Study of Brain Machine Interface System

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Abstract— A brain–computer interface (BCI), sometimes called a mind-machine interface (MMI), or sometimes called a direct neural interface (DNI), synthetic telepathy interface (STI) or a brain–machine interface (BMI), is a direct communication pathway between the brain and an external device. BCIs are often directed at assisting, augmenting, or repairing human cognitive or sensory-motor functions.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.[1][2] The papers published 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 primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement. Thanks to the remarkable cortical plasticity of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effector channels.[3] Following years of animal experimentation, the first neuroprosthetic devices implanted in humans appeared in the mid-1990s.

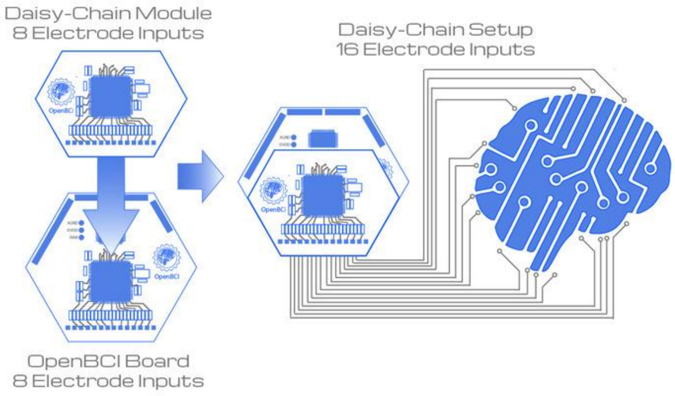
***Keywords**:* BCI, UCLA, DARPA, MMI

I. INTRODUCTION

The history of brain–computer interfaces (BCIs) starts with *Hans Berger's* discovery of the electrical activity of the human brain and the development of electroencephalography (EEG). In 1924 Berger was the first to record human brain activity by means of EEG. Berger was able to identify 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 rudimentary. 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 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.

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.

Miguel Nicolelis, a professor at Duke University, in Durham, North Carolina, 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 the 1990s, 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.[12] 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.

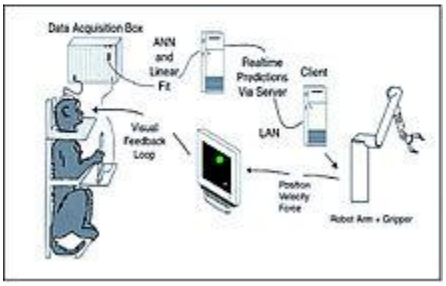
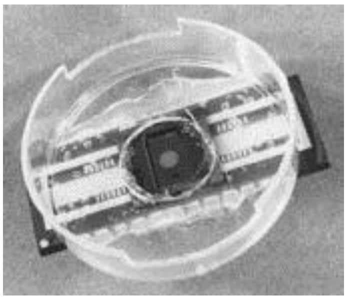


Diagram of the BCI developed by Miguel Nicolelis and colleagues for use on Rhesus monkeys

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.[13][14] The monkeys were later shown the robot directly and learned to control it by viewing its movements. The BCI used velocity predictions to control reaching movements and simultaneously predicted handgripping force.In 2011 O'Doherty and colleagues showed a BCI with sensory feedback with rhesus monkeys. The monkey was brain controlling the position of an avatar arm while receiving sensory feedback through direct intracortical stimulation (ICMS) in the arm representation area of the sensory cortex.

