IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Brain Computer Interface – A Review

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Abstract: A brain–computer interface (BCI) is a proficient result in the research field of human-computer synergy, where direct articulation between brain and an external device occurs resulting in augmenting, assisting and repairing human cognitive. In our overview study past and recent research works on brain computer interface are sincerely explored as well as their productivity in the field of BCI and critical discussions about the proposed research methods for future developments are presented in this seminar. Brain computer interfaces (BCIs) enable users to control devices with electroencephalographic (EEG) activity from the scalp or with single-neuron activity from within the brain.

Index Terms **-Electroencephalographic, Brain Computer Interface, Human-computer synergy.**

I. Introduction

For generations, publics have fantasized about the ability to connect and cooperate with machines through thought singlehanded or to create devices that can peer into person's kindness and thoughts. These ideas have captured the mind of humanity in the form of ancient myths and fashionable science fiction stories. However, it is first newly that advances in cognitive neuroscience and brain imaging technologies have trendy to provide us with the ability to interface straight with the human brain. This ability is made imaginable through the use of devices that can display some of the physical processes that happen within the brain that correspond with helpful forms of thought. The ability to supervisor a computer using only the power of the mind is faster than one power think. Brain-computer interfaces, where processors can recite and interpret signals straight from the brain, have previously accomplished clinical success in permitting quadriplegics, those grief "protected- in disorder" or people who have had a hit to transfer their own wheelchairs or even beverage coffee from a cup by monitoring the action of a robotic arm with their brain surfs as in fig 1. In addition, direct brain implants have facilitated restore partial vision to persons who have lost their sight.

II. History

The history of brain–computer interfaces (BCIs) starts with Hans Berger's detection of the electrical activity of the human brain and the development of electroencephalography (EEG). In 1924 Berger was the first to record humanoid brain activity by means of EEG. Berger was able to classify oscillatory activity in the brain by analyzing EEG traces. One wave he identified was the alpha wave (8–13 Hz), also known as Berger's wave. Berger's first recording device was very elementary. He inserted silver wires under the scalps of his patients. These were later replaced by silver foils attached to the patients' head by rubber bandages. Berger connected these sensors to a Lippmann tube electrometer, with disappointing results. More sophisticated measuring devices, such as the Siemens double-coil recording galvanometer, which shown electric voltages as small as one ten thousandth of a volt, led to success. Berger analyzed the interrelation of alternations in his EEG wave diagrams with brain diseases. EEGs permitted completely new possibilities for the research of human brain activities Research on BCIs began in the 1970s at the University of California Los Angeles (UCLA) under a endowment from the National Science Foundation, followed by a contract from DARPA. The papers indexed after this research also mark the first appearance of the expression brain–computer interface in scientific literature. The field of BCI research and development has since focused principally on neuroprosthetics submissions that aim at restoring damaged hearing, sight and movement. Thanks to the extraordinary cortical plasticity of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effector channels. Following years of animal research, the first neuroprosthetic devices implanted in humans performed in the mid-1990s

III. Animal BCI Research

Numerous laboratories have managed to greatest signals from monkey and rat cerebral cortexes in instruction to operate BCIs to carry out movement. Monkeys have crossed computer cursors on screen and demanded robotic arms to perform simple tasks merely by thinking about the task and without any motor output. Other research on cats has interpreted visual signals.

