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Research Status of International Intelligence Education

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ABSTRACT

The vigorous development of artificial intelligence continues to promote the penetration of technology in the field of education. Countries around the world are constantly setting off a wave of research on intelligence education. On the basis of sorting out the concepts of intelligence education, this article systematically reviews the research status of international intelligence education, analyzes highly-cited international journals, leading countries and scientific research institutions in the field of international intelligence education, reveals the research map in the field of international intelligence education, makes an atlas analysis of research keywords, and summarizes the fields and research hotspots of international intelligence education, so as to provide some reference for the research and development of China's intelligence education.

Keywords: *intelligence education, research status, research hotspot*

I. INTRODUCTION

Since the concept of "Artificial Intelligence" was proposed in 1956, it has set off the first wave, with symbolic reasoning and machine reasoning as the primary research priorities. Since 1976, speech recognition, speech translation and the fifth generation robot in Japan have promoted the second wave of AI development. Today, with the breakthrough of deep learning technology and image recognition technology in the ImageNet competition, and the continuous development of natural language processing, data mining, and deep learning technology, artificial intelligence has achieved a leap forward development, and the third wave of artificial intelligence is emerging and continues to penetrate all aspects of life (Liu Dejian, Du Jing, Jiang Nan & Huang Ronghuai, 2018). The same is true in education. Countries around the world are promoting the development of artificial intelligence in the field of education with different policy orientations, and have initiated extensive research and discussion on intelligence education.

II. DEFINITION OF INTELLIGENCE EDUCATION CONCEPT

From the Internet of Things to big data and then to artificial intelligence, China's artificial intelligence policy has undergone continuous evolution. The State Council wrote "Intelligence Education" in the "Development Planning of New Generation Artificial Intelligence" in July 2017. This plan proposed to "use intelligent technology to accelerate the reform of talent cultivation and teaching methods and build a new education system that includes intelligent learning and interactive learning". In April 2018, the Ministry of Education issued the "Innovative Action Plan for Artificial Intelligence in Colleges and Universities", stating that "it is necessary to promote the demonstration of intelligence education applications, accelerate the deep integration and innovative development of artificial intelligence and education, study the development strategy and standard planning of intelligence education, explore the integration path and method of artificial intelligence technology, and comprehensively promote the modernization of education." It can be seen that the state has established the height and positioning of "intelligence education" at the policy level. At the same time, it is proposed by the academic circle that for the development of educational informatization 2.0, intelligence education is the implementation way and the navigation mark (Zhu Zhiting, 2018). Artificial intelligence will have significant impacts on human education and learning methods (Jia Jiyou, 2018).

The idea of intelligence education originated from the thinking of philosophers, aiming to help people to recognize and awaken the "intelligence" of human beings (Krishnamurti, 2004). It is typical of "children's intelligence education theory" of Marlen and "intelligence balance theory" of Stemberg (2001). The emergence of "intelligence education" stems from the development of cognitive computing, learning analysis, perceptual analysis and other emerging intelligent technologies, and the "intelligence education" aims to provide more opportunities for the reform and innovation of education. On the research of "intelligence education", Chinese scholars mainly focus on the "in-depth application of intelligent technology in education and teaching" and "research on taking

artificial intelligence technology as teaching content" (Liang Yingli & Liu Chen, 2018; Liu Jiande, Du Jing, Jiang Nan & Huang Ronghuai, 2018). Zhu Zhiting proposed that intelligence education should focus on improving the full intelligence level of all kinds of talents. Therefore, he proposed the third connotation of intelligence education, namely, the "education to promote intelligent development" (Zhu Zhiting, 2018). Liu Kai and others proposed to divide intelligence education into four basic research issues from the perspective of general artificial intelligence: "human learning, human education, machine learning and machine education" (Liu Kai, Hu Xiangen, Ma Yuhui, Nadi & Zhang Yuhua, 2018). Zhang Jinbao and others put forward the promotion of core value proposition of intelligence education, the cultivation of key thinking mode and the construction of ontology knowledge of intelligence education (Zhang Jinbao & Ji Lingyan, 2018).