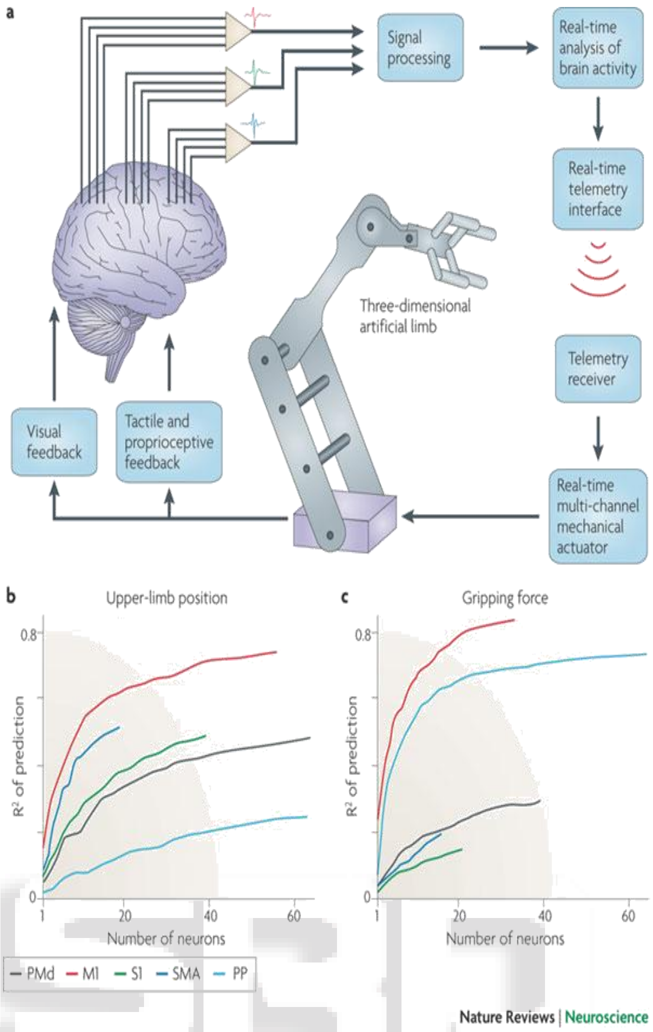
II. METHOLOGY

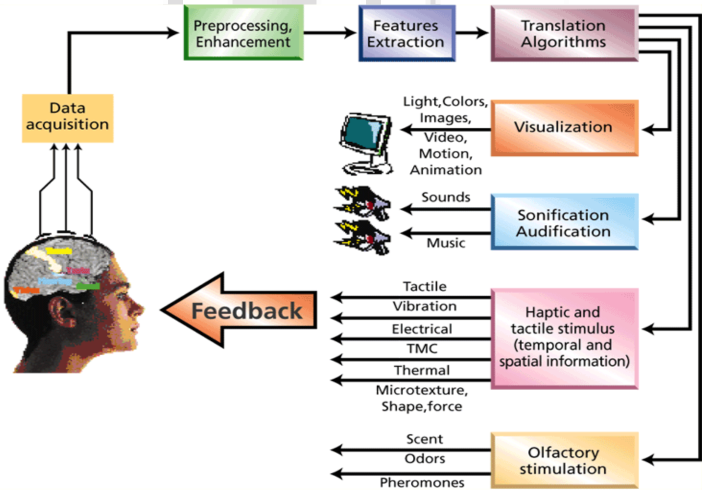
Researchers have built devices to interface with neural cells and entire neural networks in cultures outside animals. As well as furthering research on animal implantable devices, experiments on cultured neural tissue have focused on building problem-solving networks, constructing basic computers and manipulating robotic devices. Research into techniques for stimulating and recording from individual neurons grown on semiconductor chips is sometimes referred to as neuroelectronics or neurochips.[93]



The world's first Neurochip, developed by Caltech researchers Jerome Pine and Michael Maher

Development of the first working neurochip was claimed by a Caltech team led by Jerome Pine and Michael Maher in 1997.[94] The Caltech chip had room for 16 neurons.In 2003 a team led by Theodore Berger, at the University of Southern California, started work on a neurochip designed to function as an artificial or prosthetic hippocampus. The neurochip was designed to function in rat brains and was intended as a prototype for the eventual development of higher-brain prosthesis. The hippocampus was chosen because it is thought to be the most ordered and structured part of the brain and is the most studied area. Its function is to encode experiences for storage as long-term memories elsewhere in the brainhomas DeMarse at the University of Florida used a culture of 25,000 neurons taken from a rat's brain to fly a F-22 fighter jet aircraft simulator.[96] After collection, the cortical neurons were cultured in a petri dish and rapidly began to reconnect themselves to form a living neural network. The cells were arranged over a grid of 60 electrodes and used to control the pitch and yaw functions of the simulator. The study's focus was on understanding how the human brain performs and learns computational tasks at a cellular level.



