Mapping of Pavement Conditions Using Smartphone/Tablet LiDAR

Case Study: Sensor Performance Comparison

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Introduction

Road conditions, impacted by weather and use, affect millions of drivers each day, and monitoring the conditions of roads is made easier by the use of technology like LiDAR. Proper and timely assessment is necessary to better budget and plan for future needs to protect the welfare and safety of the public. LiDAR (Light Detection and Ranging) is a technology that is utilized in many aspects for remote sensing and traditional geomatics applications. The use of LiDAR is not new to assessing pavement conditions, but it can be costly. Apple has integrated a LiDAR sensor in the iPad Pro and the Apple iPhone Pro model 12 and up, originally implemented to aid in the portrait mode at night while taking pictures. This project explores the application of the Apple iPad Pro and Apple iPhone equipped with LiDAR technology using free apps that utilize the LiDAR sensor in a more traditional Geomatics Engineering method. It relies heavily on the IMU (inertial measurement unit), the integrated camera, and the single frequency GNSS (global navigation satellite system) sensor for positioning of the device to control the resultant collected data sets. A terrestrial LiDAR scanner, Leica P20, is used to produce the base surface model for comparison.

Study Methods

Study methods included the assessment of known locations of poor road conditions via a combination of visual inspection and photographic data to identify and classify pavement fatigue. A comparison was made between a survey-grade terrestrial laser scanner (Leica P20) and the iPad and iPhone LiDAR data. A 3D surface was created as the base model from the Leica P20 – regarded as truth data. The surfaces are employed to analyze the horizontal and vertical deformations in all the datasets. Finally, the 3D data was used to classify the different types of fatigue areas, such as cracking, patches, deformations, and defects, based on Caltrans Pavement Distress Manual guidelines.

Findings

Key findings include:

- The iPad Pro and iPhone-based LiDAR proved unsuitable for accurately and comprehensively assessing roadway damage.
- Two-dimensional details, aided by overlaying photographic details, are comparable to that of conventional cameras and pictures.
- Vertical deformations in surfaces less than 3-4 cm were not identifiable using both the iPad and the iPhone.

- Scans over larger areas exhibited misalignments of the measured data, leading to inaccurate surface models.
- Colorized point clouds provided some information on moderately damaged concrete surfaces, although they are less effective for asphalt surfaces.
- Limitations with global navigation satellite systems (GNSS) are a vertical tolerance of ±2-3cm. The reliance on GNSS to make corrections to the location of the LiDAR device is greatly reduced. Post-processing, relative targeting, and established benchmarks within the datasets will overcome the current limitations, but that renders the effort of off-the-shelf and out-of-the-box technology useless.

Apple iPhone and iPad LiDAR sensors are not ready for precise and accurate mapping in the transportation and surveying industry.

Policy/Practice Recommendations

- Future studies should test the use of a Gimbal Stabilization.
- Process raw data from the sensor and utilize more intensive PC-based processes to enhance the final deliverable.
- Apple's ongoing advancements in LiDAR sensor technology and inertial measurement accuracy may enhance the feasibility of using Apple products for assessing roadway damage.
- Incorporating physical control points could improve scan quality, but the associated costs may outweigh the benefits.
- Utilize dual frequency GNSS.

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2224

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