Research on the Development and Application of Brain-Computer Interface

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Abstract. The brain-computer interface is an important human-computer interaction technology that has made great progress in the past few years. In this paper, I reviewed the history of the development of brain-computer interfaces and the current level of development of brain-computer interfaces, summarized the views provided by predecessors and put forward my own subjective views. I think the future development trend of brain-computer interface will be extended and developed especially toward the focus of biology. What should be done next is to break the current generation gap between the brain-computer interface and human beings.

Keywords: Brain-computer Interface, Artificial Intelligence, Human-Computer Interaction

1 Introduction

The practical understanding of human-computer interaction is that it is a process of working through computer interaction with humans to help people complete their work more effectively and conveniently. In other words, it is how to make the computer closer to the user itself. For example, the sports training machine mentioned in class is responsible for simulating real training venues for athletes through visual sensors without occupying the venue. Its biggest advantage is cost and time savings. The development focus of computers is to achieve the most natural way of interaction between humans and computers, which means that computers can correspondingly capture activities in the human brain and complete work without delay. The closest method to perfect interaction currently is to receive voice input and other modes that minimize barriers. The previous step is the most common way of human-computer interaction that we are currently experiencing, which is to communicate with computers through keyboards or sensors or to complete communication between humans and computers through some medium. The earliest human-computer interaction required people to go through more cumbersome procedures to complete communication, such as inserting command code into a bulky computer and ultimately generating feedback. In summary, the smaller the gap between humans and computers, the more successful human-computer interaction becomes.

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Brain-computer interfaces have received widespread attention as an important research direction in brain science and brain-like intelligence. Figure 1 shows the Neuralink device. This article is based on data from brain-computer interface-related papers on the Science Citation Index Platform (SCIE) from 2010 to 2021, as well as relevant patent data collected by the Dewant Innovation Platform (DI). From the perspectives of the number of brain-computer interface papers and patents, country distribution, top institutions, and research hotspots, it analyzes the research development trends, distribution of research and development strength, and evolution of research hotspots in the field of brain-computer interfaces. The results show that the number of published papers and patent applications related to global brain-computer interfaces in the world has increased year by year in the past decade, and research hotspots have also changed significantly. At present, there are many algorithms represented by convolutional neural networks. China has the highest number of brain-computer interface papers and patents in the world, but the academic influence of related papers is relatively low, the quality of patents needs to be improved, and the participation of enterprises in research and development should be increased.

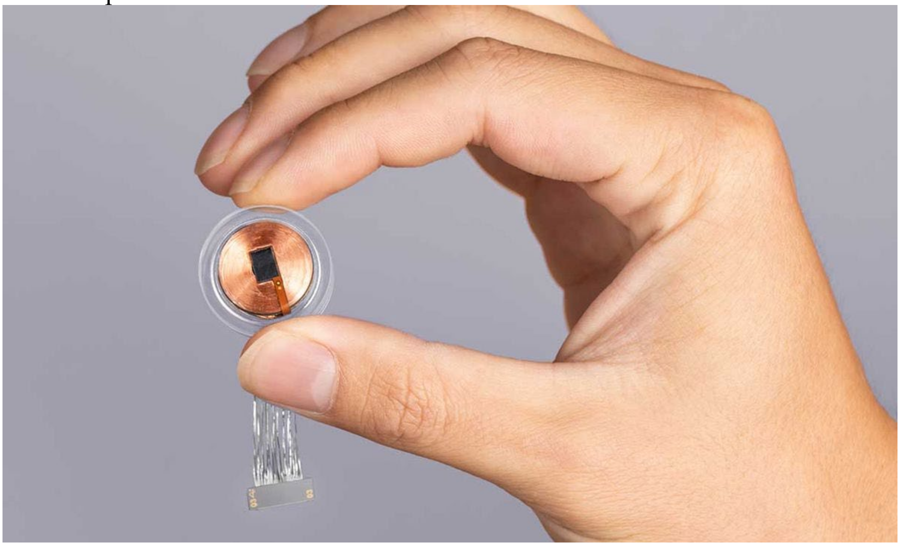

Fig. 1. The Neuralink device. (https://neuralink.com/)

In this paper, I reviewed the history of the development of brain-computer interfaces and the current level of development of brain-computer interfaces, summarized the views provided by predecessors and put forward my own subjective views. I think the future development trend of brain-computer interface will be extended and developed especially toward the focus of biology. What should be done next is to break the current generation gap between the brain-computer interface and human beings.

