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OPTIMAL TRADE-OFF BETWEEN SOLAR ENERGY AND CONTROL INPUT WHILE RENDEZVOUS AND DOCKING OF A CUBESAT WITH A ROTATING TARGET SPACECRAFT

Abstract

This paper presents an optimal control approach for rendezvous and docking of a 10 cm10 cm34 cm CubeSat with an uncontrollable target. The CubeSat is equipped with a thruster for orbit maneuvers, magnetic coils for attitude control, and four fixed rectangular solar panels. A 12-unit state vector is taken in the non-linear formulation of coupled attitude and orbital dynamics of the CubeSat. The control algorithm is divided into two optimization problems each for rendezvous and docking. The docking optimization function consists of a combination of energy and distance between the target and the chaser. It uses a back-iteration approach for docking, i.e., the CubeSat is assumed to be docked to the target, and then the CubeSat is backtracked in time to get a stepwise optimal path. To avoid a collision, a collocated point representation of CubeSat is used and their distance to the target is checked at each step. After achieving a minimum safe distance, the algorithm gives the final state of the CubeSat, which is further used as a boundary condition to solve the optimization problem for rendezvous. The optimization function for rendezvous is defined to minimize the net energy used up, i.e., a difference between energy imparted (to thruster and coils) and energy gained (from solar panels) is taken. Further, depending on the orientation of CubeSat, the shadow of the 3-unit structure is taken on panels to get the effective area under sunlight. Besides, the optimization function is modified whenever the sunlight is blocked by the Earth, and the maneuvering controls is redesigned accordingly for optimal rendezvous and docking. Numerical simulations have been carried out to show the efficacy of the proposed concept for steering the trade-off between solar energy and control while rendezvous and docking of CubeSat with a tumbling target.