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基于terminal滑模控制的小卫星机动方法

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Small satellite maneuver based on terminal sliding mode control

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摘要 采用terminal滑模控制方法研究了以单框架控制力矩陀螺(SGCMG)为执行机构的小卫星的姿态机动控制。首先,基于修正罗德里格斯(MRP)参数建立了小卫星数学模型,以terminal滑模控制方法进行控制力矩规划。然后,采用SGCMGs作为小卫星执行机构,以非对角奇异鲁棒操纵律跟踪terminal 滑模控制产生的期望力矩;通过仿真分析归纳出terminal滑模控制设计参数的变化规律和选取原则。最后,利用小卫星三轴气浮转台实验验证termianl滑模控制方法的实用性。实验显示:根据参数选取原则设定的参数进行小卫星机动稳定实验得到的姿态角和姿态角速度控制精度和稳态误差分别小于0.1°和0.01(°)/s,满足三轴气浮转台最佳控制精度。结果表明terminal滑模控制方法在小卫星机动稳定任务中具有很高的控制精度和稳定度,能够为小卫星成像任务稳定执行提供良好的基础。

关键词 : 小卫星机动稳定, terminal滑模控制, 单框架控制力矩陀螺(SGCMG), 气浮转台

Abstract : The attitude maneuver and stable task of a small satellite by using a Single Gimbal Control Moment Gyro(SGCMG) as an actuator was explored with the terminal sliding mode control method. Firstly, a small satellite mathematical model was established based on the Modified Rodrigues Parameters (MRP), and the torque planning was made in the terminal sliding mode control method. Then, command torque was given through diagonal singular robust tracking control law using the SGCMG as an actuator. The performance of the control method was studied by mathematical simulation, and the changing law and chosen rule of design parameters of the terminal sliding mode control were presented. Finally, a small satellite three-axis air flotation turntable was used to verify the adaptability of terminal sliding mode control. The experimental results show that the attitude angle and attitude angular velocity control precision and steady state error is less than 0.1 ° and 0.01(°)/s, which is within the scope of the best control precision from the parameter selection principle in the three-axis air flotation turntable for small satellite maneuver stability experiment. It concludes that the terminal sliding mode control method has high control precision and stability and is able to give a good function for small satellite maneuvers.

Key words : small satellite maneuver stability terminal sliding mode control Single Gimbal Control Moment Gyroscope (SGCMG) air flotation turntable

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