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Brain gate technology

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ABSTRACT

Who would have thought that in only a decade we would be able to read minds, or at least translate thoughts into actions without having to say a word? Advances in Neurotechnology have made great strides since the field's original arrival in the scientific community. The development of a small microchip that when implanted in the brain would enable patients, such as those with ALS, to communicate effectively is the goal. Neurotechnology is making significant advancements in the field of medicine. It is the science of altering signals from the Central Nervous System to obtain a desired or effect. The studies conducted on monkeys have shown that it is possible for an animal to use a very small electrode array device located in the brain to control the movement of a prosthetic limb or other biomedical device. At the University of Pittsburgh, an experiment is conducted to show that a monkey could control a prosthetic device in order to feed itself.

In addition to testing the animals, there have been studies involving human subjects in which a computer was used to operate a mechanical arm by harnessing signals from the brain and pressure from the skin. Cyberkinetics Neurotechnology Systems Inc. created a cyberkinetic system known as the BrainGate Neural Interface System, is able to transform thoughts into actions by monitoring neural signals from the motor cortex. The first patient to receive an implantation of a multi-electrode recording array into his brain for the purpose of monitoring his brain activity was twenty-five year old Matthew Nagle.The dream of BrainGate program is to develop a fast, reliable and unobtrusive connection between the brain of a severely disabled person and a personal computer.

Key words: Brain gate technology.

INTRODUCTION

The main concept behind this technology is the idea of implanting tissue microelectrodes known as cortical neural prosthetics (CNPs) into specific portions of the brain to permit the recording of electrical signals sent from both the surface of the brain and within the cerebral cortex region. The motor cortex is chosen as the location to implant the device because it produces the cleanest movement signal. There are thousands of different portions of the brain that control how we function and move. These signals are then translated into command signals that drive a biomedical device, such as a prosthetic limb or computer display. By implanting the CNP into the motor cortex section, nearly smooth movements can be obtained . Every CNP is composed of three building blocks without these the CNPs would not work effectively:

Microelectrodes and recording electronics

Chronic electrodes provide many individual recording sites implanted permanently in the cerebral cortex. The recording electronics condition and discriminate the recorded signal.

Extraction algorithms

These are computer programs running in

real time that take the conditioned data, such as action potential events or spike times, and convert them to end point positions .

Actuators

These can be animated computer displays, movement of a robot arm, or activation of muscles in a subject's own arm.

BrainGate

Depth scientific findings from the pilot trial of a device called BrainGate.

The BrainGate 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 BrainGate Neural Interface System is an investigational assistive device designed by Cyberkinetics, Inc. BrainGate, the technology includes an electrode array The computer chip, which is implanted into the brain, monitors brain activity in the patient and converts the intention of the user into computer commands.

A monkey can feed itself with a robotic arm simply by using signals from its brain, an advance that could enhance prosthetics for people, especially those with spinal cord injuries. Now, using the BrainGate system in the current human trials, a 25 year old quadriplegic has successfully been able to switch on lights, adjust the volume on a TV, change channels and read e-mail using only his brain. Crucially, the patient was able to do these tasks while carrying on a conversation and moving his head at the same time.

Working

The system is designed to restore functionality for a limited, immobile group of severely motor-impaired individuals. It is expected that people using the BrainGate 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.

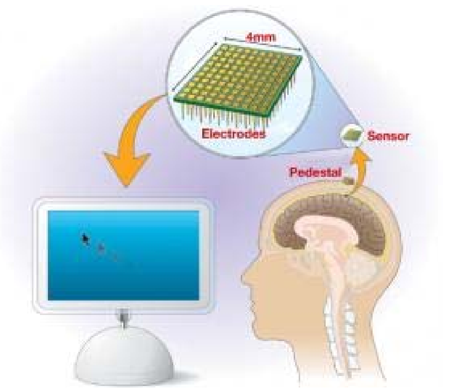
The Brain Gate System is based on Cyber kinetics' platform technology to sense, transmit, analyze and apply the language of neurons. The System consists of a sensor that is implanted on the motor cortex of the brain and a device that analyzes brain signals. The principle of operation behind the Brain 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.

