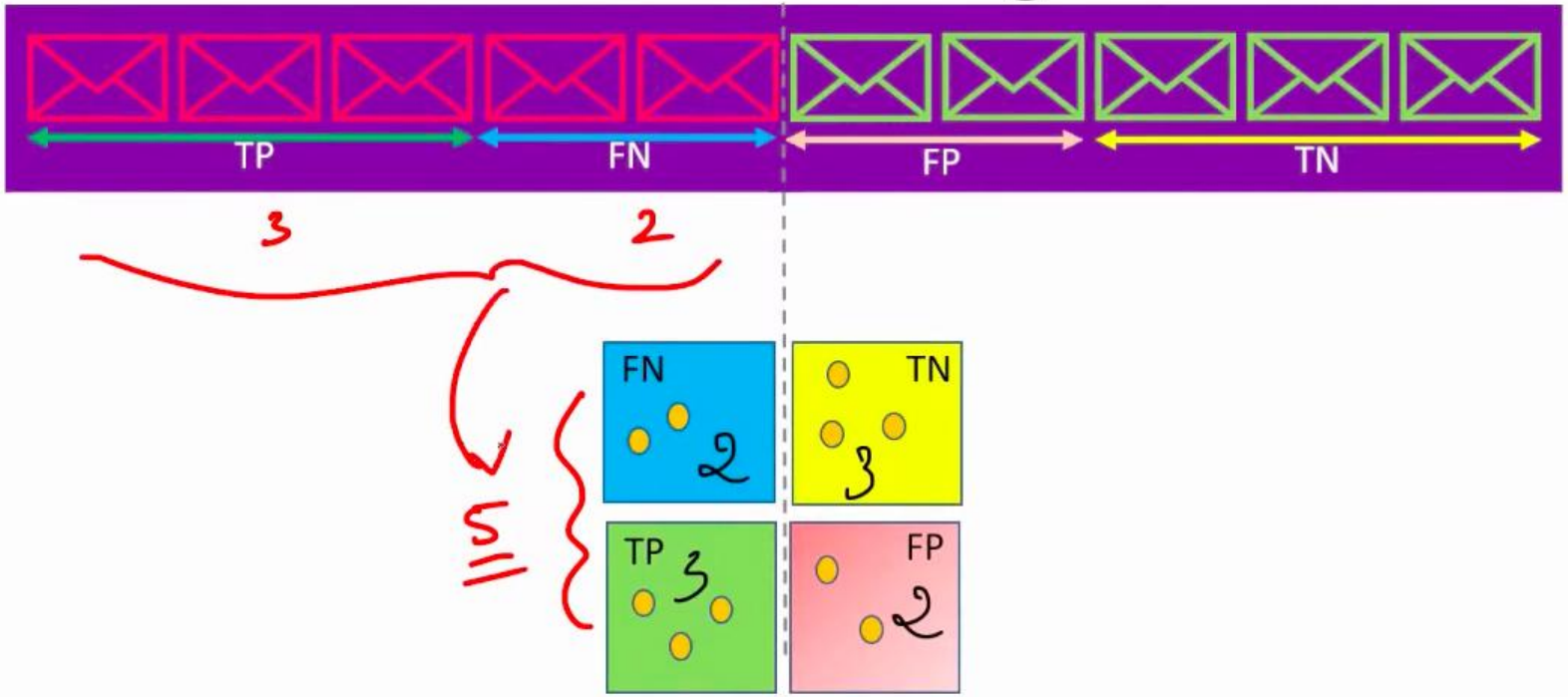
How to find Calculate Precision and Recall

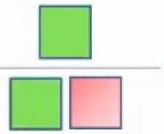


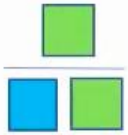
$$R = \frac{TP}{TP + FN}$$



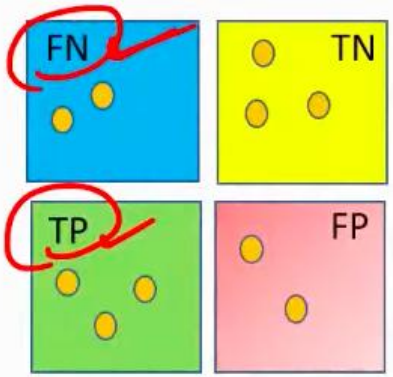
More Terminologies



Precision = 

Recall = (Sensitivity) 

