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Survey on Brain Computer Interface

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Abstract

Brain computer interface (BCI) is a collaboration between brain and external device. This device use the signals from brain and use it to perform external activity like move wheelchair, robot arm or computer cursor. In normal scenario, when person thinks to perform any task like move the cursor, then signals are generated in his brain, those signals are transferred from brain to finger on mouse through body's neuromuscular system. After that, finger move the cursor. In brain computer interface these signals are transferred to some external device where it is decoded and used to move cursor. Some people may face the problem of damaged hearing, sight and damaged movement. Main aim of research on brain computer interface is to help the people having these problems. Scientists has to face many challenges while implementing brain computer interfacing devices. The electrodes and surgical methods used in this process should be minimally invasive. Current research focused on non-invasive method of brain computer interfacing. This paper discusses different methods of brain computer interfacing, also its applications in medical area. It is also used for the purpose of entertainment like neurogaming which is discussed in detail.

Keywords: Brain computer interface (BCI), invasive brain computer interface, partially invasive brain computer interface, non-invasive brain computer interface, electroencephalography, electrocorticography etc.

1. INTRODUCTION

Research in this area began at the University of California, Los Angeles (UCLA), in the year 1970.

Hans Berger discover electrical activity of the human brain in year 1924. At the same time, there was the development of electroencephalography (EEG). Hans Berger first recorded human brain activity by using electroencephalography. When person think about doing some simple task, at that time neurons in the brain fires. Computer chips are programmed to convert these neuron signals into action. This is very much helpful for paralyze person. He can perform simple task like writing small text using cursor or even he can write a small book. He can move wheelchair to go from one place to another. He can also move robot arm and perform simple task like picking up small things [2] [3].

2. ANIMAL BRAIN COMPUTER INTERFACE RESEARCH

Scientist in several laboratories recorded the signals from brain of monkeys and rats and used it operate BCI devices which is used to produce movement [4] as shown in fig. 1. Monkeys thought to navigate computer cursors on screen. They also think to move robot arm to perform simple task. They just imagine all these things, they didn't do it actually. Their brain signals are used to complete the task successfully [4].

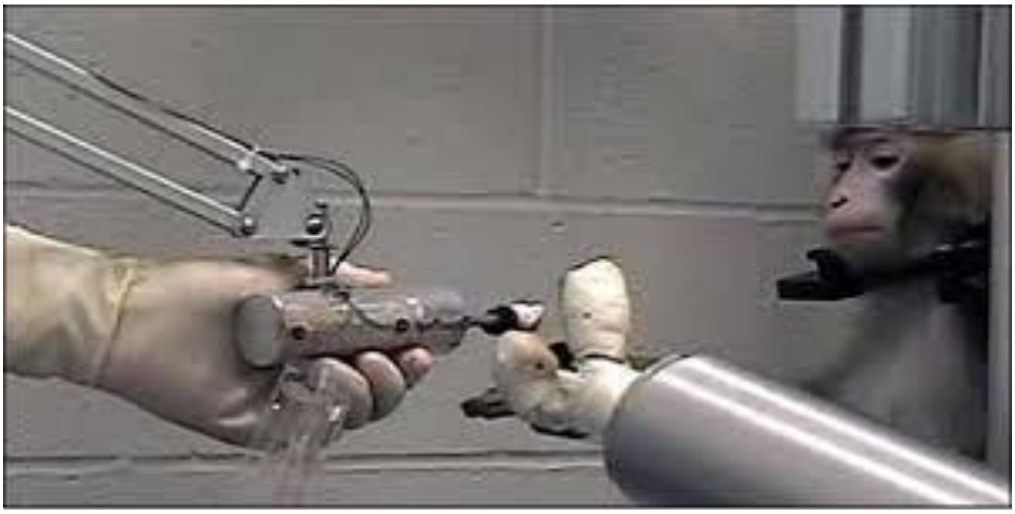

Figure 1: Experiment carried out on monkeys

In year 1999, A team of researchers which is guided by Mr. Yang Dan at the University of California, Berkeley, carried out one experiment. They show some short movies to the cat. After watching the movies, neurons in their brain was fired. Researchers recorded these signals and decode it. Decoded signals were used to reproduced the images in the videos which were seen by the cat. These images were used to reproduce the videos. Researchers could construct recognizable scenes of the videos. Scientist were able to obtained similar type of results in humans also [4].

