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AI in Innovative Building Construction Design for Environmental Technological Development

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Abstract: *the capability of a machine to imitate human behavior with the aid of algorithms to tackle complex issues is known as Artificial Intelligence (AI). Artificial Intelligence (AI) is increasingly shaping industries worldwide, and construction is no exception. Construction projects are often complex, involving multiple stakeholders, uncertain environments, and risks that affect safety, cost, and delivery. AI, with its ability to analyze data, predict outcomes, and automate processes, offers promising solutions. It can enhance planning, design, monitoring, safety, and efficiency, while also reducing waste and delays. Past studies have shown AI applications in predicting housing prices, improving site safety, and forecasting project delays. However, despite its potential, the adoption of AI in construction remains limited. The purpose of this paper, titled AI in Innovative Building Construction, is to examine how AI can address persistent industry challenges—such as delays, high costs, labor shortages, safety risks, privacy concerns, lack of skilled workers, poor infrastructure, and an aging workforce—while also exploring the barriers that hinder its full integration. Addressing these issues requires collaborative efforts from governments, industry leaders, and institutions. Suggested solutions include financial support for firms, stronger cybersecurity, continuous training, investment in infrastructure, and attracting younger, tech-savvy talent. If these challenges are tackled, AI can transform construction into a more efficient, safer, and sustainable industry, positioning it for long-term growth and competitiveness.*

Keywords; *Artificial Intelligence, Challenges, Construction, Infrastructure, Innovation, Project Management, Workforce,*

Introduction

The field of Artificial Intelligence (AI) is rapidly expanding and attracting attention from both practitioners (Gartner, 2020) and academics (Iansiti & Lakhani, 2020) across various management disciplines. It is anticipated to have a significant impact on project management (PM) (Auth et al., 2019).

The PM field was initially dominated by construction projects, but their role has become less prominent over time, although new sectors and non-traditional industries also apply PM practices and still constitutes a major part of the evolving PM body of knowledge (Carden & Egan, 2008). The construction industry, being a well-established field of professional PM, presents an intriguing case to explore how emerging technologies, like AI, can enhance and transform the profession.

The construction industry is currently encountering several major challenges, even though its importance is critical. The construction industry is facing labor shortages, as aging workforces are concerned about safety, and the supply chain disruptions have caused fluctuating material costs. Inefficient project management practices and poor communication are also contributing to delays and increased costs (Pan and Zhang, 2021).

The purpose of this paper, titled "AI in Innovative Building Construction Design for Technological Development", is to examine how Artificial Intelligence can address the construction industry's major challenges—such as delays, high costs, labor shortages, safety risks, privacy concerns, lack of skilled workers, poor infrastructure, and an aging workforce—while also exploring the barriers that limit its full adoption (Auth et al., 2019).

Concept of Artificial Intelligence (AI)

The concept of Artificial Intelligence (AI) was first coined in 1950 by Alan Turing in his work "Computing Machinery and Intelligence". In 2006, John McCarthy and his colleagues published a paper on "The Logic of Computation", in which they proposed a definition of AI as the ability of machines to perform tasks that require human-like intelligence. Since then, the field of AI has grown and evolved, with numerous advancements being made in the areas of machine

learning. AI is now being designed to consider both external factors and desired outcomes, leading to the definition of AI as "systems that exhibit intelligent behavior by analyzing their surroundings and autonomously taking actions to accomplish particular objectives" (EC, 2018), or as "a system's capability to accurately interpret external information, learn from it, and utilize those learnings to accomplish specific goals and tasks through adaptive flexibility" (Kaplan & Haenlein, 2019).

The capability of a machine to imitate human behavior with the aid of algorithms to tackle complex issues is known as AI (Salehi and Burgueño, 2018). The goal of AI is to make machines capable of reasoning, planning, processing, perceiving, moving and manipulating objects, similar to humans, in order to address complex organizational or daily problems (Adio-Moses and Asaolu, 2016). Boileau (2019) explains that AI is composed of smart systems that can process both structured and unstructured data, in order to mimic human behavior and make decisions based on that knowledge.

