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REVIEW OF DIGITAL TWIN CONSTRUCTION TECHNOLOGY FOR CIVIL ENGINEERING

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Abstract: The digital twin has not been fully understood in the field of civil construction, and the construction aspect of digital twin models is still in the explosion ration stage. This paper composes the digital twin research heat from the perspective of literature search and analyzes the current progress of digital twin in china and internally. The concept of digital twin and the six conceptual models of digital twin are outlined, while the specific practical e approaches, architectural models and application values are summarized, and finally the urgent problems of digital twin are proposed: the fusion of heterogenous data, the digital twin scale problem, the contradiction between granularity fidelity and computational complexity, And the system evolution between twin systems and real systems is explored.
Keywords: Digital Twin; Civil Construction; Twin Models; Literature Index

1. INTRODUCTION

Digital twin (an exact virtual copy of a machine or system) is revolutionized the industry [1], Especially in the field of mechanical manufacturing, digital twins. The application of more in-depth, such as NASA Monitor spacecraft with digital copies state. Energy firms GE and Chevron use digital twins Tracking Wind Turbine Operations. In addition, in information technology, human against the background of the rapid development of artificial intelligence technology, the digital twin ecological environment Further broadening, the problem of massive data in digital twin technology has been further solved To provide support for other industries to get involved in digital twin technology. For example, in the context of low-carbon emission reduction, through the digital twin of civil infrastructure students to practice and explore the path of carbon emission optimization [2]. industry and information Ministry of Chemical Industry in the " Digital Twin Technology Application White Paper (2021) " It is pointed out that from a policy perspective, digital twins have become an important tool for countries to promote economic and social development. An important starting point for the digitalization process [3-4]. 2021 In March, the country 's " Ten The Outline of the Fourth Five - Year Plan clearly proposes to explore the construction of digital twin cities, Policies that provide national strategic guidance for its construction [5], Covers general rules planning, information technology, industrial production, construction engineering, water conservancy emergency, comprehensive transportation, standard construction, energy security, urban development and other fields.

However, digital research scholars, research institutions, and enterprise units in various fields The knowledge background and knowledge structure of bit have certain influence on interdisciplinary technology. confusion. Initial explorers are often confused by digital twins, not Can deeply understand the essence of digital twins, such as scientific research institutions cannot extract The science of it ; business units fail to grasp the digital twin box shelf. In the field of civil engineering construction, many scientific research institutions and enterprises have Conduct some exploration in this field, mainly involving BIM, CIM and other related technology. BIM applications often result in only geometric dimensions being considered in the modeling process To a certain extent, the interaction between the twin system and the real system often requires human modeling intervention, which greatly reduces the intelligence perception ability of the twin system.

In this paper, the data in the field of civil engineering construction are analyzed by means of literature retrieval. The popularity of word twin research, the research level of each country, and domestic scientific research institutes Analyze and summarize research status and topics related to digital twins. From the number The digital twin concept and important conceptual models are carried out in the whole field of digital twin row summary. Digital twins in the field of civil engineering construction Analyze digital twins from the perspective of practice, architecture model, and application value The research status of the current situation, put forward the scientific problems to be solved urgently in the field of civil engineering problems, namely heterogeneous data fusion problem, multi-scale granular fidelity problem, Co-evolution of twin system and real system.

2. ANALYSIS OF CURRENT ACADEMIC RESEARCH STATUS OF DIGITAL TWIN AT HOME AND ABROAD

2. 1 Literature Statistics

This article was respectively published in CNKI (CNKI) and Web of Science (WOS) Search for papers on digital twins in. CNKI is The database with the largest collection of Chinese literature can fully reflect the digital twin Progress. WOS Science Citation Index data created by Clarivate Analytics library (SCI) Medium, including high-
level journals mainly in English. Knowing The advanced search function is used in the network, and the search string is SU = digital twin Health or TKA = digital twin or Ti = digital twin or Ky = number Twins, that is, topics, abstracts,

