

# Research Hotspots and Trends on knowledge visualization in CNKI Based on Visual Analysis

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**Abstract-** The article uses CiteSpace software to visual analysis 855 pieces of knowledge visualization research from 2011 to 2021 in the CSSCI journals included in the CNKI database. The visualization analysis was conducted on the number of pieces, authors, institutions and keywords of knowledge visualization research to explore research hotspots and trends in study of knowledge visualization. The hotspots of knowledge visualization research are identified by analysing of high-frequency keywords, and the trends of knowledge visualization are determined by detecting the trends of keywords changes over time and burst terms, which provide an essential reference for knowledge visualization researchers. We find that not only “knowledge visualization”, “visualization analysis” are the hotspots of research, but also “knowledge foundation”, “knowledge management” are hot research topics. “Cluster analysis”, “digital humanities”, and “development trend” are all the research trends. In the coming period, knowledge visualization is combined with more disciplines and fields and gets more application.

**Keywords – Knowledge Visualization, Visualization, Hotspots, Trends, CiteSpace**

## I. INTRODUCTION

In February 1987, the National Science Foundation held a workshop where "visualization" was introduced as an academic term and given the definition, fields and development direction of "Visualization in Scientific Computing" (VISC). Knowledge visualization originates from VISC but is different from VISC. The processing object of VISC is main data, and the processing object of knowledge visualization is human knowledge [1]. Up to now, there have been several thematic conferences and studies dedicated to knowledge visualization. Knowledge visualization not only aims to convey factual information, but also seeks to bring insights, experiences, attitudes, values, expectations, perspectives, opinions and predictions to others [2]. Eppler & Burkhard believed that knowledge visualization as an independent research direction originated from the three main fields of scientific computing visualization, data visualization, and information visualization [3]. They consider knowledge visualization as: improving the efficiency of knowledge dissemination between at least two people by visualizing the representation of knowledge, which in turn contributes to the innovation of knowledge. The essence of knowledge visualization is to graphically represent human's intrinsic knowledge to form an external representation of knowledge, which can act directly on human senses and influence the dissemination of knowledge and innovation finally [2].

In recent ten years, researches have transferred from basic ideas and technologies to further technologies and applications. There have been many theoretical and practical types of research of knowledge visualization. For example, in paper [4], researchers performed a formal analysis of visual representations in knowledge visualization and considered that it is only meaningful to analyze the forms formed by the interaction of symbols when studying the structure of characters; In paper [5], researchers talked about the process of knowledge visualization from the perspective of visual communication. However, few researchers have used visualization and bibliometric methods to research the hotspots and trends about knowledge visualization in recent years. In this study, using bibliometric method to visually analyze the study content of knowledge visualization in CSSIC of CNKI from 2011 to 2021.

To provide meaningful and valuable references for future research in the field of knowledge visualization, this paper studies the hotspots and trends of knowledge visualization. Specifically, we use CiteSpace 7.5 to analyze the relevant core authors, major research institutions and high-frequency keywords of the literature in knowledge visualization, and then visualize the research hotspots, research trends and research contents of knowledge visualization, and make specific summaries and outlooks.

## II. DATA SOURCE AND VISUAL TOOL

### A. Data Source

This paper used "knowledge visualization" as the keywords to retrieve papers about knowledge visualization in Chinese National Knowledge Infrastructure (CNKI), which is the largest Chinese journal full-text database in the world. The publication time limitation is 2011-2021, and the source category is limited to the Chinese Social Sciences

Citation Index (CSSCI). After the search process, up until February 1st, 2021, there are 855 articles that include knowledge visualization (Figure 1) in the CNKI.

