Brain- Computer Interface: A Non-Muscular Channel for Proclamation and Organization Facilitate to Attain Finest Relation with Soul Computer Line

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ABSTRACT:
It will seem absurd to imagine a world of device which is completely running by brain power, well not really, on going researches in this field has led to devastating successes. The mission is to create and adapt methods of human–computer interaction that will allow BCI technologies to effectively control real-world applications. Most of the existing BCI applications were designed largely for training and demonstration purposes. Our goal is to show ways of transitioning BCI control skills learned in training to real-world scenarios. This paper explores some of the problems and challenges of combining BCI outputs with human–computer interface paradigms in order to achieve optimal interaction. We utilize a variety of application domains to compare and validate BCI interactions, including communication, environmental control, neural prosthetics, and creative expression. The goal of this research is to improve quality of life for those with severe disabilities.

Keywords **:** *Brain Computer Interface (BCI), Electro Encephalograph (EEG), Electro Cardiograph (Ecog), Neuroprothesis.*

1 INTRODUCTION

Imagine a world of computers running on brainpower! Sounds straight of a science fiction movie? Well, not really. Ongoing research in this field of brain-computer interface has met with surprising success. Section one in this paper introduces the subject BCI. Section two deals with Features of BCI which includes recording types (ways to adapt BCI). Section three which is most important one highlights some of applications of the subject. Section four reveals latest researches made in the field with the help of examples. Section five mentions the vision of the future, the ongoing researches going on and the hurdles to face in overcoming the completion to the researches which is followed by a mild conclusion.

1.1 Brain-Computer Interface (BCI)

Brain-computer Interface is non-muscular information channel for sending messages and commands from the brain to the external world. A BCI transforms mental decisions and/or reactions into control signals by analyzing the bioelectrical brain activity. It is a communication system that recognizes user's command only from his or her brainwaves and reacts according to them. For this purpose PC and subject is trained. Simple task can consist of desired motion of an arrow displayed on the screen only through subject's imaginary of something (e.g. motion of his or her left or right hand). As the consequence of imaging process, certain characteristics of the brainwaves are raised and can be used for user's command recognition, e.g. motor waves (brain waves of alpha range frequency associated with physical movements or intention to move).

Types of BCI

-Invasive

The process of brain signal sense applied within of grey matter of brain.

-Partially Invasive

Another process of brain signal reading which is applied to the inside the skull but outside the grey matter. eg.Electrocardiography(ECOG)

- Non Invasive

It is the most valuable neuron signal imaging method useful to the outside of the skull, just

functional on the scalp.
Electroencephalography(EEG) is the most deliberate in the last decade and in the most modern time most of the researches are based on EEG.

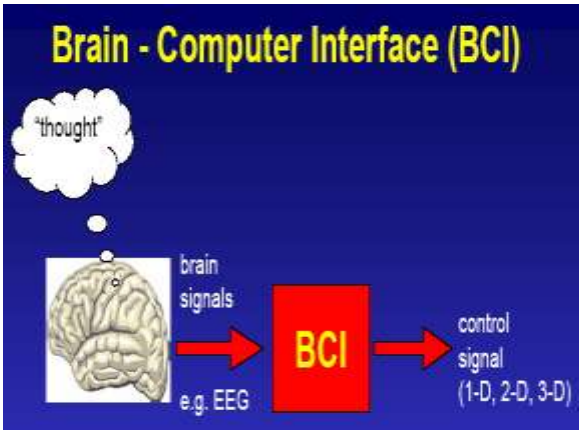

Fig. 1. Brain-Computer Interface

2. LITERATURE REVIEW

The narration of brain–computer interfaces (BCIs) starts with *Hans Berger's* invention of the electrical activity of the human brain and the growth of electroencephalography (EEG). In 1924 Berger was the first to trace human brain activity by means of EEG. By analyzing EEG traces, Berger was able to identify oscillatory activity in the brain, such as the alpha wave (8–12 Hz), also known as Berger's wave.

Berger's initial soundtrack device was very elementary. He inserted silver wires below the scalps of his patients. These were later replaced by silver foils attached to the patients' head by rubber bandages. He connected these sensors to a Lippmann capillary electrometer, with inadequate results. More stylish measuring devices, such as the Siemens double-coil recording galvanometer, which displayed electric voltages as small as one ten thousandth of a volt, led to success. Berger analyzed the interrelation of alternations in his EEG wave diagrams with brain diseases. EEGs allowed completely latest possibilities for the research of human brain activities.

