Chapter 7
An Automatic Approach to Control Wheelchair Movement for Rehabilitation Using Electroencephalogram

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ABSTRACT

Modern science and technology development enables humans to control devices using their brains. brain computer interface (BCI) system using EEG (Electroencephalogram) is a non-invasive method that uses brain signals to control robots. Brain control robots can assist people with disabilities to improve their livelihood. In our proposed work to control wheelchair movement for rehabilitation using EEG, electrodes are first placed on the subject's scalp to acquire brain signal activity. After that, the signals got filtered using fast fourier transformation (FFT) method, and then features got extracted using power spectral density (PSD). Random forest is used for the classification of wheelchair movement. For this purpose, a publicly available dataset from Kaggle is used, and an average accuracy of 96.79 is achieved. The proposed architecture has outperformed all the existing ones in its concerned domain; thus, it is suitable, cost-effective, and flexible for the users, which also helps maintain user privacy.

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INTRODUCTION

A spinal cord injury can cause a person to lose control over his motor control function. In addition to lower limbs, this injury can also affect the upper limb. Brain-computer interfaces (BCI) and robotic machines can be very helpful for people with this type of injury. Robotics can also improve the life of a normal human being. Communication within our body is done using electrical signals. BCI system enables humans to communicate with associated devices. BCI can be very useful for patients with critical injury and rehabilitation. They can regain their ability using robotics.

Electroencephalography (EEG) measures electrical activity within our brain. The EEG is used to study electrical activity in our brain to diagnose neurological states and different disorders like head injury, epilepsy, sleep disorder, brain tumor (Li et al., 2016), etc. EEG is widely used in medical science. There are two methods to record EEG signals, invasive and non-invasive. An EEG-based BCI system uses a non-invasive method to record EEG signals for communication with the machine. This technology is vital for people with disabilities. Robotic movement is possible using EEG-based BCI, where disabled people do not have to rely on someone every time. Also, BCI technology has various applications in education, neuromarketing, advertising, and games. The mostly used EEG-based BCI technologies are steady-state visually evoked potentials, P300, event-related desynchronization, and event-related synchronization (Lazarou et al., 2018). Data acquired through EEG-based BCI can further be classified using different types of machine learning methods to classify different actions of the user.

Our work aims to develop a classification scheme for wheelchair movement. For our work, we have used EEG data for hand movement of persons belonging to different age groups from Kaggle. The EEG signal is passed through Fast Fourier Transformation (FFT) at preprocessing step to acquire the desired frequency range. Then, Power Spectral Density is used to get features from that signal. Then, a random Forest algorithm is used to classify this movement. Hyperparameter tuning has been performed to identify the best combination of parameter values of the classifier, and the outcome has also been compared with the other existing classifiers. The applicability of the proposed approach in controlling wheelchair movement for real-time rehabilitation purposes has been checked by evaluating its performance based on accuracy, precision, recall, and error rate metrics (M & M.N, 2015). It is also effective in terms of robustness, computational time, and reliability.

The chapter outline is structured like the following. First, the related works section has described the related works in this domain, and their benefits and shortcomings have also been analyzed. Second, the proposed methodology section has presented the working mechanism of different steps followed in our proposed framework. Third, the experimental result and performance evaluation have been discussed in the experimental outcome session. Finally, the concluding statements and possible future directions have been discussed in the conclusion section.

RELATED WORKS

Various researchers have researched our proposed framework (Ghosh & Saha, 2020; Saha & Ghosh, 2019). Here we have discussed some of the related works. Edla et al. (2018) use Neurosky Mindwave mobile as an EEG recording device. It is a non-invasive device that connects wirelessly with a computer or mobile using Bluetooth. This device consists of two electrodes placed on the forehead at the Fp1 location according to the 10-20 system and clip-on-ear as a reference electrode, respectively. They intend to

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