Airplane Speed Control: A Fuzzy Logic Approach

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Air traffic management is a complex system that includes aircrafts, crew, air traffic controllers, automation, traffic rules and climatic conditions that can affect in decision making during the different flight phases (Callantine, 2004). The human factor is the most relevant aspect in this management process, involving controllers working under severe stress and an increasing flow of aircrafts, as well as the aircraft crew and passengers' safety that has become a major issue due to the decrease of the cost of aerial transportation that have directly impacted in the increasing number of flights leading to very high density air traffic worldwide.

The variables involved in this system are dynamic, increasing the complexity of the process proportionally to the increase in the number of simultaneously controlled aircrafts (Becker & Milke, 1998). Research works reveal that the flow of the air traffic in the last years have grown considerably, demanding new resources to provide higher safety levels to passengers and less stress to controllers. Besides, researcher works have been published on the capacity of air traffic control being directly related to the number of aircrafts that the controller can simultaneously manage (Perry, 1997).

The search for systems that aid the management of a considerable amount of variables that are in constant modification in the corresponding environment have become a major issue in research. The development of systems that support decision making by the air traffic controllers may directly impact a work area with an imminent need for means that reduce the workload, leading to a less stressful work (Reynolds & Hansman, 2002) (Perry, 1997).

The tasks performed by air traffic controllers involve the validation and planning of the flight plans to the landing and aircraft maneuvering at the arrival place. One of the critical points of the whole process is at the approaching areas, where the amount of levels, speed and size of the air space are limited, requiring an appropriate infrastructure that make possible to outline problems, as for instance, the limit of aircrafts in certain defined sections in agreement with the corresponding size, amount of available levels and, in extreme cases, meteorological conditions of the area.

One of the tasks performed by the air traffic controller is the administration of aircraft speed in certain sections of the approach area, where speed limit exist at the entrance and at the exit of the section (Fig. 1). During the administration of that task there may be several peculiarities related to the technical characteristics of the aircrafts, as for instance, the capacity to increase or to reduce its speed. The speed limits are defined here as Vmax and Vmin (maximum and minimum speed that guarantees aircraft sustentation). Those characteristics vary from section to section, from aircraft to aircraft, demanding the use of self-adapting resources.

A support system to make decision for this functionality may supply information to the traffic controller to verify if the aircraft is following the rules of the section. It will also be able to provide to the pilot the respective velocities along the section. Thus, a more accurate control and a smoother decrease of the speed along the section may result.

A fuzzy decision system for helping air-traffic experts in controlling airplane velocities and in keeping an airplane flying within several constraints established to air lane sections, is proposed in this paper. Automatic systems for air-traffic control are essential due to the ever increasing number of airplanes flying all over the world, the amount of environmental and airplane constraints and the necessity to guarantee the safety both for flights and for air-traffic control operators. The proposed system uses Mamdani direct inference method (Zadeh, 1965). Results show the effectiveness of the developed fuzzy system in controlling the airplane velocity to achieve the desired performance and encourage the adequacy of the system to include several different variables usually employed in air-traffic control.

Finding out devices and mechanisms for supporting air-traffic controllers in their tasks has been a research issue of great interest in the literature. For instance, Matosa & Powell (2003) describe the main problems when managing airplane routes (re-routing) as well as how a decision support system should be employed to assist operators in strategic activities. In this sense, Nogami *et* al (1996) present a real-time decision-support system and learning machines working in cooperation in such a way that an artificial neural network method is used to schedule airplanes .

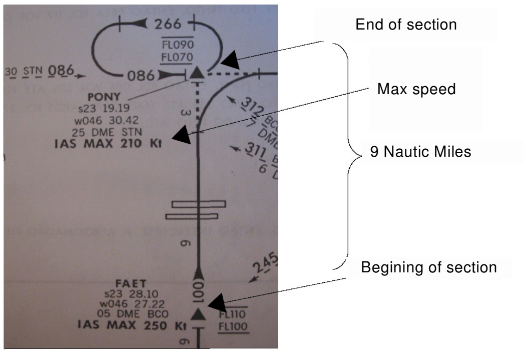

Fig. 1 Real velocity standard for air lane section velocity limits.

This paper addresses the problem of aircraft speed control for landing perimeter system based on a fuzzy decision support system. The use of a fuzzy system and approximate reasoning applied to decision and control problem have been research issues (Zimmermann, 1987) and they are alternative approaches for finding out an air-traffic control strategy for dealing with this problem. A fuzzy system uses fuzzy logic to determine the action being employed on a controlled system and can be used to imitate human behavior by carrying out methodologies and techniques used by human experts. Thus, knowledge and rules employed to compose decision mechanisms by air-traffic control experts can be brought out and, then, be translated into an intuitive natural language in a supervisory system (fuzzy decision support system) (Zadeh, 1965) (Lemoine & Debernard, 2002).

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