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The Application and Future Trend of Digital Technology in Civil Engineering

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Abstract: The application of digital technology in civil engineering is becoming increasingly widespread and covers aspects such as modeling and simulation, data analysis and monitoring, intelligent structures, and smart cities. This article reviews the current state of digital technology applications in civil engineering, focusing on building information modeling (BIM), drone technology, the Internet of Things (IoT), artificial intelligence and big data analytics. Additionally, the article explores future trends in digital technology for civil engineering, including smart building design, smart city construction, automated construction, and intelligent monitoring systems. Overall, digital technology has revolutionized the efficiency and quality of civil engineering projects with promising prospects for future development and innovation.

1. Introduction

As the cornerstone of modern society, civil engineering plays a vital role in shaping the infrastructure that underpins our daily lives. From towering skyscrapers to complex transportation systems, civil engineering covers a wide range of projects that are vital for the development and progress of society [1]. However, the civil engineering landscape is undergoing a profound transformation driven by the rapid development of digital technologies. In recent years, the integration of digital tools and technologies has revolutionized all aspects of civil engineering, from project conception to execution and management [2]. This introduction aims to give a comprehensive introduction to the application of digital technology in civil engineering and explore its multifaceted impact, challenges, and future prospects in depth.

The importance of digital technology in civil engineering is self-evident. Digital technologies have become an indispensable asset in the field of civil engineering, providing unprecedented

capabilities and efficiencies for project planning, design, and implementation [3]. Building Information Modeling (BIM), for example, has become a cornerstone of modern engineering practice, enabling engineers and architects to create detailed 3D models of structures and infrastructure. This not only enhances visualization and collaboration, but also simplifies the overall project lifecycle, resulting in increased cost effectiveness and resource optimization [4].

Additionally, drone technology has revolutionized the measurement and field monitoring process, providing high-resolution aerial imagery and data analysis capabilities. This provides real-time insights into project progress, safety compliance, and environmental impact assessments [5]. Similarly, iot provides civil engineers with smart sensors and connected devices that enable remote monitoring, predictive maintenance, and data-driven decision making.

There are still many challenges in the development of digital technology in civil engineering. Despite the transformational potential of digital technology, its widespread application in civil engineering is not without challenges. One of the major barriers is the need to train and train skilled workers to effectively utilize complex digital tools and software. In addition, concerns about data security, privacy, and interoperability pose significant barriers to achieving seamless integration and collaboration between different stakeholders in the building ecosystem.

Furthermore, the initial investment required to implement digital technology and infrastructure upgrades can be significant, especially for smaller companies and developing countries. Addressing these challenges will require the combined efforts of industry leaders, policymakers, and educational institutions to foster an environment conducive to innovation and knowledge exchange.

The future of civil engineering is inextricably linked to the continuous development of digital technology. As emerging technologies such as artificial intelligence, machine learning, and augmented reality continue to advance, they promise to further transform the way civil engineering projects are conceived, executed, and maintained. With the continuous development and innovation of science and technology, the application of digital technology in the field of civil engineering is continuously evolving, showing unprecedented potential and prospect [6]. In the future, digital technology will continue to lead the development of civil engineering and show new trends and possibilities in all aspects.

In the future, intelligent building design will become an important trend in the field of civil engineering. With the help of artificial intelligence and machine learning technology, engineers can develop more intelligent design tools and algorithms, which can automatically optimize architectural design schemes according to different needs and conditions [7]. This will greatly improve design efficiency, reduce human error, and enable more innovative and sustainable building designs. Smart city construction is another future development trend in which digital technology will play a key role. By integrating sensors, drones, iot, and big data analytics into urban infrastructure, cities will become smarter and more efficient. Smart cities will achieve intelligent traffic management, optimized resource utilization, and precision of environmental monitoring, and provide residents with a more convenient and comfortable living environment [8]. Automated construction technology will become an important development direction in civil engineering. With the continuous advancement of robotics and automation equipment, more and more construction tasks will be completed by robots and automation equipment, thus improving construction efficiency, reducing labor costs, and reducing safety risks during construction. Automated construction will also promote the digital transformation of civil engineering projects to achieve information management and intelligent monitoring. The intelligent monitoring system will become a key technology in civil engineering. Using sensor networks, real-time data analysis, and predictive models, intelligent monitoring systems can monitor the health of structures and facilities in real time, detect potential problems and risks in a timely manner, and take preventive measures. This will help extend the service life of structures and facilities, improve safety and reliability, and