The screenshot shows the CNKI search interface. At the top, there are navigation tabs: 文献, 期刊 (selected), 博硕士, 会议, 报纸, 图书, 年鉴, 百科, 词典, 专利, 标准, 成果, 更多>>. Below this is a search bar with three options: 作者发文检索, 句子检索, and 一框式检索. A red link '新型出版模式介绍' is on the right. The main search area is titled '输入检索条件:' and contains several fields: '主题' (Topic) with a dropdown menu, '知识可视化' (Knowledge Visualization) in the input field, '词频' (Term Frequency) dropdown, and '并含' (Include) dropdown. Below this is a '并且' (And) section with '篇摘' (Article Abstract) dropdown, '词频' dropdown, and '并含' dropdown. The '作者' (Author) section has a dropdown menu, '中文/英文/拼音' (Chinese/English/Pinyin) dropdown, '精确' (Exact) dropdown, and '作者单位' (Author Institution) dropdown with '全称/简称/曾用名' (Full Name/Abbreviation/Former Name) dropdown and '模糊' (Fuzzy) dropdown. The date range is set from '2011' to '2021' with '指定期' (Specify Period) and '更新时间' (Update Time) dropdown set to '不限' (No Limit). The '来源期刊' (Source Journal) field has '期刊名称/ISSN/CN' (Journal Name/ISSN/CN) dropdown and '模糊' dropdown. The '来源类别' (Source Category) section has checkboxes for '全部期刊' (All Journals), 'SCI来源期刊' (SCI Source Journals), 'EI来源期刊' (EI Source Journals), '核心期刊' (Core Journals), 'CSSCI' (checked), and 'CSCD'. The '支持基金' (Support Fund) field has a '模糊' dropdown. At the bottom, there are checkboxes for '包含资讯' (Include Information), '网络首发' (Network First), '增强出版' (Enhanced Publishing), '数据论文' (Data Paper), '中英文扩展' (checked), and '同义词扩展' (Synonym Extension). A red '检索' (Search) button is at the bottom right.

Figure 1. Results of general search in CNKI (2011-2021)

## B. 2.2 Visual Tool

The visual analysis tool used in this paper is CiteSpace to analyze the literature related to knowledge visualization. When downloading and extracting information from documents, it is saved in plain text in the "Refworks" format. CiteSpace is one of the standard tools for knowledge visualization. It is an interactive visualization tool that combines the three functions of information visualization, data mining, and document measurement so that it's easy for extracting available information [6]. The primary purpose of using CiteSpace in this paper is to visually analyze the literature of knowledge visualization and reflect the hotspots and trends in the current research phase. In this study, CiteSpace 5.7 was applied to analyze 855 articles related to knowledge visualization in CSSIC of CNKI from 2011 to 2021. The knowledge graphs were constructed from three aspects: research institutions, authors keywords, respectively.

## III. VISUAL ANALYSIS

### 3.1. Number of knowledge visualization documents

The number of academic papers published in a specific time reflects the research fervor in this field. The research trend in this field can be analyzed by counting the number of papers in consecutive time. According to the bibliometric analysis function that comes with CNKI, we can get the annual literature quantity of knowledge visualization research (Figure 2). According to the dashed line of the number of publications, we can find that the number of documents on knowledge visualization has remained at a relatively stable level in nearly ten years. From the quantitative analysis results, we can get more detailed changes. The number of knowledge visualization publications has increased every year from 2011 to 2016. The number of knowledge visualization publications was 113, reaching the highest number in 2016. Since then, the number of knowledge visualization publications has shown a decreasing trend, and the number of published papers is probably to be 86 in 2021. There are several important reasons. The theoretical foundation of knowledge visualization is quite mature before 2011, and it has gradually reached saturation in the last decade.

