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Research on the Development and Trend of Digital Twin Technology Based on Date Analysis

Jinzheng Li， Xinxin Mi， Yizhou Han, Xinyu Xie, Tingting Liu
（School of Management, Tianjin University of Technology, Tianjin 300384, China）

Abstract: *Digital twin technology which is developing rapidly in recent years provides solutions for physical information fusion of complex dynamic systems and intelligent manufacturing. The development and trend of digital twin technology has always been concerned. This paper collects literatures related to digital twin technology from Web of Science database and CNKI for the further analysis. Firstly, the development and changes of digital twin technology research in the past 12 years are longitudinally compared in time. Statistical analysis is carried out from different perspectives such as keywords, number of publications, relevant authors, etc. Secondly, the distribution of the number of publications is analyzed to compare the number of publications in various countries and regions around the world. Finally, the research visualization map of digital twin technology is drawn used by CiteSpace software. The key points and evolution process in the map are visually analyzed. The development law and characteristics of digital twin technology are summarized to predict the future development trend and application prospect.*
Key words: *digital twin technology; date analysis; visualization map; CiteSpace*

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I. The introduction

Information technology is booming at an unprecedented speed in the new economic era. Digital twin technology is a new technology that is developing rapidly. It provides solutions for the fusion of physical information of complex dynamic systems as well as the intelligent manufacturing and automation. The Ministry of Science and Technology launched 6G technology research and development in 2019. Under the background of comprehensive 5G construction and 6G deployment in advance, 6G technologies such as holographic communication, twin body area network, smart production and super transportation have quickly become the focus of industry and academia topic. The new generation of information technology represented by 6G and artificial intelligence technology has begun to lead the development direction of future technological change and innovation. The virtual network world and the real physical world are more and more closely related. The application of information management and communication in the real world is more and more urgent. Therefore, digital twin technology emerges as the times require.

The concept of digital twin was first proposed by M.W. Grieves of the University of Michigan in 2003, which was called "spatial mirror model" at that time, and was later defined as "digital twin"（ROSEN R, et al.，2019）. Since NASA first applied it to the aerospace field in 2012, the academic community has described the concept of digital twin from the perspectives of life cycle management, intelligent manufacturing, and intelligent design. Because of it's complexity and diversity, the digital twin has not yet formed a unified definition（GRIEVES，2019）. TUEGEL (2011), Edward et al.（2012）, M. Grieves et al. (2017), Zhuang et al. (2017), Tao et al. (2017) respectively carried out the concept from the perspectives of aircraft, product life cycle management, physical entity full-element reconstruction and digital mapping, product design virtual-real integration and interaction, etc. Zhang and Tao (2021) extracted 8 evaluation criteria of digital twin model, and then constructed a set of digital twin model evaluation index system. Tao et al. (2017) also proposed a five-dimensional digital twin model and discussed the model's application in ten fields application. Zhuang et al. (2017) analyzed the development background, technical connotation, system structure and development trend of digital twins. In 2015, General Electric Company of the United States effectively combined information technologies such as the Internet and big data with digital twin technology, and realized the management of the entire life cycle of the engine by using the cloud service platform (WARWICKG,2015). Wang (2016) comprehensively discussed the method of using the quality level distribution diagram to describe the product quality level and the strategic significance of the establishment of the product quality evaluation system. In 2019, Professor Tao Fei of Beijing University of Aeronautics and Astronautics published an article entitled "Make more digital twins". This review published in the international authoritative journal "Nature" pointed out that digital twin technology needs to be solved urgently in all aspects such as expert cooperation, data management, model building, etc. Miao et al. (2019) studied the application practice of digital twin technology in product life cycle management on the basis of considering all factors of production.

At this stage, digital twin technology builds digital technology and simulation models with product information, real-time data, operating status and other information generated by physical entities in the full life cycle process of the real environment, improving physical comprehensive performance and realizing technological innovation. In the future, the development, progress and innovation of the manufacturing industry in my country and around the world are closely related to the research progress of digital twin technology. Digital twin technology provides new ideas and methods for the world to search for scientific truth, explore scientific truth, and expand research fields. The progress of scientific undertakings and the optimization and upgrading of national industries are of great significance. Sorting out research hotspots, summarizing development rules and predicting future trends are of great importance to the development of digital twin technology.

