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BRAIN-COMPUTER INTERFACE

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ABSTRACT:

For many years people have speculated that electroencephalographic activity or other electrophysiological measures of brain function might provide a new non-muscular channel for sending messages and commands to the external world -a Brain–Computer Interface (BCI).Since 15 years, productive BCI research programs have been taking place. Then by understanding brain function, by the advent of powerful low-cost computer equipment and by growing needs of recognition of people and potentials of people with disabilities, these programs concentrated on developing new augmentative communication and control technology for those with severe neuromuscular disorders, such as amyotrophic lateral sclerosis, brainstem stroke, and spinal cord injury. The immediate goal is to provide these users, who may be completely 'paralyzed' with basic communication capabilities. So that they can express their wishes to care givers or even operate word processing programs or systems that can process human words. Basically the idea of Brain Computer Interface (BCI) is to connect the brain waves with an output device by using some dove tail. Aim of this journal is to clarify the potential utilization of complex EEG (Electroencephalography) signal in BCI system. For this purpose, the architecture of the software interface was designed and tested. The main task of the interface is to transfer brain activity signal into commands of intelligent robot or augmentative communicator and controller.

BCI'S maximum speed of transferring the information is 10–25 bits/min. This limited capacity can be valuable for people whose severe disabilities prevent them from using conventional augmentative communication methods. At the same time, many possible applications of BCI technology, such as neuron prosthesis control, may require higher information transfer rates. Future progress will depend on: recognition that BCI research and development is an interdisciplinary problem, involving neurobiology, psychology, engineering, mathematics, and computer science; identification of those signals, whether evoked potentials, spontaneous rhythms, or neuronal firing rates, that users are best able to controlling dependent of activity in conventional motor output pathways; development of training methods for helping users to gain and maintain that control; delineation of the best algorithms for translating these signals into device commands; attention to the identification and elimination of artifacts such as electro graphic and electro-graphic activity; adoption of precise and objective procedures for evaluating BCI performance; recognition of the need for long-term as well as short-term assessment of BCI performance; identification of appropriate BCI applications and appropriate matching of applications and users; and attention to factors that affect user acceptance of augmentative technology, including ease of use, and provision of those communication and control capacities that are most important to the user.

INTRODUCTION:

Brain Computer Interface (BCI) is a direct connection between computer's and human brain. It is the most recent development of Human Computer Interface (HCI). Unlike the traditional input devices (keyboard, mouse, pen… etc.), the BCI reads the waves produced from the brain at different locations in the human head, translates these signals into actions, and commands that can control the computer's The BCI can lead to many applications especially for disabled persons such as new ways for gamers to play games using their heads, (2) social interactions; enabling social applications to capture feelings and emotions, (3) helping— partially or fully-disabled people to interact with different computational devices, and (4) helping understanding more about brain activities and human neural networks.

The human brain is a complex system, which is an object of our research. It is regarded as the most complex system in the universe. The modern science is currently attempting to understand the complex interconnection among individual parts of the brain. [10] There are many publications, which deal with a description of the brain. The brain itself is composed of several parts, without which his activity could not be possible. One of its basic structural parts is a neuron. The neuronal cells are characterized by the fact that electrical activity is carried out in them. These cells communicate with each other by electrical signals. According to the last estimate, there are approximately neurons in the brain. Every one of them is connected with thousands of other neurons. The main source of Electroencephalography (EEG) signal is an electric activity of synapse - dendrites membrane located in the surface layer of the cortex. Each active synapse dispatches electromagnetic pulse to the environment during excitation.

HISTORY:

Hans Berger's innovation in the field of human brain research and its electrical activity has a close connection with the discovery of brain computer interfaces. Berger is credited with the development of electroencephalography, which was a major breakthrough for humans and helped researchers record human brain activity – the electroencephalogram (EEG). This was certainly a major discovery in human brain mapping, which made it possible to detect brain diseases. Richard Canton's 1875's discovery of electrical signals in animal brains was an inspiration for Berger. As one of the first common use of brain computer interface technology, EEG neurofeedback has been in use for several decades.

The year 1998 marked a significant development in the field of brain mapping when researcher Philip Kennedy implanted the first brain computer interface object into a human being. However, the BCI object was of limited function. The only benefit from this development was the use of a wireless di-electrode.

John Donohue and his team of Brown University researchers formed a public traded company, Cyber kinetics, in 2001. The goal was to commercially design a brain computer interface, the so called Brain Gate. The company has come up with NeuroPort ™- its first commercial product. Columbia University Medical Center researchers have successfully monitored and recorded electrical activity in the brain with improved precision. According to researchers, NeuroPort™ Neural Monitoring System enabled them to identify micro-seizure activity prior to epileptic seizures among patients.

June 2004 marked a significant development in the field when Matthew Nagle became the first human to be implanted with a BCI, Cyberkinetics's BrainGate™.

In December 2004, Jonathan Wolpaw and researchers at New York State Department of Health's Wadsworth Center came up with a

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research report that demonstrated the ability to control a computer using a BCI. In the study, patients were asked to wear a cap that contained electrodes to capture EEG signals from the motor cortex – part of the cerebrum governing movement.

A number of developments have been taking place in the field. By 2050, it is has been suggested that BCI could become a magic wand, helping men control objects with their mind. The day isn't far off when man may be able to guide an outside object with their thoughts in order to consistently execute both natural and complex motions of everyday life.

DEFINITION:

Brain-Computer Interface (BCI): devices that enable its users to interact with computers by mean of brain-activity only, this activity being generally measured by ElectroEncephaloGraphy (EEG).

