Measurement 101 (2017) 45–52

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

A study on the effect of psychophysiological signal features on classification methods

Erdem Erkan *, Ismail Kurnaz

Computer Engineering Department, Karabuk University, Karabuk, Turkey

ARTICLE INFO

Article history:
Received 26 April 2016
Received in revised form 9 January 2017
Accepted 11 January 2017
Available online 16 January 2017

Keywords:
ECoG
Discrete Wavelet Transform (DWT)
Classification

ABSTRACT

The most important factor affecting the performance of a BCI (Brain Computer Interface) systems, is classification feature set. Choosing the right features to increase the success of classification is the key point. In BCI systems, signals from brain are used to store into dataset. In this study, BCI Competition III dataset 1 consisting of ECoG (Electrocorticography) signals is preferred. In the first part, in order to decrease the processing load, the number of channels are reduced by eliminating channels (electrodes) which have low separation success. We developed new algorithm ADA (Arc Detection Algorithm) based on visual channel selection to determine quickly optimal channel subset. Than obtained Wavelet coefficients by Discrete Wavelet Transform (DWT) and determined classification features from Wavelet coefficients. These features are used to classify by KNN (K Nearest Neighbors), SVM (Support Vector Machine) and LDA (Linear Discriminant Analysis) by different feature set combination. The classification successes of feature combinations which are used in classification are compared. The impact on the classification performance of the right channel and the right property choice is observed. Test results are made with different frequency bands are compared with the same feature set. As a result, the highest classification accuracy of 95% was obtained by selected channels and feature.

1. Introduction

Nowadays, with the rapid improvement of biomedical and machine learning technology, the investigate of biological signals has become an important research area. Researchers have been studying to understand and classify biological signals for better diagnose diseases, developing assistive Technologies and help to humanity in various fields [1]. Electroencephalography (EEG) and electrocorti-cography (ECoG) are the most common signal types used in brain computer interface (BCI) systems. These signals are generated by the firing of many neurons in the brain.While obtaining the EEG signal more easily and securely, then higher resolution ECoG signal is more difficult and risky, which are generated by same neuron activity [2]. Obtaining both signals is shown in Fig. 1.

We used Dataset 1 which obtained from BCI Competition III. In this competition, participants try to find correct classify of test data by using the training data. Qingguo Wei and his team from Tsinghua University demonstrated the highest classification success in the competition among 27 participants with 91% accuracy rate [3]. They determined optimal channel subset by genetic algorithm then power features are extracted by common spatial pattern (CSP) and they was used Fisher discriminant analysis (FDA) for classification [4]. Paul Hammon, was second in the competition by 87% accuracy rate. Hammon and Virginia, by ECoG signals to 250 Hz sub-sampling, tried to shorten the processing time in another study. They have choosed the 8–45 Hz frequency band and used SVM and Logistic Regression for classification [5]. Demirer and his friends used channel selection method based on Tsallis entropy in Hilbert domain and the nonlinear classification of motor imagery with SVM for this dataset. They achieved 95% and 73% classification accuracy with training and test datasets respectively [6]. Yang and others used this dataset in their study. They have applied an artificial neural networks (ANN) based method, the genetic neural mathematic method, to two EEG channel selection and classification. They obtained 90% and 80% classification accuracy with training and test datasets respectively [7]. Ma and his friends used the marginalized DWT coefficients in the ECoG signal classification. They used super Dirichlet distribution based classifier in their study. They used Fisher ratio and error estimation methods for channel selection [8]. In this study, a series of tests were made to show the effect on different channels and signal features on classification method, the results have been presented comparatively. In

* Corresponding author.
E-mail addresses: erdemerkan@bartin.edu.tr (E. Erkan), ikurnaz@karabuk.edu.tr (I. Kurnaz).

http://dx.doi.org/10.1016/j.measurement.2017.01.019
0263-2241/

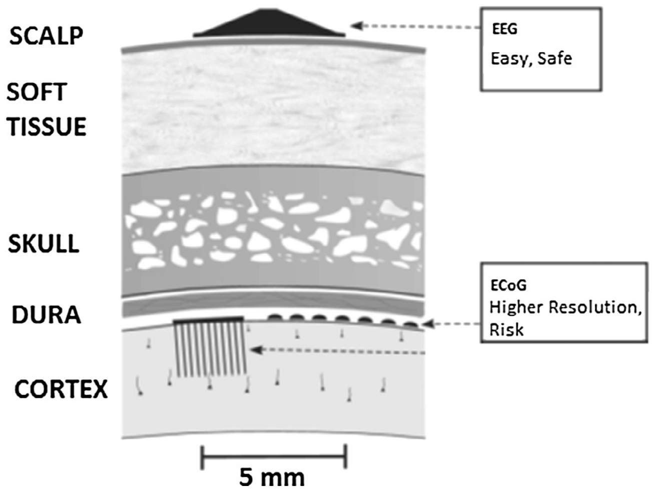

Fig. 1. Obtaining EEG and ECoG signals [2].

order to get the highest classification success, it was tried to determinate optimal channel subset and features. We developed an algorithm which name is ADA base on visual channel selection to fast detecting optimal channel subset. As a result, the highest classification accuracy of 95% was obtained by our channel subset and feature set above the literature.

