IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Human Brain to Computer - Communication for disabled with E-Interface

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Abstract

Brain is the place where we think and feel. When a particular area of the brain works harder than the arteries supply more blood to that part of brain. Medical scanners are used to observe the changes in blood transit in the brain. Using this technique, we can actually study how does brain work. A single brain cell is called neuron and it is a tiny building block of the brain. The brain has 100 billion of such neurons and is responsible to fire an electrical impulse that prompt our thoughts. These electrical signals can be captured and converted into actions to help disabled people to deal with their troubles and obstacles in daily life. It is established by the use of Brain Computer Interfaces this miracle would be achieved. This paper deals with how a human brain can control the computational devices and this revolution would help robotics domain and disabled people to get timely assistance with mini physical efforts.

Keywords: Brain computer interface (BCI), Magnetic Resonance Imaging (MRI), Neurons, E-governance, Magneto-Encephalography (MEG).

Introduction

According to 2012 census, there are about 71 million disabled people in India. One in every ten children is disabled and 3% of the country's total child population falls in this category. The government itself admits that of the total disabled population, only 2% are educated and 1% employed. Yet, no great attempt is being made to give physically challenged people a better world. Initially Magnetic Resonance Imaging (MRI) was used to visualize the internal body structures of the patient. It helped in detecting the problem of disability. Then came Brain Computer Interfaces (BCI) asshown in figure 1 and 1A. The first and most common technology picks up brain signals. Whereas a new technology has also come up which is called as magneto-encephalography (MEG).It provides more accurate signals when compared to signals picked up by electroencephalography (EEG). So when it comes to e-governance the sole purpose of introducing this concept is to throw a light on whether we can implement such designs that bridges the gap between the users and technology. And the answer to that question is obviously yes, We can! This will lead to development of a society that respects the contribution of each individual[2].

Human Brain

Every living being we think off -- mammals, birds, reptiles, fish, and amphibians has a brain.

However, the human brain is distinctive. It gives us the power to speak, solve and problem imagine. It is truly an amazing organ. It has 100 billion neurons. how many mega byte should a human brain should store(probably more than 2mega byte) our brain are much more complex than a external hard drive.

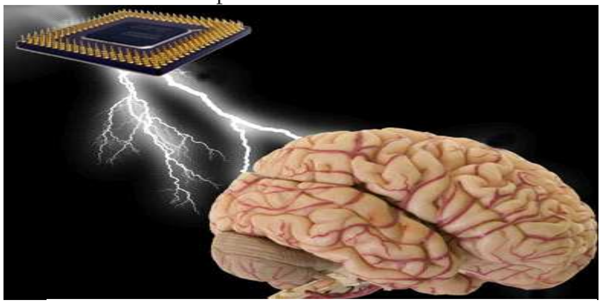

Figure 1:Symbolic representation of brain interfacing with the hardware chip technology.

The brain performs an incredible number of tasks including the following. It controls body temperature, blood pressure, heart rate and breathing. It accepts a flood of information about the world around you from your various senses seeing, hear, tasting and touching) It handles your physical movement when walking, talking, standing or sitting It lets you think, dream, reason and experience emotions.

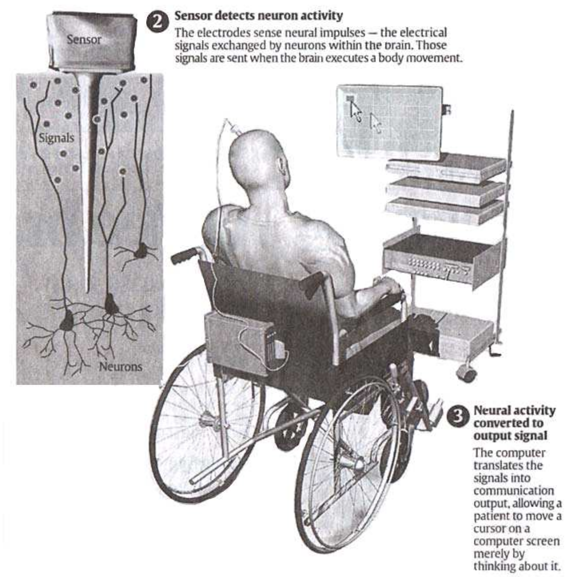

Figure 1A: A practical scenario of BCI Implementation

Magnetic Resonance Imaging (MRI)

If you put a human in a magnetic field then there is tendency of that magnetic field to line up the movements of the nuclei or spin of nuclei and hydrogen in the body, which is in the blood and muscle. Then place a radio frequency pulse says 60-mega hertz or something like that and makes this magnetization of hydrogen nuclei u turning it 90 degrees away from the direction of magnetic field. If you have coils put around the magnetic field they could induce signals. Then we can make out where the signal is coming from and also to accomplish that we put another magnetic field on top of the very homogeneous magnet. It will help determine where the signal is stronger and weaker. This can be represented in fourier series and get an MRI image. By using gradients in different directions, 2D images or 3D volumes can be obtained in any arbitrary orientation.

