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Brain-Computer Interface: Controlling Thoughts via Signals Acquisition

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ABSTRACT*:* After a set of successful experiments and recent studies it has been evident that monkeys and humans can use signals from the brain to guide the computer. Such an advancement has now been made possible using the Brain-Computer Interface (BCI). Allowing the users to communicate with others by using only brain activity without using peripheral nerves and muscles of human body is the concept that defines BCI. The Electroencephalogram (EEG) is used for recording the electrical activity along the scalp.

BCI can be defined as collaboration between the brain and a system or computer that uses the brain activity to convert them into signals and direct any system or device or an external activity. The functionality or the working of the brain is the only reason the BCI system works.

BCI thus holds a greater and unimaginable amount of potential today and in the coming future. Various advancements of greater heights can be achieved in various fields due to its functionality of enabling users to communicate and control devices with their thoughts.

KEYWORDS*:* Brain-Computer Interface (BCI), Electroencephalogram (EEG), Stroke.

I. INTRODUCTION

A direct communication between the computer(s) and the human brain is termed as Brain Computer Interface. It facilitates communication between the external device and the system by using signals measured from the brain. As it is known the main components of the central nervous system are Brain, spinal cord and peripheral ganglia. The entire functionality of brain is due to the presence of a large number of neurons which amounts to about 100 billion. Every movement, reaction and every other activity categorized with the human body is controlled and is due to these neurons and its composition.

When many of ions present in the neuron are pushed out of them, they can push their neighbors, who push their neighbors and so on which appear to take a form of a wave. When the wave of ions reaches the electrodes of EEG on the scalp, they can push and pull electrodes on the metal on the electrodes.

II. BRAIN-COMPUTER INTERFACE

BCI can be defined as collaboration between the brain and a system or computer that uses the brain activity to convert them into signals and direct any system or device or an external activity. The functionality or the working of the brain is the only reason the BCI system works.

A communication medium between the brain and the computer system is provided and made possible by the BCI. An electrochemical impulse which produces movement, expression and words helps in the communication of 100 billion neurons. The changes in the electrophysiological signals are seen due to various mental activities. BCI detects such changes and transforms such activities into a control signal which acts a mediator for the communication to take place between the system and the brain.

BCI has been a boon in the medical field by enhancing the possibility of communication for people with severe neuromuscular disorders, such as Amyotrophic Lateral Sclerosis (ALC) or spinal cord injury. Not just has it shown advancement in medicine but, it is widely used in various other applications such as for multimedia applications: for making gaming instruments.

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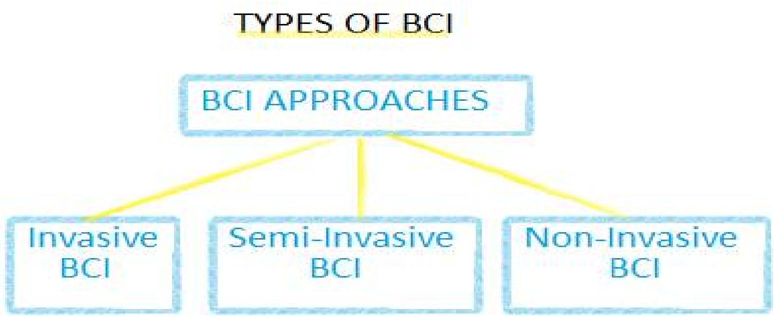
III. TYPES OF BCI