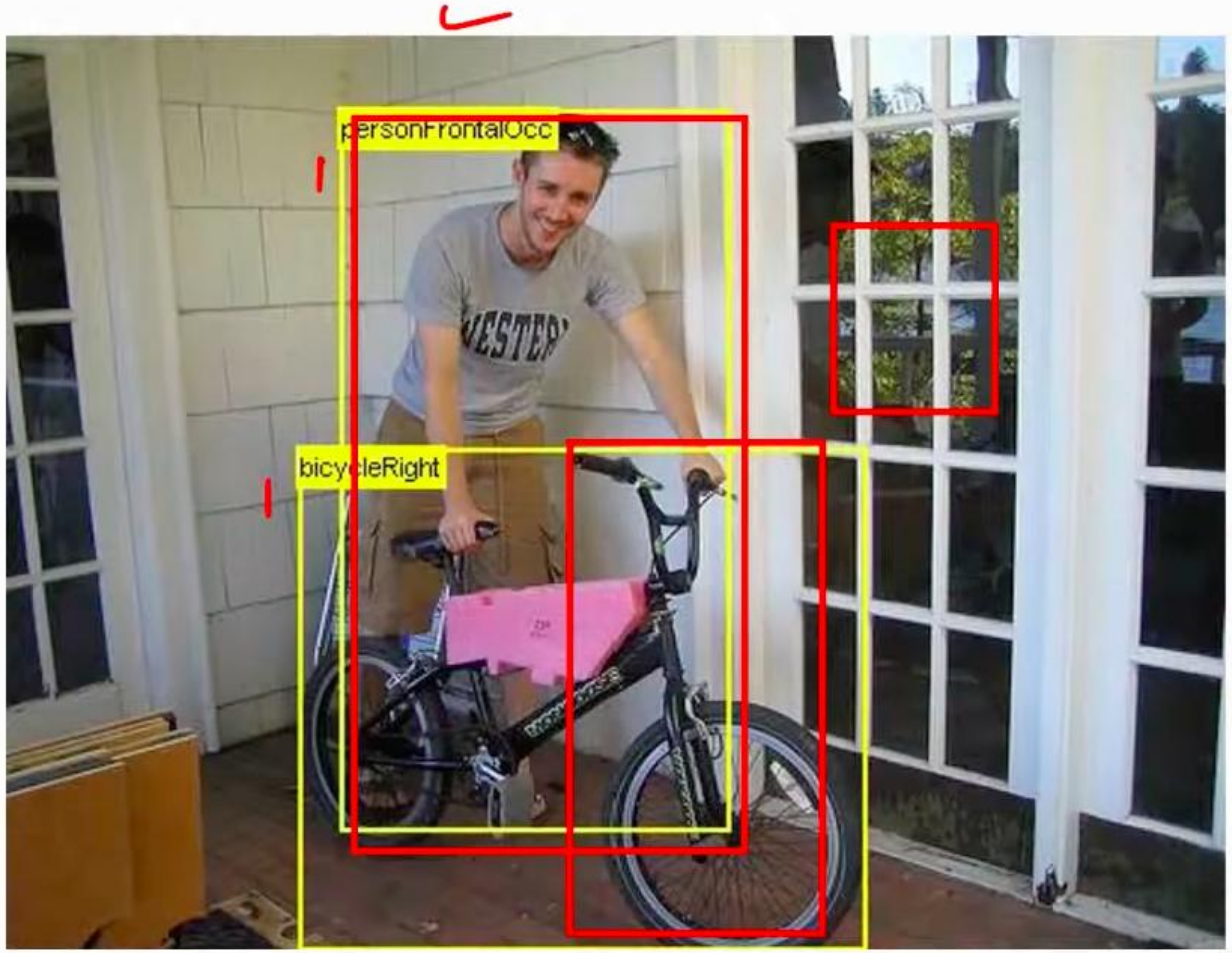
How to find Calculate Precision and Recall