Cyber kinetics is further developing the Brain Gate System to potentially provide limb movement to people with severe motor disabilities. 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 Cyberkinetics is developing products to allow for robotic control, such as a thought-controlled wheelchair.

The Brain Gate Neural Interface System is an investigational device. It is not approved for sale and is available only through a clinical study.
The sensor consists of a tiny chip smaller than a baby aspirin, with one hundred electrode sensors each thinner than a hair that detect brain cell electrical activity.

A man with paralysis of all four limbs could directly control objects around him – open simulated email, play a game of Pong, adjust the volume on the television set – using only his thoughts.

These pilot clinical trial findings, featured on the cover of *Nature,* mark major advance in neuroscience, one that offers hope to people with severe motor impairments.



Patients requirement

Based on the requirement of these patients, the team outlines three key findings:

- movement signals persist in the primary motor cortex, the area of the brain responsible for movement, long after a spinal cord injury;
- spiking from many neurons – the language of the brain – can be recorded and routed outside the human brain and decoded into command signals;
- Paralyzed humans can directly and successfully control external devices, such as a computer cursor and robotic limb, using these neural command signals.

Currently available assistive devices have significant limitations for both the person in need and the caregiver. For example, even simple switches must be adjusted frequently, a process that can be time consuming. In addition, these devices are often obtrusive and may prevent the user from being able to simultaneously use the device and at the same time establish eye contact or carry on conversations with others.

Parts of Brain gate and working

The BrainGate Neural Interface creates a direct link between a person's brain and a computer, translating neural activity into action. Matthew Nagle, without use of his limbs but fitted with a BrainGate, can now play a videogame or change channels on TV using only his mind. Here's how it works. - *Greta Lorge*

The braingate consists mainly 4 parts:

The chip

A 4-millimeter square silicon chip studded with 100 hair-thin microelectrodes is embedded in Nagle's primary motor cortex - the region of the brain responsible for controlling movement.

The connector

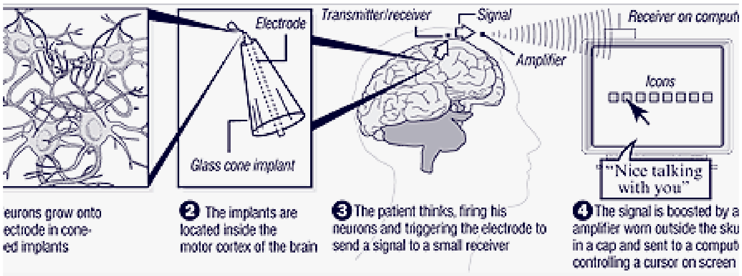
When Nagle thinks "move cursor up and left" (toward email icon), his cortical neurons fire in a distinctive pattern; the signal is transmitted through the pedestal plug attached to his skull.

The converter

The signal travels to a shoebox-sized amplifier mounted on Nagle's wheelchair, where it's converted to optical data and bounced by fiber-optic cable to a computer.

The computer

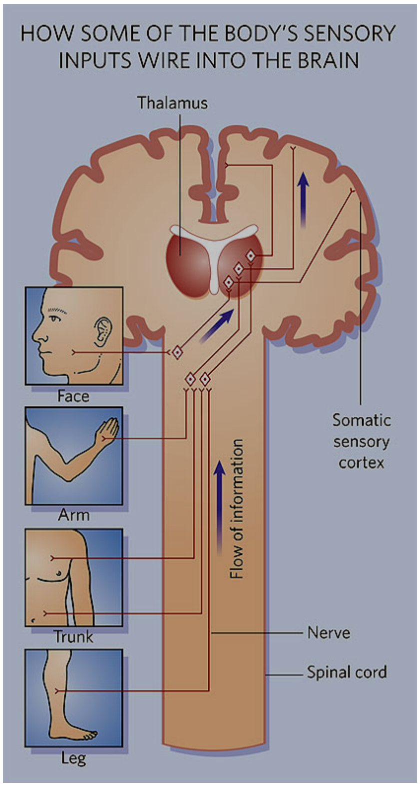
BrainGate learns to associate patterns of brain activity with particular imagined movements - up, down, left, right - and to connect those movements to a cursor.



