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### 加速度反馈的隐式动态逆鲁棒非线性控制律设计

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### Implicit NDI Robust Nonlinear Control Design with Acceleration Feedback

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摘要

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**摘要** 针对常规显式非线性动态逆(NDI)控制鲁棒性差的问题,综合隐式动态逆和奇异摄动分层设计,引入状态速率(导数)反馈和操纵面的当前位置信号反馈,设计了隐式增量形式的动态逆控制律。控制律中不显含基于标称模型的非线性直接状态反馈,不需要完整的飞机气动力模型,降低了控制律对于模型的敏感度。利用过载测量信号,采用几何的方法,构建了角加速度信号,对于其他状态速率信号,基于飞机动力学方程,以代数计算的方法求解得到。控制律结构简单,当飞机存在外形损伤、舵面失效或传感器失效时,能够迅速实现测量信号的隔离、反馈信号的重建和控制的重新分配和控制律重构。针对某飞机进行控制律设计和数值仿真,结果表明在存在气动力摄动的情况下,控制律具有良好的鲁棒性。

**关键词:** 飞行控制 鲁棒性 隐式非线性动态逆 加速度测量 控制重构

**Abstract:** In order to improve the robustness of the regular explicit nonlinear dynamic inversion (NDI) control law, an incremental version of the NDI control law is designed via the implicit dynamic inversion (DI) and singular perturbation methods, in which the state acceleration (derivative) is used as feedback to measure the effects of the aircraft model perturbation and the current position information of the effector. The complete aerodynamic model is unnecessary because there is no nonlinear direct state feedback based on the nominal aircraft model, and as a result, the sensitivity to aircraft model is reduced. The angular acceleration is established utilizing a special geometrical method through overloading information, and the other state acceleration is obtained using an algebraic method based on aircraft dynamic equations. The control structure is simple, and the isolation of measurement signals, reestablishing of feedback signal, re-allocation of control power and the reconfiguration of control law can be achieved conveniently and rapidly. The control law design and computer simulation for an aircraft with aerodynamic perturbation demonstrate that the robustness of the control law is increased.

**Keywords:** flight control robustness implicit NDI acceleration measurement reconfigurable control

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