Application Of Brain Computer Interface For Physically Challenged Individual

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***Abstract*:** A Brain Computer Interface (BCI) is a computer based system that acquires brain signals, analyse them and translates them into commands that are relayed to an output device to carry out a desired action. The main goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders. BCI helps researchers to use brain signals complex control of cursors, robotic arms, prostheses, wheelchairs, and other devices. This paper gives an insight into the various techniques that can be implemented on BCI and the challenges faced by researchers to implement it . The proposed work intends to build a proto type using BCI to improve the communication capabilities of people living with disabilities or locked in syndrome.

***Index Terms* – Electroencephalography (EEG), Electrodes, Signal processing, Brain Computer Interface (BCI)**

I. INRODUCTION

A Brain Computer Interface (BCI) is a computer based system that introduces a direct communication channel between the brain and the external world, providing a special communication and control channel for people with disabilities. It acquires brain signals, analyse them and translates them into commands that are relayed to an output device to carry out a desired action [1]. The aim of BCI is to help people with neuromuscular disorders in restoring their normal life.

BCI helps by using the brain thoughts as input signals for applications such as cursor control, robotic arms, wheelchairs, and other devices.[2]

The system does actually not use normal output pathways of the central nervous system, as nerves or muscles do, but relies only on the identification and interpretation of the physiological activity patterns in different areas of the brain. Correlations of these areas with the subject's intentions are nowadays well known and could be used for human-machine interaction purposes.[3] Thus, the various applications developed require different areas for signal recording and different signal quality is needed.

Hence, several recording methods are suitable for use: EEG (electroencephalography), FMRI (functional magnetic resonance imaging), MEG (magneto encephalography), PET (positron emission tomography), optical imaging and ECoG (electrocorticography). These method uses electrodes applied on the scalp; the main advantage of this method is the portability of the recording system.[4]

1.1 Types of techniques used in BCI

1.1.1 Invasive technique

Invasive recording methods implant electrodes under the scalp. They measure the neural activity of the brain either intracortically from within the motor cortex or on the cortical surface (electrocorticography (ECoG)). Their greatest advantage is that they provide high temporal and spatial resolution, increasing the quality of the obtained signal and its signal to noise ratio. But there are some usability issues that rise due to the surgical procedure.

1.1.1 Non-invasive technique

These recording methods follow the approach that does not require implanting of external objects into subject's brain. Thus it avoids the surgical procedures or permanent device attachment needed by invasive acquisition. Various assessment methods for different types of measured signals such as functional magnetic resonance imaging (fMRI), functional nearinfrared spectroscopy (fNIRS), magnetoencephalography (MEG), and electroencephalogram (EEG).

1.2 Some of the challenges faced by BCI

This section elaborates different challenges faced by the BCI applications

1.2.1 Training process

Training the user is a time-consuming activity either in guiding the user through the process or in the number of recorded sessions. The user is taught to deal with the system as well as to control his/her brain feedback signals in the preliminary phase, while in the calibration phase, trained subject's signal has been used to learn the used classifier.

1.2.2 Information transfer rate

It is the widely used evaluation metric for command BCI systems. It depends on the number of choices, the accuracy of target detection, and the average time for a selection. Technical challenges They are issues related to the recorded electrophysiological properties of the brain signals which include non-linearity, non-stationarity and noise, small training sets and the companying dimensionality curse.

1.2.3 Non-linearity

The brain is a highly complex nonlinear system in which chaotic behaviour of neural ensembles can be detected. Thus EEG signals can be better characterized by nonlinear dynamic methods than linear methods.

1.2.4 High dimensionality curse

In BCI systems, the signals are recorded from multiple channels to preserve high spatial accuracy. As the amount of data needed to properly describe different signals increases exponentially with the dimensionality of the vectors, various feature extraction methods have been proposed. They play an important role in identifying distinguishing characteristics. Thus the classifier performance will be affected only by the small number of distinctive traits instead of the whole recorded signals that may contain redundancy.

The section 2 of this paper will give the literature survey, section 3 gives the proposed work and section 4 gives the conclusion.

II. LITERATURE SURVEY

The authors C.C. Postelnicu, D Talaba, M.I. Toma in their paper "Brain Computer Interfaces For Medical Applications"[1] has described how the effort of developing neuroprostheses and advanced communication systems for patients with disabilities has involved considerable scientific and technological effort. In the paper "Brain-Computer Interfacing: How to Control Computers with Thoughts"[2] from the authors Alvaro Fuentes Cabrera, Omar Feix do Nascimento, Dario Farina and Kim Dremstrup ,it is been described as how the Brain-Computer Interface (BCI) technology aims at providing communication and control facilities to severely paralyzed people using its various strategies.

