الجامعة السورية الخاصة
SYRIAN PRIVATE UNIVERSITY

Week 10 | كلية الهندسة | الذكاء الصنعي العملي

Modern Computer Vision Architectures: From CNNs to Transformers

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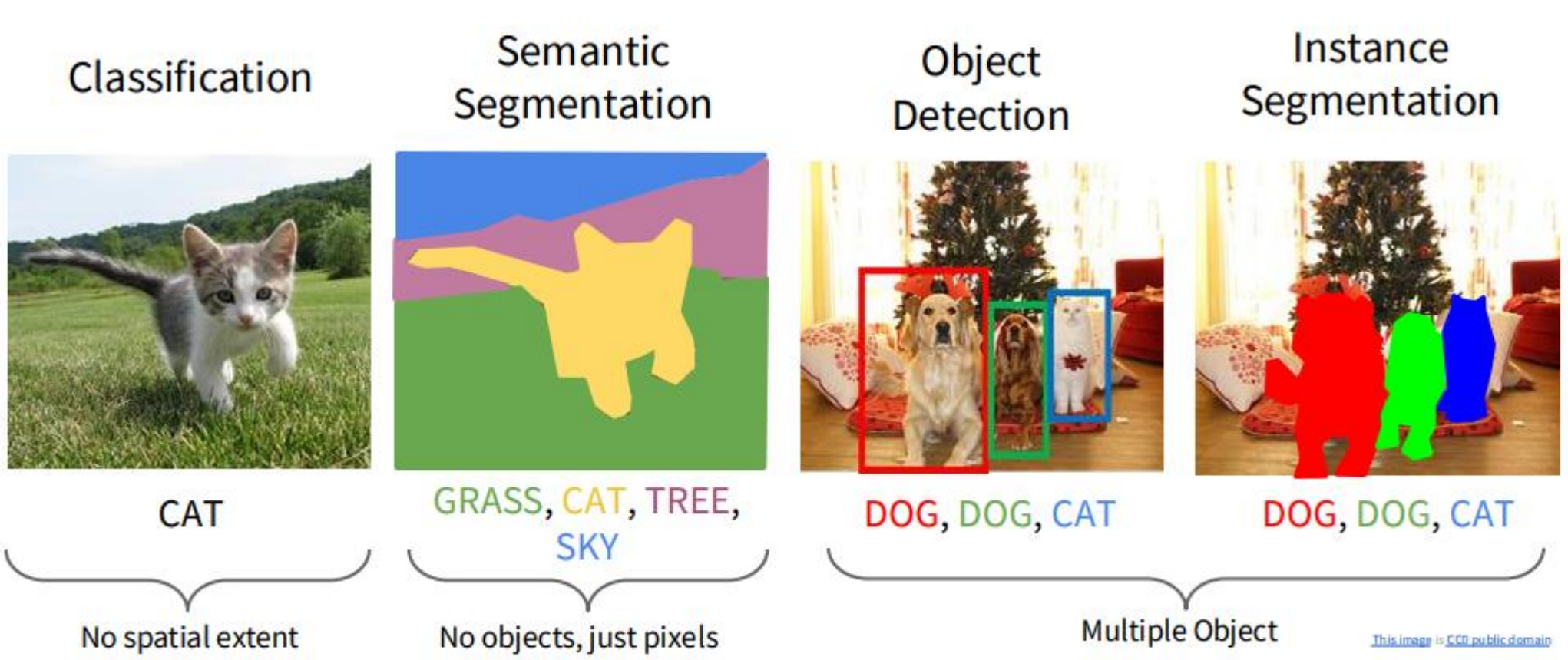
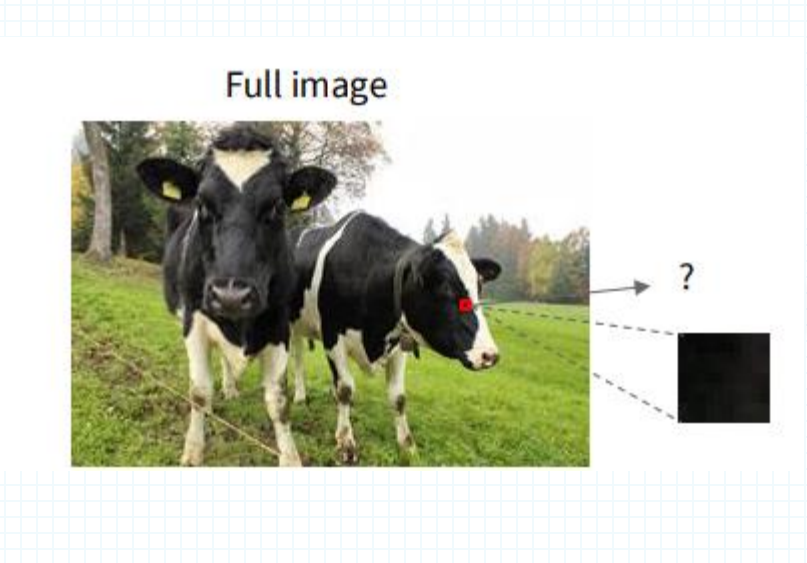
Computer Vision Tasks

