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Intelligent cockpit: eye tracking integration to enhance the pilot-aircraft interaction

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ABSTRACT

In this research, we use eye tracking to monitor the attentional behavior of pilots in the cockpit. We built a cockpit monitoring database that serves as a reference for real-time assessment of the pilot's monitoring strategies, based on numerous flight simulator sessions with eye-tracking recordings. Eye tracking may also be employed as a passive input for assistive system, future studies will also explore the possibility to adapt the notifications' modality using gaze.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**; *Human computer interaction (HCI)*;

KEYWORDS

Eye-tracking, Eye movements, Human factors, Human computer interaction, Neuroergonomics, Cockpit monitoring, Flying assistance technology

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1 RESEARCH OBJECTIVES

Nowadays, aviation is the safest mode of transportation with less than one accident per million flights [Airplane 2016]. Despite this low rate, accidents still occur; and human error is its major causal factor [Shappell et al. 2007]. Even if humans are able to cope with complex and degraded situations, the limitations of the human attentional capabilities are unavoidable and need to be taken into account. The National Transportation Safety Board (NTSB) found monitoring and cross-checking errors being involved in the majority of the accidents [Board 1994]. As such, the Federation Aviation Administration (FAA) issued a directive that includes new requirements for improving flight crew monitoring skills during the initial training [(FAA) 2013]. Moreover, the Bureau Enquetes-Accidents (BEA), the French accidents investigation agency, recommended studying pilot monitoring with eye-tracking to improve flight safety [(BEA) 2013].

2 HYPOTHESIS AND PROBLEM STATEMENT

Neuroergonomics approach proposes to use neuroscience tools to monitor the operator in order to assess its cognitive state when facing complex activities [Parasuraman and Rizzo 2008]. Far from replacing the human by machines, its goals are to enhance and optimize the human-system cooperation. A promising way to do so, the core of the current thesis project, is to integrate eye tracker on board in order to monitor pilots eye movements [Peysakhovich et al. 2016]. These data can be further used to deduce the crew attentional state, the breakdown of which can be detected early and prevented [Dehais et al. 2017, 2015; Lefrancois et al. 2016; Liu et al. 2016; Peysakhovich et al. 2018].

3 APPROACH AND METHOD

In the first part, the project aims to build a database of visual circuits. This database will serve as an optimal cockpit monitoring reference. This database will integrate different eye movement characteristics (dwell times, time without fixation, blinks, etc.) according to the different flight phases or aircraft configurations. In the second part, we will study different alerting modalities (haptic, sound, visual) that could be employed according to the pilot' attentional state. For example, literature showed that if the pilot is too much focused on visual information, auditory information can be unnoticed[Dehais et al. 2014]. A haptic alarm might be employed in such context.

4 PRELIMINARY RESULTS

A first experiment, involving 12 airlines pilots was conducted in the ISAE-SUPAERO PEGASE flight simulator. Pilots were between 23 and 52 years old (mean = 39, SD = 17.32). They had a minimum of 5800 hours of flight with airline aircraft (mean=2163, SD=1636.15). Pilots performed twice three different manual landings. Scenario 1 corresponded to a nominal manual landing. In the two others landings scenarios, pilots were asked to perform a supplementary monitoring task (double-task).

Figure 1: Cockpit Display with Areas Of Interest and Sub-AOIS: (1) Primary Flight Display (PFD), (2) Navigation Display (ND),(3) Electronic Centralized Aircraft Monitoring (ECAM), (4) Out of Window (OTW),(5) Flight Control Unit (FCU), (6) Flight Mode Annunciator (PFD.FMA) , (7) Speed Tape (PFD.SPD), (8) Attitude indicator (PFD.ATT), (9) Vertical Speed Tape (PFD.VS), (10) Heading Tape (PFD.HDG), (11) Message Zone (PFD.MSG), (12) Navigation display indicator of the PFD.