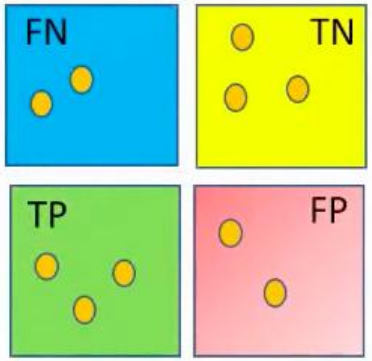
$$R = \frac{TP}{TP + FN}$$

$$\#\,GT\ Roi$$

$$= \frac{TP}{} = \frac{1}{2}$$

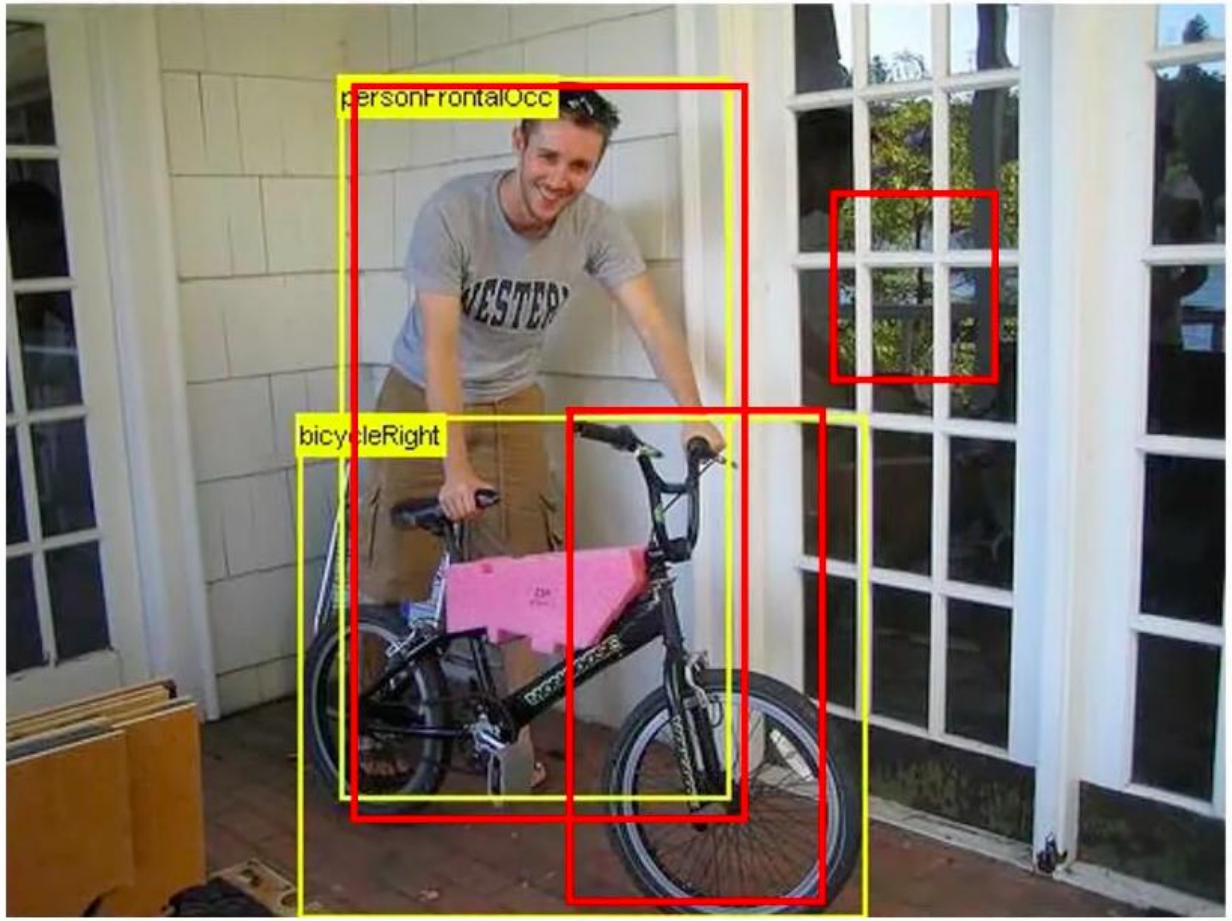


How to find Calculate Precision and Recall

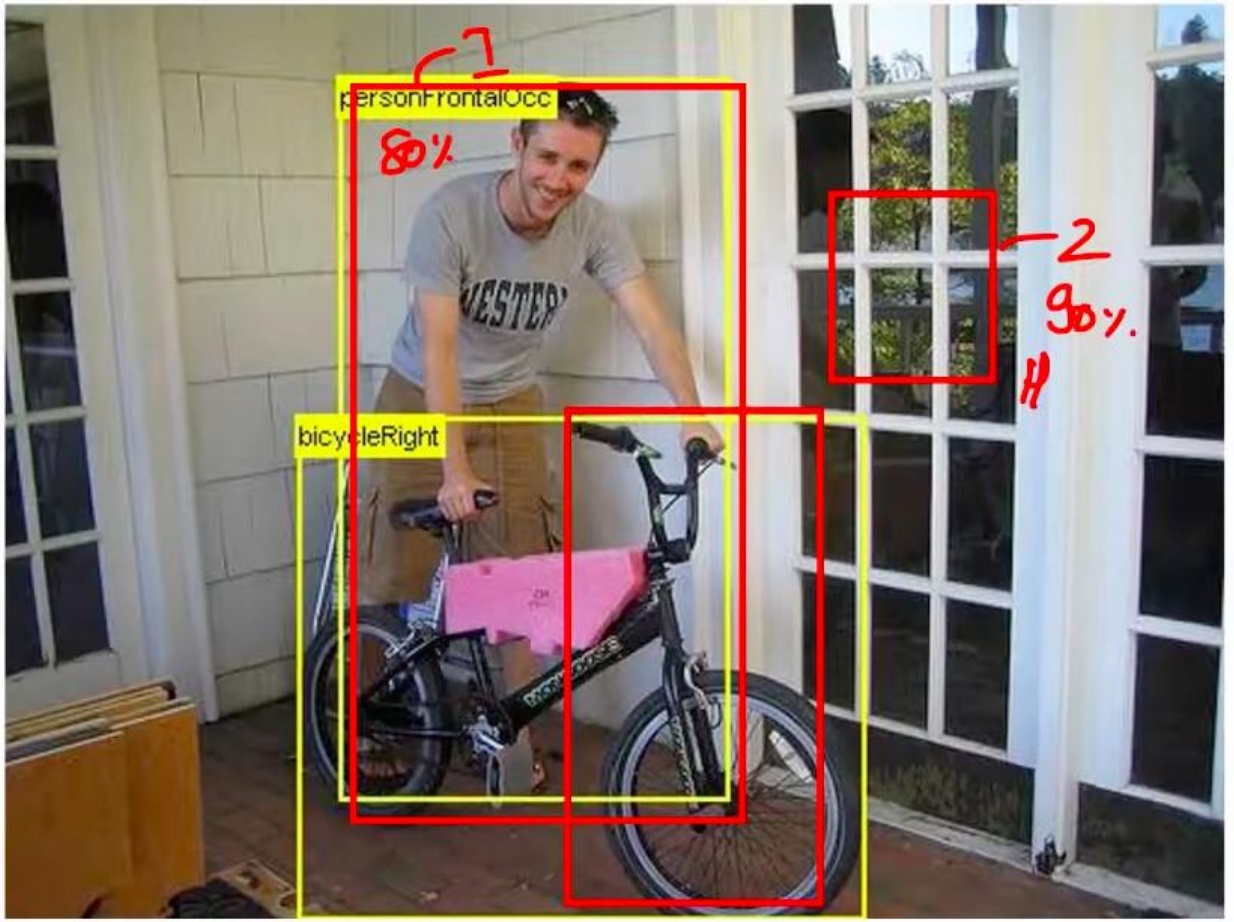


$$P = \frac{TP}{\#\ \text{RoI Proposals}}$$

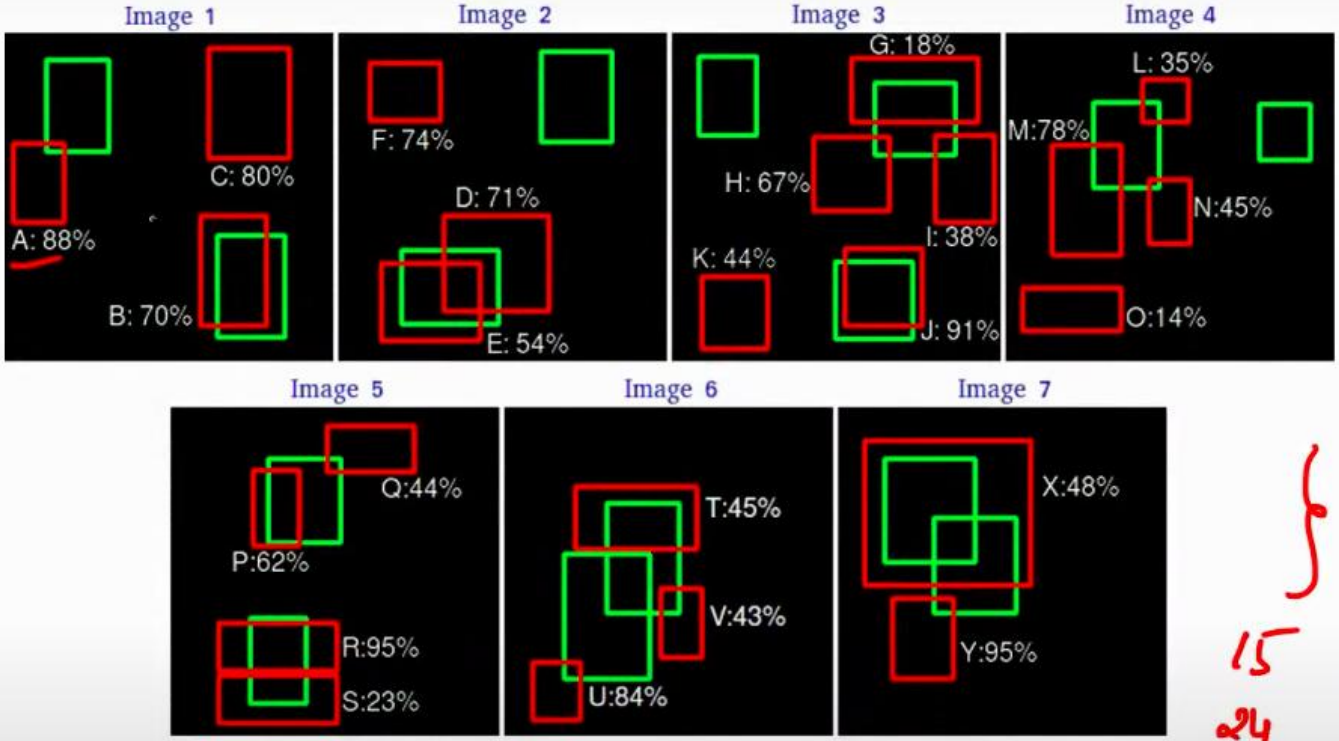
$$R = \frac{TP}{\#\ \text{GT RoIs}}$$



Confidence Scores



mAP



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Hat Tip to Rafael: https://github.com/rafaelpadilla/Object-Detection-Metrics

Images	Detections	Confidences	TP or FP
Image 1	A	88%	FP
Image 1	B	70%	TP
Image 1	C	80%	FP
Image 2	D	71%	FP
Image 2	E	54%	TP
Image 2	F	74%	FP
Image 3	G	18%	TP
Image 3	H	67%	FP
Image 3	I	38%	FP
Image 3	J	91%	TP
Image 3	K	44%	FP
Image 4	L	35%	FP
Image 4	M	78%	FP
Image 4	N	45%	FP
Image 4	O	14%	FP
Image 5	P	62%	TP
Image 5	Q	44%	FP
Image 5	R	95%	TP
Image 5	S	23%	FP
Image 6	T	45%	FP
Image 6	U	84%	FP
Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

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Image 1	A	88%	FP
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Image 5	Q	44%	FP
Image 5	R	95%	TP
Image 5	S	23%	FP
Image 6	T	45%	FP
Image 6	U	84%	FP
Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

Images	Detections	Confidences	TP	FP	Acc TP	Acc FP	Precision	Recall
Image 5	R	95%	1	0	1	0	1	0.0666
Image 7	Y	95%	0	1	1	1	0.5	0.0666
Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
Image 6	U	84%	0	1	2	3	0.4	0.1333
Image 1	C	80%	0	1	2	4	0.3333	0.1333
Image 4	M	78%	0	1	2	5	0.2857	0.1333
Image 2	F	74%	0	1	2	6	0.25	0.1333
Image 2	D	71%	0	1	2	7	0.2222	0.1333
Image 1	B	70%	1	0	3	7	0.3	0.2
Image 3	H	67%	0	1	3	8	0.2727	0.2
Image 5	P	62%	1	0	4	8	0.3333	0.2666
Image 2	E	54%	1	0	5	8	0.3846	0.3333
Image 7	X	48%	1	0	6	8	0.4285	0.4