titles and keywords are all digital twins. in WOS Medium-use advanced search function, the search string is TS = (digit al NEAR/0 twin $) or TI = (digital NEAR/0 twin $) or AB = (digital NEAR/0 t win $) or AK = (digital NEAR/0 twin $), That is, the subject, abstract, article title and keywords are digital twin or digital twins, and in Science Citation Index Expanded (SCI-EXPANDED) is carried out in the collection. Due to the uncertainty of the early concept, the digital twin is not the same as it is today, so the earlier documents are manually deleted. Excluding the earliest literature in HowNet that does not involve digital twins, that is, "Design Technology and Engineering Application of Clean, Low-Carbon and Environmental Protection Boilers Based on Digital Twins" in 2014, domestic literature shows that preliminary research on digital twins has been carried out as early as 2014. The earliest Chinese literature was published in 2014, and as of September 13, 2022, a total of 4,460 literatures have been retrieved; the earliest English literature can be traced back to 2010, and a total of 5,090 literatures have been retrieved as of September 13, 2022. Table 1 shows the number of papers published each year since 2010. The above two databases respectively represent the degree of attention to digital twins at home and abroad. It can be seen from Table 1 that domestic research on digital twins lags behind slightly, but compared with international ones, the annual number of papers published is close to the index. level growth. The number of papers published in 2021 is close to 2020 Annual Papers Published amount of 2 times by 2022 _ Annual data shows that the future lies in the digital twin Research will continue to increase.

Research digital twins can be clearly obtained based on literature searches related institutions. By searching the literature database, most of the research institutions are universities and research institutes, which is mainly due to the academic The world is the main institution for the output of papers. Top 5 Chinese Literature home research Institutions are Tsinghua University, Huazhong University of Science and Technology, Beijing University of Aeronautics and Astronautics, Zhejiang University, Tongji University. In terms of the number of colleges and universities covered, Number of documents > 20 Articles of research institutions as many as 25 Institute, and it is a leading university, which is the most likely to reflect the current research enthusiasm for digital twins. Foreign literature The top 5 institutions are Beijing University of Aeronautics and Astronautics, Siemens AG, Politecnico di Milano, Cambridge University, Nanyang Technological University Universities, many of which are non-academic institutions such as Siemens AG. WOS The number of papers in the database highlights research institutions in international academic Influence in the field, many academic institutions in China have published papers There are obvious advantages, especially in the field of digital twins, domestic universities In a neck-to-neck position, such as Beijing University of Aeronautics and Astronautics, Hong Kong Polytechnic University of Hong Kong, Hong Kong University, Tsinghua University, Huazhong University of Science and Technology and other colleges and universities are at the forefront of research in the world.

Table 1 Number Of Annual Papers Published

year year	/2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
WOS	2	0	0	1	2	5	17	73	259	617	1 008	1 746	1 358
CNKI	0	0	0	0	1	2	6	34	119	410	804	1 624	1 460

Note : Literature statistics as of 2022-09- 13

According to WOS Database statistics, as of 2022 september 13th, already 60 many countries and regions have carried out research on the field of digital twins research and publish relevant academic papers. The countries with more than 100 published papers are shown in Figure 2 As shown, a total of 19 countries. Among them, China published 1 528 papers Articles, ranking first, far surpassing the second Germany 829 articles, followed by the United States, the United Kingdom, and Italy. Compared to the overall research Germany has surpassed the United States in the field of digital twins, thanks to Industry 4. 0 Implementation of high-tech strategic plan, digital twin is highly compatible with industry 4. 0 's cyber-physical system (cyber physical s system, CPS) roughly read. The number of papers published in China ranks first, which can help implement the national " Outline of the 14th Five-Year Plan to promote the construction of digital twin cities slight implementation.

2. 2 Research Status

Based on the analysis of statistical data, various fields in digital twin research There are significant differences in the surface, as shown in Figure 3 shown. among which civil engineering domain-related research, such as building science and engineering, water conservancy and hydropower engineering, Highway and waterway transportation and mining engineering, percentage of published papers Don't be 6. 6%, 3. 4%, 2. 5%, 1. 8%. The field of civil engineering is not as good as that of computer and automation, mainly due to the birth of digital twins. Production and development rely on the advancement of industrial automation. in civil engineering domains, with building science and engineering dominating , the number of papers is much higher than that of water conservancy and hydropower engineering, road and waterway transportation Transmission and Mining Engineering. Digital twins in the field of building science and engineering The breakthrough in is largely due to BIM Modeling and construction in architectural design It provides an important tool for the construction of digital twins.