This paper firstly collects related literature on digital twin technology in the Web of Science database and CNKI. The development and changes of digital twin technology research from 2010 to 2020 are compared longitudinally in time, and statistical analysis is carried out from the perspectives of "keywords, number of publications, number of citations, relevant authors, and number of citations by authors". Through the website of the National Natural Science Foundation of China and the Humanities and Social Sciences Information Network of Chinese Universities and Colleges, the distribution of the number of publications was analyzed. The distribution of the number of publications in various countries and regions around the world was compared horizontally. Secondly, we comb the research history of digital twin technology since its development, discuss research hotspots, and analyze the innovative and transformative changes of digital twin technology in various modern fields on the basis of visual statistical analysis of relevant literature. Finally, the research map of digital twin technology is drawn through CiteSpace software, and the key points and evolution process in the map are visually analyzed. The development law and characteristics are summarized to predict the future development trend and application prospect of digital twin technology. This paper also analyze the difficulties and challenges as the digital twin technology development will face.

II. Data Sources And Research Methods

2.1 Data sources

The data and literatures of this paper are from the Web of Science data base and CNKI database. The "digital twin technology" is used as the search subject in Chinese, and the "Digital twin" is used as the search subject in Eglish. After preliminary sorting and screening, a total of 2,789 valid literature data were obtained after eliminating duplicate and invalid articles, including complete information such as authors, institutions, citations, and titles.

2.2 Research methods

This paper adopts bibliometric method using the visualization software CiteSpace developed by JAVA language, which is the most frequently used knowledge graph drawing tool in the field of scientific metrology (CHEN,2006). CiteSpace software has gradually developed under the background of scientometrics and data visualization. It is mainly used to analyze the knowledge contained in science, grasp the laws and characteristics of development and changes. It can present the structure, laws and distribution of scientific knowledge through visualization methods. Therefore, The visualization graphs analyzed by such methods are also called "scientific knowledge graphs". Using CiteSpace software, it is possible to carry out a diverse, dynamic and comprehensive quantitative description and intuitive characterization of literatures related to digital twin technology.

III. Academic Impact Analysis

The levant research literatures published in a specific subject area reflects the scientific characteristics of the field to a certain extent, which means that the development trend of a specific subject area can be predicted from the published research documents (CHEN et al.,2019). Since 2010, the digital twin technology, big data, and the Internet of Things have developed rapidly. The research situation of scholars in the past ten years, this research derives a total of 2789 related literatures from CNKI and Web of Science databases, and uses CiteSpace software to visualize and analyze the results as follows.

3.1 Analysis of scholarly literature publication volume and cooperation network

The number of papers published and collaboration map of researchers are showed as table1, Figure1 and Figure2.

Table 1 The number of papers published by researchers

CNKI		WOS	
Publications	Scholar	Publications	Scholar
42	Zhang Xuhui	14	FEI TAO
40	Du Yuyang	14	QIANG LIU
39	Bao Jinsong	10	RAY AND ZHONG
39	Wang Yan	10	H SEHITOGLU
38	Liu Shimin	9	YAN ZHANG
20	Liu Zhansheng	8	KE ZHANG
19	Ding Guofu	8	RIKARD SODERBERG
19	Tao Fei	8	L LU
16	Shi Guoliang	8	YUQIAN LU
15	Fu Xu	8	ZHIHAN LV

As shown in Table 1, there are10 scholars who have published 15 or more papers in CNKI and the top 10 scholars in Web of Science in the past 12 years. In CNKI, Zhang Xuhui and Du Yuyang occupy Chinese top with 42 and 40 papers respectively. The top two scholars in the number of published papers of WoS are FEI TAO and QIANG LIU

