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基于新型终端滑模的航天器执行器故障容错姿态控制

胡庆雷[1], 姜博严[1,2], 石忠[2,3]

1. 哈尔滨工业大学 航天学院, 黑龙江 哈尔滨 150001;
2. 中国民航大学 航空自动化学院, 天津 300300;
3. 滨州职业学院, 山东 滨州 256603

Novel Terminal Sliding Mode Based Fault Tolerant Attitude Control for Spacecraft Under Actuator Faults

HU Qinglei[1], JIANG Boyan[1,2], SHI Zhong[2,3]

1. School of Astronautics, Harbin Institute of Technology, Harbin 150001, China;
2. Aeronautical Automation College, Civil Aviation University of China, Tianjin 300300, China;
3. Binzhou Polytechnic, Binzhou 256603, China

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摘要

针对受干扰的刚体航天器冗余执行器存在故障与控制受限的姿态跟踪控制问题，提出一类基于新型指数形式的非奇异快速滑模面（ENFTSM）与趋近律的姿态容错控制器设计方法。当部分推力器发生故障时，假设剩余推力器具有输出饱和特性且能提供足够推力保证航天器执行任务，相比一般终端滑模控制器，本文设计的控制器不仅能使系统状态以更快的速度到达平衡点，且不需要在线对执行器故障信息进行检测和分离。基于Lyapunov方法证明本文设计的控制器能保证闭环系统稳定，且能有效地抑制外部干扰、控制受限和执行器故障等约束。最后对提出的控制算法进行了数值仿真，其结果表明了该控制器的有效性。

关键词： 航天器 执行器故障 控制受限 容错控制 终端滑模

Abstract:

An exponent nonsingular fast terminal sliding mode (ENFTSM) control law is investigated in this paper for a rigid spacecraft with redundant thrusters in which thruster faults, and control input saturation as well as external disturbances have to be explicitly considered simultaneously. More specifically, in this proposed control scheme, fast convergence of spacecraft attitude tracking is achieved and faster reaching time can be guaranteed in comparison with the terminal sliding mode. When thruster fault occurs, the control parameters are adjusted dynamically in such a fashion that no fault detection and isolation mechanism is required in advance, and only the remaining active thrusters are assumed to be able to produce a combined force sufficient to allow the spacecraft to perform the given operations within the saturation magnitude. Lyapunov stability analysis shows that the resulting closed-loop system is stable it can withstand the effect of external disturbances, control input saturation and even faults by appropriately choosing the design parameters. The attitude tracking performance using the controller is evaluated through a numerical example.

Keywords: spacecraft actuator fault control constraint fault tolerant control terminal sliding mode

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Corresponding Authors: 胡庆雷，Tel.：0451-86413411-8606 E-mail：huqinglei@hit.edu.cn Email: huqinglei@hit.edu.cn

About author: 胡庆雷 男，博士，教授，博士生导师。主要研究方向：容错控制，故障诊断。Tel：0451-86413411-8606 E-mail：huqinglei@hit.edu.cn；姜博严 男，硕士研究生。主要研究方向：航天器姿态控制，非线性控制。Tel：0451-86413411-8606 E-mail：jiangboyan888@163.com；石忠 男，博士，教授。主要研究方向：导航制导与控制。E-mail：sz1962@126.com

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