

A new method of feature extraction from EEG signal for brain-computer interface design

Streszczenie. W artykule przedstawiono opracowaną przez autorów nową metodę ekstrakcji cech z sygnału EEG na użytek interfejsów mózg-komputer (BCI). W opracowanych algorytmach ekstrakcji cech wykorzystano transformację falkową oraz statystyki wyższych rzędów. Przedstawiono wyniki badań związanych z wykorzystaniem proponowanych metod ekstrakcji cech do konstrukcji interfejsu mózg-komputer działającego w oparciu o wyobrażanie sobie ruchu. Eksperymenty przeprowadzono przy użyciu dwóch elektrod (**Nowa metoda ekstrakcji cech sygnału EEG na użytek interfejsów mózg-komputer**).

Abstract. The main aim of the article is to introduce a new method of feature extraction from EEG signal for brain-computer interface design. The proposed algorithms are based on wavelet transform and higher order statistics (HOS). Next authors present the research results for brain-computer interface design using motion imagining. Proposed feature extraction methods are implemented in construction of the interface. Experiments are conducted with use of two electrodes ().

Słowa kluczowe: BCI, interfejs mózg-komputer, EEG, ekstrakcja cech, transformata falkowa, statystyki wyższych rzędów

Keywords: BCI, brain-computer interface, EEG, feature extraction, wavelets, higher order statistics

Introduction

In recent years, we can observe a growing interest in brain-computer interfaces (BCI) [3]. The main advantage of the communication between brain and computer is its "directness". The brain activity is processed into information understandable by a computer omitting all indirect factors such as muscles. The application of BCI is primarily to allow contact with paralyzed people. Brain-computer interfaces can also be used in entertainment and for military purposes. At present the main factors that restrict the wider use of brain-computer interfaces are: problems with acquisition of EEG signals and low speed of information conveyed by brain-computer technology [1,2].

Although there are many ways of the brain activity examination, the most widely used is electroencephalography (EEG). To enable brain-computer interface construction an efficient method of feature extraction from EEG signal is needed. In the article authors propose a feature extraction method based on higher order statistics calculated for the details of discrete wavelet transform (DWT) of EEG signal. Next some popular classifiers have been implemented and the results compared. The aim of the research is to check whether the efficient brain-computer interface can be built using only 2 channels of EEG signal. Limiting the number of electrodes is supposed to simplify the use of the interface and reduce the cost of the EEG signal amplifier. This would also facilitate the analysis, processing and classification of signals.

BCI systems

The current brain-computer interfaces are based on the EEG signals collected from 32 or more electrodes placed on scalp surface [3,4].

One of the key advantage of using EEG is the ability to observe brain activity at the time of occurrence of a specific events. Other methods, such as tomography, functional Magnetic Resonance Imaging (fMRI) enable more accurate location of increased brain activity, but require a relatively long time, and many complex calculations.

Acquisition of EEG signal is quite a complex process. Amplitudes of signals collected from the electrodes, placed on the head are measured in just microvolts. So at first, many different disturbances, that manifest themselves as artifacts, have to be eliminated. There are two kinds of artifacts: physiological and technical. Physiological artifacts are bioelectrical signals from muscle activity, for example movements of limbs, tongue, forehead wrinkling, etc. Technical artifacts are all kinds of flaws associated with the

measurement technique and the presence of electric power frequency noise induced on the skin, in the elements of electrodes, wires and in the amplifier circuits.

EEG signal changes according to the brain activity states. Depending on these states, we can distinguish several rhythms (waves). The gamma rhythm (above 40 Hz) is associated with mental activity, perception, problem solving, awareness. The beta waves (12 Hz to approximately 28 Hz) occur during daily activities, anxiety, and under the influence of certain drugs. The alpha waves (from 8 to 13 Hz) are typical for state of relaxation, especially with closed eyes. The theta waves (4-7 Hz) occur during deep meditation, intense dreams, intense emotions. The delta waves (from about 0.5 to 3 Hz) occur during a deep sleep, are also typical for young children and for certain types of brain damage.

There are several methods of using EEG signal for brain-computer interface design. However, the most interesting and most difficult idea is to apply the imagining of movement by a human for machine control, the so-called brain potentials associated with movement [5,6]. An additional difficulty is that the imagining of motion can occur at any time (asynchronous BCI interface). During the reading of movement imagining effects the fact is used that different parts of cortex are responsible for activity of individual muscles. The brain activity is very similar during imagining of movement and the execution of the same movement. As it was already mentioned, current BCI systems based on the idea of a movement imagining use multichannel EEG signal acquired from 32, or more electrodes. Authors intention is to build such an interface using only two channels of EEG signal.

Experiment description

Data set used in experiments is provided by IDIAP Research Institute (Silvia Chiappa, José del R. Millán). The set contains data from 3 normal subjects acquired during 4 non-feedback sessions. The subjects were relaxed, sat in a normal chairs with arms resting on their legs. Each subject has two tasks to execute:

- imagination of repetitive self-paced left hand movements,
- imagination of repetitive self-paced right hand movements.

Each session lasted 4 minutes with 5-10 minutes breaks in between them. The subject performed a given task for about 15 seconds and then switched randomly to another task on the operator's request. EEG data is not split in trials