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LIDAR Based Road and Road-Edge Detection

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Problem

- Features essential for an autonomous vehicle.
- What could it be? Road and road edges.
- Can the car see like me?

https://www.reddit.com/r/pics/comments/1i6xut/mythbusting_minions_by_lars_of_looking_for_group/

Outline

- Problem
- Related Work
- Road and Road Edge Detection
  - Candidate Selection
  - Feature Selection
  - Classification
  - False Alarm Mitigation
  - Road Curb Detection
- Experiments
  - Experiment 1
  - Experiment 2
  - Experiment 3
- Conclusions

Related Work

Related Work

Road-Boundary Detection and Tracking Using Ladar Sensing

- First to use of LADAR
- Extended Kalman Filtering for filtering and detection.
- Previously mm radar waves were used.

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Road-Boundary Detection and Tracking Using Ladar Sensing

W. S. Wijesoma, *Member, IEEE*, K. R. S. Kodagoda, and Arjuna P. Balasuriya, *Member, IEEE*

***Abstract*—Road-boundary detection is an integral and important function in advanced driver-assistance systems and autonomous vehicle navigation systems. A prominent feature of roads in urban, semi-urban, and similar environments, such as in theme parks, campus sites, industrial estates, science parks, and the like, is curbs on either side defining the road's boundary. Although vision is the most common and popular sensing modality used by researchers and automotive manufacturers for road-lane detection, it can pose formidable challenges in detecting road curbs under poor illumination, bad weather, and complex driving environments. This paper proposes a novel method based on extended Kalman filtering for fast detection and tracking of road curbs using successive range/bearing readings obtained from a scanning two-dimensional ladar measurement system. As compared with millimeter wave radar methods reported in the literature, the proposed technique is simpler and computationally more efficient. This is the first of its kind reported in the literature. Qualitative experimental results are presented from the application of the technique to a campus site environment to demonstrate the viability, effectiveness, and robustness.**

***Index Terms*—Autonomous vehicles, feature extraction, laser radar, robot sensing systems.**

I. Introduction

TO MAKE ROADS safer and more efficient, research groups, publicly funded entities, and automobile manufacturers are working toward advanced driver-assistance systems and smart autonomous vehicles. Among other things,

of a sweep time, and the fact that it is a passive noninvasive sensor. However, shadows, complex driving environments, inconspicuous or missing lane/curb markings, and lower signal-to-noise ratio (SNR) of acquired images under poor lighting, visibility, and bad weather, make extraction of road features using vision alone extremely difficult, if not impossible. Although, in general, active sensor technologies such as ladar and MMWR tend to have lower resolution, slower scanning speeds (due to the scanning mechanism), and a tendency to interfere with each other in close proximity, they have their advantages. More specifically, radar operating at millimeter wavelengths has the ability to provide an alternate high-quality image of a road scene ahead over longer distances (1–100 m) in snow, haze, dust, rain, and is not susceptible to ambient light. Laser-based analogs of radar (ladar) operates over moderate distances (1–80 m), and are not usable under extreme weather conditions. For these reasons, researchers and automakers tend to favor radar over ladar. However, cost, packaging ease, operating power, signal clutter, and size considerations can tilt the balance in favor of ladar for automotive applications.

Active sensing technologies including radar and ladar in automotive applications have been applied mainly for obstacle detection. Work by Lakshmanan and Grimmer [8], Kaliyaperumal *et al.* [9], Ma *et al.* [10], and Nikolova and Hero [11] are a few instances where MMWR has been applied for road-boundary detection. Lately, ladar has been gaining popularity

Related Work

Autonomous driving in urban environments: Boss and the Urban Challenge

- Road and stationary obstacle detection.
- World and relative position estimation of the vehicle.
- Moving object tracking.
- Sensor calibration.

