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流体力学与飞行力学

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### 基于气动特性辨识的飞行器抗饱和自适应控制

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### Anti-windup Adaptive Control of Aircraft Based on Online Identification of Aerodynamic Character

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摘要

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#### 摘要

针对无人机含有未知气动参数时的大机动飞行控制问题, 设计了基于在线气动参数辨识的自适应非线性模型预测控制 (ANMPC) 的飞行器。首先, 根据无人机动力学模型设计出基于反馈线性化模型的非线性模型预测控制 (NMPC) 的飞行控制器, 通过在线求解有约束问题, 确保大机动飞行时系统状态及控制输入满足约束条件, 使控制系统具备抗饱和性能。然后, 将无人机动力学模型中的未知气动参数辨识参数矩阵, 采用基于迭代扩展卡尔曼滤波 (IEKF) 与渐消记忆最小二乘 (RLS) 的气动特性辨识两步方法, 实时辨识无人机气动非线性模型预测控制律所用模型, 消除模型误差, 增强非线性模型预测控制器的鲁棒性。最后, 对指令姿态角跟踪进行了仿真验证, 表明: 在考虑外界未知气动扰动情况下, 控制器满足设计要求, 并具有较强的鲁棒性。

关键词: 飞行控制 气动扰动 气动特性辨识 自适应控制 非线性模型预测控制 反馈线性化

#### Abstract:

A high maneuver flight controller using online identification of aerodynamic parameters based adaptive nonlinear predictive control (ANMPC) is proposed for an unmanned aerial vehicle with unknown aerodynamic parameters. A nonlinear model predictive control (NMPC) controller is designed in accordance with the feedback-linearized unmanned aerial vehicle dynamical model. The systematic handling of input and state constraint violations in a maneuvering flight is achieved by solving an online constrained optimization problem. In this way, accomplishment of anti-windup is guaranteed. Secondly, the unknown parameter matrixes, which are formed from the unknown aerodynamic parameters in the unmanned aerial vehicle dynamic model, are identified in real time by means of step method which combines the iterated extended Kalman filter (IEKF) and the recursive least square (RLS) method with forgetting. In the meantime, the unmanned aerial vehicle dynamical model is updated with identified aerodynamic parameters to compensate for model mismatch. In this way, robust performance of the NMPC controller is improved by updated model information. Finally, simulation results for attitude command tracking in the presence of perturbed aerodynamic parameters demonstrate that all performance requirements are satisfied and the robustness is successfully achieved by the designed controller.

Keywords: flight control aerodynamic disturbance identification of aerodynamic characteristic adaptive control nonlinear model predictive control feedback linearization

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