Chapter 5

EEG Feature Extraction and Pattern Classification Based on Motor Imagery in Brain–Computer Interface

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ABSTRACT

Accurate classification of EEG left and right hand motor imagery is an important issue in brain-computer interface. Firstly, discrete wavelet transform method was used to decompose the average power of C3 electrode and C4 electrode in left-right hands imagery movement during some periods of time. The reconstructed signal of approximation coefficient A6 on the sixth level was selected to build up a feature signal. Secondly, the performances by Fisher Linear Discriminant Analysis with two different threshold calculation ways and Support Vector Machine methods were compared. The final classification results showed that false classification rate by Support Vector Machine was lower and gained an ideal classification results.

INTRODUCTION

Brain-computer interface (BCI) is a communication system by which a person can send messages without any use of peripheral nerves and muscles (Wolpaw et al., 2002; Vuckovic, 2009; Schalk et al., 2008; Waldert et al., 2009). The technology holds great promise for people who can’t use their arms or hands normally because they have had the damaged region, such as amyotrophic lateral sclerosis (ALS) (Sellers et al., 2006; Iversen et al., 2008), spinal cord injury (Müller-Putz et al., 2005), brainstem stroke (Sitaram et al., 2007), or
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quadriplegic patients (Hoffmann et al. 2008). BCI system, by extracting signals directly from the brain, might help to restore abilities to patients who have lost sensory or motor function because of their disabilities (Blankertz et al., 2010; Guger et al., 2009). In fact, BCI is used as a surrogate for the people who are disabled, in the case of a neuromotor prosthesis, acts to interpret brain signals and drive the appropriate effectors (e.g., muscles or a robotic arm) (Hoffmann et al., 2008; Lee et al., 2009). So, it has great social value and application prospect. As an interdisciplinary technology, BCI has become a research hotspot of brain cognition research, rehabilitation engineering, biomedical engineering, automatic human-machine control, and so on.

A number of groups around the world are developing BCI systems, in which surface electroencephalography (EEG) is used because it is noninvasive and mobile (Li et al., 2010; Yamawaki et al., 2006). The cognitive task most commonly used in BCI studies is motor imagery, as it produces changes in EEG that occur naturally in movement planning and are relatively straightforward to detect. Motor imagery, defined as mental simulation of a kinesthetic movement (Jeannerod et al., 1999), has been well established that the imagination of each left and right hand movement results in event-related desynchronization (ERD) of mu-band power in the contralateral sensorimotor areas, which is also the case for physical hand movements (Pfurtscheller et al., 2001). Brain activities modulated by motor imagery of either the left or right hand are regarded as good features for BCIs, because such activities are readily reproducible and show consistent EEG patterns on the sensorimotor cortical areas (Hollinger et al., 1999). Moreover, thanks to the contralateral localization of the oscillatory activity, the activities evoked from left and right hand motor imagery are, comparatively, readily discriminated (Ince et al., 2006; Kamousi et al., 2007). The signals generated in the motor cortex can be recorded from electrodes over central head regions and the research has produced encouraging results (Ramsey et al., 2006; Pfurtschelle et al., 2010; Hwang et al., 2009). The aim is to train subjects to control the cursor automatically by using the operant conditioning approach (Li et al., 2010).

Many methods have been proposed to BCI in the past few years (Sitaram et al., 2007; Hoffmann et al., 2008; Blankertz et al., 2010; Li et al., 2010; Yamawaki et al., 2006; Pfurtscheller et al., 2010; Hwang et al., 2009; Ince et al., 2006). As a classifier, linear discriminant analysis (LDA), support vector machine (SVM) and neural network were used (Garrett et al., 2003; Gysels et al., 2005; Kayikcioglu et al., 2010). Recursive least squares and LDA algorithms were used to aim at classify left- or right-hand movement (Garrett et al., 2001). During mental imagination of specific movements, the adaptive multiple regressions where the result EEG recorded from the sensorimotor cortex were classified on-line and were used for cursor control (McFarland et al., 2005). Due to the high-dimensional and artificial noise (e.g., eyes blinks) of the EEG signals, the nonlinear classification methods are better than the linear ones (Garrett et al., 2003). Therefore, we will use the nonlinear methods to classify the high-dimensional and artificial noisy EEG signals.

EEG Feature extraction and pattern classification is always a difficult problem during the BCI study. In this paper, we propose a method to classify the EEG of mental tasks for left-hand movement imagination and right-hand movement imagination. The goal of this study was to prove the viability of a movement imagery prediction brain-computer interface (BCI), and to expect that the two mental tasks can be classified with higher classification rate. Firstly, a rational time window was set by calculating the average power of C3 electrode and C4 electrode in left-right hands imagery movement. The time window’s average power was then decomposed by discrete wavelet transform (DWT). The reconstructed signal of approximation coefficient A6 on the sixth level was selected to build up a feature signal. Secondly,