3. HUMAN BRAIN COMPUTER INTERFACE RESEARCH

3.1. Invasive Brain Computer Interface

Invasive BCI helps to the people who are blind or has paralysis. Using neurosurgery invasive BCI devices are implanted into the gray matter of the brain. The signals produced by the BCI devices are of highest quality as the devices are implanted directly into the gray matter of the brain. It has one disadvantage also, as the body reacts to foreign object in the brain, there are chances that scar tissues may get build-up. Because of this, signal generated by the brain may get weaker or even non-existent [3] [4].

3.1.1. Vision

Invasive brain computer interface is used for the people who has acquired blindness, i.e. blindness not from the birth but blindness acquired at any point of time in the life.

Figure 2: Jens Neumann, a man with acquired blindness

Scientist William Dobelle created the working brain interface. He carried out his first experiment in year 1978, on a person, named Jerry, who became blind in adulthood. He prepared BCI device containing 68 electrodes and implanted it in visual cortex of Jerry. Using this BCI device Jerry was able to feel the sensation of light [1] [4]. In this system, Dobelle place camera on glasses which was sending the signals to the device. Using this Jerry was able to see the shades of gray color which is present in short distance. The images were sent to the device at lower frame rate. Initially he was attached only with mainframe computers but with evolution of faster computers his artificial eye became more portable and he was able to perform simple task without any help [1] [4]. In year 2002, Dobelle created his second-generation device. This device was used by 16 blind people. It was first used by Jens Naumann, shown in fig 2. Using this device, he could drive the vehicle in the parking area of research institute [4]. Dobelle died in

2004 and he could not document his research. His patients started to face the problem with their vision and artificial device and eventually lost their sight again [4].

3.1.2. Movement

BCI is also used to help the people having paralysis. These people are connected with robot arm or computer to perform simple daily work [2]. Scientist at Emory University in Atlanta implanted a device in human brain which produces the signal of high quality. These high quality signals were used to move robot arm and cursor to perform simple task as shown in fig. 3. There was one patient Johnny Ray. He was suffering from lock-in- syndrome, i.e. he was aware about the outside world but he was not able to move his hand or legs or communicate with the people. The device was implanted in his brain in year 1998. He learnt to use the device and using it he could move the cursor [1] [2] [4].