Image 4	N	45%	0	1	6	9	0.4	0.4
Image 6	T	45%	0	1	6	10	0.375	0.4
Image 3	K	44%	0	1	6	11	0.3529	0.4
Image 5	Q	44%	0	1	6	12	0.3333	0.4
Image 6	V	43%	0	1	6	13	0.3157	0.4
Image 3	I	38%	0	1	6	14	0.3	0.4
Image 4	L	35%	0	1	6	15	0.2857	0.4
Image 5	S	23%	0	1	6	16	0.2727	0.4
Image 3	G	18%	1	0	7	16	0.3043	0.4666
Image 4	O	14%	0	1	7	17	0.2916	0.4666

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Image 1	A	88%	FP
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Image 5	R	95%	TP
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Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

Ev-ODN

Images	Detections	Confidences	TP	FP	Acc TP	Acc FP	Precision	Recall
Image 5	R	95%	1	0	1	0	1	0.0666
Image 7	Y	95%	0	1	1	1	0.5	0.0666
Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
Image 6	U	84%	0	1	2	3	0.4	0.1333
Image 1	C	80%	0	1	2	4	0.3333	0.1333
Image 4	M	78%	0	1	2	5	0.2857	0.1333
Image 2	F	74%	0	1	2	6	0.25	0.1333
Image 2	D	71%	0	1	2	7	0.2222	0.1333
Image 1	B	70%	1	0	3	7	0.3	0.2
Image 3	H	67%	0	1	3	8	0.2727	0.2
Image 5	P	62%	1	0	4	8	0.3333	0.2666
Image 2	E	54%	1	0	5	8	0.3846	0.3333
Image 7	X	48%	1	0	6	8	0.4285	0.4
Image 4	N	45%	0	1	6	9	0.4	0.4
Image 6	T	45%	0	1	6	10	0.375	0.4
Image 3	K	44%	0	1	6	11	0.3529	0.4
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Image 4	L	35%	0	1	6	15	0.2857	0.4
Image 5	S	23%	0	1	6	16	0.2727	0.4
Image 3	G	18%	1	0	7	16	0.3043	0.4666
Image 4	O	14%	0	1	7	17	0.2916	0.4666

nt

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Image 5	R	95%	TP
Image 5	S	23%	FP
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Image 7	Y	95%	0	1	1	1	0.5	0.0666
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Image 3	I	38%	0	1	6	14	0.3	0.4
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Image 3	G	18%	1	0	7	16	0.3043	0.4666
Image 4	O	14%	0	1	7	17	0.2916	0.4666