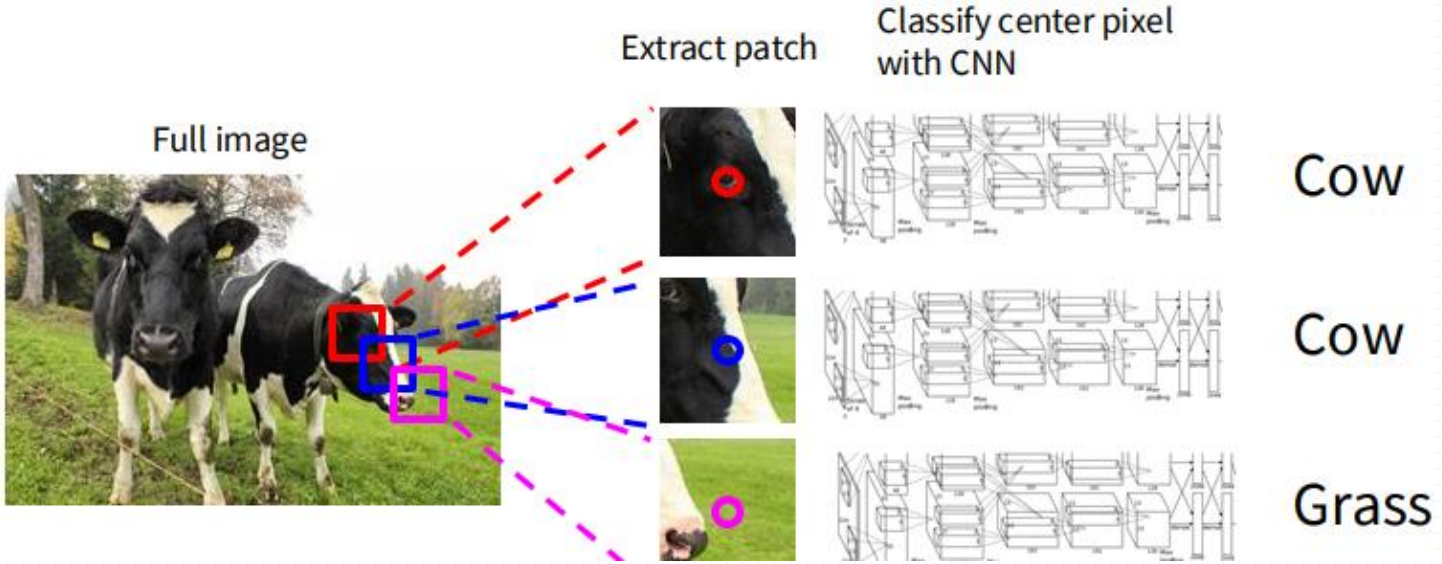


Semantic Segmentation

Semantic Segmentation

Idea: Sliding Window



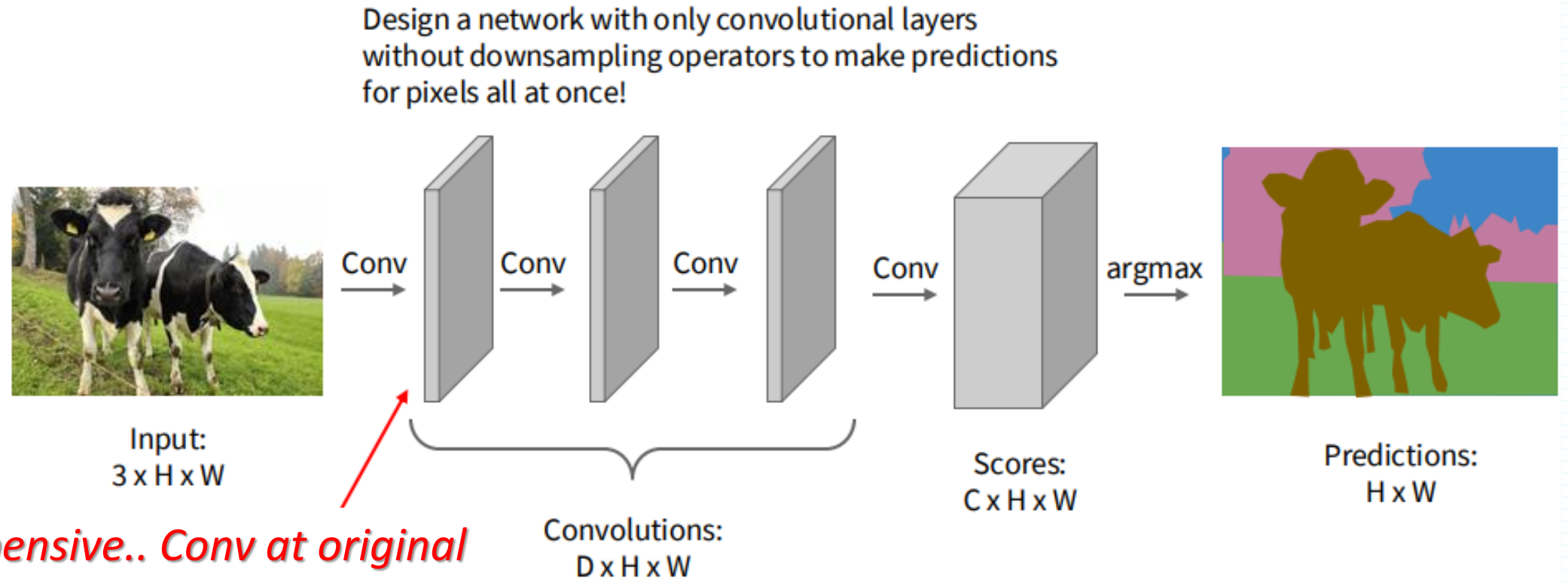


Impossible to classify without context!

But.. Inefficient! (many overlapping patches)

Semantic Segmentation

Idea: Convolution!



Still expensive.. Conv at original image resolution will be very expensive

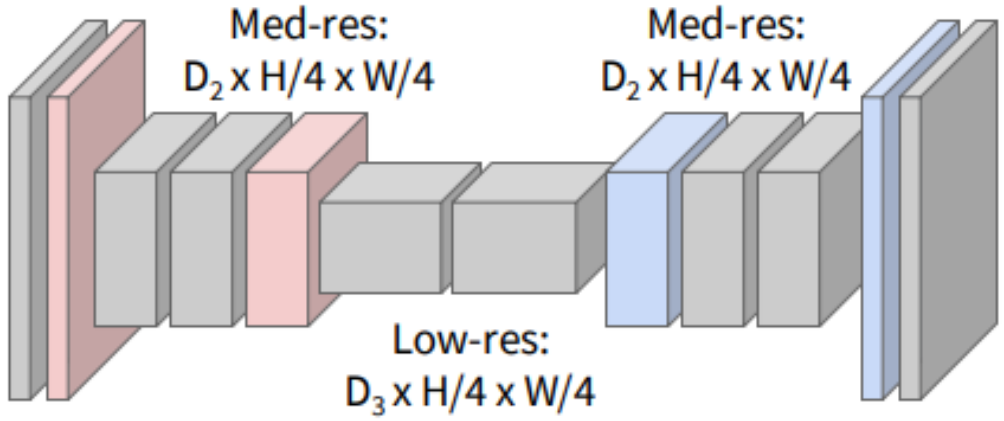
Semantic Segmentation

Solution: U-Net?

Downsampling:
Pooling, strided convolution

Design network as a bunch of convolutional layers, with downsampling and upsampling inside the network!

