The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Geo-Referenced Digital Data Acquisition and Processing System Using LiDAR Technology

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Principle Investigators:
Charles Toth
Dorota A. Grejner-Brzezinska

ODOT Contacts:

Technical:
John Ray
Administrator, OAE
614-275-1357

Administrative:
Monique R. Evans, P.E.
Administrator, R&D
614-728-6048

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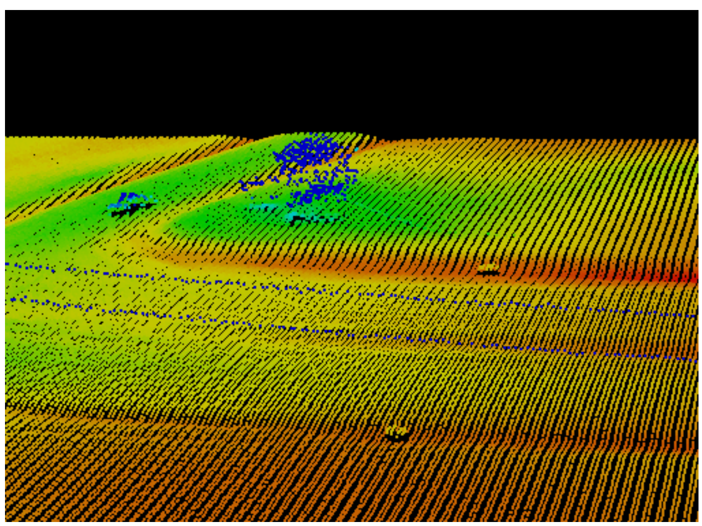
or call 614-644-8173.

Ohio Department of Transportation
Office of Research & Development
1980 West Broad Street
Columbus, OH 43223

Problem

State-of-the-art airborne mapping is in major transition, which affects both the data acquisition and data processing technologies. The IT age has brought powerful sensors and revolutionary new techniques to acquire spatial data in large volumes, rapidly, and at an accuracy level that is unprecedented in past production. Without any doubt, LiDAR (also called airborne laser scanning) systems have established themselves as a dominant player in high-precision spatial data acquisition in the last four to five years. The introduction of LiDAR into Office of Aerial Engineering (OAE) daily operations posed real challenges since, besides the very different hardware (as compared to the traditional imaging sensors), the characteristics of the data, as well as the type of required processing, were significantly different from the methods used in the past.



Objectives

- To introduce new airplane sensor suite configurations integrated from commercially available sensor components,
- To increase the standard accuracy of LiDAR systems so that true design quality is achieved,
- To carry out test flights to benchmark the performance of the procured LiDAR system,
- To perform the extended quality assurance analysis based on the above mentioned airborne tests with ample ground control,
- To consult ODOT personnel in GPS/INS technology/data acquisition and processing,
- To consult ODOT personnel on future developments, such as the introduction of high-resolution digital photogrammetric cameras.

Description

Besides extensive system calibration and performance validation, the research related to the use of LiDAR specific ground targets represented the most significant result of this project. Extensive simulations were performed to determine a favorable LiDAR-target design, including optimal target size and shape, signal response, coating pattern, and methods to accurately determine the 3-dimensional target position in the LiDAR dataset.

Conclusions & Recommendations

To assess achievable accuracy improvement using the designed LiDAR-specific targets for LiDAR data refinement, data from two test flights were analyzed. The first test flight in Ashtabula, OH, was aimed at infrastructure mapping of a transportation corridor. To support our investigations 15 pairs of targets were placed symmetrically along the two sides of the road. The second test flight at the Madison Calibration range was a dedicated test flight for investigating the target identification accuracy and the effect of targets in the improvement of LiDAR data accuracy for various LiDAR settings and target densities. Results proved that the algorithms developed to determine target coordinates in LiDAR data could provide 5-10 cm horizontal positioning accuracy (at 25 cm footprint size) and 2-3 cm vertical accuracy of the target coordinates at 5 points/m^2 LiDAR point density. Consequently, larger than 10 cm horizontal errors in the LiDAR data and vertical errors larger than 2-3 cm can be detected and corrected using the LiDAR targets.

Implementation Potential

The OSU staff worked in close collaboration with ODOT OAE personnel to ensure that all functional aspects of the system’s operation were followed during the field procedure. This included test flights, calibration, and training seminars for the OAE staff. The system is fully implemented and installed in the OAE airplane, and has been operational since fall 2004. To support daily operations and effective data processing and analysis, the “LiDAR Intensity Fusion Technology” (LIFT) program has been installed at OAE.