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Online Optimization of Visual Stimuli for Reducing Fatigue in SSVEP-based BCIs

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Introduction: Visual fatigue induced by flickering stimuli has always been a problem to steady state visual evoked potential (SSVEP)-based brain-computer interfaces (BCIs). Some previous studies revealed that different stimulation properties such as frequencies, duty cycles and colors have impact on user's fatigue and performance. Importantly, the stimulation inducing less fatigue usually causes a reduction of system performance [1], and thus to design an optimal visual stimulator for SSVEP-based BCIs, there is a tradeoff between the user's fatigue and performance. Unfortunately, so far most of the visual fatigue evaluation methods relied on subjective self-assessment, which cannot provide real time feedback for the online optimization of visual stimulator. This paper adopted an objective evaluation method based on the electroencephalography (EEG) spectral analysis proposed in [2] in order to reduce the fatigue.

Material, Methods and Results: Five subjects performed a standard SSVEP-based BCI test. During the experiment, three groups of stimuli with different properties were presented as shown in Fig. 1. The stimuli in the group one have different frequencies, the same duty cycle and color. Five indices for fatigue from our previous research [2] and two indices (i.e. SNR and amplitude) for system performance evaluation were calculated in this experiment. The stimuli were valued with scores based on these indices. The stimuli with different frequencies were sorted according to the scores, which determined the optimal frequency of the visual stimuli for the current subject. The same procedure were carried out for group two and group three, so that the optimal duty cycle and color were selected for the subject.
The selected optimal features built optimal stimuli. This optimal stimulus was then displayed, and the indices of which were compared to the indices of the stimuli in three groups. The result showed that the selected optimal stimuli reduced fatigue with system performance preserved for four out of five subjects.

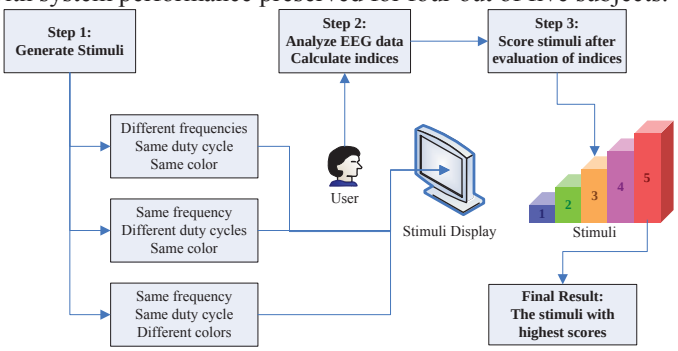

Figure 1. *The procedure of the online optimal SSVEP stimuli design.*

Discussion: One subject out of five did not achieve an improvement of optimal stimuli design. This problem maybe caused by artifacts or it could be a phenomenon such as BCI illiteracy.

Significance: This research proposed an online and automatic tuning for visual stimuli to reduce the fatigue and preserve the performance in using SSVEP-based BCIs. This could be helpful when applying SSVEP-based BCIs to real-life applications.

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