Eye movement detection in military aeronautics using EOG — Source link

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Eye movements are particularly important in aeronautics where operators rely on numerous sources of visual information. Eye-tracking reveals what we are looking at, but also the physical and psychological condition of an operator. The human perception, and more particularly the vision, is a vector of errors well known in human factors (tunnel effect, eye strain, etc.). The eyes can help finding where the attention is focused (gaze position), how the subject feels (fatigue), and interact with a system by eye movements [1]. Ocular interactions meet the need that HOTAS commands in aircraft are complexified by the high number of buttons and complex multiplexing. Oculometry has thus become a flagship sector of aeronautical research to understand human limits and interact more naturally with the system. Current solutions are largely based on video-based eye trackers, but this technology has some drawbacks: vibrations in the aircraft, visual field obstruction, and infrared illumination are signifiant issues that prevent eye trackers from being operational.

In this work, we use electro-oculometry with applications for military aeronautics to detect different eye movements. This technology consists in sticking electrodes around the eye and detect ocular dipole [2, 3]. A signal called electro-oculogram (EOG) is recorded. We designed an experiment to acquire and understand different types of EOG signals: saccades, vergence movements, fixations, blinks, winks, smooth pursuit, and reading gaze movement [4]. For this experiment, the EOG signal has been recorded using the Cyton board from OpenBCI. Vertical movement, left and right horizontal movement have been recorded with the nose as a spatial reference: horizontal signals decrease when the eye gets closer to the nose. Thus, the EOG signal during classical saccades shows crenels in phase opposition and same phase for vergence saccades. Corrugations have been shown for smooth pursuit movement. Blinks are visible on the vertical channel. Winks can be seen if two vertical channels are plugged. These recordings helped to understand how eye movements were transcribed to the EOG signal. A total of 91% of 1000 saccades have been identified. 26 EOG data files have been recorded from 12 individuals. These results have also made it possible to grasp the limits of this technology, not very precise for small movements and suffering from noise and signal fluctuations. A key issue is the "Midas Touch effect" : to clearly distinguish natural eye movement from voluntary eye movement. Therefore, the challenge was to offer eye movement "codes", patterns, and to find a balance between a complex tiresome eye movement sequence and an easier one too close to natural eye moment. EOG signal's amplitude is mostly proportional to the amplitude of eye movement. The experiment offers then patterns that provide significant amplitude and are different from natural eye movement. Interaction by eyes could help the pilot changing a view, display navigation, fuel, weapon pages, increase audio volume, or lock an enemy aircraft. This experiment also shows some physiological results. First, blink frequency can be measured and thus give an estimation for ocular tiredness. The experiment was also conducted at Mont-de-Marsan French Air Force Base 118. Some acquisitions were conducted in the Sensory Illusion Generator (SIG) by moving a cabin in which the subject was seated. Illusions were created while the cabin was moving in pitch, roll, and yaw. Angles amplitude varied between ±40° and angular speed was about 5°/s. Sensorial illusion conditions did not disturb EOG signal. Those acquisitions showed that the EOG was able to detect nystagmus in the eye during sensory illusions in pitch. No results were found for roll and yaw sensory illusion yet. The team planned to record more data in those conditions.

