Current Trends in Computer Network "OpenViBE"

Shraddha Gajare, Priyanka Deore, Sumit Wagh, Aarti Bhirud

***Abstract*— The OpenViBE software platform facilitates the design, testing and use of 'brain-computer interfaces' - in other words, systems that process the electrical signals linked with brain activity and translate them into a command that can be understood by machines," Controlling a computer by thought is now possible through the OpenViBE software platform. Acting as an interface designed to translate what happens in the brain into a computer command, this software is the outcome of a project initiated in 2005 and has a multitude of potential applications.**

***Index Terms*—ViBE, brain computer interface, multitude of potential application**

I. INTRODUCTION

OpenViBE is open Virtual Brain Environment .The OpenViBE software platform facilitates the design, testing and use of "brain-computer interfaces" - in other words, systems that process the electrical signals linked with brain activity and translate them into a command that can be understood by machines. These allow individuals to communicate with a computer or any automated system without using their hands or other movements to activate a button or remote control.

OpenViBE provides a tool that is aimed at a varied audience, from researchers and clinicians to video game developers. The Brain-Computer Interfaces and OpenViBE can be used to assist those with motor disabilities (particularly entirely paralysed persons suffering from locked-in syndrome), in multimedia (video games and virtual reality) and in general to facilitate any type of interaction with an automated system (robotics, home automation, etc.). They also open up possibilities to treat certain neurological problems (attention disorders, motor recovery after a stroke for example) through rehabilitation processes such as neurofeedback.

In technical terms, OpenViBE is a series of software libraries and modules written in C++ that can be simply and effectively integrated in order to design real-time applications. Programmer users can develop their own code, while non-programmers can use the graphical interface.

OpenViBE was designed and developed by INRIA (BUNRAKU team) in collaboration with several French partners as part of two successive projects financed by the ANR. The first project, called "OpenViBE" (2005-2009), targeted applications in disability and health. The second project, called "OpenViBE2" (2009-2012), targets applications in video games.

Manuscript received July 20, 2014.

In this paper, we present the OpenViBE platform, a novel, free and open source platform to design and tune BCI systems and connect them with real and virtual environments.

II. EXAMPLES OF APPLICATIONS DEVELOPED WITH OPENVIBE

The openvibe software platform proposes applications in two main sectors: multimedia and health

- WRITING BY THOUGHT IS NOW POSSIBLE?

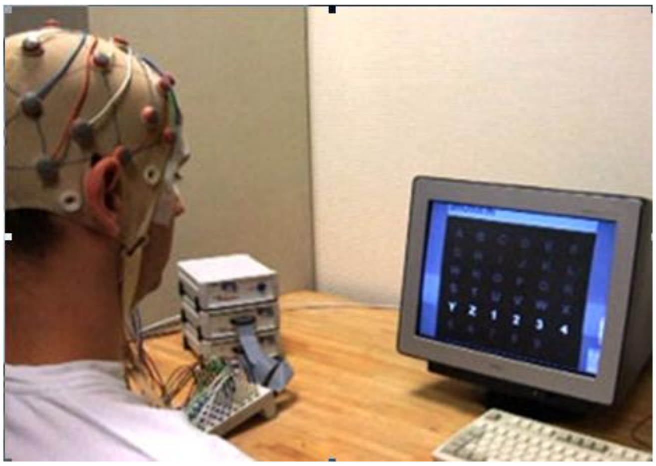


Fig. 1. Writing by thought.

A person wearing an EEG cap focuses his attention on the letter that he wants to spell out. When this letter flashes a particular brain wave is generated, which is picked up, detected and interpreted by the machine.

OpenViBE technology provides a means of writing words by selecting letters on a screen using thought alone. This method of "writing by thought" works by focusing the attention on a chosen letter.

