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ATTITUDE STABILIZATION OF UNDERACTUATED FLEXIBLE SPACECRAFT

Abstract

The stabilization of underactuated system not only guarantees safe operations of the spacecraft, but also provides a solution for small satellites and deep space probes which have weight, size and cost limitation. However, in the aspect of attitude control problem of underactuated spacecraft, existing researches mainly focus on the rigid spacecraft. Considering that almost all underactuated spacecraft have flexible attachments in actual operation, this article studies the three-axis attitude stabilization for a spacecraft which has a central rigid body fixed with a flexible beam actuated by only two working thrusters. Both underatuation and flexibility complicate the design of control law. Existing method is not perfect for such a complex problem, therefore, this article build a simple system model. Rotation model of flexible spacecraft is established by the Angular Momentum Theorem, and vibration motion model of flexible appendages is built by the variation principle, thereby we have the dynamic model of underactuated flexible spacecraft with two controls, and use (w, z) parameters to describe spacecraft attitude motions. Then, three-axis attitude stabilization control law is designed based on the backstepping control method. The first step is to stabilize dynamic equation of the underactuated axis by middle control law based on the variant couple with the other two actuated axes. The second step is to stabilize (w, z) parameters of the kinematic equation by virtual control input based on the Lyapunov control method. The third step is to stabilize dynamic equation of the actuated axes according to the error equation of dynamics and variation motion. Until now, the attitude control design is accomplished. Moreover, the global asymptotic stability of the control law is proved by the Lyapunov stability theorem and LaSalle invariance theorem. Finally, the impact of system controllability by the placement of the actuators is analyzed. Simulation is carried out and results illustrate the feasibility of the proposed controller.