Comparing the development of intelligence education in foreign countries, it is found that it is mainly centered on the "Application of artificial intelligence in education" (Jia Jiyou, 2010; Zhang Kunying & Zhang Jianian, 2018; Wang Tingting & Ren Youqun, 2018), aiming to research into "intelligent tutoring system", "intelligent learning environment", "adaptive hypertext system", "computer-aided collaborative learning system", etc. Therefore, this paper mainly uses the keyword "AIED" to make an in-depth analysis of the related research of international "intelligence education".

III. RESEARCH STATUS OF INTERNATIONAL INTELLIGENCE EDUCATION

This paper mainly uses bibliometrics to analyze the research status of "intelligence education" in the world. In the "core collection" database of the international journal retrieval platform "Web of Science (WOS)", the "artificial intelligence in education" is used as the subject for retrieval. The time span is from 1998 to now. As of November 20, 2018, 864 document records have been obtained, and 387 journal articles have been obtained, excluding conference papers, reviews and other articles. Citespace can be used to analyze the research status in a certain field. Through clustering analysis of research hotspot, knowledge characteristics can be displayed in a visual form, so it is widely used as a research tool (Chen, 2006).

A. Quantitative analysis on research results of international intelligence education

First of all, in terms of the volume of documents (see "Fig. 1"), the trend basically conforms to the wave experienced by the development of "artificial intelligence". Before and after 1998, the development of the second wave of artificial intelligence was limited by the amount of data and the test environment, which made the development of related research become flat or even low, and the growth of the research on the related topics of intelligent education from 1998 to 2014 was also relatively slow. However, after 2015, it has shown an obvious upward trend. In 2015, artificial intelligence achieved a leap forward development. For the first time, the accuracy of image recognition of artificial intelligence algorithm based on deep learning exceeded that of human eyes (the Electronic Frontier Foundation, 2017). After that, human beings have made breakthroughs in voice recognition data mining, natural language processing and other fields, and more and more researchers are also focusing on the field of intelligence education.

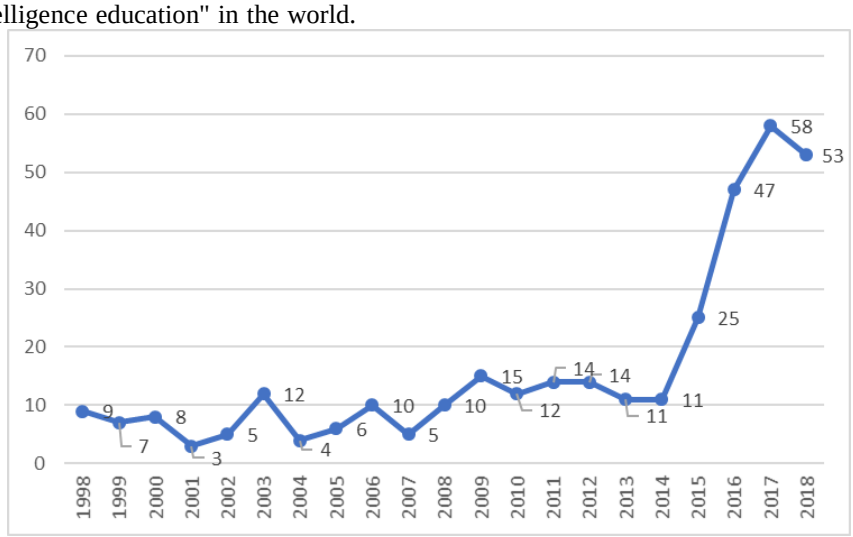

Fig. 1. Number of research documents of international intelligence education in recent 20 years.

B. Countries and research institutions of high-yield research on international intelligence education

From the perspective of countries of high-yield research (see "Table I"), the traditional developed countries such as the United States, the United Kingdom and Spain occupy the top 10, but it is worth noting that China ranks the second in the number of research results published in international journals, and the research results of Taiwan scholars are also among the top 10, which means that China's intelligence education field is producing more and more high-quality research results. At the same time, the similar situation in high-yield research institutions can be seen. International famous universities, led by the University of Georgia, Harvard University and University of London, are the main force of research. And Sagacity, a technology consulting company in the United States, also has a lot of research output in intelligence education.

