

# Exploring Recognition Methods for Asynchronous(un-cued) SSVEP-based BCI Speller System

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**Introduction:** Steady state visual evoked potential (SSVEP) is one of the prevalent paradigms to control massive class BCI speller, and there are two control modes in BCI systems such as asynchronous and synchronous systems [1]. There have been studies on the asynchronous system that operates according to the user's intent, and the different methods were used [2, 3, 4]. In this study, to explore in-depth efficacy of recognition method (detecting control state(CS) and non-control states(NS)) in 40-class SSVEP dataset, we tried to do comparative study for three recognition methods such as frequency power, canonical correlation analysis(CCA), and machine learning approach used in SSVEP studies.

**Material, Methods and Results:** 40-class SSVEP data from 40 subjects were collected using BioSemi ActiveTwo in the experiment(6 block×40 class, 2s of NS, 5s of CS). Eleven electrodes (among P1, P2, Pz, PO7, PO3, POz, PO4, PO8, O1, Oz, and O2) were used in this study. Three methods, the relative power of frequency and CCA coefficient, and support vector machine(SVM) using frequency power, were used as user intent detection methods. To determine a threshold and training SVM, a half of the trials are selected. Filter Bank-CCA having the advantage of identifying massive target numbers was applied to classification. The procedure of the asynchronous system is illustrated in Fig. 1.

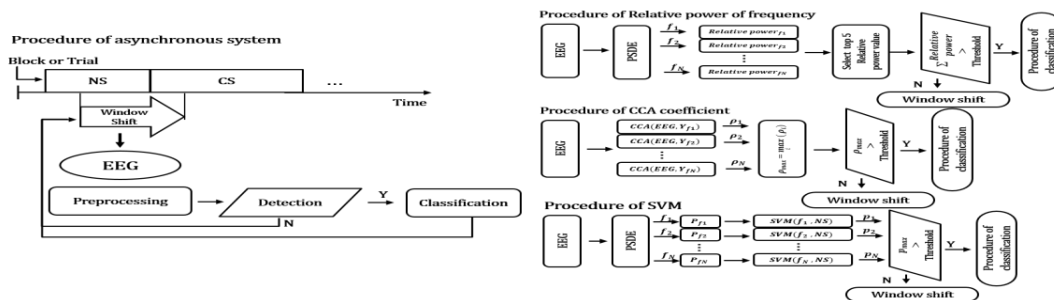


Figure 1. Procedure of asynchronous system and three methods for user intent detection.

It was found that the detection accuracies of CS were CCA ( $97.62 \pm 2.08$ ), frequency power ( $73.94 \pm 23.16$ ) and SVM( $33.67 \pm 19.21$ ). Also, the detection accuracies of NS were CCA ( $76.50 \pm 21.78$ ), frequency power( $33.99 \pm 22.33$ ) and SVM( $80.39 \pm 14.04$ ). Finally, we observed that the classification accuracies were CCA ( $75.55 \pm 10.96$ ), frequency power( $55.64 \pm 17.29$ ) and SVM( $30.93 \pm 20.38$ ).

**Discussion:** The performance of the CCA approach seems an efficient feature of user intent detection and classification. The SVM approach showed high performance in detecting NS, but low CS detection causes a decrease in classification accuracy.

**Significance:** We compared the user intent detection methods to apply a massive class (40-class) SSVEP speller system.

**Acknowledgements:** This study was supported by an IITP grants funded by the Korea government (No.2017-0-00451).

## References

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