2. Materials and methods

2.1. Dataset

The offline dataset called Dataset 1 used in this study are two-class datasets obtained from BCI Competition III on 2005. The data are collected from one subjects at multiple sessions including several trials each. Dataset was recorded by using 64 electrodes. During the experiment, a subject had to perform imagined movements of either the left small finger or the tongue. The time series of the electrical brain activity was picked up during these trials using a 8×8 ECoG platinum electrode grid which was placed on the contralateral (right) motor cortex. All recordings were performed with a sampling rate of 1000 Hz. Every trial consisted of either an imagined tongue or an imagined finger movement and was recorded for 3 s duration. Training dataset consists total 278 labelled data which are separated 139 tongue and 139 finger class [3].

2.2. Channel selection

The common spatial pattern (CSP) algorithm is used for channel selection, by the selecting channels directly according to their CSP coefficients [9]. Beside the CSP, channels can be determined by looking at time and frequency spectrums of channels [10]. In this study, we were preferred two different channel selection method. One of them is ADA which based on visual channel selection and statistical. Other is generalization error estimation approach. Sensory motor rhythms have a shape like a arc about 10 Hz [11]. The shape was determined by ADA in the frequency spectrum of numbered channel 12, 21, 29, 30, 37, 38, 39, especially range of frequency band 8–10 Hz. ADA algorithm was developed to faster detect the arc shape than visual channel selection. To achieve that, brain signals are scaled by 0–1 range and pick points are found, after that channels include arc form are found by using geometric relationship (such as point height and their distance from each other) between pick points and middle points in this picks by ADA.The performance of the channel subset can also be estimated by the generalization error with cross validation [8]. We calculated the cross validation for two, three and four element channel subset, by training a KNN based classifier with the labeled training set.

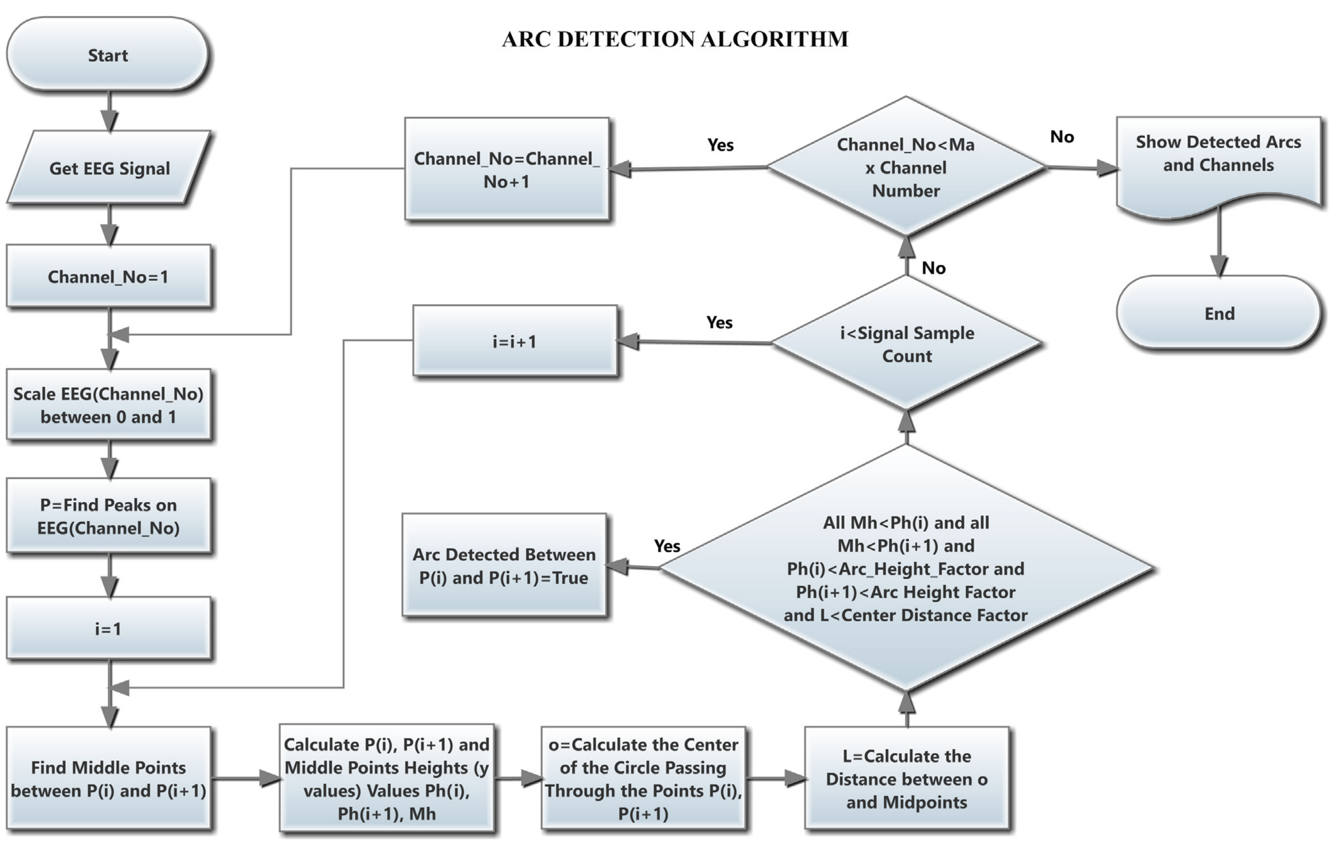

Fig. 2. ADA algorithm flow diagram.