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Brain-computer interface for the treatment of mental illness

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Abstract. A brain-computer interface is a direct communication channel between the brain and external devices. Its signals come from the central nervous system, and its transmission is independent of the peripheral nervous and muscular systems. Brain-computer interface commonly used to assist, enhance, and repair human-motor sensations. Through the classification and recognition of Electroencephalogram (EEG) signals, the monitoring and rehabilitation of some neurological and psychological diseases can be realized. Brain-computer interfaces are currently in their infancy and are being explored. Non-invasive brain-computer interfaces refer to brain-computer interfaces that are performed in the cerebral cortex. Semi-invasive brain-computer interfaces are what the chip penetrates the cerebral cortex but does not penetrate the gray matter in the brain. An immersive brain-computer interface is when the chip penetrates the gray matter of the brain. At present, Brain-computer interfaces with chips implanted in the head are mainly located in the brain. Brain-computer interfaces located in the cerebellum, brainstem and other parts have not made significant breakthroughs. The brain-computer interface first collects signals transmitted by the brain, then sequences and encodes them . Finally, transfer them to the computer. The computer controls the robotic arm through the acquired signals and finally completes the instructions. This article focuses on invasive and semi-invasive brain-computer interfaces, using case studies, combinatorial studies, and other methods. This research can help patients live better, improve patients' quality of life, and promote future research in bioelectronics and organic electronics.

Keywords: Brain-Computer Interface, Mental Illness, Challenges Of Brain-Computer Interface, The Prospect Of Brain-Computer Interfaces.

1. Introduction

Brain-computer interface refers to the direct connection created between the human or animal brain and external devices, which realize the exchange of information between the brain and the device. This concept has actually existed for a long time, but it was not until the nineties of the last century that phased results began to appear. A brain-computer interface is a direct communication channel between the brain and external devices. Its signals come from the central nervous system and are not dependent on the peripheral nervous and muscular systems. It is often used to assist, enhance, and repair the body's sensory-motor function or improve human-computer interaction. Brain-computer interfaces are divided into non-invasive, semi-invasive, and invasive brain-computer interfaces. Non-invasive brain-computer interface is more widely used and more mature in the daily treatment of mental illness. For example through brain-computer interface devices can monitor the sleep quality of patients with sleep disorders with high precision. Semi-invasive brain-computer interfaces are the focus of current research. Invasive

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brain-computer interfaces are still theoretically available in the treatment of psychiatric disorders and have not yet entered the clinical stage. At present, brain-computer interface has made great progress in the treatment of depression, autism and Cognitive impairment disease caused by high frequency signal failure of brain tissue. At present, experts are working on the study of diseases such as schizophrenia.

2. Approaches to brain-computer interfaces for the treatment of psychiatric disorders

Using a non-invasive brain-computer interface, the detection chip is attached to the active area of the cerebral cortex to detect brain activity and electrical signals. Electrical signals are recorded by the computer to facilitate the doctor's analysis and appropriate treatment. After receiving signals from the brain, the signals are sequenced and encoded. Brain signals are relayed to a computer, and instructions are issued by extra-brain devices, for example, robotic arms, rehabilitation wheelchairs, etc. The doctor repairs the original nerve through the brain-computer interface and restore its original function.

Here's an example of a non-invasive brain-computer interface to treat mental illness, treating sleep disorders. EEG is used to record the brain waves produced by the brain, and by analyzing different frequencies of brain waves, it shows the patient's sleep state and the depth and duration of sleep. Doctors can use the information from the brain-computer interface to determine whether the patient has abnormal phenomena such as sleep interruption, over excitement or fatigue, so as to make recommendations suitable for the patient. The brain-computer interface technology used here is non-invasive, has fewer side effects for patients, and is now one frequently used technologies used in medical treatment [1].

Another example is the semi-invasive brain-computer interface to restore the original function of nerves, and the treatment for depression is called deep brain stimulation. Deep brain stimulation is a neurosurgical procedure that involves the placement of a neurostimulator, also known as a brain pacemaker. Deep brain stimulation sends high-frequency electrical impulses to specific areas of the brain by implanting electrodes in specific parts of the brain and controls neural activity in the brain by controlling pulse generators outside the brain. Usually deep brain stimulation is implanted in the brain, like chopsticks, stimulus electrodes are connected to wires, and pulse generators are placed outside the brain. Because invasive brain-computer interface is riskier, there are many factors to be considered, such as whether it will cause allergic reactions, how to implant, where the target location of implantation is, etc., which will be simulated before implantation. Markers within the brain are identified by CT or MRI images and related software to locate anatomical targets. Once the simulation is completed, the needle alignment and insertion are simulated and designed in software. Simulation before surgery can greatly increase the safety of surgery and avoid unnecessary damage to blood vessels and brain tissue in the brain [2].

3. Challenge

At present, brain-computer interface still faces major challenges. Invasive brain-computer interface may impair parts of the brain's function over time and may be associated with reactive glial cell proliferation and inflammatory responses. In addition, aging, corrosion and replacement of electrodes or chips are also serious problems. However, these problems can be improved with advances in materials chemistry, nanotechnology, and computational modeling. In addition, there are some problems that have not yet been clearly improved, such as the high price of materials, and ethical issues such as privacy leakage after implantation of brain-computer interfaces .

