Artificial intelligence and applications in the construction industry in Vietnam

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KEYWORD	ABSTRACT
Artificial intelligence (AI) The benefits of AI Construction industry	The construction industry plays a crucial role in the socio-economic development of the country, providing essential infrastructure and facilitating the growth of manufacture, business, commerce, and service activities. In the context of digital transformation bringing numerous benefits to enterprises in Vietnam, digital transformation in the construction industry is essential, serving as a positive catalyst, helping construction enterprises enhance labor productivity and develop construction products in the context of global integration. Artificial Intelligence (AI) aids managers in easily identifying errors that are difficult for humans to detect, thereby minimizing potential risks in construction activities such as design, construction supervision, and urban management. This paper outlines the benefits of applying AI to certain tasks in construction projects, discussing the limitations, and proposing measures to further the development of AI technology applications in the construction industry in Vietnam.

1. Introduction

The Fourth Industrial Revolution presents an opportunity for economic growth. In June 2020, the Ministry of Construction issued Decision No. 1004/QĐ-BXD approving the "Digital Transformation Plan for the Construction Industry for the period 2020-2025, with orientation towards 2030." The purpose of digital transformation in the construction industry is to enhance labor productivity, increase the competitiveness of products, goods, and enterprises in the construction sector as well as improve the efficiency of state management in construction. The Digital Transformation Plan for the construction industry identifies specific targets within the scope of state management by the Ministry of Construction for the application of scientific and technological achievements in digital transformation such as applying Geographic Information Systems (GIS) in urban planning and construction management; applying Building Information Modeling (BIM) in construction investment activities; and applying digital technologies and AI in construction management, smart urban management, and digital enterprises [1].

AI technology is one of the four digital technologies (AI, Internet, Big Data, Cloud Computing) prioritized for research, development, and application in Vietnam during the Fourth Industrial Revolution. In line with the global trend of AI development, Vietnam is also gradually promoting research, application, and the development of high-quality human resources. On January 26, 2021, the Prime Minister issued the "National Strategy for Research, Development, and Application of AI until 2030." The strategy aims to promote research, development, and application of AI to make it a key technology sector in Vietnam. By 2030, Vietnam aims to become a hub for innovation,

creation, development of measures and applications of AI solutions in ASEAN and globally. The goal by 2030 is to establish AI as a significant technological sector in Vietnam, with the country striving to rank among the top four in ASEAN and the top 50 globally in AI research, development, and application. Additionally, the strategy aims to create 10 reputable AI brands in the region, develop three national centers for big data storage and high-performance computing, and connect domestic data centers and high-performance computing centers into a network to share big data and computing capacity for AI purposes [2].

To implement the government's strategy, on June 23, 2021, the Ministry of Science and Technology issued Decision No. 1678/QĐ-BKHCN on "The issuance of the implementation plan for the National Strategy for Research, Development, and Application of Artificial Intelligence until 2030." The Ministry of Science and Technology focuses on developing high-quality human resources in artificial intelligence in Vietnam, as well as building big data infrastructure as directed by the government.

According to the "Government AI Readiness Index" report conducted by Oxford Insights, which evaluates based on three pillars: Government, Technology, and Access to Data and Infrastructure, Vietnam's AI readiness index averaged 53.96 points after two years of implementing the strategy. This placed Vietnam 55th out of 181 countries/territories worldwide in the 2022 assessment, an improvement of 7 positions from 2021. In 2023, Vietnam achieved an average score of 54.48 points (up from 51.82 points in 2021), ranking 59th out of 193 countries/territories assessed. This marks the third

consecutive year Vietnam has surpassed the global average and ranked 5th out of 10 ASEAN countries.

In the construction industry, the application of digital technology platforms such as AI in activities ranging from design and construction to operations management, along with the use of Building Information Modeling (BIM), has led to the creation of construction products that are optimized for functionality and higher quality. These technologies

help minimize risks that might not be detected promptly by humans during implementation. However, the development of the construction sector is influenced by factors such as cost, time, health, occupational safety, productivity, and labor shortages, which contribute to the industry's slow progress in digital transformation, particularly in the application of Artificial Intelligence (AI).