2 Related Work

In the past ten years, the number of published papers and patent applications related to brain-computer interfaces in the world has shown an increasing trend year by year, and the research hotspots have also changed significantly. At present, there are many studies on algorithms represented by convolutional neural networks [1]. Document [2] is a review paper on brain-computer interface technology, covering electrocorticography (ECoG), electroencephalography (EEG), magnetoencephalography (MEG), and magnetic resonance imaging (MRI). Literature [2] further provides basic signal collection and preprocessing, feature extraction, pattern recognition and other methods, which can help readers fully understand the current development status of brain-computer interface technology. Literature [3] reviewed the typical EEG-based brain-computer interface paradigms, including the basic principles, research status and typical application scenarios of MI-BCI, P300-BCI, SSVEP-BCI and other paradigms, and evaluated the advantages and disadvantages of various paradigms. The technical and ethical risks and challenges faced in the current research are proposed, and the prospect of its development and application is prospected.

Compared with invasive brain-computer interfaces, noninvasive brain-computer interfaces have the advantages of low cost, low risk, and easy operation. In recent years, the use of noninvasive brain-computer interface technology to control peripherals has gradually become a new human-computer interaction method, and the brain-computer interface control strategy is an important part of this method. Literature [4] first introduces the classification and development of brain control strategies, then describes the basic characteristics of direct and shared control strategies in detail, then compares and analyzes the advantages and disadvantages of these two brain control strategies, and finally discusses the noninvasive brain control strategies. The strategy development direction and application prospects are analyzed and forecasted. From the aspects of input signal type, experimental paradigm, and signal fusion, literature [5] reviewed the research progress of multimodal brain-computer interfaces combined with steady-state visual evoked potential (SSVEP), helping relevant researchers understand the research trends in the field to inspire the design and implementation of high-communication rate brain-computer interface systems. At the same time, we discuss the existing problems and possible future development trends of multimodal brain-computer interfaces combined with SSVEPs to promote the development of multimodal brain-computer interface technology combined with SSVEPs.

With the development and improvement of artificial intelligence and machine learning technology [6-10], an increasing number of brain-computer interface systems have been developed. Literature [11] discusses the Neuralink-related brain-computer interface technology promoted by Musk, including the progress, development status and future prospects of this technology. Based on Neuralink, people have realized the huge application potential of brain-computer interface technology, but there are still many problems to be solved in this process to fully realize practical brain-computer interface technology.

3 Applications

3.1 Medical Applications

This is mainly reflected in rehabilitation training, auxiliary surgery, and auxiliary treatment. After all, the machines encoded by current computers can only complete routine programs with low accuracy and are only suitable for performing their skills in highly repetitive tasks. They are far less effective in surgery than humans. In addition, the diagnosis of different clinical symptoms in the field of medicine can also be extremely complex, and computers can only play an auxiliary role, mainly relying on human resources to respond and analyze. As is well known, physical impact on the human body can lead to loss of limb function, namely, fractures or bone fractures. Such injuries often require complex and periodic treatment to enable patients to recover. In other words, it is time-consuming and requires a large amount of resources. At this point, the computer can perform auxiliary functions, not only saving human resources but also making it faster and more effective. Of course, some inherited diseases (which still rely on biotechnology such as CRISPR) cannot be treated through conventional human-computer interaction methods, but they can still assist the daily life of the subject, which involves smart homes.

