2D Object Detection and Segmentation

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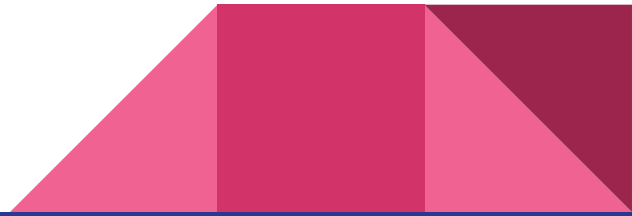
2019.10.29

Outline

- What is object detection and segmentation?
- Object detection: R-CNN
- Segmentation: U-Net



Why do we focus on R-CNN?

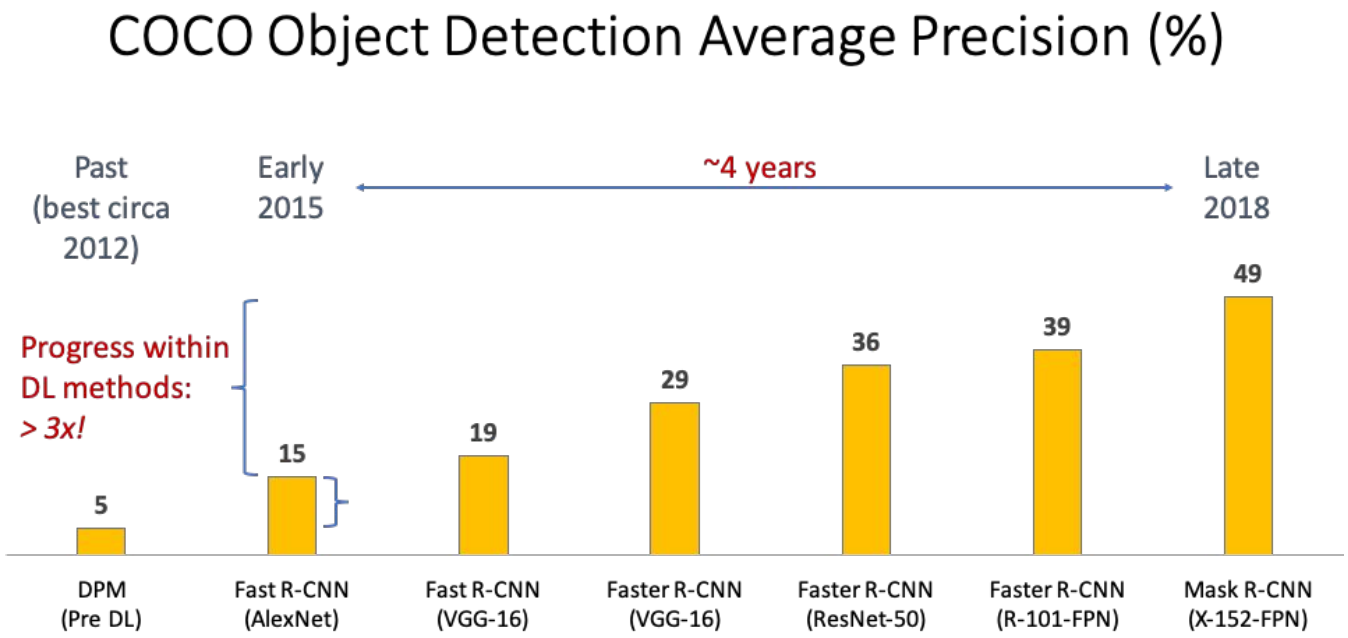


Figure from Ross Girshick tutorial at CVPR 2019

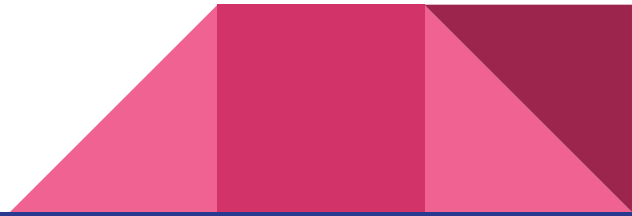
Resources

Tutorials of CVPR

- http://deeplearning.csail.mit.edu
- https://sites.google.com/view/cvpr2018-recognition-tutorial
- http://feichtenhofer.github.io/cvpr2019-recognition-tutorial

Github Repo

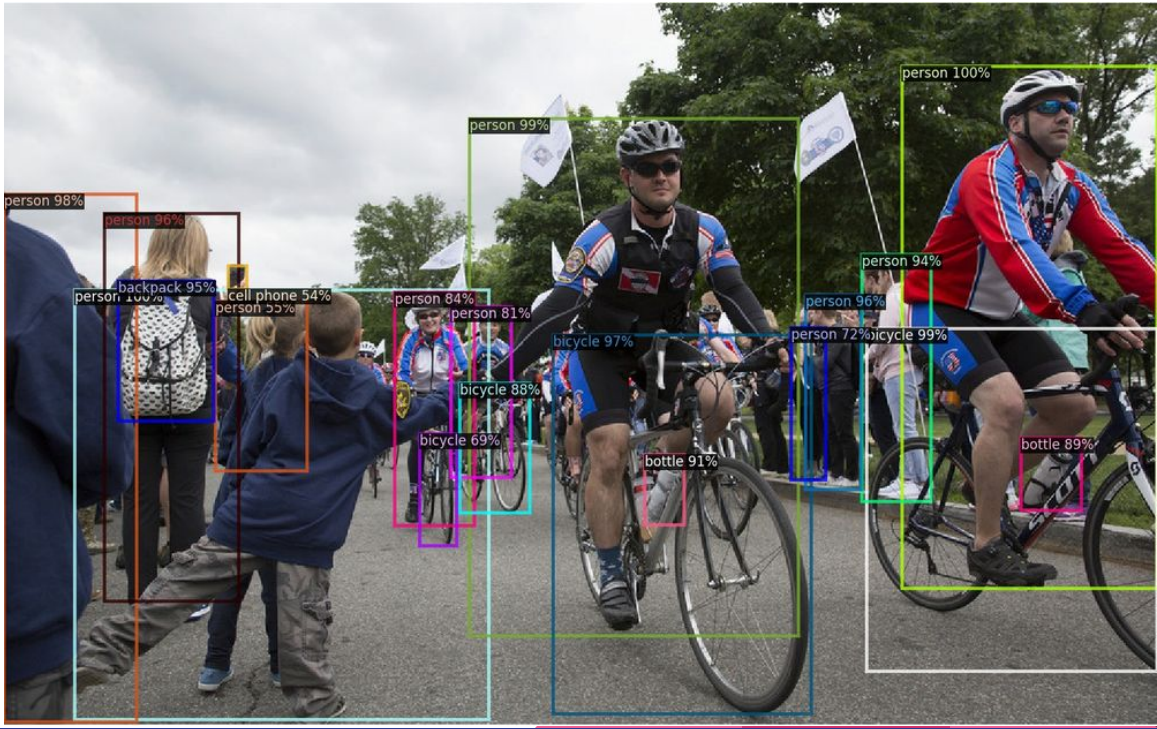
https://github.com/facebookresearch/detectron2



Background

How do we represent objects

- Bounding box



Figures from

How do we represent objects

- Bounding box
- Instance mask

Figures from

How do we represent objects

- Bounding box
- Instance mask
- Keypoint

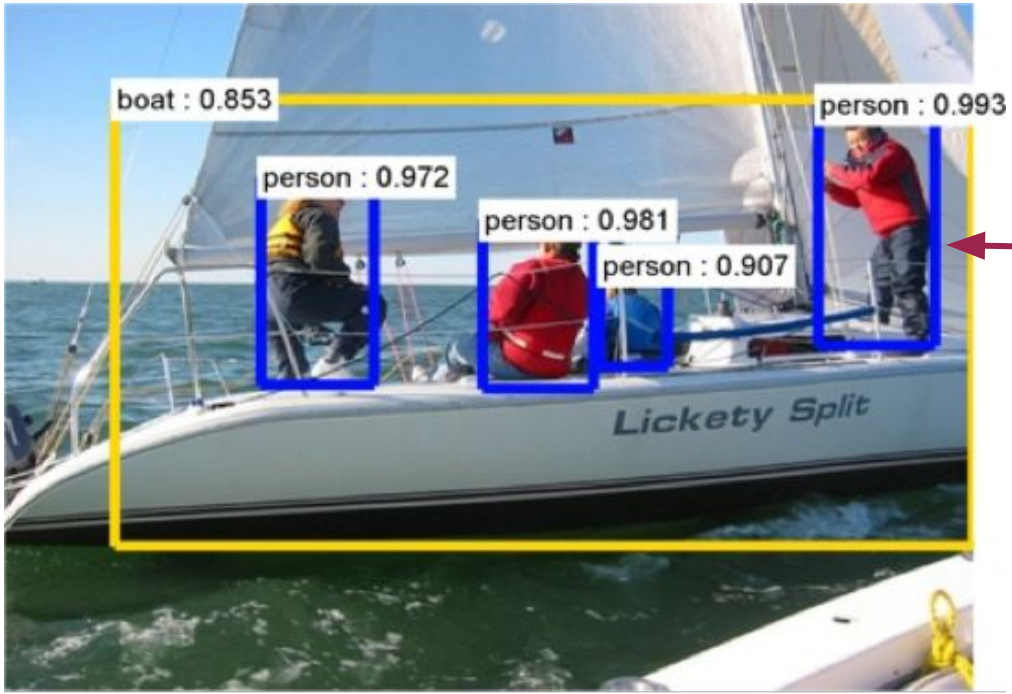
Figures from

How do we represent objects

- **Bounding box**
- Instance mask
- Keypoint

Figures from

Object Detection with Bounding Boxes



What? - Recognition/Classification

Where? - Localization/Regression

"Object detection"

Slides modified from Ross Girshick tutorial at CVPR 2019

Object Detection with Segmentation Masks

What? - Recognition

Where? - Segmentation

"Instance segmentation"