3.1. Improvement of materials

At present, using existing materials will create resistance in the current generated by the brain-computer interface. Various designs and materials for brain interface electronics have been developed to obtain high-quality signals with minimal invasiveness. EEG can measure neural activity in large areas of the brain, a method that is non-invasive and less obstructive. The method involves direct contact with the scalp , analysis of real-time information and various clinical conditions of the brain. Traditional EEG devices use conductive gels and abrasive pastes, so-called wet electrodes, to minimize the impedance of

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interfering elements such as hair and scalp. However, when the gel dries, wet electrodes cause impedance. To overcome these challenges, a dry electrode method has emerged to increase electrical contact through close contact with the skin. This electrode does not require a conductive paste [3].

3.2. Ethical issues

In addition, ethical issues are also a huge challenge for brain-computer interfaces in the future. Patients have the right to informed consent before undergoing brain-computer interface surgery, and patients have the right to know what risks they will face before undergoing surgery and whether their body will be rejected after surgery. In addition, there is currently no suitable solution for some people who cannot express their wishes and cannot ensure the patient's right to informed consent. In addition, patients should enjoy physical and mental health protection. Patients should have a doctor to provide protection for the postoperative body, brain damage and other issues before surgery, and the doctor should inform the patient in advance of the risks that will be faced after the operation. Also, some patients face privacy issues. Some patients want to transmit their thoughts and wishes to the computer through brain-computer interface technology, but this process often reveals part of the patient's privacy, such as hobbies, preferences, etc. It is also possible to mistransmit the patient's thoughts. These all need to be considered. The psychological harm caused by brain-computer interfaces to patients is also very concerning. Some patients worry that the implanted chip will harm some nerve areas of the brain, resulting in abnormal physical and mental states such as abnormal anger or abnormal behavior. Another part of patients is worried that after the brain-computer interface is integrated with people, it is difficult to distinguish whether the information conveyed by the machine is ultimately the patient's own or whether the machine is transmitted autonomously. Patients worry that their personalities will be changed involuntarily by the brain-computer interface. This can't help but make people worry about whether people control machines or machines control people, and the former is more likely at present [4].

3.3. Domestic and foreign brain-computer interface enterprises

The more famous foreign companies are Neuralink, created by Elon Musk, and Kernel, created by Braden John. Currently, Neuralink is working on invasive brain-computer interfaces. They experimented with monkeys, let monkeys play games with their minds, and implanted a Link device in the hand and arm areas of the motor cortex on both sides of the monkey's brain. When the monkey moved the joystick up, the upward neurons would significantly increase the firing rate. When the monkey moved down to the joystick, the downward neurons would increase the firing rate. In this way, with a lot of repetitive training, the monkeys can control the game using intention through the firing of neurons in different directions.

Domestic well-known enterprises such as CAS-Envision, Zhen Tec Intelligent, and others CAS-Envision mainly studies brain-computer interface and neuromodulation, and currently mainly studies artificial retinas. Zhen Tec Intelligent is committed to the research and development, production, and sales of various brain-controlled interaction, VR/AR, and medical rehabilitation robot systems, backed by Xi'an Jiaotong University , mainly in the field of medical rehabilitation.

3.4. Brain-computer interfaces compared to traditional treatments

Traditional treatment is to suppress the condition with drugs, which can cause side effects over a long period of time, and the condition may worsen. The brain-computer interface is to collect the wrong signals generated by the brain of patients with mental illness, and after processing and editing a large amount of data, it has the ability to learn, accurately predict the wrong signals sent by the brain, respond, and give the opposite stimulation so that the brain returns to the original normal signal. Brain-computer interfaces are a better and faster treatment for the recovery of patients with mental illness, but brain-computer interfaces are more expensive than traditional treatments, and have a higher risk of causing some allergies and immune problems [5].

4. Discussion

These current studies and experiments show that the use of brain-computer interfaces can help improve cognitive function, emotional control, and behavioral regulation in some psychopathic patients. However, the application of this technology is still in its infancy, and more research and experiments are needed to verify its effectiveness and safety. At present, brain-computer interface focuses on the study of depression, anxiety and other psychological diseases in the treatment of mental diseases. And, at this stage, people are exploring whether white matter in the brain controls higher emotional activity in the human body. If this is true, brain-computer interfaces could take a big step forward in the treatment of mental illness. At present, semi-invasive brain-computer interfaces, non-invasive brain-computer interfaces have a large space for development, and there are more people at home and abroad who study this aspect.

5. Conclusion

Brain-computer interfaces can be the same as non-invasive means to help doctors treat patients through monitoring, or they can be used to treat mental illness at the root of it through semi-invasive or invasive means. But invasive and semi-invasive are much more risky than non-invasive. Secondly, the price also makes the breadth of brain-computer interfaces far lower than traditional treatment methods. However, these influencing factors can be improved with the development of electronic technology and biomaterials. However, with the widespread use of brain-computer interfaces, ethical issues will also become a hot topic of discussion. Because the current non-invasive brain-computer interface has achieved great results, the future brain-computer interface will focus more on semi-invasive and invasive brain-computer interface.

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