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ADVANCED VISION BASED TECHNIQUE FOR CLOSE RANGE NAVIGATION IN ON-ORBIT SERVICING

Abstract

Over past several decades large numbers of spacecraft have been launched into orbits around Earth. Then there are components that have shredded away from spacecraft. All, piling up the space debris, costing precious orbit space and endangering active spacecraft. The need to mitigate impending dangers due to Space debris is on rise prompting for Active Debris Removal (ADR) initiatives.

There are also spacecraft those due to unexpected loss of critical functionalities such as attitude or orbit control, have remained inactive. On-Orbit Servicing (OOS), a novelty idea to reactivate such spacecraft have been considered. Both ideas involve using a new spacecraft that would physically couple with an inactive spacecraft, either to actively mitigate the debris or to extend the life span of the target by docking or berthing with it and providing maneuvering capabilities for the coupled system.

The OOS and ADR have initiated new developments among the space agencies across the world in Rendezvous and Docking (RvD) with non-cooperative spacecraft. Need for greater safety, autonomy and revolutionary concepts to tackle the problem has elevated the space robotics to a new level in terms of required knowledge and technology for relative navigation sensors, robotic manipulators and attitude and orbit control strategies for proximity operations. The tasks as such is novel, since in all previously flown missions to date (ETS-VII, Orbital Express), the target was cooperative. Existing programs around the world are however, addressing this particular task extensively (see DEOS in Germany, eDeorbit at ESA, Phoenix in the USA).

In this work we describe the developments made under FORROST project. FORROST project focused on the development of key robotic technologies to eventually make the tasks above technically feasible. Although the scope of FORRST project was wider, in this work we focus on presenting the novel developments made in the field of relative motion estimation and close range navigation using Photonic Mixer Device based sensor range camera. PMD sensor is a sensor based on Time-of-Flight principle.

Specifically, the work covers three issues. First, we present developments made in relative motion and pose estimation using PMD camera. Second, we show how these motion and pose estimations are used in real time for autonomous collision detection and collision avoidance. Finally, we address the evaluation of the PMD based navigation sensor and enhancements for RvD operations.