MEASURING PILOTS' VISUAL BEHAVIOUR

A TOOL FOR RESEARCH ON PILOTS' INSTRUMENT SCANNING AND ATTENTION

TNO innovation for life

When operating an airplane, pilots perform a repetitive systematic visual scanning of the instruments, referred to as crosschecking, to update their mental model of the situation and to effectively apply control inputs. The recording of pilots' viewing behavior with a gaze-tracking device can be useful in research on the pilot's mental state, workload or fatigue, and interface design. TNO is performing research on the value of using gaze tracking as feedback tool in pilot training.

INSTRUMENT SCAN

To safely operate an airplane, pilots visually scan the cockpit instruments to update their mental model of the situation, and to enable effective aircraft control. Since it is not possible to read all information simultaneously, pilots are trained to continuously scan the instruments, also called crosschecking.
This repetitive and systematic scanning process divides the attention between control-, performance- and navigation instruments.

GAZE TRACKING DEVICE

To measure the pilots' viewing behavior, different gaze tracking solutions are commercially available, such as remote camera systems, or head-worn devices. The gaze-tracking equipment that we are using is a head-mounted binocular system, featuring a wide-angle scene camera with two infrared eye cameras to determine the pilot's gaze direction. The system can be easily installed in a flight simulator, where it shows satisfactory performance to accurately determine at which instrument the pilot is looking.

Head-mounted binocular eye tracking system to measure the viewing behavior during different phases of flight

Calibration of gaze direction is based on world-fixed (infrared) markers placed in the cockpit. The pilot's gaze behavior can be shown real-time to the instructor, but detailed analysis of various parameters takes place off-line with special software. This allows for definition of specific

areas-of-interest (e.g. the individual instruments and looking out-the-window) within the visual scene.

Screenshot taken from the analysis software, showing the fixation marker at the ADI in relation to the different cockpit instruments

INTEGRATED FLIGHT SIMULATOR

The gaze tracker is part of the integrated measurement suite inside the Advanced Spatial Disorientation (ASD) flight simulator, used by TNO and the Royal Netherlands Airforce (RNLAF). The ASD flight simulator has a special moving base to simulate the physical aircraft motion and to create vestibular spatial disorientation illusions. In combination with realistic out-the-window visuals and visual illusions, the testbed offers the possibility to investigate the interaction of multiple challenging stressors while performing a flight task. Flight parameters, simulator motion, and the pilot's viewing behavior and physiology can be monitored real-time and are logged synchronously. Besides the gaze tracking device, this monitoring-and-logging system includes all kind of (new) measurement systems, such as pulse-oxymetry, near-infrared spectroscopy (NIRS), electrocardiography (ECG), galvanic skin response (GSR), etc.

EXAMPLE PROJECT

In a collaborative research project, TNO and the RNLAF investigated the pilots' viewing behavior and flight performance in response to unexpected spatial disorientation (SD) events. As SD is caused by unreliable sensory feedback about the airplane's motion and attitude, an effective instrument crosscheck can be the one-and-only lifeline in these events. The other way around, some vestibular effects may hamper the visual acuity, affecting the readability of the instruments. Furthermore, SD diverts the pilots' attention to regain orientation, which impairs the interpretation of cockpit instruments even more. From the study it is concluded that there is an important relation between SD and viewing behavior, and vice versa.

APPLICATION

The integrated flight simulator environment allows applied research on the (combined) effects of spatial disorientation, hypoxia, degraded visibility, heat stress, high workload, etc. on the pilots' viewing behavior, flight performance, physiology and cognitive state. Furthermore, the simulator facility also serves as a testbed for validation of (new) systems and HMI solutions (e.g. additional information, HUD- and HMD-applications, etc.). TNO is performing research on the value of using gaze tracking as feedback tool in pilot training.

The RNLAF ASD moving-base flight simulator, located at TNO Soesterberg, The Netherlands

Besides measuring the pilots' visual behavior in aerospace, eye tracking can be applied in other domains. In order to explain operator state and behavior, eye tracking is often combined with measuring performance indicators, control inputs, subjective ratings, and physiology. This multi-disciplinary approach allows to put results into perspective.

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JOINT INNOVATION

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