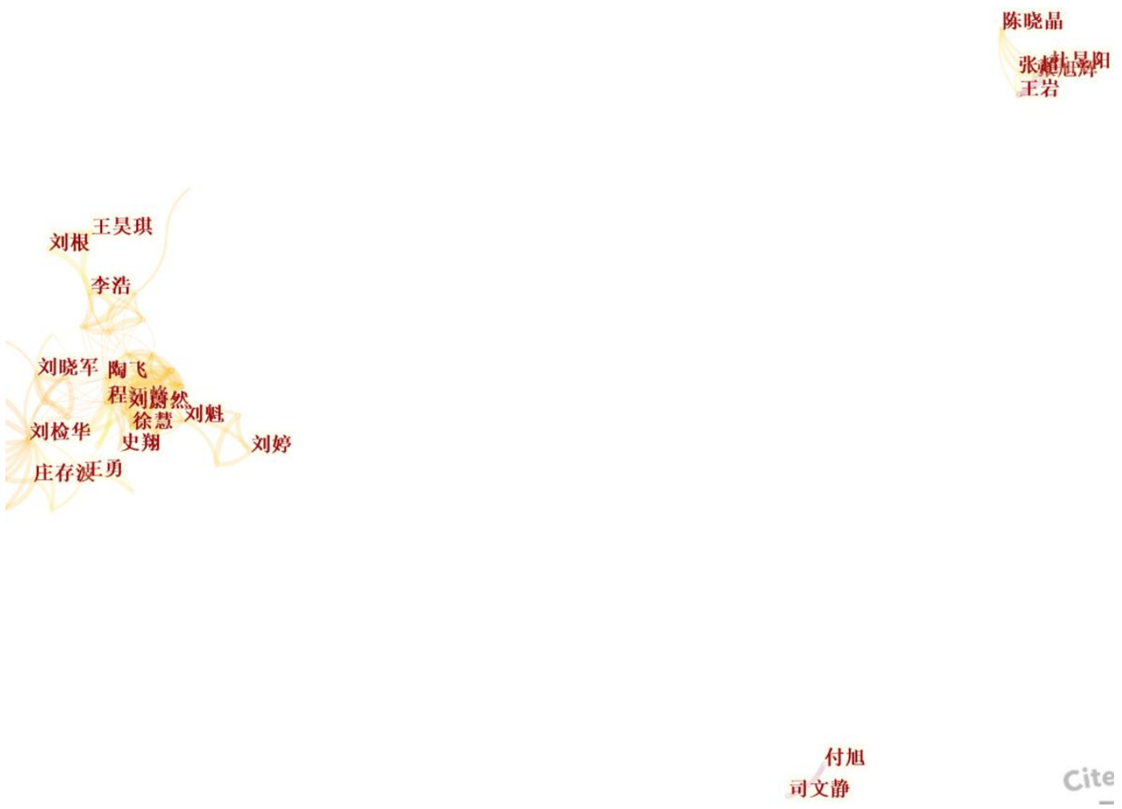

Figure 1 Collaboration map of CNKI researchers

According to the Figure 1, the scientific research cooperation between various scholars can be roughly analyzed through CNKI's scientific research cooperation map. The figure shows that the scientific research cooperation network composed of scholars. Tao Fei, Liu Weiran and Cheng Jiangfeng has a closer cooperation relationship and the most frequent cooperation. Chen Xiaojing, Zhang Chao, Wang Yan and other scholars composed the scientific research cooperation network is also relatively close. It is worth noting that the domestic frontier scholars related to digital twin technology are self-contained but interrelated and inseparable, forming a huge digital twin technology research circle, involving many scholars and extensive research content. It is believed that with the efforts of many scientific researchers, the development of the digital twin knowledge field in China will definitely be more extensive and popular.

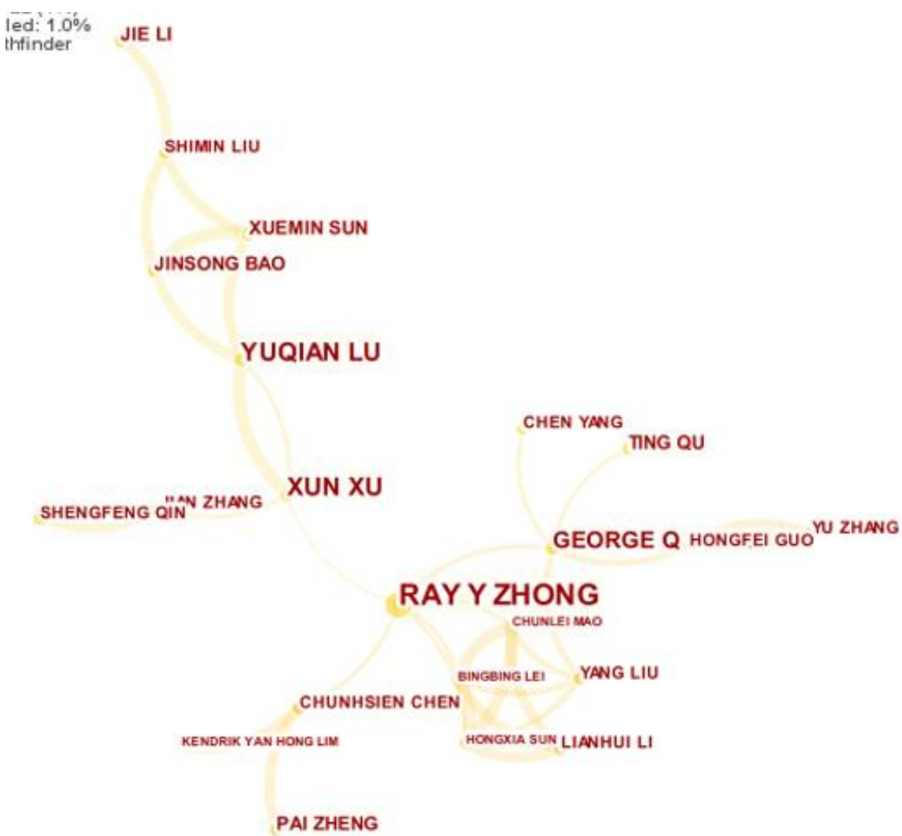

Figure 2 Collaboration map of WOS researchers

According to the Figure 2, among the top ten scholars, scholars from China account for a large proportion. It can be seen that the enthusiasm of relevant scholars in the field of digital twin technology research in China is very high. Compared with the number of relevant publications published in 2020 by Guo et al. (2020), the number of publications by researchers from China has increased significantly. Undoubtedly, the rapid development of digital twin technology has aroused extensive attention of scholars. Scholars also communicate and cooperate with different scholars through different topics while conducting their own research.