Autonomous Driving in Urban Environments: Boss and the Urban Challenge

Chris Urmson, Joshua Anhalt, Drew Bagnell, Christopher Baker, Robert Bittner, M. N. Clark, John Dolan, Dave Duggins, Tugrul Galatali, Chris Geyer, Michele Gittleman, Sam Harbaugh, Martial Hebert, Thomas M. Howard, Sascha Kolski, Alonzo Kelly, Maxim Likhachev, Matt McNaughton, Nick Miller, Kevin Peterson, Brian Pilnick, Raj Rajkumar, Paul Rybski, Bryan Salesky, Young-Woo Seo, Sanjiv Singh, Jarrod Snider, Anthony Stentz, William "Red" Whittaker, Ziv Wolkowicki, and Jason Ziglar
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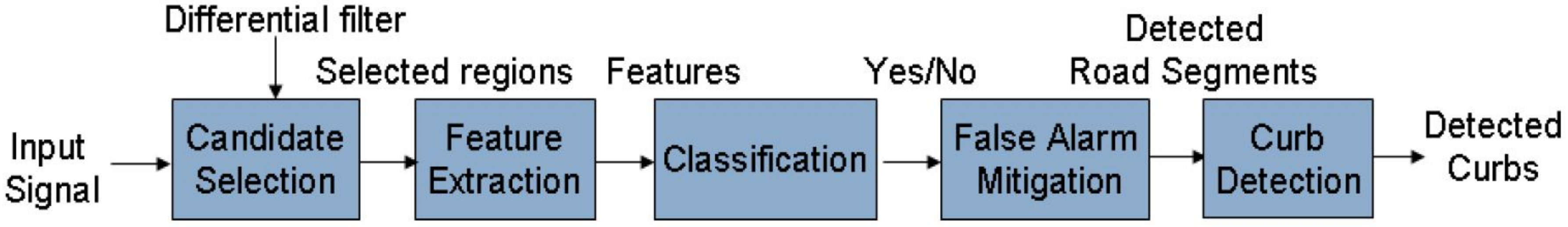
Road and Road Edge Detection

