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# DEVELOPMENT OF HIGH-SPEED BRAIN COMPUTER INTERFACING TECHNOLOGIES FOR NEUROMODULATION

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## Abstract

Brain-Computer Interface (BCI) has been widely introduced in many medical applications, for example, rehabilitation, prevention, and treatment. One exciting application is implementing BCI in neuromodulation, which is the modulation of nerve activity by delivering electricity directly to a target area. This provides an alternative intervention for severe brain diseases especially spinal cord injury. The concept is to detect one's movement intention to control treatments, e.g., transcranial magnetic stimulation (TMS). According to BCI operation, the most crucial consideration is computation time; however, general computing hardware is not fast enough for those applications. This project focuses on developing signal processing technique for such real -time BCI including system optimization for the best performance at high-speed computation. Electroencephalogram (EEG) and Electromyogram (EMG) acquired from healthy participants indicate a correlation between brain and muscles, namely Corticomuscular Coherence (CMC), which occurs before actual movement is used as a marker of movement intention. An open-access EEG dataset is primarily utilized to verify the effectiveness of the proposed system. Besides, hardware acceleration including graphics processing unit (GPU) and a field-programmable gate array (FPGA) is applied to accelerate signal processing tasks by executing in parallel computation. The system performance is evaluated regarding latency, sensitivity, and specificity. Time-frequency analysis was first implemented into an archived dataset for the feasibility study of implementing the proposed signal processing in real-time BCI. The preliminary result suggests the likelihood of employing a sophisticated algorithm to identify a movement intention. Furthermore, using hardware acceleration for signal processing resulted in a significant difference in computation time.

*Keywords: Brain-computer interface (BCI), Neuromodulation, Electroencephalogram (EEG), Corticomuscular coherence (CMC), high-performance computing*

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