3.2 Scholar Centrality

Centrality is used to measure the importance of nodes in the network. Centrality can be defined for a single node or a group of multiple nodes. Scholars conduct extensive academic cooperation based on different factors, especially through co-authoring to form a measurable and observable academic community network, each actor (scholar) becomes an important node, and co-authorship connects the actors (scholars), thereby an academic network for social network analysis is formed (Newman，M．E．J，2001). The greater the centrality corresponding to a scholar, the stronger the academic influence of the scholar in this area. The result of centrality analysis is summarized in the Table 2. The top ranked item by centrality is H SEHITOGLU (2010) in Cluster, with centrality of 8. The 10th is RAY Y ZHONG (2020) in Cluster, with centrality of 6.

Table 2 Centrality

Centrality	References
8	H SEHITOGLU, 2010, SO, 0, 0
7	CHRISTOPH WIERLING, 2019, SO, 0, 0
7	THOMAS KESSLER, 2019, SO, 0, 0
7	BODO M LANGE, 2019, SO, 0, 0
7	SOPHIA SCHADE, 2019, SUN, 0, 0
7	LESLEY A OGILVIE, 2019, SO, 0, 0
7	HANS LEHRACH, 2019, SUN, 0, 0
7	MARIELAURE YASPO, 2019, SO, 0, 0
7	MORITZ SCHUETTE, 2019, SO, 0, 0

6	RAY Y ZHONG, 2020, SO, 0, 0

3.3 Analysis of scholar's literature citations

The number of scholar's literature publications and literature citations are both important factors for judging a scholar's academic ability and academic influence. The study found that the importance of data citations in the field of library and information research is gradually increasing (Ding Nan et al.，2014). The literature citations of top ten articles in the Web of Science sample is shown in the Table 3.

Table 3 Citation Counts

Citation Counts	References	TWO
230	Tao F, 2018, INT J ADV MANUF TECH, 94, 3563	10.1007/s00170-017-0233-1
184	Tao F, 2019, IEEE T IND INFORM, 15, 2405	10.1109 / TII.2018.2873186
152	Schleich B, 2017, CIRP ANN-MANUF TECHN, 66, 141	10.1016/j.cirp.2017.04.040
141	Grieves M, 2016, TRANSDISCIPLINARY PE, 0, 85	
140	Tao F, 2017, IEEE ACCESS, 5, 20418	10.1109/ACCESS.2017.2756069
133	Qi QL, 2018, IEEE ACCESS, 6, 3585	10.1109/ACCESS.2018.2793265
124	Kritzinger W, 2018, IFAC PAPERSONLINE, 51, 1016	10.1016/j.ifacol.2018.08.474
118	Lu YQ, 2020, ROBOT CIM-INT MANUF, 61, 0	10.1016/j.rcim.2019.101837
117	Negri E, 2017, PROCEDIA MANUF, 11, 939	10.1016/j.promfg.2017.07.198
96	Soderberg R, 2017, CIRP ANN-MANUF TECHN, 66, 137	10.1016/j.cirp.2017.04.038

According to the Table 3, The top ranked item by citation counts is Tao F (2018) in Cluster, with citation counts of 230. The second one is Tao F (2019) in Cluster, with citation counts of 184. The 10th is Soderberg R (2017) in Cluster, with citation counts of 96. Among the top five cited papers in the samples extracted by Web of Science, Professor Tao Fei from Beijing University of Aeronautics and Astronautics occupies three of them, who is the most cited and most frequently cited. His academic achievements have been widely recognized by scholars all over the world, and his academic influence is evident.

3.4 Citation Centrality

Centrality refers to the number of times that a specific node in the network graph acts as the shortest data transmission "bridge" between any other two nodes. The influence of a node in the network graph is judged by the amount of data at the node and the frequency of node data transmission. Obviously, the node, the faster the data transmission frequency and the larger the amount of data, the greater the influence of the node in the network graph and the more critical its location (GE Qian,2014). Table 3 lists the articles with the top ten cited centrality in the sample extracted from the Web of Science database，the top three ranked items by centrality are Bao JS (2019), Tao F (2017)and Tao F (2018), corresponding centralities are 61, 48 and 46, respectively. The centrality of the node reflects the influence of the article in this research field. Ten articles were mainly published in 2019-2017, which to a certain extent shows that the research on digital twin technology has achieved remarkable results in this period. Secondly, it is worth noting that six of the top ten cited articles were published by Chinese scholars, which shows that Chinese scholars are at the forefront of the world in the field of digital twin technology research and have extensive influence.

