Semantic Segmentation For Road Scene Understanding

Course 3, Module 5, Lesson 3

UNIVERSITY OF TORONTO
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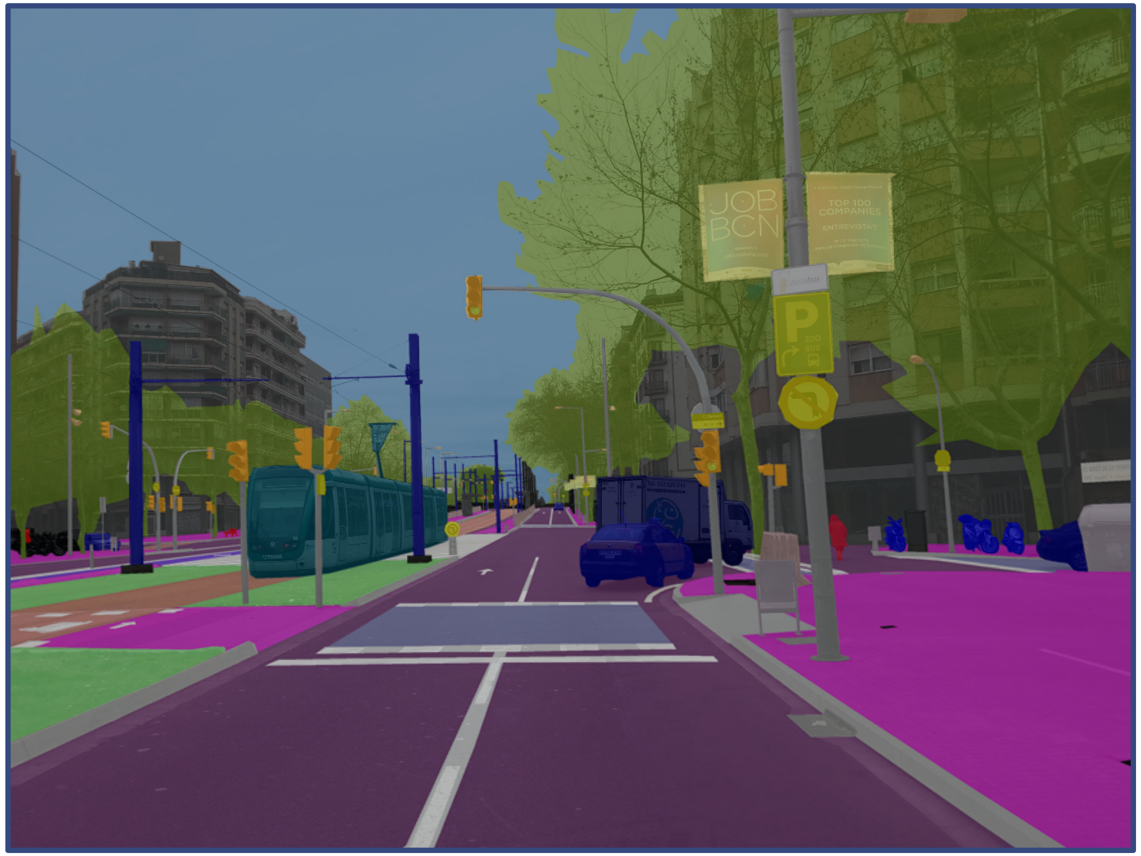
Semantic Segmentation Results

