Multi-command Brain-Computer Interface Based on SSVEP

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RECENTLY, brain-computer interface (BCI) based on steady state visual evoked potential (SSVEP) has been an increasing interest owing to its advantages of excellent signal-to-noise ratios, less user-training and high information transfer rate (ITR). The performances of these BCI systems are commonly evaluated by ITR, which depends on number of targets, accuracy, and speed. Furthermore, the system should provide a sufficient number of targets to make the system practical. Various methods tried to increase the number of targets. It is the top number that only reached 16 on a computer screen [1]. In this study, we used a sampled sinusoidal stimulation method [2] to realize 45 targets on LCD.

Stimuli were presented on an LCD screen (Acer 23.6 inch; screen resolution 1920 × 1080 pixels, refresh rate 60 Hz). Matlab and Psychophysics Toolbox Version 3 controlled the stimuli presentation. A total of 45 targets were presented on the screen during the experiment. Each target was flickering at a different frequency. The frequency band of 7-15.8 Hz (with a frequency interval of 0.2 Hz) was selected. The layout of the targets on the screen is shown in Figure 1.

Preliminary offline experiments were conducted within 2 subjects (two females; both age 25 years) to investigate the feasibility of this method and determine the optimal parameters (i.e. optimized channels, length of time window) for the following online studies. Canonical correlation analysis (CCA) mentioned in [3] was adopted in our BCI system. Nine occipital electrode sites (P3, Pz, P4, PO3, POz, PO4, O1, Oz and O2) with strong CCA weights were chosen from 64 electrode sites (according to 10-20 system of electrode placement) and further applied in the proposed online experiments. The accuracies of offline experiments with respect to different length of time window T are shown in Figure 2. Given the trade-off of accuracy and speed, a 2 s time window length was chosen for the online studies. We performed online experiments on 1 subject (one female; ages 26 years) to further investigate whether our BCI system could be used as a practical BCI system. Our online BCI system adopted nine electrode sites mentioned above with a 2 s time window length. A following 0.3 s interval was given to feedback the classification result. The online results revealed classification accuracy of 91 % and information transfer rate of 119 bit/min. The offline and online results confirmed that the SSVEP responses elicited by visual stimuli in a narrow frequency span could be classified with classification accuracy high enough to be applied to practical BCI systems. Future work will focus on collecting more data from more subjects.

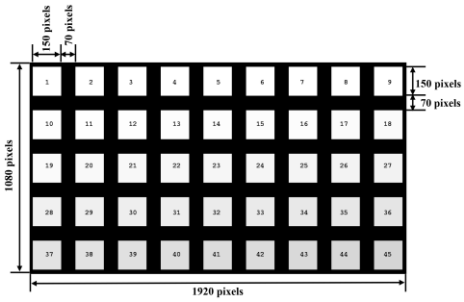

Figure 1. Layout of 45 targets on the screen.

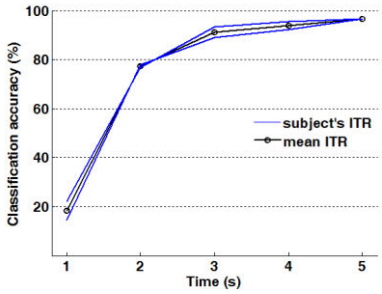

Figure 2. Relationship between accuracy and the length of time window.

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