Take the field of building science and engineering as an example to further analyze the figures Application of Twins in Civil Engineering. According to the statistical analysis of the literature, the The top 20 institutions in the number of contributions are shown in Table 2 shown. In research institutions Universities account for the main part, of which Beijing University of Technology and Tsinghua University A large number of documents are 13, 11 articles. and more companies Participation, including Glodon Technology Co., Ltd., China Urban Planning Planning and Design Institute (Beijing), China State Construction Engineering Corporation, Shanghai City Construction Engineering Group, Autodesk Software (China) Co., Ltd., China Water Electrical Engineering Consulting Group, China Mobile Communications Group Design Institute Co., Ltd. manage. The number of papers issued by enterprises is the first 20 The proportion of the organization 28%, in The number of literatures of Glodon Technology Co., Ltd. is second only to Tsinghua University study. The cooperation between research institutions and enterprises highlights the tight integration of scientific research and practice The density also reflects the necessity of digital twin construction from the side.

Table 2 Produced Results Institutions For Field Of Building Science And Engineering

Serial number	institution name	Number of papers / article
1	Beijing industry university	13
2	Tsinghua University	11
3	Glodon Technology Co., Ltd.	10
4	China Academy of Urban Planning and Design (Beijing)	9
5	Tongji University	6
6	Zhejiang University	6
7	China Planning Institute (Beijing) Planning and Design Company	5
8	Chinese Academy of Engineering	5
9	Shandong Jianzhu University	5
10	Huazhong University of Science and Technology	5
11	China State Construction Engineering Corporation	3
12	Tianjin University	3
13	Southeast University	3
14	Shanghai Construction Engineering Group	3
15	Autodesk software (China) Co., Ltd.	3
16	Huadian Electric Power Research Institute	2
17	China Hydropower Engineering Consulting Group	2
18	Dalian University of Technology	2
19	Beijing University of Science and Technology	2
20	China Mobile Communications Group Design Institute Co., Ltd.	2

Summarize the digital twin by analyzing related topics in the literature related keywords, that is, building information model (BIM), city information model (CIM), digital transformation, smart city, smart construction, big data, general contracting (EPC), prefabricated buildings, smart parks, information models, digital delivery, smart buildings and digital twin models. The frequency with which related topics co-occur in the literature is shown by. That Chinese BIM and digital twins appear most frequently, digital twins and BIM perfect fit. City Information Model (CIM) as BIM of extension, in the construction of digital twin cities with BIM have the same Use, become the basic structure of the digital twin. related topics, large Data constitutes an important way to drive the internal data of digital twins, and it is the chain An important bridge between physical entities and twins. digital twin Type research mainly includes the overall structure of the digital twin, which is the implementation of the digital twin An important guide to the concepts of life. Other related topics such as digital transformation Models, smart cities, smart construction, etc. are the functions and purposes of digital twins The exploration of applications can make digital twins play a role in various aspects.

3. DIGITAL TWIN CONCEPT AND MODEL FRAMEWORK

3. 1 Concept

number twin born roughly read most leave early now At 2011 Year Michael Grieves Place Written Virtually perfect: driving innovative and lean products through product life cycle management (" Almost Perfect : Through PLM Driving

Innovation and Lean Products "), the concept dates back to 2003 Year NASA In the Apollo project [6-7]. 2003-2011, digital twin one has been in the conceptual model stage, mainly based on Based on the concept of virtual digital expression equivalent to physical products proposed by Michael Grieves, and includes a conceptual model built on this basis, namely Physical products in the real space, virtual products in the virtual space, virtual fit real Reality product connect exist one from number According to letter interest connection [8]. Due to the electronic realization of file data in the production process, the maturity of physical product simulation technology, and the substantial improvement of computer performance, the With the rapid development of digital twin technology, it is possible to realize the implementation stage transition. 2012 In, the U.S. Air Force Research Laboratory adopted Digital twin technology solves aircraft maintenance in complex service environment problem and life prediction problem, and propose the body digital twin [9]. Through the research and application of digital twins, digital twins in a narrow sense and digital twins in a broad sense are gradually formed, and the digital twins are realized. Practicality promotion. The digital twin in the narrow sense is from the microscopic atomic level to a comprehensive description at the macroscopic geometric level, or in actual physical production virtual information. Ideally, check from physically manufactured product Any information of can be obtained from the digital twin [10], The concept comes from The twin concept, which limits the digital twin to a virtual counterpart to a physical product Virtual information set, with virtual, dynamic, multi-physics, multi-scale, integrated, Computable, surreal features [11]. In a narrow sense, the digital twin will The life cycle of a product, especially design, production, operation and maintenance, etc. Festival, according to the physical world, will have a very high level of realism in the number of products data visualization.

