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Application of Brain-Computer Interface for Disabled People on Human Factors Engineering

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ABSTRACT

Brain-Computer Interface (BCI) is a new type of human-computer interaction technology, which has achieved good theoretical results so far, but still faces many problems in the practical application of the technology. At present, the main group of people who use BCI technology is the disabled, because this technology can improve the self-care ability of disabled people, but the application design of traditional brain-computer interface in the past did not start from them well. Based on human factors engineering, this paper will analyze the characteristics of disabled people, combine the existing theoretical characteristics of BCI, optimize the application of BCI, and design unique and intelligent application scenarios for them. This can greatly improve people's awareness and acceptance of BCI technology, and promote the development of BCI technology.

Keywords: Human factor engineering, Brain-computer interface, Disabled people, Intelligent application

INTRODUCTION

As a new type of human-computer interaction technology, the BCI collects the weak electrical signals of the brain through specific equipment, then uses amplifiers and filters to process these weak signals, and finally converts them into control signals for specific machines through algorithms. This kind of technology can provide a certain degree of convenience for the disabled, but the disabled people still do not have a high sense of experience with the BCI, so that they do not accept it highly, which is mainly reflected in the signal acquisition process and usage scenarios. The main reason for this problem is that human factors engineering is ignored in the application process of BCI technology, and specific products are not designed with the actual user group as the center. Therefore, starting from human factors engineering, this paper first analyzes the differences between disabled people and non-disabled people using BCI application products, and draws their own characteristics. Then discuss the applicability of different EEG signal acquisition methods to the disabled. Then discuss and analyze the application scenarios of BCI suitable for the disabled, and design the corresponding application model in combination with the Internet of Things system. Through the above analysis and discussion, it can be reflected in the practicability and effectiveness of the application of BCI under human factors engineering.

DESIGNING BCI APPLICATIONS WITH DISABLED PEOPLE AS THE CENTER

The application of BCI for people with disabilities based on human factors emphasizes that all applications should be designed with the needs of people with disabilities in mind. The whole process includes analyzing the characteristics and needs of people with disabilities, designing corresponding EEG acquisition methods, BCI applications for corresponding functions, and suitable application scenarios for different people with disabilities. The following will discuss the design of disability-centered BCI applications through these three aspects.

Collection of EEG Signals for the Disabled

In BCI, the acquisition methods of EEG signals can be divided into two types, one is invasive and the other is non-invasive. The invasive acquisition method is to implant the electrode or chip that collects the signal into the brain, which means that the user needs to undergo a craniotomy, and the risk of the operation is extremely high, but the EEG signal obtained by this method is more accurate. It can provide more reliable EEG data for subsequent algorithm analysis. The non-invasive method is to directly use electrodes to collect the weak EEG signals of the scalp. The biggest feature of this method is safety, but because the collected EEG signals are very weak and mixed with other useless signals, its signal The processing is much more complicated, and the signal is less accurate than the intrusive one. Both methods have their own advantages.

Starting from the characteristics and needs of people with disabilities, they have limited control over their bodies, and they hope that BCI can improve their self-care ability, but at the same time, they do not want their bodies to be harmed again. Therefore, a safe and non-invasive EEG signal acquisition method should be their first choice, but the low accuracy of this method also means that the complexity of the specific application of BCI will be reduced, and a simple but practical BCI application should be brought to the disabled.

Basic Application of BCI for Disabled People

Starting from the types of people with disabilities and focusing on the needs of specific types of people with disabilities, BCI has already achieved very good application results. There are several important application bases of BCI: motor imagery (MI), steady-state visual evoked potentials (SSVEP) and P300.

Colloquially, motor imagery means that we imagine ourselves to make a certain action in the brain, and then the brain will generate specific EEG signals. Then, by analyzing these EEG signals, we can know what the patients want to do. SSVEP means that when people look at images with different flickering frequencies, the brain produces specific EEG signals. The P300 is when people observe events with different probability of occurrence, the brain will produce different EEG signals.

