BRAIN – MACHINE INTERFACE

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Abstract-BMI stands for brain machine interface which is a communication system that does not depend on the brain's normal output pathways of peripheral nerves and muscles. Infact, it is a new communication link that connects human brain with the outside world. They interface or connect with the brain to send and receive signals from it. Brain's integration with peripheral devices and systems could help in controlling, actuating and communicating with the outside world that could be achieved with the help of BMI. The implants are used to take signals from the brain to the computer without any direct brain intervention. Using the bioelectrical brain activity BMI transforms mental decisions or reactions into control signals.
The most vital function of brain machine interface study is to provide a way for people with damaged sensory functions so that they could use their brain for controlling artificial devices thus restoring their lost capabilities.

Keywords-Nerves, muscles, implant, paralysed, electro-encephalography, drastic

I. INTRODUCTION

Imagine the day we will be able to download vast amounts of knowledge directly to our brain which could help us avoid the task of learning everything from scratch. Instead of paying huge amount of money to the university we could pay to obtain "knowledge implant" and hence be able to obtain an ocean of knowledge and expertise in various fields at a tender age. Robotics and artificial intelligence are the high end computing and intelligent interfaces. In the near future, most devices would be remote/logically controlled. Researchers are working on neural interfaces, which could be helpful to mesh our mind with machines. The things we see in sci-fi movies could impact our lives in number of ways if brought into reality.BMI which is nothing but the Brain-Machine Interface is a communication system, which permits the user to control special computer applications by using only his/her thoughts. It could enable the human brain to accept and control a mechanical device as a part of the body so that data can flow from brain to the outside machinery, or vice versa. Different research groups have devised different methods to achieve this. Most of these methods are based on electroencephalography (EEG) that is recorded from the scalp. Our ultimate goal is to create a system that will allow a patient with severely damaged sensory nerves to activate outside mechanisms just with the help of brain signals. The first implantable brain machine interface was developed by Cyber kinetics Inc., which is a leader in neurotecnology. It could reliably interpret brain signal and perhaps read decisions made in brain to develop a quick, dependable, & unobtrusive connection between the brains of severely disabled person to a personal computer.

II. SUBJECT DETAILING

A. BMI (Brain Machine Interface)

A Brain Machine Interface provides communication path from a human's brain to a machine, which does not depend upon normal human output pathways. It give machine like capabilities to intelligence, asking the brain to accommodate synthetic devices, and learning how to control those devices much the way we control our arms and legs today. This has given hope that people with spinal injuries will be able to use their brain to control a bionic limb, even their own arm. A BMI i.e. Brain machine interface could allow a paralysed patient to Conway his/her intensions to a computer program. But also application in which healthy user can benefits from the direct brain computer communication are conceivable, e.g. to speed reaction time. Initially these interactions are with peripheral devices, but ultimately it may be interaction with another brain. Our approach bases on an artificial neural network that differentiate and classifies different brain activity patterns associated with carefully. Using BMI, electrical signal from computer can stimulate the brain tissue in order to transmit some particular sensory information.

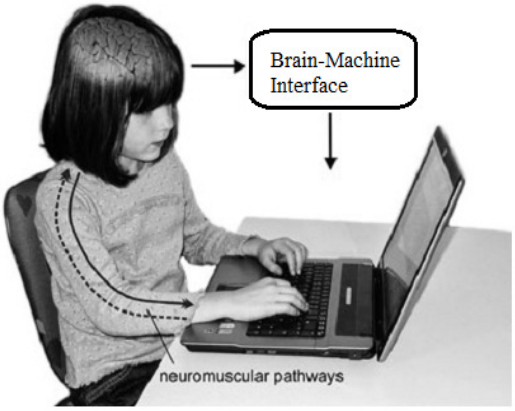

Fig 1: A BMI bypasses the normal neuro-muscular output channels

B. The Human Brain

Among all living organism undoubtly, the human brain is the most complex organ found among the carbon-based life forms. It is so complex that we have only vague information about how it does works. The average human brain weights around 1.4 Kg. The most relevant part of the brain concerning BMI's is the cerebral cortex. The cerebral cortex can be divided into different hemispheres. The hemispheres are connected together via corpus callosum. Further hemisphere can be classified into four lobes namely frontal, parietal, and occipital and temporal lobes. Cerebral cortex is responsible for many higher order functions like problem solving, language comprehension and processing of complex visual information. The cerebral cortex can be divided into several areas, which are responsible of different functions. Using this information BCI's uses the pattern recognition approach. Different mental tasks are then chosen in such a way that they activate various parts of cerebral cortex.

