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Author: Mr. Vincenzo Pesce
Politecnico di Milano, Italy, vincenzo.pesce@mail.polimi.it

Prof. Michèle Lavagna
Politecnico di Milano, Italy, michelle.lavagna@polimi.it

EXPERIMENTAL VALIDATION OF THE ESTIMATION OF UNCOOPERATIVE SPACE OBJECTS POSE, MOTION AND INERTIA PROPERTIES VIA STEREOVISION

Abstract

Over the past decade, the challenge of on-orbit autonomous close proximity operations is being high on the research and technology agenda because of the numerous mission scenarios, which would benefit from its readiness level increase. Within the close proximity Guidance Navigation and Control wide technological domain, the paper focuses on the first phase operations in proximity of an unknown target, aiming at its precise pose motion and inertia properties estimation. To deal with an unknown and uncooperative object - such as a Resident Space Object (RSO) or an asteroid - increases the problem solving complexity, being information about the target motion and configuration not available; on the other hand, is largely attractive, being applicable to space Debris Removal, On Orbit Servicing and small bodies exploration robotic missions. Starting from the already developed author's algorithm, the paper discusses the setting and results of the experimental campaign run to validate the proposed approach. Stereovision measurements only, are exploited to estimate the relative position, velocity, angular velocity, attitude and ratios of the inertia matrix elements of an uncooperative orbiting target. A particular formulation of the Iterated Extended Kalman Filter (IEKF) is applied to compute the relative state, the ratios of the inertia components included. The numerical validation highlighted satisfactory convergence of estimation errors and robustness according to initial condition and angular velocity variations. In this paper, an Unscented Kalman Filter (UKF), due to its intrinsic benefit of avoiding linearization, is implemented and convergence and estimation errors are compared. To further validate the approach, a testbed has been setup at PoliMi-DAER premise: a 7-DOF robotic arm (Mitshubishi PA-10) is used to replicate the relative motion of the target with respect to the chaser: the end effector is provided with different mockups - the motion of which is followed by a set of two stationary stereo cameras. In particular, a satellite and an asteroid mockups have been used to simulate eDeobit and AIM missions scenarios respectively. Such a setup allows reproducing the whole 6DOF relative dynamics, being more faithful to real conditions. A velocity control is imposed to the robotic arm to reproduce the desired dynamics. Properly tuning the experimental setup, different lighting conditions are simulated. An off-line procedure for point cloud reconstruction, analysis and information extraction is then performed. The acquired data are fed into the algorithm as measurements. The numerical and experimental results analysis and comparison are critically presented and discussed.