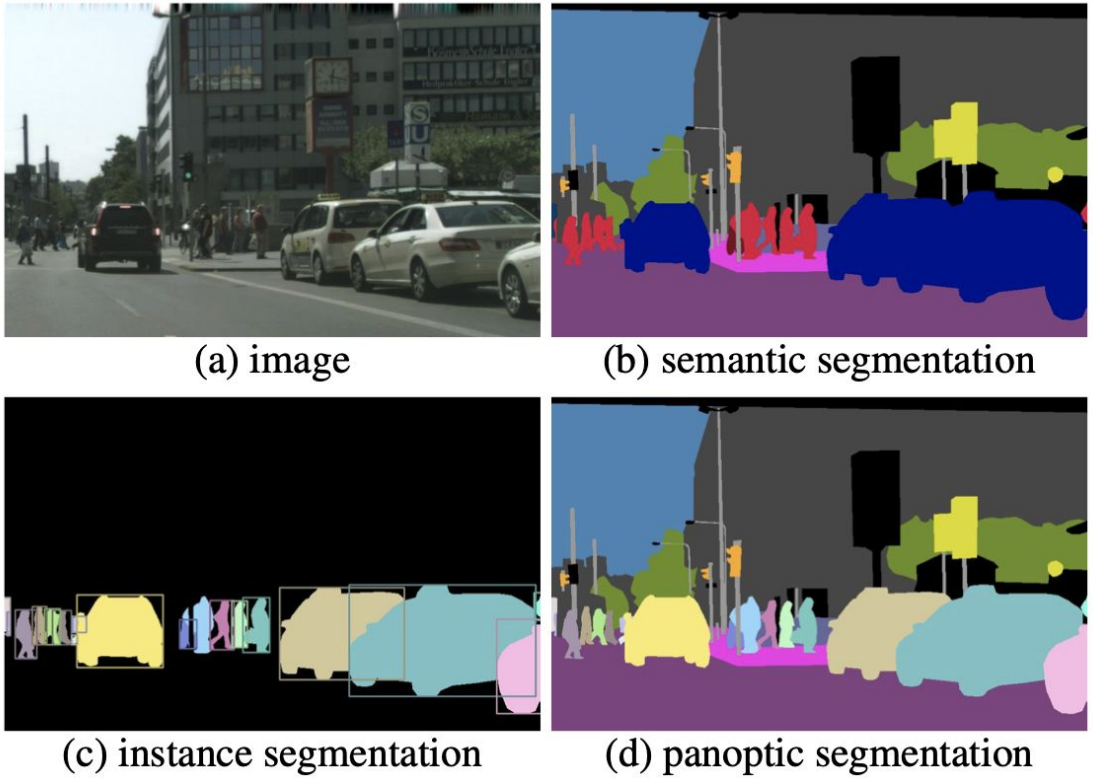
Slides modified from Ross Girshick tutorial at CVPR 2019

Semantic Segmentation

Predict a pixel-wise class label

Stuff: walls, buildings, sky, road

Things: human, cars, bikes



Figures from *Panoptic Segmentation*, CVPR 2019

Datasets

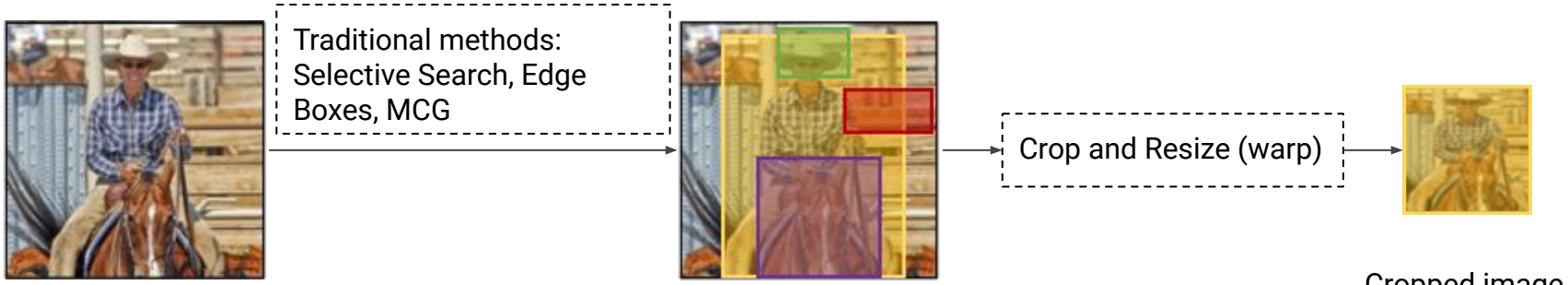


Microsoft COCO

Visual Object Classes Challenge 2012 (VOC2012)

R-CNN: Region-based CNN

Object Detection → Object Classification



We've already reduced object detection to object classification!

R-CNN

Computationally expensive

Input: an image

Traditional methods:
Selective Search, Edge Boxes, MCG

Proposals/Candidates

Cropped image
Region of Interests (RoI)

Crop and Resize (warp)

ConvNet

Class Probability

How probable is it a human?

BBox Regression

How can we modify this bounding box?

Slides modified from Ross Girshick tutorial at CVPR 2019

R-CNN: Crop→ CNN v.s. Fast R-CNN: CNN → Crop

Fast R-CNN

Input: an image

Traditional methods:
Selective Search, Edge Boxes, MCG

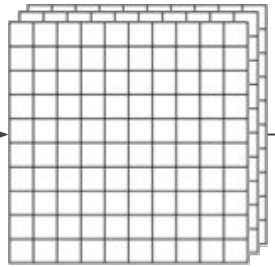
Proposals/Candidates
Region of Interests (RoI)

Class Probability

BBox Regression

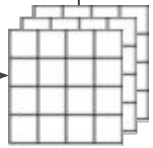
ConvNet
Multilayer Perceptron (MLP)

ConvNet



RoI-Pool

Similar to Crop & Resize

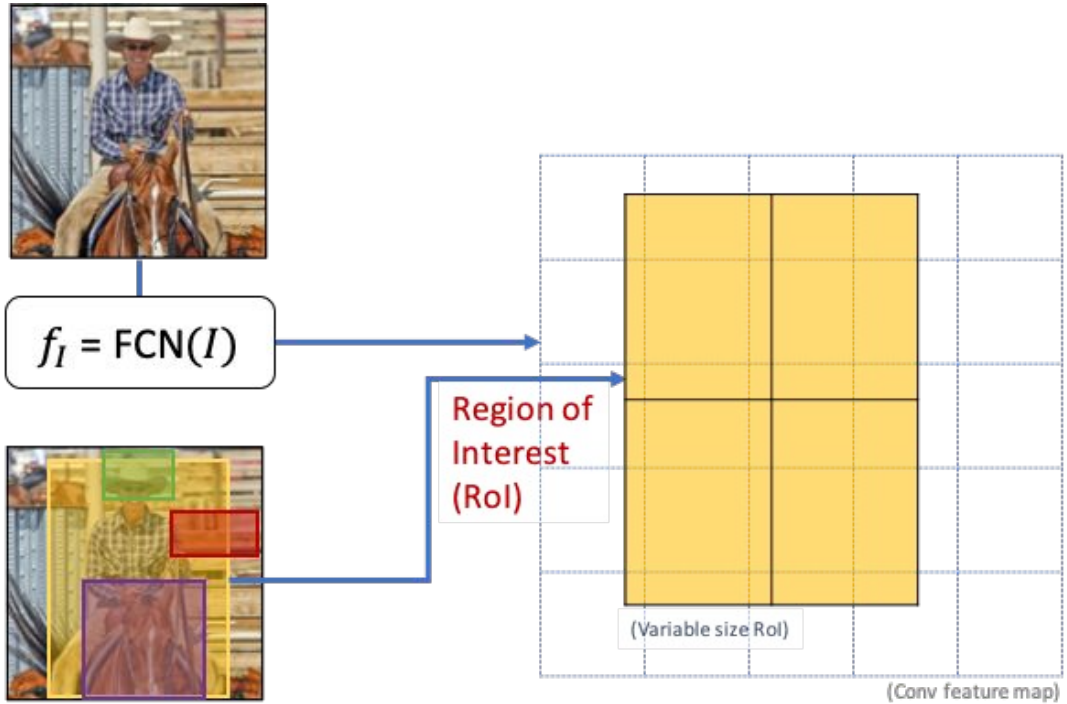


Feature map for an image

Feature map for a RoI

Slides modified from Ross Girshick tutorial at CVPR 2019

RoI Pooling (for each proposal)



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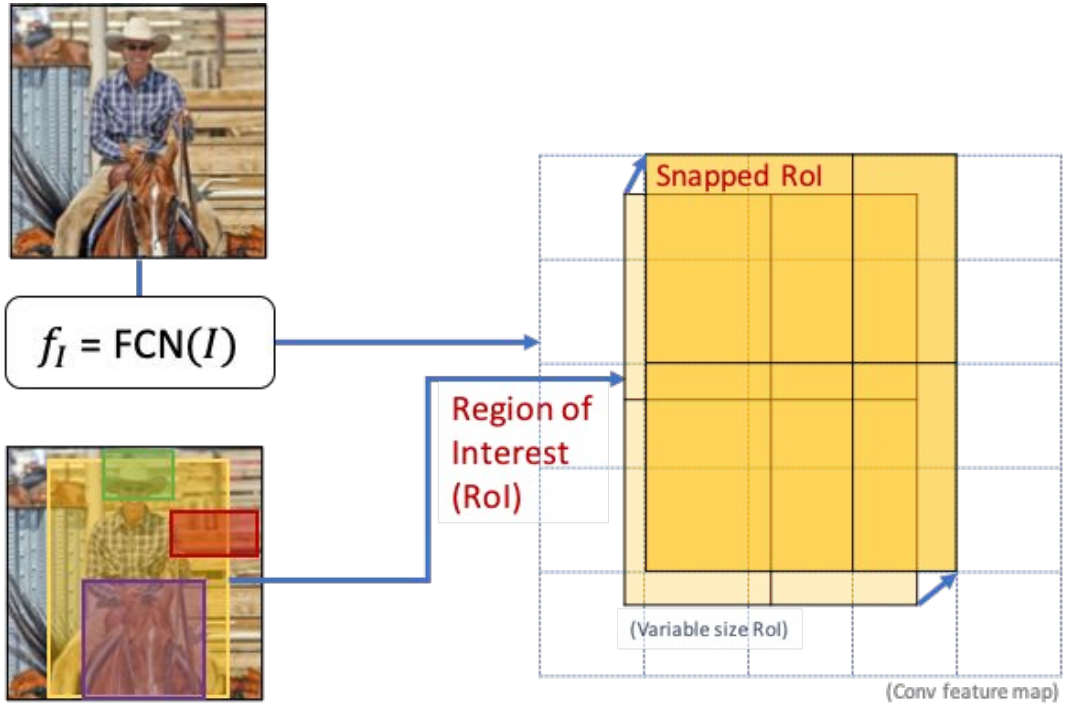