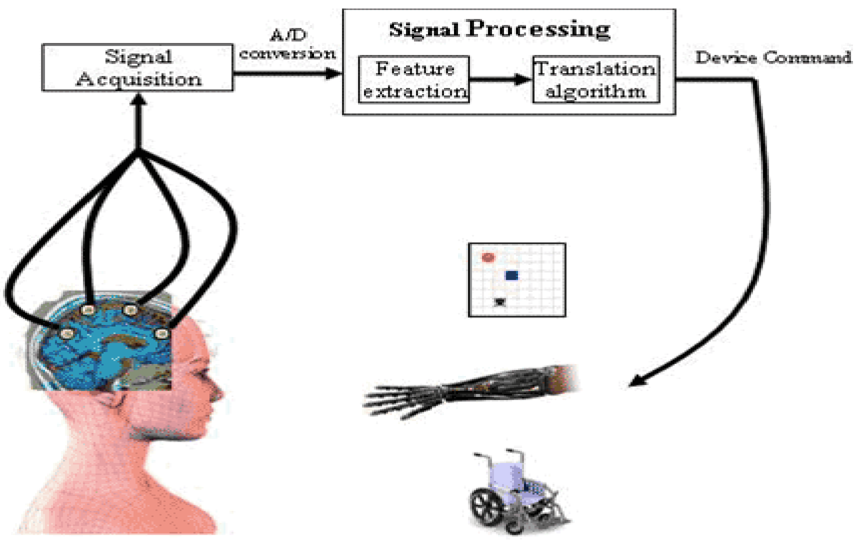
There are mainly two types of BCI:
a) Invasive and b) Non-invasive.
BCI which involves a surgery to implant electrodes on or near the surface of the brain is termed as invasive.
On the contrary, a BCI system which uses electrodes usually in a cap placed on the scalp is termed as non-invasive.
Although most currently used non-invasive systems require the use of conductive gel which must be wiped after use they still cause a little discomfort. The first non-invasive neuroimaging technique discovered was EEG. EEG is used for measuring the activity of the brain. Considering the ease of cost, its usage and the high temporal resolution, it is widely used presently.



IV. HOW DOES THE BCI WORK?

BCI acts as an interfacing platform between the brain and a device. It is a computer- that acquires brain signals. Once the required signals are acquired they are analyzed and then translated into commands that are relayed to an output device. The output device then carries out the desired action. Thus, BCI's do not use the brains but the signals generated by normal output pathways of nerves and muscles.

A BCI system consists of three components:
a) Signal or Data Acquisition
b) Signal Processing
c) Output Device



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The above diagram depicts and describes the entire process right from the signal acquisition from the human brain to processing it and finally converting it to a command.

V. APPLICATIONS

In this paper the main concentration as a part of application has been made in the medical field i.e., BCI showing significant advancement to the patients with brainstem (Locked-in syndrome) stroke or paralysis.
Locked-in syndrome (LIS) is a condition where a person is aware
of the surrounding but unable to move any muscles or communicate verbally due to complete paralysis of nearly all voluntary muscles in the body other than eyes. With sensors positioned on the scalp to monitor brain activity, a common brain response called P300 was hinged. BCI randomly produces or flashes numbers and letters and when the user focuses on the key a P300 occurs and that signal is converted to a command and compiles the words the patient wished to communicate.

Paralysis or stroke: In a stroke patient they have had an injury to one side of their brain that causes their hand to be paralyzed. So using BCI a signal from the uninjured side of the brain is taken and that signal is decoded as an intention to move. That thought of wanting to move is then converted into a machine command which is sent to a computerized exoskeleton device that moves the patient's hand.

VI. FUTURE HOLD FOR BCI

BCI technology is constantly changing. It is said the hardware will improve with wireless electrodes and with dry electrodes that eliminate the need to apply gel over the scalp. New options for typing and speaking messages are few of the many improvements that are to be seen in the software side.
Some applications like flying an airplane just by thinking, a blind driving a vehicle etc. will be coming to reality. It is said that in the coming years the robotic devices can be replaced thereby directly passing the signals to the nerves in the damaged part of the brain, and allowing the paralyzed patient to move their body.
Last but not the least, development in BCI can bring out drastic and attractive changes to the society.

VII. CONCLUSION

The current explosion of neuroscience research and neuro-technologies provides the opportunity to provide computers predictive capabilities for the emotional and cognitive states and processes of the people using them, potentially revolutionizing not only interfaces, but also the basic interactions people have with these
systems. The development of BCI technologies over the coming decades will have to overcome a number of obstacles.

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