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EXPERIMENTAL VALIDATION OF INERTIA PARAMETERS AND ATTITUDE ESTIMATION OF UNCOOPERATIVE SPACE TARGETS USING SOLID STATE LIDAR

Abstract

Despite the introduction of passive mitigation measures to ensure the long-term sustainability of space activities, many studies have highlighted the need of complementing them with the active removal of the largest debris in Earth Orbit like defunct spacecraft and rocket bodies in order to stabilize the growth of orbital debris population. In Active Debris Removal scenarios, the target is uncooperative, i.e., it is not able to actively or passively (e.g., through some easily recognizable artificial markers) communicate with the servicing spacecraft to exchange information so as to safely perform the docking or berthing operations. In addition, due to the long duration time in orbit, space target shape and inertia properties may have been changed (e.g., due to collisions or explosions). This knowledge is vital both to allow the estimate of the rotational motion during monitoring and capture phase and to control the stack in the post-capture phase. Thus, the development of reliable and robust techniques to accurately reconstruct inertia properties before performing final approach and berthing or docking operations is highly advisable. In this respect, Electro-Optical sensors represent the best option available to retrieve some useful information about target pose (position and attitude). By exploiting pose data collected during a monitoring phase, a least-square method based on the conservation of the angular momentum can be applied to produce an estimate of the inertia properties. This paper will present an algorithm for the estimation of the inertia properties of an uncooperative space target based on the measurements provided by a LIDAR system. Although similar approaches have been proposed and tested with numerical simulations in past works, this paper tackles the problem from an experimental point of view by addressing the issue related to processing of real sensor data. The algorithm has been tested within an experimental set-up including a scaled-down satellite mockup connected to a spherical air bearing that provides the rotational degrees of freedom, a low-cost solid-state LIDAR (i.e., Intel RealSense LiDAR Camera L515) to get 3D measurements of the scene and an ad-hoc designed balancing system to keep the center of rotation of the spacecraft simulator aligned with the center of gravity. The experimental facility also includes a motion capture system to track the rotational motion of the mock-up to have a benchmark for the estimated pose parameters. Performance and robustness are assessed considering various targets, in terms of both geometries and rotational dynamics.