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FUZZY-LOGIC-BASED INTEGRATED ORBIT-ATTITUDE-VIBRATION PRESCRIBED-TIME CONTROL FOR LARGE-SCALE FLEXIBLE SPACECRAFT

Abstract

Large-scale flexible spacecraft is a strategic space equipment for the utilization of space resources, the exploration of the universe mysteries and the long-term residence on-orbit, where the size would reach the magnitude of kilometers in future. Due to the large structure and appendages, there exists structural vibration, the severe nonlinear coupling effects and multi-source complex disturbance, e.g., measurement error, environment disturbance, model parameter uncertainty inevitably, which may deteriorate the performance of the control system, even cause the failure of space mission. Although some existing works have investigated the issues aforementioned, most of which only considers the orbit-attitude or attitude-vibration independently. It should be noted that the coupling effects among the orbit-attitude-vibration should be dealt with exactly. In addition, the asymptotical stabilization controller can only guarantee that the system state converges to the equilibrium point when time approaches infinity. For many practical problems, it is most desirable to reach the required stable state within a preset time. Above the aforementioned issues, the suppression of structural vibration and control of attitude-orbit in prescribed time is a significant challenge for the development of large-scale spacecraft. Accordingly, this paper proposes a fuzzy-logic-based integrated orbit-attitude-vibration prescribed-time controller for large-scale flexible spacecraft to achieve the high-precision orbit-attitude-vibration stabilization. Due to the existence of nonlinear coupling effects, a refined T-S fuzzy model based on the orbit-attitude-vibration dynamics of large-scale flexible spacecraft is constructed to represent the nonlinear characteristics. Then, a prescribed-time controller is designed to stabilize the closed-loop system within a prescribed time with precise convergence rate and favorable robustness, where Lyapunov stability analysis is performed to prove the prescribed-time stability. Results shows the effectiveness and superiority of the proposed control strategy where the system can stabilize in 60s. Moreover, the attitude can converge into a small bound at 0.001 order of magnitudes, the position can converge into 0.1 order of magnitudes and the vibration modal displacement can converge into 0.001 order of magnitudes. Compared with existing approaches, it's demonstrated that the proposed controller can implement the integrated control of orbit-attitude-vibration in prescribed time converging into small bound, where the control objective is achieved successfully.