TABLE I. COUNTRIES AND RESEARCH INSTITUTIONS OF HIGH-YIELD RESEARCH IN THE FIELD OF INTERNATIONAL INTELLIGENCE EDUCATION

Country / Region	The number of papers	Research institutions	The number of papers
U.S.A	110	University of Georgia (United States)	8
China	34	Harvard University (USA)	7
England	33	University of London (UK)	7
Spain	28	Carnegie Mellon university (USA)	6
Canada	27	University of Granada (Spain)	5
Australia	18	Rutgers University (USA)	4
Turkey	16	Sagacity Company (USA)	4
Brazil	14	Georgia Institute of Technology (USA)	4
Germany	12	Heriot-Watt University (UK)	4
Taiwan	11	Mcgill University (Canada)	4

C. Highly-cited journals in the field of international intelligence education

"Cited journal" is usually used to analyze journals with high citation rate, which also means that the journal occupies a high position in a certain field. "Table II" shows the top 10 highly-cited journals in the field of international intelligence education, mainly focusing on computer science, artificial intelligence technology, etc. Among them, the journal with highest citation rate is the conference proceedings focusing on the research of computer science and information technology, "Lecture Notes in Computer Science", which has been published since 1973 and 11207 volumes. "Computers & Education", the SSCI journal with second citation rate, aims to expand the theoretical and practical research on how digital technologies promote education by publishing high-quality research results. At the same time, it advocates receiving high-quality qualitative and quantitative research. The SCI journal "artificial intelligence", which was published in 1970, has become an internationally recognized high-level research journal in the field of artificial intelligence, mainly focusing on artificial intelligence and philosophy, automatic reasoning and trial reasoning, heuristic search and intelligent robot and other related research. In addition to the first three highly-cited journals, the list also includes the well-known "science" founded by Edison in 1880, which is one of the most authoritative academic journals in the world, as well as the "Nature" journal that has consistently published the most important breakthrough in the field of science and technology in the world since its inception in 1869.

Also, there are three journals in the table showing the state of "emergence", which means that the contents of these three journals about intelligence education have been quoted on a large scale in a short time, and have a high impact in the field. "International Journal of Artificial Intelligence in Education" is the official journal of the Artificial Intelligence in Education (AIED). It aims to publish papers on the application of artificial intelligence in education, and help to formulate principles of learning system design under the support of intelligent technology. From learning environment to system architecture, and from statistical methods to large artificial tools, the journal publishes different research topics from the perspective of interdisciplinary, and provides problem solutions that are intrinsically related to education and an international perspective on computer-based learning system design. Therefore, this paper analyzes the research status and progress in the field of international intelligence education from the perspective of emerging journals and article content.

TABLE II. TOP 10 HIGHLY-CITED JOURNALS IN THE FIELD OF INTERNATIONAL INTELLIGENCE EDUCATION

Ranking	Highly-cited international journals	Total number of citations
1	Lecture Notes in Computer Science*	58
2	Computers & Education	53
3	Artificial Intelligence	47
4	International Journal of Artificial Intelligence in Education*	45
5	Communication of the ACM	42
6	Expert System with Applications	40
7	Science	40
8	AI magazine	30
9	Cognitive Science	27
10	Nature*	24

[a.] *journals with high citation rate.

IV. ANALYSIS ON RESEARCH FIELDS AND HOTSPOTS OF INTERNATIONAL INTELLIGENCE EDUCATION

A. *Analysis on research fields*

Through the data analysis of WOS, it can see the distribution of research subjects focusing on international intelligence education. It can be found that "computer science", "educational research" and "engineering" occupy the main researches, with the ratio of 35%, 24% and 20% respectively. It means that the research in the field of international intelligence education pays attention to the combination with technology research and education. In addition, "economics", "medical informatics", "information science" and other disciplines are also constantly developing the integration with artificial intelligence technology.

