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基于MRP的全局稳定的PID刚体姿态控制

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Globally Stabilizing PID Attitude Control of Rigid Body Based on MRP

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摘要 针对刚性航天器姿态控制问题,建立了由修正Rodrigues参数(MRP)表示的混杂姿态模型,并基于此模型设计了一种具有迟滞特性的非线性比例-积分-微分(PID)切换控制器。该控制器包含一个对克里奥利力矩和期望机动力矩的前馈补偿项和一个用于消除轨迹跟踪误差的PID反馈项。通过一个特别的Lyapunov函数分析得到了全局渐进稳定的结果。该控制器可全局渐近跟踪期望姿态轨迹,无姿态转动的奇异值点,无展开现象,能够抑制常值干扰力矩,对测量噪声具有鲁棒性。针对一个航天器进行了大角度控制仿真实验,仿真结果验证了控制器具有渐近跟踪特性、可避免展开现象的特性以及对常值干扰和测量噪声的鲁棒性。

关键词: 姿态控制 修正Rodrigues参数 比例-积分-微分 混杂系统 迟滞

Abstract: For the attitude control of a rigid spacecraft, a hybrid attitude model with modified Rodrigues parameter (MRP) representation is constructed, based on which a nonlinear proportional-integral-derivative (PID) switching controller with hysteresis is proposed. The proposed controller consists of a feed-forward term, which is used to compensate for the Coriolis torque and the desired maneuver torque, and a feedback term with PID structure, which is used to eliminate the attitude trajectory tracking error. Global asymptotic stability is guaranteed by defining a particular Lyapunov function. The proposed controller is able to achieve global asymptotic tracking of the desired attitude trajectory, avoid singular orientation and unwinding, reject constant disturbance torques and it is robust against measurement noises. Simulation experiments on the large-angle attitude control of a rigid spacecraft are conducted, and the results show the asymptotical tracking property of the proposed controller as well as its avoidance of unwinding phenomenon and its robustness against constant disturbances and measurement noises.

Keywords: attitude control modified Rodrigues parameter proportional-integral-derivative hybrid system hysteresis

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