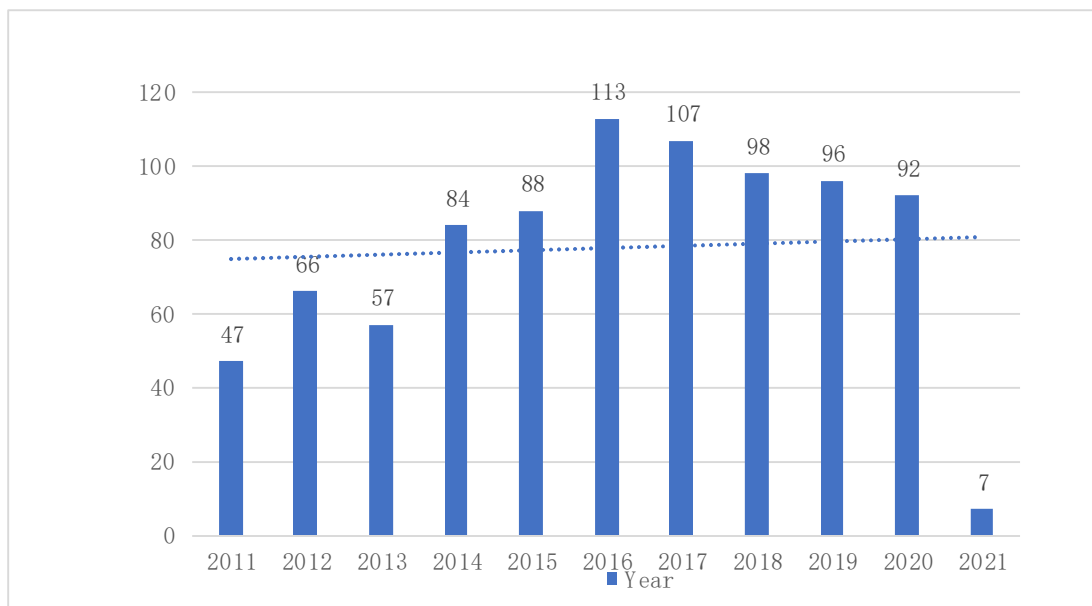


Figure 2. The number of published papers in CNKI (2009-2020)

### 3.2. Core Authors and Research Institutions

In a specific research field, knowing which authors are the core authors and which research institutions are the core research institutions can better grasp the overall research direction and keep up with the research trends. In CiteSpace, we get the top 10 authors and institutions after selecting "authors" and "institutions", respectively, respectively shown in Table-1.

Table-1. The co-occurrence graph of authors/ institutions of knowledge visualization in CKNI(2011-2021)

No.	Frequency	Core Authors	No.	Frequency	Research Institutions
1	15	Junping Qiu	1	45	School of Information Management Wuhan University
2	13	Rongying Zhao	2	21	Research Center for Chinese Science Evaluation of Wuhan University
3	9	Guoshuai Lan	3	19	The Center for the Studies of Information Resources of Wuhan University
4	7	Huichen Zhao	4	16	School of Information Management Nanjing University
5	6	Qing Wang	5	14	School of Information Management Central China Normal University
6	5	Shuyu Zhang	6	13	School of Management Jilin University
7	5	Hong Lv	7	11	Institute of Scientific and Technical Information of China
8	5	Zhanyong Qi	8	9	School of Education Science Shaanxi Normal University
9	4	Yichun Zhang	9	7	School of Education Science Henan University
10	4	Bo Yu	10	7	School of Education Science Nanjing Normal University

The author co-occurrence diagram (Figure 3), also known as the author cooperation diagram, reflects the number of papers by research authors and the cooperation relationship between authors in a particular field. The main elements of the author co-occurrence graph include nodes, lines between nodes, and labels. Each node represents an author, and the label on it represents the author's name, and the size of the node and the label reflect the number of author papers. The links between nodes reflect the collaborative relationship between authors. The author co-occurrence graph in this study shows a total of 327 nodes and 138 connections. Combined with Price's law [7], we can calculate which authors are the core authors in this field. The formula of Price's law is  $m = 0.749(n_{max})^{0.5}$ , where

$n_{max}$  represents the number of papers published by the author who publishes the most papers and  $m$  represents the minimum number of papers to be published by core authors. In this study,  $n_{max}$  is 15, and  $m$  is 2.90, after substituting the above formula, so the integer three is taken, which means that all authors with the number of publications greater than three can be considered as core authors. Finally, the total number of core authors was calculated to be 28.



Figure 3. The co-occurrence graph of knowledge visualization authors in CNKI (2011-2021)

The institutional co-occurrence graph can reflect the number of papers of research institutions, and the cooperative relationship between institutions. Its elements are similar to those in the author co-occurrence graph. In this study, there are 308 nodes and 123 connections in the institutional co-occurrence graph. School of Information Management Wuhan University, Research Center for Chinese Science Evaluation and Technology and The Center for the Studies of Information Resources of Wuhan University are the three research institutions with the highest number of papers. The number of connections between nodes can reflect the degree of institutional cooperation, and the graph shows that the three major research institutions do not have much collaboration with other institutions, and the degree of centrality index of School of Information Management Wuhan University is the highest among all institutions, but only 0.01. This reflects that there is still a lack of cooperation among research institutions in this field.



