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SINGULARITY-FREE HYBRID CONTROL FOR AUTONOMOUS BERTHING OF TWO SPACECRAFTS

Abstract

The autonomous rendezvous and docking (RD) of spacecrafts is an intriguing and complex process that requires a great degree of accuracy and precession. For one spacecraft to successfully dock with another spacecraft, there must be no relative translational or rotational motion. Once the docking process is complete, both the spacecrafts are connected to form a single unit. While the most popular application of this complex procedure is the docking with a space station for personnel and supplies transfer, RD plays a crucial role in most other space missions. One important area would be to mitigate the ever-increasing space debris. To reduce the burden on the various actuators employed to achieve translational and attitude control many actuators have been used that make use of existing environmental factors. To use the Earth's geomagnetic field a class of actuators called Coulombic actuators have been employed in this study. The major concern with this type of actuation system is the inherent underactuation due to the restriction of the generated forces and moments to particular planes. This study proposes the use of electrostatically charged magneto-coulombic plate actuators along the three body axes of the satellite for the position and attitude control. It will investigate the effect of various configurations of three pairs of these plates in terms of size and distance from the body axis origin. While varying the sizes of the plates would modify the magnitude of generated forces, the distances would produce differential torques thereby enabling the analysis of different control requirements. The underactuation concern mentioned previously, will be dealt with by use of secondary actuators like magnetic coils and thrusters and the optimal control allocation to the hybrid actuation system will be computed. Further, a pre-set time sliding mode control algorithm will be implemented to control this nonlinear system and deal with various perturbations to demonstrate effectiveness using simulations.