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Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
Image 6	U	84%	0	1	2	3	0.4	0.1333
Image 1	C	80%	0	1	2	4	0.3333	0.1333
Image 4	M	78%	0	1	2	5	0.2857	0.1333
Image 2	F	74%	0	1	2	6	0.25	0.1333
Image 2	D	71%	0	1	2	7	0.2222	0.1333
Image 1	B	70%	1	0	3	7	0.3	0.2
Image 3	H	67%	0	1	3	8	0.2727	0.2
Image 5	P	62%	1	0	4	8	0.3333	0.2666
Image 2	E	54%	1	0	5	8	0.3846	0.3333
Image 7	X	48%	1	0	6	8	0.4285	0.4
Image 4	N	45%	0	1	6	9	0.4	0.4
Image 6	T	45%	0	1	6	10	0.375	0.4
Image 3	K	44%	0	1	6	11	0.3529	0.4
Image 5	Q	44%	0	1	6	12	0.3333	0.4
Image 6	V	43%	0	1	6	13	0.3157	0.4
Image 3	I	38%	0	1	6	14	0.3	0.4
Image 4	L	35%	0	1	6	15	0.2857	0.4
Image 5	S	23%	0	1	6	16	0.2727	0.4
Image 3	G	18%	1	0	7	16	0.3043	0.4666
Image 4	O	14%	0	1	7	17	0.2916	0.4666

Ev-ODN

nt

Images	Detections	Confidences	TP or FP
Image 1	A	88%	FP
Image 1	B	70%	TP
Image 1	C	80%	FP
Image 2	D	71%	FP
Image 2	E	54%	TP
Image 2	F	74%	FP
Image 3	G	18%	TP
Image 3	H	67%	FP
Image 3	I	38%	FP
Image 3	J	91%	TP
Image 3	K	44%	FP
Image 4	L	35%	FP
Image 4	M	78%	FP
Image 4	N	45%	FP
Image 4	O	14%	FP
Image 5	P	62%	TP
Image 5	Q	44%	FP
Image 5	R	95%	TP
Image 5	S	23%	FP
Image 6	T	45%	FP
Image 6	U	84%	FP
Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

Images	Detections	Confidences	TP	FP	Acc TP	Acc FP	Precision	Recall
Image 5	R	95%	1	0	1	0	1	0.0666
Image 7	Y	95%	0	1	1	1	0.5	0.0666
Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
Image 6	U	84%	0	1	2	3	0.4	0.1333
Image 1	C	80%	0	1	2	4	0.3333	0.1333
Image 4	M	78%	0	1	2	5	0.2857	0.1333
Image 2	F	74%	0	1	2	6	0.25	0.1333
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Image 3	H	67%	0	1	3	8	0.2727	0.2
Image 5	P	62%	1	0	4	8	0.3333	0.2666
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Image 7	X	48%	1	0	6	8	0.4285	0.4
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Image 6	V	43%	0	1	6	13	0.3157	0.4
Image 3	I	38%	0	1	6	14	0.3	0.4
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Image 3	G	18%	1	0	7	16	0.3043	0.4666
Image 4	O	14%	0	1	7	17	0.2916	0.4666

Ev-ODN

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

$R = \frac{TP}{\#GTPos}$

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Images	Detections	Confidences	TP or FP
Image 1	A	88%	FP
Image 1	B	70%	TP
Image 1	C	80%	FP
Image 2	D	71%	FP
Image 2	E	54%	TP
Image 2	F	74%	FP
Image 3	G	18%	TP
Image 3	H	67%	FP
Image 3	I	38%	FP
Image 3	J	91%	TP
Image 3	K	44%	FP
Image 4	L	35%	FP
Image 4	M	78%	FP
Image 4	N	45%	FP
Image 4	O	14%	FP
Image 5	P	62%	TP
Image 5	Q	44%	FP
Image 5	R	95%	TP
Image 5	S	23%	FP
Image 6	T	45%	FP
Image 6	U	84%	FP
Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

Images	Detections	Confidences	TP	FP	Acc TP	Acc FP	Precision	Recall
Image 5	R	95%	1	0	1	0	1	0.0666
Image 7	Y	95%	0	1	1	1	0.5	0.0666
Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
Image 6	U	84%	0	1	2	3	0.4	0.1333
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Image 5	R	95%	TP
Image 5	S	23%	FP
Image 6	T	45%	FP
Image 6	U	84%	FP
Image 6	V	43%	FP
Image 7	X	48%	TP
Image 7	Y	95%	FP