reduce maintenance costs and risks [9]. Digital technologies will continue to play an important role in the field of civil engineering, driving the industry towards a more intelligent, efficient, and sustainable direction. With the continuous innovation and application of technology, we can expect to see further development and progress in the field of civil engineering.

In short, digital technologies are reshaping the civil engineering landscape, bringing unprecedented opportunities for innovation, efficiency, and sustainability.

2. Related Research

2.1. The Origin of Digitization of Civil Engineering

The history and development of digital technology in the field of civil engineering can be traced back to the rise of computer science and information technology, and the gradual application of digital tools in engineering design and construction [10]. From the first computer-aided design (CAD) software to modern building information modeling (BIM) and smart city technology, digital technology has profoundly changed the face of civil engineering, improving engineering efficiency, accuracy, and sustainability [11].

(1) The early stages

In the middle of the 20th century, with the development of computer technology, some computer software for structural analysis, soil mechanics, and hydraulic engineering began to appear in the field of civil engineering. These early software programs, though simple in function, provided engineers with a new tool that allowed them to use computers for engineering design and analysis.

(2) Introduction of CAD technology

In the 1970s, computer-aided design (CAD) technology began to be applied in the field of civil engineering. CAD software enables engineers to use computers for graphic design and drawing, thus improving design efficiency and accuracy. The application of CAD technology makes the civil engineering design process more convenient and accurate and provides great convenience to engineers.

(3) The rise of building information modeling (BIM)

In the early 2000s, Building Information Modeling (BIM) as a new digital technology began to rise in the field of civil engineering. BIM technology not only includes the three-dimensional geometric model of the building, but also includes the attribute information and relationship of the building elements, which can provide more comprehensive and integrated architectural design and management support [12]. The application of BIM technology enables engineers to understand the building design and construction process more intuitively, thus improving the efficiency and quality of the project [13].

(4) Intelligent building design and construction:

With the development of technologies such as artificial intelligence (AI) and big data analysis, intelligent building design and construction have gradually become a new trend in civil engineering [14]. AI technology can help engineers analyze and optimize design schemes, and big data analysis can mine valuable information from massive data to provide a scientific basis and decision support for civil engineering projects. Intelligent building design and construction not only improve engineering efficiency, but also help reduce costs and reduce resource waste, thus achieving sustainable development of the project.

(5) Smart city construction:

In recent years, smart city construction has become an emerging direction of digital technology in the field of civil engineering. When technologies such as sensors, the Internet of Things, and big data analysis are applied to urban infrastructure, intelligent and efficient urban management is realized. Smart cities not only improve the operational efficiency of cities, but also improve the

quality of life of residents and promote the sustainable development of cities.

(6) Future development

In the future, the application of digital technology in the field of civil engineering will continue to develop toward intelligence, automation, and sustainability [15]. With the continuous advancement and innovation of technology, we can foresee that digital technology will bring more opportunities and challenges to the field of civil engineering and make greater contributions to the construction of safer, efficient, and sustainable cities and infrastructure.