Table 1. Summary of Vietnam's Global AI Readiness Index Evaluation Results for 2021-2023.

Comparision	2021		2022		2023	
	Evaluation Score	Ranking	Evaluation Score	Ranking	Evaluation Score	Ranking
In Global	51,82	62/160	53,96	55/181	54,48	59/193
In ASEAN		6/10		6/10		5/10

(Source: [4])

2. Overview of AI

AI is a field within computer science that involves programming by humans to enable computers to exhibit human-like intelligence. This includes capabilities such as understanding and solving problems, comprehending language for communication, and image recognition, etc.

AI is a technology that enables computers and machinery to simulate human intelligence and problem-solving abilities. With the rapid advancement of science and technology, AI systems, featuring exceptional capabilities, are widely and successfully applied in various manufaturing activities and everyday life. These systems assist managers in effectively controlling operations, leading to increased profitability, efficiency, safety, and security [5].

Fields of AI technology include machine learning, computer vision, robotics, and knowledge-based systems.

- Machine learning is a field related to the design and use of computer programs that learn from experience or data in the past without requiring explicit programming to solve specific problems. Machine learning is employed to analyze large datasets for the purposes of modeling, control, or prediction using statistical techniques.

- Computer vision is a field focused on the artificial simulation of human visual systems to automatically recognize and describe images accurately and effectively. Computer vision employs methods for collecting and processing image and video data through advanced algorithms and precise image analysis to identify objects, recognize faces, and more. Numerous computer vision applications are utilized in various domains including entertainment, business, healthcare, and transportation.

- Robotics is a highly automated technology that performs physical tasks in the real world. It is an interdisciplinary field involving the design, production, operation, maintenance of robots, and other computational actions to simulate human physical movements. Robots are employed for highly specialized tasks and are designed in forms most suitable for their intended purposes, which do not necessarily have

to resemble human shapes. They interact with their environment using sensors and actuators [6].

- Knowledge-based systems are a branch of AI focused on machine decision-making based on existing knowledge. Essentially, a knowledge-based system comprises a knowledge base, an inference engine, and a user interface for interaction. The knowledge base is derived from expert knowledge in the field, past cases or experiences, or other relevant sources. Its main advantages include increased productivity and efficiency due to the easy access to and interaction with extensive domain knowledge. Knowledge-based systems provide reasoning and draw conclusions based on experience, flexibility, and transparency, while offering logical advice when necessary [5].

3. Benefits of Applying AI in the Construction Industry

The construction industry, characterized by its specialized and labor-intensive nature, has experienced a slower rate of technological advancement compared to other sectors. With the goal of enhancing the industry's capabilities by 2030 to handle all aspects of management, design, procurement, and execution of modern, complex, and large-scale construction projects, the industry aims to gradually compete and expand its market presence internationally. The application of technology in construction investment management, design, execution, and quality control is essential to achieving this objective [7].

* Project Preparation Phase: including activities related to preparing for the investment process, such as conceptual design, project proposal development, and feasibility studies. It begins with the examination of potential sites, design considerations, and the formulation of capital utilization plans.

- Design Work: This aspect plays a crucial role in ensuring that construction projects are designed efficiently and optimally, leading to savings in time and costs while delivering numerous benefits such as enhanced safety and quality, improved aesthetics and functionality, and ensuring sustainability and environmental friendliness. The application

of AI in construction design can achieve optimal outcomes by automating tasks, shortening design phases, advancing machine learning and deep learning technologies, predicting risks, personalizing customer experiences, and developing smart buildings [8].

- Investment Proposal Development: The application of AI during the initial design phase is highly beneficial for conducting feasibility studies of projects. Risks can be identified and analyzed using various data sources, including financial data, market data, and information on the potential environmental impacts of the project. Risk analysis can support decision-making regarding whether to proceed with the investment. AI technology will enhance the accuracy of the project evaluation process [9].

