Silesian University of Technology

Faculty of Automatic Control, Electronics and Computer Science

PhD in Applied Integrative Data Analysis

Doctoral thesis

Research and development of a new touch-screen based inceptors design for an aircraft control

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Doctoral thesis summary

Over the years, the aerospace field has seen many changes thanks to technological advances. However, inceptors design is a topic that was often omitted by researchers, despite some potential advantages. With the rise of touchscreen technology being introduced in the aircraft's cockpits and growing interest in urban air mobility, the author observed the possibility of exploring new means of controlling the aircraft. It was demonstrated that the engineering flight simulation would provide a critical environment for such investigations. Therefore, it was essential to have a “flexible”, reconfigurable flight simulator that would allow for research not restricted by the physical characteristics of existing cockpits. Moreover, it was important to recognise the impact of human factors in the research and development of new technologies in aviation. Based on a detailed literature review, the following hypotheses were formed: (H_1): *The introduction of alternative inceptors as flight controllers, including a touchscreen, can potentially improve the pilot's performance*; (H_2): *A novel engineering flight simulator helps to streamline the research and validate the results of radically different control methods in an aircraft*; and (H_3): *Demographic, occupational, and personal characteristics have a significant effect on the subjective experience and objective performance in the flight simulator*.

This thesis proposed two alternative inceptors: a gamepad, usually found as a controller for video game consoles, and a touchscreen, adapted from a thumbstick commonly used in mobile games. Both were compared to a conventional sidestick. A state-of-the-art engineering flight simulator, *Future Systems Simulator*, was developed and utilised to validate proposed designs. The experimental design tested the three inceptors in a series of simulated scenarios, including disturbance rejection tasks and landings. Participants included both pilots and non-pilots. Both objective measures (evaluated using the author’s original equation that considered spatial and temporal aspects from flight data recorded in the simulator) and subjective experiences (workload, situation awareness and inceptor usability rankings) were collected during the experiments.

Results were analysed using statistical methods and demonstrated that, although the gamepad controller had better performance, it was rated lower in usability than the sidestick controller, especially among professional pilots. On the other hand, the touchscreen controller, despite showing good learnability and understanding, was deemed not yet ready to be considered as a viable alternative inceptor for aircraft. However, it may have potential applications in other areas, such as ground control. These conclusions validate hypothesis (H_1). Using the state-of-the-art flight simulator developed throughout the course of this PhD, it was possible to obtain credible and satisfactory results, thus supporting hypothesis (H_2).

Additionally, it was found that flight experience significantly affected participants’ behaviour in the flight simulator. The results of this research contribute to understanding the potential benefits and challenges of introducing alternative inceptors in aircraft cockpits and highlight the importance of considering human factors in designing and implementing such technologies, which confirms hypothesis (H_3).

In summary, this thesis provided valuable insights into the engineering flight simulator design, as well as the proposal and evaluation of alternative inceptors for aircraft control and human-computer interaction methods. The results may inform future research and development in these areas.