Table 4 Centrality

Centrality	References	TWO
61	Bao JS, 2019, Enterp INF SYST-UK, 13, 534	10.1080/17517575.2018.1526324
48	Tao F, 2017, IEEE ACCESS, 5, 20418	10.1109/ACCESS.2017.2756069
46	Tao F, 2018, INT J ADV MANUF TECH, 94, 3563	10.1007/s00170-017-0233-1
44	Zhuang CB, 2018, INT J ADV MANUF TECH, 96, 1149	10.1007/s00170-018-1617-6
43	Zhang H, 2017, IEEE ACCESS, 5, 26901	10.1109/ACCESS.2017.2766453
43	Brenner B, 2017, MANUF PROCEDURE, 9, 198	10.1016/j.promfg.2017.04.039
39	Qi QL, 2018, IEEE ACCESS, 6, 3585	10.1109/ACCESS.2018.2793265
38	Uhlemann THJ, 2017, PROCEDIA MANUF, 9, 113	10.1016/j.promfg.2017.04.043
37	Schleich B, 2017, CIRP ANN-MANUF TECHN, 66, 141	10.1016/j.cirp.2017.04.040
37	Liu Q, 2019, INT J PROD RES, 57, 3903	10.1080/00207543.2018.1471243

3.5 Analysis of the amount of publications from different institutions and countries

The rapid development of digital twin technology has not only attracted wide spread attention from scholars, but also well-known universities and research institutes all over the world. Analysis result of the amount of publications from different institutions and countries is shown in Table 5. From CNKI's sample, we can see that Donghua University ranks first the with 15 publications, followed by Xi'an University of Science and Technology, Southeast University and other universities. Various research institutes and universities have also carried out cross-institutional and cross-regional cooperation in the process of research. Xi'an University of Science and Technology has carried out many cross-disciplinary scientific research cooperation with the Shaanxi Provincial Key Laboratory of Intelligent Monitoring of Mine Electromechanical Equipment. It is worth noting that in addition to the close cooperation between universities and research institutes, scientific research portfolios between universities and companies also appear frequently, such as Shanghai Maritime University and Shanghai International Port (Group) Co., Ltd., Beijing Jiaotong University and Zhongke Xingtu Co., Ltd. The joining of the company has provided sufficient funds and convenient practical foundation for scientific research activities by shortened the development process from academia to technology. The cooperation promotes the implementation of research results of scientific institutions and researchers. It is beneficial to improve the research efficiency, improve the company's economic benefits and help the company's industrial upgrading.

Table 5 The number of documents issued by different countries and institutions

CNKI		Web of Science			
Publications	Institution	Publications	Institution	Publications	Institution
15	School of Mechanical Engineering, Donghua University	37	Beihang Univ	774	USA
12	School of Mechanical Engineering, Xi'an University of Science and Technology	33	Univ Cambridge	623	CHINA
12	School of Electrical Engineering, Southeast University	33	Chinese Acad Sci	98	ENGLAND
12	School of Mechanical Engineering, Southeast University	24	Beijing Univ Technol	57	ISRAEL
12	Department of Urban Construction, Beijing University of Technology	23	Politecn Milan	27	CANADA
12	Institute of Intelligent Manufacturing, School of Mechanical Engineering, Donghua University	19	Univ Hong Kong	23	AUSTRALIA
12	Institute of Logistics Science and Engineering, Shanghai Maritime University	19	Northwestern Polytech Univ	22	FRANCE
11	China Academy of Information and Communications Technology	18	Natl Univ Singapore	18	GERMANY
10	State Key Laboratory of Bridge Structural Health and Safety	18	Beijing Inst Technol	14	JAPAN
10	School of Computer and Information Technology, Beijing Jiaotong University	18	Tsinghua Univ	11	NETHERLANDS

As shown in Table 5, in the Web of Science sample, Beijing University of Aeronautics and Astronautics, Chinese Academy of Sciences, University of Science and Technology Beijing, University of Hong Kong, Northwestern Polytechnical University, Beijing Institute of Technology and Tsinghua University from China all ranked among the top ten institutions in terms of publication volume. The top ranked item by citation counts is Beihang Univ in Cluster, with citation counts of 37. In the top ten countries with published papers, the United States and China rank with significant advantages respectively followed by England, Israel and Canada.

