BrainData – Modular software for synchronous data recording from BCI

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Abstract
Nowadays the importance of EEG signal processing for scientists and software developers is growing steadily. They constantly need reliable and quality raw data for their research. One of the problems is synchronizing the different data. The accurate and unambiguous identification of experiment results demands exact and high quality data to be received from the Brain Computer Interface (BCI) device. For this purpose we need a software which allows to record what the participants see and feel during the experiment and ensures its planning and realization. During the experiment we also need to have the opportunity to simultaneously record and process BIG DATA[3]. This includes different types of data recorded at the same time, such as: raw data from the BCI, display of participant's visual percetion, video recording of the experiment and others. For this purpose The system should allow interoperability - receiving data from the BCI system, data processing, data exporting, communication with other systems and apps, which can use this type of data. **BrainData is a modular software for synchronous data recording from BCI and surrounding environment during experiments.**
Keywords: Integrated information systems, Brain Computer Interface, BCI, BIG Data, data processing, sensors, Emotiv

Introduction

The main goal of this article is to highlight the ability to create a system, which can assist researchers to explore the possibility of using the Electroencephalography (EEG) brain signals in different parts of science. They can allow the recording of human brain-electrical activity. EEG signals refer to voltage fluctuations in the microvolt range and they have the potential to answer research questions[1]. Many studies in the research field of cognitive neuroscience rely on EEG, since EEG hardware is available at relatively low cost and EEG signals enable the capture of the neural correlates of mental acts such as attention, speech, or memory operations with millisecond precision [1]. Brain-computer interfaces (BCI) typically make use of EEG signals as well [2,3,]. The aim is to decrypt values from EEG in real time in order to exert control over a different device. The BCI can by used as part of applications to secure decoding systems, provide different-purpose communication channels in medicine, driving robots, etc.[4,5,7]. A clear drawback of the current laboratory BCI technology is that it is very difficult to provide a synchronous record of all data that we need. The application BrainData, developed in our University laboratory helps to resolve this problem.

The main goal in developing this software is to provide simultaneous screen display of received signals during the experiment, which allows the researchers to analyse, and compare data entries. For this purpose all collected data is processed and synchronized during the experiment. ***BrainData is a modular software for synchronous data recording from BCI and surrounding environment during the experiments.***

The application features include the possibilities for the simultaneous recording and processing of BIG DATA[3,6]. This means different types of data are recorded at the same time, such as: raw data from BCI, the participant visual experience, the video recording of the experiment and others. The system allows interoperability - receiving the data from the BCI system, processing, exporting the data to other systems and communication with other apps, which can use these data.

Architecture and general principles

The architecture of the proposed system is very simple and depicted in Fig. 1. It is comprised of :

- An EEG headset Epoc 14+ or Epoc 5+ insight
- A PC software
- Camera (in this case – RunCam2)

Fig. 1 The BrainData Platform

We have a licensed copy of the EMOTIV Cortex SDK software, that provides access to the raw EEG data. Cortex is an API powerhouse for creating BCI applications and integrating data streams from headsets with third party software. Built on JSON and WebSockets, Cortex makes it easy to record data for experiments. Cortex is a wrapper around Software Development Kit (SDK) and houses all the tools required to develop with EMOTIV []. It provides API access to different EMOTIV data streams, such as:

- Getting real-time data streams from the EMOTIV headset including raw EEG, motion data, data packet acquisition and loss, and contact quality; Saving recordings to our secure cloud storage and their playback or export for analysis. **We can use this data for research and analysis**;
- The Performance Metrics Detection Suite reports real time changes in the subjective emotions experienced by the user. Emotiv currently offers five performance metric detections: Engagement/Boredom, Frustration, Meditation, Instantaneous Excitement, and Long-Term Excitement Performance Metrics allows log score of Performance Metrics(including raw score and scaled score) in csv file format. **It is a very good tool for research in the area of people metrics and advertising;**
- Mental Commands detection can be used to control the movement of a 3D virtual object. It also shows the steps required to train the Mental Commands to recognize distinct mental actions for an individual user. **The mental commands SDK can be used for direct command and**

control over robots etc.

The software is developed on Microsoft Visual Studio platform – ASP C# Dot Net. The database is MySQL. The data from Emotiv can be acquired via wireless interface The software has few modules:

- Administration module – provides a description of all elements of the survey. Its main characteristics include:
  - Group of people, who participate in the experiment and their data – age, gender etc.
  - The ability to control the time each picture is shown. ○ Interval through which the buffer data is taken and recorded in the database. Cortex SDK works at intervals of one second. During this interval the buffer receives 129 entries of raw data. The data is sent into the database at every timecycle. This way we record all the data connected with the image shown to the participant, not just recording the last 129 entries of raw data;
  - Duration of the experiment; o Random time for showing the pictures during the experiment; o Channel count – different devices has different count of channel; o SDK modules, from which we will receive the data; ○ Upload the pictures, images, movies, advertisements needed to conduct the experiment;
  - etc.
- Experiment Execution Module – Module for conducting the experiment in accordance with the terms . See Fig. 2.
  o Choice of participants; o Choice of directory with Images; o Choise of experiments type.