* Project Implementation Phase: including the primary tasks of: detailed design, contractor selection, and construction execution.

- Detailed Design: The design process plays a critical role in construction activities. To achieve a well-optimized design that ensures safety given the extensive scope of work, architects must maintain a high level of focus. Utilizing AI technology can optimize the design process and identify factors influencing the design by researching and gathering data on the environment, materials, and other relevant aspects. This helps in determining a suitable design approach for the project, as well as recommending specific materials, design languages, and necessary costs based on available data.

At the *"What Are the Leading Trends in the Architecture and Construction Industry of the Future – Showcase: AI Applications in Architecture and Construction"* seminar held on December 9, 2023, in Da Nang, it was noted that before the advent of supportive machinery, designing an architectural proposal required an average of approximately 15 hours (6 hours for idea generation, 3 hours for initial sketches, and 6 hours for completion). Currently, software such as CAD, REVIT, 3D Studio Max, and Photoshop have reduced the time needed for initial sketches to about 1 hour and completion to approximately 3 hours, totaling around 10 hours for an architectural proposal. In contrast, with AI applications such as Midjourney AI, Veras, ArchitechTures, Testfit, and DALL-E, only 0.5 hours is required for entering descriptive keywords into the software, no time is spent on initial sketches, and 0.5 hours is needed for selecting the proposal (instead of finalizing the drawing) to generate 50 to 100 complete design works. This illustrates how AI applications are gradually transforming design habits, methods, and concepts in architecture for the future.

- Contractor Selection Organization: involving dividing the plan among businesses and construction contractors for the bidding process. Contractors, general contractors, and building material suppliers will assess the project scope, identify opportunities, analyze bidding strategies, and decide which contractor is awarded the contract. Contractors can utilize AI technology to streamline processes, automate repetitive tasks, enhance decision-making speed, and evaluate projects more efficiently [9].

- Construction Execution: The construction process on-site involves numerous concurrent activities managed by various teams and multiple subcontractors, particularly in large-scale projects. This environment inherently carries risks related to quality, time, and cost that are difficult to anticipate. The application of AI technology can enhance the automatic detection and monitoring of these risks, enabling timely interventions to mitigate them. Automation and mechanization in the construction process are effective solutions for reducing costs, shortening construction time, and improving the quality of the built environment. Specifically:

+ Autonomous construction machinery is employed to perform repetitive tasks more efficiently than human labor, such as concrete pouring, tile laying, welding, and demolition. Excavation and site preparation are carried out by fully or semi-autonomous bulldozers, guided by programmers to achieve precise specifications. This approach alleviates manual labor and reduces the time required to complete projects. Project managers can monitor site activities using on-site facial recognition cameras and similar technologies to assess worker productivity and compliance with operational procedures [10].

+ Prefabricated Structural Components and Robotic Assembly: Certain structural components of a construction project can utilize prefabricated elements produced in a factory, combined with robotic systems for automated assembly. This approach reduces construction costs and ensures a more accurate and efficient building process. Components such as walls can be assembled using automated assembly lines, which are more effective than manual labor. This allows workers to focus on detailed tasks, such as the installation of electrical and plumbing systems, once the prefabricated elements are assembled [10].

+ Occupational Safety: The nature of labor on construction sites inherently involves various risks and hazards. According to statistical data from several regions, the construction sector consistently reports high rates of workplace accidents, primarily due to: inadequate observation and focus on tasks; non-compliance with disciplinary standards and regulations; failure to adhere to safety procedures; and incomplete use of essential protective equipment. To monitor workers during construction activities, a construction company based in Boston, USA, has developed an algorithm that analyzes images from the job site, scans them to detect safety hazards such as workers not wearing personal protective equipment, and cross-references these images with records within the company. This system enables the organization of emergency safety meetings upon detecting high-risk threats, thereby helping to mitigate risks related to occupational safety.