Figure 3 Cooperation map of scientific research institutions

According to the cooperation map of scientific research institutions in Figure 3, the scientific research cooperation between universities and research institutes can be roughly analyzed. The picture shows the intertwined and complex scientific research cooperation network centered on institutions such as Beihang University, Cambridge University and the Chinese Academy of Sciences. The scientific research cooperation network shows that major research institutions in different countries actively carry out cross-cooperation while conducting independent research and development forming a very close scientific research cooperation relationship. The same result with different country shown in Figure 4.

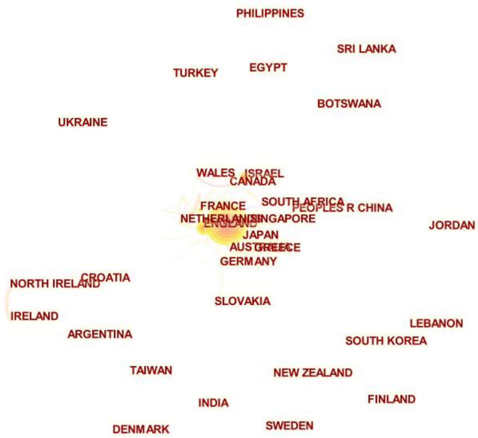

Figure 4 Cooperation map of scientific research from different country

3.6 Institutional Centrality

Centrality is a key factor for judging the importance and influence of a node in the network. According to t the Table6, the top ranked items by centrality are Natl Univ Singapore, Univ Illinois and Nanyang Technol Univ in Clusters, with centrality of 8. The 4th is Univ Calif Santa Barbara in Cluster, with centrality of 7.

Table 6 Institutional Centrality

Centrality	References
8	Natl Univ Singapore
8	Univ Illinois
8	Nanyang Technol Univ
7	Univ Calif Santa Barbara
6	Univ Cambridge

6	Beijing Univ Technol
6	Rhine Westphalia TH Aachen
6	Catholic University Leuven
6	Tianjin Univ

According to the Table7, the top ranked item by centrality is USA in Cluster 0, with centrality of 21. The second one is ENGLAND in Cluster 1, with centrality of 14. The third is FRANCE in Cluster 1, with centrality of 8. The 4th is CANADA in Cluster 4, with centrality of 4. The 5th is AUSTRALIA in Cluster 2, with centrality of 4. The 6th is GERMANY in Cluster 3, with centrality of 4. The 7th is NETHERLANDS in Cluster 0, with centrality of 4. The 8th is BELGIUM in Cluster 0, with centrality of 4. The 9th is SINGAPORE in Cluster 2, with centrality of 3. The 10th is SCOTLAND in Cluster 1, with centrality of 3.

Table 7 Institutional Centrality

Centrality	References	Cluster ID
21	USA, 1996, SO, 0, 0	0
14	ENGLAND, 1997, SO, 0, 0	1
8	FRANCE, 1998, SO, 0, 0	1
4	CANADA, 1998, SO, 0, 0	4
4	AUSTRALIA, 1998, SO, 0, 0	2
4	GERMANY, 2000, SO, 0, 0	3
4	NETHERLANDS, 2001, SO, 0, 0	0
4	BELGIUM, 2002, SO, 0, 0	0
3	SINGAPORE, 2001, SO, 0, 0	2
3	SCOTLAND, 1996, SO, 0, 0	1

IV. Research hotspot analysis

Research hotspots refer to one or more core topics that frequently appear in the process of scientific research. Research hotspots in a certain research field often represent its research content and research direction. It is mainly divided into two categories: text content analysis (word frequency analysis, co-word and topic probability model analysis) and citation analysis methods (such as co-citation and literature coupling) (Li et al.,2019). This paper analyzes the frequently appeared keywords and high-frequency nouns in the sample documents collected from CNKI and Web of Science. CiteSpace software is used to visually describe the scientific research hotspots reflected in the sample documents. The result of the research hotspots is summarized in the Table 8.

Table 8 Glossary of the research hotspots

CNKI		Web of Science	
frequency	keywords	Citation Counts	Key Word
935	digital twin	243	system
72	Smart Manufacturing	225	design
44	bim(Information Technology Model)	168	model
43	Knowledge Graph	100	framework
39	Smart City	90	simulation
35	application	90	digital twin
31	Big Data	83	optimization
29	physical entity	82	internet
27	artificial intelligence	80	management
25	Troubleshooting	71	behavior

According to the Table 8, the top ten hot words in the sample literatures extracted from CNKI are digital twin, intelligent manufacturing, bim (information technology model), knowledge graph, smart city, application, big data, physical entity, artificial intelligence, fault diagnosis. In addition to the hot words listed in the Figure 5, it also includes emerging technologies such as the Internet of Things, digital technology, data-driven, modeling technology, twin modeling, and cloud computing, as well as infrastructure construction fields such as traffic management, safety management and traditional industries such as hoisting safety, optical fiber sensing, and remanufacturing. It can be seen that related research centered on digital twin technology involves many fields. The research of scope digital twin technology is wide and the research prospect will be very broad.