How MRI is Used?

Consider if researchers are attempting to implant electrodes that will allow someone to control a robotic arm with their thoughts, they will first put the subject into an MRI and ask him or her to think about moving their actual arm. The MRI will show which area of the brain is active during arm movement, giving them a clearer target for electrode placement.

Brain-Computer Interface-BCI

BCI works with Collaboration of neurology, biology and Computer Science. An amazing accomplishment is possible to access the devices either a computer or a robotic arm brain computer interfaces. Imagine transmitting signals directly to someone's brain that would allow them to see, hear or feel specific sensory inputs. In the present era, the potential to manipulate computers or machinery is just not more than a thought. This concept is quite possible and could be a marvel for severely disabled people thus development of a brain-computer interface (BCI) could be the most important technological advancement. BCI can have multiple applications across variety of fields both medical and non medical. The classification is shown for medical and non medical BCI usage in figure 2.

Medical

In medical field it can be used as communication and device control, motor substition, Motor recovery. When it comes to entertainment it has no limit.BCI can provide solution to situational disability circumstances such as astronauts and surgeons, to improve cognitive functions (improving attention, working memory, executive functions etc) also.

Non-Medical

BCI can influence society at different levels such as Gaming, virtual reality environment, biometric identification for security or even commercial purpose, control of smart homes, robot control and entertainment and health or security .

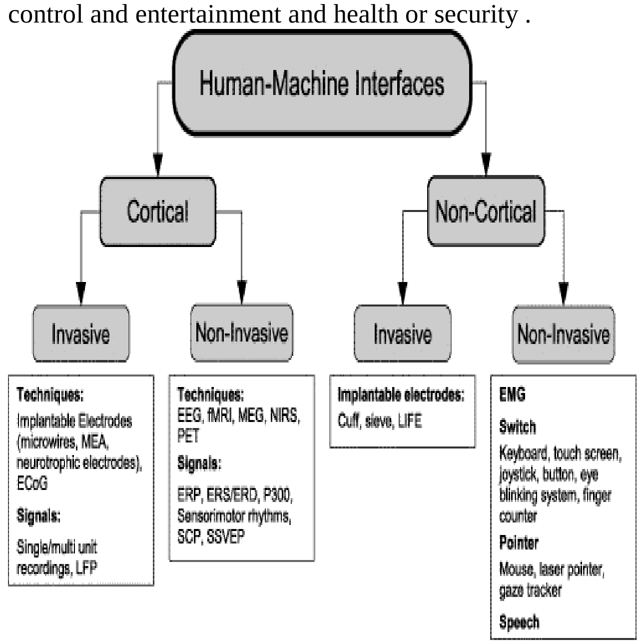

Figure 2. Classification of BCI and its Taxonomy

The Electric Brain System

Brain computer interface paves the way for treatment of severe paralysis situation also. This device fits under a scalp. You read a letter and it will read out that letter for you and resemble a video game. For paralyzed case, it could be used to

ISSN: 2277-9655

communicate with the outside world. For auto industry, a sleep warning system device used to determine whether a person is falling asleep while driving. The reason a BCI works at all is the way our brains function. Our brain is filled with neurons, individual nerve cells connected to one another by dendrites and axons. Every time we think, move, feel or remember something, our neurons are at work. That work is carried out by small electric signals that transfer from neuron to neuron .The signals are generated by differences in electric potential carried by ions on the membrane of each neuron. Although the paths the signals take are insulated by something called myelin, some of the electric signal escapes. Scientists can detect those signals, interpret what they represent and use them to direct a device of some kind. It can also work the other way around as shown in the figure 3 and 3A.

