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3D RECONSTRUCTION OF A SPACE DEBRIS CAPTURING NET TRAJECTORY DURING MICROGRAVITY EXPERIMENTS – RESULTS AND LESSON LEARNT

Abstract

A microgravity experimental campaign aims at testing technologies in representative 0-g conditions, to raise the technology readiness level (TRL) up to a level of 5 (relevant environment – scaled model). Among the different facilities such an environment can be reproduced by, the parabolic flight (PF) may be more suitable because of the experiment available space, the microgravity conditions repeatability and duration in time. The paper reports about an experiment - related to the Active space Debris Removal (ADR) challenge - flown in June 2015 and aimed at reconstructing the 3D motion of a net capturing a satellite mock-up: the net, stored in a canister, was deployed by shooting massive bullets hanged on the net corners and high-speed high-resolution camera system tracked the flexible system dynamics evolution. The 3D reconstruction results allowed to validate the dynamics numerical simulator developed at Politecnico di Milano, Department of Aerospace Science and Technologies (PoliMi-DAER), conceived to support the design of tethered-net systems for ADR. To reconstruct the trajectory of a flexible body, as the net is, while changing its configuration (deployment and wrapping around the target) through stereo-vision sensors, is a tough challenge that requires appropriate means and fine tuning of the reconstruction algorithms. To answer the goal, a 3D reconstruction tool has been implemented in-house revisiting the Matlab image processing Toolbox to answer the specific experiment data needs; in particular, the algorithm performs image processing for colour segmentation (net's knots were colour-coded with fluorescent pigments), stereo matching of the segmented knots and iterative closest point for knots time tracking. The algorithm flow is as follows: first, attention is focused on the completely deployed net images, exploited to reconstruct the net topology and attach to each knot a univocal identifier; then each knot tracking is performed backwards and forwards until they become occluded from both the stereo pairs. Of the visible knots 96The paper presents the implemented algorithm in details, going through the strategies adopted to cope with the numerous issues risen in the data post-processing: as an example, the tracking step and net topology adequate constraint setting allowed containing errors provoked by either the knots overlapping or the ambiguous matchings along epipolar lines (which the stereo matching procedure is based on). Moreover, the reconstruction results and their robustness are discussed, together with the numerical simulator validation output.