HUMAN COMPUTER INTERACTION

AkhileshBhagwani per 1st Affiliation (*Author*), ChitranshSengar per 2nd Affiliation (*Author*), JyotsnaTalwaniper 3rd Affiliation (*Author*), Shaan Sharma per 4th Affiliation (*Author*)

[1](1st Affiliation) Computer Science and Engineering, Dronacharya College of Engineering,Haryana, India;
Email:akhilesh.bhagwani@gmail.com
[2](2nd Affiliation) Computer Science and Engineering, Dronacharya College of Engineering,Haryana, India;
Email: Chitransh.sengar@gmail.com
[3](3rd Affiliation) Computer Science and Engineering, Dronacharya College of Engineering,Haryana, India;
Email: joshu.talwani@gmail.com
[4](4th Affiliation) Computer Science and Engineering, Dronacharya College of Engineering,Haryana, India;
Email: shaanstg@gmail.com

Abstract

The paper basically deals with the study of HCI (Human computer interaction) or BCI(Brain-Computer-Interfaces) Technology that can be used for capturing brain signals and translating them into commands that allow humans to control (just by thinking) devices such as computers, robots, rehabilitation technology and virtual reality environments. The HCI is based as a direct communication pathway between the brain and an external device. BCIs are often aimed at assisting, augmenting, or repairing human cognitive or sensory-motor functions.
The paper also deals with many advantages of BCI Technology along with some of its applications and some major drawbacks.

Index Terms-
Brain–computer interfaces (BCI), Magnetic Resonance Image (MRI), Electroencephalography (EEG), Brain Machine Interface (BMI)

1. INTRODUCTION

ASthe power of modern computers grows alongside our understanding of the human brain, we move ever closer to making some pretty spectacular science fiction into reality.Imagine transmitting signals directly to someone's brain that would allow them to see, hear or feel specific sensory inputs. Consider the potential to manipulate computers or machinery with nothing more than a thought. It isn't about convenience -- for severely disabled people; development of a **brain-computer interface** (BCI) could be the most important technological breakthrough in decades.Brain–computer interfaces (BCI) allow control of computers or external devices with regulation of brain activity alone

The interface enables a direct communications pathway between the brain and the object to be controlled.

2. WHAT DOES IT REALLY MEAN
2.1 History

The history of Brain-Computer-Interfaces (BCI) starts with Hans Berger's discovery of the electrical activity of human brain and the development of electroencephalography (EEG). By analyzing EEGs Berger was able to identify different waves or rhythms, which are present in a brain, as the Alpha Wave (8 – 12 Hz), also known as Berger's Wave. Berger analyzed the interrelation of alternations in his EEG wave diagrams with brain diseases. EEGs permitted completely new possibilities for the research of human brain activities. However in 1970, The Advanced Research Project Agency (ARPA) of the government of the United State of America became interested in this field of research as they had the vision of increasing the performance of mental high load tasks by enhancing human abilities with artificial computer power.
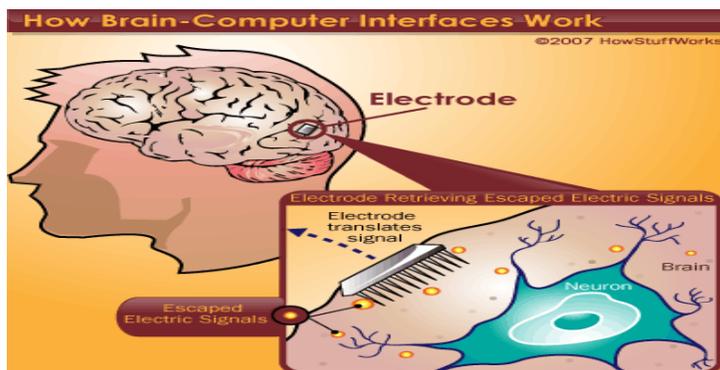
2.2 EXPERIMENTAL TESTS

The first experiments were conducted with animals more precisely on primates. Work groups led by Schmidt, Fetz and Baker found out that monkey could get control over the fire rate of individual neurons in the primary motor cortex, which is responsible for executing voluntary movements after a short period of training time. The first wireless intracortial brain-computer interface was built by Philip Kennedy and his colleagues by implanting neurotropic cone electrodes into monkey brains.