Nowadays there be a huge number of pioneering technologies that allow humans to interface among computers for the purposes of data entry, manage or communication. Most of the hard work over the years have been dedicated to the design of comprehensible and ergonomic systems to produce a more efficient and comfortable means of communication. Interfaces such as voice recognition, gesture recognition and other technologies based on physical movement have received enormous research attention over the years and successful examples of these technologies are being rolled out commercially as a consequence.

For those who have lost all voluntary muscle control, referred to as locked-in syndrome1, BCI technology offers the only means of communication or environment control. Locked-in syndrome can be caused, for example, by amyotrophic lateral sclerosis (ALS)2, brainstem stroke, mitochondrial disease, spinal-cord injury, traumatic-brain injury3 and even later-stage cerebral palsy. Despite these sufferers being completely physically paralyzed and unable to speak, they are however, cognitively intact and alert and thus have a need to communicate. It is estimated that in the order of one million people worldwide suffer from locked-in syndrome. It is this motivation that has inspired researchers to explore the opportunity of harnessing the intact brain signals of these people as a means of communication.

3.Feature of Brain Computer Interface

Following are the important features of BCI

3.1 Recording

BCI basically has following types of recording:

3.1.1 Scalp EEG

EEG means Electro Encephalograph.
In this type of recording there is no surgery to deal with, that is, it is totally non invasive. It deals with 0, 1-30Hz frequency. It requires approximately some square-cm of neurons. The electrode size is 4-10 mm. The user is required to wear a special type of cap which receives signals from the Brain and transform it to the computer, as a result reflecting your thoughts on computer. Moreover this type of technique though safe is not as useful as the effective transfer of signals is not possible due to thick bones which exist between cap and brain emitting signals [1].

Fig. 2.The cap which user wears during process

3.1.2 Multichannel Subdural Ecog

This is a bit invasive type of technique. It is more effective than SCALP EEG. It deals with 0, 1 to 90 Hz of frequency. It is effective in some square-mm thousands of Neurons. This undergoes a bit risk due to surgical in nature.

3.1.3 Multi-Electrode Intracranial Recording

This is most effective technique of all mention above. This technique is highly invasive and deals with multi-unit electrode to be inserted in the cranium of the candidate. This is highly risky as surgery deals with cranium and insertion of electrodes. The generator area is some thousands of neurons. Electrode size is say 100 electrodes glass 4*4 mm.

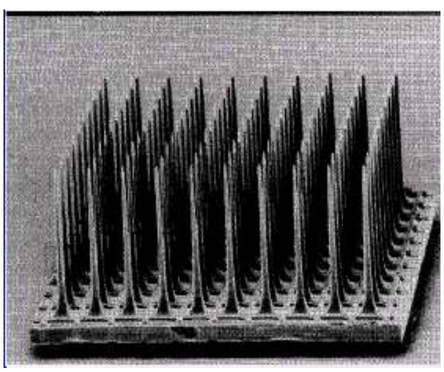

Fig. 4.An array of electrode

The implant is a hollow glass cone, the size of a ballpoint pen's tip, known as NEUTROTROPHIC ELECTRODE.

3.2 The Neutrotrophic Electrode Implantation Technique

In this implantation, the skull is drilled (a hole is made in the scale), and then the electrode is made to move inside. After that the connection of electrode is made with gold wire. Gold wire is used since it has got high conductivity. After taking out gold wire as connectors, the skull is mended using plaster of paris. Since this is highly invasive technique it involves the most amount of risk, also there are chances that body may consider the neutrotrophic electrode as unaccepted foreign body and the subject may suffer failure due to this problem. 12 percent success has been achieved in this area [1].

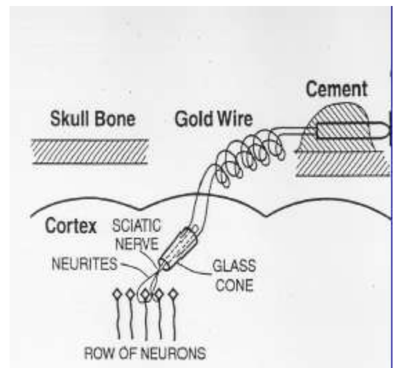

Fig.5 Implantation of electrode.