Detection Overview

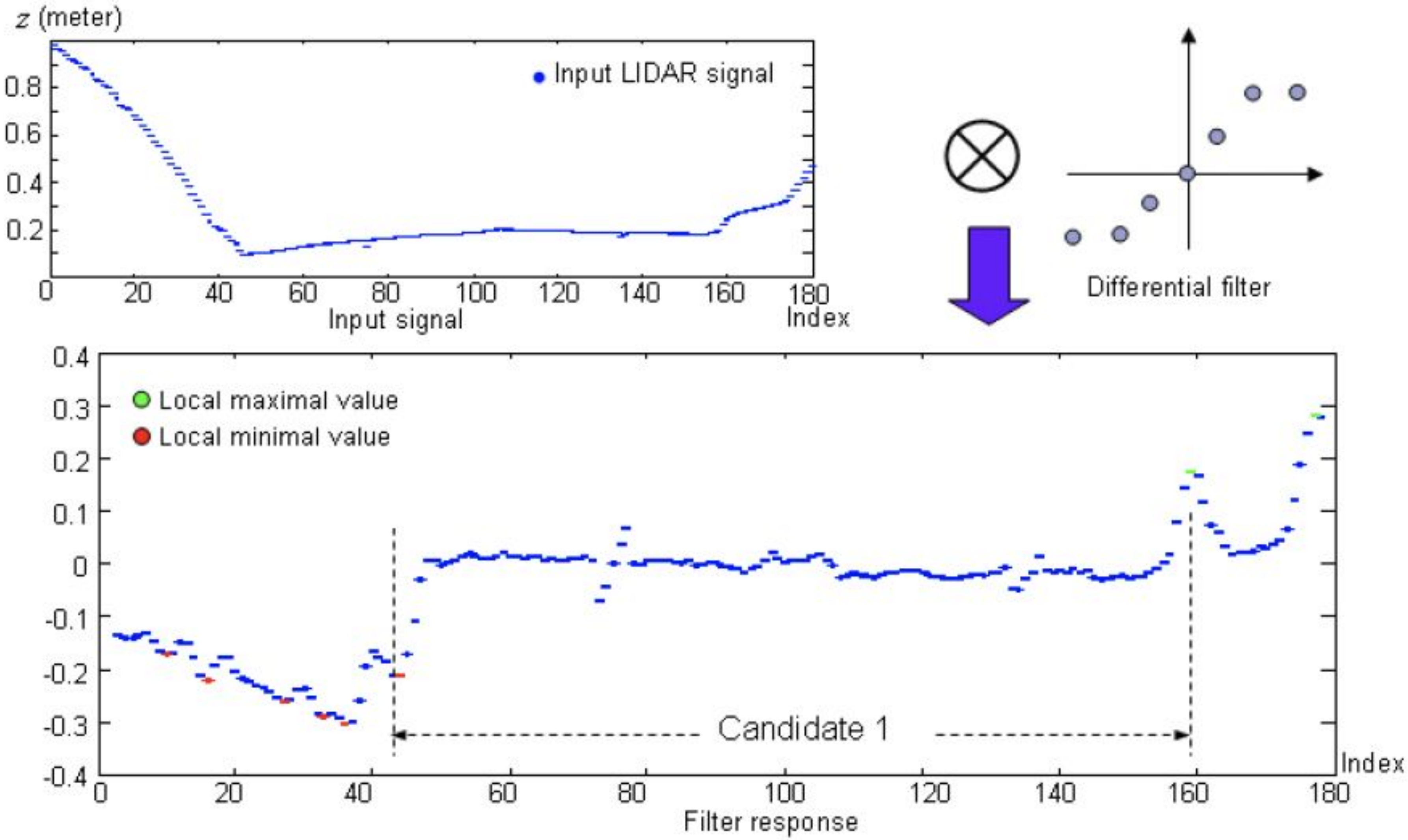
- A forward looking LIDAR sensor scans the scene with 2D point array covering 90 degree field-of-view.

- The road and road-edge points are first detected in elevation (z direction) data, and then validated on the ground plane to improve system robustness and processing speed.

