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A study on BCI from the context of Mobile based Application

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Abstract* — *A Brain Computer Interface (BCI) is a device enabling the communication between the user (human) and the computer with human thought alone. Here we have focused only on mobile phone based applications for physically disabled users, who can't speak or use conventional input device such as keyboard, mouse etc. This paper conducts a survey to give an insight on how to dial a call, compose an SMS (Short Mail Service) and also in Composing of Ringtones using the mobile phone for a BCI system with the help of an EEG based headset.

Keywords: BCI, Mobile applications, HMI, EEG, Non Invasive, EEG based headset, P300

INTRODUCTION

Human Machine Interface (HMI), sometimes referred as Operator Panel or Monitoring/Visualizing the process made by device on Human body. It can be classified as ECG, EEG, EOG, MRI's etc..This work focused on EEG based HMI known as Brain Computer Interface (BCI) that acts as a communication channel between the human and the computer which is one of the most recent emerging research areas. Basically Neuroscience is the discipline that created the necessary foundations for BCI to grow into what it has become today. Our brain is made up of billions of nerve cells which are called neurons. Neurons have the amazing ability to gather and transmit electrochemical signals. Electroencephalography (EEG) is the recording of this electrical activity and this is what is used in BCI. Every animal has a brain, but the human brain is unique, it gives us a sense of who we are and what we feel. It allows us to think, smell, taste, listen and plan [1]. This new communication method is suitable for people that are incapable of any motor functions but still retain cognitive abilities; such people are locked in their own bodies and, therefore, cannot use any of the more traditional communication methods. Such a system is their only way to communicate with the outside world [2].BCI requires at least four components for its activity, of which one is the sensor(s) that detects the brain activity, next is a signal processing system in order to translate the obtained signals from the brain activity into commands, then this information needs to be sent to an application on a device (application displayed on a monitor) etc. and finally there must be an application interface to determine how these components interact with each other and the user.
Figure 1 provides the different components of the BCI.

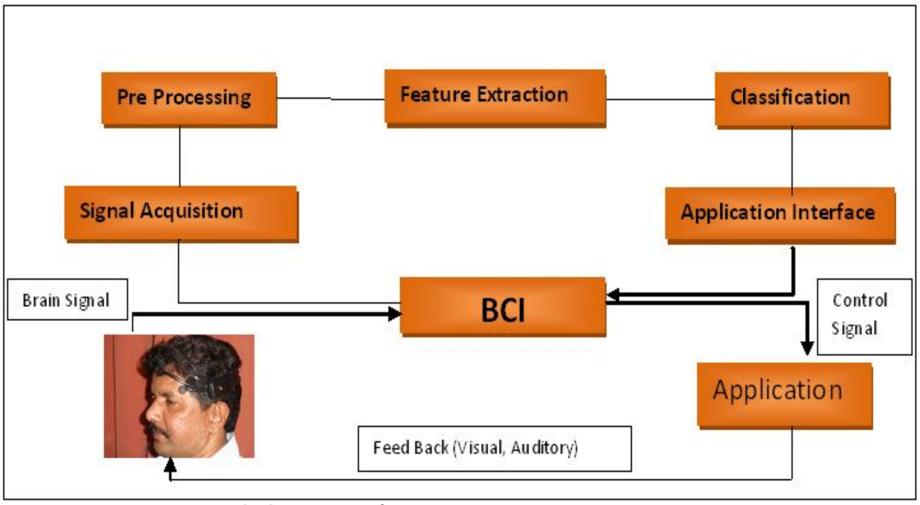

Fig 1: Block Diagram of a BCI System

I. TYPES OF BCI

1. Invasive BCI system: Invasive BCI or brain computer interfaces, are neuroprosthetics whose electrode array heads are planted within the brain itself, and left there on a permanent basis. They have by far the best signal to noise ratio and accuracy of any BCI method, but they require complex surgery to implant, and usually require a permanent hole in the skull.

