2D Object Detection With Convolutional Neural Networks

Course 3, Module 4, Lesson 2

UNIVERSITY OF TORONTO
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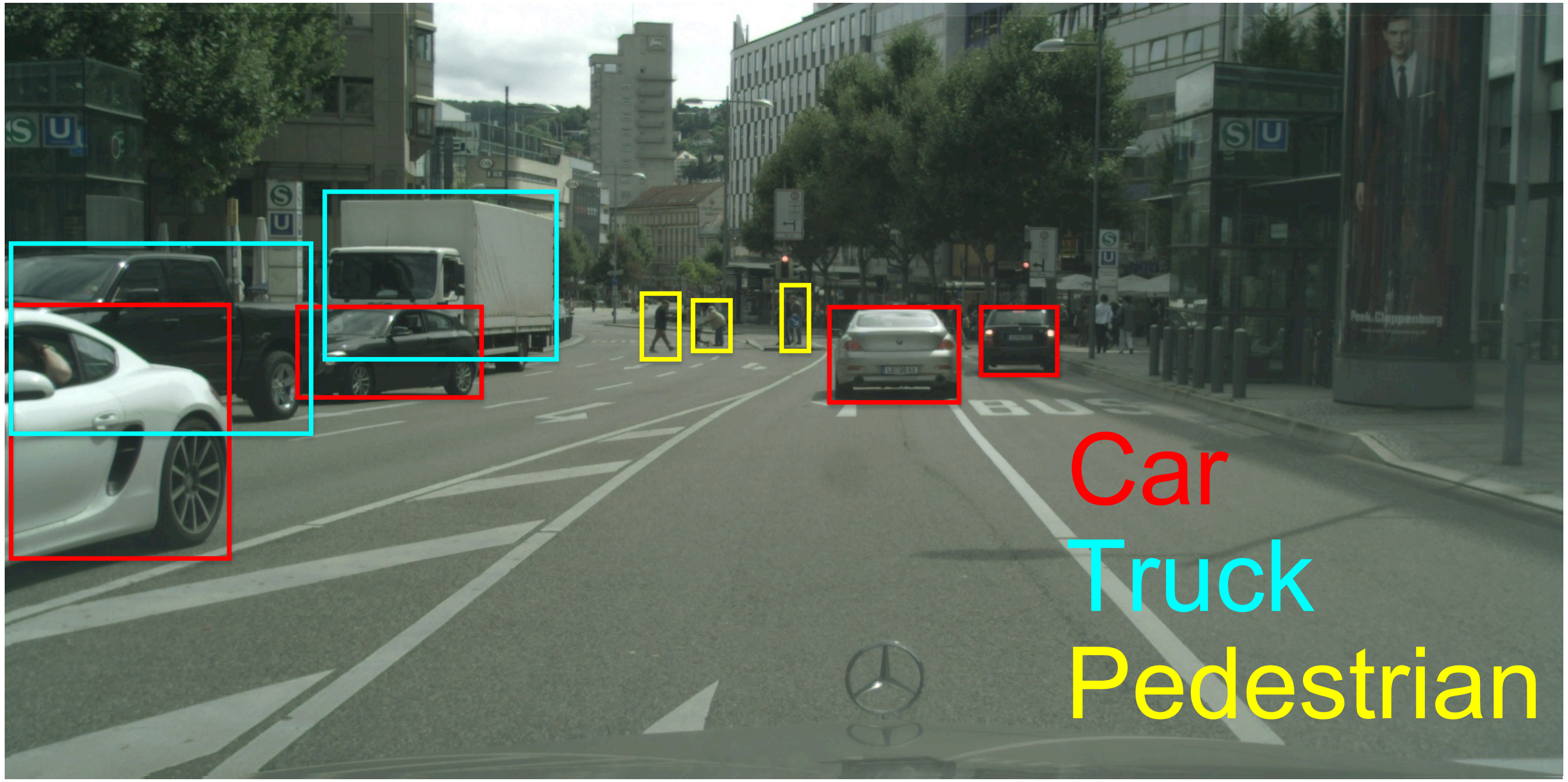
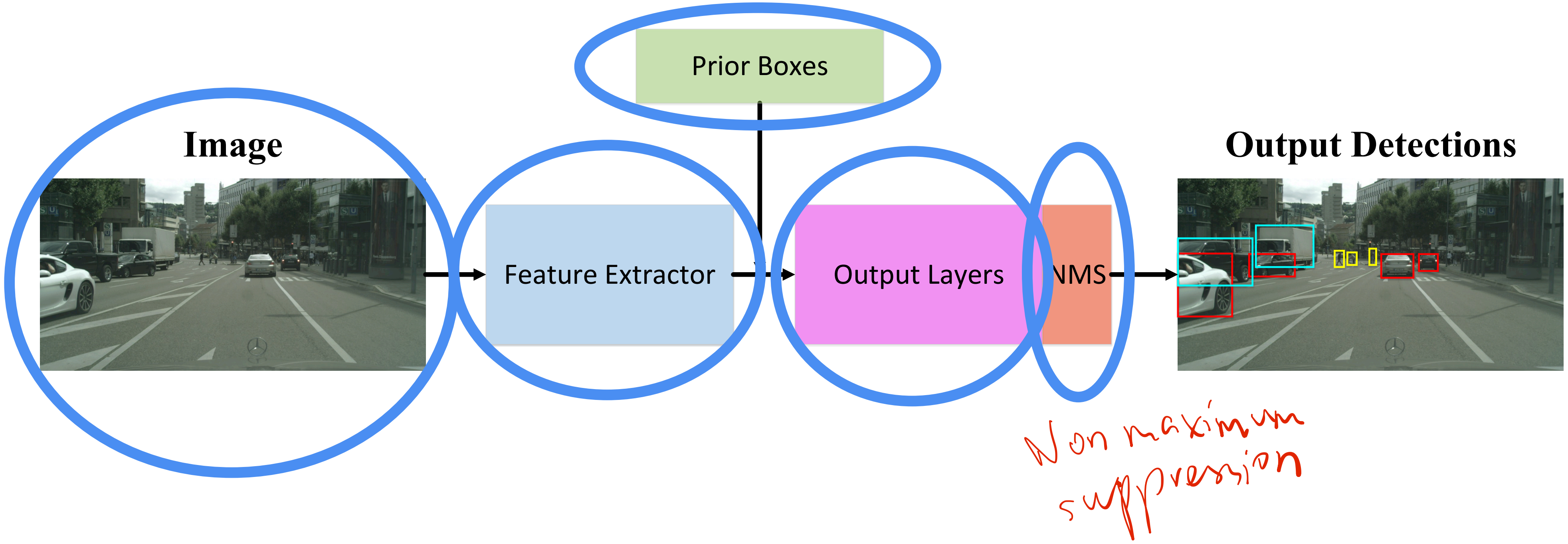
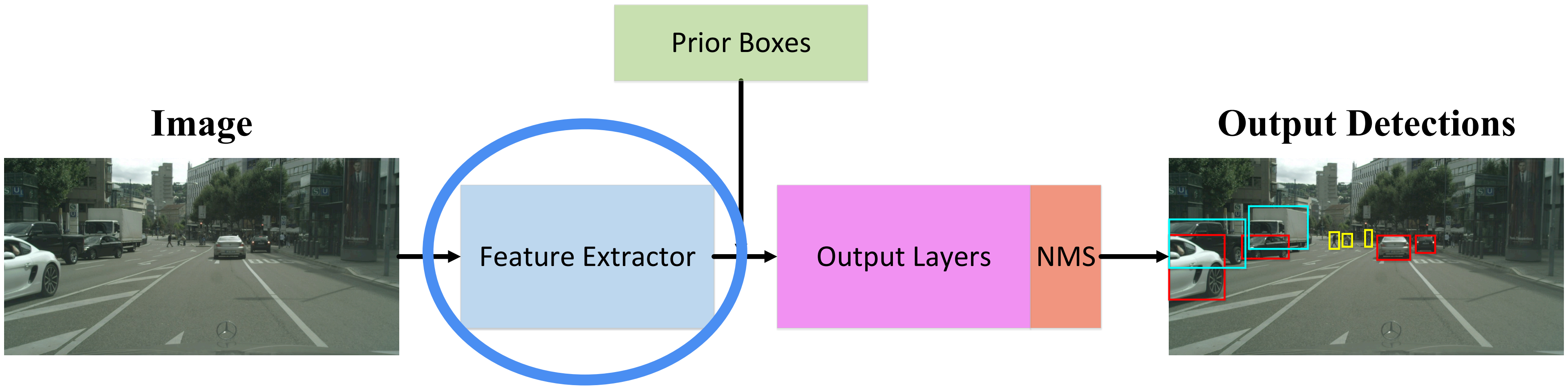
The Object Detection Problem