4.APPLICATION OF BCI

BCI has application in the following fields:

4.1 Using thoughts in aeronautics

A team of scientist at Armstrong lab, US are trying to harness brain power as a means of controlling aircraft systems. Experiments have revealed that the energy cerebral activity can be used to give commands like a change in direction of a plane. The technology may allow pilots to manage the huge amount of data they have to process. By installing better human – machine interfaces in the cockpit, stress on pilot can be lessened considerably, hence increasing efficiency and enhancing the flying performance**.**

Working

There is a device called Pilot situation estimator, which estimates position of the pilot. The other device called situation accesor is also present, both of which are sent to algorithms which carry out interfacing of the actions of pilot with the device which control plane in the cockpit.

ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013

Pilot can actually control the plane with the movements of eyes [2].

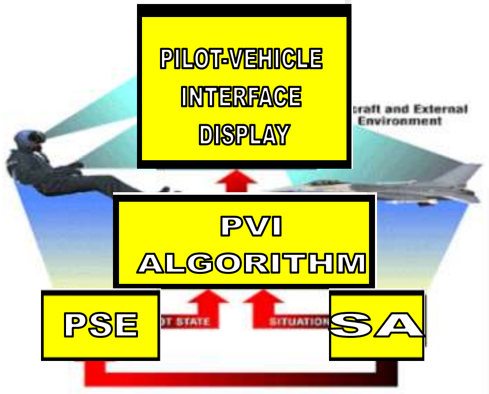

Fig 6.Pilot situation and state assessment to optimize performance**.**

4.2 Neuroprothesis

Researches are confident that the brain computer interface will one day transform the lives of severely handicapped people. It will provide them ways to interact with their environment, and they would be able to use IT enabled artificial limbs as easily as if they were there own. In the next decade, practical system for helping handicapped people communicate or even operate appliances is seen as distinct possibility. related technique, in which electrical signals to the muscles are detected and analyzed, is also being explored, to help the paralyzed operate artificial arms or legs [3]. The difference between BCIs and neuroprosthetics is mostly in how the terms are used: neuroprosthetics typically connect the nervous system to a device, whereas BCIs usually connect the brain (or nervous system) with a computer system. Practical neuroprosthetics can be linked to any part of the nervous system—for example, peripheral nerves—while the term "BCI" usually designates a narrower class of systems which interface with the central nervous system.

4.3 A Virtual Keyboard

A brain activated keyboard was developed by arranging letters of the alphabet in rows and columns that were displayed on computer screen. Rows and columns were then flashed one by one in random order. When either the row or column were flashed on the screen which contained the letter a person was thinking about, the person's brain would emit the informer signal.

Fig. 7.Working of virtual keyboard

By knowing the row and column, the computer then identified the letter user had thought about.

4.4 Virtual Reality

The signal from the brain is taken and given to BCI system. The BCI system process this thought and is interfaced with the applicant side i.e. Virtual reality system. This application helps you to convert your imagination and graphics i.e. visualization into graphics. You could be wherever you wish to be [3].

4.4.1 Using this application to come out of depression

Experiments were carried by the Californian University. They revealed that two person came out of depression by remembering the thoughts of their best golf shot which they played few years back, Isn't it interesting..[4]

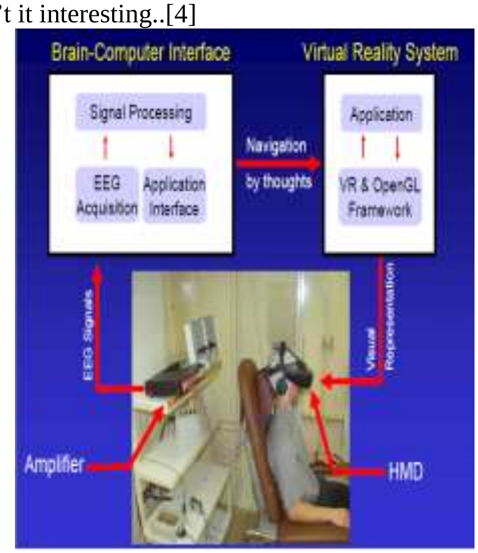

Fig.8. Interfacing with virtual reality system.

5. LATEST RESEARCHES

Researches are going on at present in various subfields of Brain-Computer Interface in Californian and Stanford Universities. One of the ongoing researches in this field is described below. A robotic arm has which has a moving shoulder and hook to hold food was constructed.

Fig. 9. A Robotic Arm

A monkey on which the experiment was to be carried out has its hands restrained. The robotic arm is loaded with food and the monkey is made excited to think about the food and it was not fed for 3 days. When monkey thought about food, then neurons fired signals to the robotic arm. The robotic arm had algorithm developed in it which decodes neural signals. Thus moved the robotic Arm towards monkey and fed it by thoughts.