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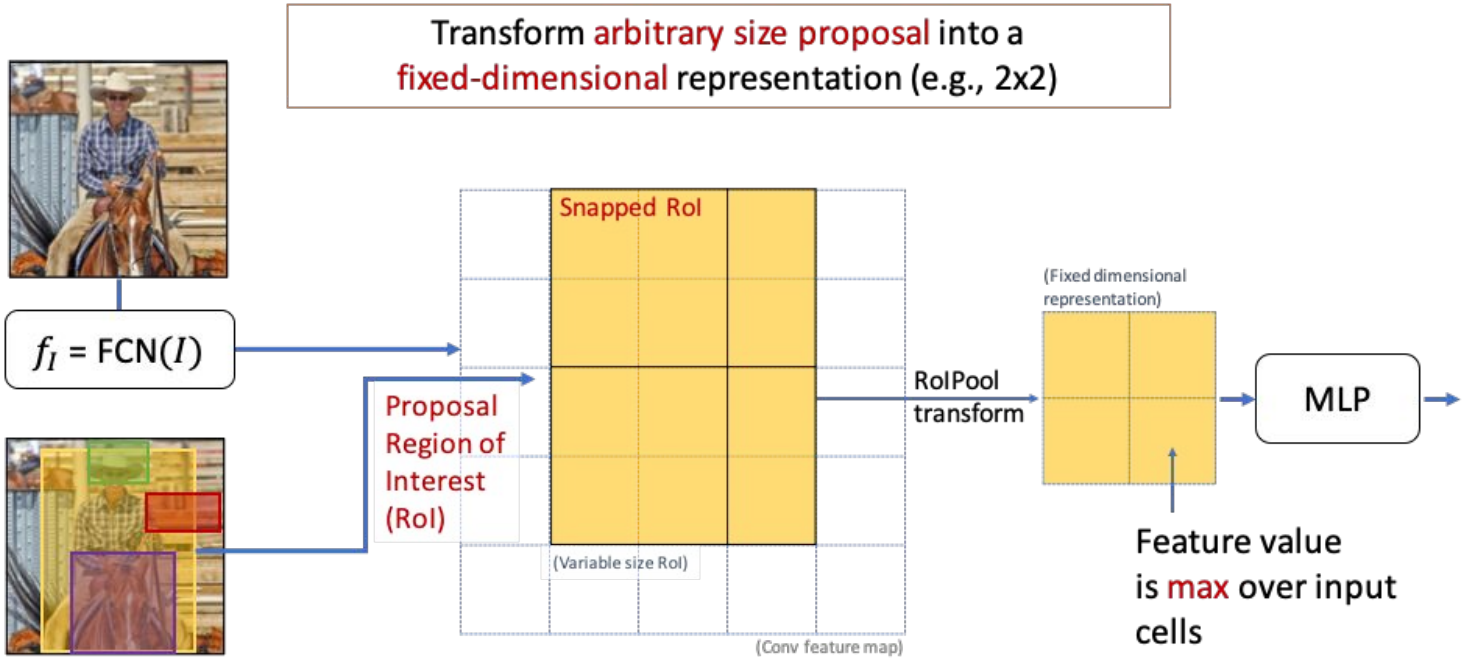


Slides modified from Ross Girshick tutorial at CVPR 2019

Fast R-CNN

Not good enough

Input: an image

Traditional methods:
Selective Search, Edge Boxes, MCG

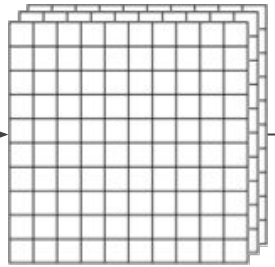
Proposals/Candidates
Region of Interests (RoI)

Class Probability

BBox Regression

ConvNet
Multilayer Perceptron (MLP)

ConvNet



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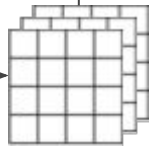
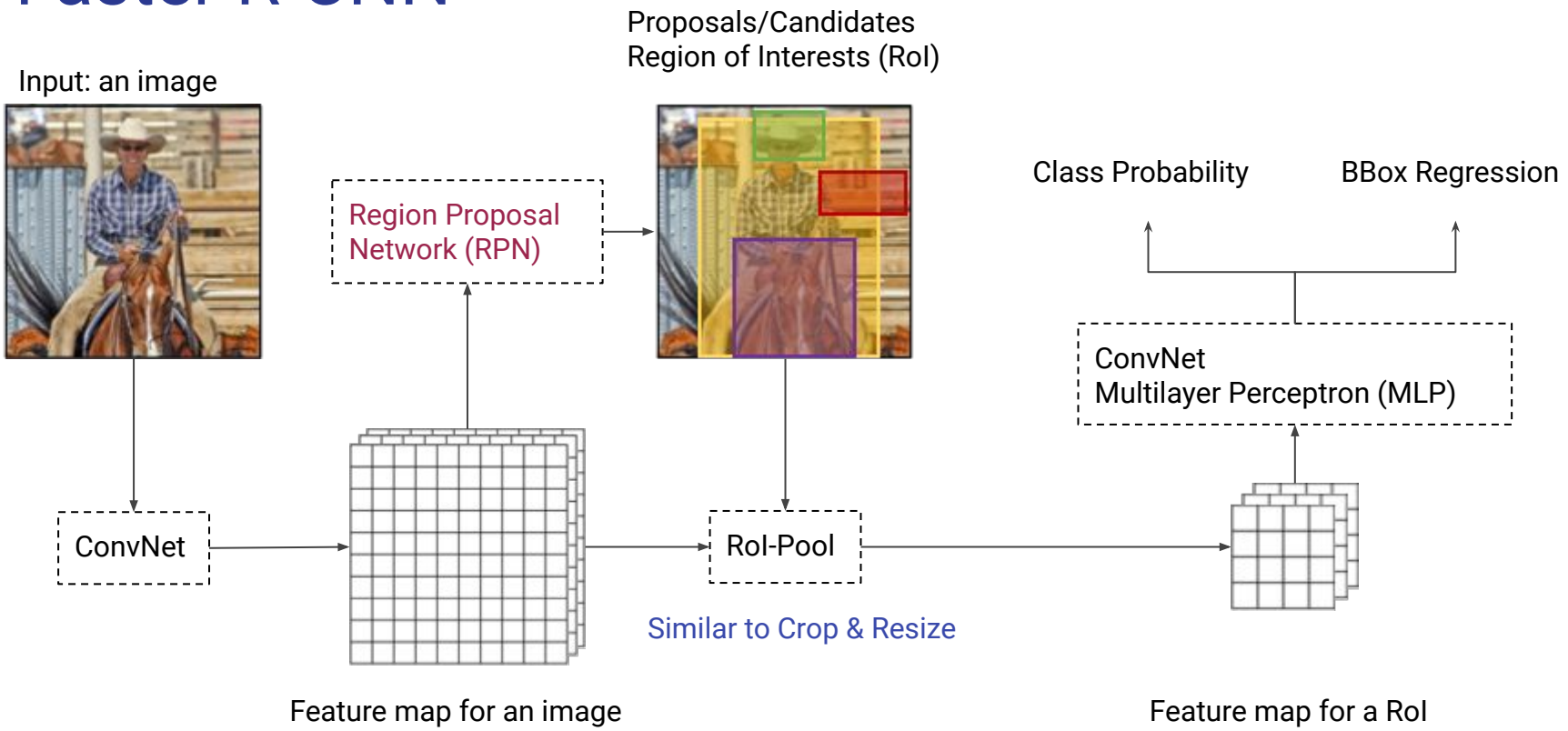


