A brain computer interface psychology essay

A Brain-Computer Interface (BCI) provides a new communication channel between the human brain and the computer. Current devices for achieving input into the computer mainly require physical or more precisely mechanical operation by the user, e. g. mouse and keyboard. Feedback from the computer is commonly given by audio/visual elements, e. g. speakers and monitors showing GUIs. However, the limitations in terms of usability and accessibility are well understood and have become apparent throughout the course of time. The main principle in overcoming these limitations is called Multimodal Interaction and there is a lot of ongoing research in this field. The field of BCI research and development has since focused primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement. Using our thoughts to control a computer or robot used to be the state of science-fiction writers. But scientists have been making combined efforts to develop the technology required to convert brain signals into commands, to support communication, mobility and independence for paralyzed people. This paper gives an overview of this small subset of HCI putting an emphasis on Brain-Computer Interaction (BCI). We will elaborate on its historical background, technologies used for implementing it and finally we will discuss possible and current applications.

A brain-computer interface (BCI), sometimes called a direct neural interface or a brain-machine interface (BMI), is a direct communication pathway between the brain and an external device. BCIs are often aimed 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 limitations in terms of usability and accessibility are well understood and have become apparent throughout the course of time. The main principle in overcoming these limitations is called Multimodal Interaction and there is a lot of ongoing research in this field. For example, current developments in Multimodal Interaction propose a combination of a visual modality with a voice modality for better usability and accessibility. A somewhat unconventional approach to achieving human-computer-interaction involves directly translating thoughts of the user into commands to the computer. In this context the term " thought" refers to the computer-aided interpretation of neuronal activities of the user. Neuronal activities may be recorded either at certain extremities of the human (arms, legs, etc.) or at the brain itself by analyzing brain waves. In principle, this approach is not limited to input into the computer but moreover may include methods for the computer to give feedback to the user by directly stimulating neurons. In the next section, basic definitions and terminology of BCI are given. Then an overview of existing technologies and also recent advances in the field is provided. This is followed up by a description on the different architectures of BCI designs.

The Human Brain

All of it happens in the brain. The brain is undoubtly the most complex organ found among the carbon-based life forms. So complex it is that we have only vague information about how it works. The average human brain weights around 1400 grams. The most relevant part of brain concerning BMI is the cerebral cortex. The cerebral cortex can be divided into two hemispheres. The hemispheres are connected with each other via corpus callosum. Each hemisphere can be divided into four lobes. They are called frontal, parietal, occipital and temporal lobes. Cerebral cortex is responsible for many higher order functions like problem solving, language comprehension and processing of complex visual information. The cerebral cortex can be divided into several areas, which are responsible of different functions. This kind of knowledge has been used when with BCI based on the pattern recognition approach. The mental tasks are chosen in such a way that they activate different parts of the cerebral cortex.

Main Principle

Main principle behind this interface is the bioelectrical activity of nerves and muscles. It is now well established that the human body, which is composed of living tissues, can be considered as a power station generating multiple electrical signals with two internal sources, namely muscles and nerves. We know that brain is the most important part of human body. It controls all the emotions and functions of the human body. The brain is composed of millions of neurons. These neurons work together in complex logic and produce thought and signals that control our bodies. When the neuron fires, or activates, there is a voltage change across the cell, (~100mv) which can be read through a variety of devices. When we want to make a voluntary action, the command generates from the frontal lobe. Signals are generated on the surface of the brain. These electric signals are different in magnitude and frequency.

By monitoring and analyzing these signals we can understand the working of brain. When we imagine ourselves doing something, small signals generate from different areas of the brain. These signals are not large enough to travel down the spine and cause actual movement. These small signals are, however, measurable. A neuron depolarizes to generate an impulse; this action causes small changes in the electric field around the neuron. These changes are measured as 0 (no impulse) or 1 (impulse generated) by the electrodes. We can control the brain functions by artificially producing these signals and sending them to respective parts. This is through stimulation of that part of the brain, which is responsible for a particular function using implanted electrodes.

History

Discovering the basics

The history of Brain-Computer-Interfaces (BCI) starts with Hans Berger's discovery of the electrical activity of human brain and the development of electroencephalography (EEG). Berger studied medicine at the University of Jena and received his doctorate in 1897. He became a professor in 1906 and the director of the University's psychiatry and neurology clinic in 1919. In 1924 Berger was the first one who recorded an EEG from a human brain. By analyzing EEGs Berger was able to identify different waves or rhythms which are present in a brain, 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 which 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 a 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. [WIKI_HB]

This paper has run the pieces from current BCI devices that can control simple robots, create simple virtual reality, or improve visual or auditory senses to an imagined future where BCI devices are used to facility brain connections to the Internet, creating human network with the possibility of true democracy! Certainly the applications for BCI devices discussed in this paper are long reaching, and BCI devices are not currently powerful enough to perform the tasks mentioned above, but the possibility of ‘ thought control’ machines would eliminate a bottleneck in data processing and computer interaction including communications that would improve not just the environment but people themselves.

These applications are not without their risks, however, and we have also seen that unless non-invasive BCIs develop to a point where they are just as sensitive or effective as the invasive BCIs, the threats may outweigh the benefits. Invasive BCIs necessarily show uniqueness to the individual that has the BCI which can cause privacy concerns. Those that refuse to get an invasive BCI would become a disadvantaged minority and could come under the threat of legislation to force all people to have them.

Frankly a single BCI from a human to a computer seems unlikely. Instead, BCIs will be application specific. A headset will allow thought control for one UAV or one Robot. A different BCI will be necessary for sensory improvement like visual aids- at least in the near future. As BCIs evolve (and perhaps this is a poor choice of words when the technology is so closely related to the organic), they will change from translation devices to network conduits that understand brain transmissions output and return input of their own to the brain.

In the short term, the next generation of BCI will be non-invasive headsets that allow the control of video games. The entertainment industry drives technical innovation of this sort that goes directly to consumers. In the meantime the sensitivity and data transmission will be improved by the medical community as cybernetics becomes more important. In 10 years, we may be using BCIs instead of Bluetooth headsets on our phones!