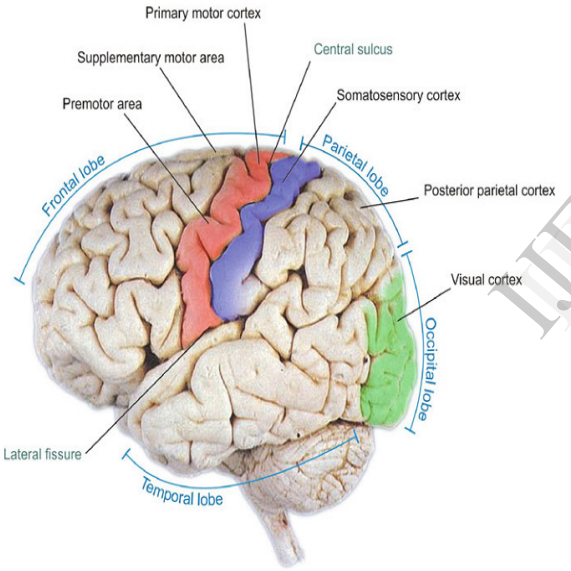

Fig. 2: The cerebrum is subdivided into four lobes: frontal, parietal, occipital, and temporal lobe. The central sulcus divides the frontal lobe from the parietal lobe.

C. MAIN PRINCIPLE

The basic principle behind this interface is the bio-electrical activity of the muscles and nerves which are present in the human brain. We know that human body, which have a large number of living tissues, can be considered as a power station for generating multiple different types of electrical signal with two internal sources, namely nerves and muscles.

As we know that the brain is the very important part of human body. It controls all the functions & emotions of the human body. The brain consists of millions of neurons. All these neurons works together in complex logic which produce signals & thought that control our bodies. When the neurons fires, or activates, there is voltage change across the cell, which is approximately 100mv that can be read through a variety of devices. When we want to make a voluntary or any other action, the command is generated by the frontal lobe. Signals are generated on the surface of the brain. These electric signals are different in magnitude and frequency.

We can understand the working of brain by monitoring and analysing these signals. When we imagine or think ourselves doing something, small signals generates from different parts of the brain. These signals have a very low amplitude & frequency that they cannot travel down the spine and cause actual movement. But these small signals are measurable. A neuron depolarises to generate an impulse which causes small changes in electric field around the neuron. These changes are measured as 0 (no impulse) or 1(Impulse generated) by the electrodes. We can control the brain functions by producing artificially these signals and sending them to different parts. This can be achieved through stimulation of that part of the brain, which is responsible for a particular function using implanted electrodes.

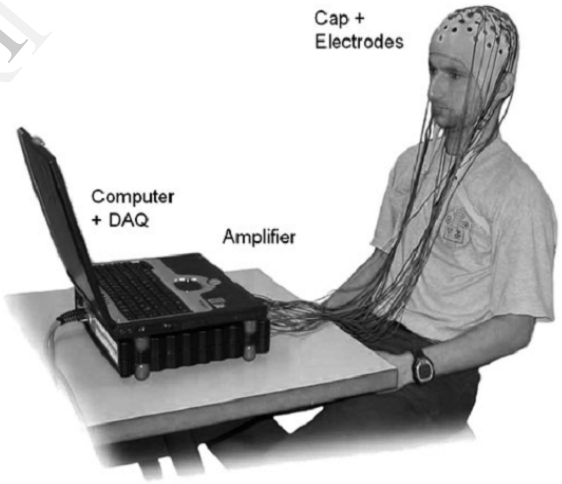

Fig. 3: A Electro-Encephalography (EEG) based BMI consists of an electrode cap with electrodes, cables for transmitting signals from the electrodes to the bio signal amplifier which converts the brain signals from A to D format, and a computer that processes the data as well as controls and often even runs the BMI application.

