Chapter 13
Motor Imagery Classification Using EEG Signals for Brain–Computer Interface Applications

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ABSTRACT

In this chapter, a nearest neighbor (k-NN)-based method for efficient classification of motor imagery using EEG for brain-computer interfacing (BCI) applications has been proposed. Electroencephalogram (EEG) signals are obtained from multiple channels from brain. These EEG signals are taken as input features and given to the k-NN-based classifier to classify motor imagery. More specifically, the chapter gives an outline of the Berlin brain-computer interface that can be operated with minimal subject change. All the design and simulation works are carried out with MATLAB software. k-NN-based classifier is trained with data from continuous signals of EEG channels. After the network is trained, it is tested with various test cases. Performance of the network is checked in terms of percentage accuracy, which is found to be 99.25%. The result suggested that the proposed method is accurate for BCI applications.

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INTRODUCTION

Until now, health research in developing countries like India has focused on highly pervasive infectious diseases and malnutrition. But, it is becoming increasingly important to study brain disorders as well, says an international team of neuroscientist. Types of brain imaging techniques prevalent now are fMRI, CT, PET, EEG etc. EEG is used to show brain activity in certain psychological states, such as alertness or drowsiness. It is useful in the diagnosis of seizures and other medical problems that involve an overabundance or lack of activity in certain parts of the brain. It can also be used for brain computer interface applications mostly helpful for paralyzed persons. Various methods have been suggested for motor imagery classification some of which are discussed below.

In Qin, Ding, and He (2005), source analysis methods such as dipole localization and cortical imaging have been applied to classification of motor imagery tasks for BCI applications. A combination of source analysis approach with signal pre-processing for classification of motor imagery tasks has been used which has classification rate of about 80%. In Sitaram et al. (2007), multichannel near-infrared spectroscopy (NIR) is studied for the development of BCI. Support vector machines (SVM) and hidden Markov model (HMM) are the pattern recognition algorithms which are used here for classification purpose. The result shows that the classification of left-hand imagery from right-hand imagery is done by SVM with an average accuracy of 73%. In Leuthardt, Schalk, Wolpaw, Ojemann, and Moran (2004), it has been shown that electrocorticographic (ECoG) based BCI is better than electroencephalographic (EEG) based BCI. It discusses that EEG based BCI works from the scalp or a single-neuron activity from within the brain is used. But both methods have disadvantages as EEG is inefficient and needs extensive training whereas the method involving single neuron can cause clinical risks.

In Wairagkar (2014), non linear artificial neural network (ANN) classifiers are combined with the signal processing techniques for classifying motor imagery for BCI. The communication with external devices such as computers can be done directly by brain with the help of BCI without using any motor pathways. The classification of the rest state, the right hand imagery and the left hand imagery could be done by BCI by using artificial neural network. Various features are classified into two classes using the non-liner radial basis function based (ANN) classifiers. The result for classifying imaginary hand movements of 16 different subjects shows 80% accuracy. In Batres-Mendoza et al. (2017), one of the most important phases in systems using BCI devices has been discussed which is feature extraction. Quaternion-based signal analysis (QSA) has been presented in this work with improved version called iQSA method. It is used in EEG signal feature extraction for real time which involves mental tasks using motor imagery. The results for QSA shows 3.31% to 40.82% without sampling window and from 33.44% to 41.07% with sampling window. iQSA method has 82.3% accuracy rate for 0.5 s sample and 73.16% accuracy rate for 3s sample.

In Millán, Renkens, Mouriño, and Gerstner (2003), a method had been proposed based on the recent experiments which show that the movement of robotics and prosthetic devices can be controlled by the use of brain electrical activity. A portable non-invasive BCI has been used which can control a mobile robot in home like environment. Advanced robotics, protocol for the analysis of online EEG signal and machine learning algorithms to report first results of a brain-actuated mobile robot by means of a portable non-invasive BCI. Various classification algorithms used to design BCI systems based on EEG are reviewed in Lotte, Congedo, Lsecuyer, Lamarche, and Arnaldi (2007) which focus on five different