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Project Title

Uses and Challenges of Collecting LiDAR Data from a Growing Autonomous Vehicle Fleet: Implications for Infrastructure Planning and Inspection Practices

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Research Needs

The use of Light Detection and Ranging (LiDAR) technology has been growing in the transportation industry in recent years. The technology has been proven to provide precise, accurate, and high-density point clouds that can be related to a global reference frame (El-Sheimy et al., 2005; Shan and Toth, 2009). Extensive research in the area has shown how this technology can be used for anything from construction quality control to safety assessments to infrastructure management (e.g. Yu et al., 2015; Riviero et al., 2016; Pu et al., 2011; Geiger et al., 2012; Lato et al., 2012; He et al., 2017, Neupane et al., 2018; Rister et al., 2018).

The direct ownership and use of LiDAR by transportation agencies has grown. National Cooperative Highway Research Program Report 748 includes guidelines for using mobile LiDAR in transportation applications (Olsen et al., 2013). Chang et al. (2014) also published guidance on how agencies could practically use and deploy LiDAR. The authors discuss common transportation applications and acquisition options of LiDAR. For example, the authors recommend the mobile LiDAR platform for applications such as construction clearance measurement, corridor mapping, safety assessments, and traffic operations. Some agencies have begun deploying LiDAR on their vehicles for data collection (Coifman et al., 2017).

As the nation approaches an era of autonomous vehicles, there will be great opportunities and challenges regarding sensing technologies and the resulting data. Research and development of sensing systems for autonomous vehicles is ongoing, both in academic arena and the automotive industry. Some studies consider specific challenges that autonomous vehicles utilizing a certain sensing technology might face (e.g. Combs et al., 2018). In 2017, an Automated Vehicles Symposium was held in San Francisco, CA, for continued communication, collaboration, and information sharing on a wide range of topics surrounding autonomous vehicles (Texas A&M

Transportation Institute, 2018). There is clearly great interest in and need of research in the area of autonomous vehicles.

Of particular interest for this project proposal is how transportation agencies can utilize the Big Data that will result from a growing fleet of autonomous vehicles. Agencies have had experience with Big Data in the past (Zhao et al., 2018). However, the Big Data of autonomous vehicles is likely to be of unprecedented magnitude (e.g. Matthews, 2018; Marr, 2017; Clerkin, 2017). How will agencies handle such a data set, should they choose to collect it? How much data can agencies expect from a variety of different scenarios? Will they need to filter the data they receive? How many uses can they get out of these data? This proposed project will help agencies answer some of those questions.

Research Objectives

The purpose of this project is to the potential uses and challenges of large-scale collection of LiDAR data from autonomous vehicles by transportation agencies. The proposed project will accomplish the following objectives:

1. Conduct a comprehensive literature review of current, small-scale uses of LiDAR in the transportation industry for ease of reference by public agencies.
2. Conduct case studies of various uses of LiDAR to demonstrate the versatility of the technology and provide concrete examples of data results.
3. Estimate large-scale data management needs for use of LiDAR data from a growing autonomous vehicles fleet and discuss the potential challenges, solutions, and benefits to public agencies.

Research Methods

In the proposed research, an extensive literature review of the use of LiDAR data in the transportation industry will be conducted. This will include stationary, airborne, and mobile LiDAR in both the public and private sectors. The purpose of this literature review is to provide an overview of the various uses of this technology that have already been explored and summarize the findings, recommendations, and challenges.

Additional case studies will be conducted by the researchers to confirm findings from the literature review and explore new use cases. Data will be collected using a mobile LiDAR system comprised of a single LiDAR unit, video/photo equipment, geospatial/inertial measurement equipment, and a mounting system. Different scenarios to be explored may consider the following variables: work zone layouts, roadway classifications, weather conditions, traffic/pedestrian volumes, vehicle speeds, etc. These case studies will result in additional findings and recommendations for agencies considering the collection of these data from autonomous vehicles. When processing the data from these case studies, consideration will be given to: distinguishability of roadway features within the point cloud; amount of “noise” in the data set from other vehicles and pedestrians; size of the data set; density of the point cloud; collusion. The data sets will also be made available for public use.

Using the data collected from the case studies, we will extrapolate to large-scale considerations. For public agencies intending to collect these data from a growing autonomous vehicle fleet, it is

important to understand the size of the data. A simple linear regression model will be developed that estimates the expected size of the data set considering vehicle speed, roadway facilities size (width and length), autonomous vehicle fleet size, LiDAR system specifications, etc. This model would help agencies estimate their future data management needs should they decide to collect these data.

Expected Outcomes

The project is expected to provide an overview of potential uses (based on a literature review and case studies) and challenges for public agencies collecting LiDAR data from autonomous vehicles. Potential findings should include data size estimates for various scenarios and sample data sets from case studies. The research findings will offer a wide range of applications, from individual projects to nationwide. The end product, an overview of the uses and challenges, will be useful to transportation agencies that are considering investing in the collection of LiDAR data.

Relevance to Strategic Goals

The proposed project contributes to two of the U.S. Department of Transportation (USDOT) strategic goals as identified by the FAST Act: State of Good Repair and Economic Competitiveness. The expected outcomes of this project include an overview of the potential uses of large-scale LiDAR data from autonomous vehicles, which include improved inspection and management of infrastructure assets. Public agencies can potentially utilize these data to supplement or replace their existing infrastructure inspection practices/equipment. This project will also provide public agencies with important information regarding the potential challenges and benefits of these data. Understanding the benefits and costs of investing in the collection of this growing data source will help agencies move forward into an era of autonomous vehicles.

Educational Benefits

One graduate student will be involved in the research and receive training in LiDAR data collection and processing. The research results will provide fresh materials and case studies to expand the transportation curricula at USU.

Technology Transfer

Research results will be disseminated through publication in peer-reviewed professional journals and presentations at state and national meetings and conferences. All data collected from the research project will be stored in a repository such that the information will be easily retrievable should anyone wish to use it. Research results will also be incorporated into a wide variety of education, training, outreach and workforce development activities.

Work Plan

The proposed project will be carried out over an 18-month period under the following timeline:

Task	Duration	Completion Date*
Literature Review We will conduct a comprehensive literature review on the uses of LiDAR technology in the transportation industry.	4 months	4
Development and Testing of LiDAR System We will develop a LiDAR system to be mounted on a vehicle for data collection during the case studies. The system will include a LiDAR unit, mounting device, GNSS/IMU unit, and other miscellaneous equipment.	3 months	7
Case Studies We will collect LiDAR data on a variety of roadway facilities under a variety of conditions (i.e. weather). These data will be used to develop a collection of case studies and examples of different uses. This time period includes the processing of these data.	6 months	13
Estimating Large-Scale Data Management Needs We will estimate the size of large-scale data sets using the system specifications of various LiDAR systems, different autonomous vehicle volumes, vehicle speeds, vehicle-miles-traveled, etc.	3 months	16
Report Writing The literature review, methodology, case studies, and overall findings will be written in the final report.	2 months	18

*Months from starting date

Project Cost

Total Project Costs:	$ 99,985.42
MPC Funds Requested:	$ 49,992.71
Matching Funds:	$ 49,992.71
Source of Matching Funds:	LTAP

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