Brain Gate Pathway

PoojaMendiratta
GGSIPU, NIEC, New Delhi, INDIA

Neha Gupta
GGSIPU, NIEC, New Delhi, INDIA

Shilpa Jain
GGSIPU, NIEC, New Delhi, INDIA

***Abstract*—Converting one's thoughts into real world actions, the Brain gate technology is a type of brain implant chip that monitors a person's brain activity using 100 hair thin electrodes that 'hear' the neurons being fired in one's brain in specific areas. It is based on the technique of mind transfer. It uses the Brain Computer Interface (BCI) device. These brain activities are further translated to electrical signals that are decoded and hence used to move objects like a computer cursor or a robotic arm thus making life easier for the paralyzed. Converting one's thoughts and intentions to actual actions, the Brain Gate technology was developed by a renowned biotech company. The sole purpose of developing this technology was to help patients who suffer from injuries in their spinal cord or diseases like ALS.**

***Keywords*—Brain gate, brain computer interface, Cyberkinetics, Utah array, electrodes, brain signal acquisition, signal processing, mind uploading.**

I. INTRODUCTION

In its current form, the brain gate technology consists of a sensor chip implanted in the patient's brain and an external decoder device. The sensor consists of Utah Array which is a group of a hundred hair thin electrodes each connected to a different neuron that monitors and senses brain activity in user and transmits it as electrical signals to the external decoder device. This decoder device decodes the transmitted signals and in turn transfers it to a prosthetic object thus helping severely physically disabled people to live a better life by making an effort to make them independent. These transmitted signals can be used to control a cursor on a computer screen, a robotic arm or even a wheelchair[9].

The technology is currently owned by an independently held company called Braingate, Co. [2].Though it involves a very expensive and risky surgery but it certainly is a very useful technology as well. It aims at making life easier for those suffering from severe spinal cord injuries or paralysis[3].

Fig. 1.BrainGate

II. WORKING OF BRAINGATE

The patient that has the brain gate chip implanted in his brain thinks of moving the cursor in front of him on his computer screen. This sends signals to various parts of his brain. These signals are sensed by the hair thin electrodes connected to the neurons in his brain which then transmit the impulses to a pedestal protruding from the scalp through connecting wires. The function of this pedestal is to filter these impulses so as to remove unwanted signals and noise and transmit it to the amplifier. The electrical signals are transmitted to the external decoder device which are in turn decoded and sent to the computer connected to the decoder and the cursor moves. Thus, bridging the gap between brain and limbs of the physically disabled person and improving the quality of life he lives[1].

The brain gate technology consists of two parts.The first part is the internal sensor chip that is implanted in the brain of the user to catch impulses produced in the user's brain and the second part consists of the external processors that convert these brain impulses to an external action intended by the user[6]. The sensor is implanted on the motor cortex of the brain which is the part of the brain that handles voluntary movements. The hair thin electrodes of the sensor

penetrate into the brain to a depth of about 1mm and pick up neural spiking and transmit them to pedestal[7]. External cables transmit signals from pedestal to the computer.

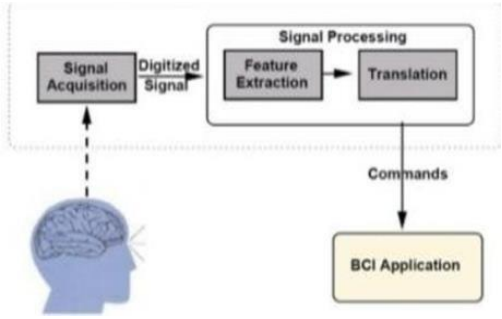

Fig. 2. Basic block diagram of a BCI system

A. BasicElements

The BrainGate technology makes use of mainly 4 basic elements.

*1) The Chip (invasive)/The electrodes (non-invasive):*In the invasive method, a chip is implanted in the brain underneath the skull by surgery. Currently the chip being used is a 4mm square chip which is embedded above the region of brain which controls movement called motor cortex and beneath the durameter (the outer membrane of the central nervous system)[5]. Alternatively, in the non-invasive method, a set of electrodes are attached to the scalp, which can read the brain signals (but not soaccurately).

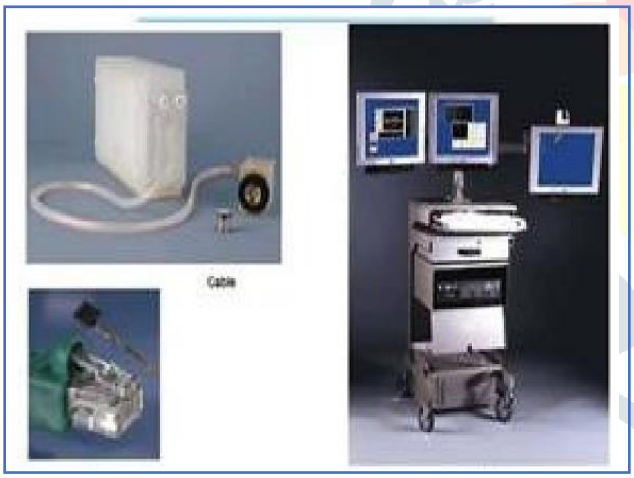

Fig. 3.BrainGate pilot device

2) The Connector: Connector is a device attached to the skull of the patient, which receives the signal from the chip and forwards it to the convertor to beprocessed.

