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Title
Study and Development of a Real-Time Pilot Performance Monitoring System Based on Physiological Signals

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Abstract
Two of the key challenges facing the aviation market today are rising operating costs, especially on short- and medium-haul flights, and the decreasing availability of pilots [1]. Indeed, despite today's regulations for most airline flights requiring a pilot and a co-pilot on board the aircraft, to address these problems, there has recently been an increasing focus on the so-called Single Pilot Operations (SPOs). However, the SPOs in aviation can be achieved only by guaranteeing the same (or higher) safety and handling quality level regulated to date in the EASA parts [2]. Therefore, a cockpit assistant with the potential to understand the cognitive workload of the pilot and his ability/inability to operate the aircraft is a fundamental need to foster this disruptive transition.
Our project aims to develop an autonomous Pilot Performance Monitoring system fully integrated into the cockpit. Our tool provides a continuous real-time output regarding the cognitive workload and the pilot's state of health during the flight mission. It is based on a multimodal approach that considers the most significant physiological signals([3], [4], [5]), such as cardiorespiratory measures, eye tracking, fNIRS (functional Near Infrared Signal), and skin activity, through ad-hoc developed electronics. Together with aircraft data, these signals feed our AI algorithm, which estimates the pilot's cognitive load. The idea is to estimate individual capacity limits by correlating these parameters' variation with the mental load's increase or decrease through specific data labeling and further classification. This information is then provided directly to the aircraft avionics and the air traffic controllers on the ground so that the pilot's physical and mental condition is always monitored. This ensures the safety levels regulations require, even with a single pilot on board the aircraft.
Initial computer cognitive tests have already been completed on thirty healthy volunteers, providing the aforementioned parameters under three mental workloads and stress conditions. This has gained a valuable data set for the test of our neural network, which is at an experimental stage. The most significant features have already been extracted from the signals, and now we are studying the most efficient AI algorithm for processing these data in real-time. Indeed, we aim to develop a system that has versatility as the key principle to have the possibility to integrate this tool not only in an aircraft cockpit but also in the control tower to monitor the mental workload of air traffic controllers.
To sum up, we decided to investigate the physiological multimodal approach and the potential of AI algorithms to foster the transition toward SPOs. This is a crucial topic for the aviation industry, which is continuously growing thanks to the exponential growth of the biomedical sensor market in the last few years [6]. The availability of smaller, cheaper, and more reliable wearable sensors allows for investigating and developing technologies that could not be realized so far to enhance safety and push the aviation sector to the next generation of aircraft.

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