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A MULTI-MODE NAVIGATION METHOD FOR SPACE ROBOTS TO CAPTURE A TUMBLING TARGET

Abstract

An uncooperative space target may be in different motion modes when a space robot attempts to capture it, such as being in contact with the robot, colliding with it, or float freely. Almost all conventional state estimation methods are oriented towards a single motion mode. Therefore, the robot has to switch algorithms according to the mode of movement during a removal mission with multiple modes, which negatively affect convergence speed and stability of the estimation. To develop a navigation method suitable for multiple motion modes, two basic strategies that are independent of the robot-target interaction are integrated. Using the momentum conservation law (MC), dynamic equations of the target-robot combination are derived. The momentum and the angular momentum of the combination are included in the state vector, simplifying the derivation. The second strategy employs continuous vision guidance to correct model predictions based on the Cubature Kalman filter (CKF). After analyzing the observability and the stability of the multi-mode estimator, two vectors are derived to indicate whether or not parts of the inertia parameters of the target can be estimated by the estimator. Several motion modes are simulated in the paper which shows that by employing the two strategies, a single Kalman filter used in the navigation technique can always estimate motion states of the target. The results of the observability analysis are also demonstrated in the simulation.