Research on the future development trend of brain science from the perspective of strategic planning

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Abstract: The difference between economic engineering and traditional brain science lies in its emphasis on engineering and quantitative methods in nervous system analysis, and the integration of brain science and engineering makes it different from other engineering fields. The 21st century will be the era of brain science. The development of brain science has reached a remarkable level, and the game among big countries around brain science is becoming increasingly fierce. From the perspective of strategic planning, it is the development focus and main task of China's basic research to include brain science and cognitive science in the forefront of basic research, promote the balanced, coordinated and cross-disciplinary development of disciplines, encourage interdisciplinary research, and organize and implement major scientific and technological projects such as brain science and brain-like research. This paper summarizes the future development trend of brain science, and puts forward some thoughts on the future development of brain science in China from the perspective of strategic planning.

1. Introduction

The brain is one of the most complex and important organs in the human body, and human beings have never stopped exploring the mysteries of the brain. Brain science is a science aimed at studying the nature and laws of cognition, consciousness and intelligence of human beings, animals and machines, and it is one of the basic scientific problems faced by human society. On the one hand, its main purpose is to solve those problems related to brain science; On the other hand, it provides a new method for the rehabilitation of nervous system function [1]. It should be reminded that the difference between neural engineering and traditional brain science lies in its emphasis on engineering and quantitative methods in nervous system analysis, and the integration of brain science and engineering makes it different from other engineering fields.

Understanding the structure and function of the brain is the most challenging frontier scientific problem in the 21st century. Understanding the neural basis of cognition, thinking, consciousness and language is the ultimate challenge for human beings to understand nature and themselves. The analysis of the neural basis of various brain functions by brain science has important clinical significance for the effective diagnosis and treatment of brain diseases; This paper summarizes the future development trend of brain science, and puts forward some thoughts on the future development of brain science in China from the perspective of strategic planning.

2. Deep learning based on brain science

At present, the knowledge explosion generated by the rapid development of information technology makes learners face a huge amount of information, but they are unable to obtain it blindly and have insufficient deep learning [2]. The theory of biological evolution makes us understand that the degradation of human characteristics will affect the overall living conditions of human beings. The main feature of human beings is learning, and learning is an important function of human brain, which is closely related to the brain. The research on the relationship between brain and learning is also an important direction of current brain science research.

From the perspective of strategic planning, it is the focus and main task of national basic

research to put' brain science and cognitive science' in the forefront of basic research, promote balanced, coordinated and cross-integrated development of disciplines, encourage interdisciplinary research, and organize and implement major scientific and technological projects such as brain science and brain-like research. National competition depends on talents, talent development depends on innovation, and the essence of innovation uses the brain [3]. In recent years, with the support of national strategy, brain science research has made unprecedented achievements. With the rapid development of various technologies, brain science has become one of the most advanced, important and active disciplines in the field of scientific research.

Deep learning is an important and effective learning type. "How did deep learning happen" is an important content of current learning research, that is, studying the occurrence mechanism and realization process of deep learning [4-5]. Deep learning itself is a form of brain activity. In this learning process, the more the brain is used scientifically, the higher the level of deep learning and the better the effect. The two are mutually reinforcing. Figure 1 shows a deep learning model based on brain science.

