Brain Gate Technology

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Abstract **- The mind-to-movement system that concedes a paraplegic man to control a computer using only his thoughts is a scientific milestone. This landmark can be accomplished to a great extend through Brain Gate technology. The Brain system has become a boon to the paralyzed. The Brain Gate System is based on Cyberkinetics platform technology to sense, transmit, analyze and apply the language of neurons. The principle of operation behind the Brain Gate System is that intact brain function, brain signals are generated even though they are not sent to the arms, hands and legs. The signals are interpreted and translated into cursor movements, offering the user an alternate Brain Gate pathway to control a computer with thought, just as individuals who have the ability to move their hands use a mouse.**

Index words - Brain Gate, Cyberkinetics, Brain Computer Interface, EEG

I. INTRODUCTION

Our human brain is still an area to be explored. It is still a mystery how it works and how well we can use it. It is a known fact that all of us are not exploiting the complete potentiality of our brain. With the endorsement of technology we can use our brain substantially in the field of communication. Brain is the region where all thoughts are born. Most of us have a problem to deliver those thoughts to others. Some people suffer from motor impairment which is the partial or total loss of function of a body part. This may result in muscle weakness, poor stamina, lack of muscle control, or total paralysis. These are often stroke victims whose perfectly healthy minds end up trapped inside bodies that are immobile. Artificial limbs, wheel chair and other such devices serve as a boon to motor impaired patients. Unfortunately they do not work as per the patients' wish. The patients have to rely on others' help for the working of such equipments. This clearly indicates the absence of a system for transmitting their thoughts into desired action. It is here that the technology called "Brain Gate" comes into action. By using this idea presented in this paper we can solve all the above stated situations with ease.

II. HARDWARE AND SOFTWARE BEHIND BRAIN GATE SYSTEM

The system consists of a "sensor" (a device implanted in the brain that records signals directly related to imagined limb movement); a "decoder" (a set of computers and embedded software that turns the brain signals into a useful command for an external device); and, the external device – which could be a standard computer desktop or other communication device, a powered wheelchair, a prosthetic or robotic limb, or, in the future, a functional electrical stimulation device that can move paralyzed limbs directly. Following are the hardware components used in Brain Gate System:

- THE CHIP
- THE CONNECTOR
- THE CONVERTER AND
- THE COMPUTER

A. The Chip

A 4-millimeter square silicon chip studded with 100 hair-thin, microelectrodes is embedded in brain primary motor cortex. The chip, about the size of a baby aspirin, contains 100 electrode sensors, each thinner than a human hair. The sensors detect tiny electrical signals generated when a user imagines. Though paralyzed, a quadriplegic still has the ability to generate such signals -- they just don't get past the damaged portion of the spinal cord. With Brain Gate, the signals travel through a wire that comes out of the skull and connects to a computer. Brain Gate uses technology similar to cochlear implants that help deaf people hear.

B. The Connector

It is attached firmly to the skull of the patient and it passes the signals received by the chip to the converter. Most handicapped people are satisfied if they can get a rudimentary connection to the outside world. Brain Gate enables them to achieve far more than that. By controlling the computer cursor, patients can access Internet information, TV entertainment, and control lights and appliances – with just their thoughts.

C. The Converter

The signal travels to a shoebox-sized amplifier where it's converted to Digital data and bounced by fiber-optic cable to a computer.

D. Neuroprosthetic Device

A neuroprosthetic device known as Brain gate converts brain activity into computer commands. A sensor is implanted on the brain, and electrodes are hooked up to wires that travel to a pedestal on the scalp. From there, a fiber optic cable carries the brain activity data to a nearby computer.

E. Brain Computer Interface (BCI)

Brain Gate learns to associate patterns of brain activity with particular imagined movements - up, down, left, right - and to connect those movements to a cursor. A brain-computer interface uses electrophysiological signals to control remote devices[4]. They consist of electrodes applied to the scalp of an individual. These electrodes pick up the signals and carry it into amplifier that amplify the signal approximately ten thousand times and then pass the signal via an analog to digital converter to a computer for processing. The computer processes the Electroencephalography (EEG) [5] signal and uses it in order to accomplish tasks such as communication and environmental control. BCIs are slow in comparison with normal human actions, because of the complexity and noisiness of the signals used, as well as the time necessary to complete recognition and signal processing.

Software behind Brain Gate System uses algorithms and pattern-matching techniques to facilitate communication. The algorithms are written in C, JAVA and MATLAB. . Signal processing software algorithms analyze the electrical activity of neurons and translate it into control signals for use in various computer-based applications**.**

III. WORKING OF BRAIN GATE

A. Detection

The detection of the input from the user and them translating it into an action could be considered as key part of any BCI system. This detection means to try to find out these mental tasks from the EEG signal. It can be done in time-domain, e.g. by comparing amplitudes of the EEG and in frequency-domain. This involves usually digital signal processing for sampling and band pass filtering the signal, then calculating these time -or frequency domain features and then classifying them. These classification algorithms include simple comparison of amplitudes linear and non-linear equations and artificial neural networks. By constant feedback from user to the system and vice versa, both partners gradually learn more from each other and improve the overall performance.