The ultimate goal is to achieve the most harmonious interaction between adults and computers. In rehabilitation training, the human exoskeleton is an excellent example. It establishes and analyzes a human gait database based on motion theory, designs a compact exoskeleton structure based on human physiological structure and ergonomics, and uses new and flexible materials for design and processing. While meeting the needs of exoskeleton walking, it reduces the overall weight of the exoskeleton and increases the portability of exoskeleton wearing, achieving the overall design and optimization of exoskeleton robots. Through the exoskeleton sensing system, the current gait of the robot is accurately judged by means of a plantar pressure sensor, joint angular acceleration sensor, leg pressure sensor, etc., to realize the intelligent judgment of the robot on the human motion intention and movement trend so that the exoskeleton robot can coordinate and synchronize with the wearer so that the wearer can control the exoskeleton robot to complete a natural and smooth gait and movement. This is the result of the synergistic effect of human–machine intelligence. An example of the application of human–machine intelligent collaboration technology to lower limb exoskeletons is a lower limb assistance exoskeleton system based on surface electromyography (EMG) signal control. By collecting weak muscle motion signals emanating from the brain on the surface of the skin, the wearer's movement intention can be determined through signal encoding and decoding principles, and then the exoskeleton robot can be controlled to simulate and complete the corresponding actions. In addition, the exoskeleton can achieve quantitative detection and evaluation methods by inputting quantitative motion stimuli, providing wearers with more scientific rehabilitation training and walking modes and providing a platform for the study of sports rehabilitation mechanisms. In summary, it refers to data conversion of the brain and electromechanical signals to determine the user's intention for training and rehabilitation purposes.

Spinal surgery robots are professional orthopedic surgery robots that still require the manipulation of surgeons to assist doctors in completing surgeries. Their surgical scope involves fixation of pedicle screws at various joint segments of the spine, fixation of screws through the atlantoaxial joint, etc. The requirements for surgical accuracy and stability are high, so there is a higher demand for natural and accurate human–machine interaction. Spinal surgery robots are mainly aimed at common diseases such as spinal fractures and degenerative diseases in the thoracolumbar spine. They require the use of multiple sensing technologies, the coordination of multiple functional modules, and human–machine intelligent collaboration technology to complete precise perception surgery and achieve surgical safety control. Without collaborative work between doctors and surgical robots, it is impossible to operate surgical robots smoothly to complete the surgery. Due to the high precision and difficulty of most surgical procedures, it is crucial to develop spine surgery robots that are highly safe, precise, stable, and easy to operate. The Robotic Spinal Surgical System (RSSS) developed by the Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, is capable of completing personalized and complex surgical operations, following and compensating for the physiological movements of respiration. It has fine intervention perception, multimodal real-time monitoring and warning functions and is equipped with a surgical simulation training system. Through supporting surgical planning and navigation software, robot-assisted stability reconstruction can be achieved by decompression surgery, vertebroplasty, etc.

Literature [12] combined a brain-computer interface and virtual reality. By connecting the brains of two people, one person can experience the environment of the other through virtual reality. This system is mainly used to help patients perform rehabilitation training or to allow patients who have lost their mobility to control objects around them in a more natural way. Literature [13] considers the application of brain-computer interface technology in clinical medicine. Based on implantable devices, patients can be monitored 7*24 and can be used at home. If such technology is successful, it can greatly reduce the monitoring pressure on hospitals and help more patients receive medical services at a lower cost.

3.2 Engineering Applications

Currently, cutting-edge human-computer interaction technology can recognize the cell membrane potential signal generated by muscle spindle protein myosin and muscle fiber pulling in muscle so that people can manipulate the machine to complete more complex work [14-18]. Although this application may not reflect value in highly repetitive work, its role can only be maximized in specialized work or research. In design, people are able to easily and quickly express their ideas.

3.3 Criminal Investigation

The brain-computer interface also has a series of applications in criminal investigation, such as artificial intelligence active investigation, artificial intelligence information collection, artificial intelligence crime prediction, artificial intelligence passive investigation, artificial intelligence data mining, artificial intelligence evidence acquisition and comparison, and crime scene intelligent equipment assistance specific applications such as investigation and intelligent arrest. In short, the use of criminal investigation can provide a huge database to improve the speed of case detection. In addition, the focus can be placed on the interrogation process of prisoners, such as lie detectors, to judge the suspect's nerve activity and heart rate to solve the case.

