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空间光通信精跟踪系统的模糊自抗扰控制

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Fuzzy active disturbance rejection control of fine tracking system for free space optical communication

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摘要

针对输入光束抖动及卫星本体微振动对空间光通信系统跟踪精度的影响,设计了模糊自抗扰控制器,提出了对精跟踪系统进行控制的方法。首先,建立了精跟踪系统模型,对系统内外扰动进行分析,并模拟了卫星振动信号。针对系统自身所受的扰动及输入光信号的不确定性,设计了模糊自抗扰控制器。提出的控制方法通过扩张状态观测器观测卫星本体振动及系统未建模动态,应用微分跟踪器提高系统动态响应性能,并用模糊控制原理改进了非线性状态误差反馈控制律,使其可以自适应调整比例和微分增益。最后进行了实验分析,结果表明:与PID控制方法相比,模糊自抗扰控制方法在不同频率及幅值的输入信号下均能提高系统跟踪精度,跟踪精度可以达到±8 μrad,跟踪误差减小了50%左右。该方法基本满足空间光通信精跟踪系统对跟踪速度、跟踪精度及抗干扰能力的要求。

关键词 : 空间光通信, 精跟踪, 模糊自抗扰, 卫星振动

Abstract :

In consideration of the effects of input beam jitter and satellite micro vibration on the tracking precision of a space optical communication system, a fuzzy active disturbance rejection controller is designed and a control method for the fine tracking system in optical communication is proposed. Firstly, a fine tracking system model is established, the internal and external disturbances of the system are analyzed and the satellite vibration signals are simulated. Then, focused on the uncertainties of system disturbance and input optical signals, the fuzzy active disturbance rejection controller is designed. The proposed method observes satellite vibration and unmodelled dynamics of the system by an extended state observer and uses a differential tracker to improve the dynamic response performance of the system. Then it utilizes fuzzy control theory to improve the nonlinear state error control law, by which the system can adjust adaptively proportion and differential gains. Finally, the experiments analysis are performed and compared with PID control method. It shows that the fuzzy active disturbance rejection control method improves the system tracking accuracy under the input signals with different frequencies and amplitudes, the tracking accuracy has reached to ±8 μrad, and the tracking error reduces about 50 percent. This method basically meets the requirements of tracking systems of optical communication for tracking speeds, tracking accuracy and antijamming capability.

Key words : free space optical communication fine tracking fuzzy active disturbance rejection vibration of satellite platform

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