Research Problem Statement

ODOT Research Section
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I. TITLE

17-042 Lidar for Maintenance of Pavement Reflective Markings

II. PROBLEM

ODOT currently tracks several metrics for compliance of pavement markings, including appearance and retro-reflectivity. The Maintenance Section of ODOT uses a van, which travels the state every summer, to capture retro-reflectivity values on lane markings. These values are then analyzed and used in creating a plan of action for maintenance. For recent applications, the warranty is examined and, if applicable, the vendor is notified to conduct replacement. For older applications, regional crews note the faulty areas and plan in-house crew work or allocate budget to contract the work. Unfortunately, issues arise due to the timing and frequency of the data acquisition. Often, individual hand-held reflectometer readings are needed after winter months to re-check compliance, which may be risky (roadside) and staff time intensive. Sign retro-reflectivity studies suffer from similar limitations. Mobile lidar scans are now being conducted on a regular basis through ODOT Geometronics. This technology supports a wide range of transportation applications (NCHRP Report #748 http://learnmobilelidar.com) within a single dataset that is acquired more safely and efficiently than conventional methods. In addition to capturing geometric information along the highways, a side product of lidar scans is intensity (return signal strength), which provides information on object reflectivity. However, for intensity measurements to be reliable, several parameters need to be determined through a process known as radiometric calibration (Kashani et al., 2015). Since most existing radiometric calibration algorithms are not designed to account for specular (i.e., mirror-like) reflection typical of retro-reflective materials, research is needed to develop and optimize algorithms for pavement markings and signs using ODOT's scanner. In addition, research is needed to evaluate the effects of challenging conditions, including rain and ice, which are commonly encountered in the winter/spring seasons after plowing when maintenance crews need to evaluate the lines for summer work.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

Researchers and practitioners are currently evaluating the ability of lidar to retroreflective values on signs [NCHRP Report 748]. However, to date a proven process has not yet been generated. The proposed research would require data mining to determine if pavement markings and signage under compliance are able to be identified with lidar scanning.

1. Perform a review of current business practices of line and sign retro-reflectivity evaluation, performance modeling, and warranty evaluation procedures. Compare national approaches to ODOTs so that a practical approach can be applied considering ODOT's current practices.
2. Perform a review of technologies utilized and current calibration procedures for retro-reflectivity measurements of transportation assets such as striping and signs.
3. Design and conduct radiometric calibration procedure for ODOT's mobile laser scanner (Leica Geosystems Pegasus 2). This task will require a controlled test with targets of various reflectivities in several geometric configurations. It is envisioned that the targets could be placed within ODOT's mobile lidar test course for repeat usage and periodic validation of the system.
4. Write supporting open-source software to perform the radiometric calibration as part of Oregon DOT's data processing workflows.
5. Compare lidar retro-reflective readings with field measurements. What error rate would we encounter (e.g. how many false-positives) in comparing lidar scans to retro-reflectivity values? What precision of length of faulty line does the maintenance crew need from a lidar scan?
6. Evaluate degradation of laser intensity data based on environmental conditions, such as rain and ice.
7. Develop an automated GIS workflow to extract lane markings from mobile lidar data, evaluate their retro-reflective condition, and correlate with additional geospatial information such as ODOT's crash database to prioritize sections for lane marking maintenance. This decision tool could display data in both tabular and visual format. The visual output could be geospatial databases viewable in GIS, Google Earth, or Microstation software.
8. Provide recommendations for mobile scanning acquisition and metadata to ensure data will be of sufficient quality for retro reflectivity measurements on striping and signage.

9. Should the mobile lidar prove unsuccessful at obtaining these readings at a level satisfactory to ODOT, provide recommendations of sensors that could be mounted on Oregon DOT's mobile lidar platform to collect this information simultaneously.

IV. POTENTIAL BENEFITS

This project has the potential to save ODOT significant money in reducing field time and effort. It will lead to more cost-effective maintenance strategies and help ODOT utilize existing warranties better for road markings. The QA/QC process can also be improved with the continuous mobile lidar coverage and reflectivity analysis compared to the currently process where results can be influenced by where the individual measurements are taken. Improved marking maintenance strategies enable safety, economical, and environmental benefits by ensuring high-quality markings while minimizing paint and other material usage. In addition to retro reflectivity, the type of lines (e.g., broken, NPL, etc.) could be determined and input into ODOT's asset management system to support future decision making. This, in turn, leads to improved safety evaluations such as passing sight distance evaluations by enabling improved extraction of road geometry.

Benefits of the project extend well above and beyond the primary purpose of lane marking maintenance. By performing the radiometric calibration on ODOT's mobile scanner, the system will be acquiring actual reflectivity measurements on a wide variety of transportation assets. This reflective information will be very useful in asset management by improving user interaction with the data as well as improving the success of automated feature extraction algorithms. The information is anticipated to greatly benefit condition assessments on these assets.

Improving retro-reflectivity measurements enables more efficient lane marking maintenance, which can benefit driver-assistance systems and driverless vehicles, which rely on lane markings for guidance. The results of this work may prove beneficial in the development of such systems, since many are likely to utilize lidar sensors.

This research also enables Oregon DOT to obtain even more value with their current mobile lidar scan acquisitions, where data are routinely being acquired for a variety of purposes across the state. The mobile lidar data acquisition has already shown solid performance, ROI, and many other benefits in ODOT. This helps reduce duplicative travel and field work, including in remote areas. It also will provide an enhanced framework utilizing the mobile lidar data for asset management, resulting in improved MAP-21 compliance.

V. IMPLEMENTATION

The project team will work closely with Oregon DOT Geometronics on performing the radiometric calibration and field testing so that this work can be completed in conjunction with their existing data collection efforts. The radiometric calibration software will be developed such that it fits readily into their existing processing workflows. We will also work with the lane marking maintenance personnel to obtain datasets on lane marking performance and to help guide the development of the decision software tool.

VI. LIST OF REFERENCES *(optional)*

Olsen, Roe, Glennie, Persi, Reedy, Hurwitz, Williams, Tuss, Squellati, and Knodler, 2013. Guidelines for the Use of Mobile Lidar in Transportation Applications, NCHRP Report #748. www.learnmobilelidar.com.

Kashani, Olsen, Parrish, and Wilson, 2015. "A review of lidar radiometric processing: from ad hoc intensity correction to rigorous radiometric calibration." Sensors, 15(11), 28099-28128, doi:10.3390/s151128099.

VII. CONTACT INFORMATION

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