"Brain-Computer Interface Based Home Automation System for Paralysed People" [3] focuses on the various problems faced by paralysed patients and how they might be helped using BCI based home controlling systems. "EEG Subspace Analysis and Classification Using Principal Angles for Brain-Computer Interfaces"[4] tells the importance of Electroencephalography (EEG) signals in implementing the prototype of the BCI applications and how it helps to have control of cursor on the computer screen.

The authors Min-Ho Lee, Siamac Fazli, Jan Mehnert and Seong-Whan Lee[5] in their paper "Hybrid Brain-Computer Interface based on EEG and NIRS Modalities" tells about the use of EEG signals and Near Infrared Spectroscopy(NIRS) measurements in classifying the performance of synchronous motor imagery(MI) tasks based on the brain signals.

Different application areas that could benefit from brain waves in facilitating or achieving their goals are discussed. Major usability and technical challenges that BCI faces and possible solutions are explained in [6]. BCI simultaneously extracts motor intentions from brain activity and generate artificial sensations using intracortical microstimulation (ICMS) which leads to development of clinical neural prostheses for restoration and rehabilitation of neural function has been expressed in [7]

In [8-10] the authors have explained regarding recent advances in the BCI implementation as how it allow patients to act on their environment by using only brain activity and without using any peripheral nerves and muscles.

The essential components of BCI system, types and signal processing techniques used with several methods of electrode placement, filtering, feature extraction and EEG signal classifications are discussed in [11-13]. "A Task-Oriented Brain-Computer Interface Rehabilitation System for Patients with Stroke Hemiplegia"[14] tells about different devices used such as wearable semidry-typed electrode for electroencephalogram (EEG) recording as well as an exoskeleton robotic device for finger movement support that helps people with stroke hemiplegia.

In [15-16] the authors have described how the BCI technology has been actively investigated to provide a new alternative to help stroke survivors to restore motor function by inducing activity-dependent brain plasticity based on motor imagery, contingent feedback for stroke patients and combination of BCI with mechanical stimulation.

The following section explains the proposed system.

III. PROPOSED SYSTEM

This proposed system helps the people with disabilities by providing the communication and control facilities using Brain Computer Interface (BCI).[7] It provides them with an opportunity to interact with the world directly by using their brain signals recorded from the electrodes attached to their scalp to manipulate objects via a computer, without transmitting the signals to the muscles of the extremities to perform the required motor skills. The following figure 3.1 gives the proposed architecture of BCI.

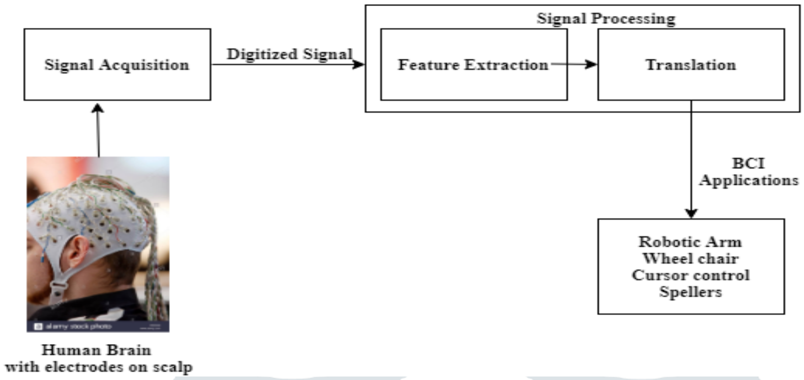

Figure 3.1 Architecture of BCI

The electrodes are attached to the brain, record the signals and transmit them as digital signal for the signal processing. The signal processing block processes all the recorded data and transforms the signals in commands for the application. The features extraction block identifies the parameters from the pre-processed signals allowing thus discriminating between different classes of commands. In order to produce a command, the user must execute a specific activity. Thus the system can associate the produced signals with the generated command.

The system can associate the recorded signal with a feature by using a special classifier. After the class feature is identified, the system can associate it with a command for the application. Electroencephalography (EEG) is a recording method, where electrodes are placed on scalp with conductive gel or paste [11] otherwise Epoc Neuro Headset is used which is a high resolution, neuro-signal acquisition and and also a processing wireless headset. BCI2000 is a general purpose system which can also be used for data acquisition is used in signal analysing. It provides audio/visual stimulation and supports input from devices such as keyboards.

Once the brain signals are analysed the features are extracted using different classifiers such as Linear Support Vector Machine (LSVM), Gaussian Support Vector Machine (GSVM), Neural Network (NN.

And Open ViBE is a free and open source software platform with a set of modules that helps in visualizing the cerebral activities and helps to monitor brain interface applications. The quality of the control is dependent on the interaction between the user's brain and the system.

