

The Semantic Segmentation Problem

Course 3, Module 5, Lesson 1



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Learning Objectives

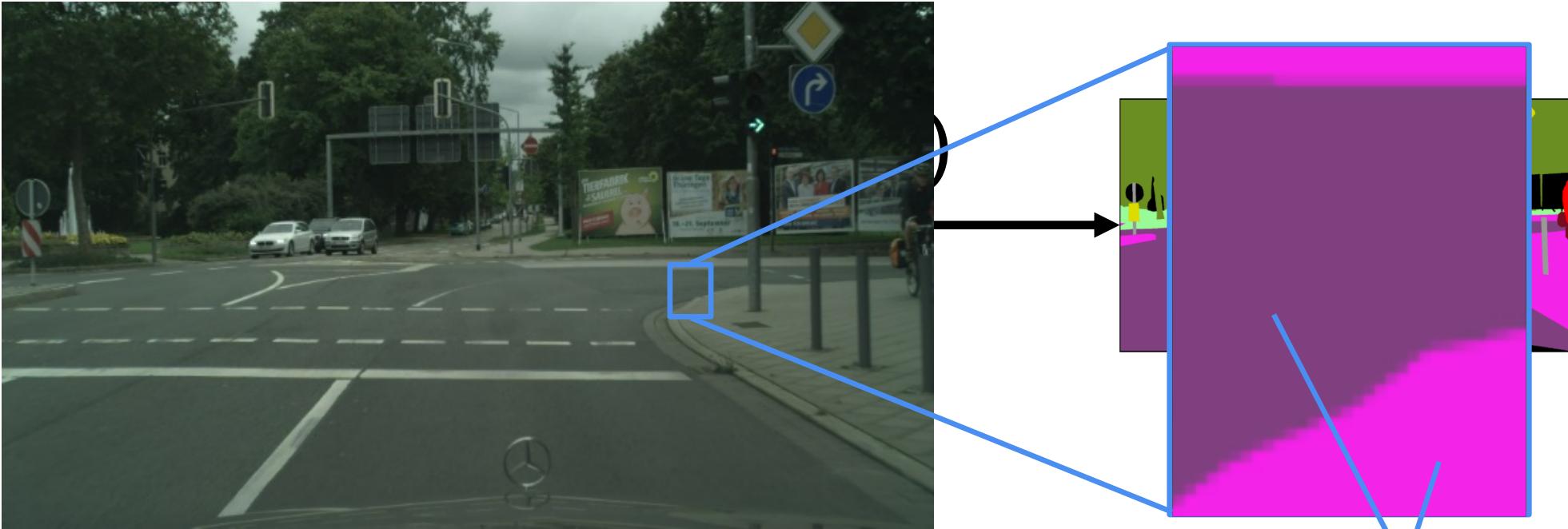
- Learn the semantic segmentation task problem formulation
- Learn to determine how well a semantic segmentation model is performing with task relevant performance measures

The Semantic Segmentation Problem



- Road
- Sidewalk
- Pole
- Traffic Light
- Traffic Signs
- Vegetation
- Terrain
- Sky
- Car
- Background

Mathematical Problem Formulation



$$f(x; \theta) = [S_{class_1}, \dots, S_{class_k}]$$

$$S_{road} = 0.9$$

$$S_{sidewalk} = 0.08$$

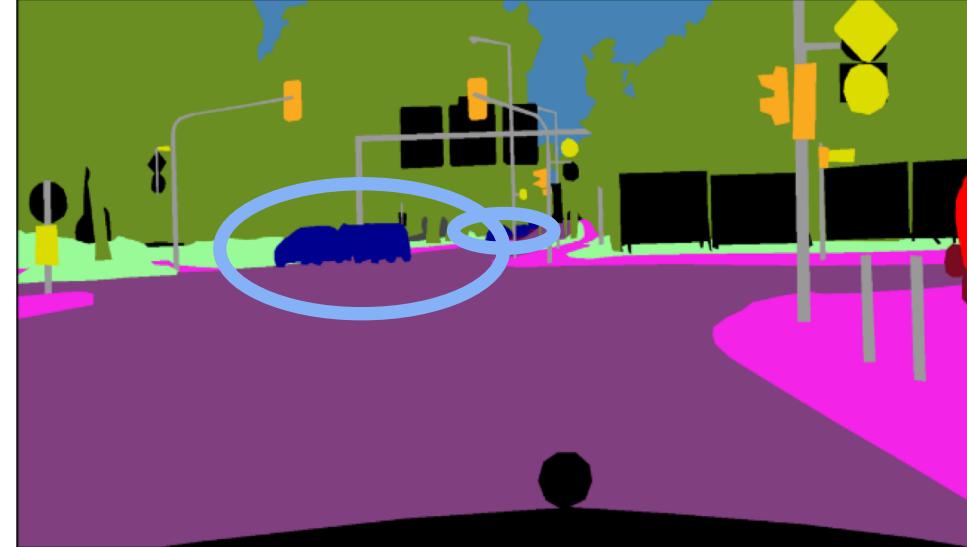
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$$S_{Background} = 0.08$$

