航空学报
ACTA AERONAUTICA ET ASTRONAUTICA SINICA
ISSN 1000-6893
CN 11-1929/V

航空学报 » 2013, Vol. 34 » Issue (4) :909-918 DOI: 10.7527/S1000-6893.2013.0152

推力器故障的刚体航天器自适应变结构容错控制

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Adaptive Variable Structure Fault Tolerant Control of Rigid Spacecraft Under Thruster Faults

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摘要 | 参考文献 | 相关文章

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摘要

针对刚体航天器存在未知惯量参数、推力器故障以及控制受限的姿态控制问题,提出了一类自适应变结构容错控制方法,显式地引入推力器输出的饱和幅值,以确保控制输出在其要求界的范围内;同时,引入控制参数在线自适应调整技术,提高了控制律对参数、干扰以及故障变化的自适应能力;对设计者而言,推力器故障信息不需要进行在线检测和分离。此外,进一步考虑存在推力偏差对系统性能的影响,设计控制器参数使得闭环系统对这类推力偏差具有L_2增益稳定性。最后,将设计的控制器应用于航天器的姿态机动控制,仿真结果表明该控制器能有效地抑制外部干扰、参数不确定性和推力器各种故障的约束,在完成姿态机动的同时,保证其控制输出满足饱和受限界的要求。

关键词: 航天器 容错控制 自适应变结构控制 控制受限 推力器故障

Abstract:

A novel fault tolerant attitude control system is investigated for a rigid spacecraft with redundant thrusters, in which unknown inertial parameters, thruster faults, control input saturation and even external disturbances are explicitly considered simultaneously, and the control torque is limited in one established scope via thruster output saturation function which is explicitly introduced. More specifically, in this proposed control scheme, the control parameters are adjusted dynamically by online adaptive control technique 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 enough to allow the spacecraft to perform the given operations within the saturation magnitude. Moreover, the effect of the thruster force magnitude deviation is analyzed and the system performance is evaluated by L_2 gain from this magnitude deviation to the penalty output, and Lyapunov stability analysis shows that the resulting closed-loop system is proven to be stable. Finally, numerical examples are also presented to demonstrate that the control algorithms developed are not only robust against external disturbances and parameter uncertainties, but also able to accommodate thruster failures under limited saturation value.

Keywords: spacecraft fault tolerant control adaptive variable structure control control constraint thruster fault

Received 2012-06-01;

Fund:

国家自然科学基金(61004072,61174200,61273175);高等学校博士学科点专项科研基金(20102302110031);教育部新世纪优秀人才计划(NCET-11-0801)

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引用本文:

胡庆雷, 张爱华, 李波. 推力器故障的刚体航天器自适应变结构容错控制[J]. 航空学报, 2013, 34(4): 909-918.DOI: 10.7527/S1000-6893.2013.0152

HU Qinglei, ZHANG Aihua, LI Bo. Adaptive Variable Structure Fault Tolerant Control of Rigid Spacecraft Under Thruster Faults[J]. Acta Aeronautica et Astronautica Sinica, 2013, 34(4): 909-918.DOI: 10.7527/S1000-6893.2013.0152