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Application and risk analysis of brain-computer interface

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Abstract. As society progresses and science and technology develop, brain-computer interface has made eye-catching achievements. Brain-computer interface (BCI) is a technology that realizes information exchange and response by establishing a direct connection between the brain and external devices. Brain-computer interface is one of the main research directions of human-computer interaction, which has great development potential and wide application in the future. However, the risks and challenges beckoned by it, on the other hand, cannot be ignored. It is of great significance to analyze its application and risk and at the same time to develop the solutions. Based on the existing literature, this paper summarized the working principle of the brain-computer interface, combed its application in various modern fields, and explained the current challenges it faces, hoping to provide certain references for the further development of the technology. Pursuant to relevant studies, it was found that the brain-computer interface has wide application prospects in medical treatment, the economy, people's livelihood, education, and the military, and currently, the main challenges cover inaccurate transmission, low safety factors, obvious ethical problems, and privacy disclosure risk.

Keywords: brain-computer interface, ethical issues, risks and challenges.

1. Introduction

As science and technology develop, the research on human-computer interaction has been focused on the brain-computer interface (BCI). In proper use, it can significantly facilitate the development of modern society. BCI has wide applications and bright prospects in medical treatment, the economy, people's livelihood, education, military and other fields. However, a heap of risks and challenges emerge at the same time.

With the advance of science and technology and the application of artificial technology, the brain-computer interface as an innovative artificial intelligence rehabilitation technology has been applied to daily life. Brain-computer interface (BCI) is a technology that realizes information exchange and response by establishing a direct connection between the brain and external devices [1], in the field of neural engineering, which is among the active research options. Through the marriage of external devices and the human brain, the brain-computer interface can carry out information exchange and control of devices, which plays a vital role in the future development of human science and technology [2]. In this paper, by reviewing relevant literature, the application progress of the brain-computer interface and the challenges encountered were explained, for the sake of providing a reference for the future development of the brain-computer interface.

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2. The working principle of brain-computer interface

Brain-computer interface, also known as "brain port" or "brain-computer fusion perception", includes signal input, signal processing, data processing, translation, and operating agreement links, which form a complex system with signal collection and matching functions. It can be said that BCI is a technology that realizes information exchange and response by establishing a direct connection between the brain and external devices [2]. According to the degree of intrusion of the interface into the human brain, the brain-computer interface can be classified as "invasive", "semi-invasive" and "non-invasive" [3], and at present, the main research has been focused on "semi-invasive" and "non-invasive".

2.1. Implantation approaches

Invasive signal acquisition implants signal acquisition devices in the cerebral cortex surgically, so as to obtain high-strength and high-resolution neural signals. This method has the advantages of a high precision rate, high sampling rate, and a high degree of freedom, etc., but it is an invasive operation, which may cause an immune reaction and lead to poor signal collection [4]. In order to avoid brain injury due to electrode implantation, at present, most BCI systems use non-invasive methods to collect electroencephalograms (EEG). The semi-invasive signal acquisition means that signal acquisition equipment is implanted between the cerebral cortex and the scalp, and the quality of signal collected is between non-invasive and invasive, which has lower surgery risk and less immune response [5]. Compared with invasive BCI, non-invasive BCI has the advantages of low cost, low risk, simple operation, and easy use. Meanwhile, users' acceptance of non-invasive BCI is much higher than that of invasive BCI [6-7].

2.2. Equipment control

Equipment control involves decoding the brain's electrical activity commands through signal processing and using it to control different devices, so as to induce functional recovery in patients. According to different functions, control devices can be divided into three categories: "function assistance", "function recovery" and "function enhancement" [8]. Among them, the first mainly helps patients to control and communicate with the outside world. Functional recovery mainly helps patients regain lost function; Function enhancement is primarily used to realize the expansion and strengthening of function [8], which is not only limited to rehabilitation medicine, but also has broad application prospects in military, education, and aerospace fields.

3. The application prospect and field of brain-computer interface

3.1. Medical treatment

Currently, rehabilitation instrument commonly used in clinic covers upper and lower limb joint rehabilitation machine, rehabilitation movement machine, etc. Although some facilities for medical use can make the limb function of patients restored to some extent, the issues such as slow recovery and not ideal rehabilitation effects still widely appear in patients. As science and technology advances and artificial intelligence emerges, intelligent rehabilitation technology that directly interferes with the central nervous system has been developed and applied in clinical rehabilitation, among which brain-computer interface technology is the representative. The brain-computer interface directly acts on the brain and can effectively improve the brain nerve conduction pathway [5], so as to help the patients engage in everyday interactions without relying on the nervous system other than the brain and the patient's own muscles. Brain-computer interface technology can greatly improve a patient's life experience during rehabilitation.

In addition, the brain-computer interface has significant effects on the psychological recovery of patients treated. Taking stroke patients as an example, the disease will affect the psychological state of patients, so that they will resist rehabilitation training, and have an avoidant psychology. As you know, the patient's psychological state and participation will have a direct impact on the rehabilitation effect. Brain-computer interface enables patients to simulate physical movements under healthy conditions

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through virtual technology, thereby slowly eliminating their negative emotions and speeding up the recovery process [9]. Studies have found that individual patients only have minor adverse reactions such as brain fatigue and head discomfort during brain-computer interface rehabilitation training, which can be significantly relieved after rest [10-11]. It can be seen that the security of the brain-computer interface is better.

