A FUZZY SUPERVISORY MODEL FOR ANALYSIS OF MANUAL LANDING CONTROL

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ABSTRACT

A new pilot model consisting of neural networks and supervisory fuzzy logic control is proposed to reveal a pilot's control characteristics in the visual approach to landing. The model is constructed from real or simulated flight and can be used for pilot training or assesment.

1. INTRODUCTION

Real and/or simulated experience is indispensable to obtain and maintain landing skills, and automatic data-analysis and generation of pilot-specific feedback is thought to greatly improve learning efficiency [1]. In both simulated and real landings the characteristics in the visual scene (cues) and the pilot's control actions were captured. For the real landings, this was achieved using 2 video cameras (see Fig. 1) and offline image processing, for the simulator experiments the cues were back-calculated from the aircraft states and scene definition. The thus obtained cue and control data are analysed and form the basis of the pilot model.

Fig. 1: The control command is recorded using a white cross marker on the column (left), the visual cues are recorded with the camera on the right.

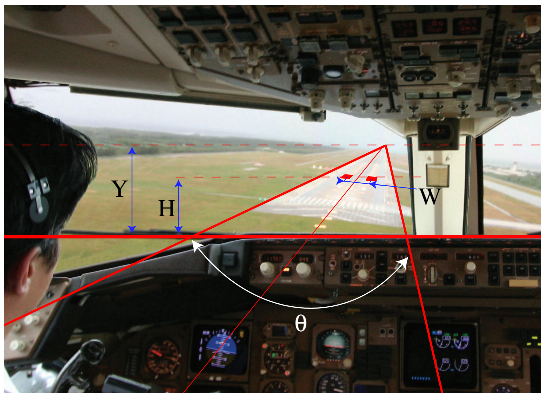

Fig. 2: Definition of visual cue variables.

2. PERCEPTION

The selection of inputs for the pilot model is a difficult task. Much research has been done to determine the visual information used by pilots (for an overview see [2]). The runway shape (perspective) is generally believed to play a role in the estimation of altitude and glide slope[3]. The use of τ (time to contact) has been suggested as a guide for the flare phase [4] and research on glide slope control revealed the importance of the (absolute) H-distance (the distance between the horizon and the aim point, measured in the visual plane) [5].

Currently, only longitudinal motion is studied, resulting in the cues shown in Fig. 2: Horizon (Y), Marker position (H), Marker size (W) and Runway angle (θ). The H-distance (Y-H), τ_θ ($\theta/\dot{\theta}$) and temporal derivatives are also considered.

It must be kept in mind that the usage of cues depends on a pilot's preference, aircraft type, visibility and varies through the phases of the landing [6]. Therefore, the selection of appropriate visual cues for each maneuver must be modeled as well, to obtain a complete view of the pilot's perception and control strategy.

3. CONTROL

It is believed that the pilot adopts different control strategies in the final approach (glide slope tracking) and flare (nose-up command) phases. These phases are therefore separated and the timing of the transition is analysed. The longitudinal control parameters are throttle lever setting and column deflection.

4. PRELIMINARY RESULTS

The current, preliminary results were obtained using simulator and real flight data available from previous research. Fuzzy c-means clustering was applied to separate the glide and flare phase data. Manual selection would have had the same result. Applying the model to these data reveals that the horizon and the τ_θ $(\theta/\dot{\theta})$ are mostly applied in the flare phase, in the glide phase τ_θ also seems to be used, but also the H-distance and marker size are identified to be important. Using these cues, very simple (3 neuron) networks were trained which proved to be able to cover the pilot's control characteristics. Figure 3 illustrates these results.

Both the quality and quantity of the currently available data are insufficient to draw hard conclusions. Dedicated simulator experiments and real flights have been performed recently and the obtained data is currently under analysis.

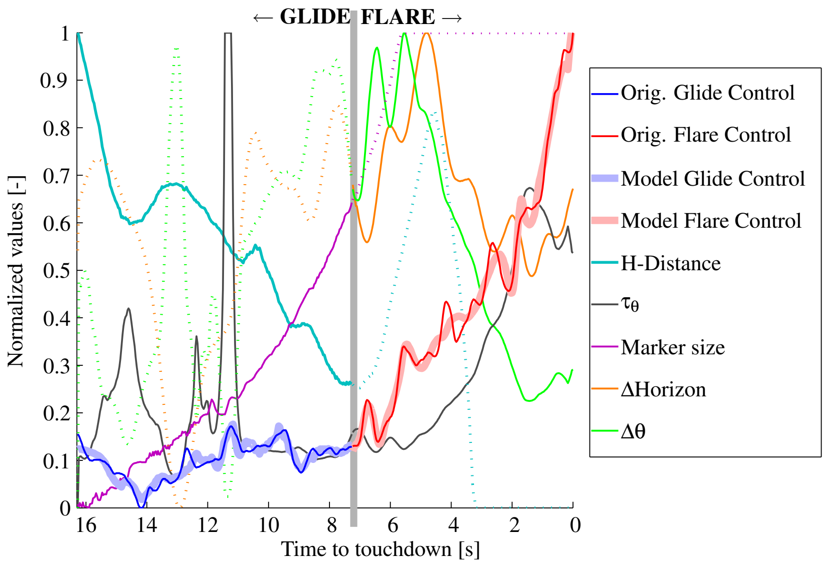

Fig. 3: Column deflection and selected visual cues in real flight. It can be seen that the pilot initiates the flare 7s before touchdown. If cues are not used in a phase, lines are dotted.

References

1. **Palmisano, S., Favelle, S., Prowse, G., Wadwell, R., and Sachtler, B.** , "investigation of visual flight cues for timing the initiation of the landing flare", Tech. Rep. B2005/02121, Australian Transport Safety Bureau, Jun. (2006).
2. **Reynolds, N.** , "an investigation into landing approach visual illusions", Master's thesis, University of Waikato, New Zealand (2007).
3. **Galanis, G., Jennings, A., and Beckett, P.** , "a mathematical model of glide-slope perception in the visual approach to landing", *International Journal of Aviation Psychology*, **8**/2, 83–101 (1998).
4. **Jump, M., and Padfield, G.** , "tau flare or not tau flare: that is the question: Developing guildelines for an approach and landing skyguide", In *AIAA Guidance, Control and Navigation Conference*, (San Fransisco) (2005). #AIAA-2005-6404.
5. **Lintern, G., and Liu, Y.** , "explicit and implicit horizons for simulated landing approaches", *Human factors*, **33**/4, 401–417 (1991).
6. **Mori, R., Suzuki, S., Sakamoto, Y., and Takahara, H.** , "analysis of visual cues during landing phase by using neural network modeling", *Journal of aircraft*, (2007). (In Press).