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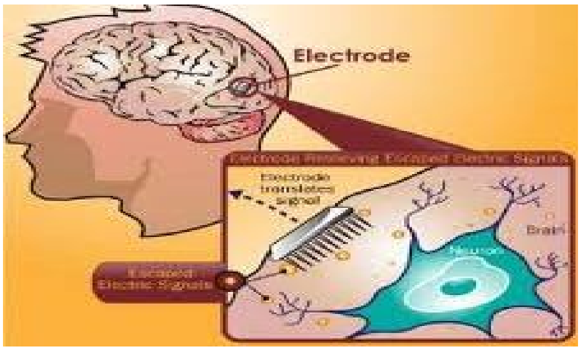

Fig 2: Invasive BCI System

(Courtesy: http://static.ddmcdn.com/gif/brain-computer-interface-3.gif)

2. Partially Invasive BCI: Partially invasive BCI or brain computer interface devices are neuroprosthetics that are implanted on a permanent basis within the skull itself, but only onto the surface of the brain. They spread out electrode arrays over the surface rather than burrowing inside. The advantage of going under the skull is that the skull acts as a significant brainwave dampener. Additionally, there is the advantage of not cutting into a living brain. Accuracy is better than non invasive systems, but not as high as invasive systems.

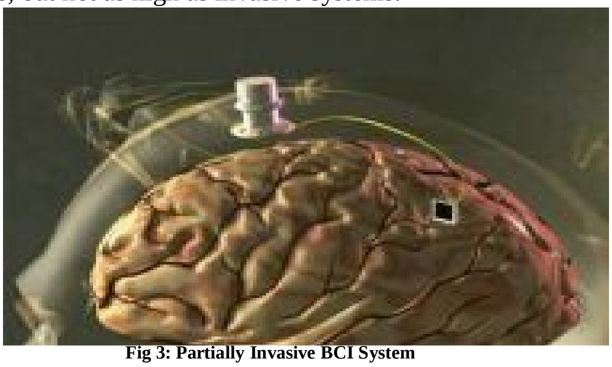

Fig 3: Partially Invasive BCI System

(Courtesy: http://halbookblog.wordpress.com/2011/11/10/the-power-of-words-and-rhetoric-in-1984)

3. Non- Invasive BCI system: Non-invasive BCI or brain computer interface is the version of interface used when only a temporary connection to the brain is required. It is the least accurate of the neuroprosthetic methods, dealing with general brainwaves that are dampened by passing through the skull. However, it is sensitive enough to perform general tasks, and gather non-specific information. Non invasive neuroprosthetics typically have the longest training curve, because they detect brainwaves at the point outside the skull, where they have run together, and greatly weakened. As a result, it typically takes considerable conscious effort to drive them.

Fig 4: Non Invasive BCI System

II. ASTERMINOLOGIES OF NON-INVASIVE BCI

*A. EEG: **(Electroencephalography)***

EEG waves are created by the firing of neurons in the brain and were first measured by Vladimir Pravdich-Neminsky who measured the electrical activity in the brains of dogs in 1912, although the term he used was “electrocerebrogram.”[5] Ten years later Hans Berger became the first to measure EEG waves in humans and, in addition to giving them their modern name, began what would become intense research in utilizing these electrical measurements in the fields of neuroscience and psychology.[6] EEG waves (figure 5) are measured using electrodes attached to the scalp which are sensitive to changes in postsynaptic potentials of neurons in the cerebral cortex. Postsynaptic potentials are created by the combination of inhibitory and excitatory potentials located in the dendrites. These potentials are created in areas of local depolarization or polarization following the change in membrane conductance as neuro transmitters is released. Each electrode has a standard sensitivity of 7µV/mm and averages the potentials measured in the area near the sensor. These [7] averages are amplified and combined to show rhythmic activity that is classified by frequency (Table 1). Electrodes are usually placed along the scalp following the "10-20 International System of Electrode Placement" developed by[8] Dr. Herbert Jasper in the 1950's which allows for standard measurements of various parts of the brain shown in Figure 6**.**