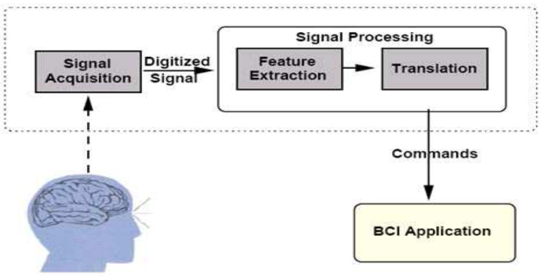

Figure 3: BCI Architecture

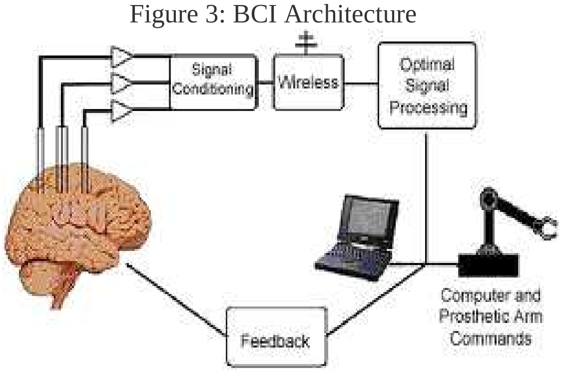

Figure 3A: BCI Implementation

As shown in figure 1A the basic mechanism is that the electrodes measure tiny differences in the voltage between neurons. The signal is then amplified and filtered. In current BCI systems, a computer program then interprets it. In the case of a sensory input the BCI function happens in reverse[1]. A computer converts a signal, such as one from a video camera, into the voltages necessary to trigger neurons. The signals are sent to an implant in the proper area of the brain, and if everything works correctly, the neurons fire and the subject receive a visual image corresponding to what the camera sees. A device known as an electroencephalograph (EEG) is attached to the human scalp. The electrodes can read brain signals. To get a higher-resolution signal, scientists can implant electrodes directly on the surface of the brain, beneath the skull. This allows for much more direct response of electric signals and allows electrode placement in the specific area of the brain where the appropriate signals are generated. This approach has many problems, however. It requires surgery to implant the electrodes. However, it would work.

Sensory Input

The most common and oldest way to use a BCI is a cochlear implant. For the average person, sound waves enter the ear and pass through several tiny organs that eventually pass the vibrations on to the auditory nerves in the form of electric signals. If the mechanism of the ear is fatally damaged, that person will be unable to hear anything. However, the auditory nerves may be functioning perfectly well. They just aren't receiving any signals.

A cochlear implant bypasses the non-functioning part of the ear, processes the sound waves into electric signals and passes them via electrodes right to the auditory nerves. The result: A previously deaf person can now hear. He might not hear perfectly, but it allows him to understand conversations. The processing of visual information by the brain is much more complex than that of audio information,. Electrodes are implanted in or near the visual cortex, the area of the brain that processes visual information from the retinas[3]. A pair of glasses holding small cameras is linked to a computer and, in turn, to the implants. After a training phase similar to the one used for remote thought-controlled movement, the subject can see. Again, the vision isn't perfect, but refinements in technology have improved it tremendously since it was first attempted in the 1970s. Jens Naumann was the recipient of a second-generation implant. He was completely blind, this process gets very close. The Next Generation television show and films, and they're both essentially the same technology. However, Naumann isn't able to "see" invisible portions of the electromagnetic spectrum.

Steps Involved in BCI

Step 1. Implant a tiny sensor in the surface of brain
Step 2. It pick up the electrical impulses from a bunch of neurons and each of those
Step 3. Neurons are like a radio broadcast towers putting around impulses-record the signals
Step 4. Conversion of signals into commands

Cortical plasticity

Early 1990s, research showed that the brain actually remains flexible even into old age. This concept is known as cortical plasticity, means that the brain is able to adapt in amazing ways to new circumstances as shown in figure 4. Learning something novel or contributing in novel activities forms new connections between neurons and reduces the onset of age-related neurological problems. If an adult undergo a brain injury, other parts of the brain are able to take over the functions of the damaged portion. It means that an adult can learn to operate with a BCI, their brain forming new connections and adapting to this new use of neurons. In situations where implants are used, it means that the brain can contain this seemingly foreign infringement and develop new connections that will treat the implant as a part of the natural brain.