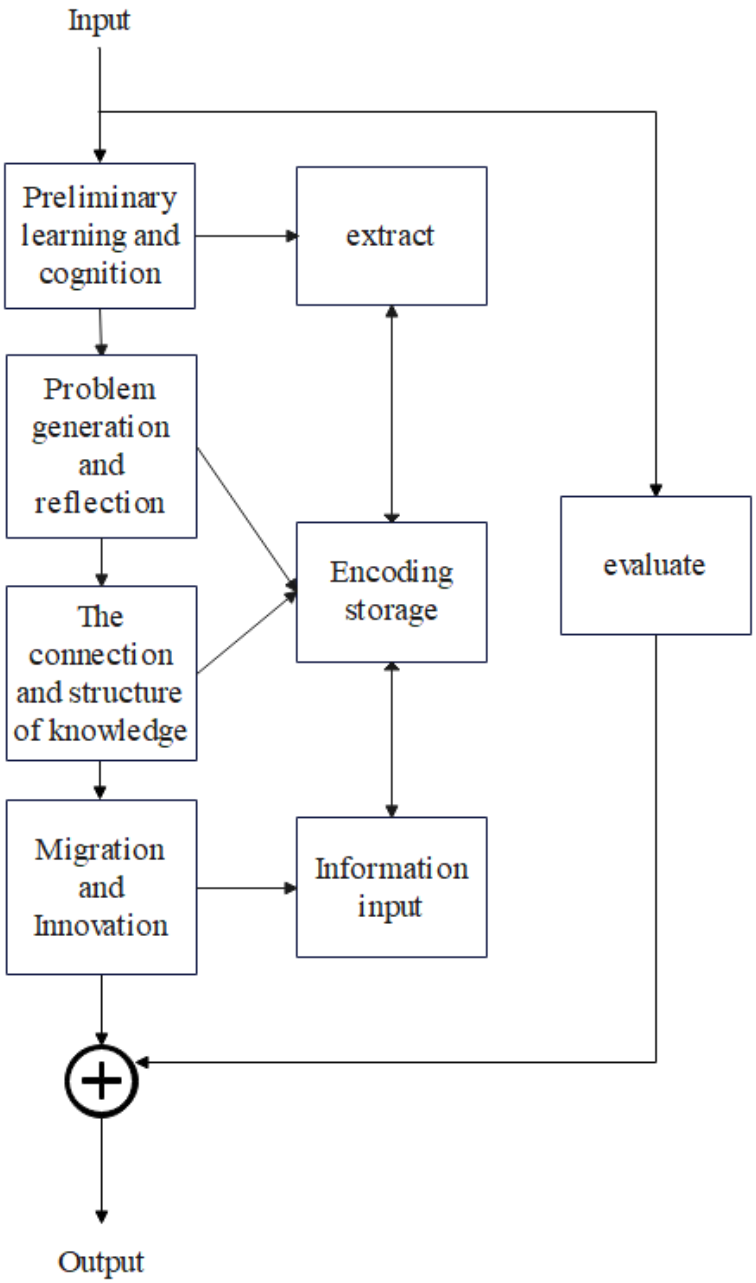

Figure 1 Deep learning model based on brain science

The environment of deep learning based on brain science is different from the general learning

environment, which requires learning to take place in a complex real environment. In this process, it is necessary to screen the knowledge that can be deeply studied, then find the internal relationship between the knowledge, and understand and analyze its relationship, and finally internalize it into a kind of deep knowledge that you have mastered [6].

The model consists of three parts: the first part includes the general process of deep learning: preliminary learning and cognition, problem generation and reflection, knowledge connection and structure, and knowledge transfer and innovation; the second part is the brain learning process corresponding to the first part: information input, coding, storage and extraction, while processing and evaluation are listed separately as the third part because they exist in the whole learning process.

3. Neuroengineering and brain-computer interface

The progress of brain science and brain-like AI technology is not only helpful for human beings to understand nature and know themselves, but also very important for effectively improving mental health and preventing and treating neurological diseases, escorting a healthy society, developing brain-like and AI systems, and seizing the opportunities for the development of intelligent society in the future [7]. For example, what brain regions and types of neurons are integrated into functional cell groups and form specific neural circuits and neural networks to realize the learning and memory process? Similar problems exist in perception, emotion, attention, thinking, decision-making and language. It is becoming an important direction of brain-like intelligence technology to use new technologies to carry out research such as brain-computer interface and decoding calculation, coding and synthesizing speech. Moreover, it is of great social and economic value to transform and apply these research results to solve the prevention, diagnosis and treatment of neuropsychiatric diseases.

The purpose of the initial research on brain-computer interface is to provide a communication channel without muscle participation, so that those patients with severe dyskinesia can use the brain-computer interface system to control external devices. Of course, this technology can also be extended to the control of more complex equipment, such as the control of neural prostheses. Like other communication systems, brain-computer interface system also includes input, output and a component between input and output. Successfully generating brain signals that can represent the wishes of subjects is one of the key problems to realize a reliable brain-computer interface system [8-9]. Therefore, it is of great significance in the research and development of brain-computer interface system to find a new brain-computer interface model, which can not only significantly improve the endogenous and exogenous components in recording EEG signals, but also avoid obvious visual fatigue.

In order to understand the research hotspots and their changes in the field of brain-computer interface in recent ten years, 2010-2023 is divided into six time periods every two years, and the highly cited papers in this time period are selected for citation coupling analysis to get clusters with similar themes, and then the clustering topics are interpreted to get the research hotspots in each time period (see Figure 2).

The research focus in the field of brain-computer interface has changed obviously with the passage of time. The pattern and algorithm of signal processing, extraction and classification account for more and more research hotspots. In recent years, learning mechanism, emotion recognition and brain function research such as brain reconstruction have also received great attention.