ConvNets For 2D Object Detection



The Feature Extractor



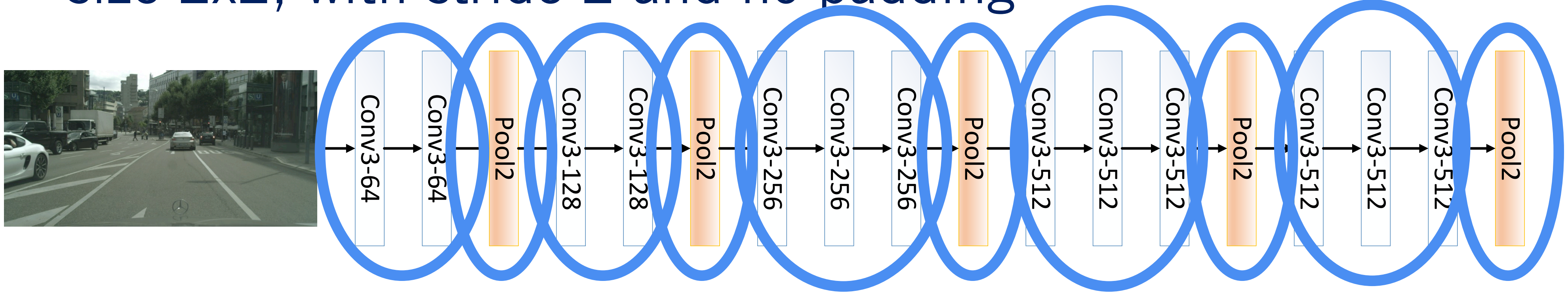
The Feature Extractor

- Feature extractors are the most computationally expensive component of the 2D object detector
- The output of feature extractors usually has much **lower width and height** than those of the input image, but much **greater depth**
- Very active area of research, with new extractors proposed on regular basis
- **Most common extractors are**: VGG, ResNet, and Inception

90% computation

VGG Feature Extractor

- Alternating convolutional and pooling layers
- All convolutional layers are of size 3x3xK, with stride 1 and 1 zero-padding
- All pooling layers use the **max** function, and are of size 2x2, with stride 2 and no padding



VGG Feature Extractor

- Convolution layer output shape:
  - $W_{out} = \frac{W_{in} - m + 2 \times P}{S} + 1$
  - $H_{out} = \frac{H_{in} - m + 2 \times P}{S} + 1$
  - $D_{out} = K$

- All convolution layers are of size 3x3xK, with stride 1 and 1 zero-padding
  - $\boldsymbol{W_{out}} = \frac{W_{in} - m + 2 \times P}{S} + 1 = \frac{H_{in} - 3 + 2 \times 1}{1} + 1 = \boldsymbol{W_{in}}$
  - $\boldsymbol{H_{out}} = \frac{H_{in} - m + 2 \times P}{S} + 1 = \frac{H_{in} - 3 + 2 \times 1}{1} + 1 = \boldsymbol{H_{in}}$
  - $\boldsymbol{D_{out}} = K$
- All pooling layers use the max function, and are of size 2x2, with stride 2 and no padding.
  - $\boldsymbol{W_{out}} = \frac{W_{in} - m}{S} + 1 = \frac{W_{in} - 2}{2} + 1 = \frac{\boldsymbol{W_{in}}}{\boldsymbol{2}}$
  - $\boldsymbol{H_{out}} = \frac{H_{in} - m}{S} + 1 = \frac{H_{in} - 2}{2} + 1 = \frac{\boldsymbol{H_{in}}}{\boldsymbol{2}}$
  - $\boldsymbol{D_{out}} = \boldsymbol{D_{in}}$