EOG dispositive

Sensorial Illusion Generator

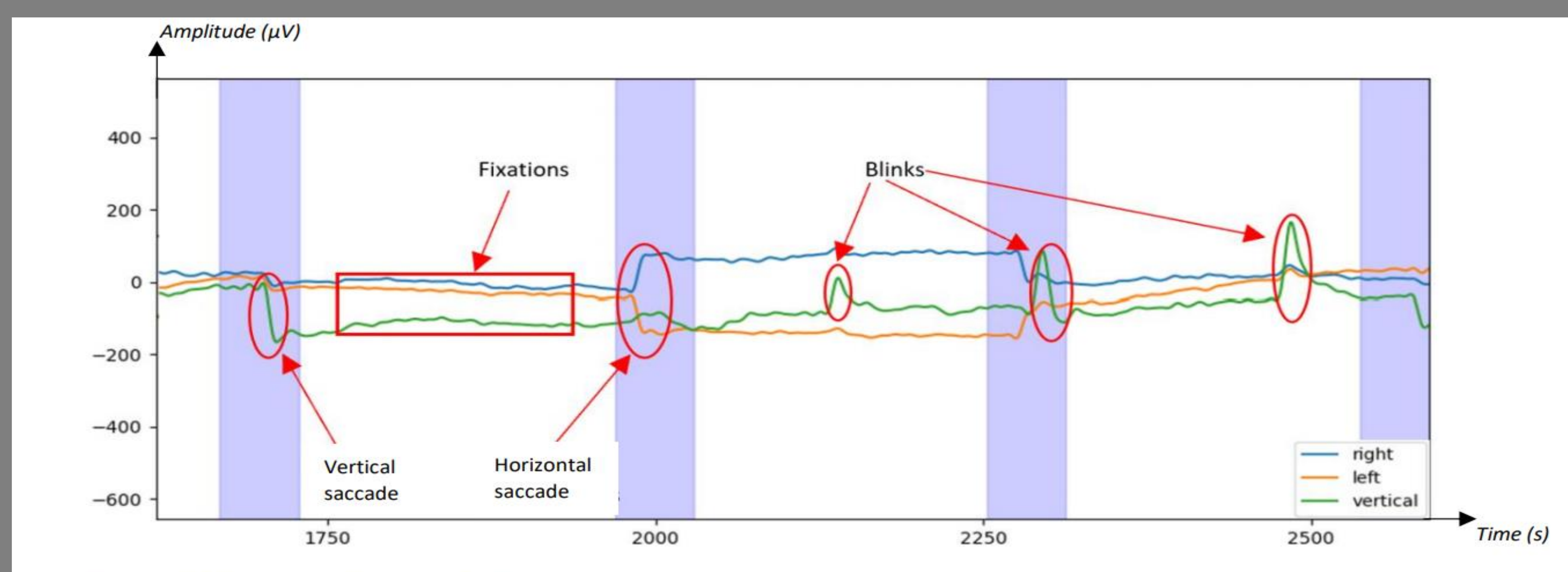

Figure 1. EOG signal. Highlighting of different eye movements.

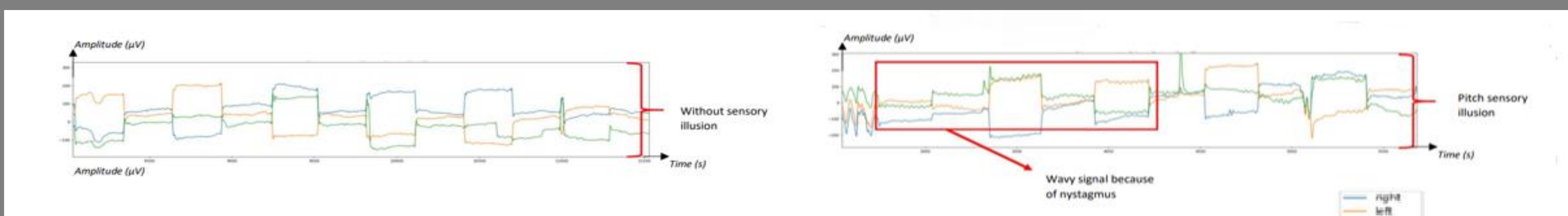

Figure 2. EOG signal. Highlighting of nystagmus during pitch sensory illusion.

Finally, EOG can be a way to detect physiological problems such as fatigue and sensory illusion. The second step was to automate the recognition of different patterns by developing two algorithms, one using wavelet transformation and the second, machine learning. Again, the results are satisfactory (above 90%), but the movements must be large to ensure they can be properly identified. Taken together, these results indicate that the integration of the EOG is not imminent. The system lacks precision in measuring small eye movements. However, if precise detection of the pupil position does not yet seem possible, high amplitude motion results for eye interaction and physiological monitoring (fatigue, syncope, sensory illusions) are promising. The solution will probably come from a composition of sensors (ECG, EEG, etc) and an EOG/eye-tracking alliance. This technology could help in reducing the gap between the human and the aircraft by detecting his limits and encouraging the symbiosis in human-aircraft interactions.

References:

[1] Belkhiria, C., & Peysakhovich, V. (2020). Last decade review of combined EEG-EOG studies and its relevance in aeronautics. Frontiers in Neuroergonomics, 1, 3.
[2] Anderson, I. H. (1937). Studies in the eye movements of good and poor readers. Psychol. Monogr. 48, 1–35. doi: 10.1037/h0093391
[3] Singh, H., and Singh, J. (2012). Human eye tracking and related issues: a review. Int. J. Sci. Res. Publ. 2.
[4] Andreas Bulling, Jamie A. Ward, Hans Gellersen and Gerhard Tro¨ster Eye Movement Analysis for Activity Recognition Using Electrooculography IEEE Transctions on pattern analysis and machine intelligence, VOL. 33, NO. 4, April 2011

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