Ev-ODN

Images	Detections	Confidences	TP	FP	Acc TP	Acc FP	Precision	Recall
Image 5	R	95%	1	0	1	0	1	0.0666
Image 7	Y	95%	0	1	1	1	0.5	0.0666
Image 3	J	91%	1	0	2	1	0.6666	0.1333
Image 1	A	88%	0	1	2	2	0.5	0.1333
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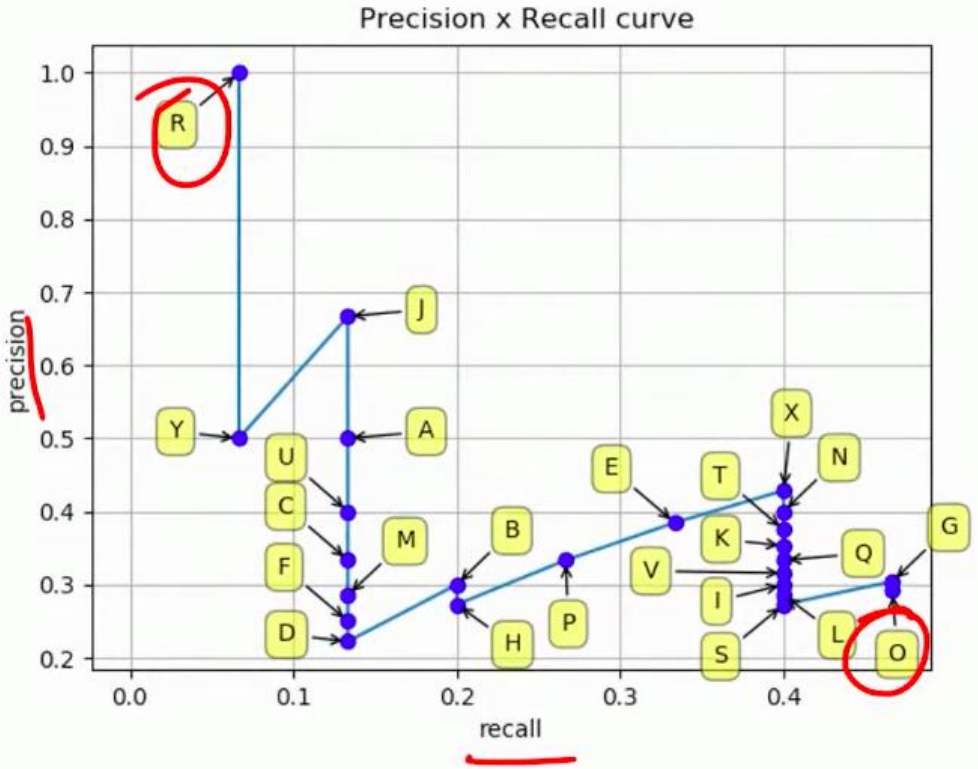

11 Point Interpolation

AP

Precision	Recall
1	0.0666
0.5	0.0666
0.6666	0.1333
0.5	0.1333
0.4	0.1333
0.3333	0.1333
0.2857	0.1333
0.25	0.1333
0.2222	0.1333
0.3	0.2
0.2727	0.2
0.3333	0.2666
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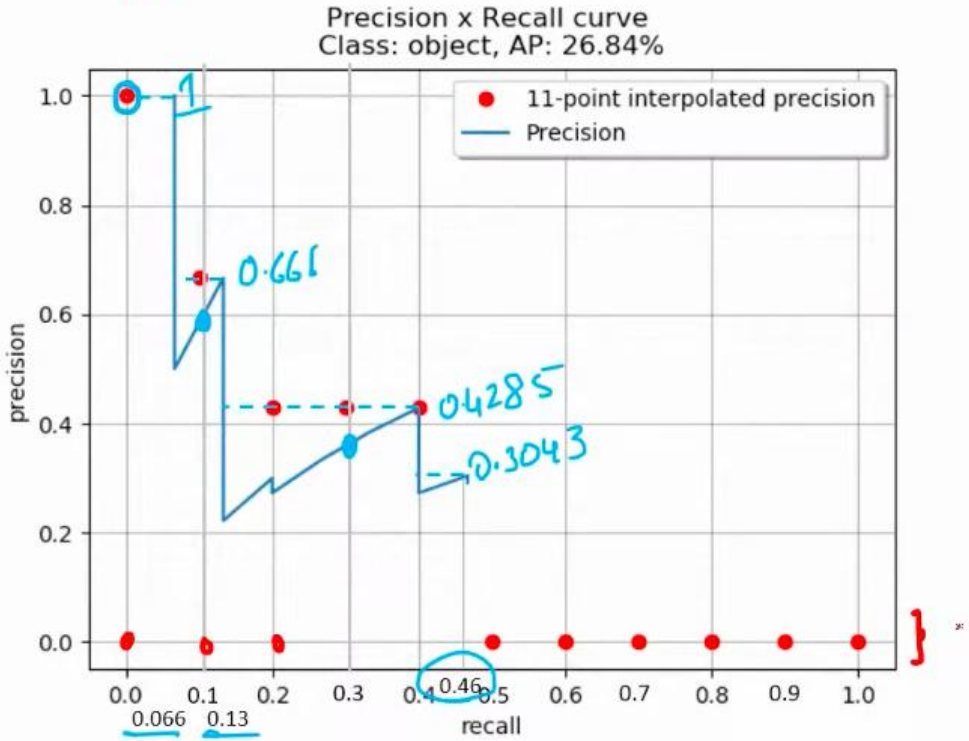
0.4	0.4
0.375	0.4
0.3529	0.4
0.3333	0.4
0.3157	0.4
0.3	0.4
0.2857	0.4
0.2727	0.4
0.3043	0.4666
0.2916	0.4666



11 Point Interpolation

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0.5	0.0666
0.6666	0.1333
0.5	0.1333
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0.3333	0.1333
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0.2222	0.1333
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0.2727	0.2
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0.3846	0.3333
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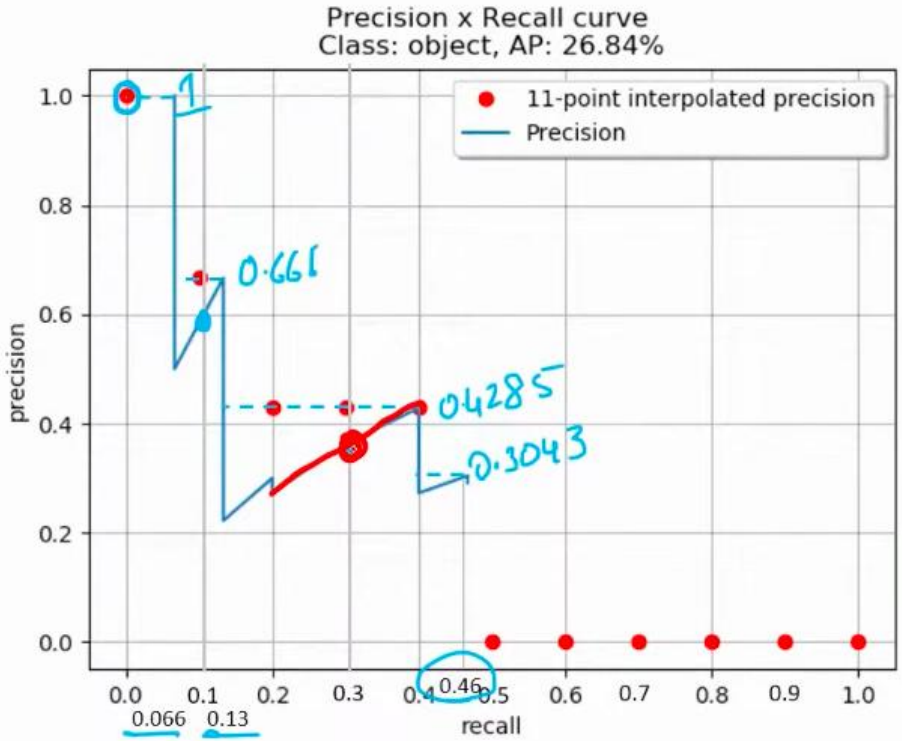
0.4	0.4
0.375	0.4
0.3529	0.4
0.3333	0.4
0.3157	0.4
0.3	0.4
0.2857	0.4
0.2727	0.4
0.3043	0.4666
0.2916	0.4666