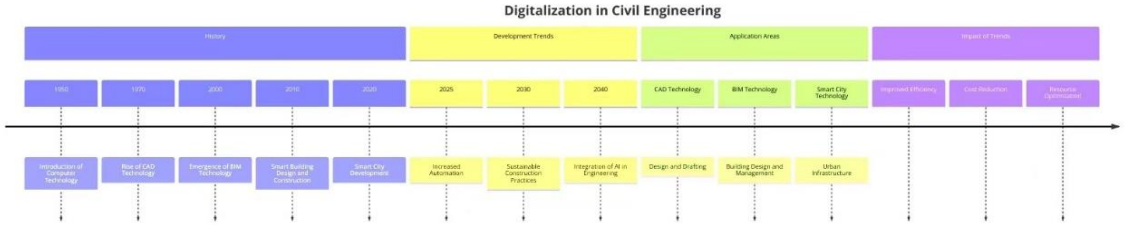

Figure 1. Digital Development of Civil Engineering

2.2. Digital Status of Civil Engineering

At present, the application of digital technology in the field of civil engineering has gradually deepened in all aspects, covering many links such as engineering design, construction management, and project monitoring [16]. The following is a detailed description of the application of digital technology in civil engineering.

(1) Application of Building Information Modeling (BIM)

Building Information Modeling (BIM) has become the core technology in civil engineering design and management. By integrating geometric models, attribute information and relational data of buildings, BIM technology realizes the integrated management of the whole life cycle of engineering design, construction, and operation management. At present, BIM technology is used in the design and management of many civil engineering projects, including large-scale buildings, bridges, roads, and urban infrastructure [17-19].

(2) Application of UAV technology

Uav technology is widely used in civil engineering. By carrying high-resolution cameras and sensors, the UAV can perform aerial photography and monitoring of the engineering site, providing a comprehensive and efficient data acquisition scheme. Uav technology can be used in engineering planning, site investigation, construction monitoring, and other aspects, greatly improving the efficiency and accuracy of project management.

(3) Application of Internet of Things technology:

The application of Internet of Things technology in civil engineering is also becoming more and more common. When sensors and intelligent devices are deployed in engineering facilities, real-time monitoring and management of engineering facilities are realized. The Internet of Things technology can be used to monitor the health status of structures, changes in environmental parameters, and operating status of equipment, etc., providing important data support for project management and maintenance [20].

(4) Application of big data analysis:

The application of big data analysis technology in civil engineering is also receiving more and more attention. By collecting, storing, and analyzing a large amount of engineering data, we can find the correlation and regularity between the data and provide scientific basis for engineering decision. Big data analysis technology can be used to optimize engineering design schemes, predict engineering risks, improve engineering efficiency, and other aspects, providing important support

for engineering management and decision making [21].

(5) Application of an intelligent monitoring system:

The application of an intelligent monitoring system in civil engineering is also gradually mature. These systems enable real-time monitoring and early warning of engineering structures and facilities through the deployment of sensor networks and real-time data analysis technologies. The intelligent monitoring system can be used to monitor the deformation, vibration, temperature, and other parameters of the structure, find potential safety hazards in time, and ensure the safe operation of the project.

(6) Application of virtual reality (VR) and augmented reality (AR) technology:

Virtual reality (VR) and augmented reality (AR) technologies are also beginning to find use in civil engineering. These technologies can present design models and engineering data in a virtual form, providing a new experience for engineering design, construction, and training. Using VR and AR technology, engineers can more intuitively understand the engineering design and construction process, improving the accuracy of the engineering design and the efficiency of construction [22].

It can be seen that the application of digital technology in civil engineering has made remarkable progress, bringing new opportunities and challenges for engineering design, construction, and management. With the continuous development and innovation of technology, we can foresee that the application of digital technology in civil engineering will further deepen and expand and make greater contributions to the construction of safer, efficient, and sustainable cities and infrastructure.

2.3. Digital Trend of Civil Engineering

Cutting-edge technologies and research progress play a pivotal role in the field of civil engineering, including the development of intelligent building design, smart city construction, automated construction, and intelligent monitoring systems, which have brought many new opportunities and challenges to civil engineering. The following is a detailed description of these cutting-edge technologies and research advances.