Feature map for an image

Feature map for a RoI

Slides modified from Ross Girshick tutorial at CVPR 2019

Faster R-CNN



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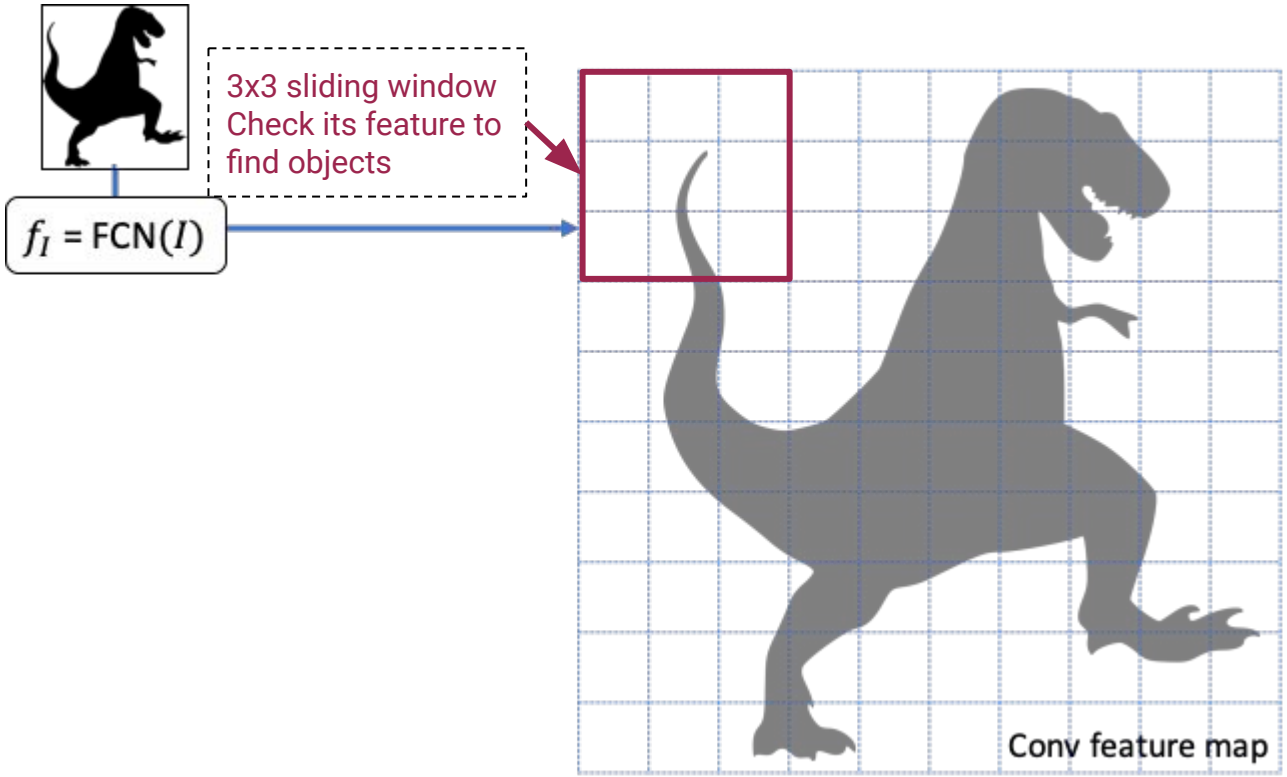
RPN: Region Proposal Network



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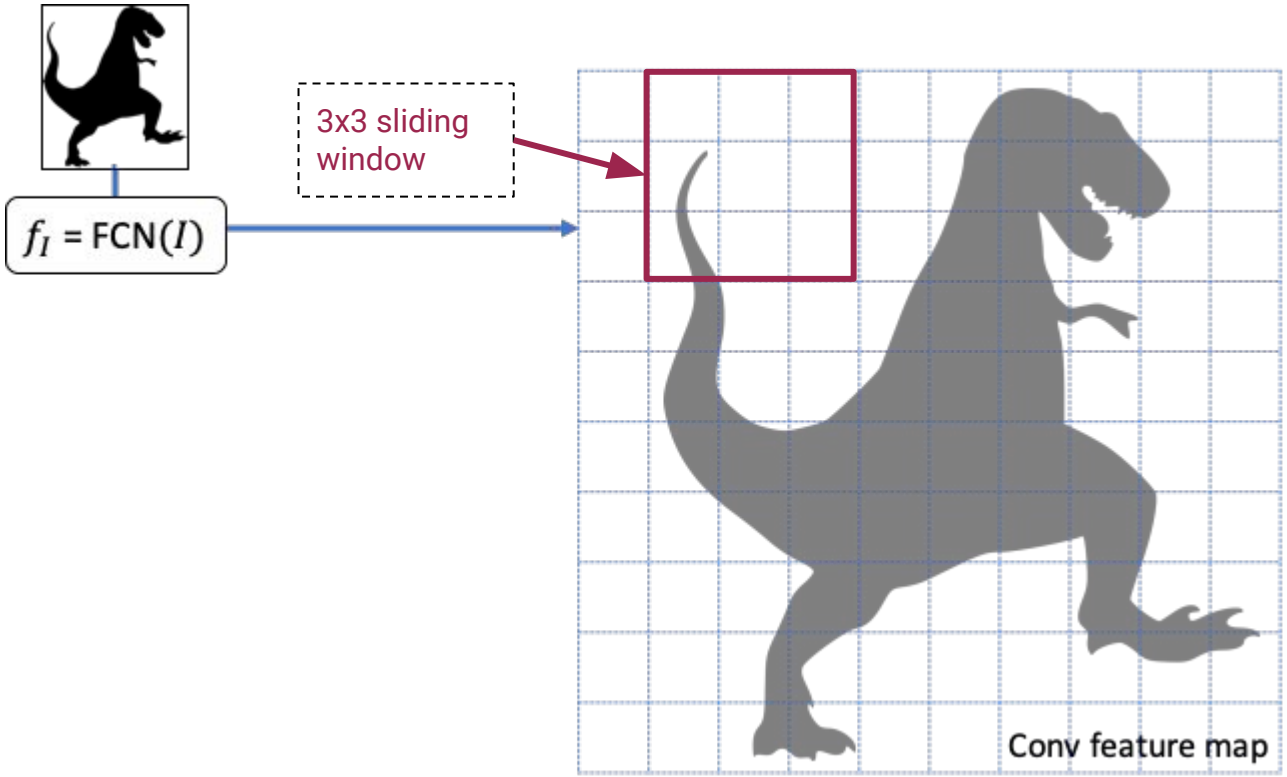
RPN: Region Proposal Network



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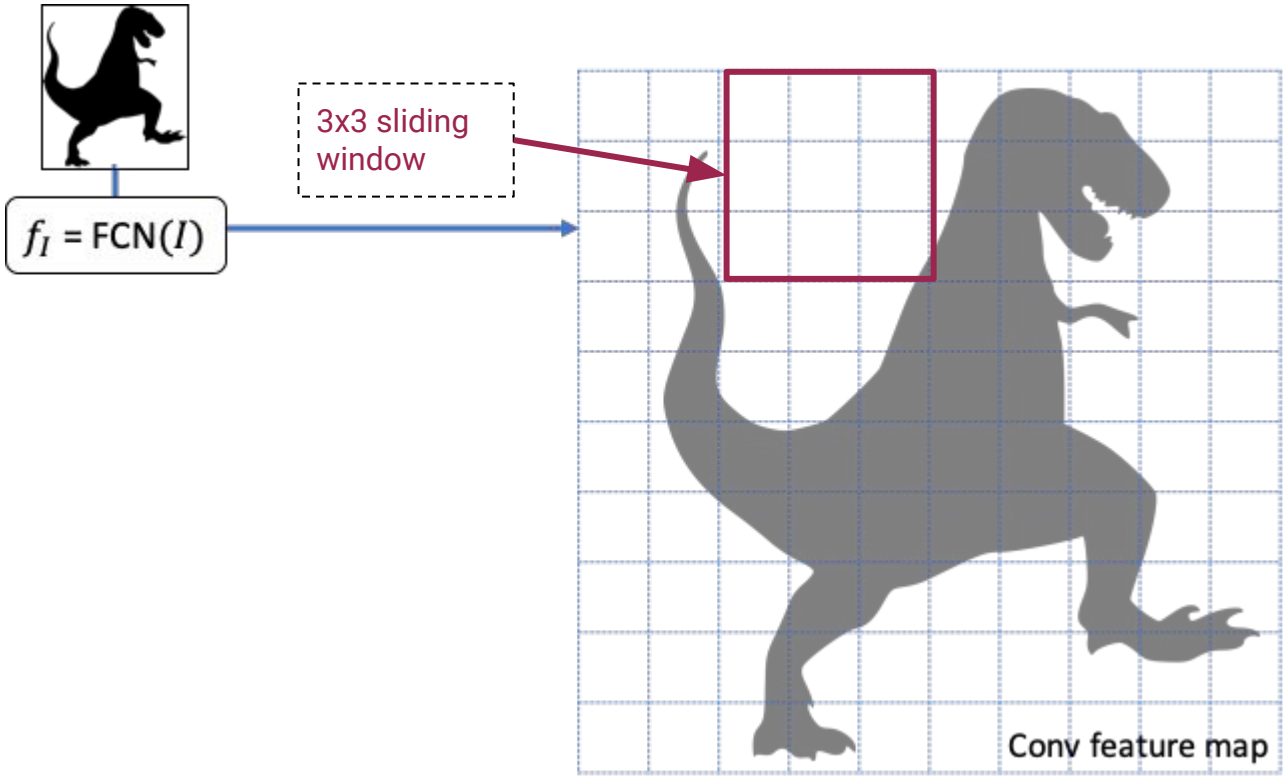

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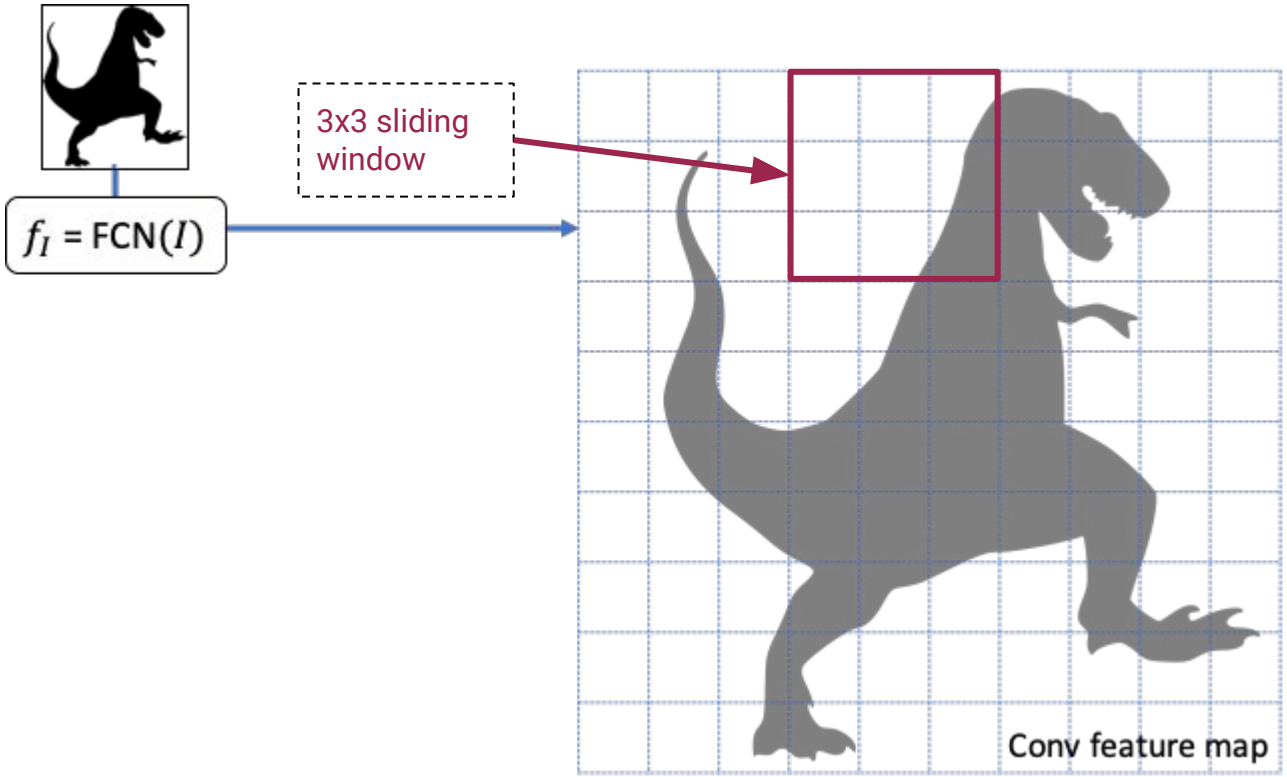