One of the first persons who benefit from all the years of BCI research is Matt Nagle. In 2004 an electrode array was implanted into his brain to restore functionalities he had lost due to paralysis and using this technology he was able to control the TV, check emails and do basically everything that can be achieved by using a mouse.

The reason a BCI works at all is because of the way our brains function. Our brains are 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 zip from neuron to neuron as fast as 250 mph .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 mean and use them to direct a device of some kind. It can also work the other way around. For example, researchers could figure out what signals are sent to the brain by the optic nerve when someone sees the color red. They could rig a camera that would send those exact signals into someone's brain whenever the camera saw red, allowing a blind person to "see" without eyes.

2.3 BCI INPUT AND OUTPUT

By reading signals from an array of neurons and using computer chips and programs to translate the signals into action, BCI can enable a person suffering from paralysis to write a book or control a motorized wheelchair or prosthetic limb through thought alone. Current brain-interface devices require deliberate conscious thought; some future applications, such as prosthetic control, are likely to work effortlessly. One of the biggest challenges in developing BCI technology has been the development of electrode devices and/or surgical methods that are minimally invasive.

One of the biggest challenges facing brain-computer interface researchers today is the basic mechanics of the interface itself. The easiest and least invasive method is a set of electrodes -- a device known as an electroencephalograph (EEG) -- attached to the scalp. The electrodes can read brain signals. However, the skull blocks a lot of the electrical signal, and it distorts what does get through.

To get a higher-resolution signal, scientists can implant electrodes directly into the gray matter of the brain itself, or on the surface of the brain, beneath the skull. This allows for much more direct reception 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 invasive surgery to implant the electrodes, and devices left in the brain long-term tend to cause the formation of scar tissue in the gray matter. This scar tissue ultimately blocks signals.

Magnetic Resonance Image (MRI)

An MRI machine is a massive, complicated device. It produces very high-resolution images of brain activity, but it can't be used as part of a permanent or semi-permanent BCI. Researchers use

it to get benchmarks for certain brain functions or to map where in the brain electrodes should be placed to measure a specific function. For example, if researchers are attempting to implant electrodes that will allow someone to control a robotic arm with their thoughts, they might 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.

3. BCI APPLICATIONS

One of the most exciting areas of BCI research is the development of devices that can be controlled by thoughts. Some of the applications of this technology may seem frivolous, such as the ability to control a video game by thought. If you think a remote control is convenient, imagine changing channels with your mind. This technology is a proving to a lot useful for medical patients in the future.

3.1 Robotics (Future Cyborgs)

One of the most active areas in research at this point is the development of brain computer interfaces (BCI) that would allow patients to control a cursor on a computer screen, or an automated wheelchair with a robotic arm. Sensors hooked directly on the cortex pick up neural signals, which are then picked up by a computer, processed, and transformed into an action or set of actions that electronic devices can understand. "Shared Control" is the concept that drives brain-computer interfaces. With a neuro-prosthetic arm, for instance, movement is a shared function between a computer and the wearer's brain. Researchers write in the latest issue of the respected journal Proceedings of the National Academy of Sciences (PNAS) that

computers and brains apparently have the ability to influence each other as they interface. This means that, while the mind is used to move cursors on computer screens, or to manipulate wheelchairs, the brain is also receiving some training, the group believes. It was demonstrated in the investigation that the signals the brain produces for controlling BCI are stronger than those produced for the same task in real-life, hinting at an adaptive mechanism.