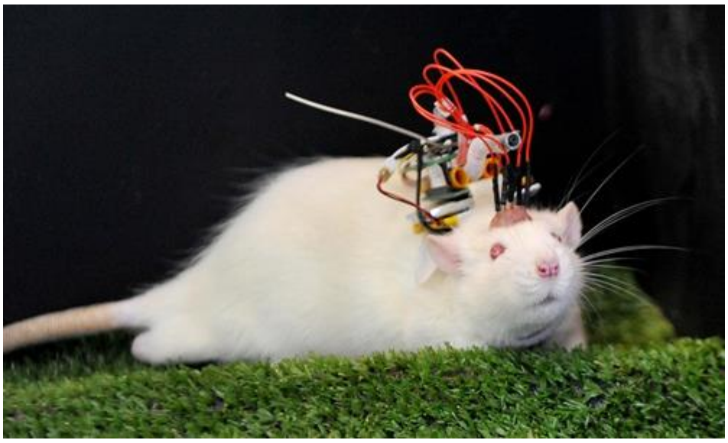

FIG. 1. RATS IMPLEMENTED WITH BCIS IN THEODORE BERGER'S EXPERIMENTS

IV. EARLY WORK

Reserches that developed algorithms to rebuild movements from motor cortex neurons, which switch movement, date back to the 1970s. Work by collections led by Schmidt, Fetz and Baker in the 1970s recognized that monkeys could rapidly learn to voluntarily control the firing rate of separate neurons in the main motor cortex afterward closed-loop operant conditioning, a training method using punishment and rewards. In the 1980s, Apostolos Georgopoulos at Johns Hopkins University originate a mathematical relationship between the electrical responses of lone motor-cortex neurons in rhesus macaque monkeys and the track that monkeys moved their arms (based on a cosine function). He also originate that dispersed groups of neurons in dissimilar areas of the brain collectively measured motor commands but was only able to greatest the firings of neurons in one area at a time because of technical limitations forced by his equipment. There has been speedy development in BCIs since the mid-1990s. Several clusters have been able to capture compound brain motor centre signals using copies from neural ensembles (groups of neurons) and use these to controller external devices, including study groups led by Richard Andersen, John Donoghue, Phillip Kennedy, Miguel Nicolelis, and Andrew Schwartz.

V. PROMINENT RESEARCH SUCCESSES

Phillip Kennedy and colleagues built the first ntracortical brain-computer interface by implanting neurotrophic-cone electrodes into monkeys. In 1999, researchers led by Garrett Stanley at Harvard University decoded neuronal firings to reproduce images seen by cats. The team used an array of electrodes embedded in the thalamus (which integrates all of the brain's sensory input) of sharp-eyed cats. Researchers targeted 177 brain cells in the thalamus lateral geniculate nucleus area, which decodes signals from the retina. The cats were shown eight short movies, and their neuron firings were recorded. Using mathematical filters, the researchers decoded the signals to generate movies of what the cats saw and were able to reconstruct recognizable scenes and moving objects. Miguel Nicolelis has been a prominent proponent of using multiple electrodes spread over a greater area of the brain to obtain neuronal signals to drive a BCI. Such neural ensembles are said to reduce the variability in output produced by single electrodes, which could make it difficult to operate a BCI. After conducting initial studies in rats during the1990s, Nicolelis and his colleagues developed BCIs that decoded brain activity in owl monkeys and used the devices to reproduce monkey movements in robotic arms. Monkeys have advanced reaching and grasping abilities and good hand manipulation skills, making them ideal test subjects for this kind of work. By 2000, the group succeeded in building a BCI that reproduced owl monkey movements while the monkey operated a joystick or reached for food. The BCI operated in real time and could also control a separate robot remotely over Internet protocol. But the monkeys could not see the arm moving and did not receive any feedback, a so- called open-loop BCI

Later experiments by Nicolelis using rhesus monkeys, succeeded in closing the feedback loop and reproduced monkey reaching and grasping movements in a robot arm. With their deeply cleft and furrowed brains, rhesus monkeys are considered to be better models for human neurophysiology than owl monkeys. The monkeys were trained to reach and grasp objects on a computer screen by manipulating a joystick while corresponding movements by a robot arm were hidden. The monkeys were later shown the robot directly and learned to control it by viewing its movements.

