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MOTION AND PARAMETER ESTIMATION FOR TUMBLING NON-COOPERATIVE TARGETS USING MULTIPLE SATELLITE FORMATION

Abstract

With the increasing demands of satellite maintenance, on-orbit update and space debris removal etc. on-orbit service has received increasing attention. Normally, the servicing targets are defunct satellites or space debris and therefore can be treated as non-cooperative targets. In order to execute further operations, the target motion prediction for capture task is required first. Nevertheless, due to the unknown prior information of non-cooperative target, including geometric configuration and mass parameters are unknown, the state estimation is a challenge problem. How to estimate the geometry shape, the mass and the inertia parameters and obtain the motion prediction of non-cooperative target is one of the challenging issues in space and has become a research hotspot in the space industry.

This paper proposes a novel estimation approach for estimation the shape geometry, the attitude and the inertia parameters of non-cooperative targets using multiple satellite formation. Considering the unknown geometric configuration of non-cooperative target and the constraints of tracking feature points of the space targets, the multiple satellites observation configuration is designed. The target's 3D point cloud data is reconstructed by cooperative observation of multiple spacecrafts. Then based on the target features and point cloud matching between adjacent frames, the target's geometry parameters can be obtained, and the attitude change can also be calculated. Furthermore, in consideration of the unknown inertia parameters of non-cooperative targets, the target attitude dynamics function is established under the effect of gravity-gradient torque. Finally, the attitude motion, including rotation rate and orientation, and the inertia parameters of non-cooperative target are estimated by applying Extended Kalman Filter (EKF) estimation scheme. Simulation cases and results show the feasibility and performance of the proposed scheme. The estimated parameters will be an essential part in on-orbit capture technology for non-cooperative targets.