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Applications of Brain Gate System

[1]Amal Razic K A
[1]Department of Electrical and Electronics Engineering
[1]Adi Shankara Institute of Engineering and Technology, Kalady, Kerala

Abstract

The mind-to-movement system that allows a quadriplegic man to control a computer using only his thoughts is a scientific milestone. It was reached, in large part, through the brain gate system. This system has become a boon to the paralyzed. The Brain Gate System is based on Cyber kinetics platform technology to sense, transmit, analyze and apply the language of neurons. The principle of operation behind the Brain Gate System is that with 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. Matthew Nagle,a 25-year-old Massachusetts man with a severe spinal cord injury, has been paralyzed from the neck down since 2001.After taking part in a clinical trial of this system, he has opened e-mail, switched TV channels, turned on lights. He even moved a robotic hand from his wheelchair.

Keyword- Brain Gate System, Neuroprosthetics, Sensor, Brain-Computer Interface (BCI)

I. Introduction

The 'Brain Gate' contains tiny spikes that will extend down about one millimeter into the brain after being implanted beneath the skull, monitoring the activity from a small group of neurons. It will now be possible for a patient with spinal cord injury to produce brain signals that relay the intention of moving the paralyzed limbs, as signals to an implanted sensor, which is then output as electronic impulses. These impulses enable the user to operate mechanical devices with the help of a computer cursor. Brain gate consists of a surgically implanted sensor that records the activity of dozens of brain cells simultaneously. The system also decodes these signals in real time to control a computer or other external devices. The brain gate technology platform was designed to take advantage of the fact that many patients with motor impairment have an intact brain that can produce movement commands allowing the brain gate system to create an output signal directly from the brain, bypassing the route through the nerves to the muscles that cannot be used in paralyzed people. The system is also the first to allow a human to control his surrounding environment using his mind.

II. The brain control motor function

The brain is "hardwired" with connections, which are made by billions of neurons that make electricity whenever they are stimulated. The electrical patterns are called brain waves. Neurons act like the wires and gates in a computer, gathering and transmitting electrochemical signals over distances as far as several feet. The brain encodes information not by relying on single neurons, but by spreading it across large populations of neurons, and by rapidly adapting to new circumstances. Motor neurons carry signals from the central nervous system to the muscles, skin and glands of the body, while sensory neurons carry signals from those outer parts of the body to the central nervous system. Receptors sense things like chemicals, light, and sound and encode this information into electrochemical signals transmitted by the sensory neurons. And interneurons tie everything together by connecting the various neurons within the brain and spinal cord. The part of the brain that controls motor skills is located at the ear of the frontal lobe. Muscles in the body's limbs contain embedded sensors called muscle spindles that measure the length and speed of the muscles as they stretch and contract as you move. Other sensors in the skin respond to stretching and pressure. Even if paralysis or disease damages the part of the brain that processes movement, the brain still makes neural signals. They're just not being sent to the arms, hands and legs. A technique called neuro feedback uses connecting sensors on the scalp to translate brain waves into information a person can learn from. The sensors register different frequencies of the signals produced in the brain. These changes brain wave patterns indicate whether someone is concentrating or suppressing his impulses, or whether he is relaxed or tense.

A. Brain Gate Neural Interface System

The Brain Gate Neural Interface System is currently the subject of a pilot clinical trial being conducted under an Investigational Device Exemption (IDE) from the FDA. The system is designed to restore functionality for a limited, immobile group of severely motor-impaired individuals. 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.

III. TECHNOLOGY

A. Brain-Computer Interface

A brain-computer interface (BCI), sometimes called a direct neural interface or a brain-machine interface, is a direct communication pathway between a human or animal brain (or brain cell culture) and an external device. In one-way BCIs, computers either accept commands from the brain or send signals to it (for example, to restore vision) but not both. Two-way BCIs would allow brains and external devices to exchange information in both directions but have yet to be successfully implanted in animals or humans.

Fig. 1: Real implementation of brain gate system on mouse

In this definition, the word brain means the brain or nervous system of an organic life form rather than the mind. Computer means any processing or computational device, from simple circuits to silicon chips (including hypothetical future technologies such as quantum computing). Research on BCIs began in the 1970s, but it wasn't until the mid-1990s that the first working experimental implants in humans appeared. Following years of animal experimentation, early working implants in humans now exist, designed to restore damaged hearing, sight and movement. The common thread throughout the research is the remarkable cortical plasticity of the brain, which often adapts to BCIs, treating prostheses controlled by implants as natural limbs. With recent advances in technology and knowledge, pioneering researchers could now conceivably attempt to produce BCIs that augment human functions rather than simply restoring them, previously only the realm of science fiction.