From the perspective of the development of human brain engineering, the primary goal of this project is to form a comprehensive cognitive principle. Through the use of brain simulation platform and neurorobot platform, the neural circuits that control specific behaviors are systematically analyzed, gene defects, pathological changes and cell loss in brain tissues at all levels are simulated, and a drug effect model is established. The second step is to recognize, diagnose and treat brain diseases. By exploring the potential of medical information platform, neural information platform and brain simulation platform, we can find biomarkers corresponding to specific brain disease processes, and further understand and simulate disease processes.

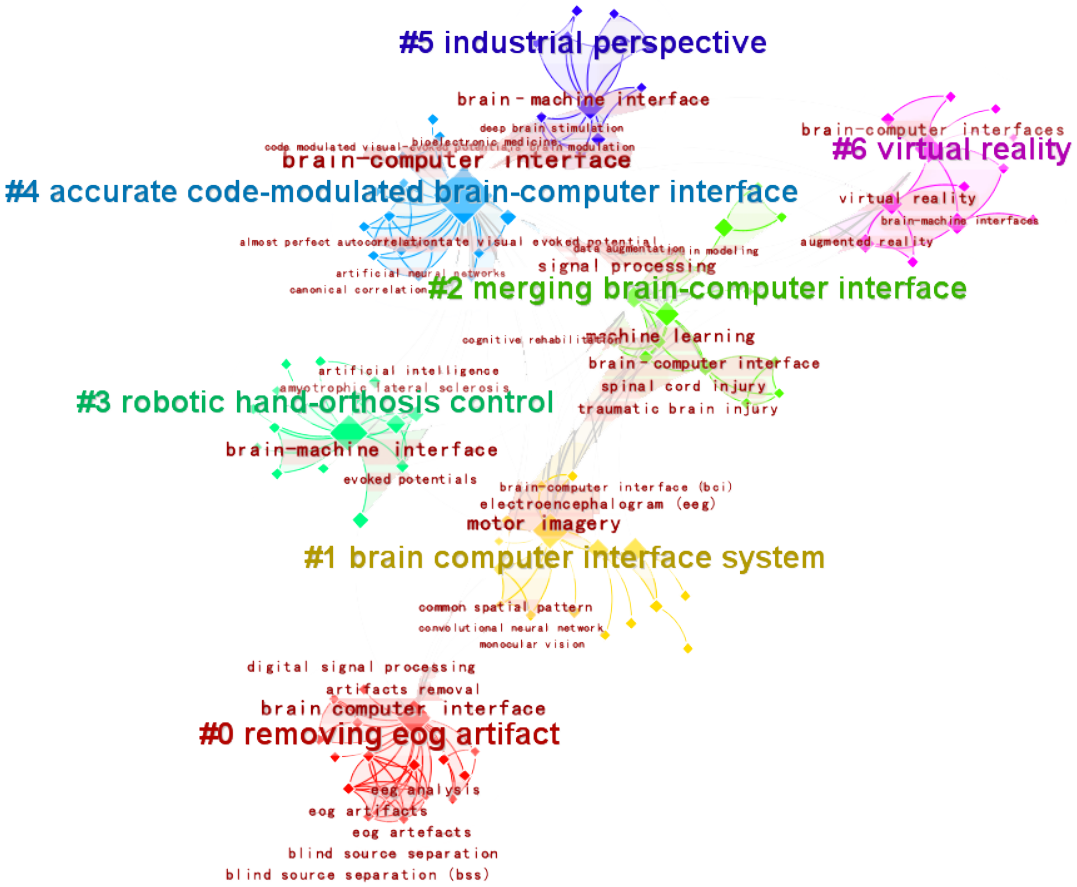

Figure 2 Cluster diagram of hot papers in the field of brain-computer interface from 2010 to 2023

At present, brain-computer interface products are mainly used to restore or replace the functions of patients with neuromuscular diseases such as amyotrophic lateral sclerosis, stroke, cerebral palsy or spinal cord injury [10]. The continuous development of virtual reality technology, the wide application of smart home control system, the continuous investment of government and research institutions, and the aging population and the increasing demand of patients with brain diseases are all important factors driving the continuous expansion of the brain-computer interface market. In fact, the brain-computer interface system is essentially to build the human brain (biological intelligence system) and the computer (AI system) on a dynamic interactive platform. This provides a new method and approach for the research of brain science. Of course, BCI also creates conditions for the development of advanced intelligent systems.