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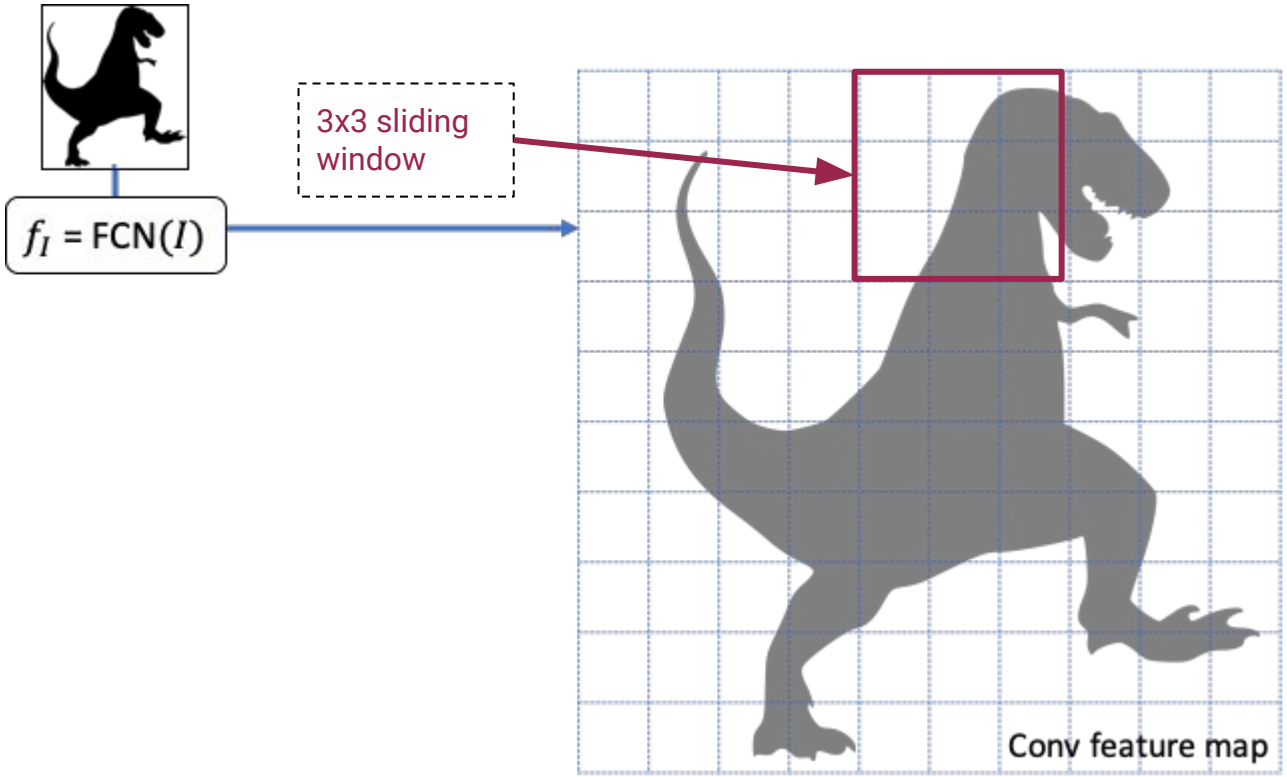
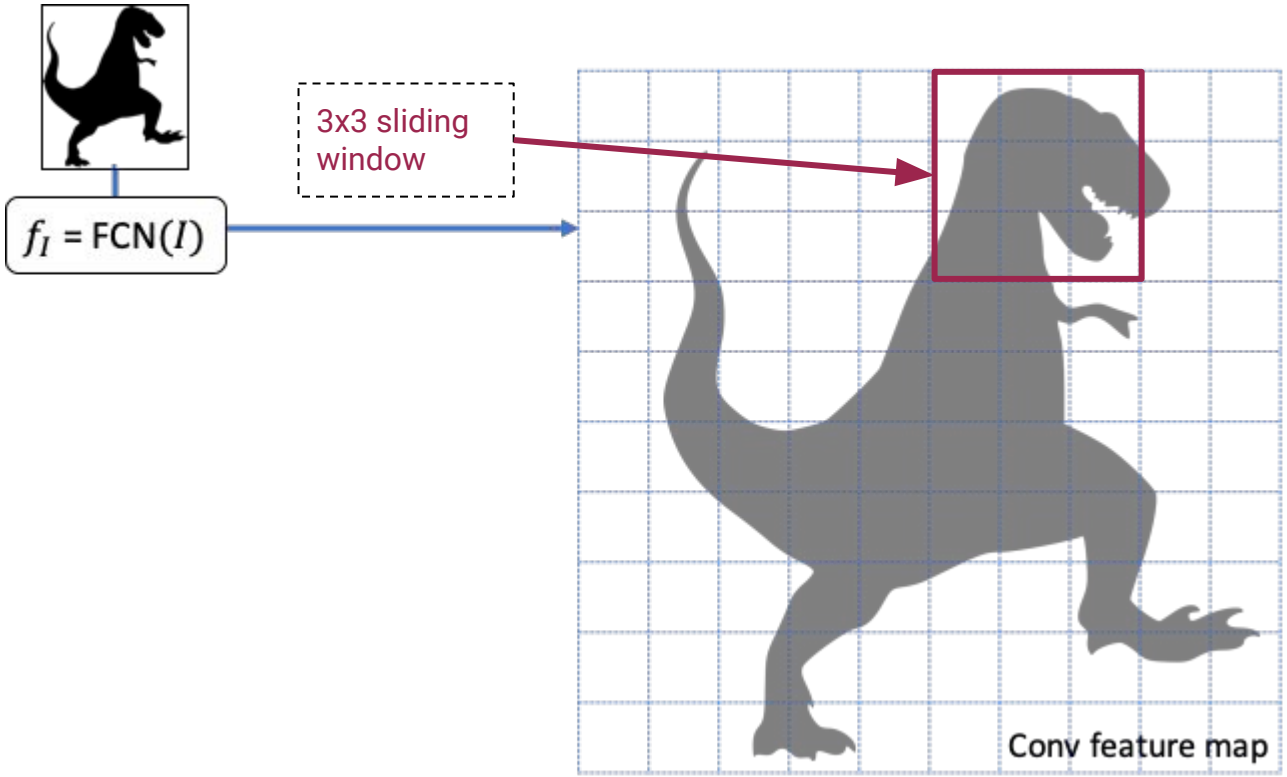


Slides modified from Ross Girshick tutorial at CVPR 2019

RPN: Region Proposal Network



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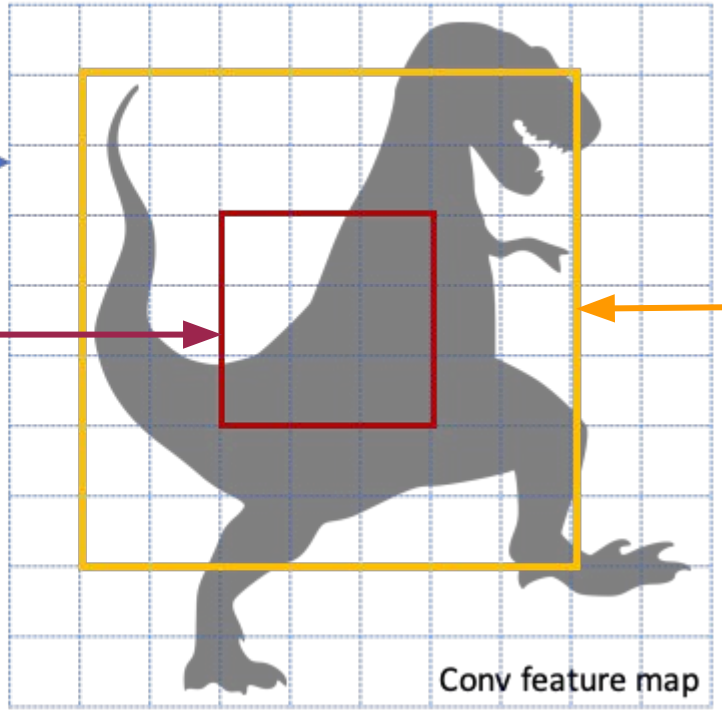
RPN: Anchor Box

$f_I = \text{FCN}(I)$



3x3 sliding window
But what's the meaning of this feature?

For this 3x3 window, we predefine a 7x7 "anchor box".