B. BCI versus Neuroprosthetics

Neuroprosthetics is an area of neuroscience concerned with neural prostheses — using artificial devices to replace the function of impaired nervous systems or sensory organs. The most widely used neuroprosthetic device is the cochlear implant, which was implanted in approximately 100,000 people worldwide as of 2006. There are also several neuroprosthetic devices that aim to restore vision, including retinal implants, although this article only discusses implants directly into the brain. The differences between BCIs and neuroprosthetics are mostly in the ways the terms are used: neuroprosthetics typically connect the nervous system, to a device, whereas the term "BCIs" usually connects the brain (or nervous system) with a computer system. Practical neuroprosthetics can be linked to any part of the nervous system, for example peripheral nerves, while the term "BCI"usually designates a narrower class of systems which interface with the central nervous system. The terms are sometimes used interchangeably and for good reason. Neuroprosthetics and BCI seek to achieve the same aims, such as restoring sight, hearing, movement, ability to communicate, and even cognitive function.

Fig. 2: Physically disabled person drinking water using brain gate system

Both use similar experimental methods and surgical techniques.

C. Neuroprosthetic Device

A neuroprosthetic device known as Brain gate convert 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.

IV. PRINCIPLE

"The principle of operation of the Brain Gate Neural Interface System is that with intact brain function, neural signals are generated even though they are not sent to the arms, hands and legs.

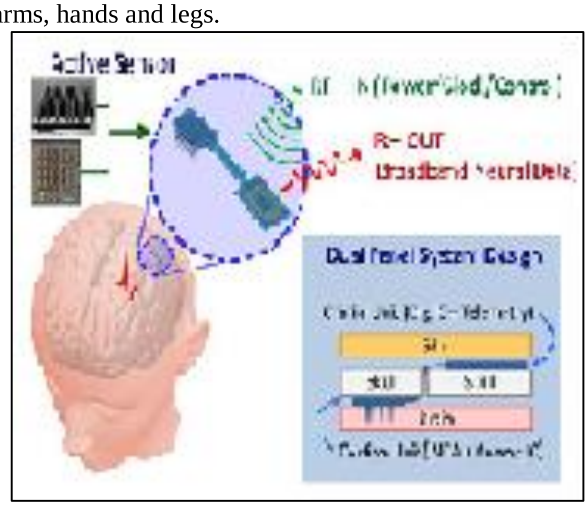

Fig. 3: Working principle

These signals are interpreted by the System and a cursor is shown to the user on a computer screen that provides an alternate "Brain Gate Pathway". The user can use that cursor to control the computer, just as a mouse is used." Brain Gate is a brain implant system Developed by the bio-tech company Cyber kinetics in 2003 in conjunction with the Department of Neuroscience at Brown University. The device was designed to help those who have lost control of their limbs, or other bodily functions, such as patients with amyotrophic lateral sclerosis (ALS) or spinal cord injury. The computer chip, which is implanted into the patient and converts the intention of the user into computer commands.

A. *The Basic Elements of Brain Gate*

1) *The Chip*
The chip uses 100 hair-thin electrodes that 'hear' neurons firing in specific areas of the brain, for example, the area that controls arm movement. The activities are translated into electrically charged signals and are then sent and decoded using a program, which can move either a robotic arm or a computer cursor.

Fig. 4: brain gate system chip

In addition to real-time analysis of neuron patterns to relay movement, the Brain gate array is also capable of recording electrical data for later analysis. A potential use of this feature would be for a neurologist to study seizure patterns in a patient with epilepsy. Brain gate is currently recruiting patients with a range of neuromuscular and neurodegenerative conditions for pilot clinical trials in the United States.

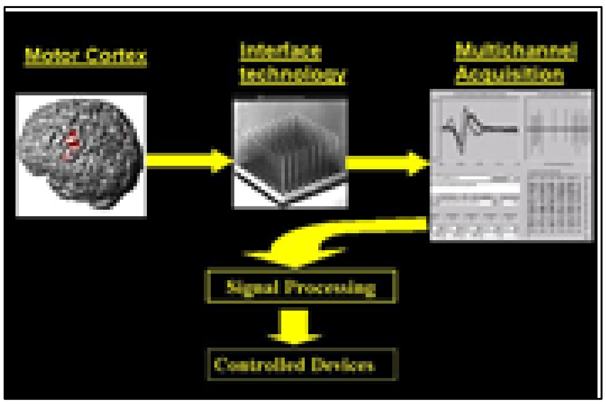

Fig. 5: Flow chart of brain gate system

2) *The Connector*
When somebody thinks “move cursor up and left” his cortical neurons fire in a distinctive pattern; the signal is transmitted through the pedestal plug attached to the skull.

3) *The Converter*
The signal travels to an amplifier where it is converted to optical data and bounced by fiber-optic cable to a computer.

4) *The Computer*
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. The Brain Gate technology platform was designed to take advantage of the fact that many patients with motor impairment have an intact brain that can produce movement commands.

B. *Working*
The sensor of the size of a contact lens is implanted in brain’s percental gyrus which control hand and arm movements. A tiny wire connects the chip to a small pedestal secured in the scull. A cable connects the pedestal to a computer. The brain's 100bn neurons fire between 20 and 200 times a second. The sensor implanted in the brain senses these electrical signals and passes to the pedestal through the wire.

