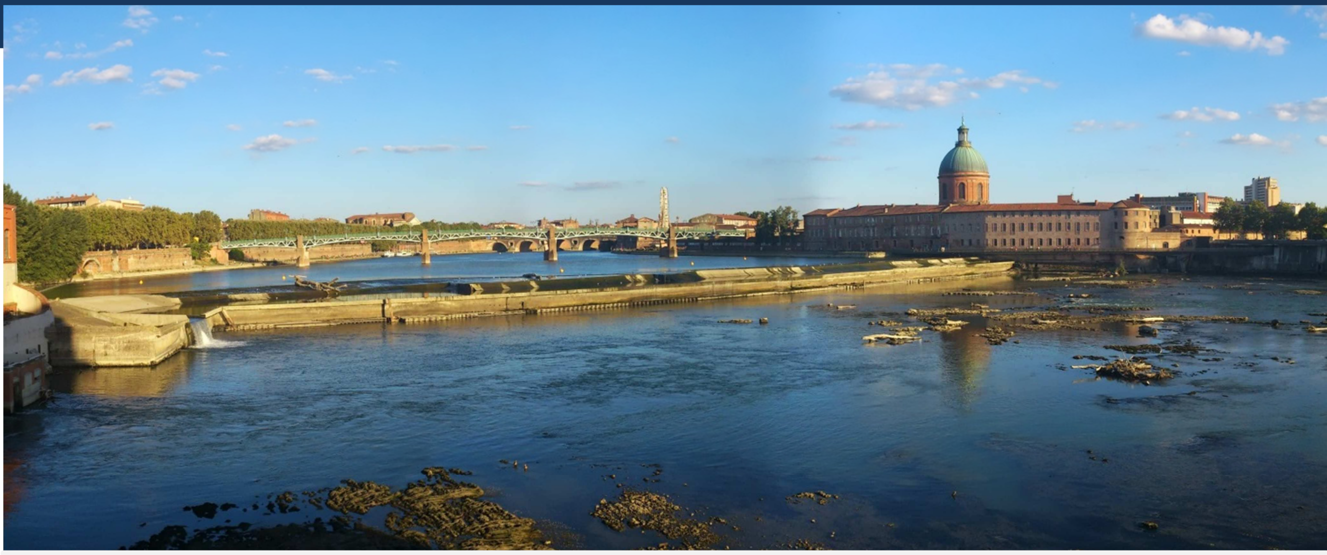

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Integrating electrodes to headsets for human-system interaction and psycho-physiological monitoring

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Content

Research in human monitoring led to development of powerful tools for users-systems communication via recording electrophysiological data and sending them to the computer system. Eye and gaze tracking are standing as important methods for a broad range of human monitoring applications such as in neuroscience, psychology, industrial engineering, aeronautics, military, and medical expertise. Nowadays, the most used eye-tracking technique is video-based tracking based on infrared illumination. However, the tools using this technique present a certain number of disadvantages. Notably, for the head-mounted tools, such systems obstruct the visual field and therefore are not suitable for integration in real operational environments. An alternative technique is the electro-oculography (EOG) which consists in measuring the standing potential between the front and back of the eyes. This potential increases when the cornea approaches an electrode and it decreases when the cornea moves in the opposite direction. EOG represents one of the easiest methods to estimate eye movements by using low-cost low-energy consumption devices without obstructing the visual field nor handling infrared light. This technique is particularly convenient for the head-mounted peripherals such as audio or virtual reality headsets. Typical features of signal processing, such as the mean of fixation duration, saccadic rates, and blinks are explored in various environments including air traffic control, pilots and co-pilots of civil and military aircraft. Interestingly, the EOG, as well as electroencephalography (EEG) features were correlated to drivers' and pilots' workload, drowsiness and fatigue.
Yet, EEG and EOG gained traction in aviation and space operations, current studies face the challenges of the intrusive and bulky nature of the equipment, the discomfort of long preparation time and dependence on gel electrodes (e.g. wet electrodes). Recent developments in dry electrodes could further decrease preparation time, removing the need to apply conductive gel/saline patch and prepare the skin as required in traditional EEG to reduce skin-electrode contact impedance.
An exciting and unprecedented approach would be the integration of both gaze-based interaction and brain activity monitoring using only one device in real operational environments. Electrodes corresponding to the available surfaces would be integrated into existing control and communication peripherals. This integration would improve the human-system interaction by making possible the monitoring of the eye movements and the psycho-physiological state. Hence, an equipped headset measuring real-time EEG and EOG may pose a great challenge with applicability and generalizability to both commercial and advanced research fields. More particularly, such technology would be of high interest in the areas based on simultaneous visual and auditory inputs, including aeronautics, helicopters, teleoperation drones, naval systems, and control-command centers. Our ELOCANS project (ref. ANR-18-ASTR-0026) addresses this lack of software and hardware for gaze-based interaction in operational environments. We aim to optimize the efficiency of the existing peripherals using integrated dry EOG and EEG electrodes. By studying this integration in the control/communication peripherals to enhance the human-system interaction and making possible the psycho-physiological monitoring (based on blink rate, for instance), this project has numerous possible applications in aeronautics (fighters, helicopters, UAV operation), naval systems, and control-command centers.

Keywords : Eye tracking, EEG, fNIRS, Other measurement methods, Brain computer Interfaces