(1) Intelligent building design

Intelligent building design is the use of artificial intelligence, machine learning, and other technologies to realize the automation and intelligence of the building design process. At present, more and more engineering design firms and architects are beginning to use intelligent design tools, such as generative design algorithms, deep learning models, etc., to assist the design process. Intelligent building design can not only improve design efficiency, but also help designers quickly generate diversified design schemes, so as to achieve more innovative and personalized building design.

(2) Smart City construction:

Smart city construction is the use of information technology, the Internet of things, big data analysis, and other technologies to achieve intelligent and efficient urban infrastructure. At present, many cities have begun to promote the construction of smart cities, through the construction of intelligent transportation systems, intelligent energy management systems, intelligent environmental monitoring systems, etc., to improve the level of urban management and service. Smart city construction can not only improve the efficiency of city operations, but also improve the quality of life of residents and promote the sustainable development of the city.

(3) Automated construction:

Automated construction is the use of robots, drones, 3D printing, and other technologies to achieve the automation and intelligence of the construction process. At present, more and more construction companies and engineering contractors have begun to use automated construction technologies, such as the use of robots for excavation of shale, the use of drones for measurement

and monitoring, and the use of 3D printers for the manufacture of building structures. Automated construction can not only improve construction efficiency, but also reduce human error and safety accidents, thereby reducing project costs and risks.

(4) Intelligent monitoring system

Intelligent monitoring system is the use of sensors, big data analysis, and other technologies to achieve real-time monitoring and early warning of engineering structures and facilities. At present, intelligent monitoring system has been widely used in bridges, tunnels, buildings, and other engineering fields, can monitor structural deformation, vibration, temperature and other parameters, timely detection of potential safety hazards. An intelligent monitoring system can not only improve the safety and reliability of the project but also extend the service life of the structure and reduce maintenance costs and risks.

Cutting-edge technologies and research advances such as intelligent building design, smart city construction, automated construction, and intelligent monitoring systems are profoundly changing the face of the civil engineering field, bringing new opportunities and challenges to engineering design, construction, and management. As technology continues to advance and innovate, we can expect to see further application and development of these cutting-edge technologies in the field of civil engineering making greater contributions to the construction of safer, more efficient, and sustainable cities and infrastructure.

3. Application of Lettering Technology in Civil Engineering

3.1. BIM Application

Building Information Modeling (BIM) technology has become a revolutionary tool in the construction and civil engineering industry in recent years. By creating and managing digital representations of construction projects, BIM not only improves design quality but also increases construction efficiency while effectively controlling project costs. BIM technology is used in many areas, such as: 1) Hudson Yards Project (New York), a large-scale urban development project in New York City that includes office space, residential, public space, and retail facilities. The project extensively uses BIM technology to achieve seamless integration and real-time updates of project information from the planning stage to construction management. BIM technology enables project team members to access and update project data in real time, enhancing collaboration between professional teams. By simulating the construction process in advance, BIM helps the project team identify and resolve potential problems, avoiding rework during construction and resulting in significant cost savings. The use of BIM technology enables project managers to plan and monitor construction progress with greater precision to ensure that the project is completed on time. 2) Expansion of London Heathrow Airport

The expansion project at London Heathrow Airport is another example of the widespread use of BIM technology. The project team used BIM technology to carry out detailed construction planning and management, ensuring smooth implementation of the complex project. The use of BIM models enables project teams to identify potential structural and safety problems in the design stage, reducing risks during construction. Effective management of construction resources through the BIM model ensures reasonable allocation and utilization of resources and improves construction efficiency. BIM technology also supports an accurate assessment of the environmental impact of the project and helps the team develop measures to reduce the environmental impact. 3) Reconstruction of Stanford University Medical Center, the Stanford University Medical Center reconstruction project successfully managed the complexity of the project and improved the quality of design and construction by adopting BIM technology. BIM technology enables design teams to evaluate the performance of different design options at an early stage and select the optimal solution. Once

completed, the BIM model provides valuable data resources for the daily operation and maintenance of the facility, simplifying the facility management process.

