IEETA Brain Computer Interface - Towards an adaptive BCI

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Abstract

This paper describes a new architecture for BCI platforms that will provide adaptability to this kind of systems. A brief overview on the most used BCI platforms is presented, along with the problem of adaptation and the limitations that this kind of platform has and, finally, an alternative architecture to fulfil this problem is introduced.

1 BCI Platforms - A Brief Overview

Brain-Computer interface (BCI) [8] research seeks to develop an alternative communication channel between humans and machines, the breakthrough of this technology is the lack of necessity of muscular intervention in this process. The goal is to give to its users, basic communication and control capabilities so that they can operate external computerized devices or applications like word processing programs or neuroprostheses.

This kind of devices determine the intent of the user from scalp-recorded electrical brain signals (EEG - Electroencephalogram), or from electrodes surgically implanted on the cortical surface (ECoG) or within the brain (neuronal action potentials or local field potentials). These signals are translated in real time into commands that operate a computerized application.

Many factors determine the performance of a BCI system [4], among which the brain activity signals, the methods used to extract signal information, the output applications, or the user himself. A BCI device must take in account all of these factors to provide a reliable performance.

There are some mainstream BCI applications used by many researchers across the world, in [6] it is made an overview to the most used BCI platforms. The two most used BCI platforms are:

- BCI2000 [7]
- OpenVibe [1, 6]

BCI2000 is a modular system designed to suit any type of BCI. It is composed of four main modules: Operator, Source, Signal Processing and application. The Operator Module (see Fig. 1) provides user interfacing, it allows the configuration and execution control of the application and also visualization tools to the user. The Source Module deals with signal acquisition devices and also provides storage capabilities. The Signal Processing Module is the main module, it holds the processing methods that will extract information from the signal and transform this information into commands. The Application Module provides the interface to the user (stimulus and feedback). For further details please consult the online documentation in [2].

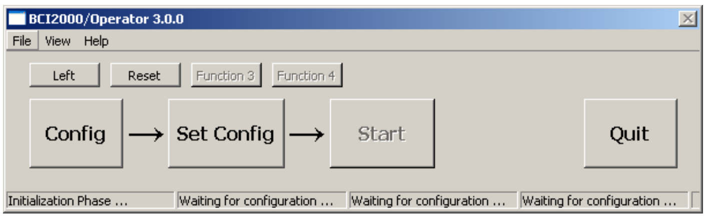

Figure 1: BCI2000 Operator Module

The OpenVibe platform, similarly to BCI2000, is a modular system, however it provides to the developer an intuitive way to build their BCI. This platform is composed by three main modules: Acquisition Server, Designer and Virtual Reality Environment. The Acquisition Server is responsible for signal acquisition. The Designer (see Fig. 2) allows the developer to intuitively build the processing scheme of a BCI system. The Virtual Reality Environment provides the interface to the user in a different type of VR Environments.

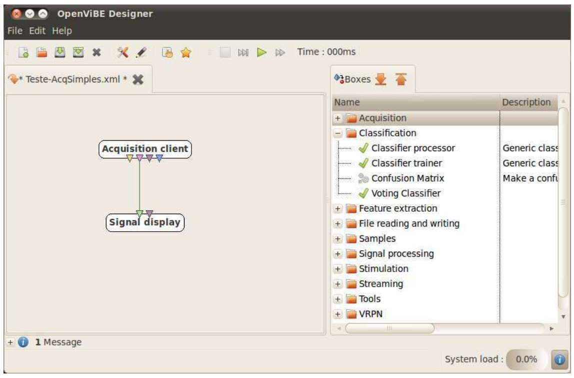

Figure 2: OpenVibe Design Window

Despite of the features that this platforms provide, they still have some limitations that will be explained in the next section. To fulfil this limitations we propose a new platform that is described in this paper.

2 Adaptation Problem

These two platforms allow the researchers to easily and in a fraction of time build a standard BCI system. However it is well known that the common BCI systems have some problems that can be resumed in these three issues: Usability, Accuracy and Speed. To address these problems alternative (and advanced) signal processing methods should be used.

These platforms share some common problems:

- The developer is not free to change the processing scheme of the application
- The internal architecture is complex and non flexible
- It is hard to implement new signal processing methods and adapt to the software architecture

One of the main characteristic that a BCI should have to address the issues mentioned is the adaptation. The BCI system must be able to automatically react to malfunctioning events in order to provide adaptability to itself. It must be able to identify them and adjust its behaviour in order to correct the error. In an usual BCI system it has two distinct and separated phases: train and test. However the EEG signal is non-stationary, the statistics of the signal changes with time, the system must be able to perform these two phases in an autonomous way.

The state of the art platforms described above don't allow the change of these two phases in runtime. In this paper, the architecture of IEETA BCI platform is described that allows to perform this kind of operation

3 IEETA BCI Architecture

The IEETA BCI Architecture includes a new data processing block that allows the system to re-adapt its parameters. This block is called "Error Evaluation" and provides an event to the signal processing block which will allow to change between train and test phases. Fig. 3 shows the proposed architecture and the differences from the actual state of the art platforms.