Input:
3 x H x W



High-res:
D_1 x H/2 x W/2

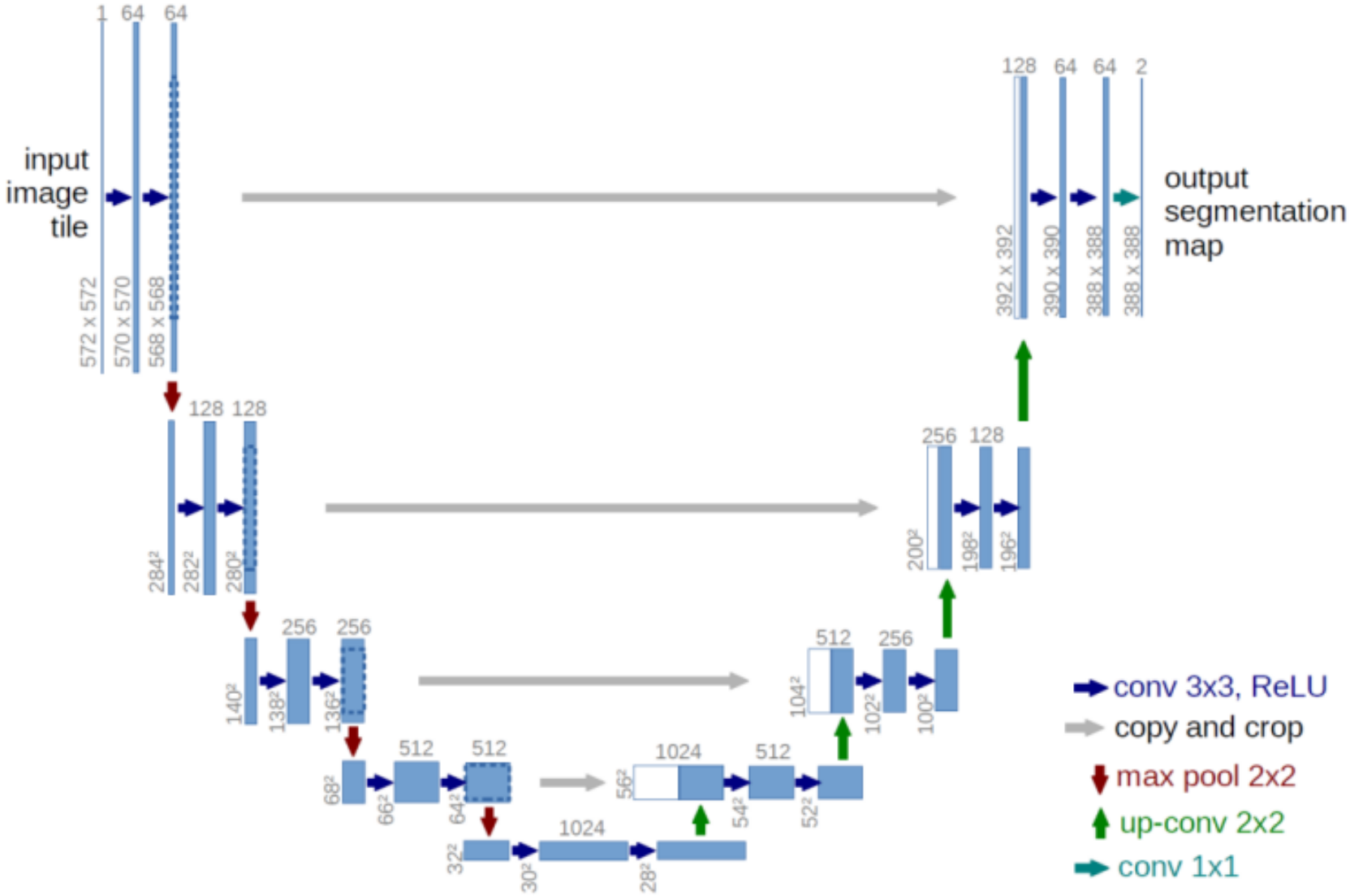
High-res:
D_1 x H/2 x W/2

C x H x W

Predictions:
H x W

Semantic Segmentation

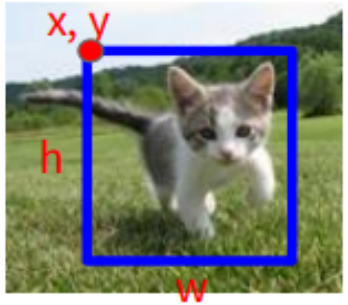
Solution: U-Net?



Object Detection

Single Object Detection

(Classification + Localization)



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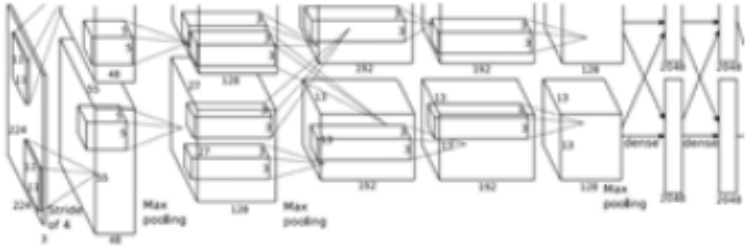


Vector: 4096

Fully Connected: 4096 to 1000

Class Scores
Cat: 0.9
Dog: 0.05
Car: 0.01
...

Softmax Loss

Correct label: Cat

Fully Connected: 4096 to 4

Box Coordinates (x, y, w, h)

L2 Loss

Correct box: (x', y', w', h')

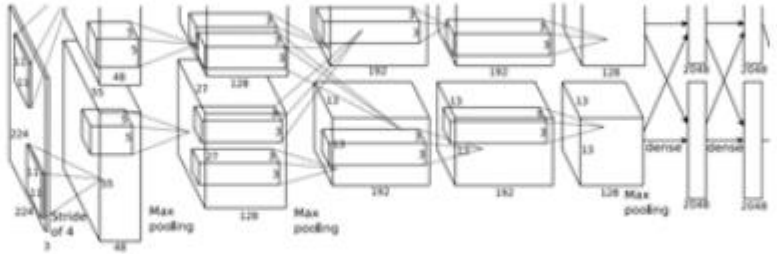
Multitask Loss

+ → Loss

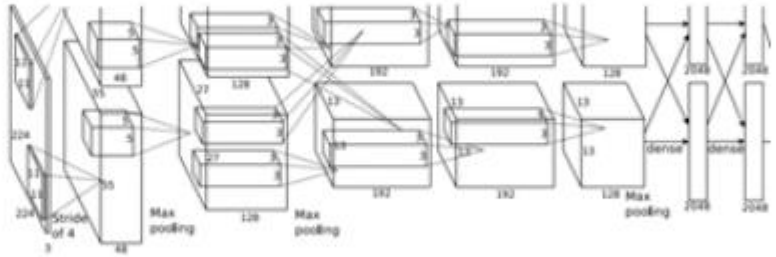
Treat localization as a regression problem!

Multiple Object Detection!

- Sliding window Solution!



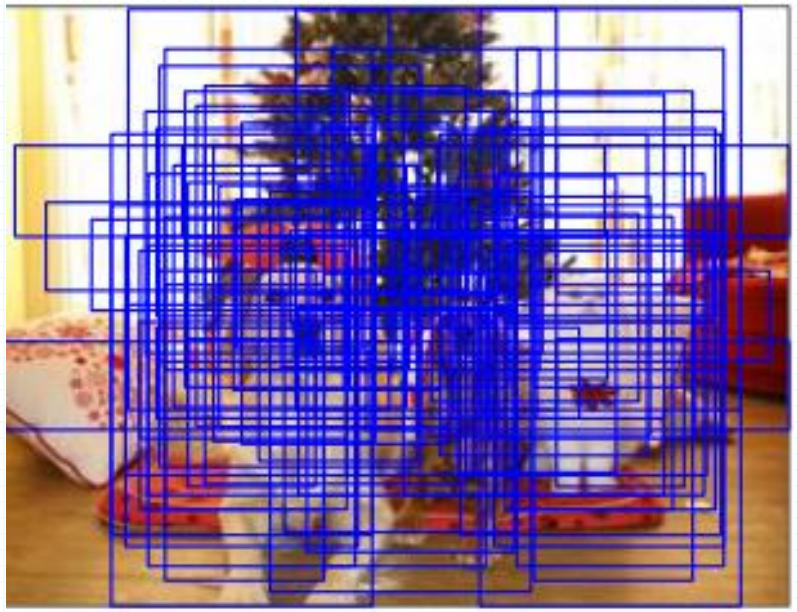
Dog? NO
Cat? NO
Background? YES



Dog? YES
Cat? NO
Background? NO

Multiple Object Detection!