The Feature Extractor

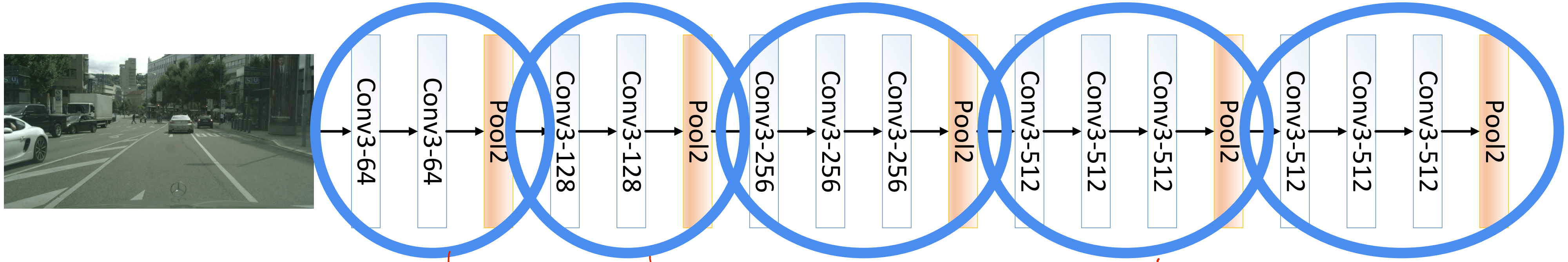
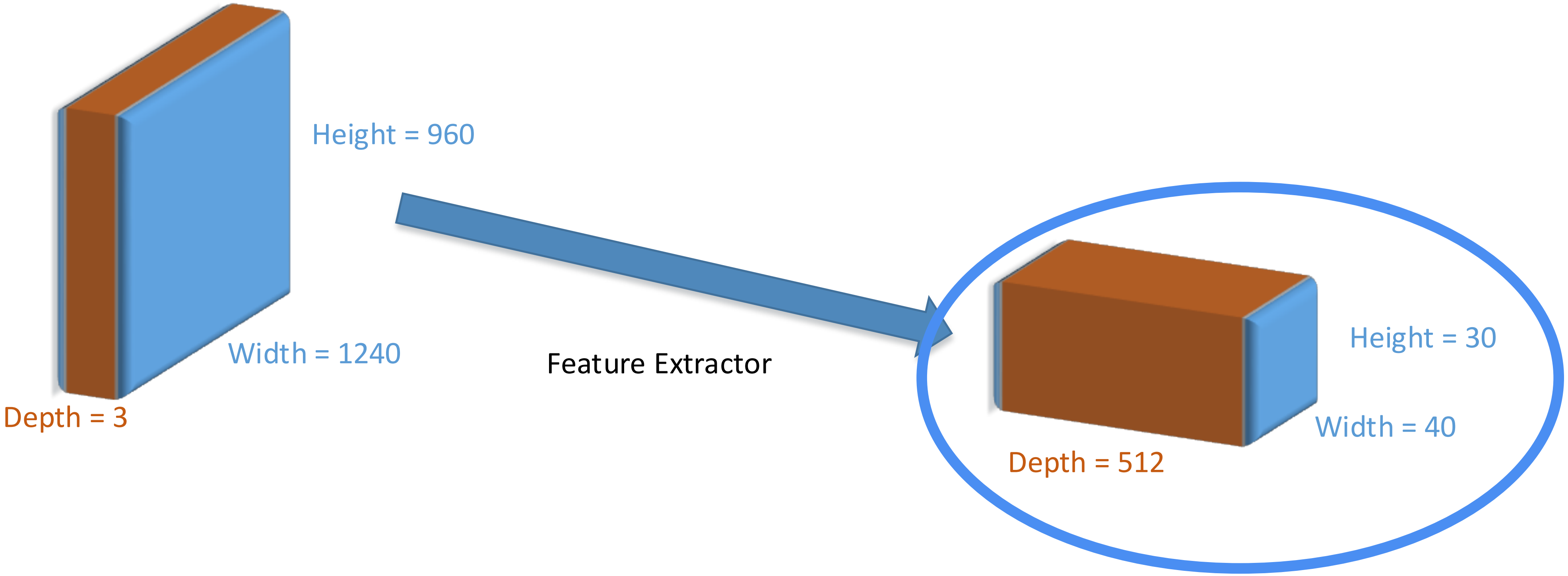


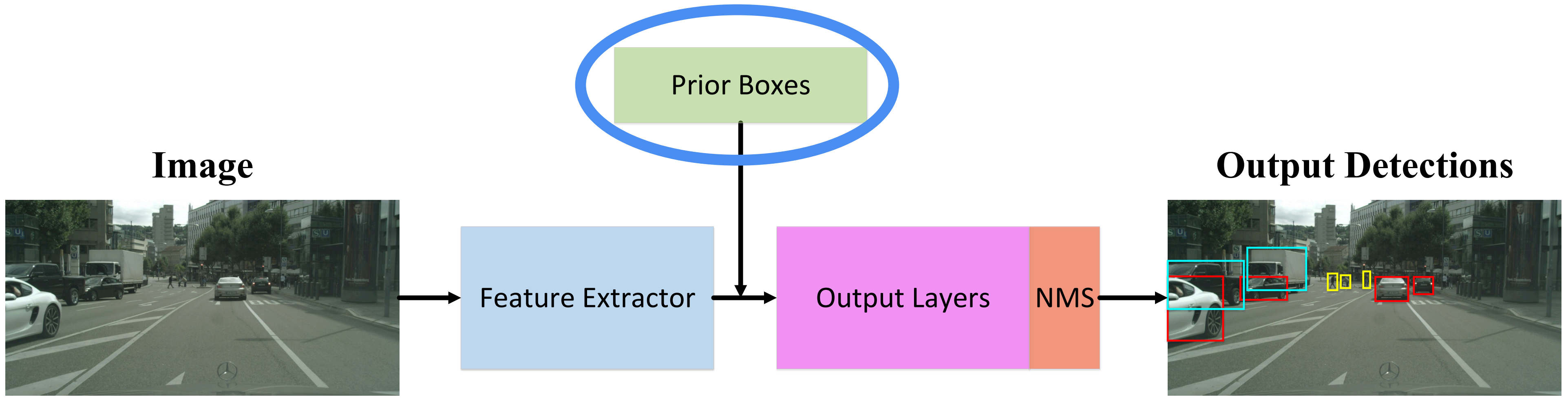
	Image	Conv1	Conv2	Conv3	Conv4	Conv5
Width	M	M/2	M/4	M/8	M/16	M/32
Height	N	N/2	N/4	N/8	N/16	N/32
Depth	3	64	128	256	512	512

