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FTCESO-BASED PREDEFINED TIME CONTROL FOR SATELLITE SWARM RECONFIGURATION

Abstract

Satellite swarm is a typical distributed system with significant advantages compared to traditional single satellite in terms of wide spatial distribution, low-cost maintenance, high reliability and superior flexibility. However, environmental disturbances, e.g., non-spherical gravity, atmospheric drag, cause the satellites drift away from each other which even impair the communication topology and then deteriorate the integrity of the constellation ultimately. Thus, there is a rapid need to dispose external disturbance accurately and investigate the control algorithms to maintain the topological relationships among satellites in the circumstance of environmental disturbance, and then reconfigure the topology to achieve the space mission successfully. Whereas, some literature has addressed this problem in recent years. A continuous finite-time convergent extended state observer (FTCESO) is proposed to estimate the satellite's angular velocity and the error extended states in finite time simultaneously, and then a non-singular fast terminal sliding mode controller (NFTSMC) instead of linear sliding mode control is developed with characteristics of finite time convergence and singularities avoidance. Moreover, the relevant research has received extensive attention in multiagent systems, though the application in satellite swarm control is rare. Accordingly, this work focuses on the natural evolutionary properties of large-scale swarm in the condition of active space environment forces, where FTCESO-based predefined-time NFTSMC is developed to the swarm reconfiguration process. Firstly, the coordinate system of the constellation is selected to construct the relative motion dynamic equations with the analysis of overall motion states of the constellation and the relative motion states among the satellites respectively. Then, by use of extended state observer and predefined-time controller, the transformation from the initial to the desired configuration for the swarm can be achieved, where the feasibility of the controller is proved via Lyapunov stability theory. Finally, numerical simulations are performed to demonstrate the effectiveness and feasibility of the control strategy. It is noted that the relative distance of the satellites keeps increasing with the influence of space environment perturbations, which makes it difficult to maintain the communication topology connection. As a consequence, the system can be stabilized in different reconfiguration at the pre-set time 300s for the application of proposed controller, which can also handle the fluctuations of control force smoothly generated during the motion to implement the desired requirements. In addition, autonomous obstacle avoidance and topology optimization for large-scale swarm transformation will be investigated to achieve the flexible control as well as application to the swarm system in future.