Personalized face image synthesis has a wide range of applications in public security criminal investigation, film and television production, entertainment, education and other fields and has attracted the attention of many researchers. However, the previous research on personalized face image synthesis was limited to experts and researchers in the computer field, and there were few cross-field cooperative studies, and the face has the characteristics of nonrigidity, similarity between classes and susceptibility to interference. It is quite difficult to solve the problem of personalized face image synthesis from the perspective of pure computer technology. At present, research on personalized face image synthesis is still in its infancy, and there are few mature applications. The emergence of cognitive science provides a platform for the integration of computers, philosophy, psychology and other disciplines and provides some new directions for solving the problem of personalized face image synthesis.

4 Discussion

4.1 Political Perspective

Currently, the country is vigorously developing industries related to brain computer interfaces and encouraging the publication of relevant papers. However, this is only limited to a few countries, and most countries have not shown a clear response to this technology.

4.2 Economic Perspective

In September 2021, the Ministry of Science and Technology issued the "Notice of the Ministry of Science and Technology on Issuing the Application Guidelines for the 2021 Major Project of Science and Technology Innovation 2030-" Brain Science and Brain like Research ", covering 59 research fields and directions. The national funding is expected to exceed 3.148 billion yuan, marking the official launch of the China Brain Plan project, which has been brewing for six years.

4.3 Social Perspective

According to my summary, the public is still in a state of two-stage differentiation regarding this new technology, and some conservative people may not support this technology even if they know the case of brain computer interfaces benefiting humans.

Therefore, for me, only those who truly need this technology can appreciate how precious it is. Those who do not have movement disorders, amyotrophic lateral sclerosis, or Alzheimer's disease cannot experience or experience the benefits of it firsthand. In summary, brain-computer interfaces are reserved for those who accept them, those who are desperate, or those who have to accept them. Therefore, the development of brain-computer interfaces is subject to ethical and moral constraints everywhere. To accurately predict trends, one can only rely on understanding people's ethical cognition and limits. Of course, I myself share the same view that no technology can violate human ethical views, and this restrictive relationship relatively maintains a balance between the two.

5 Challenges and Opportunities

Subjectively speaking, the biggest problem currently is that computers cannot replace certain human characteristics, such as relying too much on fixed programs or their own technological limitations to complete certain high-precision tasks. Currently, most of the work that requires high flexibility is mainly completed by humans, and computers only play an auxiliary role.

At present, the development of brain-computer interfaces in the medical field is the most promising. Other possible fields also include military, education, entertainment games, and normal life, and now brain computer interfaces have begun to emerge in these fields. However, the fields I mentioned above have significant differences in nature from medicine and require greater social competition and ethical accountability. While there are advantages, there are also more disadvantages. Essentially, taking education as an example, the existence of talent (human) resources such as faculty and staff supports the existing education industry, and even more advanced education models are closely related to teachers themselves. Furthermore, education is essentially about conveying and transmitting a set of values and cognitive aspects of our predecessors to the younger generation. Therefore, human-to-human communication is often more effective than the way brain computer interfaces are instilled, and the information transmitted by brain computer interfaces is often not accepted by people. The reason is precisely that people adhere to certain traditions (who knows if that fixed set of values is in line with the world, and values need to be constantly honed and formed during growth, which involves extremely complex factors that cannot be solved and replaced by brain computer interfaces). In addition to passive instillation and manipulation of fear, people are more concerned that their inner world will be presented in front of others at a glance, becoming objects that others can freely guess. Returning to the essence, as mentioned earlier, the public's acceptance of brain-computer interfaces in medicine is relatively high because they correct motor disorders or adjuvant therapy and do not touch the psychological level of humans. However, education is different. It guides how to construct the psychological level of humans, which is the reason why people reject and oppose the entry of brain-computer interfaces into certain fields. In areas with scarce educational resources, the application of brain-computer interface technology can help alleviate the shortage of teachers. The appropriate intervention of digital technologies such as brain-computer interfaces can extend students' cognitive abilities, enhance their learning experience, and stimulate their interest in in-depth learning. In the practice of smart classroom teaching, brain-computer interface technology can monitor the dynamic changes in every student's physical state, emotional state, and thinking in real time, making it convenient for teachers to adjust teaching strategies in a timely manner and provide targeted guidance to improve students' learning efficiency. Does this involve cheating?"