$M \times N \times 3$

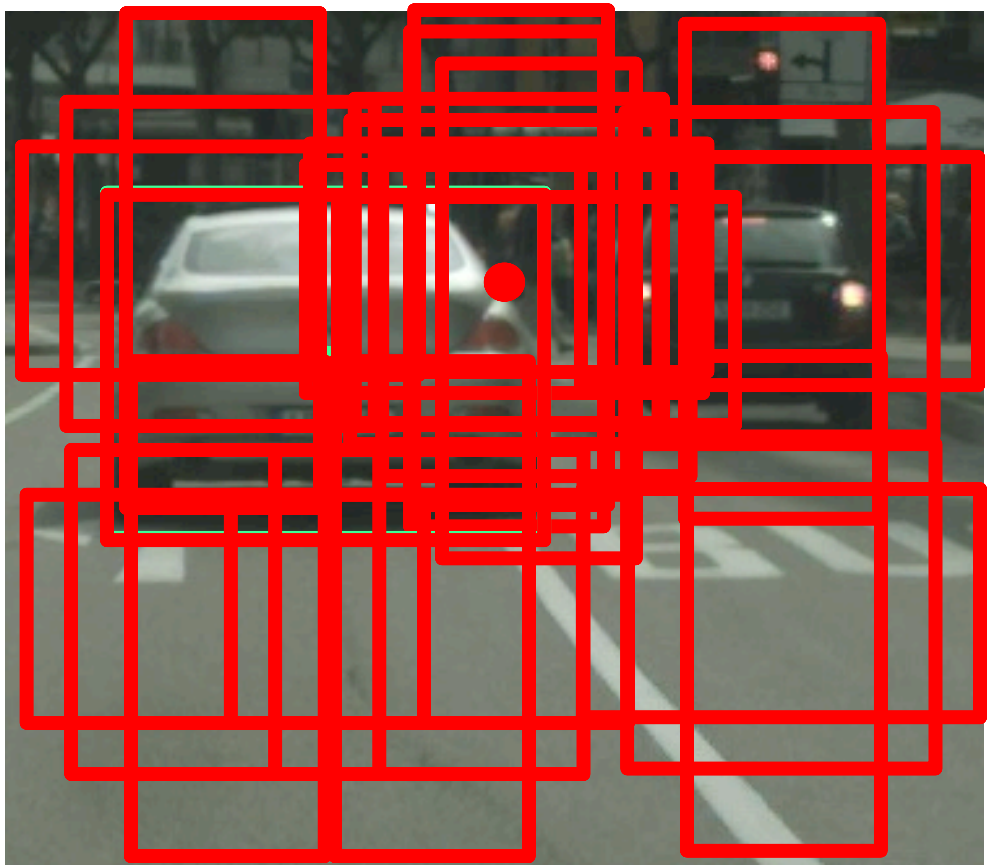
Output Volume Shape



Prior/Anchor Bounding Boxes

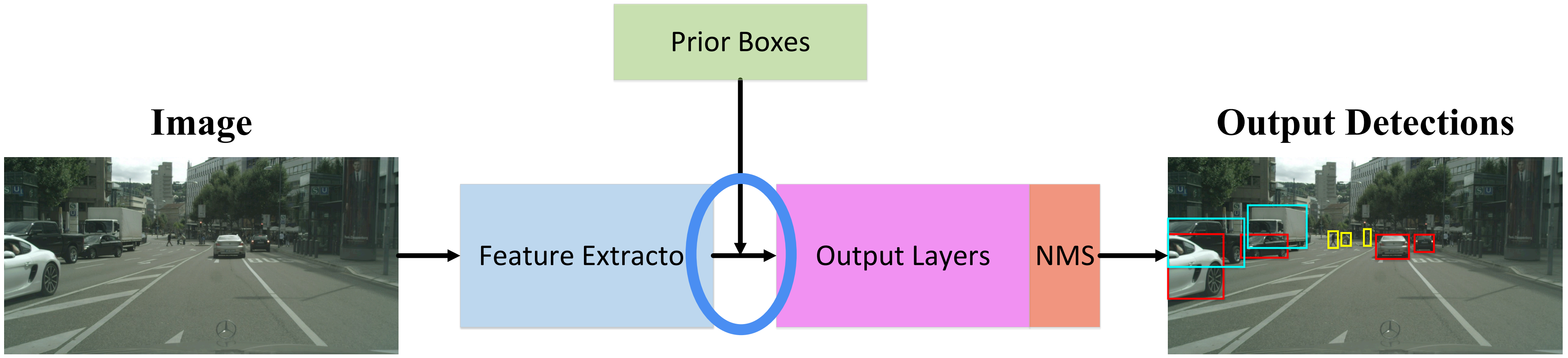


Prior/Anchor Bounding Boxes