Figure 5 CNKI hotspots

According to the sample literatures collected by Web of Science, CiteSpace software is used to visually describe frequently-occurring keywords and high-frequency nouns, and the top ten hot-spot words that appear frequently are shown in Table 8 and Figure 6. Whether it is CNKI or Web of Science, the frequency of the keyword digital twin (digit twin) is very high. However, system, design, and model occupy the top three hot words in the sample literatures of Web of Science. It is of great significance in production. Combined with the model, information network technology is used to promote the development of productive forces, promote the upgrading of industrial structure, improve production efficiency, help realize the digital and intelligent industrial production, so as to achieve the expected goal of digital twin technology.

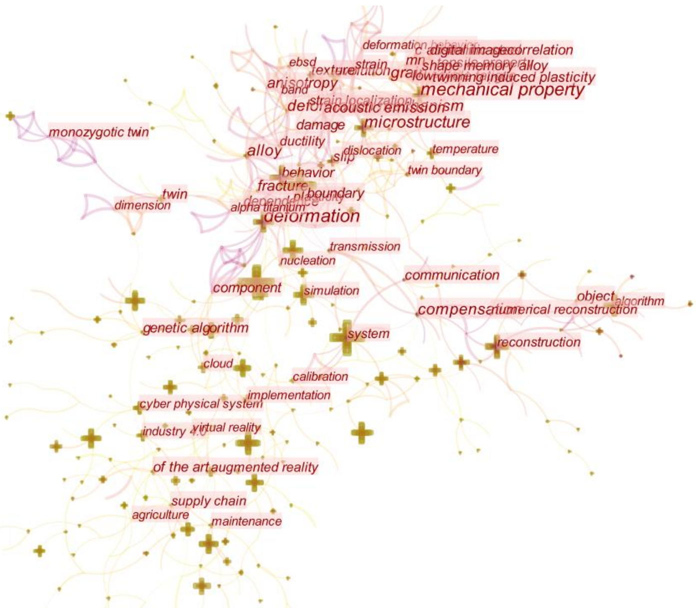

Figure 6 WOS hot words

V. Development and Challenge

Although the development of digital twin technology is not yet mature, it has attracted widespread attention due to its ability to effectively realize the integration and intelligent interconnection of the information world and the physical world. Through the analysis of the sample literature collected by CNKI, digital twin technology has been applied to industrial fields such as manufacturing, remanufacturing, and hoisting. It also plays a role in functional departments such as traffic management, safety management, and public security organs, effectively improving urban management capabilities and accelerating construction of smart cities. Some scholars predict that if digital twin technology is applied to the field of supply chain logistics, the supply chain revenue in the balance sheet will increase by 10% (YANG,2019).

In fact, digital twin technology has been widely used as a basic technology. It plays a key role in many application fields such as the development and utilization of digital intelligence as well as the systems engineering. In April, 2020, the keyword "digital twin" was mentioned many times in the "Implementation Plan for Promoting the Action of "Going to the Cloud and Empowering Intelligence with Data" issued by the National Development and Reform Commission and the Central Network Information Office. When analyzing the main directions, the plan mentioned: "Support the exploration of new-generation digital technology applications and integrations such as big data, artificial intelligence, cloud computing, digital twin, 5G and block chain in qualified industries and enterprises. Innovation." In the past two years, the direction of digital twin technology has continued to expand. In the long run, digital twin technology has a very large room for imagination. However, the advanced stage of digital twin technology is to build a mirror world, which is not only technically challenging, but also requires constant adjustment of its application ideas. From the perspective of constructing objects, the mirror world can be divided into three forms: people, things, and the interaction between people and things (Yuan et al.,2020). However, the analysis and construction of the three forms require a lot of manpower and material resources with analyzing a large amount of relevant data. In the process of digital twin construction, it will also face new difficulties, such as lack of digital twin standards, complex modeling environment, difficulty in node data collection, data abuse, security issues, and data ownership issues. There are still huge challenges ahead. The digital twin technology builds digital technology and simulation models with product information, real-time data, operating status and other information generated by physical entities in the full life cycle process of the real environment, improving physical comprehensive performance and realizing technological innovation.

