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Author: Mr. Xiaolong Wang
Northwestern Polytechnical University, China, xiaolongw@mail.nwpu.edu.cn

Mrs. Qun Fang
Northwestern Polytechnical University, China, qfang@nwpu.edu.cn
Dr. Chong Sun
Northwestern Polytechnical University, China, sunchong@nwpu.edu.cn
Mr. Qi Li
Northwestern Polytechnical University, China, liqi_nwpu@126.com

A ROBUST TASKS-PRIORITY BASED COORDINATED CONTROL APPROACH FOR SPACECRAFT'S VARIABLE CONFIGURATION FORMATION FLYING

Abstract

Many new and exciting space missions have developed around spacecraft formation flying, such as interstellar exploration, space station construction, coordinated observation and so on. It requires autonomous distributed satellite systems can be robust, scalable and flexible. To fulfill these complex missions successfully, the following basic tasks should be carried out: (1) no collisions occurs between the spacecraft and the other or between the spacecraft and external obstacles, which is viewed as the precondition of all the subsequent operations; (2) different formation configurations should be maintained in different mission periods, i.e., the spacecraft formation should adjust its transient behavior in real time and quickly according to mission needs; (3) velocity synchronization with the target, which implies that each spacecraft in the formation should track the movement of the target as it reaches the target area. However, as the tasks are generally conflict one with the other, all the assigned goals can not be accomplished at the same time by a single control command. To tackle the accomplishment of these basic tasks, this paper proposes a tasks-priority based coordinated control approach for the complex missions that requires variable formation configuration in different mission periods, and it can avoid the conflict among different tasks. Firstly, we assign a relative priority to each basic task and design different control commands. Specifically, among these tasks, the collision avoidance and the obstacle avoidance tasks are assigned with highest priority, formation maintenance and formation reconstruction tasks refer to the lower priority accordingly, and velocity synchronization has the lowest priority. Meanwhile, the bifurcation theory is introduced on the basis of the artificial potential function method, and various formation configurations can be achieved autonomously by a simple free parameter change. Different from the previous studies on the control law design mainly focus on the achievability of a prescribed formation, this method can adjust the transient behavior of spacecraft formation quickly. Secondly, the control command of the low-priority task is projected to the null space of the higher-priority task, and the integrated task output is used as the final control command. In this way, the multiple basic tasks can be integrated simultaneously, and avoid any unwanted conflict among the tasks. Finally, numerical simulations are implemented to verify the effectiveness of our method. The results show that the proposed control approach can realize formation reconstruction autonomously according to mission requirements while avoiding the obstacles and the collisions among spacecrafts.