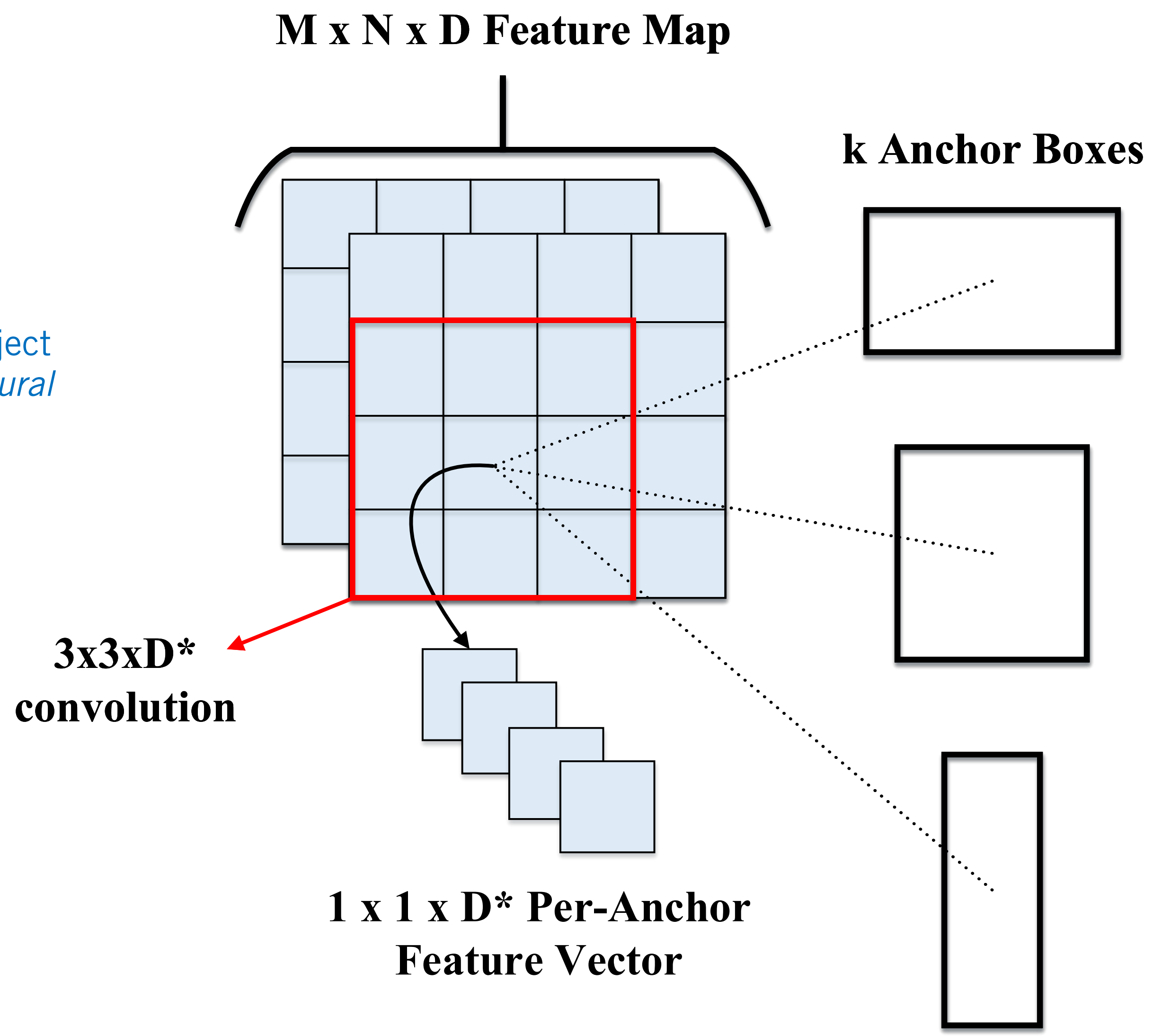
residual
learning

Prior/Anchor Bounding Boxes

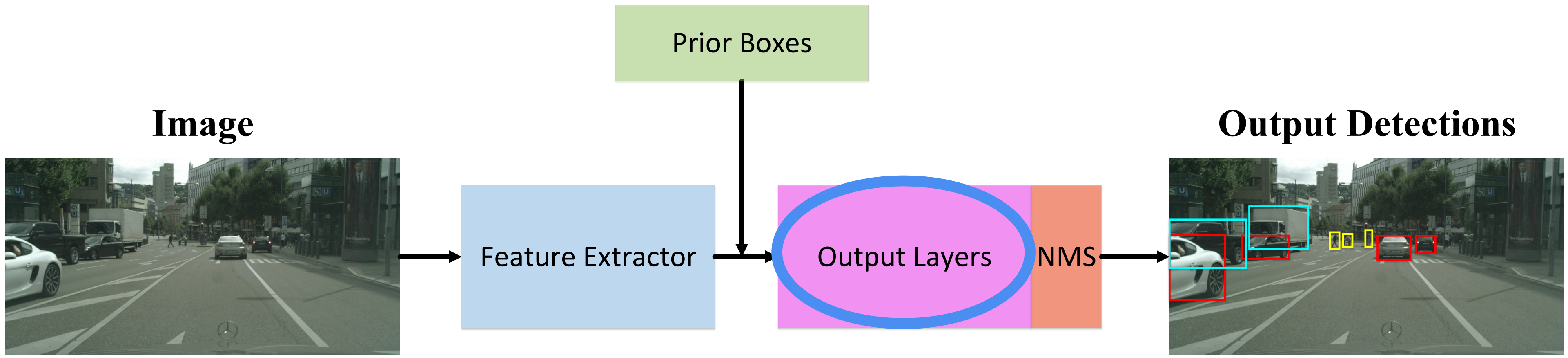


Using Anchor Boxes

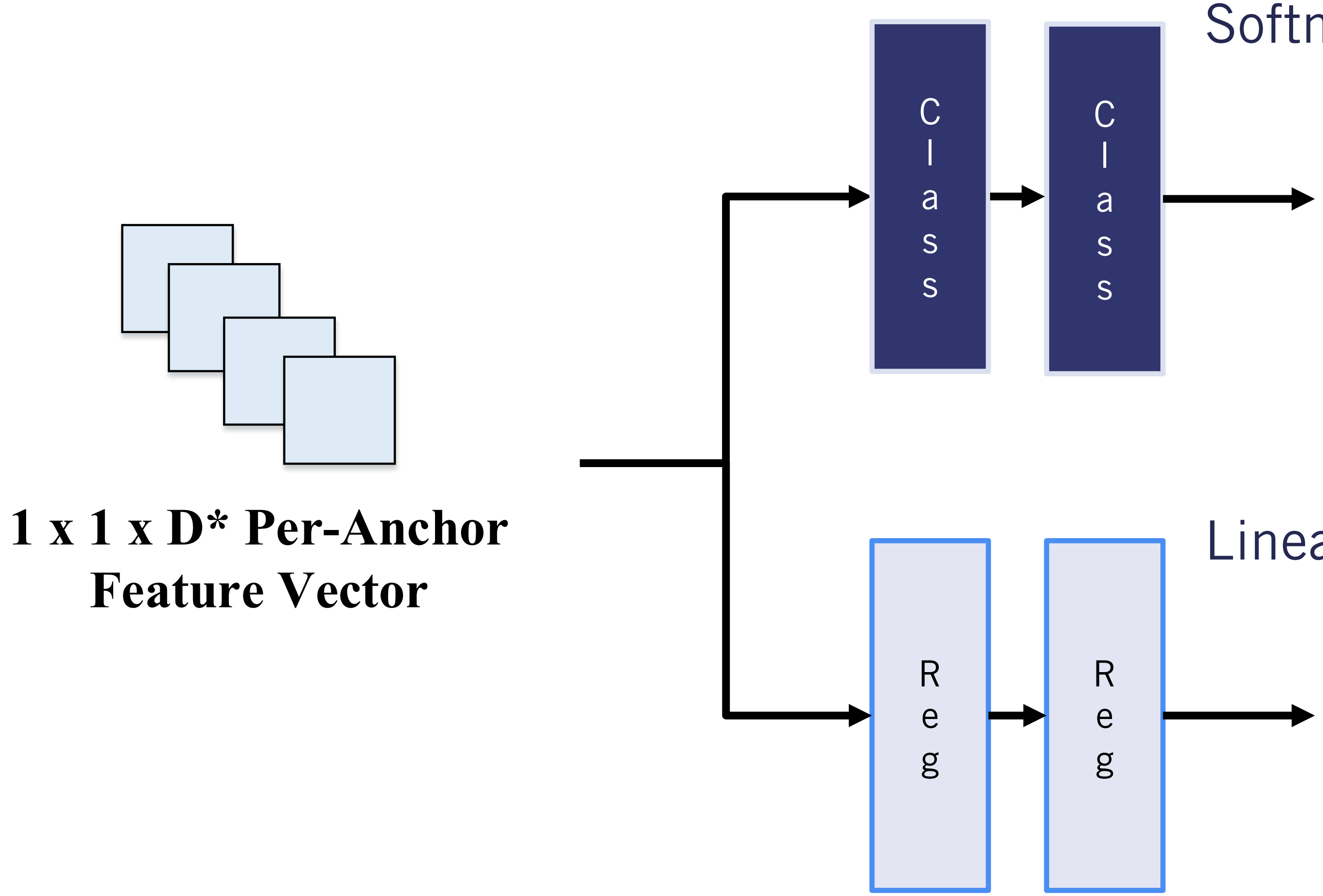
Ren, Shaoqing, et al. "Faster r-cnn: Towards real-time object detection with region proposal networks." *Advances in neural information processing systems*. 2015



