A Basic Study on Measurement and Analysis of Multi-channel Brain Potentials for Voluntary Body Movement Detection

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ABSTRACT

Brain-Computer Interface (BCI) is a technology that enables the input and output of information with the outside world using electrical bio-signals generated by the brain, without involving the sensory organs or other physical bodies. There are two types of BCIs: input and output. Input-type BCIs refer to the input of information via the brain, while output-type BCIs, by their nature, don't rely on muscles and sensory organs, allowing direct operation of external devices like computers through the brain. This holds potential to assist individuals facing challenges in limb movement, such as those with paralysis, amputations, or conditions like ALS.

This study focused on a non-invasive BCI, eliminating the need for surgery. Non-invasive BCIs primarily use electroencephalogram (EEG) signals, which vary based on brain activity and functional localization. Among these, μ-waves exhibit changes in amplitude before and after movement, and event-related desynchronization (ERD), a characteristic amplitude decrease, occurs not only during actual movement but also during mental imagery, making it accessible for individuals with limited physical mobility. However, challenges include accurately detecting signal information, extracting motor thoughts in multiple scenarios, and eliminating noise and background EEG interference during measurement.

Previous research identified potential in discriminating between hand and leg movements and left and right hand movements. However, issues arose, including the need to increase the number of subjects and data, as well as improving measurement accuracy. In this experiment, five levels of intensity and load (10 kg, 15 kg, 20 kg, 25 kg, and 30 kg) were set for right-hand grasping exercises, which hadn't been clearly defined before. EEG was measured under various intensity conditions, and analysis revealed μ-waves and ERD, characteristic EEG features during exercise, with different ERD frequencies observed based on the trial.

C3-Cz electrode positions were identified as reflecting the motor state more prominently, providing stable EEG measurements. While no clear trend in ERD detection frequency proportional to exercise intensity was observed, there was a slight tendency for ERD detection frequency to differ between weak and strong exercise, suggesting the potential for broad exercise intensity discrimination. Focusing on 10 kg (weak exercise) and 30 kg (strong exercise) trials in multiple subjects, ERD was slightly more predominant in 10 kg trials compared to 30 kg trials. Further data collection on an individual basis is crucial to address potential individual differences.