Roadside Asset Extraction from Mobile LiDAR Point Cloud

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Introduction

Mobile LiDAR systems are powerful tools that help us map roads and their surroundings in 3D with great speed and precision. These systems are often mounted on vehicles and can scan everything from pavement and road markings to signs, poles, and trees—all while driving at highway speeds. They collect massive amounts of data in the form of points, which can be very useful but also overwhelming to analyze manually. This project focuses on creating smarter, automated ways to process this point cloud data. By combining traditional mapping techniques with modern deep learning (AI) tools, the research team investigated a method to identify road lanes and slope analysis and to classify features such as road lanes and roadside objects. This can help transportation departments do asset surveys more consistently and efficiently, saving time and money. It also supports efforts to improve road safety, plan for the future, and maintain roads in a smarter, data-driven way.

Study Methods

The dataset was collected along California State Route 76 using a high-resolution RIEGL VMX-1HA Mobile Terrestrial Laser Scanning (MTLS) system. The survey generated over 5.7 billion points from 68 LAS files, covering approximately 8 miles of roadway and including both main and secondary roads. The raw point cloud data was preprocessed through merging, tiling, and denoising to eliminate noise and shadow effects, ensuring higher quality and denser coverage. The preprocessing helps clarify the data so it is easier to use.

Digital Elevation Models (DEMs) and high-resolution (3 cm) intensity rasters (or maps) were created from the processed point cloud data. These raster maps enabled image based analyses of surface geometry and reflectivity, which are key to detecting road features such as lane markings and slope changes. The research team analyzed the data using a variety of techniques. Specifically, road lane extraction was performed using adaptive thresholding of the intensity raster, followed by edge detection using the Sobel operator and Hough transform-based line fitting to delineate road markings, including dashed and solid lines.
For elevation-based analysis, the study conducted cross-section slope profiling across multiple road segments. Using regularly spaced cross-sections perpendicular to the road centerline, slope percentages were calculated on both sides of the road. These profiles were then compared to design standards to assess roadway conformance and detect drainage or structural issues. This kind of analysis is important for ensuring roads are safe, properly drained, and built to engineering standards.

In addition, a deep learning-based classification model was developed using PyTorch and a PointNet-style architecture. Over 500 million labeled points were compiled to train the model, which incorporated spatial features (location coordinates), radiometric data (how reflective a surface is), and geometric details (such as the slope and height above ground). The model was trained to perform both binary classification—sorting features into ground and non-ground—and multi-class classification, identifying specific types of objects such as vegetation, poles, dividers, and signs. These outputs, saved as classified LAS files, can then be used in mapping software to support infrastructure planning and maintenance.

Findings

The project demonstrated the technical and practical feasibility of using Mobile LiDAR and AI deep learning to automate the identification of roadside assets classification. Key findings include:

- **Road Lane Extraction**: By combining DEM and intensity raster processing with image-based edge detection, the method delineated both dashed and solid lane markings. Extracted lane data aligned well with satellite imagery, meaning the method successfully identified and classified different types of lane markings on roads.

- **Slope Analysis**: Cross-section slope profiles obtained from the point cloud data matched typical highway standards (1.5%–2.5% cross slopes). This confirms that MTLS is accurate and precise enough to assess roadway drainage and safety features.
- **Deep Learning Classification**: The PointNet model achieved strong performance in both binary and multi-class scenarios. It effectively distinguished ground, vegetation, dividers, and structural features, even in high-density urban areas.
- **Commercial Software**: Compared to proprietary tools, such as Trimble Business Center (TBC), Global Mapper Pro (GMP), and Cyclone 3DR, the custom workflow developed in this study demonstrated competitive accuracy while offering improved adaptability for large-scale applications. TBC performed well in lane marking extraction, GMP excelled in power line detection, and Cyclone 3DR provided balanced results with AI-assisted classification. However, the study's approach proved more flexible in handling diverse asset types and scalable for processing high-density LiDAR data across extensive roadway networks.

Policy/Practice Recommendations

Transportation agencies can significantly benefit from integrating Mobile Terrestrial Laser Scanning (MTLS) and deep learning-based classification tools to enhance the efficiency and accuracy of roadside asset management. The workflow developed in this study enables consistent and scalable identification of infrastructure elements such as road lanes and vegetation, reducing the need for labor-intensive manual surveys. This approach supports the modernization of asset inventory practices, allowing for more frequent and data-driven assessments of roadway conditions. Furthermore, by embedding MTLS-based analytics into existing pavement management systems and broader smart city initiatives, agencies can improve long-term planning, safety evaluations, and infrastructure resilience. Standardizing point cloud processing workflows across departments would also help ensure uniformity and reproducibility of results, supporting interagency collaboration and data sharing. Finally, investing in the development of in-house technical capabilities—including staff training and computational infrastructure—can help reduce reliance on commercial platforms and empower agencies to adopt cutting-edge, cost-effective solutions tailored to their specific operational needs.

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For more details about the study, download the full report at transweb.sjsu.edu/research/2448

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