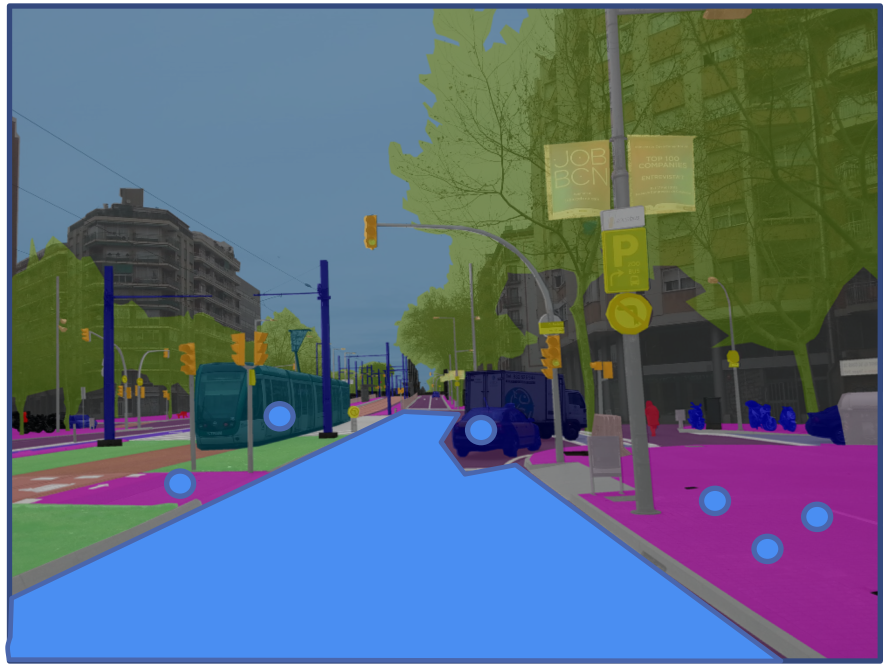


Data From:
https://www.mapillary.com/dataset/vistas?pKey=rwbBtYKofke2NeLIvj8j-A

3D Drivable Surface Estimation

ConvNet

1. Generate semantic segmentation output
2. Associate 3D point coordinates with 2D image pixels from stereo data or projecting lidar point cloud to image plane
3. Choose 3D points belonging to the **Drivable Surface** category
4. Estimate 3D **drivable surface model**



3D Drivable Surface Estimation

- Plane Model:

$$ax + by + z = d$$

- Least squares formulation:

$$p = [a, b, d], \qquad \underset{A}{\operatorname{argmin}}(Ap - B)$$

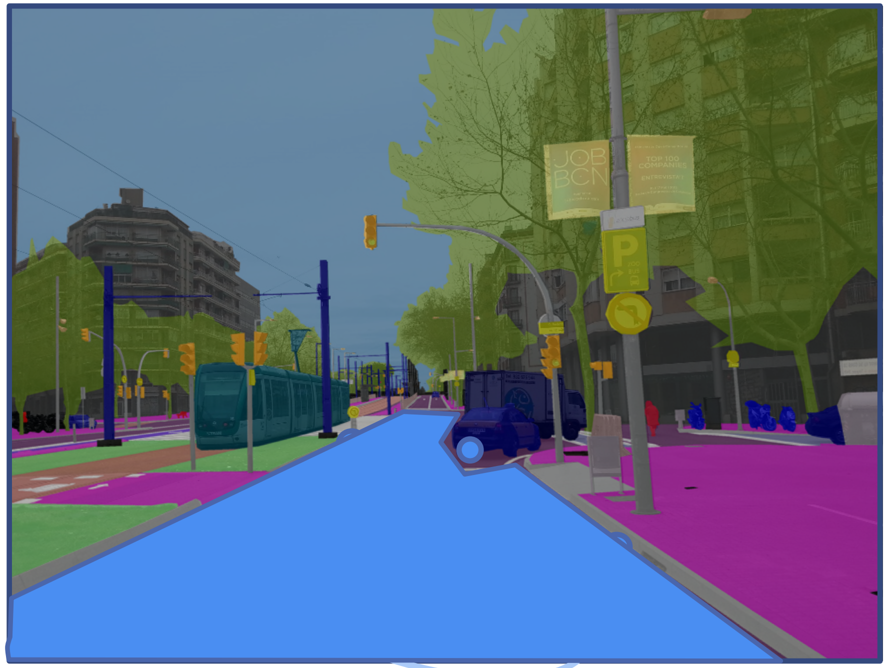
$$A = \begin{bmatrix} x_1 & y_1 & -1 \\ x_2 & y_2 & -1 \\ \vdots & \vdots & \vdots \\ x_N & y_N & -1 \end{bmatrix}, \qquad B = \begin{bmatrix} -z_1 \\ -z_2 \\ \vdots \\ -z_N \end{bmatrix}$$