In a broad sense, digital twins can simulate, monitor, calculate, adjust, An integrated system that controls system status and process, with individualized, high Efficiency, highly realistic features [12]. Digital twins contain physical Space, Digital Space and Connections 2 The information processing layer part of a space. The system features data-driven, intellisense, virtual reality mapping and Features of Collaborative Interaction. In terms of industrial applications, compared to traditional manufacturing system, the generalized digital twin has a large number of distributed computing design equipment, more complete data system, better data collection and transmission system, a wider product traceability and control network, enabling Systematic, comprehensive and real-time control of capital flow, capital flow and information flow, Effectively coordinate and optimize business activities within the system.

3. 2 Model Framework

The general conceptual model of digital twin in the academic theory stage is obtained To the following expansion and evolution : ① Space mirror model ; ②Digital twin Five-dimensional model ; ③Twin model of product life cycle ; ④Based on reflection fed digital twin model ; ⑤ digital twin reference model ; ⑥ digital Twin function model. The general conceptual model of digital twin Domain understanding of digital twins and the construction of digital twins play a guiding role. The above-mentioned digital twins include the usage requirements of various application scenarios. Through literature research, research institutions in various fields have proposed proprietary digital twin raw model.

1) Coming up with numbers in Michael Grieves and John Vickers When twinning concepts, the mirror space model is proposed, including the real space Physical products in the virtual space, virtual products in the virtual space, and virtual and real product data and information products.

2) 2017 In 2010, Tao Fei et al [13] extended the traditional 3D model development, increase twin data and services2 a new dimension, proposing the digital twin five-dimensional model DT _ = (PE, VE, S the s, DD, CN), In the formula PE Represents a physical entity, VE represents a virtual entity, S the s means service, DD means twin data, CN Indicates links between components.

Zheng et al. [12] explained the digital twin from broad and narrow senses. The concept and characteristics of life, on this basis, put forward the product life cycle The digital twin application framework for period management, as shown in Figure 8 shown. in physics The total factor information perception technology of production is discussed in detail in the space. exist The information processing layer builds data storage, data processing, and data mapping main To function module. Describing full parametric virtual modeling in virtual space The implementation process and the construction idea of the digital twin application subsystem. Liu wait [14] Considering the static configuration and dynamic. The underlying closed-loop feedback mechanism between executions, a digital twin-based Iterative optimization design logic model between static configuration and dynamic execution, As shown in Figure 9 shown. Static design is verified by dynamic execution results, while dynamic Static execution can be facilitated by static design adjustments to maintain iterative design Convergence of calculation optimization. Through a limited number of repeated coordination, it is possible to Achieve a design balance between dynamic configuration and dynamic execution mechanism. Schleich et al. [15] draw on solid modeling and geometric product specification format ISO standard, developed to include all features, and throughout the product A fully described digital twin at the concept level of the full life cycle, such as Figure 10 shown. The model is based on the original twin model The distinction between models and abstract models. Based on this abstract model, it is possible to extract Capture, understand, and describe physical entities and their behavior and environment at the image level territory. Information transfer and observation from physical entity to digital twin It is related to the perception of physical entities, but the digital twins to physical entities Information transfer derived from scientific hypotheses, simulations and virtual test models should Appropriately deal with its uncertainty, used to predict some characteristics of physical entities sign and behavior. Furthermore, the virtual table of the conceptual model and its digital twin important model properties such as model extensibility, interoperability workability, fidelity. Among them, scalability can provide different scale insights (from fine details to

large systems); interoperability enables Convert, combine, establish equivalence between different models ; fidelity is the ability to describe the closeness to the physical product. Zhou Youcheng et al. In order to comprehensively display the interaction between information and physical domains of intelligent products, the module groups are divided according to the characteristics of intelligent products into, using the digital twin to re-express the modular function of smart products can be achieved,. According to the digital twin model, the Designers can effectively clarify the conceptual structural elements and function, quickly discover the deficiencies of the system, and improve product innovation design efficiency and quality of the meter.