3) The Convertor: The convertor amplifies and convertsthe signal into digital signal. In the invasive method, this conversion of neural signals to digital signals is done by ElectroCorticoGram(or ECoG). In the non-invasive method, it is done by using ElectroEncephaloGram(also known asEEG).

*4) The Computer:*The digital signal is sent to a connected computer using optical fibre cable, where a specialized software is used to learn and associate the patterns of received digital signals, or optionally forward the signal to another device(such as another bio-implant or a roboticarm).

B.Sensing Techniques

The signals sent by the neurons can be sensed in two ways.

1) ECoG (Electrocorticography) -Invasive method: In this technique, the electrodes are placed just above the motor cortex. It has many advantages such as better signal to noise ratio, higher spatial resolution and a wider frequency range. The clinical risks and technical difficulty is higher in this technique as compared to EEG.[7] It requires invasive surgery and the device left in the brain ends up blocking thesignal.

2) EEG (Electroencephalography) - Non-invasive method: This technique uses Electroencephalograph device which is attached to the scalp. It is used to track and record brain wave patterns. One of the barriers to EEG is the extensive training required before the patient can start using this on hisown[1].

Fig. 4. Chip implanted in the brain by surgery

III. Applications

- The BrainGate technology can make interaction between a human and a computer as easy as thinking about it (e.g. thinking of moving the cursor) so that even a person with paralysis can operate acomputer.
- This technology can enable a person who has lost control of his/her limbs, or other bodily functions (e.g. due to a spinal cord injury, nerve damage) can regain the ability to control it up to someextent[6].
- It can be used to control robotic implants and other machines (such as a bionic arm, electric wheelchair) in physically challengedpeople[10].
- It can also be used to play videogames.

IV. Advantages

- The BrainGate Neural Interface System is being developed for utilizing our brain better than we currently are using it[3].

- The technology offers substantial improvement over existing assistive technologies for physically challenged people[4].
- This system can remain safely implanted in the brain for long period of time, and can safely be removed aswell.
- There is no training necessary (in the invasive method) to use BrainGate system after installation. The user just needs to think of an action[8].

V. DISADVANTAGES

- The invasive method requires surgical implantation of the sensor chip, and over time can cause blockage of signals[2].
- The non-invasive method produces poor signal as the skull dampens the signals, dispersing and blurring the electromagnetic waves created by the neurons[5].
- BrainGate technology is still not approved by theFDA.
- Due to daily movement of the patient, the switches/electrodes may need to be adjusted from time to time.
- Reading the brain signals can be a very difficult task, such as raising a hand, require a lot of brain activity. Due to this, the sensors/electrodes can sometimes misinterpret the patients' brain signal[3].

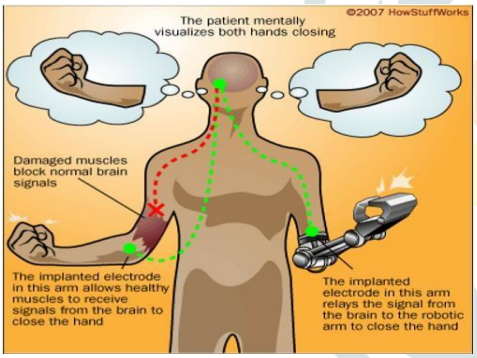

Fig. 5. BrainGate can also be used to control a robotic arm

VI. CONCLUSION

The idea of moving real life objects whether it is a robotic arm or just a computer cursor by merely thinking about moving it is fascinating in its own belief. There are many neural or muscular paralytic medical conditions that are deemed incurable by even the best of doctors. The brain gate technology provides a potential for the disabled to lead their life closer to a normal manner by providing them with the ability to perform routine activities. This technology can provide the paralyzed people to communicate with the use of just thoughts and some computer equipment. Normal human beings may also be able to use the technology provided they are willing to undergo theimplant.

REFERENCES

[1] William D. Penny, Stephen J. Roberts, "EEG-based communication: A pattern recognition approach," IEEE Trans. Rehab. Eng., vol. 8, pp. 214–215, June2000.

[2] Jonathan. R. Wolpaw, "Brain-computer interface technology: A review of the first international meeting," IEEE Trans. on Rehab. Eng. 2000; 8:164–173.

[3] KeshviChauhan, "Implementation of Brain Computer Interface," International Journal of Engineering Research and Applications (IJERA) Vol. 1, Issue 3, pp.807-812.

[4] Luca Citi, "Defining brain machine interface application by matching interface performance with device requirements" Journal of Neuroscience methods,167 (2008)91–104.

[5] John P. Donoghue, "Connecting cortex to machine: recent advances in brain interfaces", Nature publishing group,5,1085-1088.

[6] Melody M. Moore, "Real-World Applications for Brain-Computer Interface Technology," IEEE Trans. on Neural Syst. Rehabil. Eng. 11, NO. 2, June2003.

[7] Wolpaw et al., "Brain-computer interfaces for communication and control," Clin. Neurophysiol., vol. 113, p. 767,2002.

[8] K. Crowley et al., "Evaluating a Brain-Computer Interface to Categorise Human Emotional Response", IEEE, 2010.

[9] BrainGate website. [Online] Available:www.braingate.com

[10] Brain Computer Interface website. [Online]Available: www.braincomputerinterface.com