Paper ID: 72762
student

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

Author: Mr. Hamdy Elsayed
Ryerson University, Canada, hamdy.elsayed@ryerson.ca

PROPOSING A COST- AND POWER-EFFICIENT HYBRID LIDAR IMAGING SYSTEM FOR SPACE PROXIMITY OPERATIONS

Abstract

LiDAR has been used in different applications such as Earth observations, topographic mapping, structure inspection, autonomous vehicles, planetary exploration, space docking, and rendezvous. This research aims to build a robust, miniature, cost and power-efficient 3D LiDAR Imaging System primarily for space applications and potentially for other civil applications. The paper explains the system design parameters in terms of the selection criteria for the laser, deflection mirrors and the TOF "time-of-flight" depth camera in addition to the implementation details of each subsystem. Moreover, the individual subsystem testing, and the overall system test scenarios are also detailed thoroughly including the testing site specifications and different testing environments, for example high or low temperature, and bright versus dark illumination conditions. It also includes building a theoretical performance model based on the statistical error propagation model using the variance-covariance parameters of the system measurements including the imager pixel performance and the laser driver modulation homogeneity. This model is used to predict the system performance based on the initial design parameters and used for optimization. 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 environment. Also, this paper will provide an intensive insight on obtaining and processing the raw datasets out of the TOF imager throughout the project and the associated data analysis and stats. Also, we address the laser beam's evaluation, the optical lens system that commands the beam size and its characteristics, and the depth camera intensity and range data examination and interpretation. Another important investigation in this research is studying the different noise sources that impact the TOF imager performance such as the spatial and temporal noises. The critical contribution of this research is introducing a new system of its type for the space industry, it is lightweight, compact, power and cost-efficient way to provide 3D maps for any target or surface. It's very helpful in conducting proximity operations such as docking and rendezvous. It will also help in landing spacecrafts on rough landing sites safely. This system gives a scalable range of detection up to 200 meters with a few decimeters accuracy, which is exactly what is required for these space operations.