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COLLISION AVOIDANCE MANEUVER FOR ELECTROMAGNETIC SATELLITE FORMATIONS

Abstract

An alternative actuation system for distributed spacecraft is to use electromagnetic force without the expenditure of fuel. By equipping with three orthogonal magnetic coils and three orthogonal reaction wheels for each spacecraft, any force and torque can be easily generated by controlling currents running through magnetic coils. A significant amount of work on electromagnetic formation flight has been done by the Space Systems Laboratory at the MIT, such as magnetic dipole modeling, dynamics and control design, and ground simulations. However, the collision avoidance maneuver issue was little addressed.

Firstly, the exact electromagnetic force model and far-field model are investigated, which reveal that the electromagnetic force and torque decrease quickly as the inter-spacecraft distance increases. Thus, the inter-spacecraft distances among the electromagnetic system are usually small; the collision avoidance is very significant. Secondly, the collision probability calculation model is established, which can predict the collision hazard. Then, the collision avoidance system based on the electromagnetic force is designed. When the collision probability is above the predefined threshold, the polarity of the dipoles switches, then, the approaching two spacecraft repel with each other. When the relative distance is within the safe region, the polarity of the dipoles switches according to the mission requirements. According to Newton third law, the electromagnetic system is an under constrained system, the center of mass can not be moved. We formulate this problem as a control allocation issue, this is an optimization problem. By choosing different performance indexes, we can obtain the unique magnetic dipoles. Finally, the numerical simulations are carried out to validate the proposed methods.

This paper investigates the collision avoidance maneuver issue for electromagnetic satellite formations. The repellant and attractions of the magnetic dipoles make the design of the collision avoidance system more flexible. Simulations show the feasibility of the proposed control allocation method as well as the suitability of collision avoidance maneuver approach. Electromagnetic control is a promising technique for distributed spacecraft, which is propellaneless and contamination free.