Apparently, I personally believe that development also requires moderation, and we must not touch on the interests of humanity itself (such as the significant changes in the social structure framework caused by the replacement of human teachers with brain computer interfaces, as well as the consequences of unemployment, chaos, conflicts, and even wars). The true purpose of brain-computer interfaces is to provide convenience and new research directions based on human manipulation in the above fields.

The first is the technical challenge. Overall, the current brain-computer interface technology is only applicable to some simple application scenarios, such as understanding the emotional changes of the subject and controlling external devices, and cannot obtain precise details of information such as memory and thinking in the brain through brain-computer interface technology. The development of brain-computer interfaces currently faces many technical challenges, such as how to accurately extract useful information from complex biological EEG signals, how to establish an accurate relationship between brain mental signals and actual behavior, and how to clarify the boundary between disease repair and performance enhancement, which are all unresolved issues. Especially for the core working mechanism of the brain, neuroscience has not yet studied it clearly, which will restrict the development and application of brain computer interface technology.

Second, there are security risks. The invasive brain-computer interface needs to implant electrodes or chips in the cerebral cortex, which easily causes intracranial hemorrhage and infection and may also produce rejection reactions after surgery. Long-term implanted electrodes or chips are also prone to aging, corrosion and displacement over time, thus causing negative health effects on users of brain-computer interfaces. In addition, implanting physical devices into the human brain through brain computer interfaces will inevitably change the original state of the brain to a certain extent and can also easily bring psychological burden and pressure to users. Once the "enhancement ability" brought about by brain-computer interfaces disappears, it may lead to cognitive disorders, psychological anxiety, and other issues for the parties involved.

6 Opinions

6.1 Subjective

In terms of subjective opinion, I believe that the development of brain-computer interfaces in the field of biology has high prospects, mainly due to the following reasons:

First, from the perspective of patients or injured individuals, they are likely to accept treatment based on brain computer interfaces without fear of moral or ethical barriers, as they are in a passive position and will take the lead in accepting the most effective treatment plan for their long-term goal of recovery. Brain-computer interfaces have demonstrated their value and advantages in the treatment of neurodegenerative diseases, especially in the course of treatment. Second, the application of brain-computer interfaces in the field of biology is currently the most advanced among several fields and has also undergone a period of on-site testing. For example, many hospitals are equipped with brain-computer interface devices, such as the auxiliary exoskeletons mentioned earlier. The effectiveness it embodies is also evident to all. Finally, in terms of the overall environment, many domestic policies contribute to the sustainable development of brain-computer interfaces in the medical field. In addition, I believe that brain-computer interfaces can also deepen psychological treatment and diagnosis, opening up a new path for drug therapy by changing the trajectory of neural electrical signals in the brain. In addition to the biological field, brain-computer interfaces may also have potential applications in unexpected fields. The field of criminal investigation is worth mentioning. At present, the earliest instrument similar to the brain-computer interface in the field of criminal investigation is the polygraph used when interrogating prisoners. Its principle is also to judge interrogation information by observing the physiological changes caused by the changes in the psychological activities of suspects. However, the polygraph can also be defeated by professionals through their flawless response skills. Brain computer interfaces can achieve more accurate prediction and mitigate error detection in the future. Although the use of brain-computer interfaces in criminal investigation may be seen as prying into the suspect's privacy and thus risking the defendant, such measures still need to be applied in national legislatures to abate possibilities for crime.

6.2 Objective

In addition to its applications in the medical and health fields, brain-computer interface technology also has potential wide applications in other nonmedical fields.