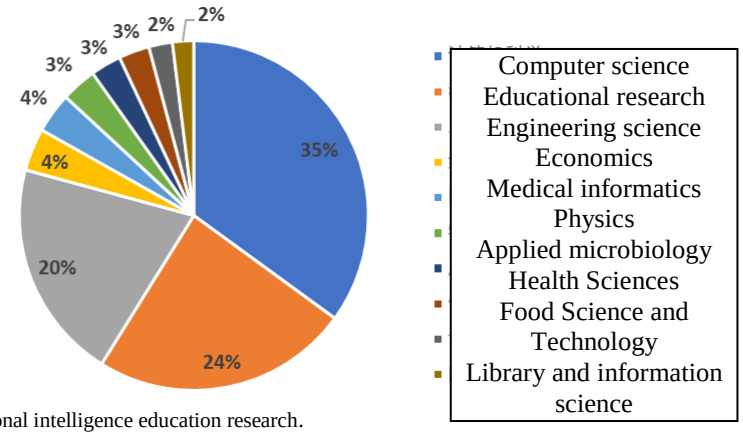

Fig. 2. Discipline distribution of international intelligence education research.

"Carrot search" can discover high-frequency keywords in a certain field and present them in the form of tree diagram layout. The area of polygons represents the times of keywords (Zhou & Zhao, 2015). Therefore, with the help of "carrot search", it can have a deep look at the research topics in the field of intelligence education. It can be found from "Fig. 3" that among the research topics related to "artificial intelligence in education", neural network, proposed method, artificial intelligence in medical and prediction model, robot, adaptive and assistant are the main contents. In particular, unsupervised adaptive method has been introduced into facial expression recognition to train a convolutional neural network (CNN) with good performance by generating a GAN on the target data set. The results show that the adaptive method is effective in four facial expression recognition data collections (Wang, Wang & Ni, 2018). In terms of genetics, talent in cognitive development is the result of genetic variation with different effects. Some scholars have proposed neural computing models for cognitive development, using artificial neural networks to simulate the development of children's groups, and instantiating polygenic models, changes in the level of environmental stimulation, etc. The "gifted" networks at the computing level tend to have higher capacity and strong plasticity, which is verified by experiments. In the field of surgical data science, Ross et al. (2018) used automatic image annotation solutions with in-depth learning. The availability of algorithm reference annotation has become a research bottleneck, proposing to use self-monitoring learning to solve this problem.

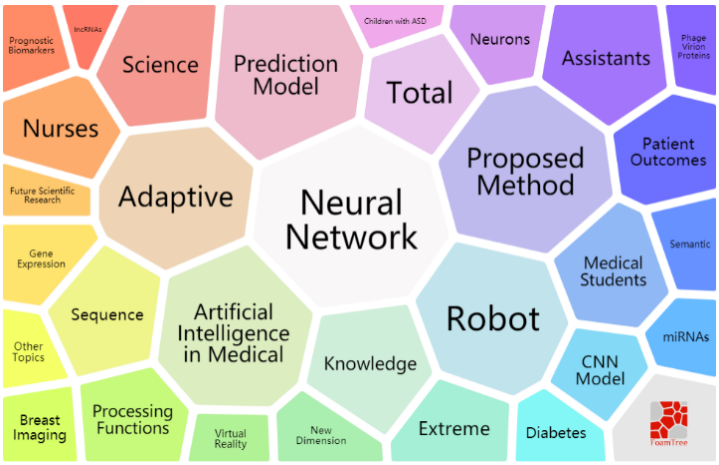

Fig. 3. Tree diagram of research hotspots in the field of international intelligence education.

B. Analysis on research hotspot

The key words of the paper reflect the theme of the paper and the research interests of the author. Therefore, the analysis of the key words can provide research hotspots and research interests of researchers in a certain field (Xie, Zhang & Ho, 2008). Citespace is used to analyze the keyword co-occurrence network of the bibliographic data. The co-occurrence map of high-frequency key terms, that is, the map of research hotspot knowledge, is analyzed. As shown in "Fig. 4", the size and color of key words represent the importance of their position in the whole network. It is to sort the keywords in descending order. In addition to the two search keywords, research related to the "system", "model" and "design" is relatively hot, and related research topics such as "technology", "ITS (Intelligent Tutoring System)" and "E-learning" have been extended consistently.