- Solution:

$$p = (A^T A)^{-1} A^T B$$

3D Drivable Surface Estimation

- Minimum number of points to estimate model: 3 non-collinear points
- RANSAC Algorithm: (eliminate outliers)
  1. From your data, randomly select 3 points. in this case
  2. Compute model parameters a, b, and d using least squares estimation.
  3. Compute number of inliers, N.
  4. If N > threshold, terminate and return the computed plane parameters. Else, go back to step 1.
  5. Recompute the model parameter using all the inliers in the inlier set.

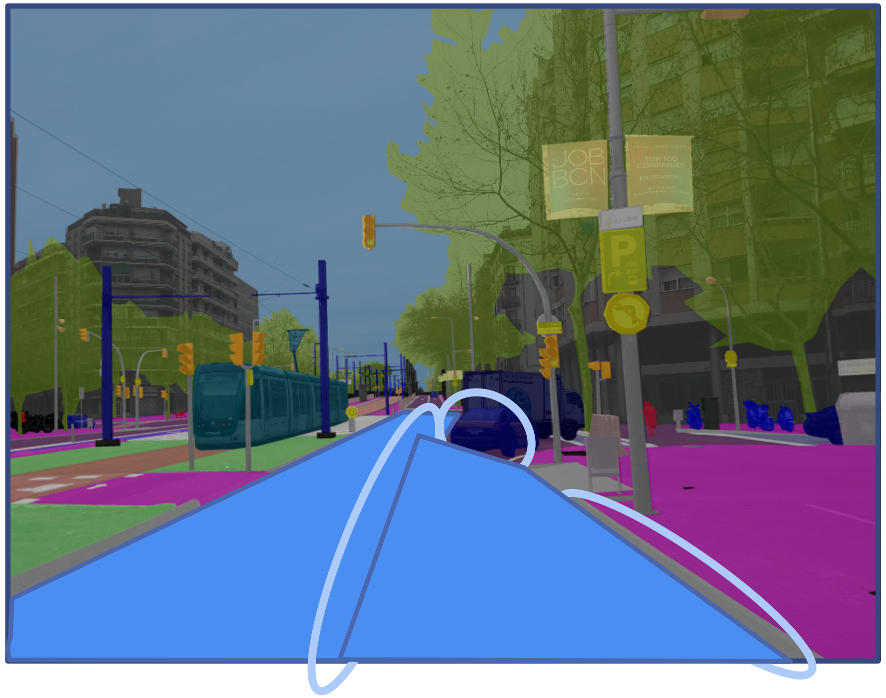


More complex models are needed for complex road scenarios

Semantic Lane Estimation

from ConvNet

- Estimate the **lane,** the area where the car can drive on the drivable surface
- Estimate what is at the **boundaries** of the lane:
  - Curb
  - Road
  - Car



Semantic Lane Estimation

1. Extract segmentation mask from pixels belonging to lane separators such as lane **markings** or **curbs**.
2. Extract edges from this segmentation mask using an **edge detector**. Canny edge detector
3. **Linear Lane Model**: Use the Hough transform to detect lines in the output edge map.
4. Filter lines based on slope to remove horizontal lines.
5. Remove any line that does not belong to the drivable space.
6. Determine which classes occur at the boundary of the lane.

Auxiliary Material

- **Hough Transform Line Detection**: https://docs.opencv.org/3.4.3/d9/db0/tutorial_hough_lines.html

- **Canny Edge Detection**: https://docs.opencv.org/3.4.3/da/d22/tutorial_py_canny.html

Summary

- Semantic Segmentation Results can be used to estimate drivable space, and what classes occurs at its boundaries
- Semantic Segmentation Results can be used to estimate lanes
- Semantic Segmentation Results can be used to aid in 2D object detection

- **Next: Course Project**