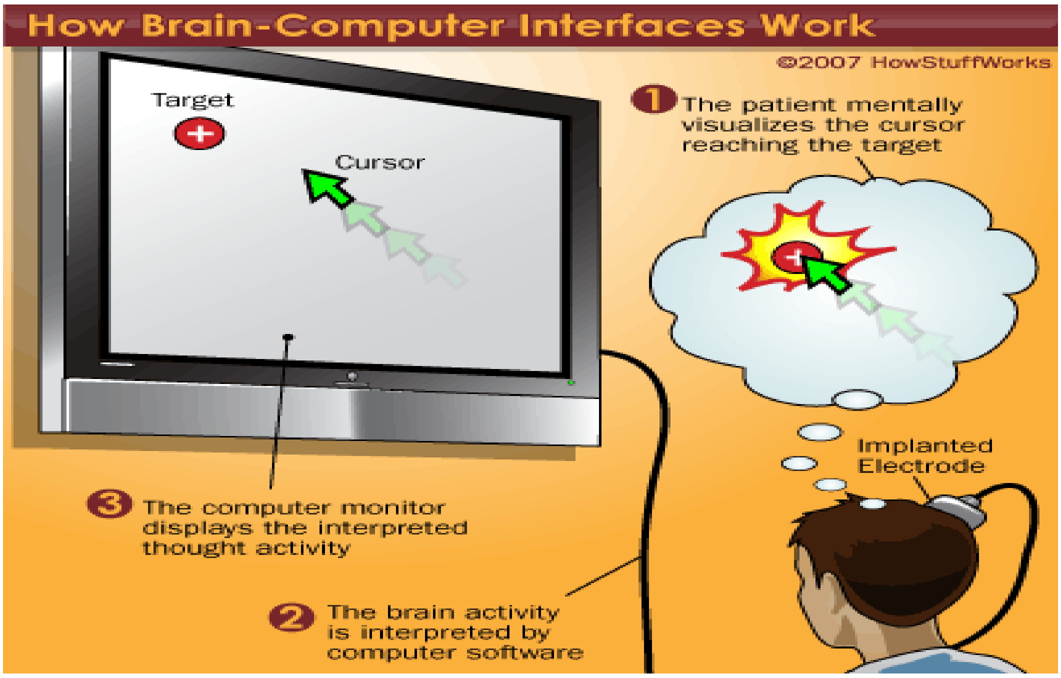

Figure 3: Human thoughts are used for moving the cursor

Brain Gate chip was first implanted in a person Matt Nagle who was not able to move his hands and legs. This chip consisted of sensors implanted in brain which sense firing of neurons in the specific areas of the brain, like the areas which control arm movement. These signals were sent to an external device where it was decoded. These decoded signals were used to move robot arm or cursor [3] as shown in fig. 4. It can also be used to control wheelchair by a paralyze person. Thus, brain gate enable a paralyze person to perform simple task just by thinking about the task in the brain and using the signals generated by the brain [2].

Figure 4: Paralyze person thinking to move his arm

3.2. Partially Invasive Brain Computer Interface

These devices remain present outside the brain, instead of grey matter of the brain. The signals produce by these devices are better than non-invasive BCI devices. There is less risk of forming scar-tissue in the brain as compared to fully invasive BCI devices [1].

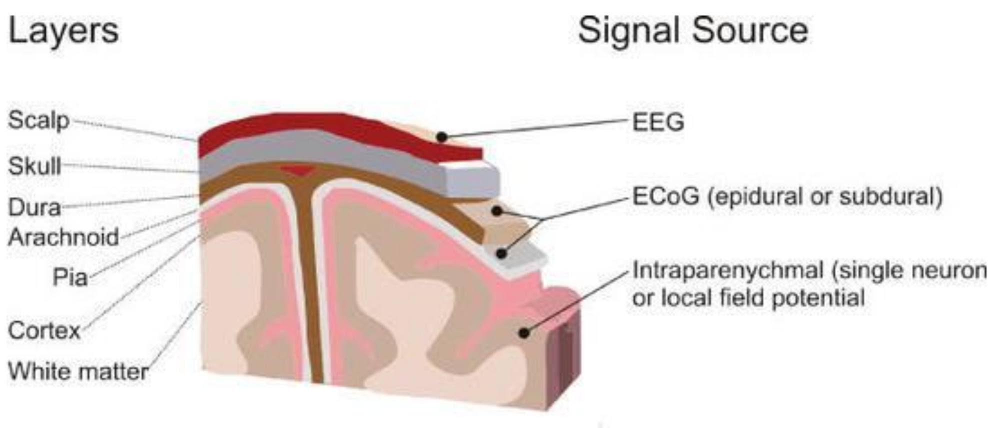

Figure 5: Layers of brain

Signals generated by electrical activity of the brain is measured by Electrocorticography (ECoG). The signals are taken from beneath the skull. Here the electrodes are placed in a thin plastic pad above the cortex, below the duramater of the brain as shown in fig. 5. ECoG was first trialed by Leuthardt and Daniel Moran from Washington University in

St Louis in 2004. A teenage boy was able to play space invaders using his ECoG implant. This technology requires less training and control is rapid [1].

ECoG has many benefits like less training requirements, wider frequency range, better signal-to-noise ratio and higher spatial resolution. It has less technical complexity. Its stability is more and risk is less. This technology is very good for the people who cannot use their hand or leg [1]. Future step may be the light reactive imaging BCI devices. Here laser is implanted inside the skull. This laser is trained on a single neuron. Signals generated by neurons are measured by a sensor. The laser light pattern reflected by neuron changes slightly when the neuron fires. Using this technique, researchers can monitor single neuron. Also, there is less contact with tissue so less chance of damaged tissues [1].