D. ELECTROENCEPHALOGRAPHY

Electroencephalography is the neurophysiologic measurement of the electrical activity of the brain by recording from electrodes placed on the scalp or, in special cases, subdurally or in C cerebral cortex. The resulting traces are known as an electroencephalogram (EEG) and represent an electrical signal (postsynaptic potentials) from a large number of neurons. These are sometimes called brainwaves, though this use is discouraged. The EEG is a

brain function test, but in clinical use it is a gross correlate of brain activity. Electrical currents are not measured, but 1 rather voltage differences between different parts of the brain. Several types of electrodes may be used to record EEG. These include: Peel and Stick electrodes, Silver plated cup electrodes and Needle electrodes. EEG electrodes are smaller in size than ECG electrode. They may be applied separately to the scalp or may be mounted in special bands, the peak-to-peak amplitude of the waves that can pick up from the scalp is normally 100microV or less while that on the exposed brain, is about 1mV. The frequency varies greatly with different behavioural states. The normal EEG frequency content ranges from 0.5 to 50 Hz. Frequency information is particularly significant since the basic frequency of the EEG range is classified into five bands for purposes of EEG analysis. These bands are called brain rhythms and are named after Greek letters. Most of the brain research in concentrated in these channels and especially alpha and beta bands are important for BCI research. The reason why the bands do not follow the Greek letter magnitude (alpha is not the lowest band) is that this is the order in which they were discovered.

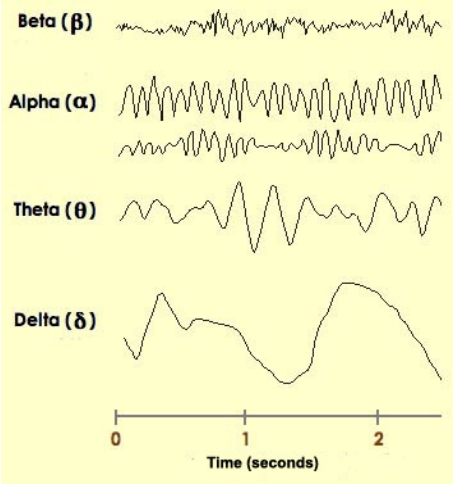

Fig. 4: Different wave-forms generated by human brain.

E. BMI APPROACHES

What are the different thoughts think by the user in order to control a BMI? An ideal BMI should be able to detect the user's wishes & commands directly. Unfortunately, this is not possible with today's modern technology. Therefore, to design BMI applications, researches have used the knowledge they have had of the human brain and the EEG. There are basically two different methods that have been used in order to design BMI. The primary one called a pattern recognition approach which is based on cognitive mental tasks. The second one is called as an operant conditioning approach which is based on the self-regulation of the EEG response.

In the first approach, the subject is made to concentrates on a few mental tasks that produce different EEG patterns. The BMI can then be trained to classify these patterns.

In the second approach, the user is made to learn how to self-regulate his/her EEG response, for e.g. changing the beta rhythm amplitude. Unlike in the pattern recognition approach, the BMI itself is not trained but it looks for particular changes (for example higher amplitude of a certain frequency) in the EEG signal. This requires usually a long training period, because the entire training load is on the user.

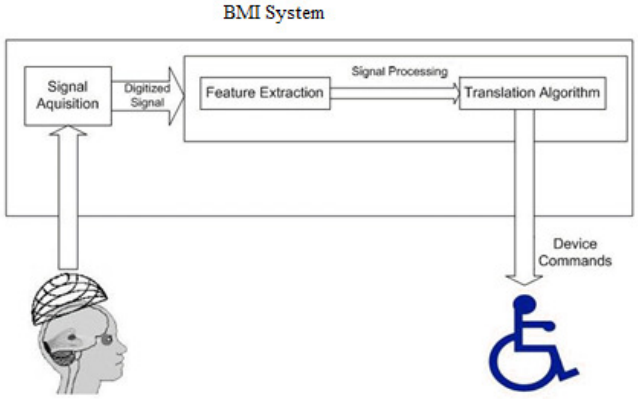

Fig. 5: BMI System

F. BLOCK DESCRIPTION

The BMI consists of several components:

1. The implant device, or chronic multi-electrode array,
2. The signal recording and processing section,
3. An external device the subject uses to produces and control motion and
4. Feedback section to the subject.

The first component is an implanted array of microelectrodes into the frontal and parietal lobes—areas of the brain involved in producing multiple output commands to control complex muscle movements. This device record action potential of individual neurons and then represent the neural signal using a rate code. The second component consists of spike detection algorithms, neural encoding and decoding systems, data acquisition and real time processing systems etc. High performance DSP architecture is used for this purpose. The external device that the subject uses may be a robotic arm, a wheel chair etc. depending upon the application. Feedback is an important factor in BCI's based on the operant conditioning approach, feedback training is essential for the user to acquire the control of his or her EEG response. However, feedback can speed up the learning process and improve performance.

