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Advances in Flight Control Systems

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The interest in the field of flying control qualities stands for over 100 years, with remarkable results in the last 20 years, with the development of the aerospace industry and with the possibility to use high performance computing tools.

The general framework we refer to for the classification of the proposed theme is the evaluation, the reduction and the control of the potential risks affecting an unmanned aerial vehicle.

The military and civil possible applications generated an increased concern regarding the architecture and the behaviour of an unmanned aerial vehicle (UAV). Engineers, computer scientist and researchers in domains like Mathematics and Physics joined their efforts in studying nonlinearities that affect the flight of an UAV, their most recent and valuable results being gathered in ***Advances in Flight Control Systems***. As the editor mentions in the beginning of the introduction, this book has an ambitious target: "*to provide a comprehensive coverage of advanced and modern topics in flight control*".

Six parts could be identified upon the content of the 14 chapters, with authors from different regions of the world and with a wide range of expertise.

The adaptive flight control is the domain captured in the first part, through 4 chapters. The attention is guided towards the technical language, basic notions and short presentation of different flight devices with control actuators and of mechanisms specific to missiles and munitions used on board of UAVs. The *second chapter* is dedicated to the nonlinear high-fidelity model F-16, a nonlinear adaptive flight-path control system being developed for guaranteeing the stability and the maneuverability of the model, in the context of several flight conditions.

We move on to the *third chapter*, with a simulation study performed on a NASA wing-damaged transport aircraft model. A hybrid adaptive flight control system is developed in order to control the airplane, the simulation performed indicating an improvement of the control performance under different flight characteristics.

The *final chapter* of this section introduces the reader into the domain of genetic algorithmic, through an application developed for the "*design and tuning of a compensator*" for attenuation of interaction produced by the actuator dynamics.

The next four chapters, organized in the second part of this book, are dedicate to the **fault tolerant flight control**. Adaptive nonlinear dynamic inversion is preferred, in the *fifth chapter*, as modeling tool for interacting with the controller. Simulations are conducted on the RECOVER simulation model, the multiple experiments suggesting that this method is appropriate to be used for rapid identification of damaged aircraft models.

Due to the fact that unpredicted situations could arise during the flight of an UAV, the necessity of distinguishing between faults and natural influences appeared. To solve this

problem, an intelligent flight control system based on a neural network was designed, with simulations performed on a six-degree of freedom nonlinear system.

The control surface failure can affect the stability of an UAV, so a nonlinear model based on is proposed in the *seventh chapter* to "*detect, isolate and estimate faults*", using signal processing method.

The robustness of the adaptive control technique and the explicit actuators failure treatment of the control allocation method are analyzed in the *eight chapter*, a fault-tolerant architecture for the flight control system being proposed to the reader. Numerical simulation performed on a large transport aircraft model indicate positive results regarding the use of this fault-tolerant model in the case of "*severe failure and damages*".

The next section of the book, namely the *ninth chapter*, deals with the **acceleration based flight control,** all three dimensions of the flight envelope being considered. The results of numerical simulations on the proposed model validate the assumption of reduction of the airplane to a mass point with acceleration, regarding the 3D guidance perspective.

Further on, three chapters are focused on the **helicopter flight control**, due to the multiple possible use of helicopters and to the fact that we are dealing with a very unstable aerial vehicle. *Chapter ten* is dedicated to the "*flight control design for the longitudinal motion of a helicopter*". Matlab/Simulink simulation prove the effectiveness of the proposed polytopic model, with less error than previous models used for analysis.

The *eleventh chapter* presents the study of the autonomous flight system through the use of a wireless camera installed on the helicopter. Experiments performed indicate that further improvements are required, but this method can be considered for detection of the position and posture of the helicopter.

The *next chapter* is dedicated to the hierarchical control design method, with a detailed description of the UAV helicopter model and structure and of the controller design. A systematic approach is used for "*designing a P-controller for MIMO systems*" that can be easily implemented on the UAV.

The **comparison of flight control systems** is analyzed in the *thirteenth chapter* of the book, passing from conventional design methods such as optimal control or pole placement method, to intelligent control techniques – neural networks, fuzzy logic based control design, in a special phase of the UAV movement: the landing phase.

The *last chapter* of this book covers another interesting topic in the behavior of UAVs: **the oscillation susceptibility in the case of failure of the automatic flight control system**. The experiments and the theoretical proofs are provided for a simplified mathematical model for ADMIRE (Aero Data Model In Research Environment), with a broken automatic flight control system. Analysis is centered around the oscillatory movements around the centre of mass, in flight characterized by a longitudinal flight with constant forward velocity.

This book offers an outstanding overview of recent research results in flight control systems, a useful reference material for both for students and active researchers in this field.

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