3.3. Non-Invasive Brain Computer Interface

Many experiments were carried out on using non-invasive neuroimaging technologies as interfaces in humans. Lots of research work is publish on noninvasive EEG based BCI. Non-invasive EEG based BCI is used in many applications. This technology does not require surgery. A person can wear EEG based BCI devices as shown in fig. 6. These devices have less spatial resolution. Received signals are not very strong as the signals generated by the brain become weaker while crossing the bones of skull [3]. User needs to do the practice for using Non-invasive EEG based BCI devices. Invasive and non-EEG based devices do not require practice before use [1] [2].

Figure 6: Non-invasive brain computer interface

In EEG based non-invasive interface temporal resolution is good, it is easy to use, its set-up cost is low and it is portable [1] [2] [3]. Niels Birbaumer at the University of Tübingen in Germany carried out one experiment in mid-1990. He selects some paralyzed people and trained them to self-regulate the slow cortical potentials in their EEG and these signals were used to control cursor [2]. This process required lots of training. Patient took more than an hour to write 100 characters with cursor [3] [4].

4. NEUROGAMING

Figure 7: Player using neurogaming software

Neurogaming is a new field of gaming. It uses non-invasive BCI. In this gaming software, brain waves, heart rate, expressions, pupil dilation, and even emotions of the player can be used and task in the game is completed [2], as shown in fig. 7. Emotiv, a company which is developing and manufacturing wearable EEG based devices have created non-invasive BCI, which determines the mood of a player. Then background music or scenery in the game is adjusted accordingly. Because of this player gets more realistic gaming experience [4].

5. FUTURE DIRECTIONS

5.1. Disorders of Consciousness (DOC)

BCI research is used to help the people suffering from disorder of consciousness i.e. people in comma [2]. Patient may wear headphones or vibrotactile stimulators which can be placed on wrist, neck, leg or other location. Some people may become conscious or unconscious at unpredictable time, so the tool must be easy to set such that family members or other person who do not have technical or medical background can also be able to use it. It reduces the cost and time to use this tool [4]. Patients can be asked simple questions like is your name ‘sunny’? Do you stay in japan? Patient can reply by focusing attention to stimuli on left or right wrist. This helps to determine whether patient can communicate or not. BCI based communication devices are provided to these patients. Using these devices, they can covey simple things like adjust AC or bed position, ventilation etc. [4].

5.2 Functional Brain Mapping

Patients Suffering from tumors or epilepsy undergo brain mapping during neurosurgery. It is used to identify functional areas in the brain, like which area is responsible for movement or speak. Patient is awake during the surgery. He is asked to move hand or speak some word. Using this, surgeons can remove the desired tissues and save others. If less tissues are removed then disease may not be treated totally. If more tissues are removed then there may be permanent damage. BCI technology can be used to improve neurosurgical mapping [4].

6. CONCLUSION

Brain computer interface is a collaboration between brain and external device. This device is used to perform simple task like move the cursor or move the robot arm or wheelchair. BCI devices are very much useful for paralyze and blind people. This paper explored research carried out in the area of brain computer interface. Three different types of brain computer interfaces are discussed, they are invasive BCI, Partially invasive BCI and non-invasive BCI. We saw that it can also be used for the people having disorder of consciousness. It is also useful for functional brain mapping.

REFERENCES

[1] Anupama.H.S, N.K.Cauvery, Lingaraju.G.M, May 2012, "Brain Computer Interface and Its Types - A Study", International Journal of Advances in Engineering & Technology, ISSN: 2231-1963, Vol. 3, Issue 2, pp. 739-745.

[2] Brent J. Lance, Scott E. Kerick, Anthony J. Ries, Kelvin S. Oie, and Kaleb McDowell, 13th May 2012 "Brain–Computer Interface Technologies in the Coming Decades", IEEE proceedings, Vol. 100, pp. 1585-1599.

[3] Nidhi Behl, Vikrant Manocha, Keshvi Chauhan, "Implementation of Brain Computer Interface", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 1, Issue 3, pp. 807-812.

[4] https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface