EEG-validated Camera-based System for detecting the onset of Cognitive Fatigue

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Abstract

The onset of cognitive fatigue is associated with a period of transient, subconscious decrease in maximal cognitive ability, typically influencing decision making. The ability to visually detect this early stage of fatigue can help prevent numerous workplace hazards where top cognitive performance is of utmost importance. In this work, we developed a camera-based system that utilizes visual symptoms of fatigue to estimate its early stage. From a 90-minute long, fatigue-inducing experiment conducted on 4 test subjects, we acquired synchronous camera (visual) and Electroencephalography EEG (brain) data. We extracted eyelids and head-movement related features to train a binary Support Vector Machine classifier to distinguish between Non-Fatigue (early stage) and Fatigue (late stage), achieving test accuracy of 98%. We propose a temporal sliding window technique of using this binary classifier for detecting a gradual change in the level of fatigue. We observed a progressive increment in detection of Fatigue class inside this window as it moves towards the later stages of the experiment timeline. For validation, we compared our models results with fatigue-induced brain signals, namely the alpha band (8-12 Hz) power. Regressing alpha power on camera-based features yielded an average $\hat{r}^2 = 0.6$, while EEG electrodes above fatigue-related brain areas had $\hat{r}^2 = 0.8$. Our results demonstrate promise in terms of using a vision-guided fatigue estimation model for designing a real-time fatigue detection system.