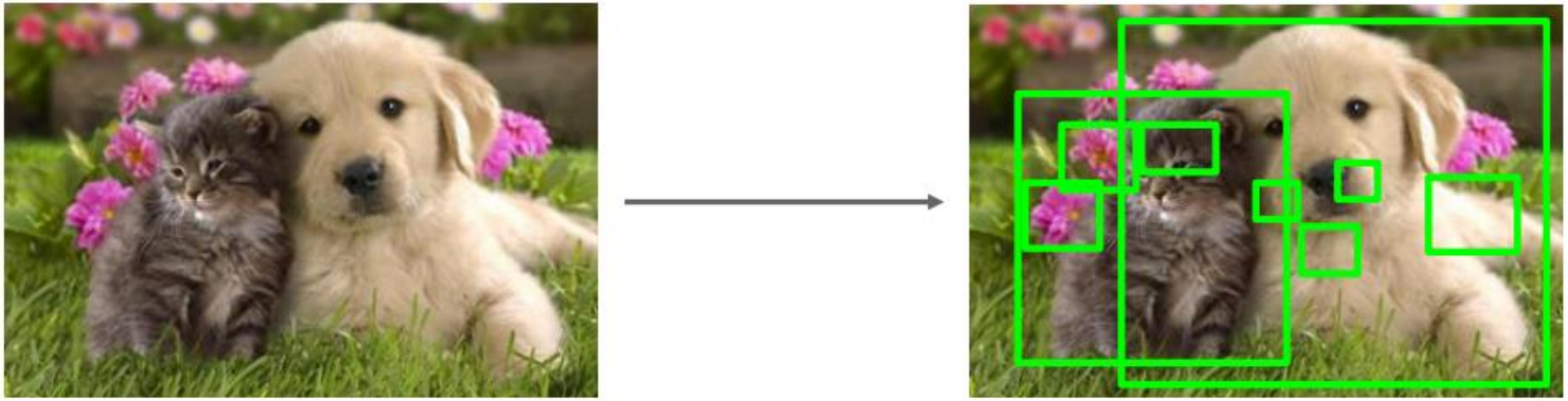
- Sliding window Solution!



Problem: Need to apply CNN to huge number of locations, scales, and aspect ratios, very computationally expensive!

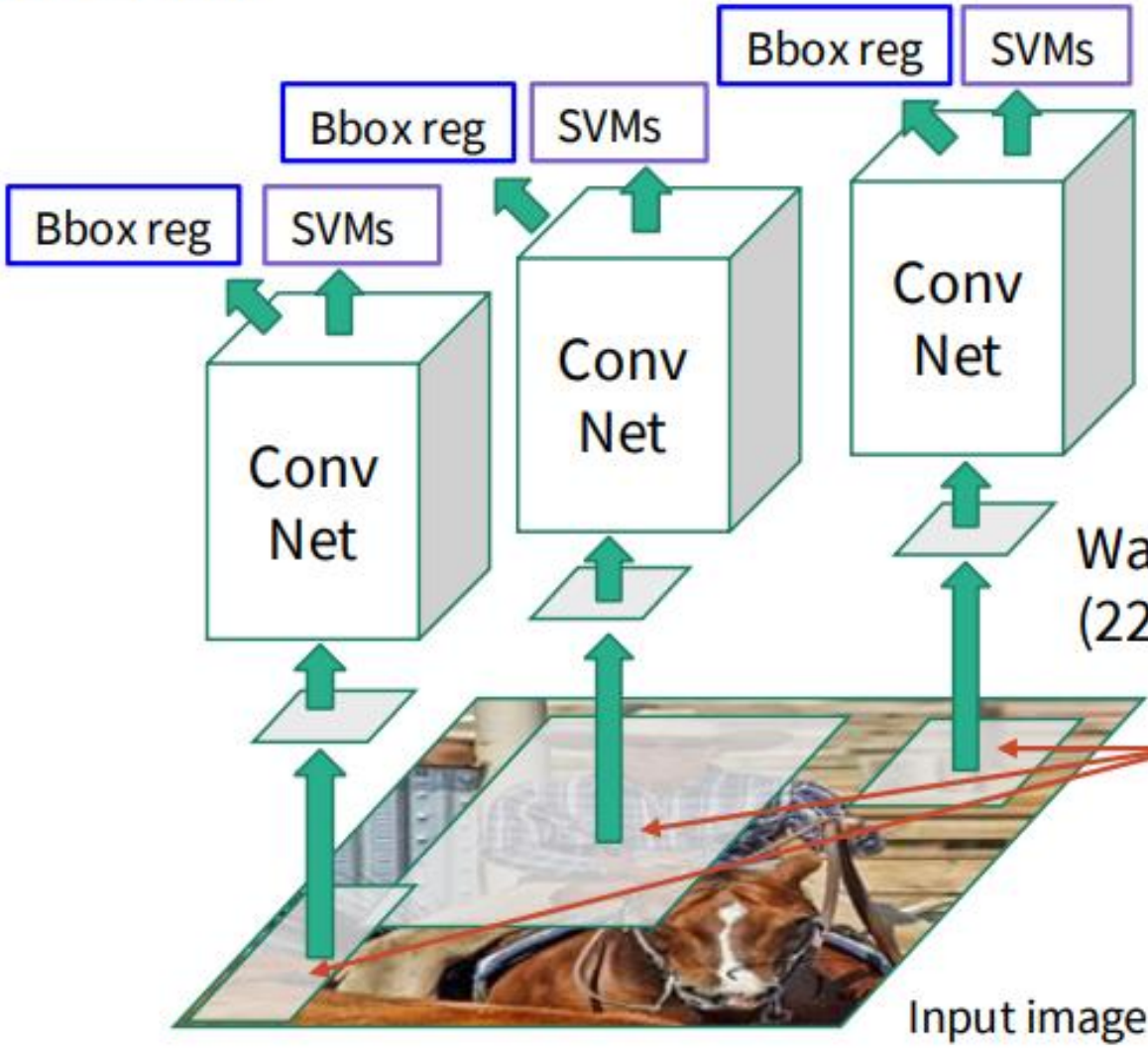
Multiple Object Detection
Better Solution – R CNN (Region Proposals)

- Find “blobby” image regions that are likely to contain objects
- Relatively fast to run; e.g. Selective Search gives 2000 region proposals in a few seconds on CPU



R-CNN

Predict "corrections" to the RoI: 4 numbers: (dx, dy, dw, dh)



Classify regions with SVMs

Forward each region through ConvNet

Warped image regions (224x224 pixels)

Regions of Interest (RoI) from a proposal method (~2k)

Problem: Very slow! Need to do ~2k independent forward passes for each image!

Girshick et al, "Rich feature hierarchies for accurate object detection and semantic segmentation", CVPR 2014.
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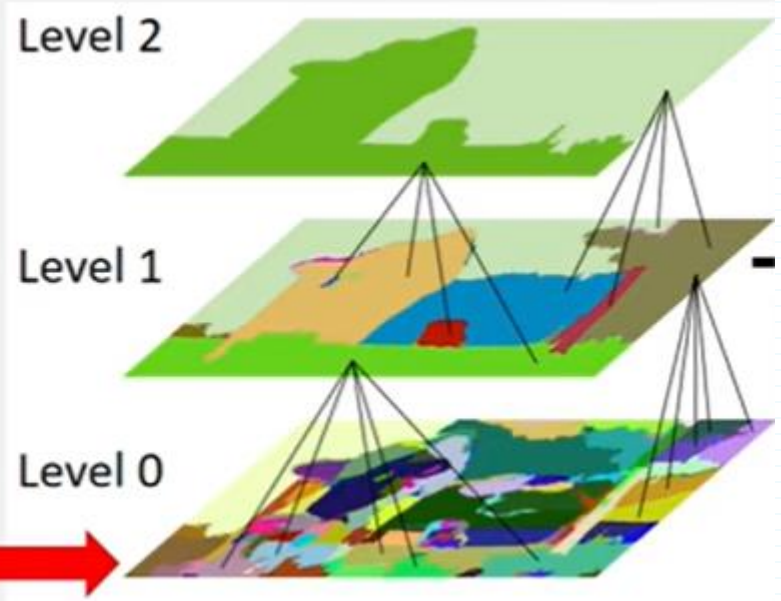
Multiple Object Detection – R-CNN
(1) Generate Region Proposal

