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# An Online Brain-Computer Interface Using Dynamically Detected Steady-State Visual Evoked Potentials

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*Introduction:* The performance of steady-state visual evoked potential (SSVEP)-based brain-computer interfaces (BCIs) has been considerably improved in the past few years [1, 2]. In conventional SSVEP-based BCIs, the speed of a single target selection is fixed towards high performance based on the analysis of preliminary offline data. However, due to inter-trial variability, the optimal selection time to achieve sufficient accuracy could vary across trials. To optimize the performance of SSVEP-based BCIs, our previous study proposed a dynamic stopping method that can adaptively determine the selection time in each trial by applying the threshold to the probability of detecting a target [3]. This study aims to extend our previous study to demonstrate the feasibility of the dynamic stopping approach in an online BCI system.

*Material, Methods and Results:* This study employs the dynamic stopping method based on a Bayesian approach proposed in our previous study [3] to reduce the average selection time without decreasing the target identification accuracy in online operation. Fig. 1 depicts the diagram of the proposed online BCI system. In the training phase, target identification accuracy for different data lengths was calculated based on the combination method of the canonical correlation analysis (CCA) with individual training data [4] and the filter bank approach [5]. Subject-specific probability density functions of the likelihood for target and non-target feature values were estimated by kernel density estimation with individual optimal data length that led to the highest accuracy. In the online operation, posterior probabilities for target and non-target classes are calculated based on the Bayes' rule with sequentially obtained electroencephalogram (EEG) signals from a data buffer. This process is repeated every 100 ms until the posterior probability of single trial feature values meets the stopping criterion. Here, all of data stored in the buffer are used for feature calculation to maintain the reliability of the probability distribution. Once the posterior probability exceeds a threshold derived from the training phase, target identification is conducted by the aforementioned method and the buffer is flushed.

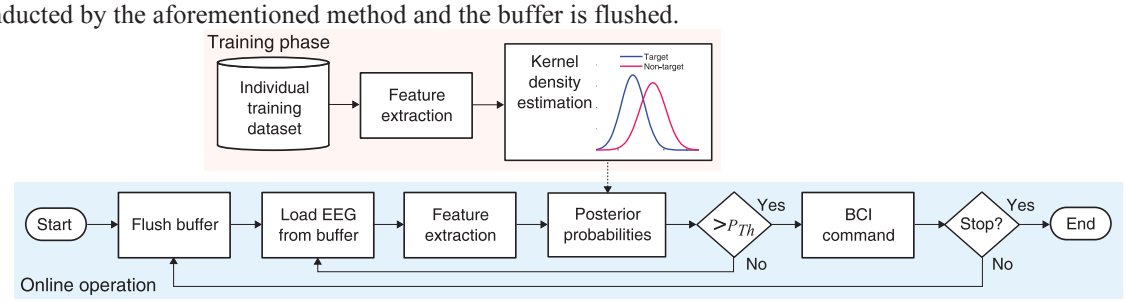


***Figure 1.*** *Diagram of the proposed online SSVEP-based BCI system with the dynamic stopping method.*

*Discussion:* In our previous study, the simulated online experiments showed that the dynamic stopping method could reduce the averaged selection time compared with a conventional fixed stopping method with comparable accuracy [3]. As the result, the simulated online information transfer rate (ITR) with the dynamic stopping method was also significantly higher than that of the fixed stopping method. Based on these results, the proposed system has potential to significantly improve the online performance of SSVEP-based BCIs.

*Significance:* The proposed online SSVEP-based BCI system with the dynamic stopping method has the potential to lead to numerous applications that require high-speed communication for both patients with motor disabilities and healthy people.

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