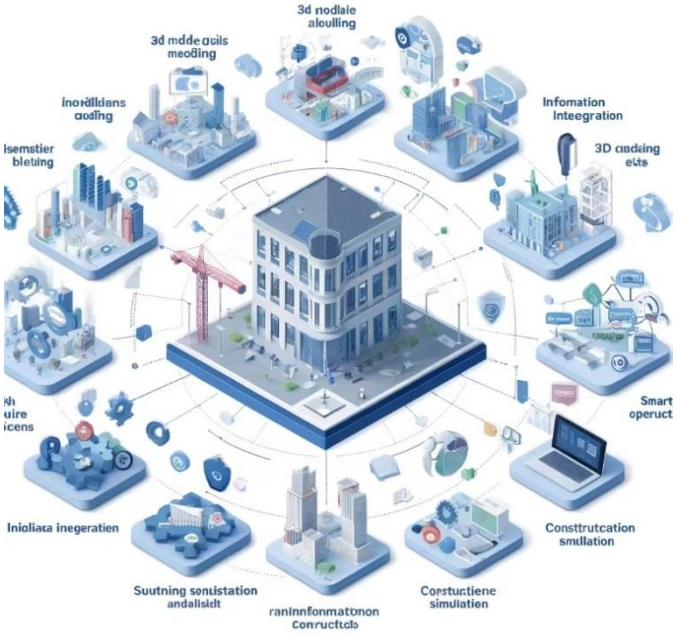

Figure 2. Composition of BIM technology

It can be seen that the application of BIM technology in construction and civil engineering projects can bring significant benefits, including improving design and construction efficiency, saving costs, reducing risks, and improving the quality of project management. As BIM technology continues to develop and improve, its application in global construction and civil engineering projects will become more and more widespread, and it is expected to become part of the industry standard, driving the entire industry in a more efficient and sustainable direction.

3.2. UAV Application

The application of UAV technology in the field of civil engineering has become a trend, and it has brought revolutionary changes to civil engineering projects with its advantages of high efficiency, flexibility, and economy. The application of UAV technology in civil engineering is almost essential and its advantages are also significant.

(1) Land mapping and investigation

During the initial phase of the project, drones will be able to rapidly map and survey large areas of land. Compared to traditional ground survey methods, UAVs can provide more detailed and accurate terrain and geomorphic data. They are able to fly over complex terrain and capture high-resolution images and video, providing reliable foundational data for engineering design.

(2) Construction monitoring and management

In the construction process, the application of UAV technology can greatly improve the monitoring efficiency of the construction site. The UAV can fly regularly to photograph the construction site, monitor the progress and quality of the project in real time, and find and solve problems in time. Additionally, by analyzing the images captured by drones, project managers can more effectively allocate and schedule resources to ensure that the project progresses smoothly as planned.

(3) Structural detection and evaluation

Drone technology presents unique advantages in the maintenance inspection of existing buildings and structures. Equipped with high-definition cameras and sensors, the drones are capable of conducting safety checks on inaccessible structures such as Bridges, DAMS, and tall buildings. Compared to traditional inspection methods, drones not only improve inspection safety and efficiency, but also reduce impact on traffic and daily operations.

(4) Environmental Impact Assessment

Drone technology is also proving to be unique in assessing the environmental impact of projects. Drones capture environmental changes before and after construction to help assess the impact on vegetation, water bodies, and wildlife habitat. This information is essential for developing environmental protection measures and meeting regulatory requirements.

(5) Security monitoring

Drones can also be used for security monitoring at construction sites. Through real-time video streaming, project managers can remotely monitor the safety status of field workers and detect and prevent potential safety hazards in a timely manner. The application of UAV has significantly improved the level of safety management of the construction site.