4. APPLICATION OF DIGITAL TWIN TECHNOLOGY IN CIVIL ENGINEERING CONSTRUCTION

4. 1 Digital Twin Practice

The literature search shows that in the field of civil engineering, the research related to the construction of digital twins is mainly concentrated in the application of BIM technology. BIM has a mature system in model construction, construction organization management, and digital archive standardization, which makes BIM application inevitable. Liu Zhansheng et al. applied BIM and IoT to the digital twin model of evacuation, and used Dijkstra algorithm for evacuation path planning. Xie Linlin et al. built a prefabricated construction project scheduling management platform based on BIM+ digital twin technology by integrating BIM, IoT, big data, AI and other information technologies. Wang Qiang et al. applied BIM+ digital twin technology to the production management of prefabricated components of prefabricated urban rail transit projects, and studied its internal mechanism to realize the information interaction between physical production and virtual construction, and dynamically manage component production to solve production problems. Difficulties in organizing and coordinating the whole process. Zhang et al. put forward one framework, leverage digital twins and extend BIM level of detail to Conduct construction site management, study analysis and improve the operation of digital twins principles, mechanisms, including based on Digital representation of BIM, IoT, data storage, integration and analysis, interaction with physical environment. questionnaire and Interview results confirmed that the framework can support construction site monitoring and management, improve quality, efficiency. sun wait proposed a digital twin building information hybrid model based on AI technology to analyze requirements, make decisions, Scheduling resources, updating databases, identifying resource shortages. compared to Applying individual technologies to the same application, this hybrid model yields produce better results and help schedules in construction projects to a greater extent system. Wang et al. use BIM Research on digital twins of energy-saving buildings students, exploring the key technologies of digital twins. Digital twins in buildings It can be regarded as an expression of BIM +, which originates from digital description and has an impact on physical Comprehensive perception of the system is the prerequisite for the implementation of digital twins. BIM energy saving The design includes the choice of building orientation and building shape, BIM energy consumption Analysis can compare different materials, test the performance of each material, and provide a basis for the building structure Choose the most suitable and energy-efficient materials.

BIM The model expression of the existing environment has certain disadvantages. Environmental dynamic perception and more macro scene modeling, especially for expressways Projects that are strongly dependent on the environment, such as roads, bridges and tunnels, have research research meaning. Many scholars in BIM Based on the introduction of GIS technology to _ To make up for the dependence of macro scenarios, data fusion is a different technical system The key to the establishment of the twin model is whether the twin body can be unified important factor. Bao Qiaoling et al. Based on the construction of Xiongan New Area foundation, build GIS and BIM Converged digital twin. Wang Jianxiang and others via BIM with GIS The combination of the application of the system complements the advantages and disadvantages of the two, and realizes the use conditions and characteristics based on the scene. Formulate optimal planning, traffic flow relationship, and entity functional construction in a short period of time Layout, etc. provide data support. Wang Qiang used UAV tilt camera Obtain the real-scene model of the project area through video technology, create a 3D visual design environment, and use 3DGIS PlatformSuperMap _ GIS FusionGIS _ Data and Bridge BIM data to build digital twins. Zhu et al. Using shapefiles Formats Facilitate BIM use in GIS, And through the development of integrated computer graphics technology, the industrial basic class (IFC) converted to Shapefiles, can be promoted in used in GIS BIM information, useful for research on digital twins and smart cities. in these research In the study, the building model will be processed and integrated in GIS, or any other need to manipulate IFC in depth the study of geometry. Xia wait considered GIS Data can provide urban geospatial information and insights into urban design to Critical Spatial Analysis Capabilities. BIM including building digitization body, the passive presentation of microscopic digital information on entities, and models Proactive application throughout the life cycle of the architecture, engineering and construction industry.

There is no lack of introduction of more NewIT in the above research get physics entity data to meet the twinning granularity of specific service functions, such as based on BIM + IoT The park digital twin model. Due to the digital twin In order to meet the requirements of granularity, multi-technology integration will become inevitable.