5 Steps Process



Candidate Selection



Feature Extraction

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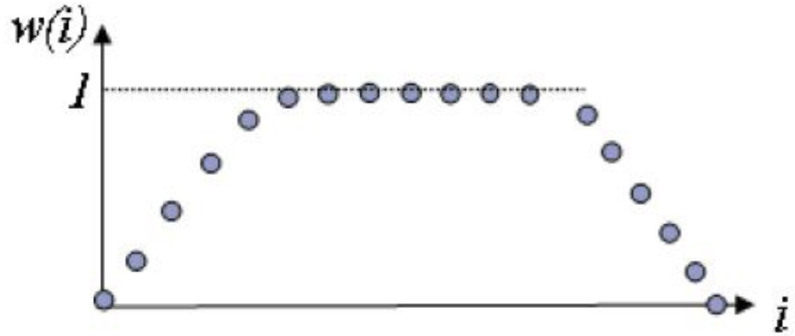
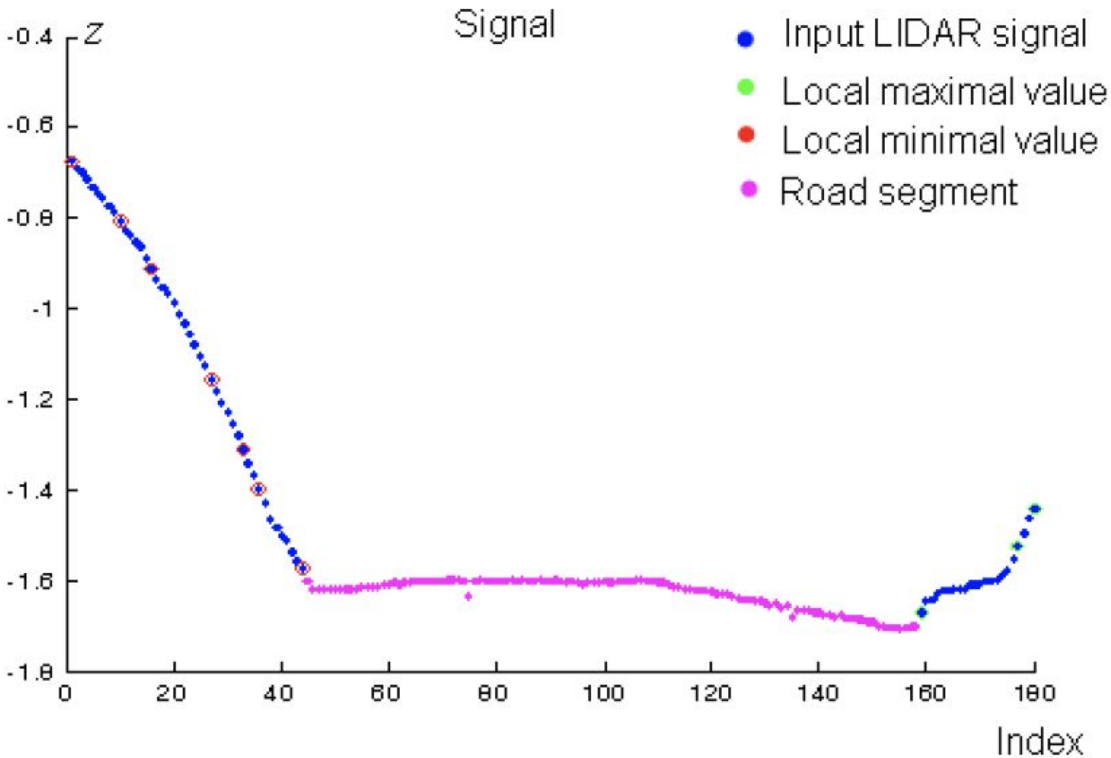
The variance of ground elevation is used as a feature. The weighted standard deviation σz of elevation z is calculated in the candidate road-segment region. The statistic is biased towards the center region

$$w(i)=\begin{cases} a(i), & a(i)<=1 \\ 1, & \text{otherwise} \end{cases}, \quad a(i)=2*\sin(i*\pi/(N-1)), \; i=0,1,\ldots,N-1$$



Classification

A classifier is applied to determine whether the candidate region is a road-segment to strike the balance between the weighted standard deviation of road-segment elevation and the total number of points N within the candidate region.

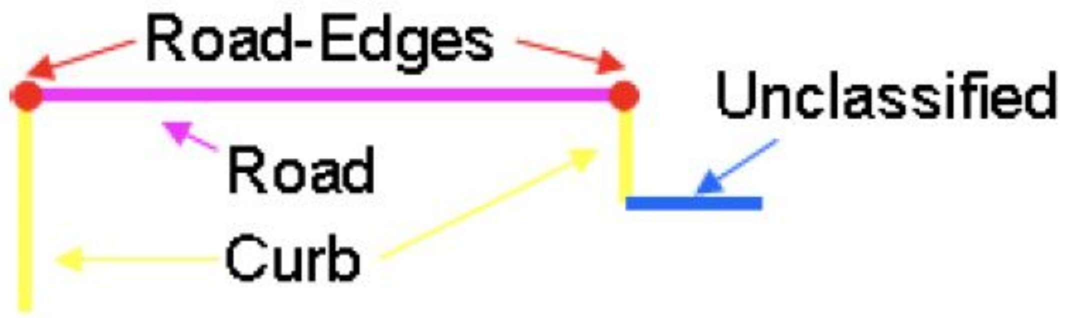


False Alarm Mitigation

- Regions identified as potential road regions are validated.
- The width d of the road segment has to be greater than a threshold (4 meters in our system). The width d is defined as the distance between adjacent local minimal and maximal points.