Output Layers



Classification VS Regression Heads



Softmax Output Layer

$[S_{class_1}, \dots, S_{class_k}]$

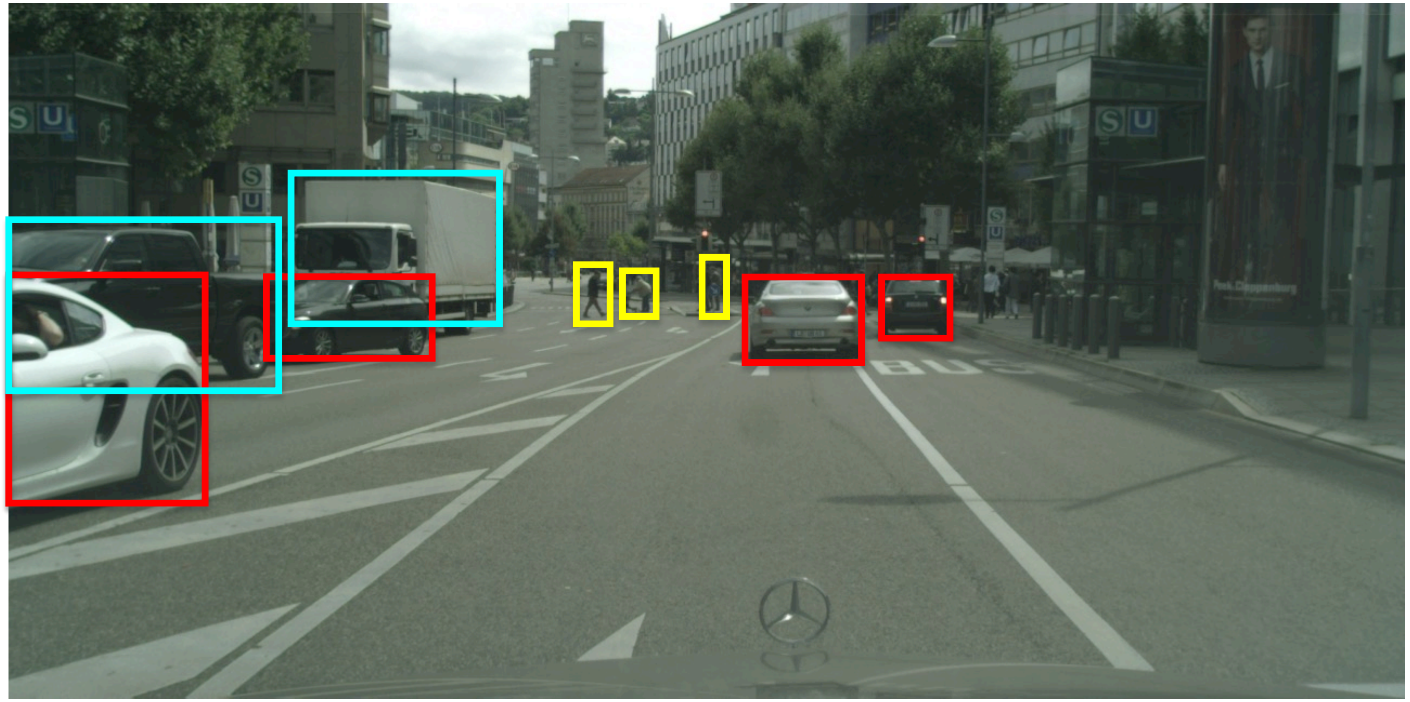
Linear Output Layer

$[\Delta x_{center}, \Delta y_{center}, f_w, f_h]$

$[\Delta x_{min}, \Delta y_{min}, \Delta x_{max}, \Delta y_{max}]$

Or. $[\Delta x_{center}, \Delta y_{center}, f_w, f_h]$

Output handling



Summary

- 2D object detectors can be performed using convolutional neural networks
- Usually, anchor boxes are used as priors for the neural network to shift around to achieve object classification and localization

- **Next: Training vs Inference**