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Traffic Sign Extraction from Mobile LiDAR Point Cloud

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Yushin Ahn, PhD Riadh Munjy, PhD Ziyuan Li

Introduction

Various roadside infrastructures along the state and local road are routinely managed by a state's Department of Transportation (DOT). Challenges exist in collecting the data and maintaining the inventory. Recently, state departments of transportation have been adapting laser scanning technology, which digitally stores roadside information in the form of a massive number of three-dimensional points. Laser scanning refers to technology that computes three-dimensional coordinates using laser-based distance and direction measurements. Laser scanning data refers to three-dimensional point cloud information obtained from a laser scanner. When mounted on mobile platforms, such as vehicles, it is called Mobile Terrestrial Laser Scanning (MTLS), offering a comprehensive 3D representation of the surrounding environment along the road. Note that the terms "LiDAR" and "Laser scanning" can be used interchangeably to refer to the same technology which utilizes laser pulses to measure 3D positions. Among the many applications of these dataset, the extraction of traffic signs from MTLS point cloud data has become a pivotal focus in research, driven by the growing integration of LiDAR remote-sensing technologies in transportation applications. The advantage of efficient data collection for large-scale road networks is particularly evident with Mobile LiDAR systems mounted on vehicles. This study focuses on the development and refinement of techniques for the extraction of traffic signs from Mobile LiDAR point cloud data. Accurate detection and localization of traffic signs play a pivotal role in enhancing road safety, navigation systems, and intelligent transportation solutions. The utilization of LiDAR technology in this context opens up new possibilities for automating the process of traffic sign recognition and mapping.

Study Methods

The data set used for this study is located on Highway 76, between Los Angeles and San Diego. It covers approximately 8 miles of road. The scans were executed multiple times, covering both main lanes (four times each) and secondary roads (two times each). When combined, the total distance is about 173 miles. The point density per square foot is 400–500 points/ft2, which is a common specification for MTLS used in transportation projects. This density enables a 2-cm resolution grid and effectively observes the condition of the road. This study undertakes various pre-processing steps: (1) merging multiple scans minimizes occluded areas, (2) splitting the total length into 221 small rectangles eases computational load, and (3) filtering removes erroneous points or outliers. These steps aim to prepare the Mobile Terrestrial Laser Scanning data (MTLS) into manageable sizes, facilitating the detection of traffic sign areas. The main steps involve: (1) separating ground and non-ground points to enforce the constraints that the traffic signs are located on non-ground points, (2) height filtering to remove points with a certain height above the specified traffic sign height, and (3) creating an intensity map. 3D points are grided in 2D to detect high intensity line segments that belongs to traffic signs. Finally, extracting points on traffic signs and calculating their central locations are performed. The locations of signs can be placed on the map and saved as a Keyhole Markup Language (KML) file which stores locations, image overlays, and modeling information, such as shapes in programs such as Google Earth Pro.

Findings

Traffic signs are specifically designed to be retro-reflective, ensuring readability both during the day and at night through a property known as "retro reflectivity." The Federal Highway Administration (FHA) has established standards in the Manual on Uniform Traffic Control Devices (MUTCD) mandating agencies to uphold a minimum level of retro reflectivity for traffic signs. The detection process leverages the high-intensity characteristic present in the point cloud intensity map. This is achieved through a sequence of filtering and thresholding image processing algorithms.

- The high retro-reflective surface on traffic signs plays an important role in separating points of signs from other points.
- The intensity-based sign extraction method effectively identifies traffic signs, traffic signals, and other retro-reflective objects. It offers valuable insights for transportation asset management.
- The positions of the signs can be computed in geographic coordinates (latitude/longitude) so that identified targets are placed in Google Earth Pro and other Geographic Information System platforms.
- Mobile Terrestrial Laser Scanning data provides a safe and efficient way for road side asset management.

Policy/Practice Recommendations

MTLS provides comprehensive data of the road and roadside as if a field worker were observing it on site. Supporting research and innovation in MTLS technology, including data processing algorithm development and applications to enhance the versatility of data collection and analysis, will increase efficiency and safety in transportation asset management. The intensity-based sign extraction method proves to be effective in discerning traffic signs, traffic signals, and other retro-reflective objects. This approach provides valuable insights for transportation asset management.

About the Authors

Yushin Ahn, PhD, is an associate professor in the Department of Civil and Geomatics Engineering at California State University, Fresno.

Riadh Munjy, PhD, is emeritus professor in the Department of Civil and Geomatics Engineering at California State University, Fresno.

Ziyuan Li is a senior undergraduate student in Electrical Engineering at California State University, Fresno.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2354

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