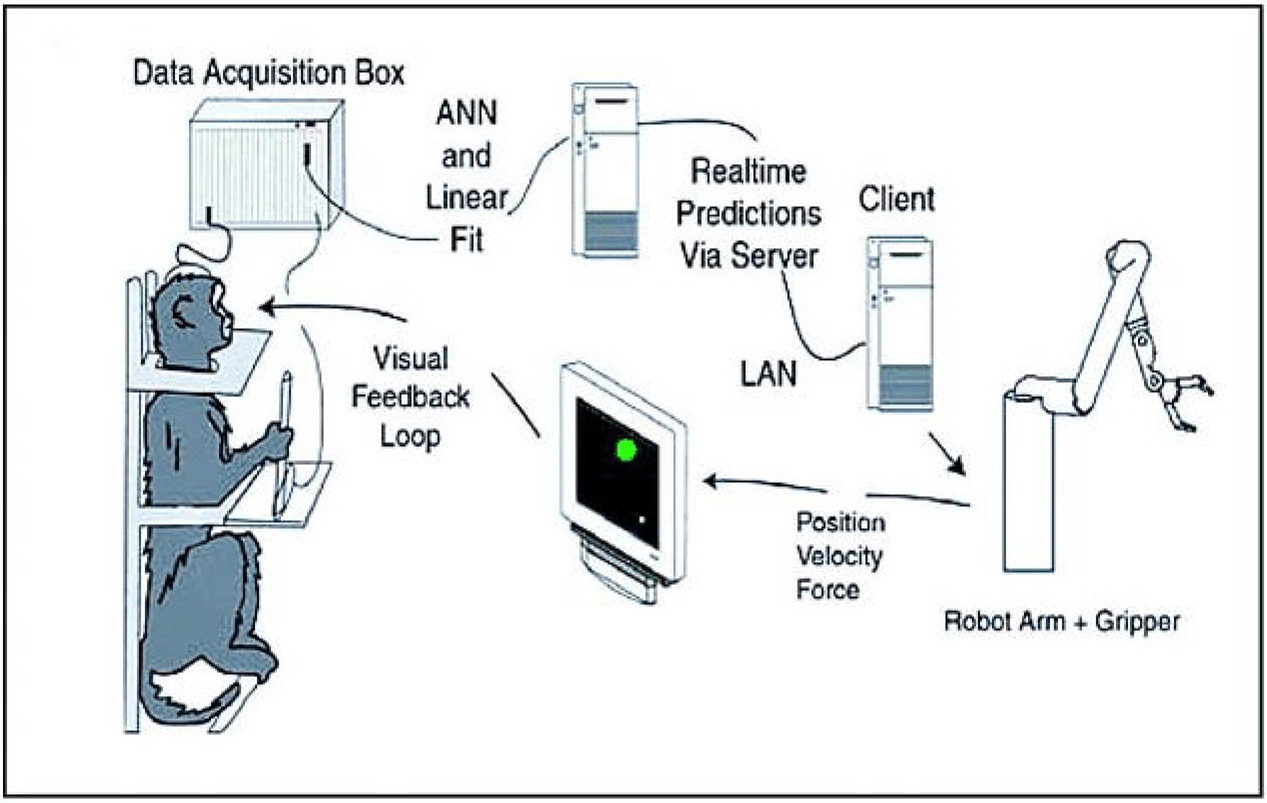

Fig. 2. BCI developed by Miguel Nicolelis and colleagues

The BCI used velocity predictions to control reaching movements and simultaneously predicted hand gripping force. Other labs that develop BCIs and algorithms that decode neuron signals include John Donoghue from Brown University, Andrew Schwartz from the University of Pittsburgh and Richard Andersen from Caltech. These researchers were able to produce working BCIs even though they recorded signals from far fewer neurons than Nicolelis (15–30 neurons versus 50–200 neurons). Donoghue's group reported training rhesus monkeys to use a BCI to track visual targets on a computer screen with or without assistance of a joystick (closed-loop BCI).Schwartz's group created a BCI for three-dimensional tracking in virtual reality and also reproduced BCI control in a robotic arm. The group created headlines when they demonstrated that a monkey could feed itself pieces of zucchini using a robotic arm powered by the animal's own brain signals. Andersen's group used recordings of premovement activity from the posterior parietal cortex in their BCI, including signals created when experimental animals anticipated receiving a reward. In addition to predicting kinematic and kinetic parameters of limb movements, BCIs that predict electromyographic or electrical activity of muscles are being developed. Such BCIs could be used to restore mobility in paralyzed limbs by electrically stimulating muscles.