4. 2 Digital Twin Architecture Model

On the basis of the digital twin conceptual model, the field of civil construction has emerged The emergence of a more concrete digital twin architecture model is often more targeted and has more reference significance for the construction

of industry digital twins. Xiong'an New Area Planning and Construction BIM The management platform integrates GIS and BIM, Based on the urban 2D and 3D integration engine, using integrated data Digital methods such as data and artificial intelligence analysis, centering on the improvement of project approval Reform and expand the important application of platform CIM + to build a digital spatial spectrum system and intelligent rule system to achieve precise and seamless control from macro to micro Impairment conduction. In terms of transportation infrastructure, Lin Shutao proposed a platform architecture model for transportation infrastructure. The model is based on components It is the basic unit of data, and it is continuously enriched with the engineering construction twin body rich. The model has strong scalability and module migration capabilities. Greatly reduce the complexity of the initial stage of model construction. Liu Zhansheng et al. based on the digital twin five-dimensional model, proposed a Multidimensional model of dynamic fire evacuation, as shown in Figure 14 shown. The model should for 2020 Real-time collection of environmental information, 3D visualization of indoor layout, fire alarm Alarm, indoor personnel positioning, path evacuation planning and other functions. Xie Linlin et al.based on BIM Scheduling intelligence with digital twin technology The energy management platform is divided into data acquisition layer, data processing layer, digital twin function layer, and human-computer interaction layer from the basic data acquisition layer to the top application layer. Platform 4 The levels are interlocking, Each level structure is established on the basis of the upper levels, and each level The function realization of each level is the enrichment and expansion of each level of the upper level. Pan wait. Based on BIM The massive IoT data empowered by the Develop a data-driven digital twin framework to build physical world and digital world closed loop. The digital twin conceptual architecture can be fully generated throughout the project function in the life cycle for intelligent construction monitoring and management.

4. 3 Digital Twin Application Value

The development of the definition of digital twin highlights the application of digital twin data and the exploration of digital twin service capabilities, the value of digital twin The value lies here, and the true reflection of the physical entity is realized in many ways. It is undeniable that this is the premise of building a digital twin, but digital Not the purpose of digital twins, but the way. The current manufacturing industry follows In the traditional production management mode, digital mining work is not a workflow An important part of the process, while the end of product production represents the producer The work division is over, and the product life cycle feedback has not been re-emphasized. See. Digital twins provide the link between product manufacturing and value generation through the path.

The establishment of digital twin systems is often limited to the physical reality In the reconstruction of body digitization, but the meaning of digital twin is through digital Rebuilds Feedback on Physical Models. With the adoption of various technical means Build a digital twin, which generates massive multi-source data. root According to literature search, nearly 2 year representative twin data management method (see Table 3). Twin data processing methods mainly include physical models, simulation models, experience, artificial intelligence, etc., of which physical simulation Both the model and the experience are based on knowledge, known as knowledge-based evaluation judgment. The current artificial intelligence method is to process data more intelligently The method of energyization is also the main means of big data processing. At the same time based on The knowledge- and data-driven research method has been obtained in other research fields. From application to application, artificial intelligence methods are introduced without abandoning existing knowledge.

A digital twin is a digital mapping of a physical entity, a twin A large amount of data provides a data-driven basis for changing the civil construction mode. Digital twin has the ability to predict the whole life cycle, managers need Rational tools incorporate digital twin data-driven capabilities into real-time decision-making During the policy process. Through data analysis, digital twins can help managers Understand, predict, assess impact on future scenarios. In addition, the digital twin Generators can integrate multiple data sources throughout the asset lifecycle, including Simple conditional or performance data to environmental or economic inputs, relying on data Complete comprehensive and accurate asset decision-making based on simulation and forecasting capabilities. B roo, etc.stated that the proposed digital twin architecture aims to learn from stakeholders identify common goals among the contributions of the continuous estimation. m e ža wait for roads built using secondary raw materials Lu proposes a digital twin architecture. The theme of sustainability is not only its research All of the scope of the study, and present in the equipment, are useful for monitoring mechanical stability Sexual impact matters and leads to improvements. Research shows that the