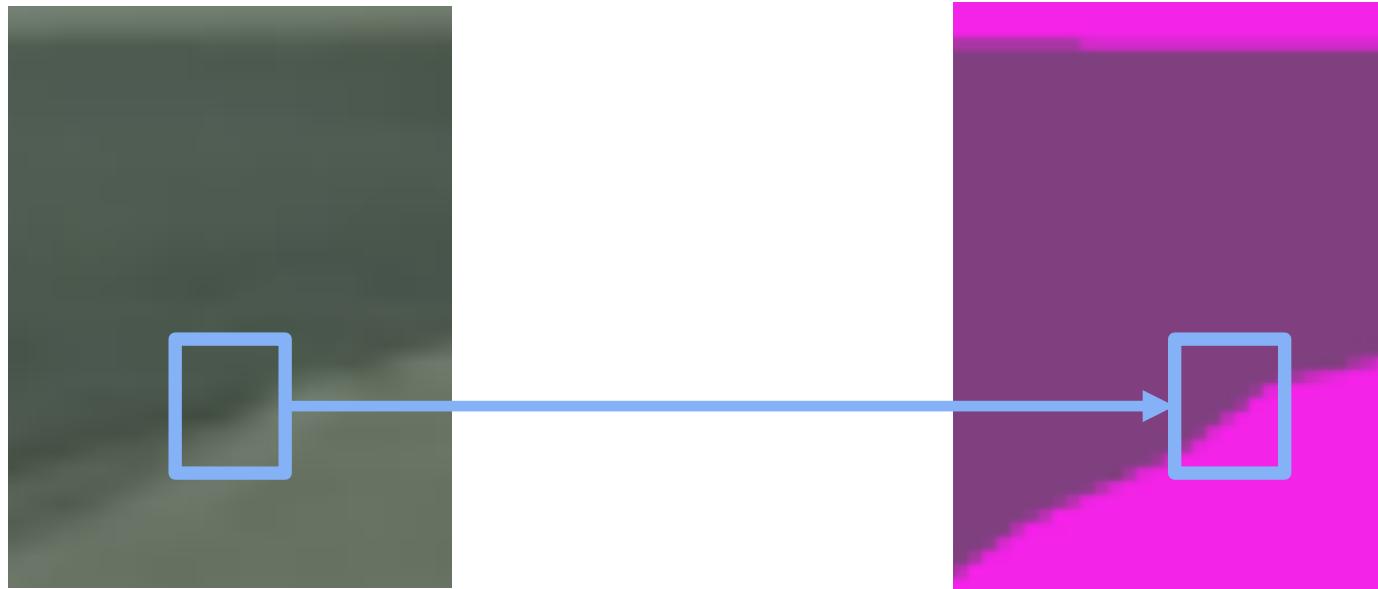
Semantic Segmentation is Not Trivial !

- Occlusion, truncation, scale, and illumination changes



Semantic Segmentation is Not Trivial !

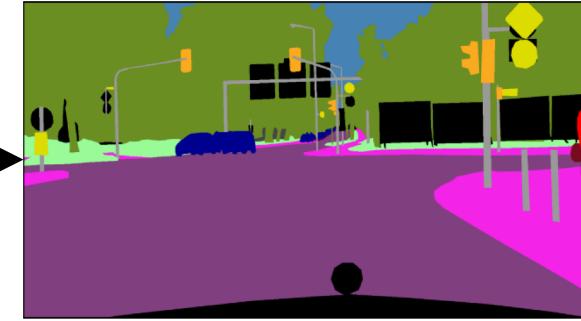
- Occlusion, truncation, scale, and illumination changes
- Smooth boundaries



ConvNets For Semantic Segmentation



$$f(x; \theta)$$



ConvNet



Evaluation Metrics

- **True Positive (TP):** The number of correctly classified pixels belonging to class X
- **False Positive (FP):** The number of pixels that **do not belong** to class X in ground truth but **are classified** that class by the algorithm
- **False Negative (FN):** The number of pixels that **do belong** to class X in ground truth, but **are not classified** as that class by the algorithm

$$IOU_{class} = \frac{TP}{TP + FP + FN}$$

Evaluation Metrics

Ground Truth

R	R	R
R	R	S
S	S	S

Prediction

S	R	S
R	R	S
S	S	S

Evaluation Metrics

Ground Truth

R	R	R
R	R	S
S	S	S

Prediction

S	R	S
R	R	S
S	S	S

Class: Road

$$TP = 3$$

$$FP = 0$$

$$FN = 2$$

$$IOU_{Road} = \frac{3}{3 + 0 + 2} = \frac{3}{5}$$

Evaluation Metrics

Ground Truth

R	R	R
R	R	S
S	S	S

Prediction

S	R	S
R	R	S
S	S	S

Class: **Sidewalk**

$$TP = 4$$

$$FP = 2$$

$$FN = 0$$

$$IOU_{Road} = \frac{4}{4 + 2 + 0} = \frac{4}{6}$$

Evaluation Metrics

- **Class IOU** over all the data is calculated by computing the sum of TP, FP, FN for all images first
- Averaging the class IOU is usually not a very good idea!
- CityScapes Segmentation Dataset



Summary

- Semantic segmentation consists of providing a class label for every pixel in a 2D image
- Semantic segmentation models can be evaluated using class IOU
- **Next: ConvNets for Semantic Segmentation**