Electroencephalography (EEG): physiological method of choice to record the electrical activity generated by the brain via electrodes placed on the scalp surface.

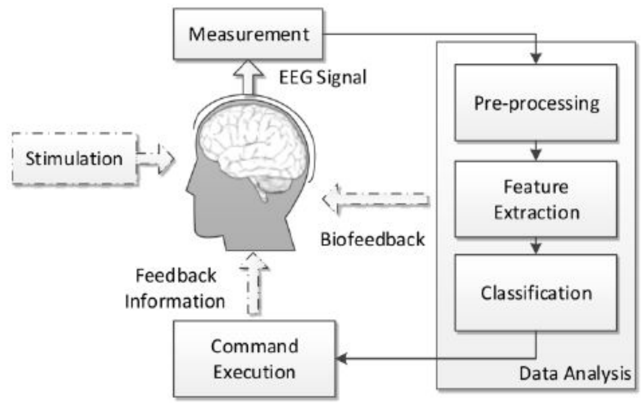
Functional magnetic resonance imaging (FMRI): measures brain activity by detecting changes associated with blood flow.

Functional Near-Infrared Spectroscopy (FNIRS): the use of near-infrared spectroscopy (NIRS) for the purpose of functional neuroimaging. Using fNIRS, brain activity is measured through hemodynamic responses associated with neuron behaviour.

Convolutional Neural Network (CNN): a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data.

Visual Cortex: part of the cerebral cortex that receives and processes sensory nerve impulses from the eyes

ARCHITECTURE:



WORKING:

Brain Signals:

A BCI records and interprets or decodes brain signals. Brain cells (neurons) communicate with each other by sending and receiving very small electrical signals. It is possible to 'listen' to these signals (generally referred to as 'brain activity') with advanced electrical sensors. Healthy people are able to move because the brain sends signals via the central nervous system to the muscles of the body. All interaction of a person (such as speaking or shaking hands) requires precise communication between the brain and muscles. Medical conditions such as stroke or neuromuscular diseases can disrupt or break the communication between the brain and body muscles and lead to paralysis (or the loss of the ability to control one's body, such as cerebral palsy). However, in many cases the brain is still able to generate the activity for intended movements and a BCI can use the brain activity to control assistive devices.

Measuring Brain Signals:

ACTIVITY BAND	FREQUENCY	STATE OF MIND
Beta	13-30 Hz	Associated with active thinking and active attention.
Alpha	8-13 Hz	Strongest over the occipital cortex and also over frontal cortex. They represent both relaxed awareness and also intended attention.
Theta	4-7 Hz	Emotional stress, creative inspiration and deep meditation.
Delta	0.5-4 Hz	Associated with deep sleep.
Gamma	>=35 Hz	Associated with higher mental activity , including perception and consciousness.
Mu	8-12 Hz	Associated with motor activities and recorded over motor cortex.

Brain signals can be measure with various techniques that each have pros and cons. A commonly used technique is electroencephalograph (EEG). This technique uses electrical sensors (electrodes) that are places on the scalp.

Electrodes can also be placed under the scalp directly on or in the brain tissue. A surgical procedure is necessary to place such electrodes. Electrodes that are placed on the surface of the brain do not damage the brain. The quality of this signal is significantly better that signals recorded from the scalp. It is for this reason that implantable BCIs are now being developed for paralyzed people.

Other techniques for measuring brain activity are functional MRI (fMRI), which measures brain activity with a MRI-scanner, and "Magneto Encephalography" (MEG), which measures brain activity with an MEG-scanner. Both of these techniques require large and expensive machines that will not become suitable for home use.

An additional technique is near-infrared spectroscopy (NIRS), which measures brain activity by shining near-infrared light through the skull. NIRS can be made portable and does not require any surgery. However, at this time the quality of the brain activity measurement is not sufficient for use with BCI.

Types of signals:

Brain Function:

In general each part of the body has its own 'control center' in the brain that is responsible for orchestrating it movements. For example making a fist with your left hand and wiggling your right big toe are controlled by distinct areas in your brain.

The different techniques used to measure brain activity can 'see' when different control centers are active. This allows BCIs to detect the movement of body parts from the brain activity. A special quality of the brain is that these control centers are also active why you simply think about making a movement without actually moving.

In general people who suffer from LIS still have fully functioning control centers in the brain. Hence they are able to activate distinct areas in their brain by thinking about, or attempting to make, movements even if they are no longer able to move the part of the body that that area of the brain normally controls.

In addition to movements a number of other brain functions can be detected. For example, there is a small area in the brain that is activated when you do a numeric calculation in your head. Other areas are involved in different aspects of understanding language and speaking. When these areas are active a BCI can detect if a person is adding in their head, or is talking.

Hence, there are many distinct areas in the brain that a person can intentionally turn on and off by performing different mental (for example; by counting backwards in steps of 7 in their head) or physical tasks. The fact that a person suffering from paralysis can also intentionally activate specific areas of their brain by performing mental tasks, makes a BCI a realistic and promising assistive device technology.

Conclusion:

The BCI reads the signals produced from the brain at different locations in the human brain and translates these signals into actions, and commands that can control the system. Brain computer interface can be classified into three main groups which depend on the way that the electrical signal is obtained from neuron cells in the human brain. Several techniques have been used to monitor brain activities; each technique has its own characteristics as well as advantages and disadvantages. BCI is interesting area for researchers because it can solve many problems which seem to be impossible. Many applications focused in entertainment and playing games especially after using 3 monitors, certain glasses and an EEG headset where the control on the game will be by thoughts. Researchers in this filed are looking in the future for more development in trends and applications. Since the current trends are focused on utilizing of motor system.

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