AI in innovating building construction and it's application

Eber (2020) suggests that AI has the capacity to address issues that are beyond the capabilities of the human mind due to their complexity or the sheer volume of data involved. Güngör (2020) states that it also generates ease, enhances efficiency, and adds worth to a system. Vinuesa et al. (2020) have discovered that AI can be used in various fields and has a beneficial impact on the environment, society, and economy.

The construction industry is a perfect fit for AI due to its complexity and uniqueness. As an example, projects in the industry are unique, construction products are stationary, numerous stakeholders and regulatory bodies are involved, and work packages are disjointed. The complexity of the industry's features makes project management challenging and overwhelming for humans, which hinders the industry's performance. The construction industry is plagued with performance problems such as cost and time overruns, safety issues, legal disputes, waste production, and environmental contamination (Hayati et al., 2017, Durdyev, 2021 and Luangcharoenrat et al., 2019). Salehi and Burgueño (2018) and Afolabi et al. (2020) state that AI can improve the speed and quality of construction activities, and lower the amount of material and risk involved (Froese, 2010). The construction industry can benefit from the use of BIM, as it can help with the planning, design, monitoring, and maintenance of construction facilities (Allam and Dhunny, 2019), which can improve the overall performance and competitiveness of the industry.

In the past, there have been studies conducted on the use of AI in the construction industry. For example, in 2018, Khobragade et al., applied Artificial Neural Network (ANN) algorithm to forecast housing rates for enhancing the planning, construction, and sales of buildings. According to Poh et al. (2018), machine learning was employed to create indicators that can categorize construction sites based on their safety levels. Mohan and Varghese (2019) employed AI to enhance safety at construction sites. The delay in construction projects was predicted with the help of AI by Yaseen et al. (2020). In 2021, Egwim et al. employed ensemble algorithms to enhance the accuracy of single algorithms in predicting construction project delay. Abioye et al. (2021), Eber (2020), Prieto (2019), Parveen (2018) and Mosly (2017) are some of the reviews that have been conducted on AI in the construction sector.

Challenges in Applying AI in building construction

Despite recognizing the advantages of AI applications, there are still numerous challenges that are pertinent to AI in the construction industry. Pan and Zhang (2021) have identified some challenges; -

1) High Cost: AI systems are expensive to buy and maintain, making it hard for small and medium companies to afford them, even though they may save money in the long run.
2) Privacy and Security: AI needs large amounts of data, but sharing this data can lead to risks like cyberattacks and privacy leaks.
3) Workforce Adaptation: Many workers lack the digital skills needed to use AI tools effectively, so training is necessary.
4) Poor Infrastructure: Some construction sites, especially in remote areas, don't have strong internet or the right equipment to support AI.
5) Aging Workforce: The construction industry finds it hard to bring in younger, tech-oriented workers, while many of the existing workers are older and often less willing to embrace new technologies.

Solutions to Identified Challenges

1) Governments and industry leaders can provide funding support, subsidies, or flexible financing plans to help small and medium companies afford AI tools. Over time, wider adoption will also reduce costs (NIST, 2023).
2) Strong data protection policies, secure networks, and regular system updates can reduce risks of cyberattacks and keep sensitive information safe (ISO, 2023).

3) Offering continuous training and upskilling programs will help workers gain the digital skills needed to use AI effectively (CITB, 2024).
4) Investment in reliable internet, electricity, and modern equipment is needed, especially in remote project sites, to make AI tools work smoothly (NIST, 2023).
5) The construction sector can draw in younger, tech-skilled workers by making the work environment more digital, offering opportunities for advancement, and highlighting how technology is changing the industry (CPWR, 2024).

Conclusions

AI solutions could be the key to the construction industry staying ahead of the curve in a rapidly evolving market. It is important for contractors to monitor AI due to its forward-looking nature. The books by Iglesia (2024) and Zhang et al. (2021) provide additional details on the use of artificial intelligence in the construction industry.

AI can transform construction by making it faster, safer, and more sustainable. The main barriers—cost, security, skills gaps, poor infrastructure, and an aging workforce—can be solved through investment, training, and attracting young talent. If addressed, AI will help the industry grow stronger, more innovative, and future-ready.

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