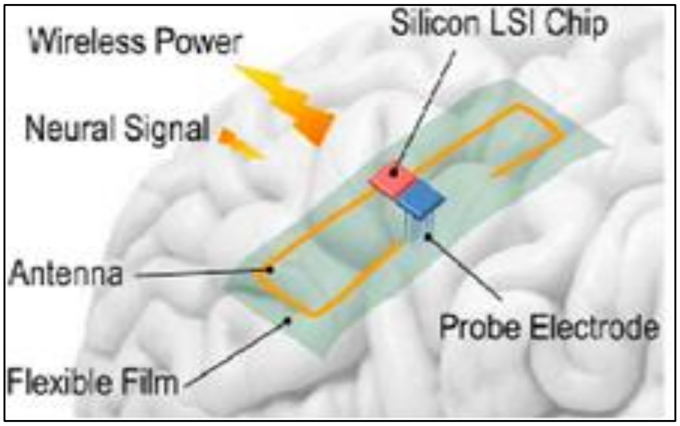

Fig. 6: sensor used in brain gate system

The Brain Gate System, a bundle consisting of one hundred gold wires connects the array to a pedestal which extends through the scalp. The pedestal is connected by an external cable to a set of computers in which the data can be stored for off-line analysis or analyzed in real-time. The Brain Gate Neural Interface Device is a proprietary brain-computer interface that consists of an internal neural signal sensor and external processors that convert neural signals into an output signal under the users own control. The pedestal passes this signal to the computer through the cable.

Fig. 7: sensor detects neural activity

The computer translates the signals into a communication output, allowing a person to move a cursor on a computer screen merely by thinking about it.

1) With A Brain gate You Can
- Turn on or off the lights on your room
- Check and read E-mails
- Play games in computer
- Use your PC
- Watch and control your Television
- Control a robotic arm

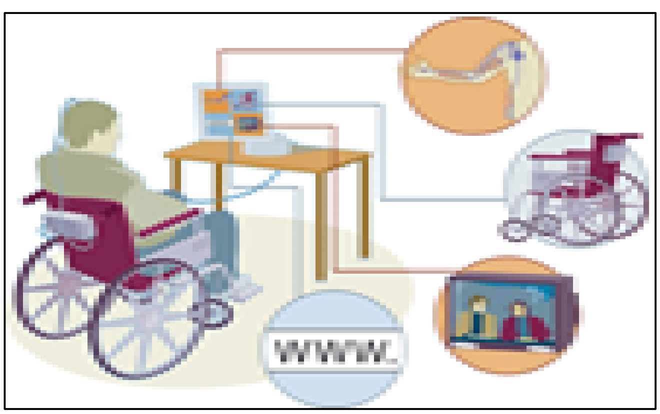

Fig. 8: works done by using brain gate system

C. Achievement

Matthew Nagle's achievement is a historic one, and is in the same league as conquering Mount Everest or putting a human being on the moon. He is the first paralyzed person to have operated a prosthetic arm using just his mind. On July 4, 2001, Nagle became paralyzed from the neck downwards after being assaulted by a person wielding a knife. He was confined to his wheel chair and was unable to breath without a respirator. Fortunately there was a scientist and a new device to help him overcome his disabilities. The scientist was Professor John Donoghue and the device was Brain Gate.

Fig. 9: Matthew Nagle using brain system

On June 22, 2004, Donoghue's team implanted a small chip into Nagle's brain. This implanted sensor picked up the electric signals that command the limbs of the body to move. In the case of a healthy man, these signals would have been forwarded to the spinal cord. But as Nagle's spinal cord was damaged, the signals were collected and sent through wires and fiber-optic cable to hardware and software that translated into computer-driven movements. This implanted device enabled Nagle to do things like check his-mail, turn the TV on or off, draw a crude circle on the screen, play the game Pong, and control a prosthetic arm-with just his thoughts. Of course, he needed months of training to perform these tasks but his achievement underlines the staggering potential of BCI Technology.

Another example is that, Cathy Hutchinson, who has been paralyzed for more than 15 years due to a stroke, recently directed "a robotic arm to pick up a bottle of coffee and bring it to her lips," using only her mind—and some mind-bending new technology.

Clinical trials began in 2009 under the name "BrainGate2 Neural Interface System". As of October 2014, Stanford University, Massachusetts General Hospital, Case Western Reserve University (Ohio) and Providence VA Medical Center were actively recruiting participants for the ongoing BrainGate2 clinical trial.

V. THE FUTURE BECKONS

The primary goal of this technology and devices like Brain gate to help those who are paralyzed to perform routine activities that are part of normal human existence. Further development in the Brain Gate System is to potentially provide limb movement to people with severe motor disabilities i.e., a direct connection from the computer to a muscle. Brain gate right now has a bulky look with cable processors the device has to be less bulky to make the technology stream. This will lead to a wireless Brain gate giving the patient greater freedom, 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.

VI. CONCLUSION

Here by, conclude that neural interfaces have emerged as effective interventions to reduce the burden associated with some neurological diseases, injuries and disabilities. The Brain Gate helps the quadriplegic patients who cannot perform even simple actions without the help of another person are able to do things like checking e-mails, turn the TV on or off and control a prosthetic arm—with just their thoughts. Brain gate technology does not promise miracles-it does not, for instance, say that a paralyzed man will one day walk using an artificial leg by his thoughts alone.

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