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折叠翼飞行器发射段鲁棒非线性控制系统设计

曹立佳, 张胜修, 李晓峰, 刘毅男

第二炮兵工程大学 自动控制工程系, 陕西 西安 710025

Robust Nonlinear Control System Design for Folding-wing Aerial Vehicles During Launching Time

CAO Lijia, ZHANG Shengxiu, LI Xiaofeng, LIU Yinan

Department of Automatic Control Engineering, The Second Artillery Engineering University, Xi'an 710025, China

摘要 为解决折叠翼飞行器在发射段各项特性变化较大、对飞行控制律鲁棒性要求较高的问题,设计了一种以块控反步法为基础的自适应鲁棒非线性控制器。在发射段动态模型基础上,该控制器采用径向基函数(RBF)神经网络自适应逼近飞行器特性变化时的系统未知不确定性和干扰,通过在虚拟控制律中引入动态面控制技术避免多重微分运算,克服了传统反步法所带来的"项数膨胀"问题。利用Lyapunov稳定性定理证明了闭环系统有界且跟踪误差指数收敛于零的一个小邻域。在考虑未知不确定性的情况下,对某型折叠翼飞行器进行的6自由度(DOF)飞行仿真结果验证了所设计控制器的有效性和鲁棒性。

关键词： 折叠翼飞行器 飞行控制 反步法 RBF神经网络 动态面 未知不确定性

Abstract: The characteristics of a folding-wing aerial vehicle undergo fairly great changes during its launching time. To fulfill the high robustness requirements of a flight control system, an adaptive robust nonlinear flight controller based on block backstepping is designed. A variable dynamic model is established, and the unknown uncertainty and disturbance caused by aerodynamic characteristic changes are adaptively approximated by radial basis function (RBF) neural networks. Dynamic surface control is employed to replace the differentiations of the virtual control law in traditional backstepping to overcome the problem of "term explosion". The closed-loop system is guaranteed to be bounded and the tracking errors are also proved to converge exponentially to a small neighborhood around zero by the Lyapunov approach. Furthermore,the effectiveness and robustness of the designed flight controller are verified by six degree-of-freedom (DOF) nonlinear flight simulations for the folding-wing aerial vehicle with unknown uncertainty.

Keywords: folding-wing aerial vehicle flight control backstepping RBF neural network dynamic surface unknown uncertainty

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Corresponding Authors: Tel.:029-84741963 E-mail: zsx1963@yahoo.com.cn Email: zsx1963@yahoo.com.cn

About author: 曹立佳(1982-) 男,博士研究生。主要研究方向:飞行器控制、仿真与决策。 Tel: 029-84741963 E-mail: caolijia82@gmail.com;张胜修(1963-) 男,博士,教授,博士生导师。主要研究方向:组合导航与飞行器制导控制。 Tel: 029-84741963 E-mail: zsx1963@yahoo.com.cn;李晓峰(1982-) 男,博士研究生。主要研究方向:飞行器控制与成像制导。 Tel: 029-84741963 E-mail: xiaofeng_li@126.com;刘毅男(1983-) 男,博士研究生。主要研究方向:飞行器控制、仿真与决策。 Tel: 029-84741963 E-mail: spacemanren@qq.com

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