4. Meet national needs and serve economic and social development

The progress of brain science research affects human's production and life style, learning and memory style, emotion generation and coping style, thinking and decision-making style from the ideological source, thus having a far-reaching impact on economy, society, education and national defense security, and greatly promoting the progress of human civilization. Brain like computing model and AI products based on the development of brain science research results can be used to serve the long-term goals of new industry cultivation, scientific and technological progress, national security, social harmony and sustainable economic development. The "smart+"industrial form will surely bring great changes to human production and lifestyle.

The 21st century will be the era of brain science. The development of brain science has reached a remarkable level, and the game among big countries around brain science is becoming increasingly fierce. As a powerful country in science and technology under construction, China's brain science and brain-like intelligence have entered a critical period, and it is necessary to comprehensively grasp the development trends, general trends and key gaps at home and abroad in the field of brain

science and put forward highly targeted countermeasures in time. In the future, new imaging, neural monitoring and control technologies will promote the rapid development of brain cognition, brain diseases and brain-like intelligence. In addition, more and more attention will be paid to data governance and ethical safety supervision in the field of brain science and brain-like intelligence.

5. Thoughts on the future development of brain science in China from the perspective of strategic planning

In recent years, China has strengthened research deployment and institutional collaboration in brain and cognitive science, with obvious input and output. On the whole, brain science and brain-like AI have gained a certain international discourse power, and reached the international level of "parallel running" in animal disease models and high-resolution neuroimaging. Organized by the Ministry of Science and Technology, experts in brain science and intelligent technology in China held more than 10 discussions. The basic consensus reached at these meetings is that China urgently needs to launch a national-level "brain science and brain-like research" plan; In the next 15 years, the basic research of brain cognition, brain-like research and major brain diseases in China will reach the international advanced level and play a leading role in some fields. Brain-like research and brain-computer intelligence technology are the keys to the future high-tech field; The breakthrough of brain like computing system will promote China's information industry and promote the leap-forward development of industry, agriculture, finance and national defense.

China's brain science and brain-like AI are on the eve of great changes in international brain science and technology, and have reached a critical period when they must make a difference. However, compared with developed countries, there is still a considerable gap between the overall scientific and technological level of brain science and brain-like AI in China. In the face of a new round of strong attack by western countries in brain science and brain-like AI, as a powerful country in science and technology under construction, China's brain science and brain-like AI have entered a critical period in which they must make a difference. Brain science and cognitive science is a long-term key deployment field in China. The outline of the national medium-and long-term scientific and technological development plan regards brain science and brain-like research as a major scientific and technological project in scientific and technological innovation 2030, in order to seize the commanding heights of the frontier research of brain science. By 2025, major breakthroughs will be made in neural principles of brain cognitive activity, prevention and treatment of major brain diseases, brain-like computers and brain-like AI. At present, a platform of interdisciplinary research institutions related to brain science and brain-like AI has been established in China, which has realized the substantial integration of brain science and intelligent technology for the first time in the world, laying a solid foundation for the development of brain intelligence science and the start of brain plan in China.

A striking feature of the fourth industrial revolution is the need for deep interdisciplinary integration of disciplines, including not only the integration of physics, big data and biology, but also the integration of industrial production and services, as well as the integration of science, technology, engineering, mathematics, medicine and social sciences. Both the American Brain Project and the European Brain Project involve researchers in the fields of science, engineering, mathematics and technology. To carry out interdisciplinary cooperation requires scientists to dare to jump out of the "comfort zone" of scientific research and do pioneering work, actively talk about the common interests of all parties and give full play to their advantages. Interdisciplinary integration also depends on the establishment and development of interdisciplinary research institutions. It is suggested to break the disciplinary boundaries at the level of postgraduate enrollment in order to cultivate compound talents.

6. Conclusions

Understanding the structure and function of the brain is the most challenging frontier scientific problem in the 21st century. Understanding the neural basis of cognition, thinking, consciousness

and language is the ultimate challenge for human beings to understand nature and themselves. The analysis of the neural basis of various brain functions by brain science has important clinical significance for the effective diagnosis and treatment of brain diseases; The theory of evolution of things makes us understand that the degradation of human characteristics will affect the overall living conditions of human beings. The main feature of human beings is learning, and learning is an important function of human brain, which is closely related to it. The research on the relationship between brain and learning is also an important direction of current brain science research. In order to improve the research and development level and depth of brain science in China and reach the international advanced level as soon as possible, international cooperation is a necessary part of development. Form a basic strategic plan for international cooperation in brain science in China, and strive to launch major international science and technology plans in the basic field of brain science.

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