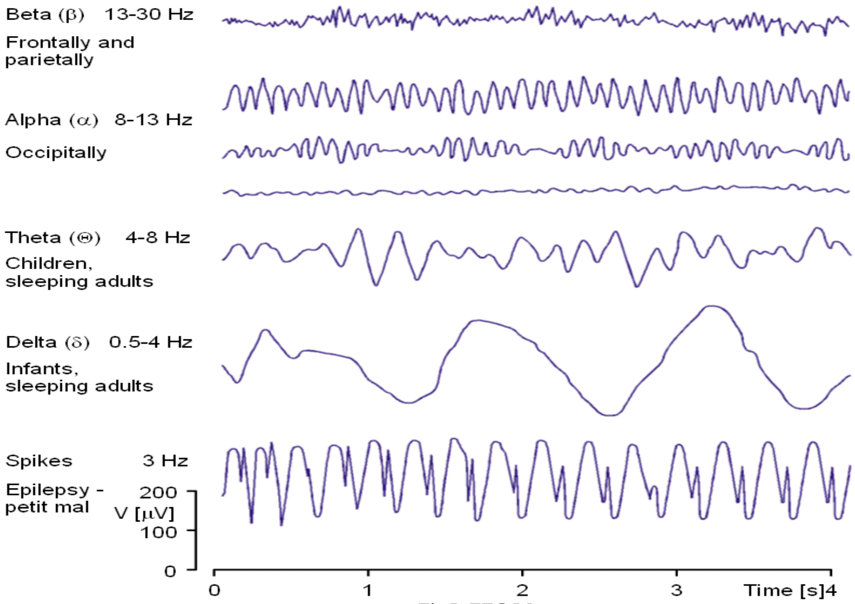

Fig 5: EEG Waves

Band	Frequency (Hz)
Delta	1-4
Theta	4-7
Alpha	7-13
Beta	13-30
Gamma	30+

Table 1: EEG Band & Frequencies

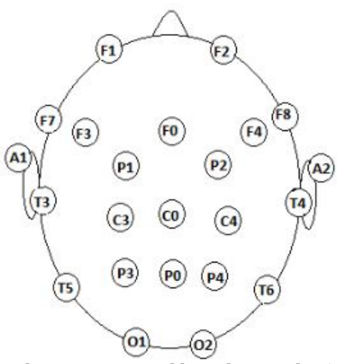

Fig6: Electrode Placement according to the International 10-20 System. Odd numbers on the right, even on the left. Letters correspond to lobes – F(rontal), T(emporal), P(arietal), and O(ccipital). C stands for Central

B. P300:

Variant brain signals can be utilized as the input of BCI system. Electroencephalography (EEG) based BCI is the most studied potential non-invasive interface, mainly due to its fine temporal resolution and ease of use. As one component of EEG signal, P300 potential is a positive peak with a latency of about 300 ms after the target stimulus onset in the EEG, occurring in response to infrequent or particularly significant stimuli. This positive peak is known as the P300 signal in neuroscience literature. In 1988, Farwell and Donchin developed a P300 based BCI speller which presented letters and symbols in a matrix and repeatedly flashed each row and column. [9, 10]. P300 is referred to the central-parietal region of the brain and can be found throughout the EEG on a number of channels.

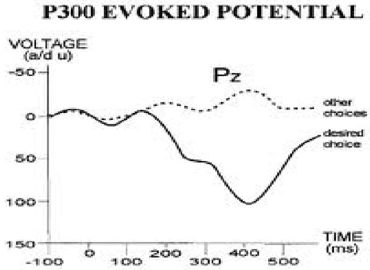

Fig7: P300 signal

C. EEG based wireless headset

Among many products, Emotiv System has been used, whose tag-line is “you think, therefore you can,” bills itself as a “revolutionary new personal interface for human computer interaction.” It is based around the EPOC headset for recording EEG measurements and a software suit which processes and analyzes the data. Emotiv offers both a consumer headset which only works with approved applications and a developer headset which supports product development and includes a software bundle. Both headsets are wireless and utilize a proprietary USB dongle to communicate using the 2.4GHz band. This work refer to the EPOC headset which contains a rechargeable 12 hour lithium battery, 14 saline EEG sensors offer optimal positioning for accurate spatial resolution and a Gyroscope generates optimal positional information for cursor and camera controls and has an effective bandwidth of 0.16- 43Hz (Figures 8, 9). Emotiv offers 6 different software development kits which grant various control over the EPOC headset API and detection libraries and come with up to 4 different programs. The Research Edition includes the Emotiv Control Panel, EmoComposer (an emulator for simulating EEG signals), EmoKey (a tool for mapping various events detected by the headset into keystrokes), the Test Bench, and an upgraded API which enables the capture of raw EEG data from each individual sensor [11, 12]. With a system requirement of 2.4GHz Intel Pentium Processor or equivalent with Microsoft Windows XP with Service Pack 2, Windows Vista or Windows 7, 1GB RAM with 50MB available disk space. One or two unused USB 2.0 ports (depending on the number of neuro headsets user can use simultaneously).

