International Journal of Innovative Computing, Information and Control
Volume **6**, Number **2**, February **2010**

ICIC International ©2010 ISSN 1349-4198
pp. **615–625**

ROBUST MULTIMODE CONTROL DESIGN FOR AN UNMANNED HELICOPTER WITH MULTILOOP FLIGHT STRUCTURE

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Received June 2008; revised December 2008

Abstract. *A novel multiloop control design strategy, based on robust H_∞ and PI control, is proposed for multimode flight of an unmanned helicopter, in this paper. The problems of model uncertainty, atmospheric disturbances and handling qualities specification requirements (as in ADS-33E) are all considered at the same time during the control design phase. Robust H_∞ technique is applied in inner loop ensuring stability of unmanned helicopter system (in case of change of helicopter dynamics and model uncertainty) and the effectively reduces effect of gust disturbance on helicopter states and collective/cyclic inputs. In outer loop, PI control is utilized to improve dynamic and static operation characteristics. Based on the proposed control design method, attitude control and attitude holding (ACAH) flight mode is designed. Analysis and simulation results demonstrate that satisfactory command response and decoupling characteristics are achieved in accordance with Level 1 handling requirements, as defined in ADS-33E.*
Keywords: Mutimode flight control, Unmanned helicopter, Model uncertainty, Atmospheric disturbances, Handling qualities specification

1. Introduction.

Unmanned Air Helicopters (UAH), because of their unique thrust generation and operation principle; have unique flight capabilities, in comparison with fixed-wing aircraft, such as vertical takeoff/landing (VTOL), hover, pirouette and slalom [1,2]. Thus they can perform many missions, such as experimental data collection, surveillance, reconnaissance, scouting missions and fire extinguishing, etc.

Control design for unmanned helicopter has been considered as a challenge in aeronautical field over decades [3-6,8-17]. Main difficulties, in designing controllers for UAH can be generally characterized as underactuated, cross-coupled, large uncertainty, open-loop instability and highly nonlinear dynamics [2,3,5].

Helicopters are multi-input multi-output (MIMO) underactuated systems [2], i.e., they have smaller number of control inputs than the number of generalized coordinates. In helicopters modeling of rotor aerodynamics and aerodynamic interaction, effects between main rotor and fuselage is usually represented by empirical relationship or approximation of wind tunnel experimental data [2,3]. Thus, unavoidably, the mathematical model of helicopter is affected by large uncertainties and unmodeled dynamics. Furthermore, helicopters are sensitive to wind atmospheric disturbances in flight, which may result in increased oscillations, degrade flight qualities and threaten flight safety especially in Nap-Of-the-Earth (NOE) flight [5].