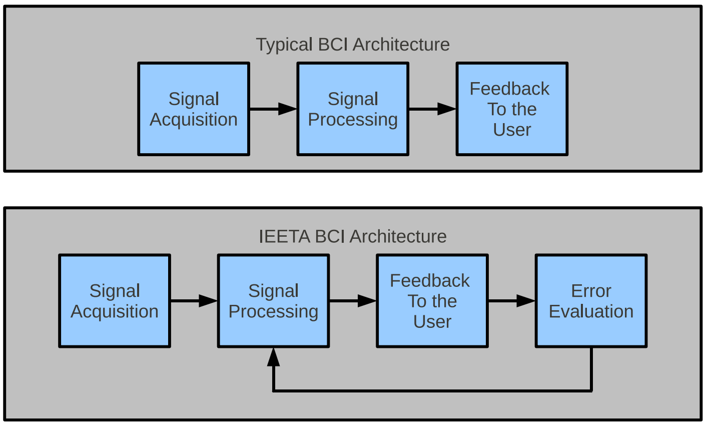

Figure 3: IEETA BCI Architecture: A new data processing block allowing the system to automatically re-adapt its parameters is included.

One of the key issues regarding this new approach is how to identify malfunctions on BCI systems. To address this problem we propose two approaches:

- Error Potentials [3]
- Error Detection by the application itself

In the first approach the "Error Evaluation" module identifies the malfunctioning event by analysing the brain activity. If an error is identified the system is informed and will run Train sections to re-adapt its parameters. This procedure demands for a robust identification of this kind of brain activity.

In the last approach the application itself must be able to identify the error by analysing its performance (or expected performance). For instance in a speller application, in which the objective is to provide speller skills to the user, it is possible to identify if the word exist in a specific dictionary. The non-existence of the written word will identify an error. It is also possible to identify error by statistical analysis, for instance, in a two choice application (right or left) it is possible to study the expected probability of choose each one of the possibilities. If the result probability is different from the expected an error event should be identified.

4 Future Perspectives

Fig. 5 shows the Main Window of IEETA BCI platform. At this point all the signal processing modules support separated test and train phases and allows to change the states in runtime operation. Our intent is to develop the Error Evaluation module as described in the previous section. In a first phase we will start to implement an error detection algorithm to the speller (P300 paradigm [5], see Fig. 4) by addressing the second approach. In a second phase we will develop an algorithm to identify Error Potencials, taking in special attention the elimination of false positives.

These two approaches will allow the BCI system in the future to deal with the non-stationary nature of EEG signal. The solution proposed in this paper will increase the reliability of the system improving the accuracy and usability of BCIs.

5 Acknowledgements

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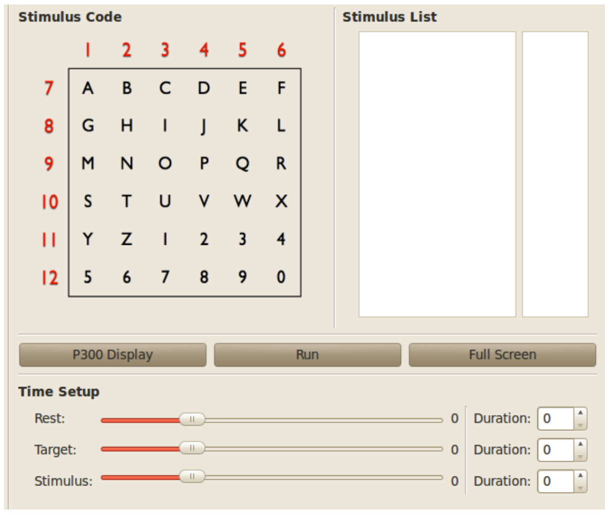

Figure 4: P300 Configuration

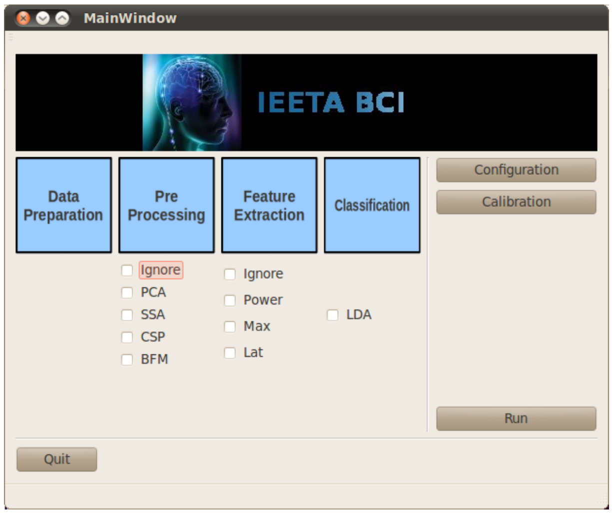

Figure 5: IEETA BCI Application

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