The Role of Artificial Intelligence in Construction Management: A Case Study of Smart Worksite Systems

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Abstract: Over the past few years, the progressive evolution of information technologies, including cloud computing, big data, artificial intelligence, and the Internet of Things, has become increasingly pervasive across diverse sectors of social development. This integration has spurred a widespread shift towards digitization, empowering various industries to embark on a journey toward high-quality development. Through meticulous analysis, this paper explores the profound impact of intelligent site systems on construction management, emphasizing the pivotal role played by artificial intelligence (AI) in augmenting efficiency, optimizing resources, and reinforcing safety protocols. Drawing insights from diverse case studies, the paper elaborates on how AI-driven smart site systems stimulate innovation and reform in the construction sector. By ushering in the era of digitization and intelligence, these systems propel the entire industry towards a technologically advanced future. In the context of this research, a profound understanding emerges of how intelligent construction management systems are instrumental in shaping the evolving landscape of the construction industry, steering it towards not only heightened efficiency but also a more sustainable and technologically integrated future.

1. Introduction

In recent years, with the innovative development of information technologies such as cloud computing, big data, artificial intelligence, and the Internet of Things, they have increasingly integrated into various fields of social development, promoting all walks of life to begin to transform to digital, and empowering high-quality development. In this context, the construction industry has also been deepening the information construction, and has entered the development period with intelligent construction as the core, and the smart site, as an important part of the realization of intelligent construction, has also attracted much attention. However, due to the novelty of the research object of smart construction site, it is still in the initial stage of development, and smart construction site has not yet realized its "wisdom", and the integrated application of more emerging technologies in smart construction site needs to be explored.

2. The Application Role of Artificial Intelligence Technology in Construction Management

2.1 Smart site Safety Management - Monitoring and Prevention

An important role of artificial intelligence in construction management is to enhance the safety of the site. Through intelligent monitoring cameras and sensors, the system is able to detect and analyze the behavior of workers and equipment in real time and identify potential safety hazards [1-2]. Intelligent algorithms are also able to predict possible accident risks and issue real-time warnings to help management teams take timely measures to ensure site safety. The contents of safety management are shown in Table 1.

Table 1: Content of safety management of smart site

Management content		Technology application	Software/hardware equipment
Hazard management	Hazard identification	BIM technology	Management platform
	Safety inspection	Mobile technology	Mobile terminal
	Video surveillance alert	AI identification technology, video surveillance technology	Surveillance equipment
Personnel safety management	Personnel real name system management	Face recognition technology, Internet technology	Intelligent access control equipment
	Personnel location	BIM technology, iot technology(RFID, GPS)	Smart helmet,RFID tag, GPS positioning device
	Unsafe behavior monitoring	AI recognition technology	Intelligent video surveillance
	Safety education	VR technology	VR experience equipment
Mechanical equipment safety management	Tower crane,lift, unloading platform safety monitoring	Video surveillance technology, Internet of Things technology, Internet technology	Monitoring sensing Sound and light alarm
Safety management	High support mold, deep foundation pit	Internet of Things technology, Internet technology	Sensingequipment, soundand light alarm
Dangerous area safety warning	Dangerous area alarm	Internet of Things technology	Electronic fence, infrared proximity detector, sound and light alarm
	Border protection monitoring	Internet of Things Technology	
	Perimeter protection	Iot technology	

2.2 Application of Artificial Intelligence Technology in Construction Schedule Management

Through literature research and web project example retrieval, the current content of smart site progress management mainly includes visual progress planning, construction progress simulation and dynamic progress tracking [3-4]. This paper searches for four examples of intelligent site engineering projects through the Internet, namely Hangzhou Center, Asian Cup Qingdao Youth Football Stadium, Xiongan station house and Zhejiang Construction. Through the literature and

project examples, the current intelligent site schedule management is mainly based on BIM technology. The specific management content and technical application are shown in Table 2.

