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ESTIMATION OF INERTIA PARAMETERS OF A SPACE DEBRIS FOR ITS TETHER-ASSISTED REMOVAL

Abstract

The objective of this work is to develop a methodology to estimate the unknown inertial parameters of space debris, during the post-capture phase of a space debris capture and retrieval mission. Our interest in this problem is motivated by applications of on-orbit servicing and space debris remediation. The particular scenario considered is where a tethered device is deployed from the chaser spacecraft to capture the debris, referred to as target. The need for inertial parameter estimation arises when the target is unknown with respect to its inertial properties, while their knowledge is required for the subsequent tasks of retrieval and deorbiting in the space debris remediation mission. Furthermore, the solution proposed here also assumes that the target is uncooperative, and thus, its attitude is not communicated to the chaser spacecraft. The specific scheme put forward for inertial parameter estimation is based on the dynamics equations of the chaser-tether-debris system. To this end, the first part of the paper presents the development of a planar dynamics model of the system where the chaser and the target are modeled as rigid bodies and the attachment points of the tether are off-set from the centers of mass of the two bodies. The variable-length tether is treated as rigid and of uniform mass. The first step in the development of the parameter identification scheme is to simplify the equations of motion for the post-capture phase and by dropping second-order terms in the inertial parameters.Based on the reduced equations of motion during the post-capture phase, a new formulation for on-line inertial parameter estimation for space debris is presented. Since the debris is treated as an uncooperative target, measurements of its attitude motion are not available and these must be propagated from the pitch dynamics equation of the debris. The main steps of the identification procedure are: first, based on the point-mass dynamics equations and the measurements of the in-plane angle of tether, a coarse estimate of the target mass is obtained, while the tethered system is experiencing in-plane oscillations. Then, with the initial guesses of the unknown parameters and the coarse mass estimate, the moment of inertia and center of mass offsets of the debris are estimated from the reduced rigid-body equations of motion. The linear parameter estimation problems, both for the mass and the other inertial parameters are solved by employing the standard recursive least squares technique with a specially designed forgetting factor algorithm.