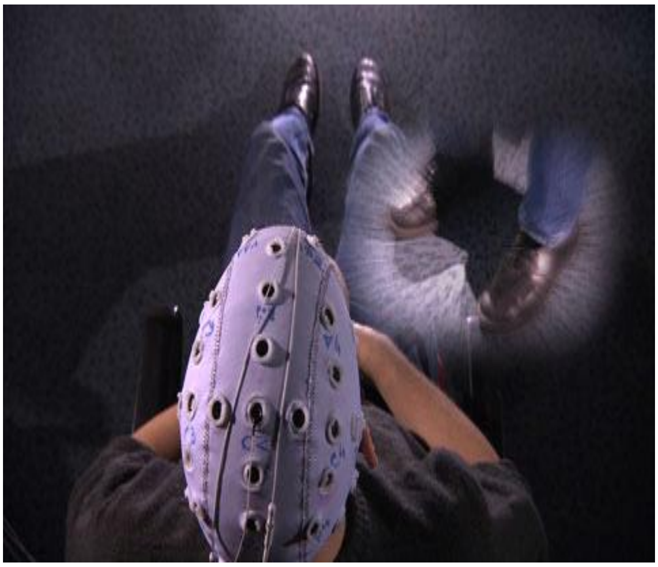
In this system, called "P300 Speller", rows and columns of letters are highlighted in turn on a screen. The persons are then asked to focus their attention on a letter that they want to spell out. When the row or column contains the chosen letter, a particular brain response is generated. This response (P300), which is a known phenomenon among researchers, is triggered when a person detects an anticipated stimulus that appears unpredictably. It occurs around 300 ms after the stimulus and indicates on which letter a person is focusing their attention.

- CAN VIDEO GAMES BE CONTROLLED BY THOUGHT?

Whereas the text editor example above requires an external stimulus (in this case a light flash), another family of brain-machine interfaces uses the brain activity that a person can generate himself. This is the case with the mental imaging of movement, for example, in which a person imagines moving their right or left hand. This mental activity changes the amplitude of brain waves in the brain's left or right hemisphere depending on which hand is used. After a series of processing tasks are completed, it is possible to determine which hand was used for the movement imagined. With a small amount of training, this application can be used to move a cursor on the screen, which could be put to good use in a variety of office software and video games. The application examples detailed below are also shown in the video.

- USE-THE-FORCE: ARE YOU A JEDI?

This entertainment application is inspired by the well-known George Lucas film "Star Wars" and places users in a futuristic environment containing a spaceship. Subjects then have to control the "force" in their brain (just like in the well-known film) to lift up the ship and make it take off using their thought alone. This entertainment application, which can be "mastered" by most people on their first few attempts illustrates a simple use of the software in a virtual reality game. It involves the use of our motor imagination, in other words imagining moving the feet or hands.

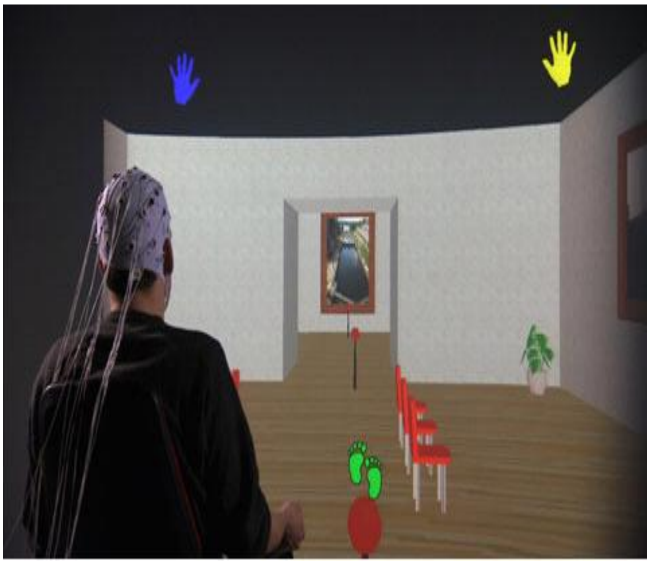


The aim of the demonstration is to make a spaceship take off using thought alone by imagining a repetitive movement of the feet. When the subject stops thinking about this movement a peak in brain activity occurs, which the software detects straight away. This event causes the spaceship to take off immediately.

- VIRTUAL HANDBALL

The objective in this game is to control a ball to score goals. This application is based on two mental commands involving movement imagination. Two goals are placed at each end of a handball court, with a ball placed between them in the centre of the screen. Players have to control the ball to score goals at either end of the court. During the control phases, an onscreen signal tells players when they have to mentally move the ball to score. To do so, the players must mentally imagine moving their left or right hand in order to move the ball in the chosen direction.