Fig8: Emotiv EPOC Headset

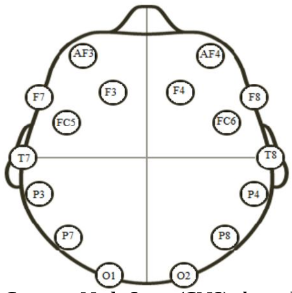

Fig9: The 14 EPOC Headset 14 contacts. In addition there is a Common Mode Sense (CMS) electrode in the P3 location and a Driven Right Leg (DRL) electrode in the P4 location which form a feedback loop for referencing the other measurements.

III. METHODOLOGY FOR MOBILE APPLICATION

1. BCI system to make a call from the mobile phone:

This methodology has used the neural signals generated from the human brain in order to have a hands free human-mobile interaction in making phone calls from one mobile to other phone (Neuro Phone System). This method has been tested on an iphones connected with an EEG based headsets [3]. It also takes various measures in increasing signal noise ratio (SNR) by band pass filtering [13] and independent component analysis (ICA) [14]. It has been tested for the wink and think modes for a various scenarios.

For wink modes is done based on sitting relaxed or walking state of a subject using a Bayesian classifier. For the Think modes is carried on P300 experiments using Dial Tim experiments.

2. BCI system to send sms:

This methodology helps in application for locked-in patients to communicate with other people by translating brain activities into machine/computer commands. BCI instant messaging system (i.e. BCI messenger), which is a P300-based Chinese typewriter [16, 17]. The BCI messenger can serve as a daily communication tool, with which the patients can type and send messages to either computer clients or cell phones. The typewriter interface is implemented following the design of modern cell phone keypad, where every key can act as a specific element in different input modes and multiple input modes including Chinese, English, numbers and symbols are integrated. Since P300 potentials exhibit various amplitudes and latencies on different individuals, some intensification parameters (e.g. variable stimulus round, inter-stimulus interval), and even some advanced intensification methods (e.g. stimulus size enhancement) could be customized to reinforce the elicitation of P300. Six subjects participated in the experiments of the BCI system above. A short training period is requested to allow task completion. The experiment results demonstrate that BCIs can provide locked-in patients with effective communication [9].

3. BCI system to create ringtones:

This methodology has proposed an application for combining Brain computer interface technology with mobile phones. After, signal acquisition from brain and applying various techniques, the alphabets are composed for sending SMS from the brain signals with the help of fuzzy artmap. The signals in Morse code form are directly processed by FPGA. The text can then be sent using SMS without the user having to type anything on mobile phone. Simulation in verilog is done for explanation of signals output. Text generated by the brain and processed can be used for composing ringtones on the mobile phones which already has inbuilt softwares to convert text into ringtones. Mobile phones can have a mode for selecting specifically BCI communication with mobile phones [2].

It can be divided into two sub modes in BCI MODE:-

a. Text mode (for SMS)
b. Ringtone mode

4. Proposed areas:

With this literature discussed related to combination of BCI & Mobile phone application, it is under investigating in different applications such as:

a. In the above literature related to patients, main drawback of the system is training, In this context researching to find a unique feature exhibiting the status of patients & thereby sending a message to Doctor's and patient's attendants.

b. A driver who drunk & drive can be stopped from possibility of accidents by identifying the unique feature using BCI signals related to alcohol content through experimental studies and also to design a mobile based communication system to prevent the drunken drive.

c. Similarly work may be extended to study the various signals related to sleepy conscious, in order to avoid accidents from a driver especially during early morning for the restless night drive of a transport means such as Busses, Lorries and other vehicles. In this context proposed to design a device that alerts (wakes up) the driver.

d. Thought interpreter is also the study to be implemented for a dumb people where the brain signals generated in a human being is classified & extract the same into generate output in an audio device.

IV. Conclusion

The use of EEG signals as a vector of communication between man and machines represents one of the current challenges in signal theory research. The principal element of such a communication system is known as "Brain Computer Interface". BCI is the interpretation of the EEG signals related to the characteristic parameters of brain electrical activity. This is one among the new emerging research area. Here a detailed Survey is made on use of mobile application over the BCI system using EEG based headset. Future work would regard in exploring of BCI on different approaches that increases reliability of EEG readings, more algorithms and architecture designed for much more better applications like detection of car driver who is either drunk or sleepy while driving and to extract the features related to hypotension (low BP) people.