* Operation Phase: Maintenance of Structures: During the operational phase, the maintenance of a building is essential to ensure its normal and safe functioning in accordance with design specifications. Maintenance involves the use of energy and materials during repair and renovation processes. Therefore, by collecting structural data through sensors, drones, and other wireless technologies, advanced AI-supported analytical algorithms can gather information on performance and surrounding environmental factors, facilitating

sustainable and timely maintenance of the building. Additionally, AI technology can predict when certain structural components might fail or when heavily used components require attention. AI can assist in automating scheduling, detecting faults, and providing recommendations to maintenance personnel. This contributes to saving time and costs associated with maintenance while minimizing material consumption [10, 11].

4. Development of Artificial Intelligence Applications in the Construction Industry in Vietnam

4.1. Some Limitations in the Application of AI in the Construction Industry

- The legal framework for the application of AI technology in Vietnam lacks specific regulations.

- Data Security: With the advancement of society, data security has become a top concern in the digital transformation process. The application of AI technology, which involves large databases, can pose risks to data security, as information theft has become a significant threat to individuals and businesses.

- High Investment Costs: The investment required for AI technology in the construction sector is significantly large compared to the scale of implementation by enterprises. This high cost is one of the factors that slows down the adoption of scientific and technological advancements in the construction industry. These costs encompass data infrastructure, data collection and management, and expenses related to maintaining and updating systems in line with evolving trends.

- Workload: The construction industry, characterized by its heavy-duty nature, large volume of work, and interwoven tasks during project execution, presents a challenge that must be addressed when integrating modern technologies.

- Labor Supply: The construction industry's harsh working conditions, outdoor environments, high risk levels, and low wages contribute to a shortage of workers, particularly skilled labor, which is critical when implementing AI technologies in construction.

4.2. Solutions to Promote the Application of AI in the Construction Industry in Vietnam

The development of AI technology applications is an inevitable trend in the era of Industry 4.0. Therefore, to advance the application of AI in construction, there is a need for urgent research, analysis, and implementation of suitable AI technologies throughout the project execution, construction process, and operational management. Some specific solutions include:

(1) Develop and complete the legal framework, mechanisms, and policies to ensure the rights and responsibilities of enterprises in the implementation and application of AI technologies in the design, management, supervision, and operation of construction projects. As of July 2024, there are currently no legal regulations in Vietnam regarding the development and application of artificial intelligence, and there are no specific regulations guiding its application in the construction field. To develop a comprehensive legal system for artificial intelligence, it is important to base on existing laws such as the Civil Code, Law on Enterprises, Law on Cybersecurity, Law on Information Technology, Law on Consumer Protection, Personal Data Protection Decree, etc. For example, the Civil Code can address issues of liability and ownership of AI technology, the Law on Cybersecurity and the Personal Data Protection Decree can help prevent, detect, deter and handle violations related to personal data in AI systems.

(2) The government should implement policies to support enterprises with the investment costs for AI technologies, facilitating early access to more advanced technologies. It is also essential to create conditions for construction firms to train skilled and highly qualified labor, while enhancing income levels to attract talent.

(3) Develop a training plan to equip the workforce with knowledge of AI technologies and to guide the future development of AI. Establish regulations that encourage employees to be proactive and engaged in learning, researching, and applying new technologies.

(4) Enhance cybersecurity measures to ensure the protection of personal and corporate databases during the exploitation and use of such data.

(5) Develop a clear and specific plan and roadmap for the application of AI technology. Regularly assess and derive lessons from these evaluations to leverage the advantages and strengths while addressing limitations, with the aim of expanding the implementation of AI technology in the construction industry at an early stage.

5. Conclusion

Artificial Intelligence (AI) represents a global trend that is significantly impacting production and daily life, offering numerous benefits in terms of time efficiency and increased labor productivity. It is essential to actively research, learn, and apply new AI technologies to enhance the quality of construction products. This approach will help meet the expectations of users and investors by creating optimized, high-quality products that are cost-effective and time-efficient while maintaining superior quality.

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