The monitoring task consisted in calling out the distance in nautical miles (Nm) between the aircraft and a designed radio beacon. The pilots were asked to call out the distance either every 0.5 Nm (scenario 2) or every 0.2 Nm (scenario 3). A Smart Eye system recorded eye movements of the pilots. The cockpit has been divided into several Areas Of Interest (AOIs, Figure 1) corresponding to the flight instruments. The Figure 2 presents the result of this experiment with the non-monitored AOIs, the time during which the AOIs were not fixed.

5 PLANS FOR FUTURE WORK

Both types of eye movements characteristics (i.e. non-monitored and fixations frequency) will allow adding in the cockpit an adaptive system with some rules about pilot's eye movements. The time threshold that defined tolerance for non-monitored AOIs will be included in a Flight Eye-Tracking Assistant (FETA). The priority of the alarms will be defined by the fixations frequency in order to manage potential conflicts between concurrent alerts. Next experiment will try to compare pilot' performance during landing task with and without FETA system in order to validate the system efficiency in baseline case.

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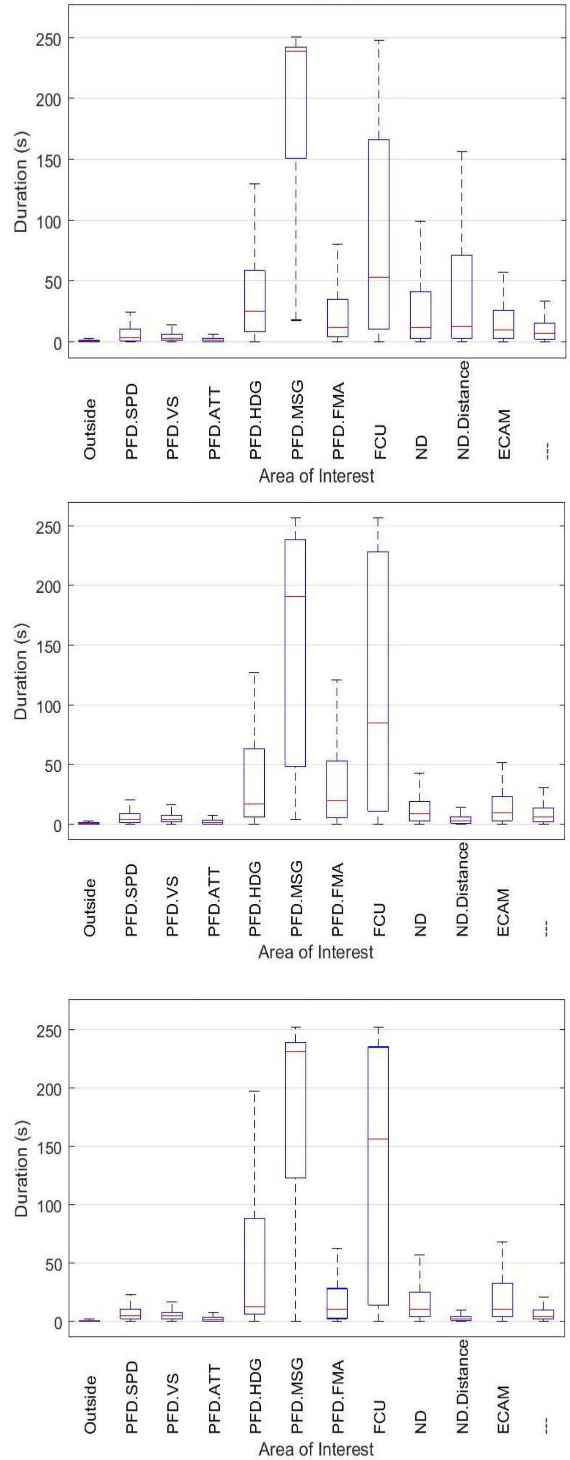

Figure 2: From the top to bottom, box plots of non-monitored AOIs for each scenario 1, 2, 3.

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