B.Control

The final part consists of applying the will of the user to the used application. The user chooses an action by controlling his brain activity, which is then detected and classified to corresponding action. Feedback is provided to user by audio-visual means e.g. when typing with virtual keyboard, letter appears to the message box etc.

C. Training

The training is the part where the user adapts to the BCI system. This training begins with very simple exercises where the user is familiarized with mental activity which is used to relay the information to the computer.

D. Bio-Feedback

The definition of the biofeedback is biological information which is returned to the source that created it, so that source can understand it and have control over it. This biofeedback in BCI systems is usually provided visually, e.g. the user sees cursor moving up or down or letter being selected from the alphabet.

IV. RESEARCH AND EXPERIMENTAL RESULTS

The initial clinical trial of Brain Gate, led by researchers at Massachusetts General Hospital, Brown University, and the Department of Veterans Affairs, ran from 2004 to 2006 and studied four patients with tetraplegia[6]. The results showed that a human with tetraplegia was able to control a cursor on a computer screen just by thinking, enabling him to open emails, and to operate devices such as a television[7]. One participant, Matt Nagle, had a spinal cord injury, whilst another had advanced ALS. In July 2009, a second clinical trial (dubbed "BrainGate2") was initiated. In May 2012, Brain Gate researchers published a study in *Nature*[8]demonstrating that two people paralyzed by brainstem stroke several years earlier were able to control robotic arms for reaching and grasping.Since 2009, clinical trials are being conducted under the name "BrainGate2 Neural Interface System". As of October 14, 2014, Stanford University, Massachusetts General Hospital, Case Western Reserve University (Ohio) and Providence VA Medical Center are actively recruiting participants for the ongoing BrainGate2 clinical trial.

V. ADVANTAGES

The Brain Gate technology requires very minimal and simple training for its functioning. One of the amazing things about this system is that the patients can communicate by thinking of what they want to say and then it is translated through text or a robotic voice and works almost 100% of the time. (within 60 Minutes)

The user's ability to operate the device is not affected by their speech, eye movements or noise. Therefore it can be used in an interactive environment and doesn't require the person using the device to talk or have their actions affected by noise around them. It is expected that people using the Brain Gate System will employ a personal computer as the gateway to a range of self-directed activities. These activities may extend beyond typical computer functions (e.g., communication) to include the control of objects in the environment such as a telephone, a television and lights.

VI. DISADVANTAGES

As of now the technology still craves for the device to be physically implanted in the person's brain. We could use the electronic magnetic cap without the need for a chip to be surgically implanted in the brain, but it does not work nearly as well. Although the chip is extremely small, it still means surgery on the brain, which is always risky and can be dangerous.

At this time the Brain gate technology is not wireless so it requires a plug to be plugged into the top of their head. Therefore this technology is not yet mobile, it restricts the person to be in the area of the device.

Even though this technology allows the person to communicate with people using his/her thoughts, the process is still very slow and takes a very long time. The person must think of each letter individually which is translated into text or voice. The losers might be the people who have to fund this project because it is extremely expensive and advanced technology. The Brain Gate technology is not yet available for people to buy in the market, but they estimate that the technology will cost hundreds of thousands of dollars.

VII. OTHER APPLICATIONS

Brain gate technology can be used for controlling remote devices. This system can be used for making and receiving telephone calls and accessing the internet. Control over the robotic arm is another widely used application of the system. It helps the motor impaired patients to watch and control television, use the pc, locking or unlocking doors. It assists them to use their motorized wheelchair without any external help.

VIII. FURTHER SCOPE

Brain gate technology's scope includes a second-generation interface software M*Power controller that will enable users to perform a wide variety of daily activities without assistances of technician. The system can be made smaller and wireless. This solves the issue of portability. Moreover the user will have an improved control of respiratory system, limb with muscle stimulation or robotics. The goal of this development program would be to allow these individuals to one day use their own arms and hands again. Limb movement developments are currently at the research stage and are not available for use with the existing Brain Gate System. In addition, products are in development to allow for robotic control, such as a thought-controlled wheelchair. In the future, the Brain Gate System could be used by those individuals whose injuries are less severe. Next generation products may be able to provide an individual with the ability to control devices that allow breathing, bladder and bowel movements. Currently The Brain Gate Neural Interface System is an investigational device and is not approved for sale. However it is available through a clinical study. Although Brain Gate being developed by The Brain Gate Company and other Brain Computer Interface are still in the early stages, they indicate future directions for what is possible[9].

CONCLUSION

The concept of mobile robots or prosthetic devices not by manual control, but by mere "thinking" (i.e., the brain activity of human subjects) has been a fascinated approach. Medical cures are unavailable for many forms of neural and muscular paralysis. The enormity of the deficits caused by paralysis is a strong motivation to pursue BMI solutions. So this idea helps many patients to control the prosthetic devices of their own by simply thinking about the task.

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Cyberkinetics hopes to refine the Brain Gate in the next two years to develop a wireless device that is completely implantable and doesn't have a plug, making it safer and less visible. And once the basics of brain mapping are worked out there is potential for a wide variety of further applications. This technology is well supported by the latest fields of biomedical instrumentation, micro-electronics; signal processing, Artificial Neural Networks and Robotics which has overwhelming developments. Hope these systems will be effectively implemented for many biomedical applications.

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