IV. CONCLUSION

BCI provides channeling facilities between brain and the external devices. It has helped in the medical field providing alternate solutions to people with neuromuscular disorders. The recording method in BCI involves two techniques, Invasive which requires implanting surgery and Non-invasive which involves attaching electrodes to human scalp. Different challenges faced by BCI have been discussed and process of BCI working has been explained. The implementation of the proposed system will enable the physically challenged people to lead a comfortable life in future.

References

[1] C.C. Postelnicu, D Talaba, M.I. Toma, 2010, Brain Computer Interfaces For Medical Applications, Bulletin of the Transilvania University of Braşov • Vol. 3 (52)

[2] Alvaro Fuentes Cabrera, Omar Feix do Nascimento, Dario Farina and Kim Dremstrup, Brain-Computer Interfacing: How to Control Computers with Thoughts, Center for Sensory-Motor Interaction (SMI) Department of Health Science and Technology, Aalborg University, Aalborg 9220, Denmark

[3] Desai Pratikkumar Bhemjibhaih , Garde Deval Sanjay , Sreejith V3, Bijil Prakash, Brain-Computer Interface Based Home Automation System for Paralysed People, 3Department of Computer Science and Information Systems, 4 Department of Mathematics BITS-Pilani K K Birla, Goa campus, Goa, India

[4] Rehab Ashari, Charles Anderson, EEG Subspace Analysis and Classification Using Principal Angles for Brain-Computer Interfaces, Department of Computer Science Colorado State University Fort Collins, Colorado 80523

[5] Sarah N. Abdulkader *, Ayman Atia, Mostafa-Sami M. Mostafa, 2015, Brain computer interfacing: Applications and challenges, HCI-LAB, Department of Computer Science, Faculty of Computers and Information, Helwan University, Cairo, Egypt

[6] Min-Ho Lee, Siamac Fazli, Jan Mehnert and Seong-Whan Lee, Hybrid Brain-Computer Interface based on EEG and NIRS Modalities, 1Department of Brain and Cognitive Engineering, Korea University, Seoul, Korea 2Department of Computer Science, Berlin Institute of Technology, Berlin, Germany

[7] Mikhail A Lebedev, Towards a versatile brain-machine interface: Neural decoding of multiple behavioral variables and delivering sensory feedback, Department of Neurobiology Duke University Durham, USA

[8] Ulrich Hoffmann, Jean-Marc Vesin, Touradj Ebrahimi, Recent Advances in Brain-Computer Interfaces, Ulrich Hoffmann, Jean-Marc Vesin, Touradj Ebrahimi Signal Processing Institute Ecole Polytechnique F´ed´erale de Lausanne (EPFL), Switzerland

[9] Kup-Sze Choi, Shuang Liang, Enhancing the Performance of Brain-Computer Interface with Haptics, Centre for Smart Health, School of Nursing The Hong Kong Polytechnic University Hong Kong, China

[10] Chang-Hee Han, Chang-Hwan Im, EEG-based Brain-Computer Interface for Real-Time Communication of Patients in Completely Locked-in State, Dept. of Biomedical engineering Hanyang University Seoul, Republic of Korea

[11] Tomislav Milekovic, Brain-computer interfaces based on intracortical recordings of neural activity for restoration of movement and communication of people with paralysis, Department of Fundamental Neuroscience, Faculty of Medicine, University of Geneva, Geneva, Switzerland 2 Center for Neuroprosthetics and Brain Mind Institute, School of Life Sciences, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland

[12] N.A. Md Norani, W. Mansor, L.Y. Khuan, A Review of Signal Processing in Brain Computer Interface System, Faculty of Electrical Engineering Universiti Teknologi Mara, 40450 Shah A1am, Selangor, Malaysia

[13] Michael Pereira , Aleksander Sobolewski and Jose del R. Millan, Modulation of the inter-hemispheric asymmetry of motor-related brain activity using brain-computer interfaces

[14] Junichi Ushiba, Ph.D., Asuka Morishita, M.S. and Tsuyoshi Maeda, M.S., A Task-Oriented Brain-Computer Interface Rehabilitation System for Patients with Stroke Hemiplegia, Department of Biosciences and Informatics, Faculty of Science and Technology, Keio University 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa, Japan

[15] Cuntai Guan, Brain-Computer Interface for Stroke Rehabilitation with Clinical Studies, Brain-Computer Interface Laboratory Institute for Infocomm Research, A*STAR, Singapore

[16] Keun-Tae Kim , Tom Carlson and Seong-Whan Lee, Design of a Robotic Wheelchair with a Motor Imagery based Brain-Computer Interface, Department of Brain and Cognitive Engineering, Korea University, Seoul, Korea 2Defitech Chair in Non-Invasive Brain-Machine Interface, EPFL, Lausanne, Switzerland