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A Study on Interface between Human Brain and Computer Systems

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Abstract: ***This paper describes about BCI (Brain Computer Interface) system. What's it all about, what are its elements, what are the types of BCI, its working.***

Keywords: ***Brain Computer Interface (BCI), Mind-Machine Interface (MMI), Direct Neural Interface, Brain Machine Interface (BMI).***

I. INTRODUCTION

In the past decade, electronic and computer technology started research groups around the world to develop brain computer/machine interface (BCI). A brain–computer interface (BCI), often called a mind-machine interface (MMI), or sometimes called a direct neural interface or a brain–machine interface (BMI), is a direct communication pathway between the brain and an external device. Brain-computer interface (BCI) is a fast-growing emergent technology, in which researchers aim to build a direct channel between the human brain and the computer. A Brain Computer Interface (BCI) is a collaboration in which a brain accepts and controls a mechanical device as a natural part of its representation of the body. Computer-brain interfaces are designed to restore sensory function, transmit sensory information to the brain, or stimulate the brain through artificially generated electrical signals. BCIs read electrical signals or other manifestations of brain activity and translate them into a digital form that computers can understand, process, and convert into actions of some kind, such as moving a cursor or turning on a TV.BCI can help people with inabilities to control computers, wheelchairs, televisions, or other devices with brain activity signals.

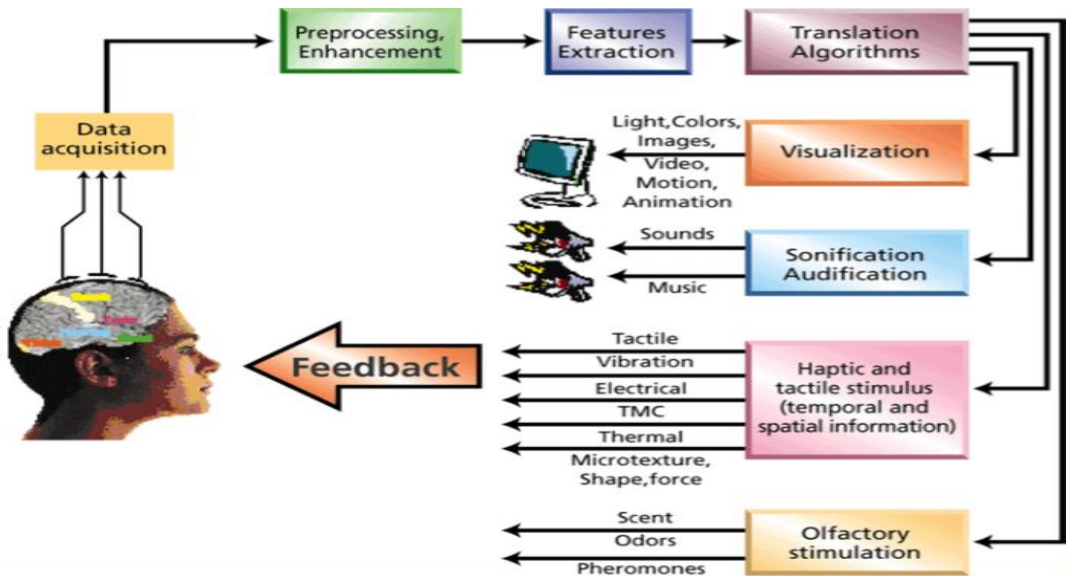

Fig.1 : BCI Cycle

II. Motivation

The goal of the Brain computer interface is to develop a fast and reliable connection between the brain of a severely disabled person and a personal computer. The ‘Brain computer interface ‘can provide paralyzed or motor-impaired patients a mode of communication through the translation of thought into direct computer control. It allows patients to control a computer by conscious changes of brain activity and provide a means of communication to completely paralyzed patients such as Amyotrophic Lateral Sclerosis (ALS), cerebral palsy, locked in syndrome. It can be used to control a cursor, select symbols, control external devices like orthesis / prosthesis (depending on type of BCI).

III. History

Research on BCIs began in the 1970s at the University of California Los Angeles (UCLA) under a grant from the National Science Foundation, followed by a contract from DARPA.The history of brain–computer interfaces (BCIs) starts with Hans Berger's discovery of the electrical activity of human brain and the development of electroencephalography (EEG). In 1924 Berger was the first one who recorded an EEG from a human brain. By analysing EEGs, Berger was able to identify oscillatory activity in the brain, such as the alpha wave (8–12 Hz), also known as Berger's wave. Berger's first recording device was very rudimentary. He inserted silver wires under the scalp of his patients. Those were replaced by silver foils that were attached to the patients head by rubber bandages later on. Berger connected these sensors to a Lippmann capillary electrometer, with disappointing results. More sophisticated measuring devices such as the Siemens double-coil recording galvanometer, which displayed electric voltages as small as one ten thousandth of a volt, led to success.