- NAVIGATING BY THOUGHT: "THE VIRTUAL MUSEUM"



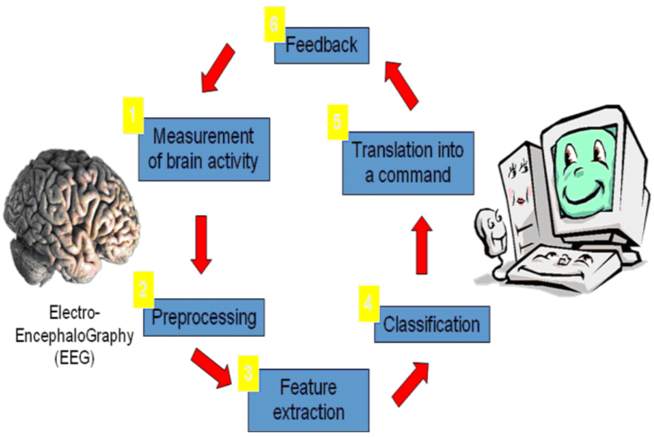
The "Virtual Museum" is an application that lets users move around a museum "by thought" using three mental commands: imagined movements of the feet, the right hand and the left hand. To utilise this small number of commands, this innovative application adopts a new approach in which the user sends high-level "orders". With this technique, users can gradually select their final destination through a sequence of left/right binary choices. In addition to these two commands, users can cancel any of their choices using imagined movements of their feet. Once a navigation point has been selected, the application automatically goes to the destination, leaving users free to enjoy their visit.

III. BRAIN-COMPUTER INTERFACE

A Brain-Computer Interface or BCI allows users to send commands to a computer or machine directly through their brain activity.It is possible to measure brain activity using electroencephalography (EEG) systems, which use electrodes placed on the surface of the skull to capture the brain's electrical activity. To use a brain-computer interface, a person simply puts on an EEG cap fitted with electrodes linked to a device that allows the brain to communicate with a computer. The number of electrodes varies depending on the brain functions used and the desired type of application. Once this equipment is prepared and installed, the application can be launched.

More specifically, a brain-computer interface can be described as a closed-loop system comprising six main stages:

1. Measuring the brain activity (using data capture machines such as an EEG).
2. Pre-processing and filtering of brain signals (often containing a lot of noise).
3. Extracting the characteristics of the signals (leaving only the useful information).
4. Classifying the signals (to identify the mental activity and assign a class to it).
5. Translating a command (sent to the computer or machine).
6. Perceptive feedback (the user sees the result of their mental command and will gradually learn to control the system more effectively).



IV. EEG

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. The brain's electrical charge is maintained by billions of neurons. Neurons are electrically charged (or "polarized") by membrane transport proteins that pump ions across their membranes. When a neuron receives a signal from its neighbor via an action potential, it responds by releasing ions into the space outside the cell. Ions of like charge repel each other, and when many ions are pushed out of many neurons at the same time, they can push their neighbors, who push their neighbors, and so on, in a wave. This process is known as volume conduction. When the wave of ions reaches the electrodes on the scalp, they can push or pull electrons on the metal on the electrodes. Since metal conducts the push and pull of electrons easily, the difference in push, or voltage, between any two electrodes can be measured by a voltmeter. Recording these voltages over time gives us the EEG.

Scalp EEG activity shows oscillations at a variety of frequencies. Several of these oscillations have characteristic frequency ranges, spatial distributions and are associated with different states of brain functioning (e.g., waking and the various sleep stages). These oscillations represent synchronized activity over a network of neurons. The neuronal networks underlying some of these oscillations are understood (e.g., the thalamocortical resonance underlying sleep spindles), while many others are not (e.g., the system that generates the posterior basic rhythm). Research that measures both EEG and neuron spiking finds the relationship between the two is complex with the power of surface EEG only in two bands that of gamma and delta relating to neuron spike activity.

V. SCIENTIFIC ADVANCES FROM THE PROJECT

There are many scientific challenges posed by brain-computer interfaces. Research in neuroscience and neurophysiology aim to discover and validate the mental activities that can be easily controllable by a user and detectable by a system. The technologies developed should then enable the real-time analysis of the mental activities and electrical signals emitted by the user. Research is also being carried out to optimise the possible uses of brain-computer interfaces. As part of the OpenViBE project, researchers have helped to significantly improve all fields of research

VI. INNOVATIONS IN THE FIELD OF SIGNAL PROCESSING

. One of the OpenViBE project's main achievements has been the creation of new techniques for analysing and filtering data and brain signals, enabling an overall improvement in the performance of brain-computer interfaces. The researchers have developed techniques that improve recognition rates in mental activities. These techniques are varied and use phenomena such as Gaussian processes, and fuzzy theory.

The switch from a traditionally 2D approach (analysing electrical potentials on the 2D surface of the skull) to a 3D approach that now proposes to reconstruct in real time all of the brain activity inside the skull. This new 3D approach facilitates the location of sources of brain activity within the brain. Knowledge in neurophysiology allows a given type of brain activity to be associated with a source (location) of a given brain activity. This 3D approach improves the monitoring of a subject's mental activity based on targeted brain regions.

VII. ADVANTAGES

- **Modularity and reusability.** Our platform is a set of software modules devoted to the acquisition, pre-processing, processing and visualization of cerebral data, as well as to the interaction with virtual reality displays. OpenViBE being a general purpose software implies users should be able to easily add new software modules in order to fit their needs.

- **Different types of user.** OpenViBE is designed for different types of user: developers, clinicians, BCI researchers, etc. Their various needs are addressed and different tools are proposed for each of them, depending on their programming skills and their knowledge in brain processes.
- **Portability.** The platform operates independently from the different software and hardware targets. It includes an abstraction allowing to run with various acquisition machines, such as EEG or MEG. It can run on Windows and Linux and also includes different data visualisation techniques. Also, it is based on free and portable software (e.g., GTK+, IT++, GSL, VRPN, GCC).
- **Connection with virtual reality (VR).** Our software can be integrated with high-end VR applications. OpenViBE can serve as an external peripheral to connect a BCI system to any kind of VR application. It also takes advantage of VR displays thanks to a light abstraction of a scenegraph management library, allowing to visualize cerebral activity more efficiently or to provide incentive training environments (e.g., for neurofeedback).

VIII. CONCLUSION

OpenViBE is open source software dedicated to design, test and use of Computer-Brain interfaces. Key aspects of this software are: it's modularity, its extensibility, its scalability, its close relation to virtual reality, its user friendliness, and its wide range of potential users. This is evolutionary technique for Health and Gaming purpose.

REFERENCES

[1] Arrou¨et, C., Congedo, M., Marvie, J. E., Lamarche, F., Lecuyer, A., & Arnaldi, B. (2005). "Open-ViBE : a 3D platform for real-time neuroscience" Journal of Neurotherapy, 9(1), 3-25

[2] B.Z. Allison, E.W. Wolpaw, and J.R. Wolpaw "Brain-Computer Interface Systems: Progress and Prospects," Expert Rev. of Medical Devices

[3] Kennedy P.R., Bakay R.A., Moore M.M., Adams K., and Goldwaithe J. (2000). "Direct control of a computer from the human central nervous system." IEEE Trans Rehabilitation Engineering. 2000 June

[4] BCI-info.org

[5] "Current trends in Brain-Computer Interface (BCI) research." IEEE Transaction 2000 Issue 8 Pages: 216-219.

[6] Kenji Nakayama, Yasuaki Kaneda, Akihiro Hirano, "A Brain Computer Interface based on FFT and Multilayer Neural Network-Feature Extraction and Generalization", Proceedings of ISPACS(2007) International Symposium on Intelligent Signal Processing and Communication Systems Nov.28-Dec.1, 2007 Xiamen, China

[7] Kenji Nakayama Kiyoto Inagaki, "A Brain Computer Interface Based on Neural Network with Efficient Pre-Processing", (ISPACS2006)

[8] Burke D P, Kelly S P, de Chazal P, Reilly R B and Finucane C 2005 "A parametric feature extraction and classification strategy for brain–computer interfacing" IEEE Trans. Neural Syst. Rehabil.

[9] Wang Y, Zhang Z, Gao X and Gao S 2004c "Lead selection for SSVEP-based brain–computer interface" Proc. 26th Annual Int.Conf. of the IEEE Engineering in Medicine and Biology Society (San Francisco, CA)

[10] Sam Darvishi and Ahmed Al-Ani , "Brain-Computer Interface Analysis using Continuous Wavelet transform and Adaptive Neuro-Fuzzy Classifier "Proceedings of the 29th Annual International Conference of the IEEE EMBS Cite Internationale, Lyon, France August 23-26, 2007.

[11] Zachary A. Keirn."Alternative modes of communication between man and machine".Master_s thesis, Purdue University, 1988

[12] "EEG Signal Classification for Brain Computer Interface Applications " Ecole Polytechniq Federale De Lausanne http/bci.epfl.ch/publications/baztarricadiplomaproject.pdf

[13] A. Bashashati, M. Fatourechi, R. K. Ward and G. E. Birch, "A survey of signal processing algorithms in brain–computer interfaces based on electrical brain signals", Journal of Neural Engineering vol. 4, IOP Publishing, pp. 32-57, 2007.