Figure 4. The co-occurrence research institutions of knowledge visualization in CNKI (2011-2021)

### 3.3. Keywords Analysis

#### 3.3.1. Keywords Co-occurrence Analysis

The keywords that appear with high frequency in a specific field are generally the core content in this field. The statistics and analysis of keywords in the field of knowledge visualization can understand the current research hotspots and cores. We use CiteSpace to count the keywords in the field of knowledge visualization from 2011 to 2021. The 15 most frequent keywords are shown in Table-2 in order, among which the three most frequent keywords are “knowledge mapping”, “visualization”, “visualization analysis”, appeared 493 times, 219 times, and 188 times, respectively.

Table-2. The co-occurrence of knowledge visualization keywords in CNKI(2011-2021)

No.	Frequency	Centrality	Year	Keywords
1	493	0.00	2011	knowledge mapping
2	219	0.00	2011	visualization
3	188	0.05	2011	visualization analysis
4	128	0.01	2011	CiteSpace
5	95	0.02	2011	research hotspot
6	71	0.14	2011	knowledge visualization
7	65	0.08	2012	bibliometrics
8	62	0.03	2011	information visualization
9	39	0.00	2011	research frontier
10	29	0.13	2011	CiteSpace II
11	22	0.02	2011	social network analysis
12	22	0.32	2011	Scientific knowledge graph
13	22	0.11	2014	Knowledge foundation
14	19	0.04	2011	co-word analysis
15	18	0.03	2011	knowledge management

Both knowledge visualization and knowledge mapping are the main concepts and branch content of the visualization field. As a rapidly emerging and developing interdisciplinary research field, knowledge mapping is generally different in the research focus in different disciplines. Knowledge mapping has many advantages such as more intuitive, quantitative, simple and objective. It is an effective and comprehensive visual analysis method, which is widely used and achieved relatively reliable conclusions. It has become a research hotspot and practical exploration trend in the fields of Scientometrics, management, science and information science [8]. More than half of the articles are researching or applying knowledge mappings. For example, knowledge mapping of the domain about big data [9], knowledge mapping of research on international e-government [10], et al. Knowledge mapping, as one of the main contents of visualization field, becomes the first hotspot. It is not difficult to understand that visualization is the second hotspot. The process of knowledge visualization and the creation of the knowledge map are all visualization processes.

The third word of high-frequency keywords is “visualization analysis”. Eppler and Burkard [3] believes that knowledge visualization can be used to construct and convey all the graphical means and methods of complex ideas and content. Most of the research fields and disciplines can use the mature tool of knowledge visualization to analyze knowledge and express knowledge graphically, and form an external form of knowledge that can directly affect human senses, thereby promoting the dissemination and innovation of knowledge.

#### 3.3.2. Keywords Clustering Analysis

Keyword clustering analysis can reflect research hotspots and topics with great attention. To better grasp research hotspots, we performed the keywords clustering analysis. Labelling clusters with indexing term, Figure 5 shows the results after keyword clustering. In the clustering result index, the module Q value is 0.89, higher than 0.3, and the S value is 0.97, higher than 0.7, which indicates that the clustering effect is significant and convincing. The top 10 clustering results are sorted from 0 to 9. The smaller the number, the more keywords are included in the clusters.