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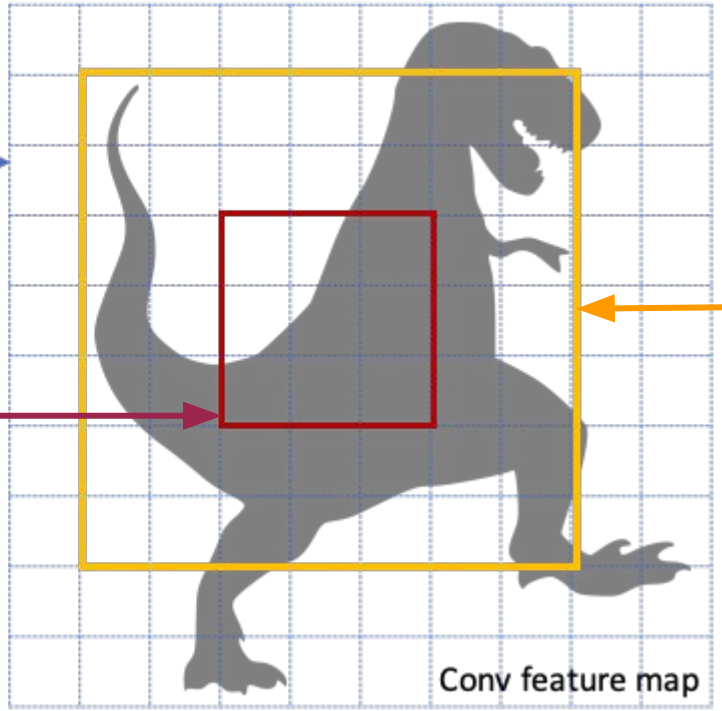
RPN: Anchor Box

$f_I = \text{FCN}(I)$



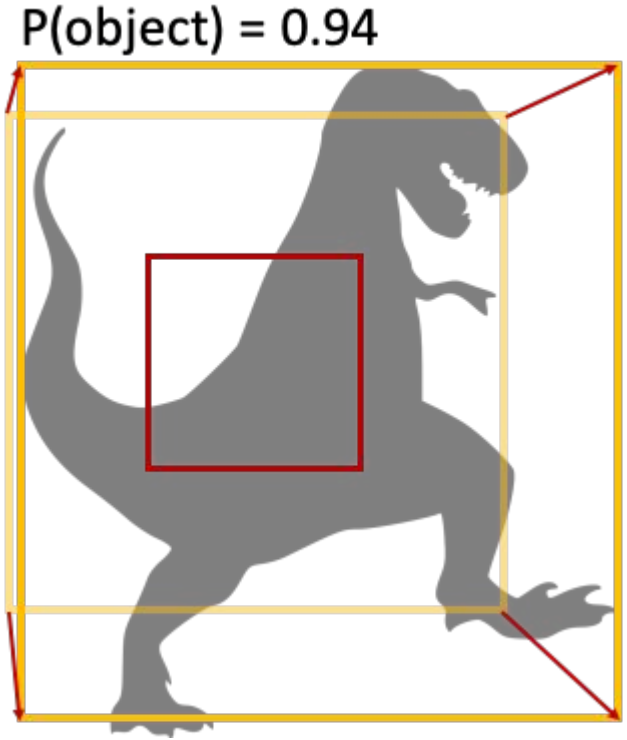
3x3 sliding window
But what's the meaning of this feature?

- Is the anchor box an object?
- Where is the accurate box?

For this 3x3 window, we predefine a 7x7 "anchor box".

Slides modified from Ross Girshick tutorial at CVPR 2019

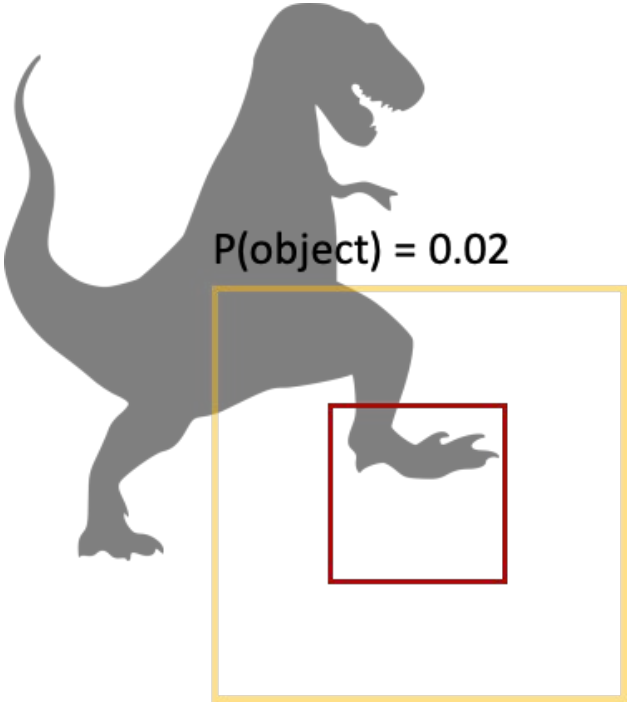
RPN: Prediction (on object)



Direction to the accurate box

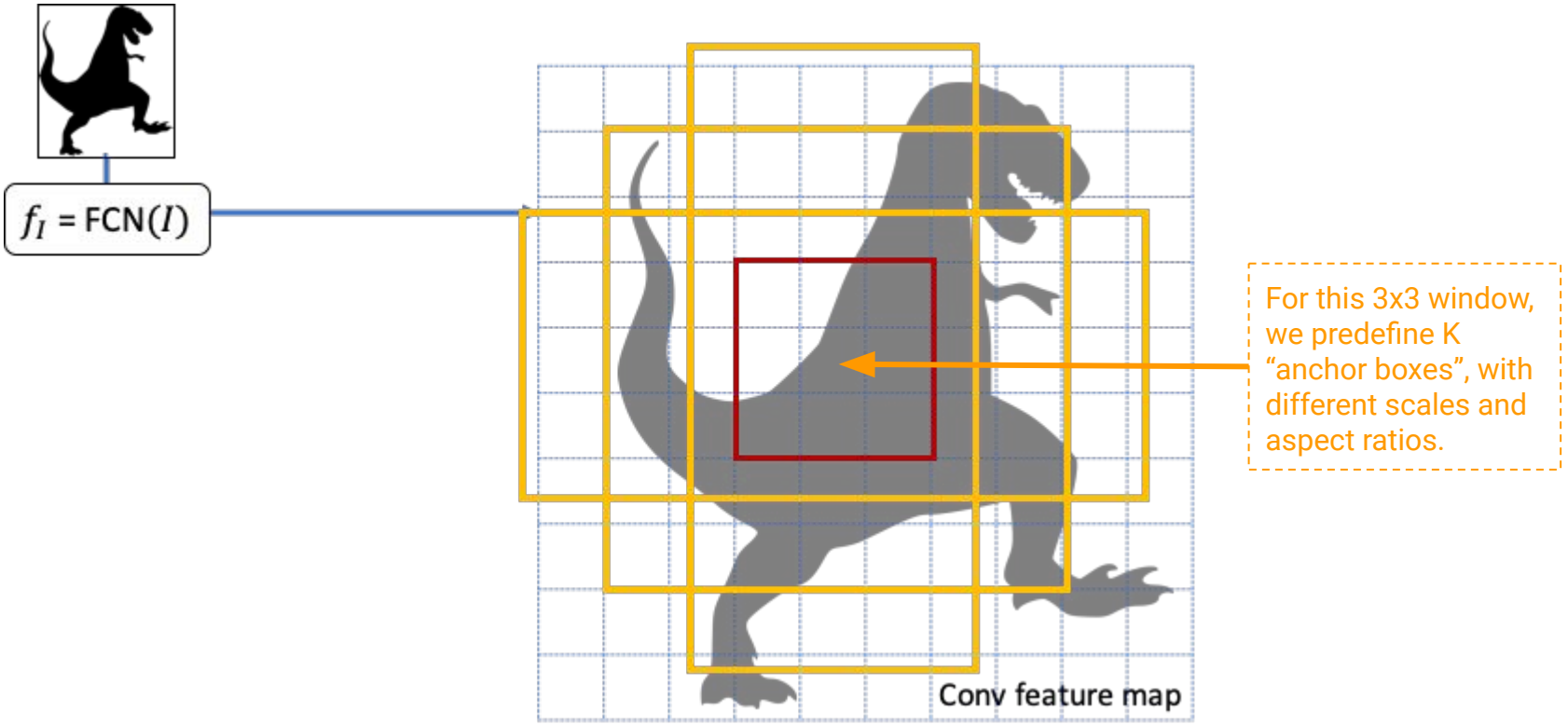
Slides modified from Ross Girshick tutorial at CVPR 2019

RPN: Prediction (off object)