A thin sensor the size of an aspirin is implanted on the brain's surface to monitor the signals that control muscles. The sensor is connected by wires to a small pedestal on the scalp. This pedestal allows the BrainGate computer to be connected to the brain by a fiberoptic cable. The System processes the brain signals, which may allow people to control the cursor on a computer screen by thinking.

Without these 4 components, the neural signals would not be able to be properly monitored and recorder. As figure 2 (below) displays, the motor cortex, including the somatic sensory cortex, is the chief connection between the brain and the movement of the body parts.

The research and surgery were led by a specialized team from Brown University in Providence, Rhode Island. The team, led by neuroscientist, John Donoghue, worked persistently for several years to develop the BrainGate System. Donoghue, who himself endures limited physical mobility due to a childhood disease, is able to relate to his patients' difficulties. "I'm almost certain I'll never see somebody playing piano," stated Donoghue. "But feeding themselves, doing simple tasks, I'm hoping that that's one thing that would happen".



After allowing Nagle to recover from surgery for three weeks, the team was thrilled to observe that the system was working correctly and they were able to accurately monitor Nagle's neural signals. Nagle then went through many training session to teach him how to carefully concentrate on performing a skill in his mind only, instead of actually doing the task with his hands. Since the surgery, Nagel has been able to perform basic skills such as controlling a computer cursor and turning down the television volume using only his mind. In order to perform such activities, a connector in Nagle's scalp is attached to computers by a bundle of wires as thick as a coaxial cable [9]. Nagle is also assisted by a team of technicians who are present to help guide him through different thought processes and help with anything that he needs. They are also there to monitor the signals being recorded and how much his progress increases with each day.

Remarkable progress involving neuroprosthetic research with human subjects has been made recently, and these advances can potentially improve the lives of impaired individuals around the world. There are currently four patients with these implantations who are being worked with daily. These developments could not have been made without the principal companies and universities that are behind the neurotechnology research.

Monkey experiment

A great portion of the mammalian brain is devoted to sampling and processing sensory information generated by the animal's active exploration of its surrounding environment. The main reason behind using male rhesus monkeys between the age of three and four is that rhesus monkeys have the lowest level of cognitive ability that will allow for this type of study. The choice of age is important since it impacts how far along the monkeys have progressed in their cognitive development. Scientists are pursuing a range of strategies to achieve the goal of direct mind control over machines. Some efforts measure signals inside the brain, while others use brain waves that can be recorded outside the skull.