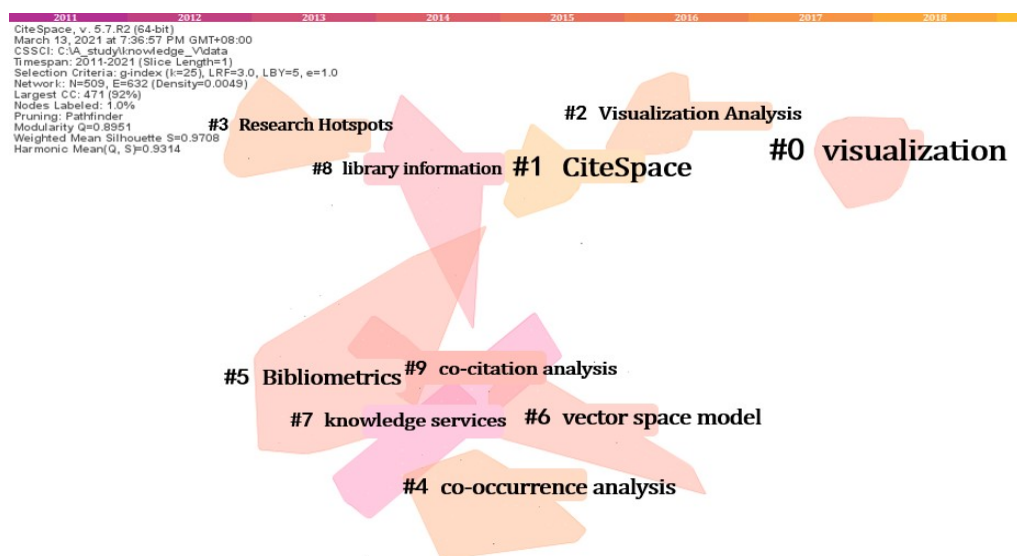


Figure 5. The Keywords clustering graph of knowledge visualization research in CNKI (2011-2021)

As shown in Figure 5, "visualization", "visualization analysis" and "CiteSpace" are the top three clusters of keywords. The "visualization" cluster contains 77 nodes, which is the largest cluster. Visualization has advantages over information processing and expression that cannot be replaced by other methods. Its characteristics can be summarized as visibility, interactivity and multidimensionality [11]. In recent years, visualization research in the field of information technology has been continuously developed and deepened. In paper [12], the characteristics of scientometrics visualization were analyzed in domestic library and information community. Combining visualization technology with information retrieval, article [13] studied the development law of visual information retrieval; Visualization theory and application research is becoming more and more perfect. There is no doubt that visualization is a hotspot of knowledge visualization.

### 3.3.3. Keywords Timeline Analysis

A keyword timeline graph is a graphical representation showing the development of keywords over time, where each keyword can be clustered to obtain. Essentially, it is also a clustering graph, only clustered by time and showing the clustering results. Figure 6 shows the keyword timeline graph for knowledge visualization, from which we can see the lineage of the development of knowledge visualization research in the last decade. As we know, the knowledge visualization theory was relatively complete and mature in 2004. After 2011, knowledge visualization is more applied in various disciplines and research fields, which helps to present and spread knowledge. In 2011, information visualization, visualization mappings and visual representation have become research focuses. Knowledge visualization has been extensively applied to the field of information retrieval in particular. By 2013, knowledge visualization was applied in modern technology, such as cloud computing and big data. In 2014, knowledge visualization was used in more fields, and visualization analysis in a specific field utilizing a visualization software tool is very heat to obtain knowledge base, research status, frontier topics and so on. In 2016, knowledge visualization was widely used in competitive intelligence and anti-competitive intelligence. Around 2020, knowledge visualization is used in town and country planning and educational science, which is related to China's policy of poverty eradication and robust development of education.



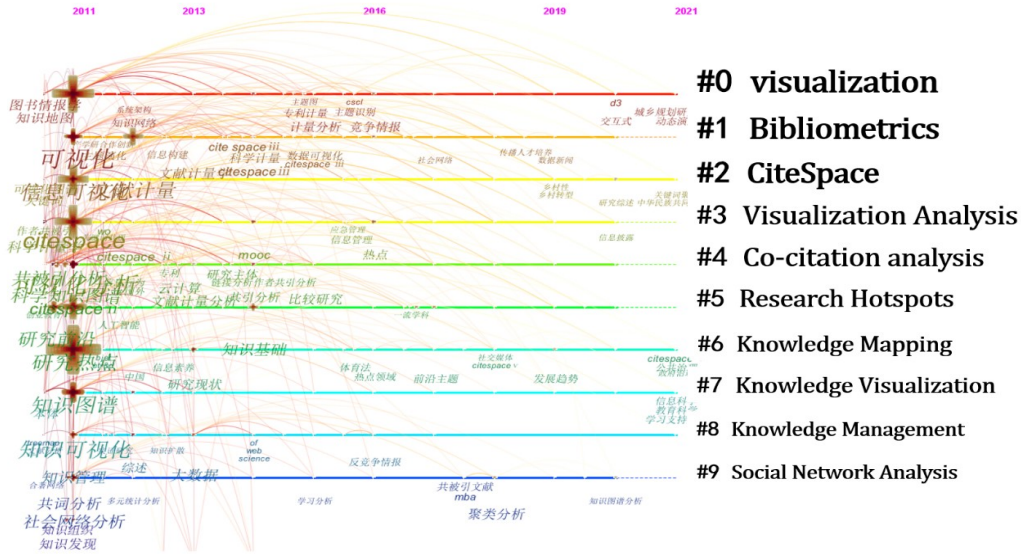


Figure 6. Timeline graph of knowledge visualization research in CNKI (2011-2021)