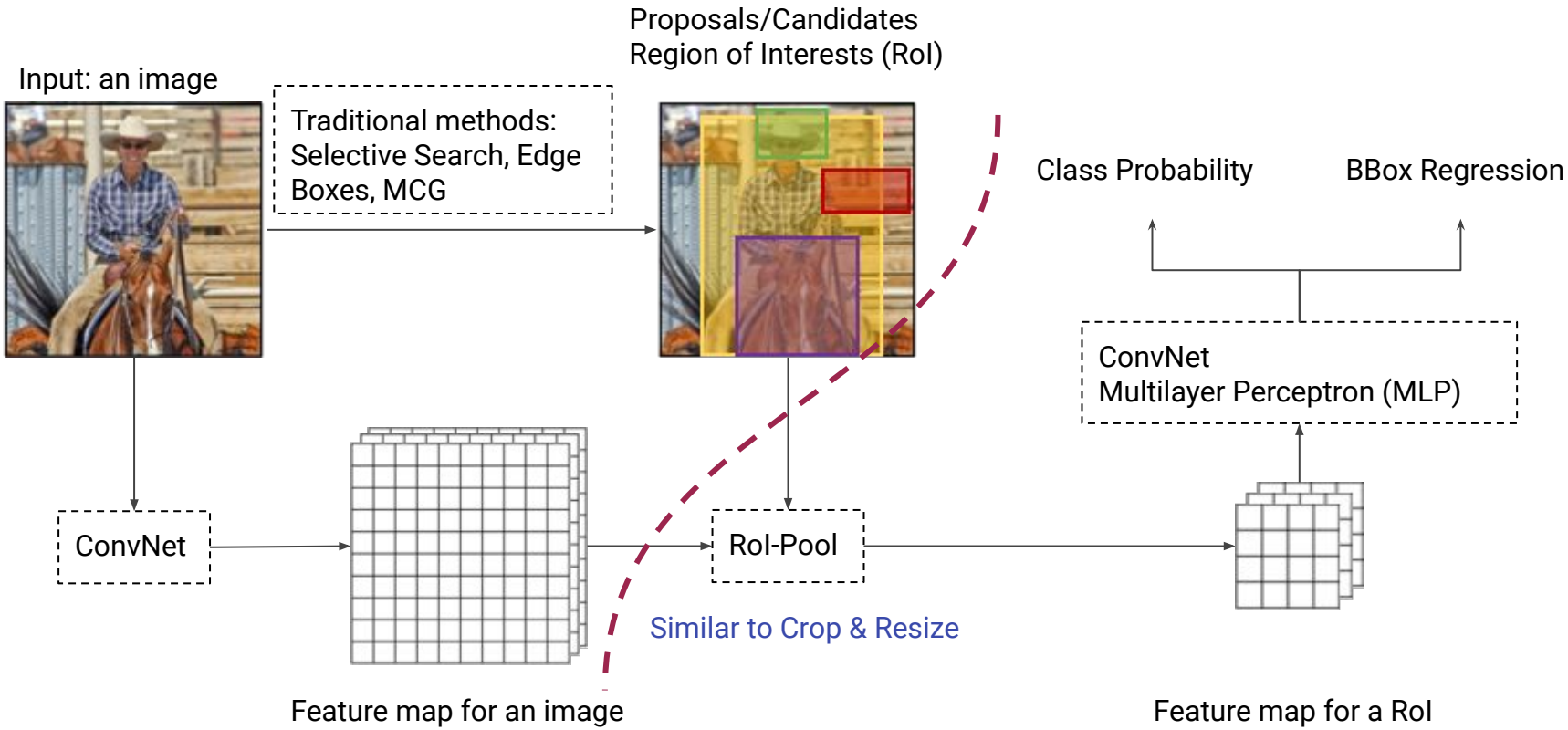
Slides modified from Ross Girshick tutorial at CVPR 2019

RPN: Multiple Anchors

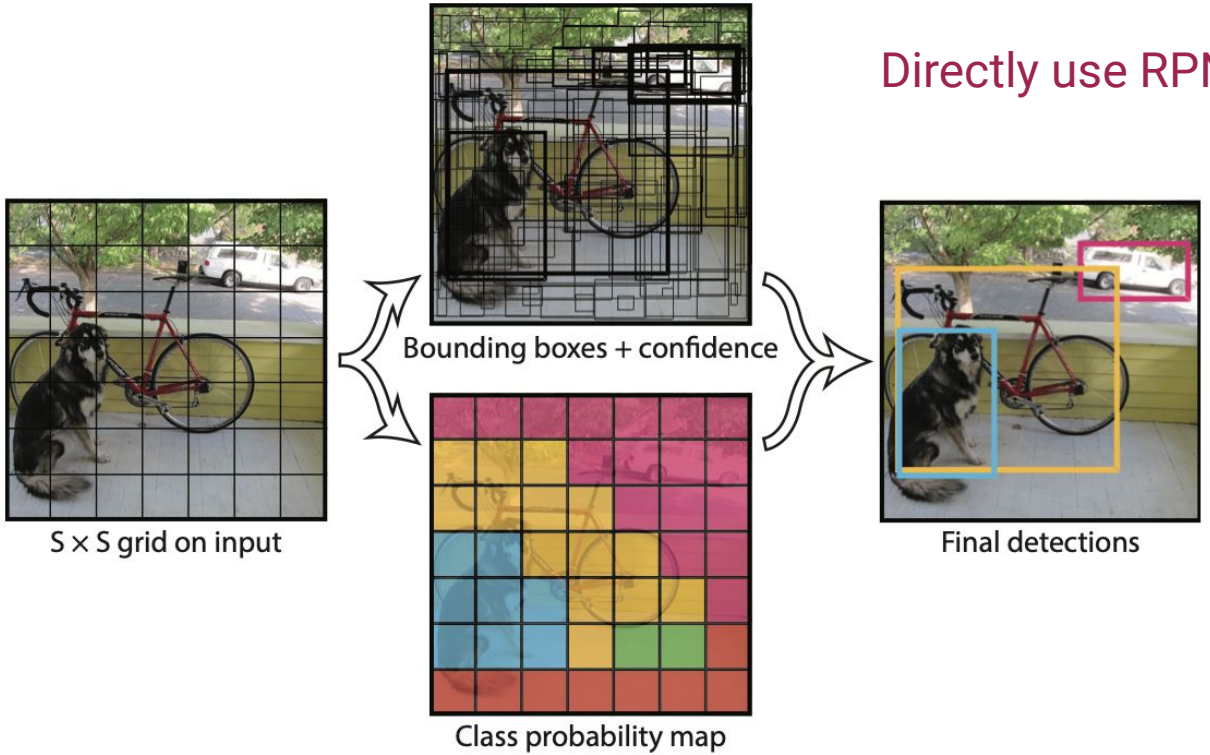


Slides modified from Ross Girshick tutorial at CVPR 2019

Two stages or one stage?



You Look Only Once (YOLO)



Directly use RPN!

Figure from You Only Look Once: Unified, Real-Time Object Detection

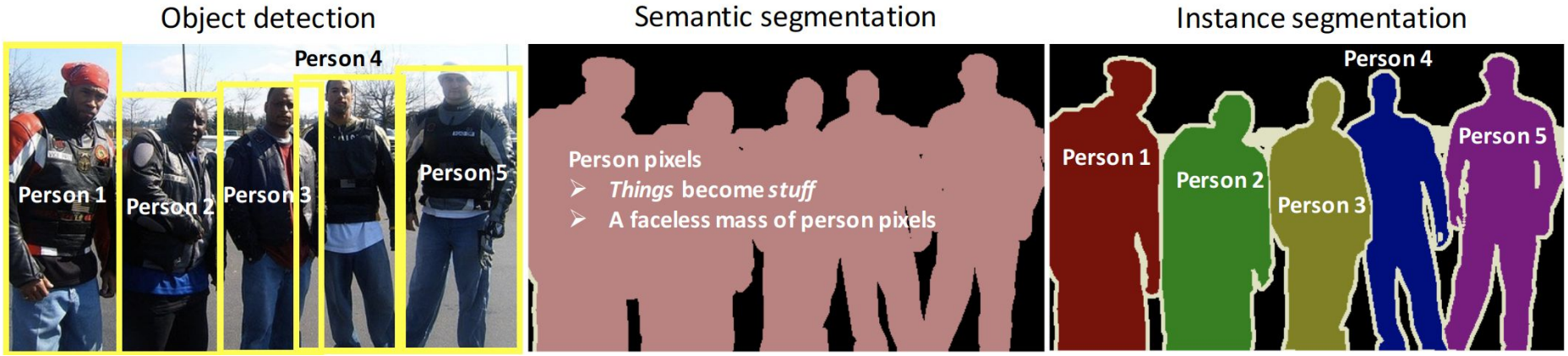
Other Methods

http://web.stanford.edu/class/cs231a/lectures/lecture12_2D_detection.pdf

- VJ Face
- Deformable Part Model
- Implicit Shape Model

U-Net

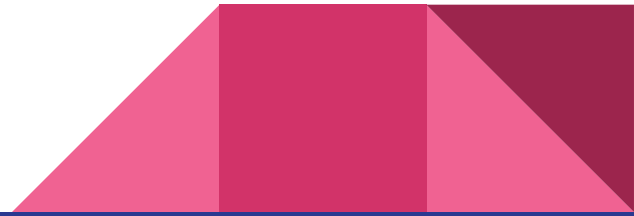
Semantic vs. Instance Segmentation



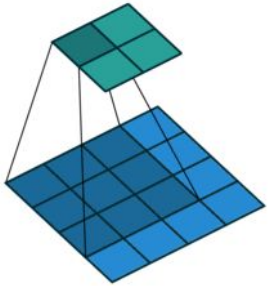
Slides modified from Ross Girshick tutorial at CVPR 2017

How shall we modify CNN?

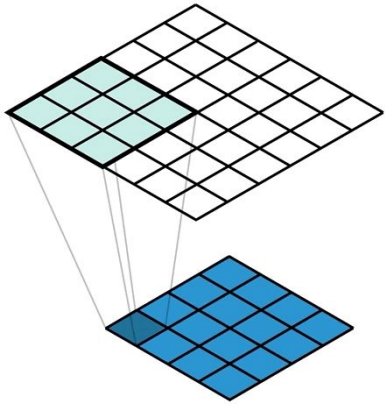
- We need to predict a label for each pixel, but CNN has downsampled our input to a very small scale (e.g. from 224x224 to 7x7).
- Thus, we need a layer to upsample feature maps to the original size.