References

1. James Cannan and Huosheng Hu. Human-Machine Interaction (HMI): A Survey, Technical report: CES -508 School of Computer Science & Electronic Engineering, University of Essex
2. Pranav Bhardwaj and Gaurav Bhateja. Composing SMS and Ringtones by thought– Brain Computer Interface application, 0-7803-9564-6/06 ©2006, IEEE

3. Andrew T. Campbell, Tanzeem Choudhury, Shaohan Hu, Hong Lu,Matthew K. Mukerjee!, Mashfiqui Rabbi, and Rajeev D. S. Raizada. NeuroPhone: Brain-Mobile Phone Interface using a Wireless EEG Headset, Copyright 2010, ACM
4. http://futurenci.org/index.php?option=com_content&view=article&id=58&Itemid=59, BCI Basics
5. Swartz, B.E; Goldensohn, ES. "Timeline of the history of EEG and associated fields." *Electroencephalography and Clinical Neurophysiology*. Vol. 106, pp.173–176, 1998
6. Millett, David. "Hans Berger: from psychic energy to the EEG." *Perspectives in Biology and Medicine,* Johns Hopkins University Press,. 44.4 pp. 522–542, 2001
7. Nunez PL, Srinivasan R. *Electric Fields of the Brain: The Neurophysics of EEG*. Oxford University Press. 1981
8. Niedermeyer, Ernst and da Silva, Fernando Lopes. *Electroencephalography: Basic Principles, Clinical Applications,and Related Fields, Fifth Edition.* Lippincott Williams & Wilkins, 2005. pp 140
9. Yi Li, Jianhui Zhang, Yu Su, Weidong Chen, Yu Qi, Jicai Zhang, Xiaoxiang Zheng. P300 Based BCI Messenger, 978-1-4244-3316-2/09/ ©2009 IEEE
10. Farwell, L.A. and E. Donchin, Talking off the top of your head: toward a mental prosthesis utilizing event-related brain potentials. Electroencephalography and Clinical Neurophysiology, 1988. 70(6): p. 510-523
11. Emotiv Website. <http://www.emotiv.com>.
12. Daniel J. Szafir Senior Honors Thesis Advised by Prof. Robert Signorile, Non-Invasive BCI through EEG **,** An Exploration of the Utilization of Electroencephalography to Create Thought-Based Brain-Computer Interfaces, Boston College Computer Science Department, 2009-10
13. J. Malmivuo and R. Plonsey. Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields. Oxford University Press, New York, 1995.
14. N. Xu, X. Gao, B. Hong, X. Miao, S. Gao, and F. Yang. BCI competition 2003-data set IIb: enhancing P300 wave detection using ICA-based subspace projections for BCI applications. IEEE Transactions on Biomedical Engineering, 51(6):1067–1072, 2004.
15. Vaidehi Baporikar , Dr.N.G.Bawane , A Literature Survey on Wireless sensor network for Brain Computer Interface using ATMEGA128RFA1, International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462 NCICT Special Issue Feb 2011
16. Su Y, Wu B, Chen W D, P300-based brain computer interface: Prototype of a Chinese speller. Journal of Computational Information Systems, p.1515-1522, 2008.
17. Wu B, Su Y, Chen W D, Designing P300-based Brain-Computer Interface for Chinese Typewriter. Proceedings of the 4th International Brain-Computer Interface Workshop and Training Course: p. 268-273 , 2008
18. Jonathan R. Wolpaw and Niels Birbaumer, Brain–computer interfaces for communication and control, Selzer-33.qxd 21/10/2005 Page 602
19. Tao Geng and John Q. Gan, Motor Prediction in Brain-Computer Interfaces for Controlling Mobile Robots, 30th Annual International IEEE EMBS Conference Vancouver, British Columbia, Canada, August 20-24, 2008
20. Jonathan R. Wolpaw, Niels Birbaumerc,d, Dennis J. McFarlanda, Gert Pfurtschellere, Theresa M. Vaughana, Invited reviewBrain–computer interfaces for communication and control, Clinical Neurophysiology 113 (2002) 767–791