For disabled people with severe brain damage and loss of motor imagery, motor imagery will not be able to be used as the basis for BCI applications. Apart from that, SSVEP and P300 are not suitable for visually impaired persons. Therefore, in the specific application, it is necessary to select a feasible BCI method according to the type of disabled people(Lu et al. 2021).

For disabled people with high paraplegia or muscular dystrophy who have limited language skills but normal vision, they can use the SSVEP-based BCI spelling application (Shi, 2020). People with disabilities can generate different potentials by observing flashing pictures of different frequencies, and finally select the characters to be spelled. At present, the realization of high-performance motor imagination has high requirements on trainees. Therefore, for the disabled, they can also experience the convenience of BCI by optimizing the functional requirements. Through training, they can imagine that their body is turning left or right, and then cooperate with visual or auditory guidance, so as to realize the output of control signals, so that they can have a certain ability to control external things. Just like the wheelchairs of the disabled, there can be continuous and short-term motor imagery BCI control (Wang and Bezerianos, 2017), and it can also be controlled by non-invasive BCI using P300 (Sivabalakrishnan and Jeeva, 2019). Therefore, for the control of the same kind of target, because the characteristics of the users are different, different control methods are provided.

BCI Practical Application Scenarios for Disabled People

According to the mobility characteristics of the disabled, the application scenarios of BCI can be divided into fixed and mobile. Some disabled people can only stay in bed for a long time due to high paraplegia, and they cannot take care of themselves. At present, the Internet of Things technology is developing rapidly, and the popularity of smart home systems is becoming more and more widespread, which can greatly improve the convenience of people's lives. The combination of the brain-computer interface and the smart home control system (Gao et al. 2018) enables the disabled to control the room smart home by controlling the output of their own EEG signals, which greatly improves the disabled people's self-care ability.

The application significance of BCI provides a feasible direction for the popularization of BCI application. People with high paraplegia can only rely on the help of others to travel, because they cannot control the wheelchair with their hands, and their ability to receive information from the surrounding environment is weakened. However, the application formed by the combination of BCI and transportation equipment is suitable for this scenario, such as the wheelchair controlled by BCI mentioned above.

For the disabled, the possibility of seeking rehabilitation is a major goal of their life, so the application of BCI should also appear in the rehabilitation scene of the disabled. The low self-care ability of people with disabilities reduces their opportunities to contact the external environment, and the current mature development of virtual reality technology can combine BCI and VR to assist the neurorehabilitation of people with disabilities (Robert and Daniel, 2020). Starting from the psychological level that disabled people want to restore health, because brain-computer interface can help neurological rehabilitation, this will make invasive brain-computer interface acceptable to disabled people to a certain extent. So this can continue to advance the theory and practice of brain-computer interfaces.

In addition to people with physical disabilities, there are also people with psychological and spiritual disabilities, which should also be discussed in the application of BCI under human factors engineering. Mental and psychiatric illnesses are not as easy to quantify as physical illnesses, nor are they easy to detect. At present, BCI performance is sensitive to short-term changes in mental states such as fatigue, frustration, and attention (Myrden and Chau, 2016), so we can try to apply BCI to the diagnosis and treatment of mental diseases to help patients have a clearer understanding of themselves. At the same time, it also provides a new reference index for medical staff.

CONCLUSION

In order to make the disabled people's BCI application center on the disabled people, this paper proposes that the designer should consider from three aspects. In the process of EEG signal acquisition, the experience and specific needs of people with disabilities should be considered, rather than blindly seeking the authenticity and validity of the data. In the selection of basic applications, the physical level of the disabled should also be considered, and one or a combination of applications should be selected according to their degree of disability. Finally, the practical application of BCI for disabled people should consider specific application scenarios, including the physical and psychological factors of disabled people. Only by comprehensively considering the above three aspects, the BCI application of the disabled can be combined with human factors engineering, so as to improve the acceptance of the BCI application by the disabled, and at the same time, this can continue to promote the research and theoretical development of the BCI for the disabled, and finally for the disabled people to provide more reasonable and useful BCI applications. To sum up, there is still a lot of room for development of BCI applications for people with disabilities based on human factors engineering.

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