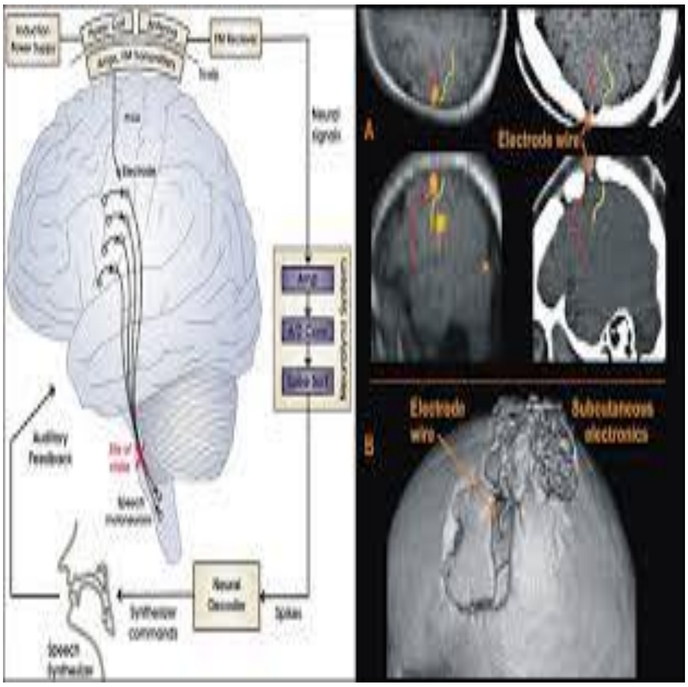


OpenBCI is built around Texas Instrument's ADS1299 IC. The ADS1299 is an 8-channel, low-noise, 24-bit analog-to-digital converter designed specifically for measuring teeny-tiny EEG signals. It has lots of bells and whistles, like the ability to generate internal signals for testing and calibration, as well as EEG-specific functions like lead off detection, to ensure that the electrodes are making good contact with the subject. It has a programmable Bias signal (DRL) and a very flexible input multiplexer. If you dork out on hardware, like we do, you'll want to take a look at the datasheet. Because this data sheet can be pretty scary for people that don't have a background in electrical engineering, we made the OpenBCI board and code libraries so that communicating with and controlling the ADS1299 chip is easy.

III. CONCLUSION

BCIs focusing on *motor neuroprosthetics* aim to either restore movement in individuals with paralysis or provide devices to assist them, such as interfaces with computers or robot arms.Researchers at Emory University in Atlanta, led by Philip Kennedy and Roy Bakay, were first to install a brain implant in a human that produced signals of high enough quality to simulate movement. Their patient, Johnny Ray (1944–2002), suffered from 'locked-in syndrome' after suffering a brain-stem stroke in 1997. Ray's implant was installed in 1998 and he lived long enough to start working with the implant, eventually learning to control a computer cursor; he died in 2002 of a brain aneurysm.[29]

Tetraplegic Matt Nagle became the first person to control an artificial hand using a BCI in 2005 as part of the first nine-month human trial of Cyberkinetics's BrainGate chip-implant. Implanted in Nagle's right precentral gyrus (area of the motor cortex for arm movement), the 96-electrode BrainGate implant allowed Nagle to control a robotic arm by thinking about moving his hand as well as a computer cursor, lights and TV.[30] One year later, professor Jonathan Wolpaw received the prize of the Altran Foundation for Innovation to develop a Brain Computer Interface with electrodes located on the surface of the skull, instead of directly in the brain.



More recently, research teams led by the Braingate group at Brown University[31] and a group led by University of Pittsburgh Medical Center,[32] both in collaborations with the United States Department of Veterans Affairs, have demonstrated further success in direct control of robotic prosthetic limbs with many degrees of freedom using direct connections to arrays of neurons in the motor cortex of patients with tetraplegia.

Electronic neural networks have been deployed which shift the learning phase from the user to the computer. Experiments by scientists at the Fraunhofer Society in 2004 using neural networks led to noticeable improvements within 30 minutes of training.[51]

Experiments by Eduardo Miranda, at the University of Plymouth in the UK, has aimed to use EEG recordings of mental activity associated with music to allow the disabled to express themselves musically through an encephalophone.[52] Ramaswamy Palaniappan has pioneered the development of BCI for use in biometrics to identify/authenticate a person.[53] The method has also been suggested for use as PIN generation device (for example in ATM and internet banking transactions.[54] The group which is now at University of Wolverhampton has previously developed analogue cursor control using thoughts.[55]

Researchers at the University of Twente in the Netherlands have been conducting research on using BCIs for non-disabled individuals, proposing that BCIs could improve error handling, task performance, and user experience and that they could broaden the user spectrum.[56] They particularly focused on BCI games,[57] suggesting that BCI games could provide challenge, fantasy and sociality to game players and could, thus, improve player experience.[58] The Emotiv company has been selling a commercial video game controller, known as The Epoc, since December 2009. The Epoc uses electromagnetic sensors.

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