Original Image

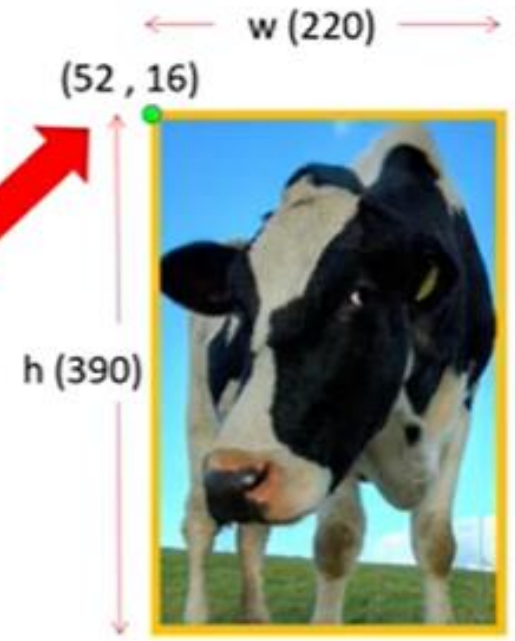


Output of the selective search is region proposals.

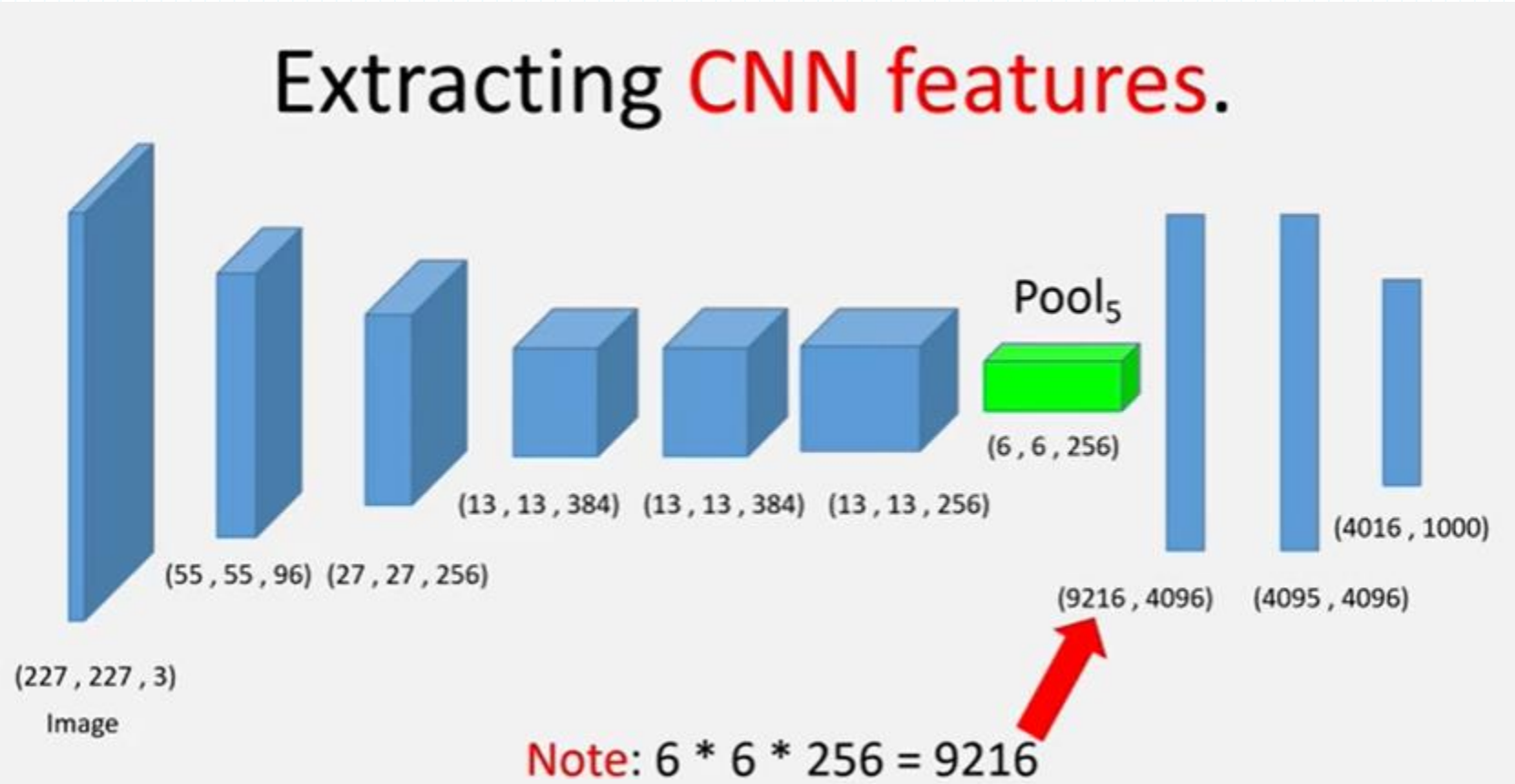
Region	x	y	w	h	level
r_1	21	35	10	12	0
r_2	...	...	...		0
r_3	...				0

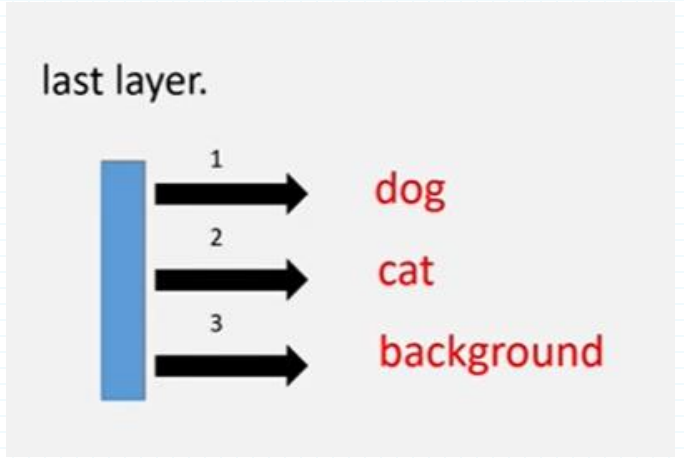
Multiple Object Detection – R-CNN
(2) Generate Region Proposal

Region	x	y	w	h	level
r_1	21	35	10	12	0
r_2	...	...	...		0
r_3	...				0
...		...			0
...			...		0
r_n				...	0
r_{n+1}	52	16	220	390	1
...	...				1
r_m		...			2



