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THE SPACE DEBRIS MOTION RECONSTRUCTION TECHNOLOGY BASED ON THE MICRO-NANOSATELLITE CLUSTER

Abstract

The continued growth of space debris such as invalid satellites not only takes up a large amount of orbital resources, but also seriously threatens the safety of active spacecraft. Therefore, the active removal technology of space debris is currently a hot issue at home and abroad. The core problem of space debris removal is to realize the control of the debris out of control movement. According to the development of current micro-satellite technology and adhesion technology, a space debris motion reconstruction technology based on micro-satellite cluster is proposed in this paper, and a new method of space debris motion control is established. This process can be divided into three stages: the process of the micro-nanosatellite cluster approaching the target debris, the process of the micro-nanosatellite attached to the target, and the control process of the micro-nanosatellite /target combination. This paper focuses on the implementation of the first and third stage. Firstly, considering the coupling problem of spacecraft attitude and orbit, the integrated dynamic model combined with dual quaternion and mechanics principle of micro-nanosatellite group relative debris is established. Then, the pre-design specific adhesion positions are used as reference information. Assuming that the collision problem is not considered, the distributed coordination coupled control algorithm is proposed according to the micro- nanosatellite group communication topology structure combined with consensus knowledge. Finally, the micro-nanosatellite/target combination dynamics model based on dual quaternion is proposed, and the distributed multi-constraint thrust allocation algorithm, considering constraints such as thrust limit, is put forward according to the model. The simulation results show that when there is at least a spanning tree in the communication topology graph, each satellite collaboratively approaches to the surface of target debris, and the effectiveness of the distributed coordination coupling control algorithm is verified. Given the expected movement of the combination, the error between final attitude and orbit state with the expected value is smaller,

and the thrust size of each satellite calculated meets the constraints according to the thrust allocation algorithm proposed. The algorithm proposed in this paper basically realizes the motion reconstruction of space debris, which lays a theoretical foundation for the ultimate realization of the active removal of space debris and the follow-up space engineering practice.

Keywords: Micro-nanosatellite cluster; Space debris; Motion reconstruction; Dual quaternion; Attitude and orbit integrated modeling; Distributed coordination control algorithm; Multi-constraint thrust allocation.