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Author: Prof. Ma Weihua
National Key Laboratory of Aerospace Flight Dynamic, Northwestern Polytechnical University, China, whma_npu@nwpu.edu.cn

Mr. Xinyuan Lu
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an, China, xinyuanlu0410@163.com
Mr. Chenggang Hou
National Key Laboratory of Aerospace Flight Dynamics, Northwestern Polytechnical University, Xi'an, China, hcg1995@mail.nwpu.edu.cn
Prof. Jianjun Luo
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an, China, jjluo@nwpu.edu.cn
Prof. Yuan Jianping
National Key Laboratory of Aerospace Flight Dynamics,Northwestern Polytechnical University,Xi'an, China, jyuan@nwpu.edu.cn

DISTRIBUTED COORDINATION CONTROL FOR MULTIPLE SPACECRAFT WITH COUPLED ATTITUDE AND ORBIT DYNAMICS UNDER THE DIRECTED GRAPH

Abstract

The Micro-spacecraft has the characteristics of light weight, short development cycle and high reliability. Meanwhile, the multi-spacecraft system that cooperates in formation, cluster and other forms can accomplish some complicated missions that a single spacecraft can not achieve. Therefore, micro-spacecraft cooperative flying has a wide application prospects in the fields of deep space exploration, electronic reconnaissance and stereo imaging. With the increasement of space mission requirements, the single attitude coordination control or orbit coordination control can not meet the required control precision, so it is needed to consider the attitude and orbit coupling during spacecraft cooperative flying, establish the integrated dynamics model and design coupled control law. In addition, due to the complexity of space environment, communications between spacecraft might be unidirectional, while there are communication delays, communication topology change, etc. Therefore, considering the problem of attitude and orbit coupling during the cooperative flying in this paper, the coupled attitude and orbit dynamics model is established based on the dual quaternion and the basic principles of mechanics. Assuming that there is a virtual chief spacecraft, which reference information can be obtained by only part of the multi-spacecraft system, the communication topology graph is established. Then, a distributed coordination coupled control algorithm based on the consensus theory is proposed. Under the premise that communication delays are bounded, the attitude and orbit of each spacecraft can converge to the expected value when there is at least a directed spanning tree in topology graph. Finally, the stability of the algorithm is proved by a method based on Lyapunov theory. Numerical simulation results are given to demonstrate the effectiveness of the algorithm proposed.

Keywords: Cooperative flying; Directed Graph; Dual quaternion; Coupled attitude and orbit dynamics; consensus; Distributed coordination control; Communication delays; Switching communication topologies; Lyapunov theory.