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挠性航天器的退步直接自适应姿态跟踪控制

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Direct Adaptive Attitude Tracking Control of Flexible Spacecraft Based on Backstepping Method

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摘要 针对参数不确定的挠性航天器姿态跟踪控制问题,提出了一种退步直接自适应控制算法。首先验证了挠性航天器动力学子系统的近似严格正实性,并设计了具有理想控制性能的参考模型;然后对以姿态四元数描述的运动学子系统设计常系数输出反馈中间控制律,使航天器姿态四元数输出渐近跟踪参考模型输出;最后退一步,对具有参数不确定特性的动力学子系统,基于非线性直接自适应控制理论和Lyapunov稳定性理论,设计了退步直接自适应姿态跟踪控制器,并证明了闭环系统的稳定性。仿真结果表明,所提控制方法能有效抑制挠性附件的振动,对挠性航天器的控制是有效的。

关键词： 挠性航天器 不确定性 姿态控制 退步控制 非线性直接自适应控制 正实性

Abstract： A backstepping direct adaptive control strategy is proposed for the attitude tracking of large flexible spacecraft with parameter uncertainties. First, the almost strictly positive real property of a flexible spacecraft dynamics subsystem is confirmed and a reference model with ideal control performance is designed. Second, a consistent output feedback intermediate control law is designed for the kinematics subsystem described by attitude quaternion, which can make the attitude quaternion track the reference output asymptotically. Then backing a step, a backstepping direct adaptive attitude tracking controller is derived for the parameter unknown dynamics subsystem based on the nonlinear direct adaptive control theory and the Lyapunov stability theory, and its close-loop stability is proved. Finally, the control strategy is employed to design an attitude tracking controller for a flexible spacecraft. Numerical simulation results indicate that the controller can damp the vibration of the flexible components of the spacecraft, and it is effective for its control.

Keywords： flexible spacecraft uncertainty attitude control backstepping control nonlinear direct adaptive control positive real property

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