III. ADVANTAGES

Depending on how the technology is used, there could be good as well as adverse effects that are listed below:

1. If developed to its full potential it would drastically reduce the deadly diseases that are getting common in this era.
2. Also it could provide a better living with more features and more advancement in technologies etc.

3. It would lead to the creation of superhuman just by linking people via chip implants to super intelligent machines.
4. Such a linking could help gain immediate access to the internet, enabling phenomenal math capabilities and computer memory.

IV. CHALLENGES

There are two sides of a coin which means that if there are advantages there has to be some challenges to it too. Some of these challenges have been mentioned in the following paragraph:
1. Connecting the brain to the nervous system could lead to permanent damage that could lead to loss of feelings or movement as well as continual pain.
2. without feelings and emotions how will we are called humans.
3. With virus attacks brain could be severely damaged.

V. APPLICATIONS

The BMI technologies of today can be broken into three major areas. They are

- Auditory and visual prosthesis
- Functional-neuromuscular stimulation (FNS)
- Prosthetic limb control

1. Auditory and visual prosthesis
-Cochlear implants
-Brainstem implants
These implants could provide a deaf person with the sense of hearing.
-Synthetic Vision that could provide clear and intuitive means of understanding our external environment.
-Artificial silicon retina that could act as the eyes for the blind person.
2. Functional-neuromuscular stimulation (FNS)
-FNS system is in experimental stages and is used in the cases where spinal cord damage or a stroke has served the link between brain and the peripheral nervous system (PNS). They can use signals received from brain to control their own limbs by this system.
3. Prosthetic limb control
-Thought controlled monitories wheel chair that could mobilize a disabled person just with his thoughts.
-Thought controlled prosthetic arm for amputee that could act as his arms as he wants to.
-Large number of neuroprosthetic devices

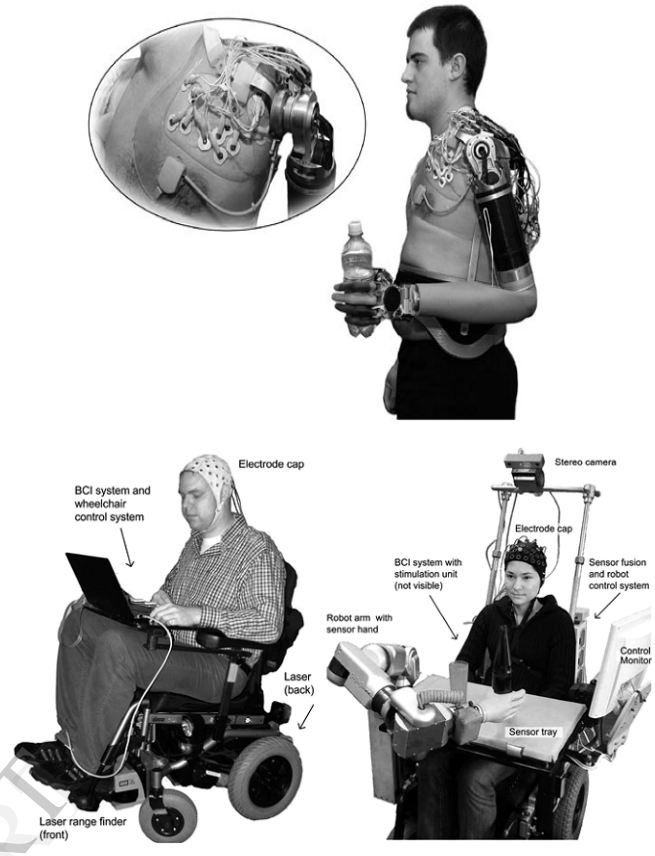

Fig 6: Practical application of BMI

VI. CONCLUSION

Human life is of utmost value regardless of diverse ethics, individual liberties and is above machines. What happens when humans integrate with machines? The question is not how computers will be in the future, but instead, what we, the human beings, will be like?
BMI's can provide the disabled with the ability to see and hear. It can also change a person's outlook of the world. In future these devices might get more common than keyboards. The possible questions that could arise that, is someone with a synthetic eye, less a person than someone without? Coming years could see the rise of such technologies that could make humans to process signals like ultraviolet, X-rays or ultrasounds as robots do. Such a day will open a new chapter in the history of human civilization.

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