3.2 Medical Research

Much of the current BCI work aims to improve the lives of patients with severe neuromuscular disorders in which many patients lose control of their physical bodies, including simple functions such as eye-gaze. However, many of these patients retain full control of their higher-level cognitive abilities. These disorders cause extreme mental frustration or social isolation caused by having no way to communicate with the external world. Providing these patients with brain-computer interfaces that allow them to control computers directly with their brain signals could dramatically increase their quality of life. The complexity of this control ranges from simple binary decisions, to moving a cursor on the screen, to more ambitious control of mechanical prosthetic devices.
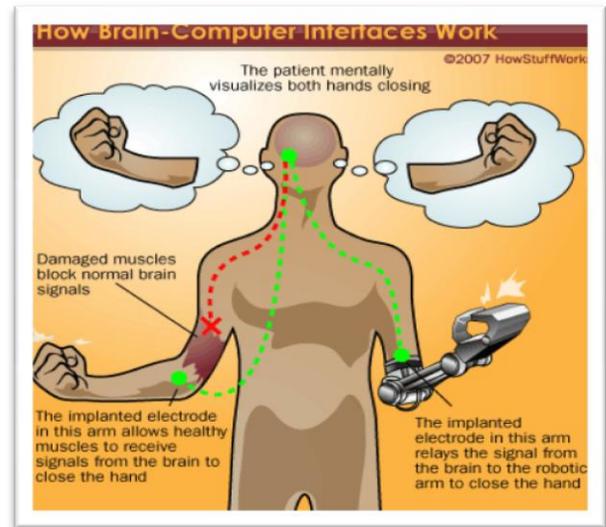
3.3 Future Gaming Technology

Basically gaming is the most popular or hot topic not only in kids but adults also these days. Most of us usually have latest consoles like PS3,X-Box 360 or   Wii but eventually all of them use the same traditional way of gaming interface using the controllers and with the rise of virtualization everyone wants to witness or play the game as a real life situation, this could be made possible using BCI technology. For example in 2008 Emotiv Systems released their EPOC neuroheadset which is worn on the head but does not restrict movement in any way as it is wireless. It also detects conscious thoughts, expressions and non-conscious emotions based on electrical signals around the brain. And as of today it opens up a plethora of new applications, which can be controlled with our thoughts, expressions and emotions. The Emotiv EPOC detects and processes human conscious thoughts and expressions and non-conscious emotions. By integrating the Emotiv EPOC into their games or other applications, developers can dramatically enhance interactivity, gameplay and player enjoyment by, for example, enabling characters to respond to a player's smile, laugh or frown; by adjusting the game dynamically in response to player emotions such as frustration or excitement; and enabling players to manipulate objects in a game or even make them disappear using the power of their thoughts.

4. DRAWBACKS WITH BCI TECHNOLOGY

As it's said every technology has some drawbacks and so does BCI and there are several reasons for this.

1. The brain is incredibly complex. To say that all thoughts or actions are the result of simple electric signals in the brain is a gross understatement. There are about 100 billion neurons in a human brain .Each neuron is constantly sending and receiving signals through a complex web of connections. There are chemical processes involved as well, which EEGs can't pick up on.

2. The signal is weak and prone to interference. EEGs measure tiny voltage potentials. Something as simple as the blinking eyelids of the subject can generate much stronger signals. Refinements in EEGs and implants will probably overcome this problem to some extent in the future, but for now, reading brain signals is like listening to a bad phone connection.

3. The equipment is less than portable. It's far better than it used to be; early systems were hardwired to massive mainframe computers. But some BCIs still require a wired connection to the equipment, and those that are wireless require the subject to carry a computer that can weigh around 10 pounds. Like all technology, this will surely become lighter and more wireless in the future.

5. FUTURE OF BCI

Currently research is being conducted the fields of neuroscience and neuroengineering regarding BCI and BMI. Using chips implanted against the brain that have hundreds of pins less than the width of a human hair protruding from them and penetrating the cerebral cortex, scientists are able to read the firings of hundreds of neurons in the brain.
Now there are 3 future BCI technologies currently in the development process to make BCI suitable for everyday use.
1. Early BCI/BMI: signal splicing into human sensory nerve pathways, most importantly the visual nerve.

2. Mid-term BCI/BMI: more direct links into the brain with the ability to read certain thoughts and copy a wide range of data and information into various parts of the brain.

3. Final BCI/BMI: direct control over the activities of all individual neurons by means of Nano robots. Arbitrary read/write access to the whole brain. The line between the mind and the computer is blurred. Partial or full uploading is possible and inevitable.

CONCLUSION

Though referred to as brain wave of future and still being in its development stage BCI has made its impact felt ,through the early research we can only say that once fully developed it will change the way of living of the humans and with its speed and accuracy it will make the human dream of virtualization come true in no time and we might see that BMI in the next 10–20 years includes a fully implan- table recording system that wirelessly transmits multiple streams of electrical signals, derived from thousands of neurons, to a BMI capable of decoding spatial and temporal characteristics of movements and intermittent periods of immobility, in addition to cognitive characteristics of the intended actions.

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