Multiple Object Detection – R-CNN
(2) Classify Region Proposal



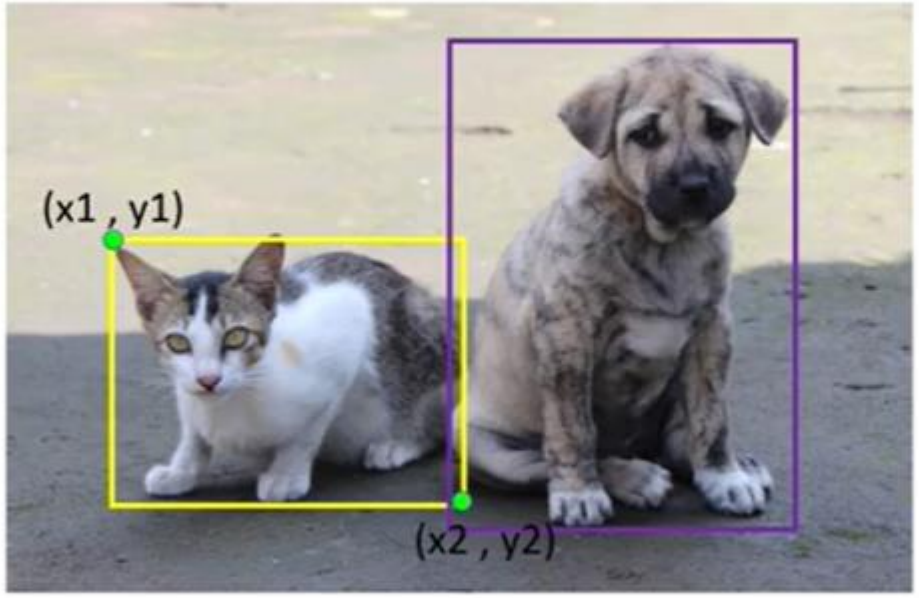


Fine Tune AlexNet.

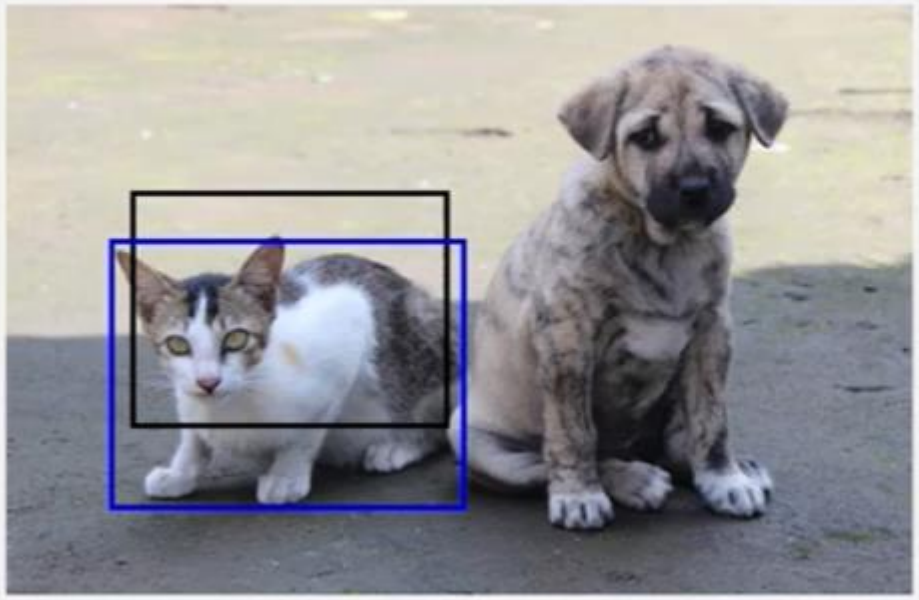
1. Remove last layer and replace by a new layer.
2. Redefine dataset and classify region proposals (RP).

Multiple Object Detection – R-CNN
(2) Classify Region Proposal (Dataset?)

Ground Truth bounding boxes.



Region Proposal bounding boxes.



IOU = 0.7

Positive for cat

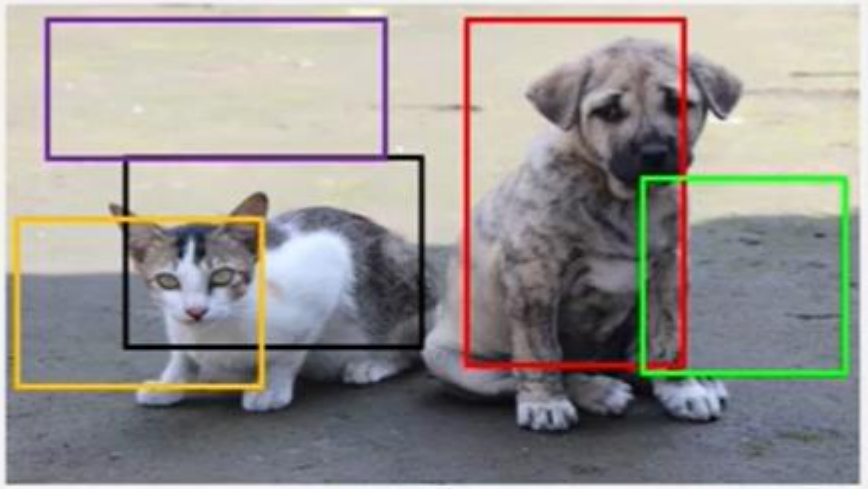
Ground truth boun

Classify Region Proposals.