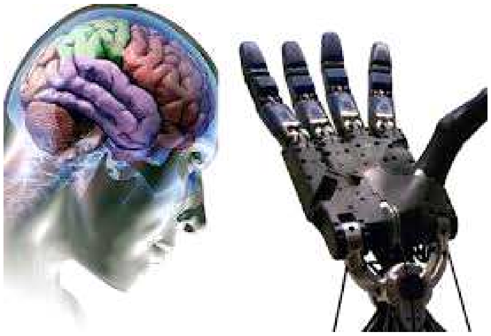

Figure 4: Cortical Plasticity

Early research used monkeys with implanted electrodes. The monkeys used a joystick to control a robotic arm. Scientists measured the signals coming from the electrodes. Eventually, they changed the controls so that the robotic arm was being controlled only by the signals coming form the electrodes, not the joystick[5]. A more difficult task is to understand the brain signals for movement in someone who cannot physically move their own arm. With an EEG or implant in place, the subject would visualize closing his or her right hand. Software connected to a robotic hand is programmed to receive the close hand signal and interpret it to mean that the robotic hand should close. At that point, when the subject thinks about closing the hand, the signals are sent and the robotic hand closes. A similar method is used to manipulate a computer cursor, with the subject thinking about forward, left, right and back movements of the cursor. With enough practice, users can gain adequate control over a cursor to draw a circle, access computer programs and control a television.

Magneto Encephalography(MEG)

Electroencephalography (EEG) --where electrodes are placed against the scalp are used to pick up brain signals. the approach is not nearly as accurate as direct neural contact and can only pickup weak readings. The other, much newer, and much more accurate non-invasive technology is magneto encephalography (MEG) but is also more equipment intensive. Using MEG requires a room filled with super-conducting magnets and giant super-cooling helium tanks surrounded by shielded walls[6]. This technology, while providing the speed and accuracy needed for a successful non-invasive BMI that is Brain machine interface, will require significant improvement of technology in order to be realistic for everyday use. Let's consider the following case Studies for better understanding of how Brain computer interfaces perform amazing job of converting our thoughts into action:

1. A person blind learns to 'see' with his tongue(3years ago)-At first an inch-long camera hidden in sunglasses sends image to a handled control unit. Then the control unit converts the image into a low resolution black, white and grey picture. Next Image recreated on a grid of 400 electrodes. Each one pulses according to how much light is in that area of the picture. after that User 'feels' the shape and detects movement on the tongue. so brain eventually learns to 'see' the shape detected on tongue.
2. Man see's with bionic eye-pretty much anyone who loses an eye will make a joke atleast i should make a camera put in there! It's not an out of this world concept.
3. Controlling a computer cursor via mental commands would represent a revolutionary improvement in quality of life

Area Of Application And Future Scope

Medical Phosthesis: When nerves are no longer available their thoughts could be used to do the work they wish. if think of a letter it will read will read out for them. Gaming & Entertainment: BCI can enrich the gaming and entertainment experience by thought.

Human State Monitoring Automobiles: Could alert sleepy drivers. It is also called as sleep warning system Scientific Research As Bci Can Monitor The Acting Brain In Real Time And In The Real World, It Seems It Will Lead To More Amazing Inventions Teaching And Training : It can also be used for the purpose of improved methods of teaching and training Cognitive Improvement : It's a common nonmedical application involving a BCI is neuro feedback training, in which operant conditioning alters brain activity to improve attention, working memory, and executive function Safety and Security: In order to implement safety and security image inspection might be faster than is possible by current methods available today[4].

Conclusion

Based on the above it is evident that now disabled can do things they wished to do independently for so many years. Its an amazing accomplishment for them. and they are extremely proud of it. Development of a brain-computer interface (BCI) could be the most important technological breakthrough in the upcoming decades. However, there are exists still some hurdles that will need to be addressed in this area include i.) What kinds of signals would be most efficacious for cognitive prostheses? And how can the current research on cognitive prosthetics in highly trained monkeys be generalized for use in human patients? Another interesting research direction is the use of multiple types of signals simultaneously. It could be advantageous to combine spikes and LFP recordings since they may represent different types of information:

Future directions in this area are:

i) Which spatial scales (single units, multi-units, local field potentials, or electrocorticography), are the most useful for different BCI applications? Additional studies should be performed where data are recorded via different invasive modalities simultaneously.

ii) How can recordings at these different spatial scales be optimally combined? Finally, whereas plasticity was previously posed as a problem in the new era of robust BCIs. The findings and study of this paper would be a good comprehension for the readers and research working on BCI applications and related products.

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