It is worth noting that in recent three years, researchers have paid close attention to three key words: "big data", "student" and "machine learning". As early as the 1980s, the word "big data" has been known to the public, and some people attribute it to the contribution of Mashey J (1998), an American computer scientist. Today, "big data is a parallel computing tool for data processing." Mayer, V & Cukier (2013) defined machine learning as a mode in big data: "big data usually does not ask the reason, but only test mode". Big data is characterized by 4V (volume, variety, velocity and veracity). In 2011, McKinsey Global Institute described the main parts of big data as follows: data analysis technology (A / B test, machine learning and natural language processing), technical features (business intelligence, cloud computing and database), visualization (chart, graph or other display) (McKinsey Global Institute, 2011). The influence of big data in the field of education is reflected in the following aspects. The first is "digital education governance", which means that big data can provide "data visualization", "predictive analysis" and "real-time policy tools" for education, such as visualizing highly complex digital interactive data to construct knowledge of education system, tracking and predicting the performance of learners by using learning analysis platform, and using digital policy tools to demonstrate how database tools and infrastructure are at the heart of national and global governance education, governance and management (Williamson, 2015). Eynon (2013) discusses what the rise of big data means for education, technology and media research. For the field of education, big data has become a new and rapidly growing topic. Education data mining and stress analysis are becoming research identifiers. The government began to publish a report on the potential of big data education. However, considering the use of data to improve efficiency, enhance transparency and the tool to evaluate performance, it will still cause critical thinking of the public. Against the background of higher education, the implementation of big data still faces some opportunities and challenges. Data warehouse can be an effective way to release the value of big data in higher education. It provides researchers with the opportunity to conduct real-time analysis of learning activities, and create prediction models to check students at risk and provide appropriate interventions, so that teachers can adjust their teaching or conduct personalized counseling. However, the continued growth of learning analytics means that people need to consider not only the huge opportunities for better and more effective decision-making in higher education, but also the ethical challenges of institutionalizing learning analytics (Daniel, 2015).

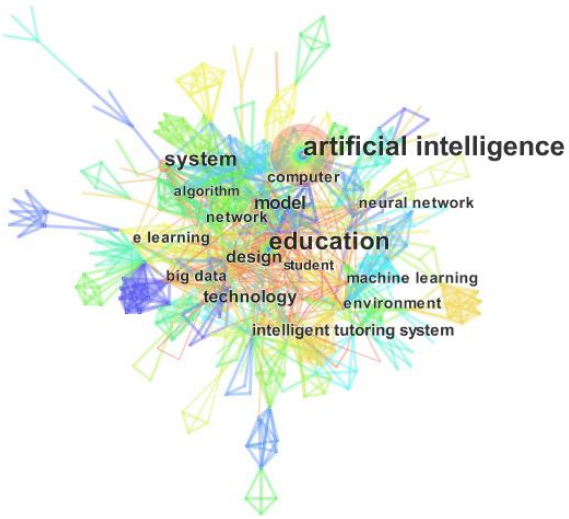

Fig. 4. Keywords co-occurrence map of international intelligence education research.

V. CONCLUSION

This paper systematically reviews the research status of international intelligence education and reveals the research map of international intelligence education (including the number of research results, leading countries / research institutions and highly-cited journals). Combined with the analysis on focus areas and hotspots of research keyword, three research hotspots of "big data, students and machine learning" are mined out. The purpose of this paper is to provide some reference for the development of intelligence education and the researchers who pay attention to it.

With the rapid development of artificial intelligence technology, more and more new technologies or applications will appear in the future to promote the development of educational informatization. However, in the process of the application of artificial intelligence education, there are still many factors worthy of discussion. Michael Wooldridge, an artificial intelligence researcher at the department of computer science in University of Oxford, said, "there is an obviously AI bubble at the moment. Will the bubble burst, like the Internet bubble burst from 1996 to 2001, or is it slightly deflated?" For human beings, it is a question worth thinking about. At the same time, with the development of technology, there are many challenges, such as the privacy of education data, the role transformation of teachers and students in the intelligent era, the intelligence education management of schools, and the change of teaching environment. In the face of the changes brought by artificial intelligence, education must take the initiative and adjust in time to maximize the advantages of technology, so as to realize the cultivation of pillar talents with core literacy in the new era and better serve the social economy and development.

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