Find Intersection Over Union (IOU) with Ground Truth Bounding Box

If IOU > 0.5 --> Positive for that class , else negative

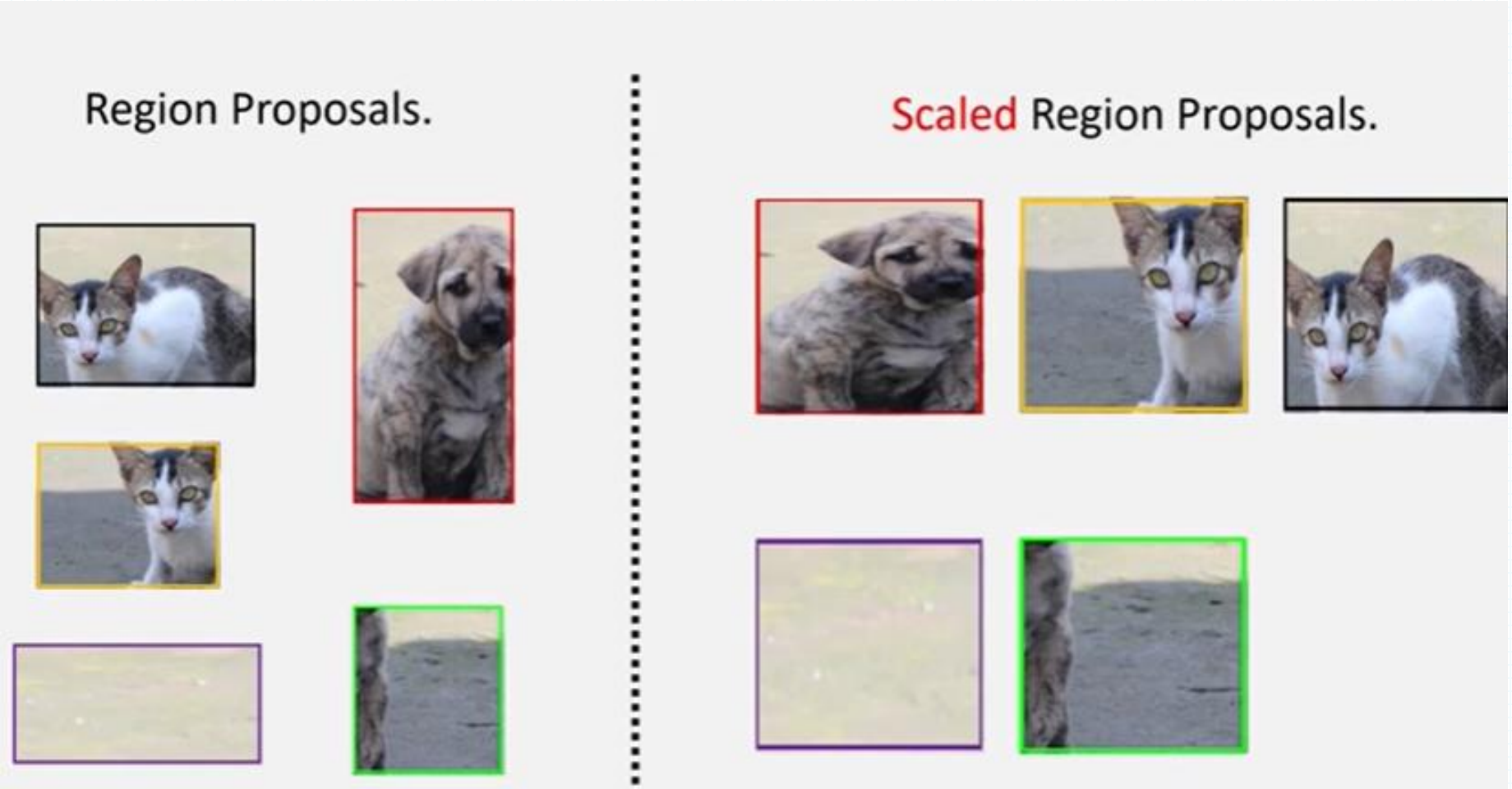
Multiple Object Detection – R-CNN
(2) Classify Region Proposal (Dataset?)



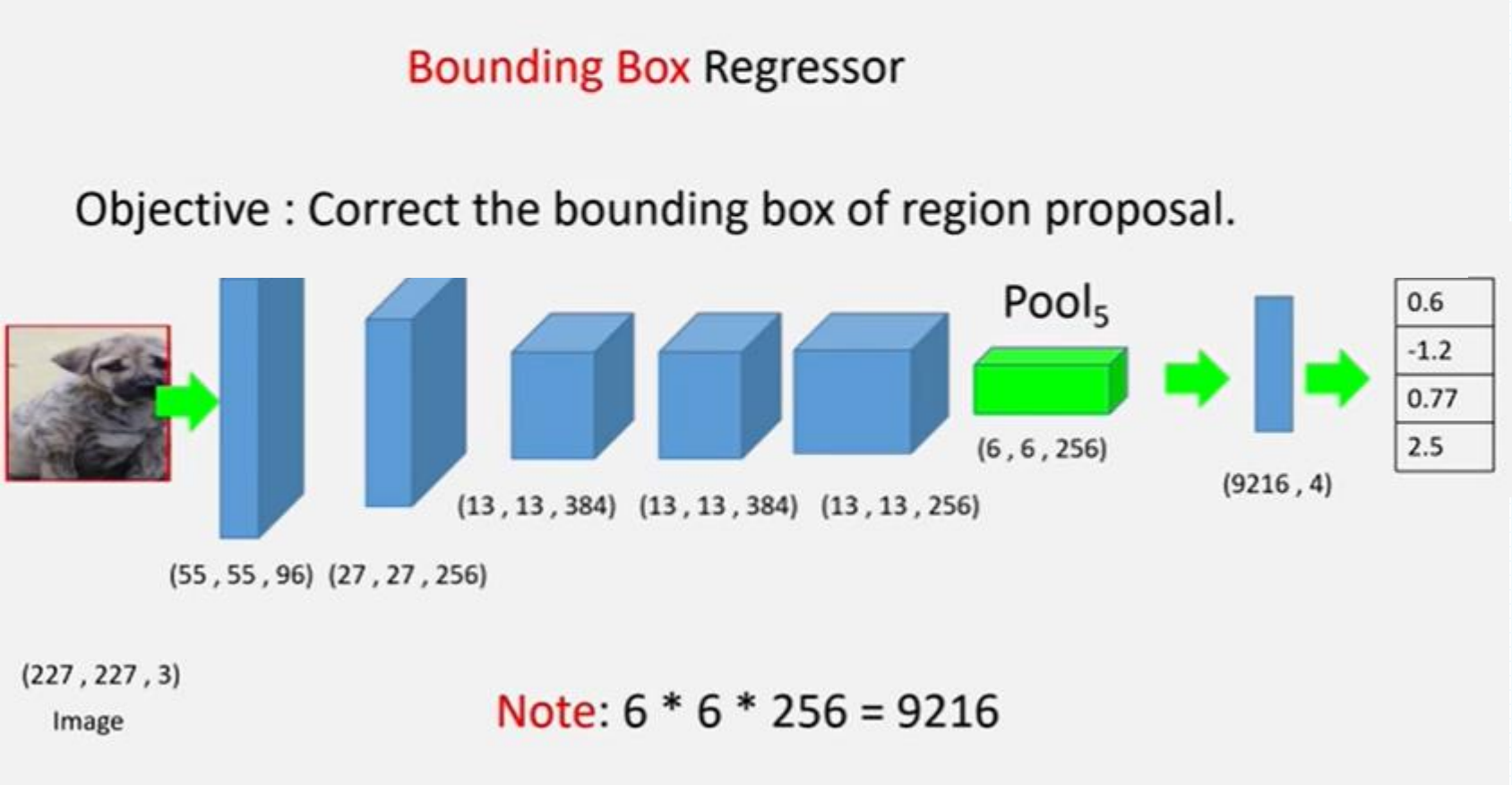
Dataset

Region	x1	y1	x2	y2	IOU	class (neuron)
Red	300	20	70	290	0.8	dog (1)
Green	375	180	60	70	0.3	negative (3)
Black	...	...	...	...	0.7	cat (2)
orange	...	...	...	...	0.4	negative (3)
purple	...	...	...	...	0.0	negative (3)

Multiple Object Detection – R-CNN
(2) Classify Region Proposal (Dataset?)



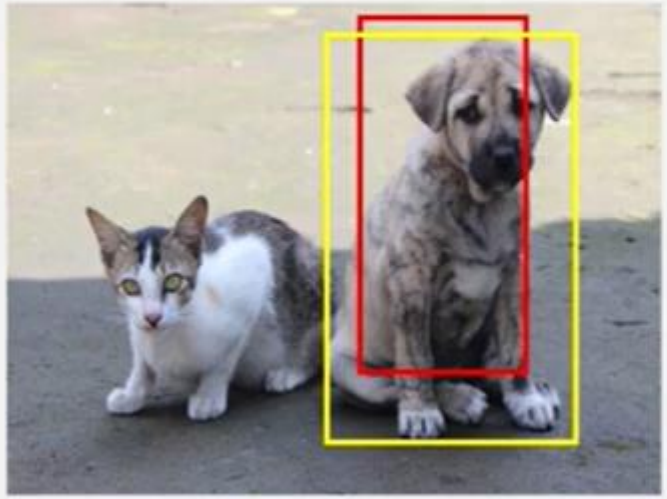
Multiple Object Detection – R-CNN Extra Step.. Bounding Box Correction



$$t_x = (G_x - P_x)/P_w$$
$$t_y = (G_y - P_y)/P_h$$
$$t_w = \log(G_w/P_w)$$
$$t_h = \log(G_h/P_h).$$

Multiple Object Detection – R-CNN
Extra Step.. Bounding Box Correction (Dataset?)