Fig.10. A Monkey fed by thoughts

Another experiment which was carried out in University of California in 2001. In this experiment neurons were taken from a healthy person. Algorithms were developed which made these neurons to control the starring of the car in the initial stage. Later entire car was driven by these neurons for 55 Km at speed of 60 Km/hr using feedback mechanisms. This was a great day for achievements in the subject. [5]

6. VISION OF FUTURE

Many projects under the subject have been started by the well known universities of the world. This section discusses the two important projects which will bring revolution in the subject after their completion.

6.1 The Aware Chair Project

The Aware Chair Project uses a power wheel chair as a mobile platform for the context aware computing. The chair learns user's habits and provides emotional expressions. It is a context-aware intelligent power wheelchair which integratesen vironmental control, communication, and multilevel prediction based on context and user history. The communication and environmental control systems are informed by environmental sensors, user history, time of day, medical status, and other information in order to predictively narrow the selection space, thereby improving user performance. We are currently adapting the *Aware 'Chair* for neural control and incorporating word, sentence, and life-event prediction algorithms. A special feature of the aware chair is that it will be controlled neurally i.e. directly by the user's brain, by non-invasive (scalp electrode) EEG and the standard BCI2000 system. [6]

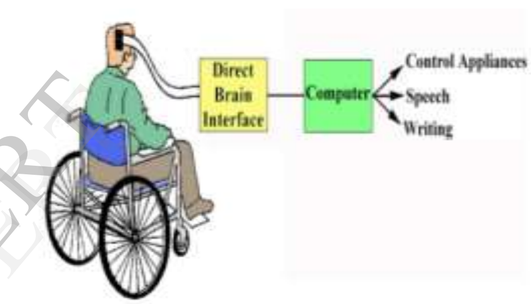

Fig.11 The Aware Chair

BCI 2000 SYSTEM

This system consists of software which is compatible with windows 2000/xp/nt.
The system uses different languages for example c++, Mat lab etc. C++ shows flexibility and hence help in movements of the chair, whereas mat lab proves to be a good tool in conversion of thoughts in real activated signals. [7]

6.2 Brain Trainer—Subject Training

The Brain Trainer project researches the most effective ways of teaching a person the brain-signal control needed to interact with a device. The Brain Trainer toolset allows researchers to compose trials by providing simple tasks, such as targeting, navigation, selection, and timing, that can be combined to produce an appropriate-level task for a particular subject. It also allows the researcher to incorporate different forms of visual and auditory biofeedback. Brain Trainer automatically instruments the resulting application for data recording such as error rates, speed, and accuracy of task performance. [8]

7. HURDLES TO FACE

There are pros and cons of every matter. Following are the points which highlights the problems in the development of BCI

1. The new techniques might not prove practical for computer control because they require machines that cost several hundred millions of rupees.
2. Reading magnetic brain signals requires a person to be in a special, magnetically shielded room and to wear a special helmet.

3. The effective BCI requires invasive techniques which always develops a risk.

Complete human-to-brain computer interaction, thus, still has to resolve many more glitches before it can hope to make science fiction a reality!

8. CONCLUSION

The key to moving BCI technology beyond the demonstration stage is to determine which methods of interaction are the most effective and to incorporate these into real-world applications. All of the applications and interaction techniques described have been tested with brain-signal emulation and offline data, which is sufficient for assuring correct functionality but not sufficient to draw conclusions about the efficacy of the user interface paradigms. Previously, researchers worked with invasive technique (neurotrophic electrode) locked-in patients [3], but their availability is very low due to illnesses and rapid fatigue. Therefore, they have expanded research agenda to include non invasive techniques, which will allow including other subject populations with disabilities and also able-bodied subjects. Researchers are in the process of addressing the following research questions.

1) What existing human-computer interaction paradigms are most adaptable for brain-signal control? Are there new paradigms that are even more effective?
2) What are the best mappings for control signals to interaction techniques or devices?
3) How can we compare the performance of different BCI systems for use with real-world applications? Can we develop benchmark? applications?
4) What are the best methods of feedback for neural control in a real-world scenario?
5) To what extent can assistive techniques such as prediction be incorporated into a BCI to increase performance?
6) How do we assess the usability of a BCI? What factors affect usability?

Solution to the above mentioned question will certainly convert fiction to reality.

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IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING, VOL. 11, NO. 2, JUNE 2003 165