Monkeys in Pittsburgh

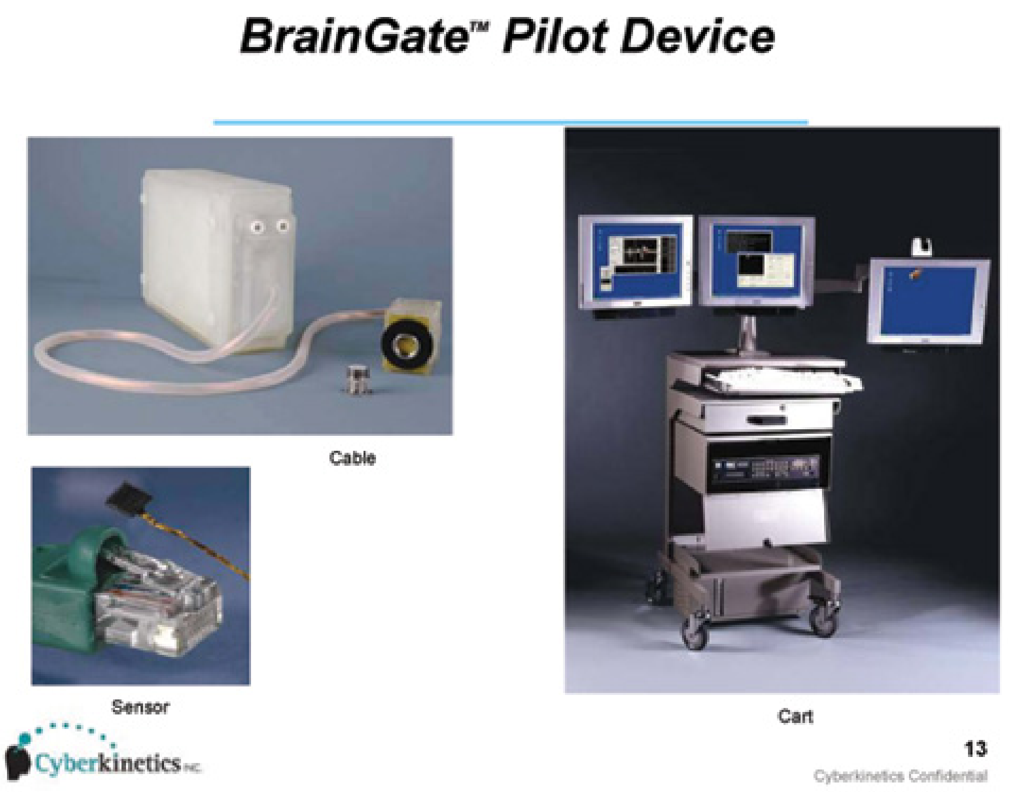
The Pittsburgh University has been working on an experiment involving rhesus monkeys and a closed-loop system. The major idea behind this experiment is to allow a monkey to feed itself using a prosthetic limb controlled solely by the monkey's thoughts. In the experiment, the monkey's arms are restrained at its sides and as the monkey thinks about bringing food to its mouth, electrodes in the monkey's brain intercept the neuronal firings that are taking place in the motor cortex. This is a region of the brain responsible for voluntary movement. The brain activity is fed to a computer where an algorithm interprets the neuronal messages and sends them to the robotic arm.

Advances in human research

Scientists and engineers have decided to take their Neurotechnology developments, particularly in the concentration of neuroprosthetics, begun completing trials on human patients. Although this type of research can pose many health risks to the patient, experts in the field of neurotechnology believe the implantation process is extremely worthwhile. Implanting an array of electrodes into the human brain versus the brain of a monkey produces many more difficulties and complications. The motor cortex, which is the part of the brain that controls muscle movement, is easily accessible in the brain of a monkey, making the implant operation much less complicated.

Platform technology

At Cyberkinetics, we have the technology to sense, transmit, analyze and apply the language of neurons. We are developing products to restore function, as well as to monitor, detect, and respond to a variety of neurological diseases and disorders.



Sense

Cyberkinetics' unique technology is able to simultaneously sense the electrical activity of many individual neurons. Our sensor consists of a silicon array about the size of a baby aspirin that contains one hundred electrodes, each thinner than a human hair. The array is implanted on the surface of the brain. In the BrainGate™ Neural Interface System, the array is implanted in the area of the brain responsible for limb movement. In other applications the array may be implanted in areas of the brain responsible for other body processes.

Transmit and Analyze

The human brain is a super computer with the ability to instantaneously process vast amounts of information. Cyberkinetics' technology allows for an extensive amount of electrical activity data to be transmitted from neurons in the brain to computers for analysis. In the current BrainGate 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. Signal processing software algorithms analyze the electrical activity of neurons and translate it into control signals for use in various computer-based applications.

Apply

Cyberkinetics' ability to generate control signals and develop computer application interfaces provides us with a platform to develop multiple clinical products. For example, using the BrainGate Neural Interface System, a person may be able to use his thoughts to control cursor motion and/or replicate keystrokes on a computer screen. In another example, a doctor may study patterns of brain electrical activity in patients with epilepsy before, during and after seizures.