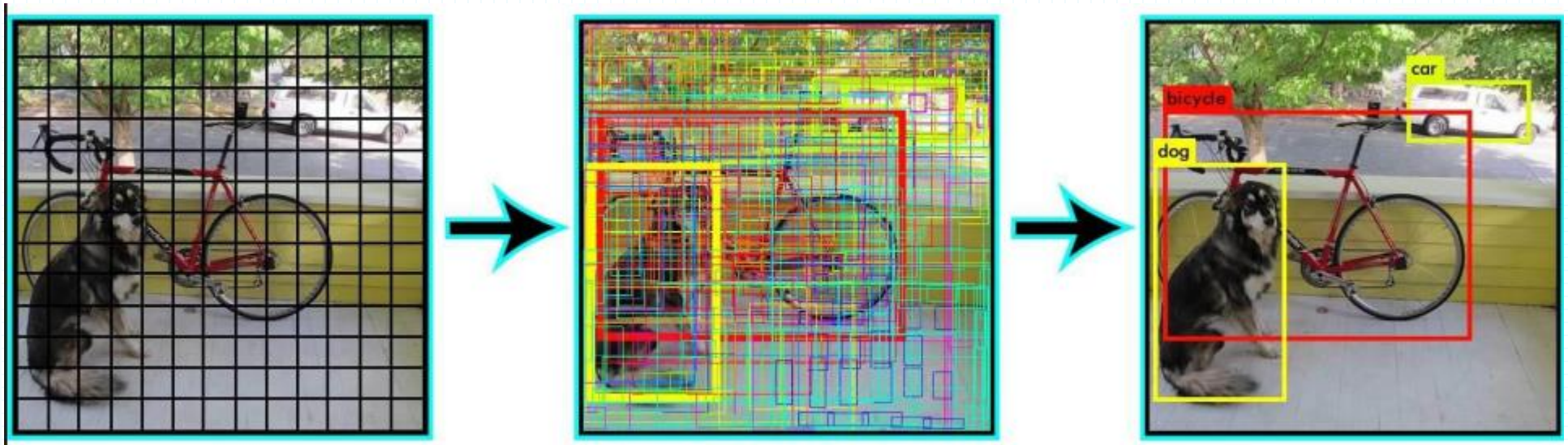
	Region	x1	y1	x2	y2	IOU	class (neuron)
✓	Red	300	20	70	290	0.8	dog
✗	Green	375	180	60	70	0.3	negative
✓	Black	...	...	...	...	0.7	cat
✗	orange	...	...	...	...	0.4	negative
✗	purple	...	...	...	...	0.0	negative



Ground truth

Region Proposal

YOLO



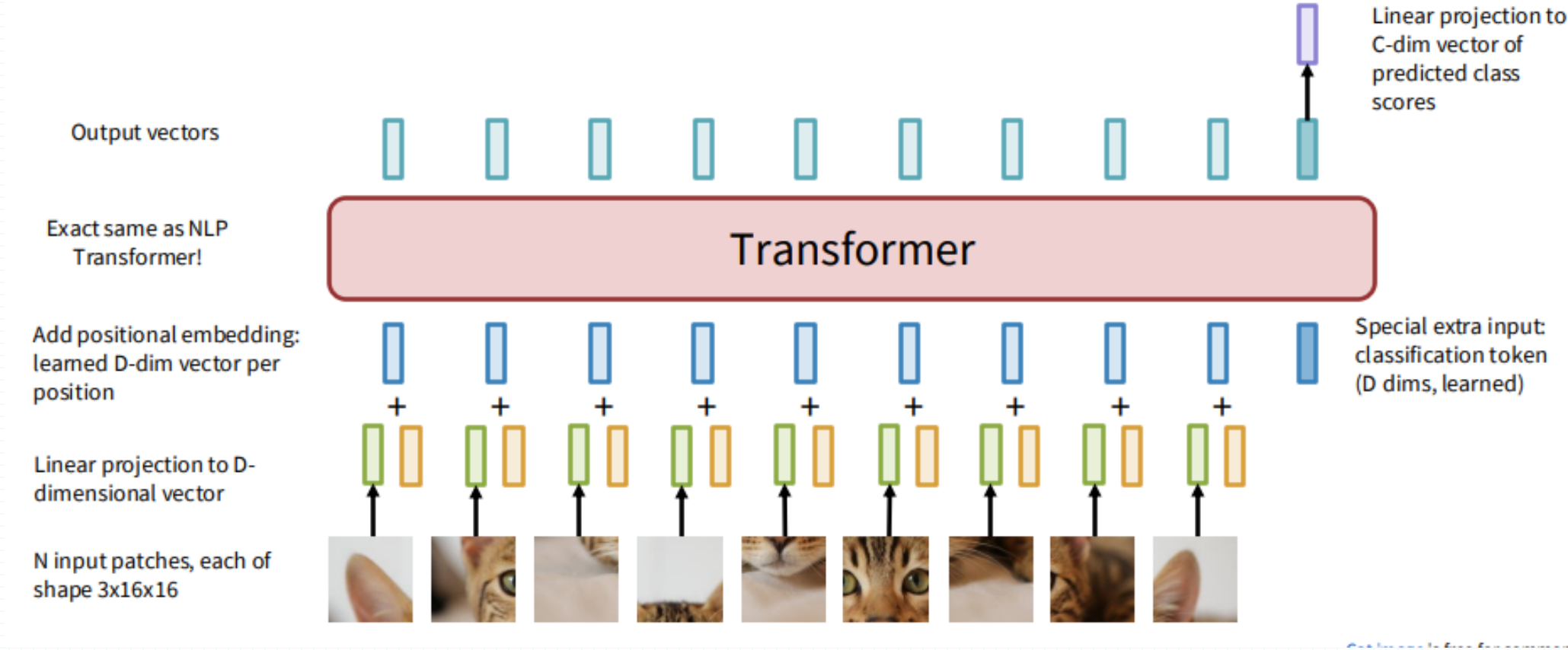
SxS Grid

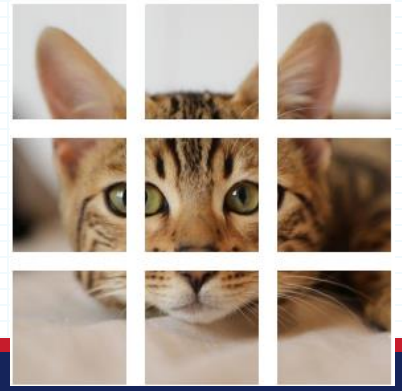
For each box output:

- P(object): probability that the box contains an object
- B bounding boxes (x, y, h, w)
- P(class): probability of belonging to a class

Transformers in CV

ViT as backbone





Object Detection with Transformers (DETR)