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A Novel Brain Computer Interface Based on Principle Component Analysis

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Abstract

The main issue to build applicable Brain-Computer Interfaces is the capability to classify the Electroencephalograms (EEG). During the last decade, researchers developed lots of interests in this field. The purpose behind this research is to improve a model for EEG signals analysis. The purpose behind this research is to improve a model for brain signals analysis. We have used high pass filter to remove artifacts, discrete wavelet transform algorithms for feature extraction and statistical features like Mean Absolute Value, Root Mean Square, and Simple Square Integral are used, also we have used principle component analysis to reduce the size of feature vector. It has been depicted from results that the proposed integrated techniques outperform a better performance than methods mentioned in literature.

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1. Introduction

Brain-Computer Interface (BCI) is a developing research field attracting researchers worldwide. BCI provided a new communication channel that allows a person to send commands to an electronic device using his/her brain activities[1]. Electronic devices control by severely handicapped patients with brain diseases, such as epilepsy, dementia and sleeping disorders [2] is the main target of BCI systems. According to Brain Computer Interface definition, it should be able to detect human objectives and translate them to the computer where suitable actions

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take place.

BCI systems can be classified as an invasive or non-invasive BCI, according to the way of used by BCI system to measure brain activity. If the sensors used for measurement are placed within the brain, within the skull for example, the BCI system is classified as invasive BCI. But, if the sensors used for measurement are placed outside the head, on the scalp for example, the BCI system is classified as non-invasive BCI.[2]The advantage of non-invasive BCI systems over invasive systems is that they avoid health risks and associated ethical concerns. In case of normal personnel, it is obvious that invasive methods are not the optimum choice[1, 3].

Typically, BCI system is composed of several components: brain signals, signal acquisition, signal processing, application operation and feedback presentation. Human objectives modulate electrical brain signals which are detected and recorded by signal acquisition and then filtered by signal pre-processing. The signal processing step includes processes such as feature extraction and classification, and subsequently the analysis of captured signals, and then it provides corresponding instructions to appropriate devices. During the operation of these devices, some feedback may be returned to the user(s). Technically, BCI system can be divided into four major components (1) signal acquisition, (2) feature extraction, (3) feature translation, and (4) device output. These four components are controlled by an operating protocol that defines the onset and timing of operation, signal processing details, device commands nature, and performance inaccuracy. Efficient operating protocol allows a BCI system to be flexible and to serve the particular needs of each user.

EEG measures electric brain activity based on electric currents produced during synaptic excitations of the neurons dendrites and is extremely sensitive to the secondary currents properties. EEG recording system is composed of electrodes, amplifiers, A/D converter, and a recording device. The electrodes acquire the signal from the scalp, then the amplifiers process the analog signal to enlarge the amplitude of the EEG signals so that A/D converter can digitize the signal in a more accurate way. Finally, the recording device, which may be a personal computer or similar, stores, and displays the data.

The electrodes are used to record EEG signals. The electrodes placed over the scalp are commonly based on the International 10–20 system, which has been standardized by the American Electroencephalographic Society. The 10–20 system uses two reference points in the head to define the electrode location. One of these reference points is the nasion, located at the top of the nose at the same level of the eyes. The other reference point is the inion, which is found in the bony lump at the base of the skull. The transverse and median planes divide the skull from these two points. The locations of the electrodes are determined by marking these planes at intervals of 10% and 20%.

The remaining part of the paper is organized as follows. Preliminaries are discussed in section (2). Section (3) presents the proposed model. Experimental results are discussed in section (4). Finally, the paper conclusion is in section (5).

2. Preliminaries

2.1. Wavelet Transform

Wavelet transform is a technique which function is known as decomposition of an input signal of interest into a group of elementary waveforms, these elementary waveforms are called "wavelets", additionally it gives an approach to analyze the signal by examining the coefficients (or weights) of these wavelets. A time-frequency method like wavelet transform gives a perfect approach for analyzing non-stationary signals like EEG. Coefficients are Ca1 that is the approximation coefficient and Cd1 is the detail coefficient at first level of signal decomposition. It is important to select the appropriate wavelet and the number of levels of decomposition for analysis of signals using DWT. In light of the dominant frequency component of the signal the number of levels of decomposition is chosen. The levels are chosen in a way that those parts of the signal that correlate in a good way with the frequencies necessary for classification of the signal are retained in the wavelet coefficients. [4]