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COMPARISON OF RELATIVE MOTION CONTROL ALGORITHMS FOR POINT CAPTURING OF SPACE DEBRIS OBJECT

Abstract

One of the most perspective approach for the active space debris removal is to use small satellites, which are capable of capturing non-cooperating space debris objects. Using the onboard propulsion system the satellites are able to change debris orbit. Such a scheme requires an on-board capturing system, which can be a robotic arm or a magnetic grab. For such capturing systems, it is required to define an area or a point on the object that satisfies the capturing conditions. After defining this point the satellite obtains such a relative motion to accomplish the capturing. The required for capturing relative motion is achieved by the onboard translational and angular motion control systems.

In this paper, a small satellite equipped with thrusters providing continuous limited thrust for translational control is considered. The angular motion of the satellite is controlled by onboard reaction-wheels. The position of the capturing point of the space debris object and the position of the capturing system in the satellite body frame are assumed to be specified. One of the proposed control algorithm is constructed based on State-Dependent Riccati Equation to provide the required relative attitude and position of these two points for the capturing. The control algorithm requires linearization of nonlinear motion equations in the vicinity of the current state vector. The optimal control coefficients are determined by solving the Riccati equation at each time step. Another approach is to use artificial potentials to develop a control algorithm for achieving capturing conditions. Attractive and repulsive potentials are virtually placed in the space debris center of mass, and a conical selective potential is in the vicinity of capturing point. The satellite reaches the required relative distance and capture the object in case the point of the space debris object and the position of the capturing system are close to each other. These two control algorithms performance is studied using numerical simulation with defined parameters of supposed active space debris removal mission. The results of the algorithms application are compared, their main features and shortcomings are analyzed.