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TRAJECTORY TRACKING AND STABILITY CONTROL OF THE SPACE NET ROBOT FOR RECONFIGURATION

Abstract

Ever since on-orbit service and active space debris removal become popular research subjects in the space technology field, the mechanism design, dynamics and control of space capture operations have seen a great deal of research. The space tether is still considered an innovative approach to debris capture offering a wide array of technological and scientific research opportunities. Space Net Robot (SNR) is a new concept, which is effectually a combination of the Tethered Space Robot (TSR) and Tethered Space Net (TSN). It is composed of a space net and four Maneuverable Units (MUs) located on the four net corners. The proposal inherits the maneuverability and long working range from the TSR, as well as the easy-capture capability from the TSN. Since the traditional TSN is unmaneuverable, the control problem of the space net is still a blank topic. Because of the flexibility and elasticity of the net, a slight movement on any MU may excite an oscillation over the whole net via the knitted tether. An appropriate control scheme is necessary for the Space Net Robot, especially for system reconfiguration. To solve this problem, a fuzzy based adaptive super twisting sliding mode control scheme is proposed in this paper. Accordingly the stability and tracking performance of the scheme is proved by Lyapunov function. To suppress the oscillations during the reconfiguration, the tethers oscillations are treated as equivalent superposition of the disturbances working on each MU. So the complex uncertainties working on each MU are composed of three parts: the equivalent superposition of the oscillations, uncertain space environment such as cosmical aerodynamics and the orbit perturbation, and the errors of the mathematical equations. To approximate these time-varying uncertainties, a fuzzy scheme with adaptive learning law is employed to estimate the complex disturbance. Adaptive super-twisting sliding mode scheme is employed as a main controller because of its strong robustness which is just the necessary. The well-known chattering problem of the sliding mode control is skillfully alleviated and attenuated via the hybrid control scheme proposed in this paper. The stability analysis and approximation convergence of the addressed control scheme is verified via Lyapunov stability analysis. Numerical simulations on the SNR are given to confirm the effectiveness and robustness of the proposed scheme.