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TOWARD AUTONOMOUS RELATIVE NAVIGATION USING FLASH LIDAR

Abstract

Proximity navigation is important for a number of space applications, including orbiting about small bodies, rendezvous and proximity operations between multiple spacecraft, active debris removal, and terrain relative navigation for landing. Several of the fundamental challenges that must be addressed for relative navigation in each of these cases are determination of the shape model and determination of the pose between the observing spacecraft and its target. Furthermore, to move toward an autonomous process, special care must be taken to address issues of robustness and computational requirements in solving these challenges.

Many studies to date in this area have focused on using optical navigation or single beam LIDAR to address this problem. However, in this study we focus on the use of flash LIDAR instruments. A flash LIDAR can return an array of range measurements to its target, and can be thought of as a 3-dimensional image o a point cloud with fixed angular relationships. This data type is extremely powerful for both shape and pose determination as it combines many of the strengths of both optical imaging and single range measurements. In many cases, the strength of this data makes it computationally cheaper to achieve a desired level of relative navigation accuracy than with optical measurements, as well as not being subject to the lighting constraints and detailed BRDF knowledge that can be required for precise optical navigation.

In this work, we demonstrate the performance of flash LIDAR based relative navigation in several scenarios. We will focus our results on the robustness of the solution in the presence of errors, the capability to find a priori shape and pose information to start a navigation filter, shape model refinement, and the reduced data resolution processing that can maintain highly accurate navigation solutions. The combination of these results illustrates the breadth of research being conducted in this area to approach the realization of autonomous relative navigation using flash LIDAR instruments.