11 Point Interpolation

Precision	Recall
1	0.0666
0.5	0.0666
0.6666	0.1333
0.5	0.1333
0.4	0.1333
0.3333	0.1333
0.2857	0.1333
0.25	0.1333
0.2222	0.1333
0.3	0.2
0.2727	0.2
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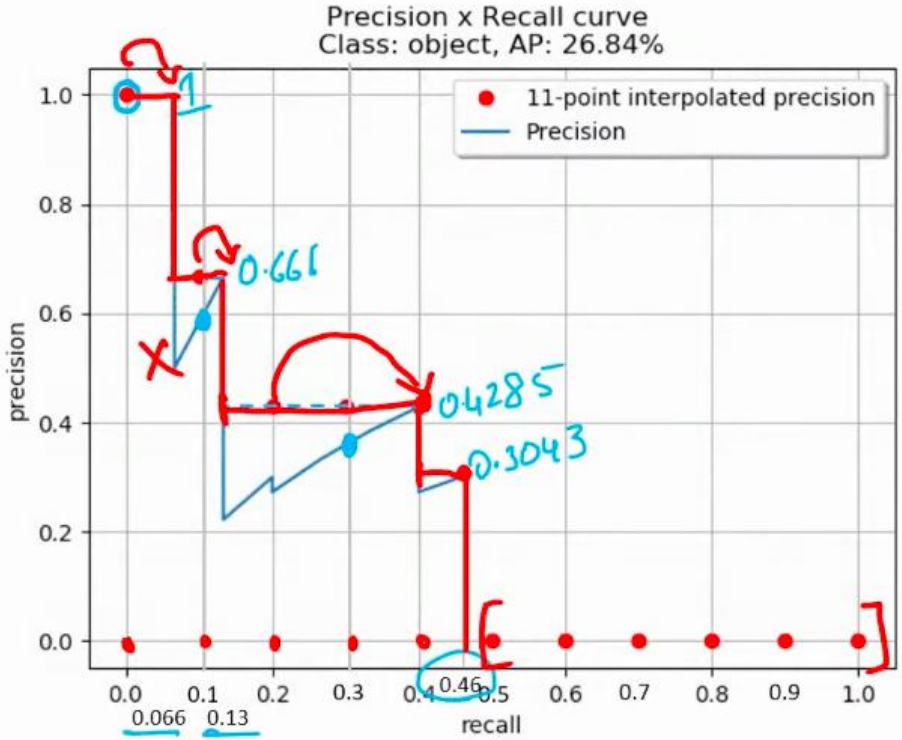
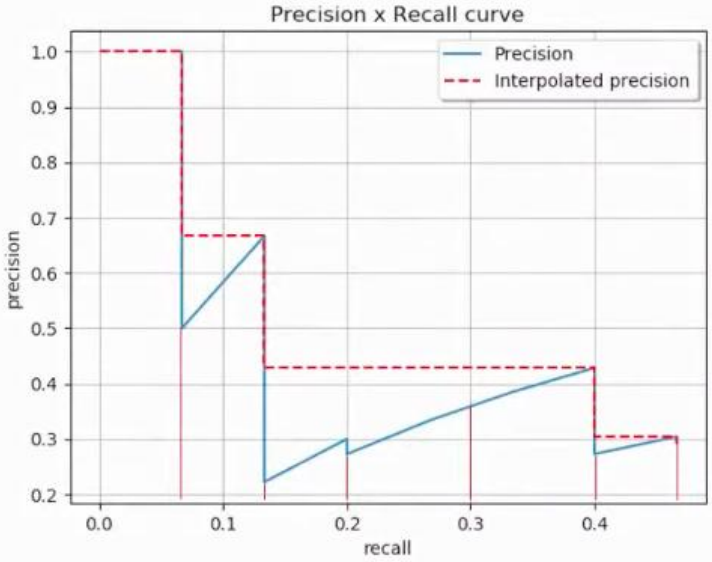
0.3846	0.3333
0.4285	0.4
0.4	0.4
0.375	0.4
0.3529	0.4
0.3333	0.4
0.3157	0.4
0.3	0.4
0.2857	0.4
0.2727	0.4
0.3043	0.4666
0.2916	0.4666



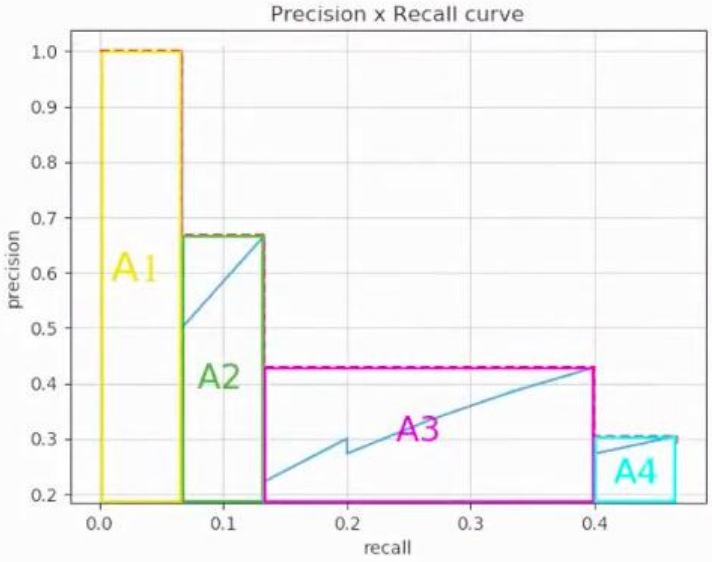
$$AP = \frac{1}{11}(1 + 0.666 + \dots$$
$$= 3 \times 0.4285 + 0)$$
$$= 26.84\%$$