In late March, at the Neuro-disease Branch of the Center for Clinical Translation Research on Brain-Computer Regulation at Zhejiang University, the research team is working hard to decipher brain activity related to mind writing, and the latest research results will be published soon. At present, the research team is conducting large-scale clinical trials, and dozens of clinical patients from all over the country is receiving closed-loop nerve stimulation machine implantation, for the sake of evaluating the long-term efficacy [12].

3.2. Economy

Brain-computer interface can connect the human brain with many working devices, and achieve the goal of fast operating equipment by reading human electroencephalogram, which provides convenience for workers to operate and improves the efficiency of production. What is more, with the help of this technology, bedridden patients and disabled people with mobility difficulties can also return to work, contributing to the construction of a better society and social and economic development. At the World Artificial Intelligence Conference in 2022, the brain-computer interface and its related products such as intelligent bionic hands attracted many visitors to the exhibition. "Brain-computer interface is a technology that connects a person's brain through a computer, detects very weak signals in the brain and directly controls external devices through the computer. In the field of brain-computer interface, there are two main types of technology implementation paths: invasive and non-invasive. "In terms of commercialization, invasive methods mainly solve problems related to severe brain diseases, while non-invasive one has a wider range of commercial application and problem-solving", said Han Bicheng, founder and CEO of BrainCo. According to the "Brain-Computer Interface Technology Innovation and Industrial Development Research Report (2021)" released by the China Academy of Information and Communication Technology, it is predicted that brain-computer interface-related market size may exceed 3 billion US dollars in 2027. The future industry represented by brain science and brain-like research is also becoming a new track for local economic development [13].

3.3. People's livelihood

Brain-computer interface also has promising applications in the current hot field of the Internet of Things, combined with the area, which can enable an intelligent lifestyle and improve people's lives. For example, with respect to smart homes, the current smart home still needs people to take the initiative to make instructions. With the brain-computer interface, home devices can be controlled using only the brain. Likewise, in the aspect of entertainment, brain-computer interface technology can also realize the integration of virtual reality technology, and thus bring users a more convenient and real experience. Beyond that, in 2011, Japanese technology company Neurowear developed brain-computer interface devices called "electroencephalogram cat ears" and "electroencephalogram cat tails". In 2019, American technology company BrainCo developed a mind-enabling head ring that can detect and improve attention and in 2021, Beijing Naolu Technology Co., LTD launched a sleep product Sleep Up.

4. Risks addressed by brain-computer interface

4.1. User security problems due to immature technology

At present, the brain-computer interface is not very mature, which may lead to data loss in the process of information transmission, and the reading of users' electroencephalograms may not be very accurate, which cannot fully reflect users' thinking. The speed of information processing is also far from the almost instantaneous processing speed of humans themselves. Invasive brain-computer interfaces may cause serious problems such as infection during surgery, which may harm the physical health of patients.

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That is to say, due to the limitations of its current technological development, brain-computer interface technology may cause direct harm to users, especially in the links requiring surgical intervention [14]. The reception of electroencephalogram by the brain-computer interface may lead to the reception and decoding of a part of users' mental activity that they do not want anyone to know about. Such excessive use may result in users' personal privacy leaks, and lead to inconveniences and inferiority in users' psychology and life.

4.2. Ethical problems caused by the misuse of technology

From the perspective of modernization, the level of ethical quality is often an important factor affecting the development and progress of technology [15]. Technology development depends on the cultural and social background in which ethics locates, and is affected profoundly by it. Among them, public opinion related to technology is one of the most important factors [16]. The universally recognized and respected values of human society, such as fairness, justice, and diligence, should not be degraded with the innovation and use of new technologies. If brain-computer interface technology gradually penetrates into every field and level of society and forms alienation of the beautiful value of human society by virtue of its excellent "enhancement" effect, and at this time, the public opinion still treats the value impact of BCI with a numb and indulgent attitude, basically we can judge that the development of BCI technology is in a "problematic" cultural and social background, which is extremely unfavorable to the construction and development of this kind of technology. For example, some students, enhanced by the brain-computer interface, have obtained excellent learning abilities that ordinary people can hardly match no matter how hard they try, while the public opinion environment at this time is still numb and inclined to use the final result (rather than the process of hard learning) to judge the value, then the value of diligence, effort and fairness in the field of education will become increasingly weak because BCI users will become more and more arrogant and lazy considering that they can easily make achievements that are beyond the reach of ordinary people without putting in as much effort as ordinary people do; For another thing, those who do not receive BCI will lose confidence and motivation, and will no longer believe that their diligence and effort will make a difference because anyway, they will not be able to reach the heights that "enhanced people" can achieve.

5. Conclusion

In this paper, the pros and cons of brain-computer interface (BCI) as an emerging technology are analyzed by summarizing the articles on BCI and human enhancement technology in recent years. Brain-computer interface, while being expected to help treat a series of serious diseases, enhance human abilities, and improve people's lives, also beckons a series of social, ethical, and safety issues that need to be considered. Despite no small disadvantages in these three aspects, in the face of the huge benefits of brain-computer interface technology, it is worth solving these problems. Moreover, in attempting to apply this technology, we must fully appreciate the complexity of human life and its unique importance, and ensure that this application does not undermine the basic forms of human life and the associated human values.

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