Biocybernetics and Biomedical Engineering
2013, Volume 33, Number 1, pp. 3–20

Comparison of Performance of Different Feature Extraction Methods in Detection of P300

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The aim of this paper is to design a pattern recognition based system to detect the P300 component in the EEG trials. This system has two main blocks, feature extraction and classification. In the feature extraction block, in addition to morphological features, some new features including intelligent segmentation, common spatial pattern (CSP) and combined features (CSP + Segmentation) have also been used. Two criteria were used for the feature evaluation. Firstly, a t-test has been applied. Secondly, each of these four groups of features was evaluated by a Linear Discriminant Analysis (LDA) classifier. Afterwards, the best set of features was selected by using Stepwise Linear Discriminant Analysis (SWLDA). In the classification phase, the LDA was used as a linear classifier. The algorithm described here was tested with dataset II from the BCI competition 2005. In this research, the best result for the P300 detection was 97.4% .This result has proven to be more accurate than the results of previous works carried out in this filed.

K e y w o r d s: P300, brain computer interface (BCI), pattern recognition, feature extraction, classification

1. Introduction

Brain computer interface (BCI) is a system that creates a direct channel between computer and the brain. Among various BCI systems, electroencephalography (EEG) is still the most common method because of its non-invasive nature. By analyzing the electroencephalographic activities recorded from the scalp, a computer can recognize the brain's intention and translate it to commands for output devices such as a computer application or a neuroprothesis.

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Received 04 April 2012; accepted 11 September 2012

Infrequent or particularly significant auditory, visual, or somatosensory stimuli, when interspersed with frequent or routine stimuli, typically evoke a positive peak at about 300 ms in the EEG over parietal cortex. Donchin and his colleagues have used this 'P300' or 'oddball' response in a BCI [1]. Inbar used the P300 component for communication between the brain and computer. The BCI developed in his work was based on the BCI described by Farwell and Donchin in 1988, which allows a subject to communicate one of 36 symbols presented on a 6 × 6 matrix [2].

A P300-based BCI has an apparent advantage in that it requires no initial user training: the P300 is a typical or naive response to a desired choice.

The P300 speller paradigm is a kind of BCI which uses the P300 potential to spell the intended character of the user. The BCI Competition is a competition that is held every two years since 2000 and the P300 speller system is one of its parts**.** The P300 speller paradigm used to produce the dataset IIb of the BCI Competition 2003 and the dataset II of the BCI Competition 2005 is basically the same as that of Farwell and Donchin's [3].

Since that time**,** many research groups and investigators in this line of research have worked on the P300 Speller system. For example Sellers' group have carried out several studies and examined the effect of some cases such as the P300-Speller matrix size, expanding the classical P300 feature space, the performance of different linear and nonlinear classifiers on the BCI system accuracy [4, 5]. In their latest research, this group has tried to make changes in the stimulus paradigm to reduce the probability of error in the P300 detection [6].

Seyyedsalehi in 2008 [7] used a feature set as inputs into committee machines (CM) based on the LDA, MLP and SVM. This algorithm achieved an accuracy of 94% in the P300 detection.

Rakotomamonjy and Guigue proposed a method that detects the P300 through an ensemble of classifiers approach. Each classifier is composed of a linear support vector machine trained on a small part of the available data for which a channel selection procedure has been performed. Performance of their algorithm has been evaluated on the dataset II of the BCI Competition III and has yielded the best performance (96.5% accuracy) in the competition [8].

In 2009 Salvaris [9] tried to introduce a novel classification method included discrete-wavelet transform (DWT) preprocessing and an ensemble of Fisher's Linear Discriminants for classification. The performance of the proposed method was slightly worse than the state of the art method for the BCI competition III data sets. But the proposed method was far less computationally expensive than the current state of the art method. The best accuracy that he could achieve was 95% on the dataset II of the BCI Competition III.

In this paper a pattern recognition system depicted in Fig.1 is used for detection of the P300 component. In this study, emphasis is on the feature extraction block. Thus, taking into account priori Neurophysiologic knowledge and different available processing methods, we decide to extract features through some new and suitable

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