Paper ID: 62563
student

IAF SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems (1)

Author: Mr. Hamdy Elsayed
Ryerson University, Canada

Prof. Ahmed Shaker
Ryerson University, Canada
Dr. Grant Cunningham
Canada

DESIGN, IMPLEMENTATION, AND ANALYSIS OF A NOVEL LIDAR SYSTEM FOR SPACE MISSIONS USING A COMBINATION OF MEMS STEERING AND FLASH TECHNOLOGIES, SEMICONDUCTOR LASERS, AND TIME-OF-FLIGHT IMAGERS

Abstract

LiDAR stands for Light Detection and Ranging. It has been used in different applications such as earth observations, terrain mapping, autonomous vehicles, planetary exploration, space docking, and rendezvous.

This research aims to build a robust, miniature, cost, time and power-efficient LiDAR system for space applications. The proposed system combines the flash and steering laser technologies along with the use of Time-of-Flight depth cameras and inexpensive semiconductor lasers to introduce a new innovative solution for 3D scanning of objects and mapping in space missions.

The first part of this paper is a survey on the state-of-the-art technologies used in building the proposed system, including the Micro Electrotechnical Mechanical System (MEMS) mirrors, semiconductor lasers, and two-dimensional time-of-flight imagers. The subsystem's selection criteria for each subsystem are also explained and justified based on the provided requirements of the Canadian Space Agency. Furthermore, this study proposes using MEMS mirrors for steering the laser spot within the area of interest; the MEMS mirrors are miniature microstructure and can be controlled by different actuation mechanisms such as electrostatic or electromagnetic actuation methods.

Secondly, the paper explains the system design parameters and the implementation details of each component. In addition to that, the unit-based and the overall system test scenarios are also detailed thoroughly. It also includes the method of building a theoretical performance model that is used to predict the system performance based on the initial design parameters and assumptions. After building and consolidating the system components and it became operational, the model was adjusted to validate all parameters and assumptions' soundness and inclusion. The comparison showed the legitimacy of the math model and how good are the design parameters and hypotheses. The model was also used to optimize the system capabilities and scalability by investigating the scanning quality of targets at very long distances, which were not practical for testing in the lab.

The third and final section in this research paper is allocated to obtain and process datasets throughout the project timeline and the associated data analysis and stats. This part also addresses the evaluation of the used laser beam, the optical lens system that commands the beam size and its characteristics, and the intensity and range data examination and interpretation.

In a nutshell, this research provides insights on the feasibility of using the proposed hybrid LiDAR system in space applications, and offers recommendations for the future use of the system.