### 3.3.4. Keywords Bursts Term Analysis

Keywords bursts can reveal research hotspots in future subject areas. Many researchers study topic bursts from the perspective of keywords bursts. Keywords bursts mean that the value of a variable has changed one or more times within a short period. In Figure 7, we can see the strongest citation bursts of knowledge visualization keywords. "CiteSpace", "cluster analysis", "digital humanities", and "development trend" are research frontiers of knowledge visualization. Based on these burst terms, we can infer that at this period, many fields use CiteSpace, a knowledge visualization tool, to visualize knowledge. They use CiteSpace to study development trends through clustering analysis of keywords or cited documents. At the same time, knowledge visualization also pays attention to visualization research about digital humanities. For example, in paper [14], Song and Guo have conducted a comparative analysis of domestic and international digital humanities research from the perspective of scientific knowledge mapping.

### Top 18 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2011 - 2021
Citespace II	2011	11.1	2011	2014	
Information Visualization	2011	4.97	2011	2013	
Scientometrics	2011	4.17	2011	2012	
Knowledge Visualization	2011	3.34	2011	2012	
social network analysis	2011	3.19	2011	2012	
visual representation	2011	2.49	2011	2012	
Co-citation analysis	2011	3.78	2012	2014	
overview	2011	2.55	2012	2013	
Intelligence	2011	2.32	2013	2016	
moooc	2011	2.73	2015	2017	
think tank	2011	2.33	2015	2016	
Hotspots	2011	3.34	2016	2018	
hot topics	2011	2.77	2017	2018	
cite space	2011	2.31	2017	2018	
citespace	2011	10.64	2018	2021	
clustering analysis	2011	2.26	2018	2021	
digital humanities	2011	3.4	2019	2021	
development trends	2011	2.84	2019	2021	

Figure 7. The bursts of visualization research in CNKI (2011-2021)

## IV.CONCLUSION

### 4.1. Status and hotspots of knowledge visualization research

Judging from the number of documents published per year, the development status of knowledge visualization has been relatively stable in the past ten years. From the trend of dot-line graphs, knowledge visualization has received more and more attention. Knowledge visualization has become one of the important methods to analyze the development status of a specific study field and promote the dissemination of knowledge. From the co-occurrence graph of keywords and the cluster mapping of keywords, we explored the hotspots in knowledge visualization research. Some keywords appear in both graphs at the same time, such as “knowledge visualization”, “visualization analysis”, “knowledge foundation”, “knowledge management”, “CiteSpace”, etc. These keywords are not only high-frequency words but also hotspots in the field. Besides, research hotspots include “knowledge mappings” and “knowledge services”, “social network analysis”, “co-citation analysis”, et al. From these hotspots, we can see that the current research hotspots include not only the research on knowledge visualization theory but also the practical application of knowledge visualization.

### 4.2. Evolution and Trends of knowledge visualization research

According to the keyword timeline graph, we can see as the change of time, the focus of knowledge visualization research changes a bit. Combined with the bursts of knowledge visualization keywords, we can infer the knowledge visualization research trends. In the coming period, knowledge visualization is combined with more disciplines and fields and gets more application. First, visual analysis is widely used so that the researchers can obtain the research status and the development trends of some fields. Secondly, knowledge visualization is combined with education and educational science to promote the dissemination of knowledge and improve the quality and efficiency of education. Thirdly, knowledge visualization is applied to digital humanities and dedicated to integrating technology into academic research.

### 4.3. Limitations and expectations of the research

In this paper, we visualize and analyze the literature related to knowledge visualization, and the hotspots and trends are obtained on knowledge visualization. Still, there are some limitations in these conclusions. First, knowledge visualization covers a wide range of domain content, so it is needed to narrow the topic’s scope to make the results more target-oriented and practical. Second, we summarize the knowledge visualization trends based on visual analysis mapping of knowledge visualization and our understanding of knowledge visualization. Due to the limitation of the researcher's experience and ability, the prediction of the development trend inevitably has deviation. Third, many visual analysis tools are available, and this paper uses the most mainstream software, CiteSpace, but the analysis results may differ due to the different analysis tools. It is hoped that the future research will improve these limitations.

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