Road Curb Detection

The road curb lines are perpendicular to the road surface on the projected ground plane. Therefore, road edges and curbs of the road segment are further validated using curb detection in the top-down view by projecting the input data to the ground plane



Experiments

Experiment - 1

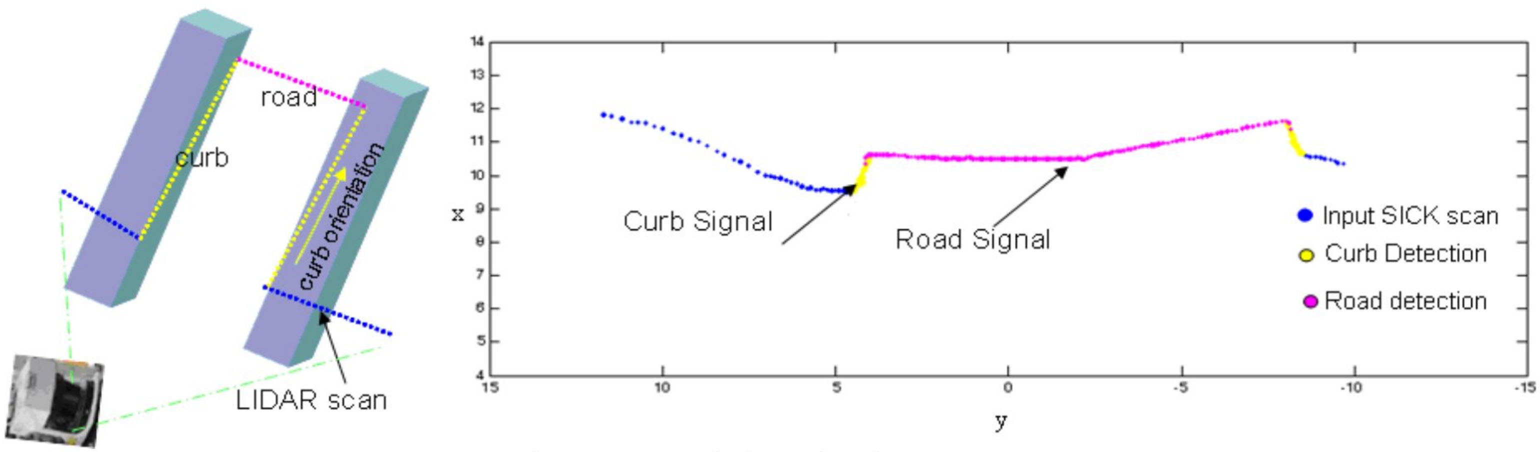


Figure 10. Curb detection in x-y space

Experiment - 2