Drones make civil engineering more efficient, economical, safe, precise, and flexible. Drones can quickly cover vast areas, dramatically reducing data collection time. Compared to traditional methods, drone mapping is less costly and requires less human resources. Drones can visit dangerous or inaccessible areas, reducing safety risks for people. The high-resolution images captured by drones provide accurate data support for engineering design and construction. Drones can operate in a variety of environments and conditions and are suitable for a variety of civil engineering projects.

It can be seen that the application of UAV technology in civil engineering provides a new perspective and method for engineering design, construction management and maintenance, and the advantages it brings are unmatched by traditional methods.

3.3. Internet of Things Applications

The application of Internet of Things (IoT) technology in civil engineering is becoming an increasingly important force driving the industry forward. By connecting sensors, devices, and people, IoT technology not only greatly improves the efficiency and safety of engineering projects, but also provides a new perspective on engineering management and maintenance. At every stage of design, construction, and maintenance, iot technology provides real-time data support to help engineers make more accurate and timely decisions.

During the project planning and design phase, iot technology can assist engineers in assessing project feasibility and design optimization by collecting environmental and geographic information data. Using geographic information systems (GIS) and environmental monitoring sensors, the project team can better understand the environmental conditions of the construction site, such as soil moisture, geological stability, and the surrounding ecological environment, information that is critical for developing sustainable engineering designs. During the construction process, the Internet of Things technology can realize real-time monitoring of the construction site, including personnel positioning, equipment operating status, and construction progress. By installing sensors on construction equipment, project managers can obtain real-time information about equipment usage and efficiency and adjust construction plans and resource allocation in a timely manner. Additionally, with the use of iot technology, the safety environment of the construction site can be continuously monitored, such as through air quality sensors and noise monitoring equipment, to ensure that the construction site environment meets safety standards. After the completion of the project, the Internet of Things technology also plays an important role in the operation and

maintenance management of buildings and infrastructure. By embedding sensors in the structure, it is possible to continuously monitor the health of the building, such as cracks, deformation, or vibration, and these data can help engineers identify potential structural problems in a timely manner and take repair measures. In addition, iot technology can optimize energy management, enabling efficient use of energy in buildings through smart lighting, temperature control systems, and energy efficiency monitoring.

With the continuous development of Internet of Things technology, its application in civil engineering will also be further expanded. Combined with AI and big data analytics, future Iot systems will be able to provide more intelligent forecasting and decision support, making civil engineering projects not only more efficient and safe, but also more sustainable and intelligent. The in-depth application of the Internet of Things technology indicates that the civil engineering industry will usher in a new era of more intelligent and digital.

3.4. Artificial Intelligence Big Data Application

In civil engineering, the integration of artificial intelligence (AI) and big data analytics technologies is constantly opening up new possibilities, bringing innovation and transformation to this traditional industry. By intelligently analyzing massive data, these technologies provide scientific decision support for design, construction, maintenance, and other aspects, greatly improving the efficiency and safety of projects.

In the engineering design phase, AI technology can help engineers efficiently evaluate design solutions and predict structural performance through machine learning models, thus optimizing the design process. For example, AI models can simulate the response of different materials and structural designs under specific environmental conditions, helping engineers choose the best design options. Additionally, AI can automatically identify potential design problems at the design stage, reducing the need for later modifications, thus saving time and costs. In the construction phase, big data analysis technology provides a new perspective for construction management by real-time monitoring of construction site data, such as personnel location, equipment status, and environmental conditions. By analyzing these data, project managers can adjust construction plans in time, optimize resource allocation, and improve construction efficiency. At the same time, combined with AI technology, it can predict possible risks in the construction process, formulate countermeasures in advance, and ensure construction safety. In the engineering maintenance phase, AI and big data technology also play an important role. Through the analysis of the data collected by the structural health monitoring system, the AI model can predict the likely damage and longevity of the structure, providing a scientific basis for maintenance decisions. This condition-based maintenance strategy is more efficient and economical than traditional periodic maintenance and can significantly extend the service life of engineering structures.