Table 3 Data-Driven Evaluation And Prediction Methods

First author	Document title	years	data-driven approach
Liu Zhansheng	Research on intelligent prediction method of prestressed cable force driven by digital twin	2021	physical model
Lu Jiajun	TBM based on digital twin Research and Realization of Virtual Drilling System	2022	artificial intelligence LSTM
Gong Siyi	Research on Intelligent Analysis Method of Shield Tunnel Ground Subsidence Based on Digital Twin	2021	knowledge map
Zhang Fan Ding Hua	Based on DT-LSTM _ Fatigue life prediction of top beam of mine hydraulic support	2022 2020	Physical model + artificial intelligence LSTM artificial

			intelligence gate recurrent neural network
Ye Chenlei	Construction and Application of Urban Flood Digital Twin System :Taking Fuzhou City as an Example	2022	physical simulation model
Li Hang	Research on spoke-type cable-supported roof based on digital twin corrosion and temperature factors	2022	physical simulation model
Jing Haixiang	Research on Predictive Fault Diagnosis of Mine Ventilator Based on Digital Twin and Probabilistic Neural Network	2021	artificial intelligence deep learning

The perception of physical entities is to ensure the safety and operability of the whole life cycle key to creativity. C all cut wait [2] Digital twins could improve customs clearance, say Efficiency and Sustainability of Critical Infrastructure Systems. Number of infrastructure The collection of data allows stakeholders to reduce emissions, make sustainable decisions about business and proactively manage climate resilience. Kim et al Discussion on the use of digital twins in acoustic barrier tunnels to support Decisions about the life of assets to improve sustainability. research form demonstrates that using digital twins to assess the condition of infrastructure can help Determine lifespan and forecast resource procurement, production and replacement times to improve sustainability. The above studies have shown that monitoring throughout the life cycle Real-time asset control improves asset data quality, helping to improve asset The decision-making process in management, such as through better planning, resource use and monitoring of the environmental impact of assets, ultimately improves the efficient use of assets. In the specific construction management system, Bao Qiaoling et al. Xiong'an The new district serves as a platform to build a digital twin framework and apply it. compared to traditional Planning requires the issuance of planning conditions, land transfer, project approval, etc. planning documents, standards and audit indicators, the digital twin greatly Reduce work intensity and improve work efficiency. At the same time based on data planning The examination and approval process is more scientific and objective, while improving the level of management flat. The digital twin platform can be efficiently integrated and displayed in practical applications BIM, GIS, UAV and other data to provide real-time information for project collaborative management Data based on. Liu Zhansheng et al. showed that the use of digital twins The model gives real-time feedback and regulation to the whole construction process, which can improve the confidence interest rate. For intelligent construction services, in BIM, IoT, DM Integrated, Pan wait Develop a detailed framework for digital twins including physical models, virtual models, and connected data. The significance of establishing a cycle is to promote the automation, digitization, and intelligence of construction project management, which may Less susceptible to human cognitive errors. Oti put forward A framework that leverages feedback loops from building energy consumption using Light Scanners, Cameras Inform and Improve Devices in Digital Twin Environments Design and facilities management, bridging the gap between the stages of the building life cycle distance. Martinez wait conducted building simulations to assess building energy performance Yes, consider the real behavior of individuals in real pilot sites to reduce energy, money consumption. Welch et al. introduced that the use of digital twins can The following ways to assist in assessing and mitigating earthquake risks: ① BIM able to provide The characteristic data of structural and non-structural components in the building, in order to realize the Reliable overall earthquake risk assessment ; The injury information obtained by health monitoring technology can be used for self-diagnosis ; ③ exist construction management, an emergency management center should be established, implement the control program sequence, supervisor Measurement and closed after the earthquake damaged mechanical suit service. Lyu wait developed based on GIS, GPS, BIM and remote sensing technology for metro System Flood Risk Assessment System, which can realize the early warning and flood risk management. However, due to the low frequency of disasters, using The reliability of digital twins for disaster prevention and mitigation is difficult to obtain in practice. to prove.