Fig. 2 Experiment Execution Module Interface

When the experiment is running (Fig. 3), several concurrent processes are running.

Fig. 3 – Experiment in process

- The participant observes the corresponding picture or video, which appears on the screen and mentally orders to execute the appropriate command. The pictures can be changed at random time intervals;
- On the screen are also shown the results from **Emotiv Brain Activity Map.** This software displays a real-time map of your mental activity in four significant brainwave frequency bands;
- During the specified time interval one small app captures the screen;
- Data, that was received at the time the corresponding picture was displayed is retrieved from the buffer and sent into the database;
- The app receives data from EEG DataLogger SDK module and sends it to a Database;
 The app receives data from EEG PerformanceMetrics SDK module and sends it to a Database;
- The app receives data from EEG MentalCommand SDK module and sends it to a Database;
- If necessary, we can shoot a video during the experiment;
- The display data is captured and recorded as a movie;
- With an embedded camera we capture the facial expressions and mimics of the participant.

After finishing the experiment, a storage procedure is started. This procedure equals the time of each snapshot and the data, received from SDK Modules. If there is a video-record of the experiment, we can also upload the movie into the system.

- Module for preview and analysis of the result of Experiments. This module gives the opportunity for detailed preview and analysis of experimental data and uploads many additional captured video-records and documents, which further describe the experiment. Fig.4 displays a list of conducted experiments. The database includes date, participant, row count with data etc., for each experiment in the group.

Fig. 4 Selection of an experiment for preview

- Preview as stream. Sharing data as a stream gives opportunity for preview, with the ability to stop at any time. In this case, we can get a detailed view of any data, connected to the shown picture. Preview as stream is shown in Fig.5

- Detailed preview snapshot after snapshot, including raw data. This way we can see all data in details, picture by picture. Also we can see the database data row by row and Performance Metrix, connected to each picture. This is shown in Fig. 6

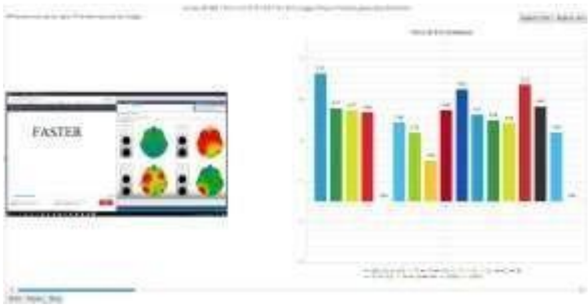

Fig. 5 Preview as stream

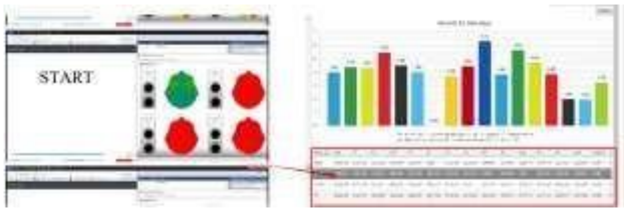

Fig.6 Detailed preview snapshot

- Export result – gives the ability to export the data in XSL/XLSX or CSV format. Also, many stored procedures have been created in the database to facilitate the export of the required data.

RAW data obtained during the experiment

At the final stage, we receive all necessary data, collected and stored for offline statistical processing and analysis – such as, for example the RAW data obtained as a result of "Faster" and "Slow" signal analysis study.

We conducted the study with 3 participants. During the experiment, each participant monitors in turn 8 different pictures (commands). The pictures change at different time intervals - 0.25, 0.5, 1 and 1.25 seconds arbitrarily. Every participant, after seeing the photo, deliberately selects the corresponding command - FASTER or SLOW. Each participant makes 7 attempts. Each command is displayed more than 360 times in total or 120 times for each participant.

Real-time alerts received from Epoc are transferred via Bluetooth to your computer. During the experiment the RAW data registered is 129 entries per second.

As example - Table 1 shows of data obtained at selecting the command "FASTER" from 5 different channels on Epoc 5+ device:

Table 1 Raw data – "START"

AF3	T7	O1	T8	AF4
4233.07	4572.24	4195.39	4188.37	4172.35
4233.52	4570.72	4225.62	4216.47	4179.49

……..	……..	……..	……..	……..
4229.48	4494.43	4231.28	4165.12	4176.22

To conclude, the capabilities of our software, presented in the above article, provide opportunities for a more comprehensive coverage of the data obtaining process during scientist research.

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CONCLUSIONS

In recent years Human-Computer Interaction is steadily growing. Many Practical Applications are focused mainly in two areas - in medicine and robotics. But to help the researchers and to speed up the technical development of these and other areas it is necessary to have a good knowledge of modular applications. This paper presented the operating prototype of a system which can provide the researchers enough data for further analysis. Ours system, tested on a still limited number of participants, showed that it could record simultaneously big missives of data. Analysis of this data could possibly enable further researches and provide new opportunities to analyze signals, received by BCI.

Last, but not least, working on scientific innovation projects gives students a unique experience to participate in real teamwork. Identification of the separate brain signals and using this for interaction driven devices, where only the first steps are done, will significantly increase in the next years.

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