Military field

Brain computer interface technology belongs to prospective research and experimental applications in the military field. For example, soldiers can issue combat commands to corresponding weapons by wearing brain signal acquisition hats, achieving the goal of reducing casualties and strengthening combat capabilities. It can also monitor the physiological and psychological status of combat personnel and use the monitored data to analyze physiological and psychological indicators such as soldiers' emotions, attention, and memory in a timely manner, thus enhancing the performance of military skills of relevant combat personnel. In August 2020, the US think tank RAND Corporation released a preliminary evaluation of the role of brain-computer interfaces in US military applications, stating that BCI technology is likely to have practical applications in future battlefields, such as improving communication speed, enhancing environmental situational awareness, and allowing operators to control multiple technology platforms simultaneously.

Education field

In terms of education, brain-computer interface technology can monitor students' brain state in real time and establish a personalized teaching environment based on BCI by analyzing and evaluating the relationship between brain state and academic performance. In the field of special education, brain-computer interface technology can help learners enhance or even reconstruct their sensory functions due to physical defects, improve learning efficiency by manipulating auxiliary devices of the limbs, rebuild and smooth the entire learning reflection chain, and thus successfully complete various learning tasks. In areas with scarce educational resources, the application of brain-computer interface technology can help alleviate the shortage of teachers. The appropriate intervention of digital technologies such as brain computer interfaces can extend students' cognitive abilities, enhance their learning experience, and stimulate their interest in deep learning. In the practice of smart classroom teaching, brain-computer interface technology can monitor the dynamic changes in every student's physical state, emotional state, and thinking in real time, facilitating teachers to adjust teaching strategies in a timely manner and provide targeted guidance to students. When integrated into virtual reality devices, it is more conducive to creating an immersive atmosphere, enabling students to enhance sensory effects, enhance physical experiences, and further improve learning efficiency.

Entertainment and gaming field

In terms of entertainment games, brain-computer interface technology can be combined with virtual reality (VR) technology to collect brain signals through sensors worn on the player's scalp and then transmit the signals to the computer. The decoding algorithm converts the signals into instructions to be executed in the game, which can achieve the use of "ideas" to play games. This not only improves the entertainment of the game but also greatly enhances the friendliness of the game for players with physical disabilities. The collection of EEG signals is one of the important links in brain-computer interface games. Currently, the main brain signals used to characterize the functional state of the brain include electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), and functional near-infrared spectroscopy (fNIRS). Compared with other types of EEG signals, scalp-based BCI (EEG-based BCI) has the characteristics of noninvasiveness, high temporal resolution, low cost, and good portability. It is currently the main implementation method used in brain-computer interface game BCI.

(4) Field of daily life

In daily life, taking smart homes as an example, brain-computer interface technology can not only control external home devices by measuring and extracting signals from the central nervous system of the human brain but also regulate the central nervous system through stimulation and neural feedback from external devices, forming a closed-loop system with neural feedback regulation between the human brain and external devices and achieving intelligent integration of human machines or brain computers. The brain computer interface plays a role similar to that of "remote control", helping people use their "mind" to control the opening and closing of lights, doors, curtains, etc., further allowing them to control intelligent household robots. Brain computer interface technology can also be combined with communication systems to develop autonomous vehicles. The application of brain networking based on brain interfaces is a more cutting-edge potential research and application direction in the future.

Brain computer interface technology is known as the "next step in artificial intelligence", showcasing infinite possibilities, attracting scientists to continue and tirelessly tackle key issues and will also be the focus of international competition.

7 Conclusion

In recent years, the field of brain-computer interfaces has witnessed remarkable advancements. This article comprehensively summarizes the latest research panorama in the past three years, both domestically and internationally. It meticulously examines the current state of technological development, including the progress in signal processing, device miniaturization, and neural decoding algorithms. Subsequently, it delves into the profound issues and formidable challenges that have emerged. In the ethical realm, concerns such as privacy protection, informed consent, and potential misuse of brain data are analyzed. From an industrial perspective, issues like high production costs, regulatory uncertainties, and market acceptance are discussed. Finally, based on the current situation and challenges, the article astutely summarizes the prospective technological exploration directions, such as the pursuit of more stable and efficient signal transmission, enhanced biocompatibility of implants, and the development of novel application scenarios, aiming to provide valuable insights for future research and development in this burgeoning field.

