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A COMPLETE IP-BASED NAVIGATION SOLUTION FOR THE APPROACH AND CAPTURE OF ACTIVE DEBRIS

Abstract

Because of the exponential growth of space debris, the access to space in the medium-term future is considered as being seriously compromised, particularly within LEO polar Sun-synchronous orbits and within geostationary orbits. Active Debris Removal (ADR) missions are being studied at the different space agencies as a potential method to mitigate the space debris problem.

Nevertheless, ADR missions poses challenging requirements on the Guidance, Navigation and Control. More concretely, and focusing on the navigation, where the relative position and attitude of the target with respect to the chaser needs to be determined, two main directions are being explored.

LIDAR-based solutions offer a good solution for pose estimation in most of the cases, as they are independent of the illumination conditions and can provide range information. Their major drawback is the lack of accuracy especially in bore sight direction and their large power demands. Image-based solutions, on the other hand, present the advantage of increased accuracy, especially in transversal directions at minimum power consumption and high reliability of the sensor. Still, range information is harder to obtain.

We propose a complete IP-based solution to cover the complete approach and capture phases of a debris removal mission: far range for the approach to the target, where LoS and range measurements are estimated; mid-range for the debris observation and attitude synchronization, with full 6DOF measurements; and close range for the final capture, also with full 6DOF estimates. Different solutions have been addressed in line with the operational requirements and restrictions of each of these phases.

Applicability to multi-spectral imagery has also been studied to take advantage of the information coming from other bands of the spectrum and thus extend the usage of the visual-based navigation to less optimal illumination conditions, such as eclipses.

The algorithms have been tested on real images coming from previous missions and from GMV testing facility (platform-art®) where a fully engineering simulator has been implemented to emulate an active debris removal mission using a target mock-up and a camera mounted on a robotic arm simulating the chaser. Testing has been complemented with several synthetic datasets to cover a wider range of missions and situations.

This paper presents a description of the algorithms, the design challenges as well the results obtained during the different testing campaigns.