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REAL TIME RELATIVE POSE ESTIMATION OF TWO SATELLITES USING LIDAR SENSOR THROUGH THE USE OF ITERATIVE CLOSEST POINT ALGORITHM

Abstract

The widespread use of LIDAR today has enabled a variety of interesting space applications such as safe landing site detection, digital elevation map analysis, altitude measurement, and satellite position estimation. The use of the Iterative Closest Point (ICP) algorithm and other variants like Sparse ICP, Point-to-Plane ICP have brought more value to LIDAR in the field of pose estimation. This work proposes a novel framework for estimating the relative attitude between two satellites during rendezvous and docking processes using ICP algorithms with lidar sensors. Since ICP is an iterative algorithm, it can get stuck in local minima before converging to the optimal solution. To overcome this problem, we have used Random Sample Consensus (RANSAC) algorithm for outliers removal. In addition, an impulse-based learning rate is implemented to increase robustness and speed up convergence to reach the optimal solution. The ICP algorithm iteratively estimates pose using the mean position and direction of the maximum covariance of the two point clouds. This is computationally less expensive compared to traditional methods of pose estimation. Consequently, real-time relative pose estimation is achieved, which is essential in space applications. For validation of the algorithm, extensive simulations were performed using point clouds of various shapes and Gaussian perturbations, resulting in accuracies of 0.01% for translational rates and 0.1% for rotational rates. There was also a demonstration on ground using LeddarTech's 3D Pixell Flash LIDAR to estimate real-time body rate with 2.0% accuracy achieved in translational and rotational rates. The proposed relative pose estimation algorithm is currently being implemented in the ISRO Servicer Mission.

Keywords: Co-axial helicopter, Martian terrain, Navigation, Guidance and control