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**Brain-computer Interface**

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What is BCI? In 1960 DARPA (Defense Advanced Research Projects Agency) suggested the creation of an interface based on interaction with the brain. These interfaces work by scanning brain activity and translating it into commands. Due to the fact that the brain transmits information through neurons by electronic impulses, integration with electronics is much easier to implement. The brain-computer interface (BCI) is a system of information exchange between the human brain and an electronic device [1].

BCI, being an interdisciplinary field, combines a number of scientific fields such as neuroscience, physiology, engineering, information technologies, psychology and etc. The main goal of the BCI design is to develop ways for interpreting the information encoded in the electrical activity of neural groups using a computer system. These signals should be analyzed in real time and converted into control commands for the artificial device.

The first person to talk about BCI was Jacques Vidal, in his article "Towards Direct Brain-Computer Communication" in 1973 [1]. The basis for such technologies was founded by the fundamental work on the study of the cerebral cortex of I.P. Pavlov in the field of regulation and functioning of the cerebral cortex, which was later continued by the Soviet physiologist P. K. Anokhin, and N. P. Berekhteva in deciphering mental codes. The BCI technology has been developing rapidly since the mid-1990s. Several groups of researchers were able to capture complex signals from the motor cortex by recording them from so-called neural ensembles (groups of neurons) and using them to control external devices. But the idea of BCI has received the most development during the last decade. The strategic goal of the past and current decades in this field is to fully recognize and create a model of the brain's electronic impulse pathways. The central nervous system is a complex communication network. There are 80 billion neurons in the brain alone, with trillions of connections between them. At any moment, the distribution of electrons changes in each neuron causing the reaction. Depending on the type of neurotransmitter, the nature of the transmission changes, and the reaction also depends on the nature and rhythm of the impulses, and most importantly on the system. So the nervous system is not just a collection of wires, but is a much more complex system [2].

The BCI functionality includes three stages. Firstly, the BCI reads commands based on the recording of electrical activity in the brain. The main task of this stage is to decipher the electrical signal. The program has a set of "patterns", or "events", consisting of various signal characteristics: oscillation frequencies, activity peaks, cortical locations, and other data. These signals can be read in an invasive or non-invasive way. In the first case, the scanning electrodes are implanted under the cortex or on its surface, and in the second, they are attached to the surface of the head, which is also known as electroencephalography (EEG) which then captures the field status at a particular moment due to the potential change during transmission

Next, you need to define the signal to determine the intentions behind it. At the second stage, the received signal is processed, its shape is refined, and interference with clear transmission is eliminated. There are two possible ways to decipher the data: the first algorithm, which is not limited by search parameters, classifies the "crude" signal itself and finds elements, predicting intentions with the highest probability; the second decoding algorithm searches for the particular signal and codes itself through the execution.

The resulting cleared signal is already interpreted into binary code. After that, the signals are classified and sent to the control parts. Then the digitized signal is sent to the machine that executes the command.

In the development of BCI today, there are 4 main directions to be distinguished: brain-computer-brain feedback systems, high-precision processing of brain activity, technical improvement and miniaturization and neural conductors [3].

Obviously, the BCI has been widely publicized today. The technology has moved out of the sphere of pure theory and is now in the stage of active study and implementation. Since the end of the last decade, small and large businesses have been interested in developing BCI, and governments and private organizations have been creating laboratories to study the brain and integrate it with technology. Despite the fact that the main achievements in this field are connected with the help of people with disabilities, today many new ways of using BCI are being implemented in virtual reality games to autonomous vehicles.

The areas of the BCI application include: prosthetics, interactive interfaces, rehabilitation systems, virtual reality, stimulation systems.

Examples of the BCI implementation:

Exoskeleton - The Walk Again project, which is led by the IINN-ELS partner group of institutes led by Miguel Nicolelis. The developed exoskeleton allows a person to freely control their limbs and speed of movement.

Virtual Reality - The most well-known application of BCI, in such systems it is used for the most basic control, but according to assurances, this is the first stage and soon we will be able to get a full immersion technology similar to “The Matrix”.

Neurochat – An innovative project of the Russian group for neurocommunication and neurotraining, which allows you to type text arrays with the power of thought, train a person's cognitive abilities.

Exocortes – one of the important and promising developments is an external system to complement brain capabilities. The exocortex should be understood as an external computing machine connected to our brain and designed to increase its abilities.

Brain computer interface is the most perspective view on the human machine interaction. It provides enormous possibilities for enhancement of human mind and body, upgrading the quality of digital interfaces. Scientists have already implemented the results in the areas of medicine and e-entertainment. For sure, it will have much impact on the design of devices in the future.

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