VI. HUMAN BRAIN

The human brain has the similar general structure as the brains of other creatures, but has a more advanced cerebral cortex than any other. Dimension of the brain is occasionally measured by weight and sometimes by volume. An normal adult have brain volume of 1130 cubic centimeter for women and 1260 cubic centimeter for men. Heaviness of brain in an adult is 1250 gram for female and 1360 gram for masculine; and for a new born baby it's just 350 gram to 400gram. Significant active changes in brain construction take place through adulthood and aging, with considerable variation between individuals. In later years, men show greater volume loss in whole brain capacity and in the frontal lobes, and sequential lobes, whereas in women there is enlarged volume loss in the hippocampi and parietal lobes.

VII. ARCHITECTURE OF BCI

The planning of Brain Computer Interface consists of primarily 3 parts:

i. Signal Acquisition, i.e., Input
ii. Signal Processing
iii. Elector Device, i.e., Output

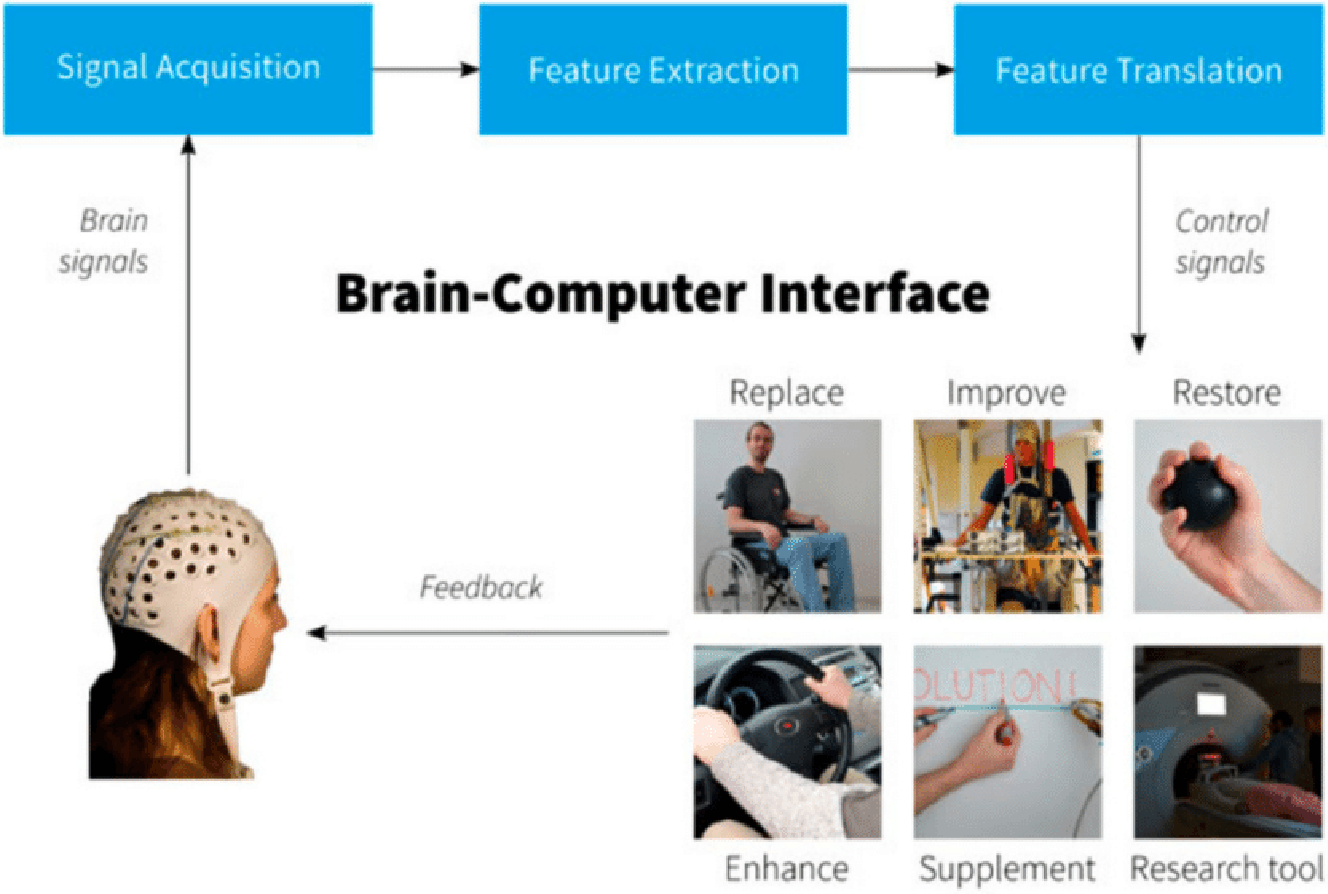

Fig. 4. Simple Architecture of Brain Computer Interface.

Signal Attainment: the EEG signals are found from the brain through aggressive or non-invasive methods (for example, electrodes). After, the indication is amplified and sampled. 2) Signal Pre-Processing: once the signals are developed, it is necessary to clean them. 3) Signal Classification: once the signals are cleaned, they will be processed and classified to find out which kind of mental task the subject is performing. Computer Interaction: once the signals are categorized, they will be used by an suitable algorithm for the growth of a assured application.

VII CONCLUSION

Research and growth in Brain Computer Interfaces has detonated in the last ten years, both in the technologies obtainable and the number of administrations involved in the field. BCIs have now progressed beyond laboratory experimental systems and some are now offered as gainful products. No lengthier, the realm of science fiction, BCIs are becoming a feasible and active alternative for assistive knowledge and a plethora of ordinary applications. New paradigms of interface open even more possibilities for BCI and create new fields of study, such as neural imaging for computational user involvement.