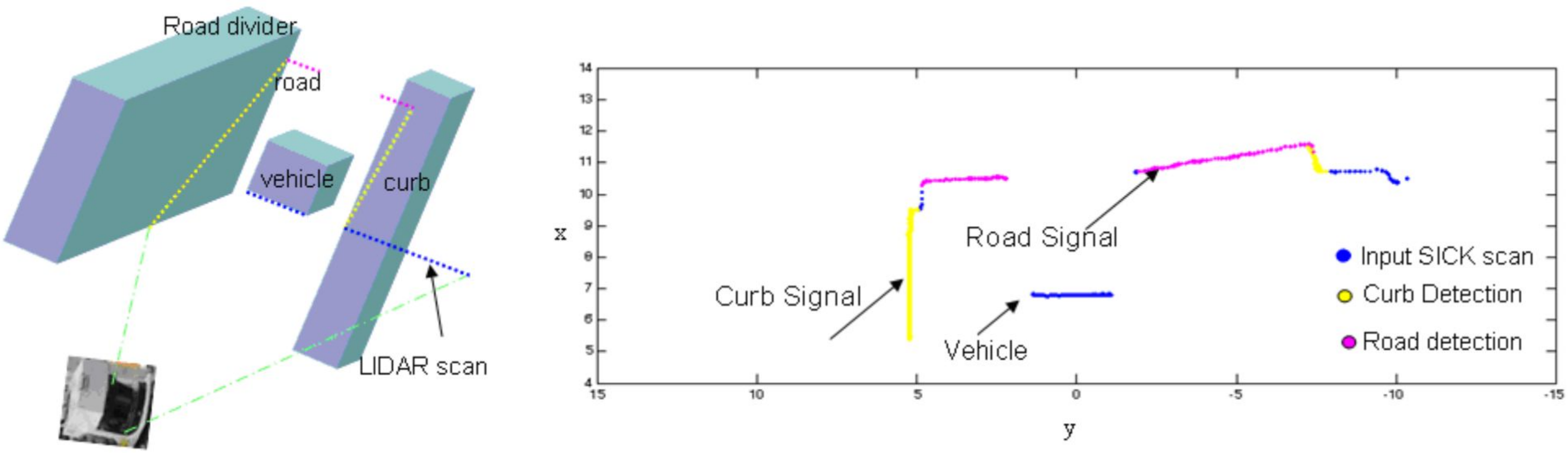
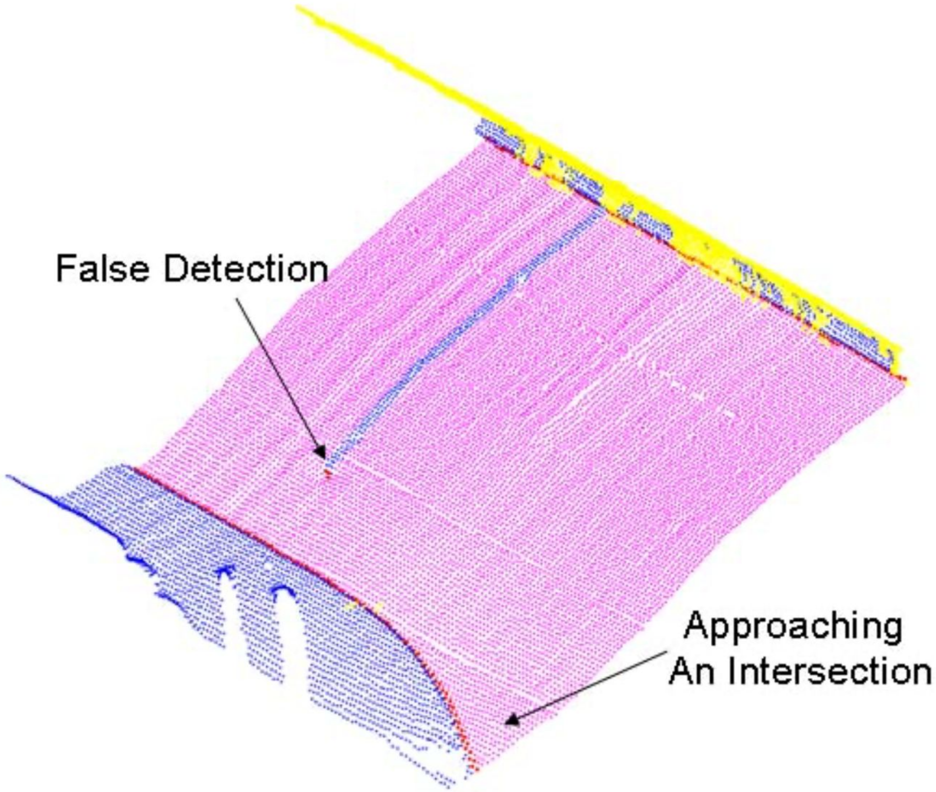


Figure 11. Detection result in a single scan


False Detection
Approaching
An Intersection

Conclusion

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- The system can detect road, road edges and curb lines with orientation in a single LIDAR scan.
- The robustness and efficiency of the algorithms has been demonstrated in various testing scenarios

Demo