In addition, AI and big data technologies also play an important role in environmental impact assessment, energy management, and smart city construction in the field of civil engineering. By intelligently analyzing and processing large amounts of environmental data, engineering projects can ensure structural safety and function, while minimizing environmental impact, and achieving sustainable development.

Artificial intelligence and big data analytics technologies are showing strong potential and value in the field of civil engineering. They not only improve the efficiency and safety of engineering projects, but also promote the development of civil engineering in the direction of more intelligent, automated, and sustainable. With the continuous advancement and application of these technologies, the civil engineering of the future will be more efficient, smart, and green.

4. Digital Future Trend of Civil Engineering

4.1. Prospect of Intelligent Building Design

Intelligent building design is in rapid development, and it uses advanced information technology, artificial intelligence (AI), and big data analysis to bring revolutionary changes to the field of architectural design. With the continuous advancement of technology, the development direction of intelligent building design is moving towards a more efficient, sustainable, and user-friendly direction. Looking forward to the future, intelligent building design is expected to achieve several important development goals and bring a profound impact on human life and social development.

Intelligent building design will pay more attention to the energy efficiency and environmental friendliness of buildings. By using AI for accurate energy simulation and analysis, designers can fully consider the building's energy needs and environmental impact at the design stage, and adopt the best design solutions and materials to reduce energy consumption and carbon emissions. In addition, intelligent design can also optimize the building's natural lighting and ventilation, improve the comfort of living and use, while reducing energy consumption. Second, future intelligent building design will pay more attention to user experience and interactivity. By integrating advanced sensors and intelligent control systems, buildings will be able to respond to occupants' needs and preferences in real time, automatically adjusting indoor environmental parameters such as temperature, humidity, light, etc., thus providing occupants with a more personalized and comfortable living experience. In addition, by analyzing user behavior data, intelligent design can continuously optimize building functions and spatial layout to meet the changing needs of users. Finally, with the development of digital twin technology, intelligent building design can realize the digital management of the entire building life cycle in the future. The digital twin of the building will contain all the information and data of the building, and every link from design, construction, to operation, and maintenance can be simulated, analyzed, and optimized in the digital space. This will greatly improve the management efficiency of construction projects, reduce operation and maintenance costs, and also provide strong technical support for the sustainable development of buildings.

The future of intelligent building design is full of infinite possibilities, it will make the architectural design more scientific and refined, but the relationship between the building and people, the environment is closely linked. With the continuous development and application of technology, intelligent building design is expected to make an important contribution to creating more efficient, sustainable, and humane living spaces.

4.2. Prospects of Smart City Construction

Smart city construction is rapidly becoming an important trend in global urban development, which leverages advanced technologies such as information and communication technology (ICT) and the Internet of Things (IoT) to improve urban management efficiency, improve the quality of life of residents, and achieve sustainable development. In the future, the development of smart cities will focus more on the integration and sharing of data, the widespread application of artificial intelligence, and the practice of digital twin technology. These technologies will make urban management more intelligent, able to respond in real time to various needs and challenges in urban operation, while optimizing resource allocation and improving residents' life experience. However, the construction of smart cities also faces a series of challenges. Data security and privacy protection are one of the most critical issues. How to ensure the security of massive urban data and prevent data leakage and abuse is a difficult problem that must be solved in the development of smart cities. In addition, upgrading technology and infrastructure requires huge investment, and

how to balance economic benefits and construction costs is also an important challenge facing smart cities. Finally, the construction of smart cities requires cross-field cooperation and coordination, including the extensive participation of governments, enterprises, and citizens. The question of how to break departmental barriers and achieve effective collaboration is also a key factor in achieving the vision of smart cities.

In short, the future of smart city construction is full of hope, but also faces many challenges. Through continuous innovation and improvement and active response to challenges, smart cities are expected to provide strong support for sustainable urban development and create a more efficient, livable, and smart city of the future.