References

1. Fu J, Ju W, Qi J, et al. (2023). Research and Development Situation Analysis of Brain-Computer Interface. Global Science, Technology and Economy Outlook,2022,37(07):59-68.
2. Bablani, A., Edla, D. R., Tripathi, D., & Cheruku, R. (2019). Survey on brain-computer interface: An emerging computational intelligence paradigm. ACM computing surveys (CSUR), 52(1), 1-32.
3. Jiang G, Zhao C. (2023). A Review of the Brain-computer Interface Development Based on EEG. Computer Measurement & Control,2022,30(07):1-8.
4. Cao H, Zhong Z, Chen Y, et al. (2023). Research advances in noninvasive brain-computer interface control strategies. Journal of Biomedical Engineering,2022,39(05):1033-1040.
5. Chi X, Cui H, Chen X. (2023). Advances in Multi-Modal Brain-Computer Interface Combined with Steady-State Visual Evoked Potential. Chinese Journal of Biomedical Engineering,2022,41(02):204-213.
6. Jiang, W., & Luo, J. (2022). Graph neural network for traffic forecasting: A survey. Expert Systems with Applications, 117921.
7. Jiang, W. (2021). Applications of deep learning in stock market prediction: recent progress. Expert Systems with Applications, 184, 115537.
8. Jiang, W. (2022). Graph-based deep learning for communication networks: A survey. Computer Communications, 185, 40-54.
9. Jiang, W. (2022). Cellular traffic prediction with machine learning: A survey. Expert Systems with Applications, 117163.

10. Jiang, W. (2022). Bike sharing usage prediction with deep learning: a survey. Neural Computing and Applications, 34(18), 15369-15385.
11. Armstrong, W., & Michael, K. (2020, November). The Implications of Neuralink and Brain Machine Interface Technologies. In 2020 IEEE International Symposium on Technology and Society (ISTAS) (pp. 201-203). IEEE.
12. Taheri, M., & Kalnikaite, D. (2022, January). A study of how Virtual Reality and Brain Computer Interface can manipulate the brain. In 2022 The 5th International Conference on Software Engineering and Information Management (ICSIM) (pp. 6-10).
13. Hirata, M., Kameda, S., Palmer, J., Ando, H., Suzuki, T., Jiang, Y., ... & Koike, Y. (2018, October). Clinical Application of Implantable Brain Machine Interfaces. In 2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC) (pp. 119-122). IEEE.
14. Hieda, N. (2017, October). Mobile brain-computer interface for dance and somatic practice. In Adjunct Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology (pp. 25-26).
15. Hamad, E. M., Al-Gharabli, S. I., Saket, M. M., & Jubran, O. (2017, July). A Brain Machine Interface for command-based control of a wheelchair using conditioning of oscillatory brain activity. In 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 1002-1005). IEEE.
16. Achanccaray, D., Chau, J. M., Pirca, J., Sepulveda, F., & Hayashibe, M. (2019, March). Assistive robot arm controlled by a P300-based brain machine interface for daily activities. In 2019 9th International IEEE/EMBS Conference on Neural Engineering (NER) (pp. 1171-1174). IEEE.
17. Zhang, Y. (2020, September). Mechanism Research and Application of Brain-computer Interface. In Proceedings of the 1st International Symposium on Artificial Intelligence in Medical Sciences (pp. 187-192).
18. Chen, X., Ye, Z., Xie, X., Liu, Y., Gao, X., Su, W., ... & Ma, S. (2022, February). Web Search via an Efficient and Effective Brain-Machine Interface. In Proceedings of the Fifteenth ACM International Conference on Web Search and Data Mining (pp. 1569-1572).