At Cyberkinetics, we are leveraging our core technology to sense, transmit and analyze the language of neurons to developing products to restore function, as well as to monitor, detect, and respond to a variety of neurological diseases and disorders.

Current Problems

One of the issues with this technology is that CNPs are implanted directly into the brain tissue. This is a particularly dangerous process since brain tissue is very sensitive. All objects that are inserted into the brain damage the parenchyma, the key elements of an organ essential to its functioning. Blood vessels can be damaged and cause micro hemorrhaging during insertion. Neurons can also be ripped and destroyed. How to best avoid this type of tissue and cell damage during implantation is still not well understood. The shape and size of the electrode, and the way it is inserted, are probably critical factors in determining the type of damage incurred. Another practical concern is the speed at which a patient can learn how to control movement in order to manage a number of tasks. The technology has to deliver to patients short-term benefits while they continue to expand their capabilities over time. Minimizing the learning curve is key. As these technology hurdles are resolved and the capacity to deploy commercially improves, the existing gaps between researchers, manufacturers, and patients will begin to dissipate.

Quality of Life

According to a report by the World Commission on Environment and Development, known as the Brundtland Report, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Neurotechnology has the potential to allow quadriplegics, amputees, cerebral palsy patients, those with multiple sclerosis, stroke patients, paraplegics, and people with other types of spinal cord injuries the ability to function in a more normal manner. The movement and communication options available for people with these types of debilitating injuries are rather rudimentary. The only options available are such things as retinal sensors. These allow one to point to letters on a board to spell, switch driven devices, allowing advantage to be taken of what little movement the patient has left, or "sip and puff" devices like those used to guide a wheelchair. In February, the U.S. Defense Advanced Research Projects Agency (DARPA) kicked off two programs backed by $48.5 million in funding to create artificial limbs, including ones that can be operated by the wearer's thoughts.

Applications

They believe the BrainGate sensor, which involves implanting electrodes in the brain, could offer new hope to people Paralyzed by injuries or illnesses.

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.

In a medical breakthrough worthy of an illusionist's act, a U.S. quadriplegic has been able to move objects around him through the power of thought.

Cyberkinetics Neurotechnology Systems, a leader in brain interface technology, is developing products to treat nervous system diseases and disorders by bringing together advances in neuroscience, computer science and engineering.

Advantages:

1. Medical benefits, helping or "curing" a huge list of things.
2. Very long lives.
3. "Awake" for extremely long hours.
4. Bio-war resistance.
5. Super human mental and physical abilities, "Super Soldiers".
6. Entertainment, pleasure, orgasms, drug like states and extreme visuals.

Competitive advantage

The BrainGate Neural Interface System is being designed to one day allow the user to interface with a computer and/or other devices at a level of speed, accuracy and precision that is comparable to, or even faster than, what is possible with the hands of a non-disabled person.

Potential advantages

Potential advantages of the BrainGate System over other muscle driven or brain-based computer interface approaches include: its potential to interface with a computer without weeks or months of training; its potential to be used in an interactive environment, where the user's ability to operate the device is not affected by their speech, eye movements or ambient noise; and the ability to provide significantly more usefulness and utility than other approaches by connecting directly to the part of the brain that controls hand movement and gestures.

Disadvantages

1. Being subjected to remote control, enslavement.
2. Moral and social destruction, especially between humans and cyborgs.
3. Hackers, doing things we can only imagine.
4. Young ones getting into extreme adult material.
5. Death or others problems from product malfunctions.
6. Possible Self Destruct, or instant death if someone got in control. Brainwashing like never before

Precautions

1. The patient must be 18 to 60 years old and quadriplegic.
2. The protocol for this pilot study allows for only 5 subjects to receive the BrainGate.
3. A detailed screening evaluation will be done to ensure that patients meet the study requirements.
4. This involves a medical history, a mental status exam, a physical exam, an EKG, chest x-ray, brain CT scan, and some blood tests.

CONCLUSION

The Brain Gate Technology is used for the future implementation of neural networks. In the future, the BrainGate 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.

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