Table 2: Content of smart site progress management

Management content	Technology application	Software/hardware equipment
Visual progress planning	BIM technology, Internet technology	BIM software and management platform
Construction progress simulation	BIM technology	BIM software and management platform
Dynamic progress tracking	BIM technology, mobile Internet technology, Internet of Things	Management platform, mobile APP, drone

2.3 Application of Artificial Intelligence Technology in Construction Quality Control and Intelligent Inspection

In the field of construction, the application of artificial intelligence technology has shown significant potential in quality control and intelligent inspection. With the help of visual recognition technology and sensor data, the system can monitor quality indicators during construction in real time to ensure that the project complies with relevant standards and specifications. The introduction of this intelligent inspection not only improves the quality level during the construction phase, but also is expected to reduce the defect rate and reduce later maintenance costs. The collection and analysis of sensor data is also an important application of artificial intelligence in quality control. By deploying various kinds of sensors on the site, such as temperature sensors, humidity sensors, vibration sensors, etc., the system can monitor the physical state of construction materials and structures in real time. The real-time analysis of this data helps to identify potential problems, such as cracks, deformations or material defects, in advance, so that preventive measures can be taken to ensure that the construction quality meets the expected level [5-6].

2.4 Application of Artificial Intelligence Technology in Intelligent Resource Management

In terms of intelligent resource management, the application of artificial intelligence technology involves the intelligent allocation of human, material and financial resources, which provides more efficient means of resource planning and management for projects [7-8]. Through data analysis and machine learning algorithms, the system can predict the resource demand at each stage of a project, thus helping the management team to plan and dispatch personnel, equipment and financial resources more intelligently.

3. Smart Worksite System Innovation Case Study

The smart site system has demonstrated its multi-level and multifaceted application value in practice. This not only improves the efficiency and quality of construction management, but also lays a solid foundation for the digital transformation of the entire construction industry. These cases demonstrate the potential of AI in construction management and provide powerful implications for wider applications and innovations in the future (Table 3).

Table 3: Smart worksite system innovation case

Innovative Application Topics	Specific practices	Innovative points
Real-time monitoring and forecasting	A smart site system has been introduced to collect data from the construction site in real time through a large number of sensors and monitoring devices.	Through artificia intelligence algorithms, the system is able to analyze data on workers, equipment and the environment in real time, and predict possible problems and delay factors.
Intelligent resource scheduling and optimization	The smart site system is introduced to solve the problem of low efficiency of resource allocation and scheduling in Traditional construction management.	Through machine learning and real-time data analysis, the system is able to intelligently dispatch personnel and equipment according to different engineering stages and task requirements.
Intelligent safety monitoring and accident prevention	A smart site system has been introduced at the construction site to improve the level of site safety management.	The smart site system combines camera and sensor technology to monitor the behavior of workers and equipment in real time.
Intelligent quality inspection and automated review	Use a smart site system to improve quality control during construction.	Through the introduction of visual recognition technology, the system is able to monitor the quality of building materials and engineering structures in real time.
Data-driven decision support system	Commit to smarter project decision making with Smart worksite systems.	The Smart Worksite system provides comprehensive project Insight through big data analysis.

4. Problems Existing in Intelligent Building Construction Management

4.1 The Technical Level Is Not High

Although the concept of intelligent construction management has been gradually introduced into the construction industry, the actualapplication, the technical level is still relatively low. On the one hand, the technical update of the construction industry is slow, and many construction enterprises lag behind in the updating of technical equipment, resulting in a relatively low level of information technology on the construction site, and intelligent construction management can not fully play its role[9]. On the other hand, the current intelligent construction management technology on the market is not mature enough, there are some technical problems, such as sensor technology, artificial intelligence algorithm and other aspects still need to be further improved and perfected, in order to improve its reliability and effect in actual construction.

4.2 Lack of System Planning Concept

Intelligent construction management should be a system project, need to carry out comprehensive planning and design for the entire construction process, including project management, schedule management, quality management, safety management and other links. However, in the practical application, many construction enterprises only pay attention to the intelligent construction management of a single link, the lack of overall planning concept, resulting in poor management results. For example, some enterprises may only introduce intelligent

technology in project management, but still adopt traditional ways in schedule management, quality management and safety management, resulting in poor information transmission in the construction process, and problems are difficult to find and solve in time.

4.3 Lack of Rationality of Competition in the Same Industry

In the current environment of fierce market competition, some construction enterprises may lack rationality in intelligent construction management in order to pursue the number and speed of projects. For example, just to stand out in the competition, some enterprises may blindly introduce some immature or not in line with the actual needs of the project intelligent technology, leading to waste of resources and poor results. At the same time, due to the lack of reasonable competition mechanism and norms, some enterprises may lack active cooperation and coordination in intelligent construction management, leading to the problem of resource dispersion, information imcirculation and poor management effect.