Fig. 1 and Fig. 3: Examples of Animal BCI Research

Researchers began conducting initial studies on rats. Picture given below depicts this. Rats implanted with BCIs in Theodore Berger's experiments. After conducting initial studies in rats during the 1990s, researchers developed Brain Computer Interfaces that decoded brain activity in monkeys and used the devices to reproduce movements in monkeys and used the devices to reproduce monkey movements in robotic arms. Several laboratories have managed to record signals from monkey and rat cerebral cortices to operate BCIs to carry out movement. Monkeys have navigated computer cursors on screen and commanded robotic arms to perform simple tasks simply by thinking about the task and without any motor output. Other research on cats has decoded visual signals. The first Intra-Cortical Brain-Computer Interface was built by implanting electrodes into monkeys. Monkey operating a robotic arm with brain–computer interfacing Following years of animal experimentation, the first BCI devices implanted in humans appeared in the mid-1990s.All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

IV. Basic Elements of BCI

The BCI System is used to sense, transmit, analyze and apply the language of neurons.

1. The Chip
2. The Connector
3. The Converter

4. The Computer

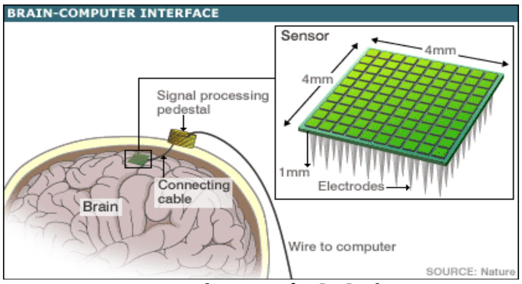

Fig.4 : Elements of BCI Cycle

1. THE CHIP:

A four-millimeter square silicon chip studded with hundred hair microelectrodes is embedded in the primary motor cortex.

2. THE CONNECTOR:

When somebody thinks "move cursor up and left "his cortical neuron 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 fibre-optic cable to a computer.

4. THE COMPUTER:

The computer translate brain activity and generate a communication output using decoding software.

V. TYPES OF BCI

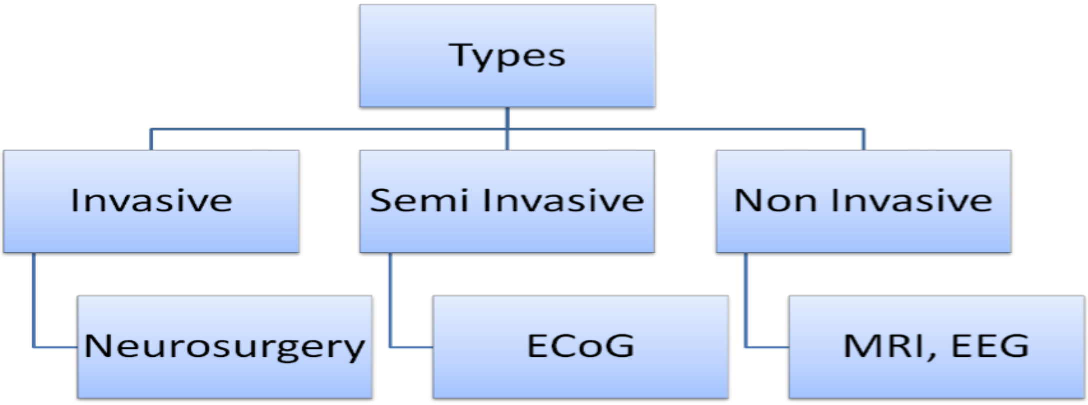

Fig.4: Types of BCI

Invasive BCIs

These techniques involves implanting electrodes directly into the grey matter of the brain during neurosurgery .The patient's brain gradually adapts its signals to be sent through the electrodes.

As they rest in the grey matter, invasive devices produce the highest quality signals of BCI devices but are prone to scar-tissue build-up, causing the signal to become weaker or even lost as the body reacts to a foreign object in the brain.

