ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (3)

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MONTE CARLO ANALYSIS OF LIDAR-BASED POSE CALCULATION WITH RESPECT TO NATURAL AND ARTIFICIAL OBJECTS IN THE SPACE ENVIRONMENT

Abstract

A variety of groups have demonstrated the usefulness of LIDARs as a key sensor in autonomous rendezvous and docking with a cooperative spacecraft. More recent research has examined the potential for navigation relative to a non-cooperative spacecraft, such as for servicing or refueling a communications satellite. Most methods for LIDAR-based non-cooperative relative navigation utilize variants of the iterative closest point (ICP) algorithm for computing the 6-degree of freedom relative position and attitude (sometimes called pose); however, ICP requires an initial guess, and a bad initial guess may cause the algorithm to converge to an inappropriate solution. While a number of techniques use the previous ICP iteration or Kalman filter's output as an initial guess, these methods may propagate poor solutions to a point from whence the flight software cannot recover. In such a situation, the LIDAR data may contain the information to usefully estimate pose, but the algorithm is incapable of finding this solution because it is dependent on an erroneous initial guess from an error encountered earlier in the rendezvous. When problem geometry allows, it is desirable to break this feedback loop to prevent earlier wrong solutions from corrupting the spacecraft's ability to navigate using new measurements. This work is centered around two key improvements. Firstly, a reasonable initial pose is to be calculated in real-time using only the data in a single LIDAR image and a model of the observed object; and this initial guess is converged to a final solution using a typical ICP-based approach. Secondly, pose is calculated not only relative to artificial targets, but based on natural targets with known models, such as an arbitrary space rock or small asteroid. Also demonstrated are an OpenGL-based LIDAR simulator as well as a Monte Carlo framework for comparing and optimizing initial pose estimation methods, which shall be made available under an open source license. The best-performing methods are tested for real-world applicability using a SwissRanger 4000 Time-of-Flight camera (sometimes called a continuous wave LIDAR) in the West Virginia Robotic Technology Center.