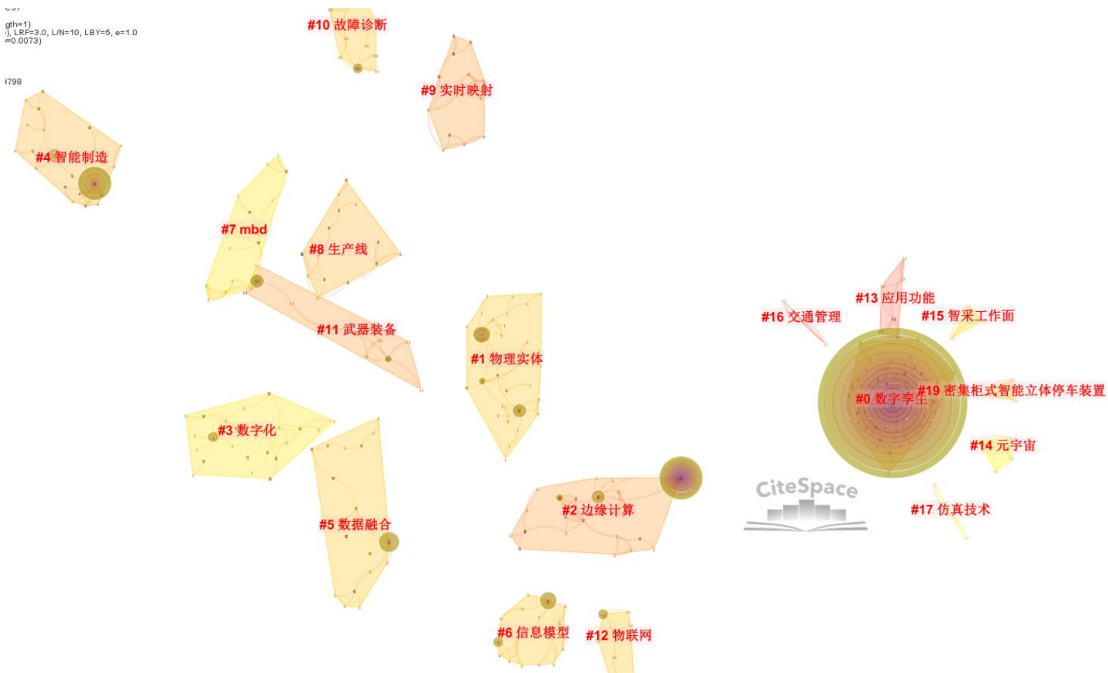

Figure 7 Domain clusters

VI. Conclusion

Information technology is booming at an unprecedented speed in the new economic era, constantly optimizing and iterating in the process of change and innovation. Digital twin technology is a new technology which is developing rapidly. It provides solutions for the fusion of physical information of complex dynamic systems. Furthermore, it is an important solution for intelligent manufacturing and automation. This paper selects CNKI and Web of Science databases to extract a total of 2,789 sample documents published after 2010, and uses the visualization software CiteSpace developed in Java language to analyze the authors, institutions, citations and other information, trying to describe the digital twin technology in the past 12 years. Research situation.

Through research, we found that the per capita publication volume of scholars who publish literature on CNKI is higher than that of scholars who publish literature on Web of Science, which to a certain extent shows that Chinese scholars have higher research output efficiency. At the same time, the data shows that Western scholars are more scholarly Strong, indicating that Western scholars have a wider influence. In terms of literature citation performance, scholars from both sides are basically equal, with almost half of the top ten literature cited in the literature. The research results of scholars have been widely recognized by the academic community, but the research between frontier scholars is self-contained. They are also related to each other, forming a huge digital twin technology research circle, involving many scholars and a wide range of research contents. However, the cooperation relationship between scholars is obviously limited by regions. Compared with domestic cooperation, there are fewer cross-border cooperation and the relationship is more alienated. This paper recommends The deepening of cross-regional cooperation between scholars may help to increase the quantity and quality of digital twin-themed publications, tap more development space for digital twin technology, and further promote the development of digital twin technology. In contrast, in terms of cooperation between institutions and the state, the cooperation between universities and research institutes is very close, and scientific research combinations between universities and companies also appear frequently. The joining of the company provides sufficient funds and a very convenient practice foundation for scientific research activities, promotes the implementation of research results of scientific research institutions and researchers, and also improves the company's economic benefits and helps the company's industrial upgrading. It is a win-win research method worthy of advocacy. . Major research institutes in different countries actively carry out cross-cooperation while conducting independent research and development. The number of collaborations is frequent, involving many institutions, with a wide range of research contents and diverse research directions, forming a very close scientific research cooperation network. The development of digital twin technology to the current stage has emerged with the distribution characteristics of "one center, multiple axes and multiple points". With digital twin technology as the core, many emerging research hotspots have been derived, such as digital twin technology and supply chain, digital twin technology and smart city, digital twin technology. There are many related fields and rich contents, such as twinning and artificial intelligence, and have very broad development prospects. However, due to the immature modeling environment and the lack of digital twin standards, the future development of digital twin technology still faces huge challenges. Looking into the future, the development, progress and innovation of the manufacturing industry in my country and the world are closely related to the research progress of digital twin technology. The progress of the cause and the optimization and upgrading of the industry are of great significance.

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