4.3. Prospects of Automated Construction Technology

Automated construction technology is gradually becoming a major innovation direction in the field of civil engineering, indicating the future transformation of building construction methods from traditional manual operation to efficient and accurate automated processes. With the development and application of technologies such as robotics, artificial intelligence, 3D printing, and drones, automated construction technology can not only improve construction efficiency and quality, but also reduce labor costs and safety risks to a certain extent. For example, by using 3D printing technology, complex building structures can be printed in a very short time, while drones can carry out efficient construction site monitoring and data collection. The application prospect of automated construction technology is broad, and it is expected to play an important role in the future urban infrastructure construction, residential and commercial building construction, and other fields. Furthermore, with the promotion of smart city and green building concepts, automated construction technologies will also play a key role in achieving environmental sustainability and energy efficiency optimization of building projects. However, the promotion and application of automated construction technology also faces a series of challenges, including the cost of technology research and development, the changing needs of construction industry practitioners, and the improvement of relevant laws, regulations, and standards. In the future, interdisciplinary cooperation, technological innovation, and policy support will be the key factors to promote the development of automated construction technology. With the gradual solution of these problems, automated construction technology is expected to achieve a wider application in the construction industry, bringing fundamental changes to the field of building construction.

4.4. Prospect of an Intelligent Monitoring System

The development of intelligent monitoring systems is advancing at an unprecedented rate, using advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics to provide comprehensive real-time monitoring services for urban infrastructure, buildings, and engineering projects. These systems collect data by installing a variety of sensors and then use AI algorithms to analyze the data to predict and identify potential problems, so maintenance or repair measures can be taken in advance, ensuring the safety of the structure and extending its service life. Intelligent monitoring systems have a wide range of application scenarios, from the health monitoring of large infrastructure such as bridges, tunnels, DAMS, to the energy efficiency and safety monitoring of urban buildings such as high-rise buildings, residential buildings, commercial centers, and then to the status monitoring of traffic networks such as roads and railways. In these applications, intelligent monitoring systems can not only monitor the physical state of the structure in real time, such as temperature, humidity, vibration, etc., but also monitor environmental factors, such as air quality and water level, etc., providing important support for urban management and disaster prevention. In the future, with the continuous progress of technology, the development

direction of development of the intelligent monitoring system will pay more attention to the integration and intelligence of the system. On the one hand, the system will be more convenient to integrate into various engineering projects and urban infrastructure to achieve a wider range of applications; On the other hand, by utilizing more advanced AI algorithms and big data technologies, intelligent monitoring systems will be able to provide more accurate predictions and diagnoses and achieve automated decision support. In addition, with the popularization of 5G communication technology, intelligent monitoring systems' data transmission will be faster and more reliable, further improving the real-time and accuracy of the system.

5. Conclusions

This paper provides an in-depth look at the widespread use of digital technology in civil engineering and the significant changes it is bringing, particularly the integrated use of building information modeling (BIM), drone technology, Internet of Things (IoT), artificial intelligence (AI) and big data analytics, which together are driving civil engineering towards a more efficient, smarter, and more sustainable development. Through the analysis of the application practice of these technologies in design, construction, monitoring, and maintenance, it can be seen that digital technology not only improves the design quality and construction efficiency of engineering projects, but also enhances the safety and durability of engineering structures, and provides important technical support for urban management and disaster prevention.

Although the application of digital technology has brought great benefits to civil engineering, it also faces challenges such as data security, technical costs, and personnel training. In the future, interdisciplinary collaboration, continued technological innovation, and policy support will be key to driving the wider adoption of these advanced technologies. With the continuous evolution of technology and the deepening of application practice, digital technology is expected to play a greater role in the field of civil engineering, promoting the industry to achieve digital, intelligent, and green transformation, and laying a solid foundation for the construction of a safer, more efficient, and livable future city.

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Any should be placed before the references section without numbering.

Data Availability

Data sharing is not applicable to this article, as no new data was created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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