Chapter IX

On the Modelling of a Human Pilot Using Fuzzy Logic Control

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ABSTRACT

This chapter discusses the possibility to model the control behaviour of a human pilot by fuzzy logic control. *For this investigation a special flight task is considered, the ILS tracking task, and an evaluation pilot has to perform this task in a ground based flight simulator. During the ILS tracking task all necessary flight data are stored in a database and additionally the pilot commands are recorded. The development of the described fuzzy controller (the* fuzzy pilot*) is based on cognitive analysis by evaluating the recorded flight data with the associated pilot comments. Finally the fuzzy pilot is compared with the human pilot and it can be verified that the* fuzzy pilot *and the human pilot are based on the same control concept.*

INTRODUCTION

It is a must for manned real-time simulations to take Man/Machine Interface (MMI) aspects into account. The demanded quality of the MMI-simulation depends on the particular aim of the simulation. Up to now, however, no clear

answer is given to the question: how realistic the real-time simulation at least has to be in relation to a certain flight task? One typical example is the application of motion cues. Simulated motion is not necessary in the case of so-called Flight Training Devices (FTDs) used generally for initial and procedure training. These less complex simulators replicate the actual aircraft cockpit, but do not provide a visual system or motion system. On the other hand, it is well known that the pilot's behaviour is influenced by the aircraft motion in the case of high precision tasks, e.g., when he has to perform an ILS-approach under bad weather conditions such as heavy wind shear, turbulence and gusts (see, e.g., Bussolari et al., 1984; Schänzer et al., 1995). High gain tasks increase the workload of the pilot significantly. Hence, a deeper understanding of these subjectively sensed influences on the pilot's reactions is necessary.

Particular aspects of MMI problems are covered at the Institute of Flight Research of the German Aerospace Center (DLR) by a project named AIDA (Airborne Identification and Development of simulation fidelity criteria using ATTAS). It deals with the comparison of ground-based simulation and real flight. Different experienced commercial pilots have to perform well defined tasks on two simulators with different equipment standards and on the DLR in-flight simulator ATTAS. The results are used twofold: (1) to classify the pilot tasks and (2) to define the demands on the simulator equipment to enable an adequate conduction of the given task. The project also provides additional information related to pilot workload aspects, which leads to a better understanding of the man/machine interface between pilot and aircraft (see Bauschat, 2000).

The data gained from the simulator sessions and flight-tests are evaluated in various ways to gain as much information as possible. Data evaluation in the time domain delivers a good idea about the quality of a task solution. The assessment of the solution quality is additionally supported by statistical evaluations. Pilot's effort to solve a task can be described in the frequency domain, where power spectral density data are used. But the investigation of the individual strategies pilots are using to achieve a good performance during a particular task makes it necessary to model the pilot and the MMI. Investigations based on pilot models support a better understanding of the interaction between pilot and MMI. Sub-models describing particular behaviour patterns, which have been found evaluating the AIDA database, should be easily added to the pilot model. Such a sub-model may, for example, include the influence of the pilot's subjective impressions on his task performance.

With respect to the idea of the AIDA project, it was soon clear that a knowledge-based method should be used to model the control characteristic of a pilot. In this particular case a fuzzy logic approach has been chosen. Fuzzy logic provides a lot of benefits, because verbal descriptions which an expert has given can

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