Transposed Convolution



3x3 Convolution



3x3 Transposed Convolution

http://deeplearning.net/software/theano/tutorial/conv_arithmetic.html
https://medium.com/apache-mxnet/transposed-convolutions-explained-with-ms-excel-52d13030c7e8

Encoder-Decoder

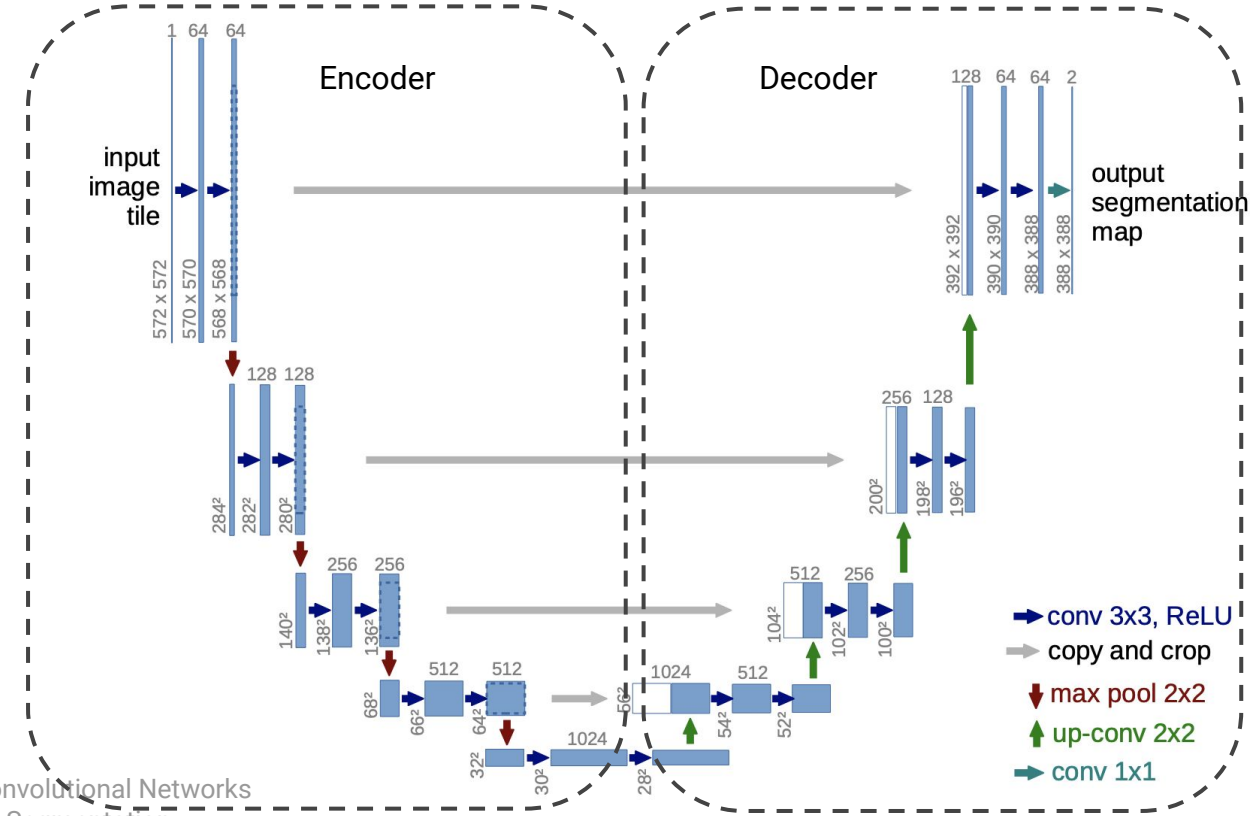


Figure from U-Net: Convolutional Networks for Biomedical Image Segmentation

Transposed Convolution

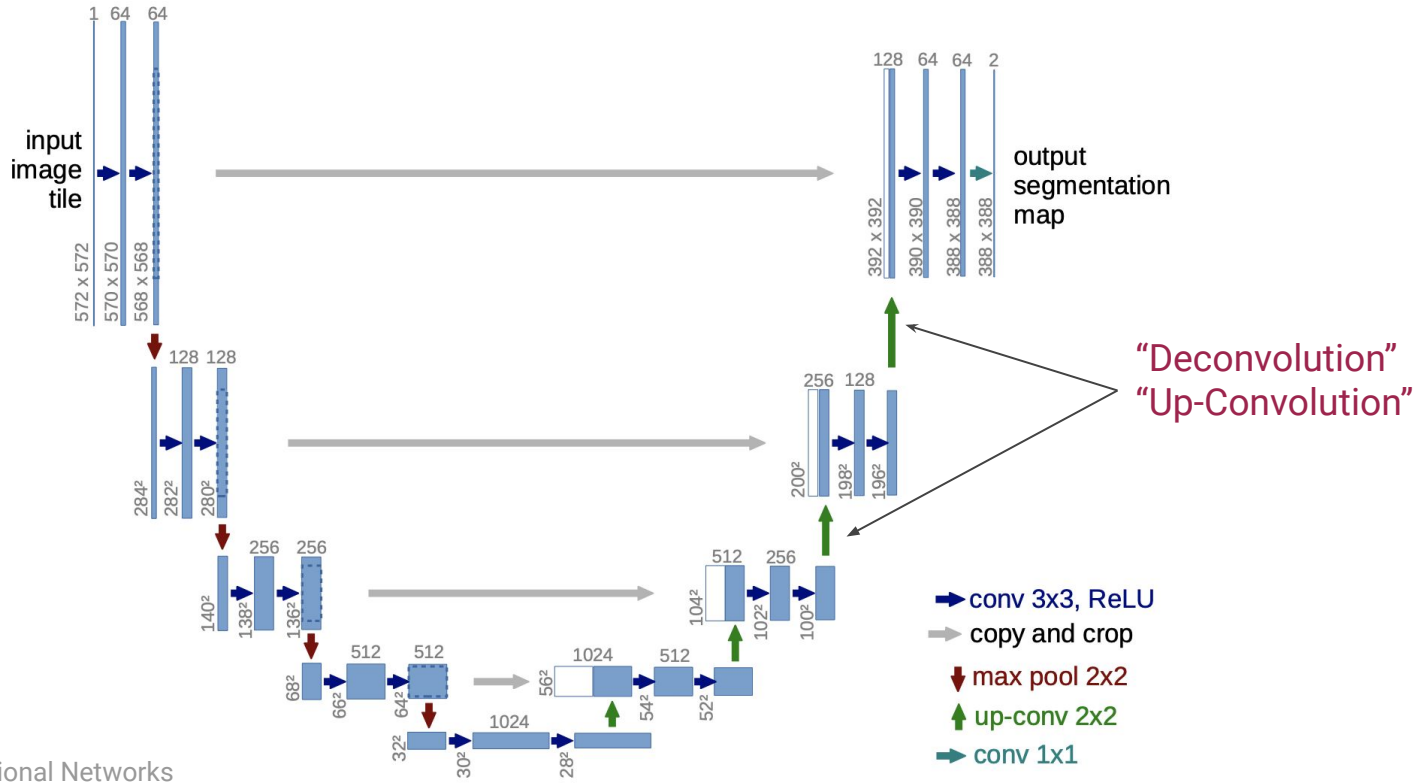


Figure from U-Net: Convolutional Networks for Biomedical Image Segmentation

Skip Layer

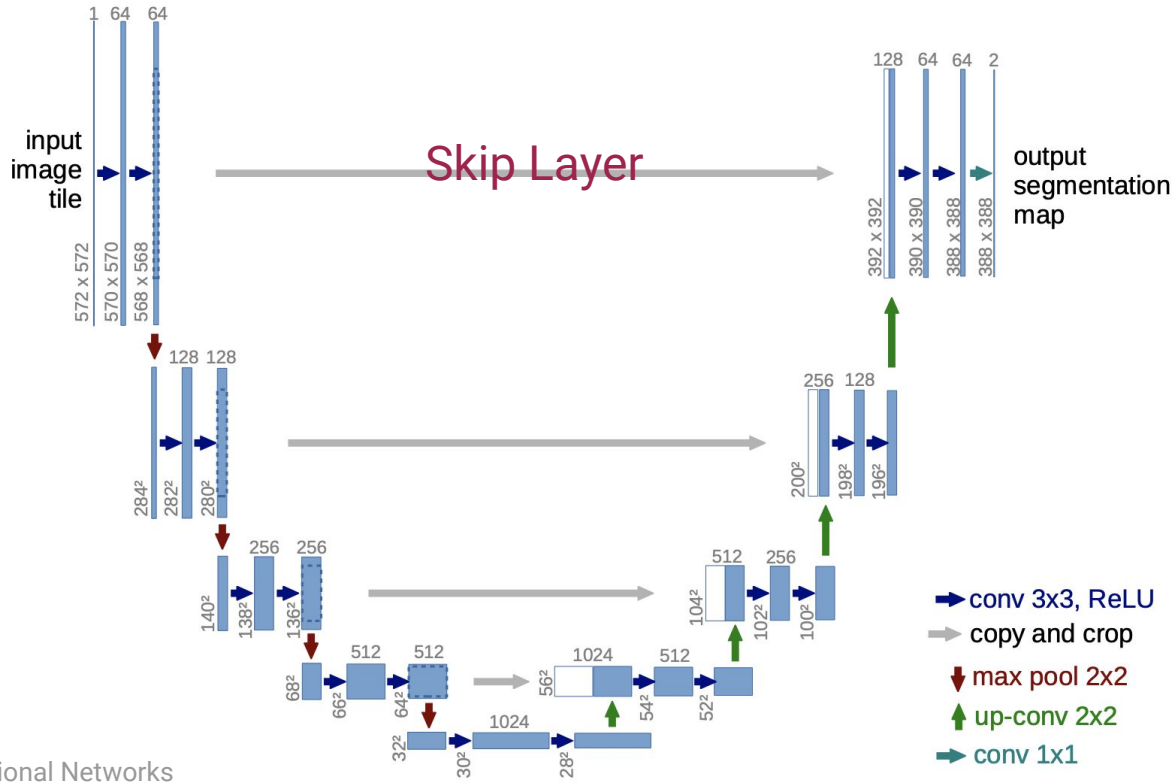


Figure from U-Net: Convolutional Networks for Biomedical Image Segmentation

References

[1] S. Ren, K. He, R. Girshick, and J. Sun, “Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks,” pp. 1–9, 2015.

[2] R. Girshick, “Fast R-CNN,” *Proc. IEEE Int. Conf. Comput. Vis.*, vol. 11-18-Dece, pp. 1440–1448, 2016.

[3] R. Girshick, J. Donahue, T. Darrell, and J. Malik, “Rich feature hierarchies for accurate object detection and semantic segmentation,” *Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.*, pp. 580–587, 2014.

[4] O. Ronneberger, P. Fischer, and T. Brox, “U-net: Convolutional networks for biomedical image segmentation,” in *International Conference on Medical image computing and computer-assisted intervention*, 2015, pp. 234–241.

Thanks