Partially invasive BCIs

Partially invasive BCI devices are implanted inside the skull but rest outside the brain rather than within the grey matter. They produce better resolution signals than non-invasive BCIs where the bone tissue of the cranium deflects and deforms signals and have a lower risk of forming scar-tissue in the brain than fully invasive BCIs. Output: ECoG

Non-invasive BCIs

These techniques involves putting electrodes on the scalp of the patient or medical scanning devices or sensors are mounted on caps or headbands to read brain signals .Signals recorded in this way have been used to power muscle implants and restore partial movement in an experimental volunteer. Although they are easy to wear, non-invasive implants produce poor signal resolution because the skull dampens signals, dispersing and blurring the electromagnetic waves created by the neurons. Although the waves can still be detected it is more difficult to determine the area of the brain that created them or the actions of individual neurons. Output: EEG, MEG.

VI. WORKING OF BCI CYCLE

The BCI cycle starts with the user engaging in a cognitive task while receiving possible stimuli. Traces of brain activity are picked up by sensors. These signals are preprocessed, relevant features are extracted, and an outcome is predicted that is supposed to reflect the user's intention, either on a continuous scale or as discrete symbols. The outcome acts as an output signal for

Controlling an external device. The cycle is closed by the user perceiving the output, which allows a judgement about the appropriateness of the device's behavior and an adaptation of the mental activity. The output can be presented in multiple forms and modalities, depending on the user's abilities. While iterating through the cycle, both the user and the computer may learn to adapt, thereby increasing the performance of this man–machine system.

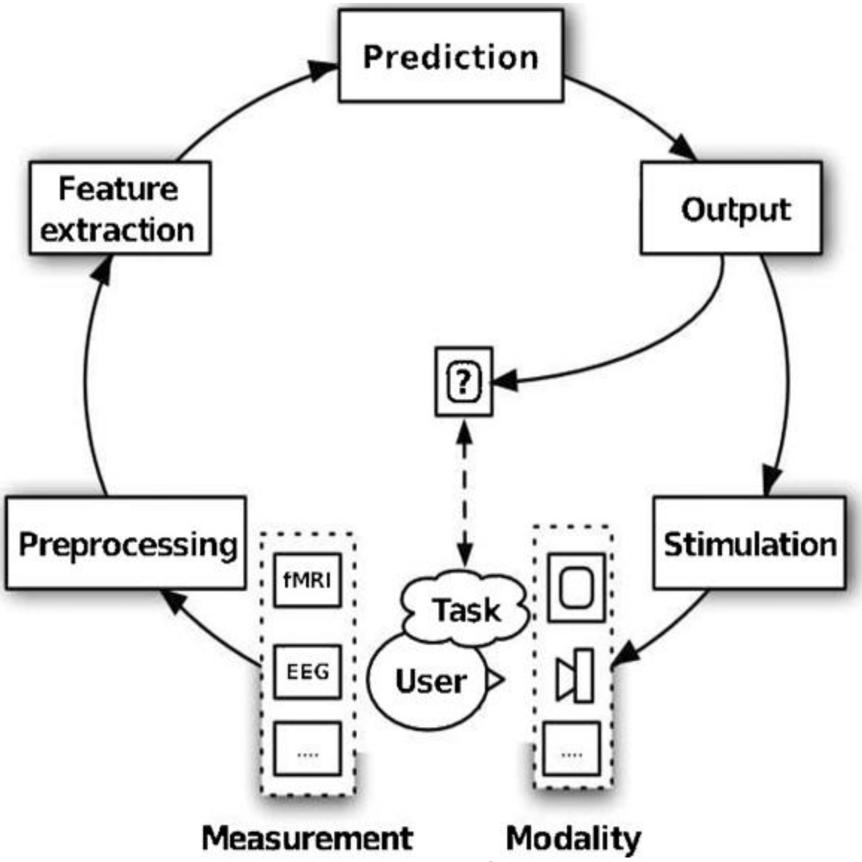

Fig.5: BCI Cycle

VII. CONCLUSION

A potential therapeutic tool .BCI is an advancing technology promising paradigm shift in areas like Machine Control, Human Enhancement, Virtual reality and etc. So, it's potentially high impact technology. Several potential applications of BCI hold promise for rehabilitation and improving performance, such as treating emotional disorders (for example, depression or anxiety), easing chronic pain, and overcoming movement disabilities due to stroke. It will enable us to achieve singularity very soon .Intense R&D in future to attain intuitive efficiency.

VIII. FUTURE WORK

It includes describing about the applications of BCI in real world, about EEG (Electro Encephalo Graphy), about SSVEP (Steady State Visual Evoked Potential) and signal processing method used in the research.

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Manisha Wadhwa, received the M.Sc. degree in Computer Science from University of Delhi in 2014. During 2014-2016, she stayed in Nagarro Software Private Limited, Gurgaon as a Software Engineer. She is now with RLA, DU as Assistant Professor.