VIII FUTURE WORK

In the BCI research world, that has more everyday purposes, the early work will be revised and better to get a new result.

1. Thought-Communication Device

A new thought-communication device might soon help severely disabled people get their independence by allowing them to steer a wheelchair with their mind. Mind- machine interfaces will be available in the near future, and several methods hold promise for implanting information. Linking people via chip implants to super intelligent machines seems to a natural progression creating in effect, super humans. These cyborgs will be one step ahead of humans. And just as humans have always valued themselves above other forms of life, it is likely that cyborgs look down on humans who have yet to evolve.

2. Virtual Reality

The early work, in BCI virtual environments, in controlling a virtual apartment and a virtual simulator can be extended. Using some enhancement, the person with inabilities can walk through the virtual world by imagining the foot movement, and can touch things in the virtual world by imagining reaching and hand movement.

3. Communication

Communication systems that do not depend on the brains normal output pathways of peripheral nerves and muscles. In these systems, users explicitly manipulate their brain activity instead of using motor movements to produce signals that can be used to control computers or communication devices. The impact of this work is extremely high, especially to those who suffer from devastating neuromuscular injuries and neurodegenerative diseases such as amyotrophic lateral sclerosis, which eventually strips individuals of voluntary muscular activity while leaving cognitive function intact. Will people want to have their heads opened and wired? Technology moves in light speed now. In that accelerated future, todays hot neural interface could become tomorrow's neuro trash. Will you need to learn any math if you can call up a computer merely by your thoughts? Thought communication will place telephones firmly in the history books.

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