Average Precision



11 Point Interpolation

$$AP = \frac{1}{11}(1 + 0.6666 + 0.4285 + 0.4285 + 0.4285 + 0 + 0 + 0 + 0 + 0 + 0)$$
$$AP = 26.84\%$$



All Point Interpolation

Calculating the total area, we have the AP:

$$AP = A1 + A2 + A3 + A4$$

with:

$$A1 = (0.0666 - 0) \times 1 = \mathbf{0.0666}$$
$$A2 = (0.1333 - 0.0666) \times 0.6666 = \mathbf{0.04446222}$$
$$A3 = (0.4 - 0.1333) \times 0.4285 = \mathbf{0.11428095}$$
$$A4 = (0.4666 - 0.4) \times 0.3043 = \mathbf{0.02026638}$$

$$AP = 0.0666 + 0.04446222 + 0.11428095 + 0.02026638$$
$$AP = 0.24560955$$
$$AP = \mathbf{24.56}\%$$

mAP Examples – Pascal VOC

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Method	data	mAP	aero	bike	bird	boat	bottle	bus	car	cat	chair	cow	table	dog	horse	mbike	person	plant	sheep	sofa	train	tv
Fast [6]	07	66.9	74.5	78.3	69.2	53.2	36.6	77.3	78.2	82.0	40.7	72.7	67.9	79.6	79.2	73.0	69.0	30.1	65.4	70.2	75.8	65.8

Results on Pascal VOC 2007

mAP Examples – Pascal VOC

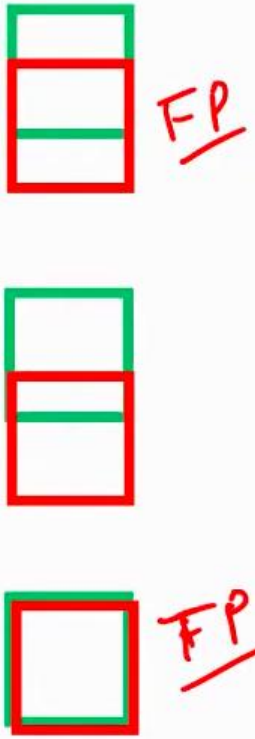
Method	data	mAP	aero	bike	bird	boat	bottle	bus	car	cat	chair	cow	table	dog	horse	mbike	person	plant	sheep	sofa	train	tv
Fast [6]	07	66.9	74.5	78.3	69.2	53.2	36.6	77.3	78.2	82.0	40.7	72.7	67.9	79.6	79.2	73.0	69.0	30.1	65.4	70.2	75.8	65.8
Fast [6]	07+12	70.0	77.0	78.1	69.3	59.4	38.3	81.6	78.6	86.7	42.8	78.8	68.9	84.7	82.0	76.6	69.9	31.8	70.1	74.8	80.4	70.4
Faster [2]	07	69.9	70.0	80.6	70.1	57.3	49.9	78.2	80.4	82.0	52.2	75.3	67.2	80.3	79.8	75.0	76.3	39.1	68.3	67.3	81.1	67.6
Faster [2]	07+12	73.2	76.5	79.0	70.9	65.5	52.1	83.1	84.7	86.4	52.0	81.9	65.7	84.8	84.6	77.5	76.7	38.8	73.6	73.9	83.0	72.6
Faster [2]	07+12+COCO	78.8	84.3	82.0	77.7	68.9	65.7	88.1	88.4	88.9	63.6	86.3	70.8	85.9	87.6	80.1	82.3	53.6	80.4	75.8	86.6	78.9

Results on Pascal VOC 2007

Pascal 2007	Pascal 2012	COCO
Train	Train	Train
Val	Val	Val
Test	Test	Test

mAP Examples - COCO

$$IOU = \frac{\text{area of overlap}}{\text{area of union}}$$



mAP$_{50}$ mAP$_{55}$ . . . mAP$_{95}$

	backbone	AP	AP$_{50}$	AP$_{75}$	AP$_S$	AP$_M$	AP$_L$
Two-stage methods							
Faster R-CNN+++ [3]	ResNet-101-C4	34.9	55.7	37.4	15.6	38.7	50.9
Faster R-CNN w FPN [6]	ResNet-101-FPN	36.2	59.1	39.0	18.2	39.0	48.2
Faster R-CNN by G-RMI [4]	Inception-ResNet-v2 [19]	34.7	55.5	36.7	13.5	38.1	52.0
Faster R-CNN w TDM [18]	Inception-ResNet-v2-TDM	36.8	57.7	39.2	16.2	39.8	**52.1**
One-stage methods							
YOLOv2 [13]	DarkNet-19 [13]	21.6	44.0	19.2	5.0	22.4	35.5
SSD513 [9, 2]	ResNet-101-SSD	31.2	50.4	33.3	10.2	34.5	49.8
DSSD513 [2]	ResNet-101-DSSD	33.2	53.3	35.2	13.0	35.4	51.1
RetinaNet [7]	ResNet-101-FPN	39.1	59.1	42.3	21.8	42.7	50.2
RetinaNet [7]	ResNeXt-101-FPN	**40.8**	**61.1**	**44.1**	**24.1**	**44.2**	51.2
YOLOv3 608 × 608	Darknet-53	33.0	57.9	34.4	18.3	35.4	41.9

COCO for YOLOv3