5. SCIENTIFIC PROBLEMS TO BE SOLVED BY DIGITAL TWINS IN THE FIELD OF CIVIL ENGINEERING

5.1 Heterogeneous Data (Heterogeneous Data) Fusion Problem

Civil engineering construction process involves people, materials, machinery, regulations and the environment, etc., the mapping of the digital twin to the physical space needs to be Different components take specific solutions, such as personnel data packages Including working status, working position and even personnel emotions, etc., material data Including material performance, material scheduling, etc., the environment includes spatial data, map shape data etc.. The above data tend to follow the customary data in various fields Standard, digital twin data-driven only rely on a single data, often out of From the significance of digital twin construction, relying on multiple types of data to drive The quality of service will inevitably lead to data heterogeneity problems, such as structural mechanics The response data is often a time series, and the aerial photography data of the drone is a picture or video, combined to analyze the 2 This kind of data is a technical difficulty. in the system project eXtensible Markup Language XML (eXtensible markup language), Store and exchange system heterogeneous data change in _ BIM Formed during the modeling process Gbxml, IFC, DWG, IDF and other formats are used to improve the efficiency of data exchange. Analyzing heterogeneous data Aspect, Yao wait proposed intelligent prediction for multi-source heterogeneous data.

5.2 The Contradiction Between Digital Twin Scale, Granularity Fidelity And Computational Complexity

Different application scenarios have different fineness of the twin model demand, the machinery manufacturing industry often has micron-level processing requirements, soil millimeter scale is often required in the field of wood engineering construction, while the process of civil engineering management often requires cm-level. Different digital twin service requirements Twins have different precision requirements, and the purpose of establishing a digital twin model is often To determine the accuracy of digital twins. Furthermore, from a macro perspective, the machine The largest scale of the component products in the machinery manufacturing industry is up to 100 meters, and the highway The road scale is generally kilometer level. Therefore, in terms of geometric fineness and geometric The aspect of scale brings great difficulties to the establishment of twins, often resulting in Problems of large-scale data storage and simulation calculation difficulties. against For different service purposes, it is urgent to dynamically adjust the calculation model accuracy The problem. For example, in the process of expressway route planning, in order to fully consider Considering the largest scale problem of long-line engineering, the fineness reaches meter level ; In the foundation or bridge construction, the fineness needs to reach the millimeter level. In terms of degree, it can be limited to work points and work sections. Digital twins are not limited to geometric dimensions, physical dimensions, behavioral dimensions, and time dimensions are all is an integral part of twin model building. Missing scale, missing dimension Both lead to the fact that the twin model cannot objectively and truly reflect the state of the physical entity. And then affect the objective and credible twin service. Therefore in processing Faced with multi-scale, multi-dimensional problems and consideration of computational complexity challenge.

5. 3 Co-Evolution Between Twin System And Real System

An important part of the digital twin is the full life cycle service capability, The digital twin architecture is not a process from physical entities to twins and then to services One-way structure, but the interaction and coordination between twins and physical entities same problem. Real-time update between heterogeneous data to data network transmission Capabilities have strict requirements. network robustness, network latency, network The difference in speed directly affects the timeliness and accuracy of the twin model. Before 5G Network technology can well meet the needs of data transmission, which is the current twin construction IoT The main method of network transmission between devices Mode. In terms of twin model updates, initial twin builds tend to Requires a lot of manual assistance, such as BIM In the modeling phase, the risk assessment is The time sensitivity is not strong, but during the construction process, manual update BIM mold type will cause time delays and reduce twin fidelity. Based on data The construction efficiency and accuracy of twin model independent construction technology are further improved subject of further study. In terms of twin services, twin models often rely on Engine-driven twin servers based on big data, artificial intelligence, and simulation tasks, such as progress and personnel safety risk control, etc.. but in the whole life cycle During the period, what kind of impact will the generation of new twin data have on the driving engine? Whether the universality of the driving engine to new data meets the service requirements beg. Due to the fact that projects have different project attributes in the whole life cycle, The evolution between the twin system and the real system will be the entire digital twin An important part of the whole life cycle service.

6. CONCLUSION

This paper analyzes the research enthusiasm of digital twins from the perspective of literature retrieval. Sort out and analyze the research progress of digital twins at home and abroad. overview numbers The concept of twins and digital twin models, and at the same time, specific practices, Summarize the architectural model and application value, in order to be able to learn from practice Provide model building ideas for scientific research institutions and companies. propose The urgent problem to be solved in the digital twin is the fusion of heterogeneous data ; Digital twin scale problem, granularity fidelity and computational complexity contradiction ; system evolution between twin system and real system. sincerity However, many scholars should further refine and summarize in the digital twin practice To conclude the research questions, the continuous enrichment process of the digital twin ecology is a broad The process of joint promotion of major research scholars.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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