5. Strengthen the Concrete Measures of Intelligent Construction Management of Buildings

5.1 To Enhance the Intensity of Technology Research and Development

The government, enterprises and scientific research institutions should increase investment to promote the development and application of intelligent construction management related technologies. First, in terms of hardware, enterprises can develop and introduce more advanced building construction equipment and tools, such as intelligent robotic arms, drones, laser scanners, etc., to improve the automation level of construction sites[10-11]. Secondly, in terms of software, enterprises can develop software systems for building construction management, including construction schedule management, resource allocation management, quality inspection management, safety management, etc., so as to realize the digital management of the construction process. In addition, enterprises can also strengthen the research and application of big data, cloud computing, artificial intelligence and other technologies, so as to provide more advanced data processing and decision support for intelligent construction management of buildings. At the same time, enterprises need to develop suitable intelligent construction management solutions for different projects and scenarios. Different projects and scenarios have different construction management needs, so technology research and development and application need to be carried out according to the actual situation [12-13]. For example, in the field of residential construction, intelligent prefabrication technology can be developed to realize industrial production and intelligent construction of residential buildings; In the field of large-scale infrastructure construction, intelligent construction machinery and monitoring system can be developed, so as to realize the intelligent management of complex construction environment.

5.2 Strengthen Effective Supervision of Engineering Supervision

In order to ensure the compliant operation and effective management of the construction process, the regulatory authorities should first formulate clear regulatory standards and norms, including the technical, operational, data security and other requirements of intelligent construction management. This involves specifications on equipment performance, data processing safety, environmental protection and production safety. Through the formulation of these standards, enterprises can be guided to comply with the operation and ensure the quality, safety and environmental protection of projects. Secondly, the regulatory authorities should send professional inspectors to carry out regular inspections to ensure the construction operation, equipment safety and quality control.

Violations found should be corrected in a timely manner, and legal responsibilities should be pursued, and a strong supervision mechanism should be established. At the same time, communication and cooperation with enterprises should be strengthened, information sharing and technical support should be strengthened, and enterprises should be promoted to improve the level of intelligent construction management. The regulatory authorities also need to continuously improve the level of supervision technology and apply technologies such as monitoring, data collection and processing, and identification of violations to improve the effectiveness and efficiency of supervision [14]. Finally, an inter-departmental liaison mechanism should be established to cooperate with relevant departments to jointly promote the healthy development of intelligent construction management of buildings. For example, establish an information sharing platform with construction, planning, environmental protection, public security and other departments to realize the interconnection of construction site information so as to detect and deal with violations in a timely manner.

5.3 Strengthening and Improving Relevant Laws and Regulations

First of all, intelligent building construction management involves the design, construction, acceptance and other links of construction projects, which need to comply with national and local building laws and regulations. With the increasing application of intelligent technology in the field of construction, building regulations should be revised and improved accordingly to the technical requirements, operating processes and data security of intelligent construction management, so as to ensure compliance and safety in the building construction process [15]. Secondly, the intelligent construction management of buildings relies on information technology, including the application of cloud computing, big data, Internet of Things and other technologies. Relevant information technology regulations should adapt to the intelligent construction management, clarify the compliance requirements of data collection, storage, transmission, processing and other links, and protect user privacy and data security. In addition, the intelligent construction management of buildings involves a large number of sensors, monitoring equipment and other data collection and processing, involving the privacy information of the construction site and practitioners. Therefore, privacy protection regulations should regulate the data collection and processing in intelligent construction management to protect the privacy and information security of relevant personnel. Finally, the intelligent construction management of buildings involves a large number of data collection, transmission and storage, including construction site monitoring data, material management data, and construction personnel information and so on. Relevant data security regulations should standardize the data security in intelligent construction management, ensure the safe transmission, storage and use of data, and prevent data leakage and abuse [16].

6. Conclusions

The application of artificial intelligence in construction management is highly extensive. Through the implementation of smart site systems, AI technology plays a pivotal role in enhancing efficiency, optimizing resources, and strengthening safety management. The real-time monitoring and data analysis provided by the system offer construction teams swift and accurate means for resource allocation and schedule planning. Simultaneously, innovative monitoring of quality and safety is achieved through visual recognition technology and sensor data. This application not only propels the digital transformation of construction management but also aligns with the trend of multidisciplinary collaboration, providing substantial insights for the future development of the construction industry.

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