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A Comprehensive Review of Artificial Intelligence Applications in the Construction Industry: Current Trends, Potential Impacts, and Future Directions

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Abstract: The construction industry is pivotal to global economic growth but faces numerous challenges, including low productivity, limited digitization, and resistance to technological change. Artificial Intelligence (AI) offers transformative potential to address these issues by automating processes, optimizing resource allocation, and enhancing project management. This paper provides a comprehensive review of AI applications in the construction industry, exploring its current trends, potential impacts, and future directions. It examines AI-driven innovations such as robotics, autonomous machinery, and defect detection systems, emphasizing their contributions to efficiency, sustainability, and safety. Case studies highlight successful AI implementations, while discussions on workforce implications and adoption barriers shed light on ongoing challenges. The paper concludes by emphasizing the need for strategic investments, workforce training, and ethical considerations to harness AI's transformative potential effectively.

Keywords: Artificial Intelligence, Construction Industry, Digitization, Sustainable Infrastructure, Robotics.

INTRODUCTION

For the prosperity of any nation, the construction industry is quintessential. It is one of the cannonading industries of today that has a great impact on the economy of any nation (Holloway, 2018). The world has gradually moved from the traditional way of solving problems especially in building and construction to technology based approach and as the world becomes more technologically advanced and digitized (Oladunmoye 2020). The construction industry contributes largely to economic growth by generation of output, creation of employment, generation of income and redistribution. The construction industry accounts for more than 10% of global GDP (6-9% in developed countries) and employs about 7% of the global workforce (around 273m+ people). The output of the global construction industry was worth an estimated $10.8 trillion in 2017 (Technofunc, 2020). The construction industry also provides infrastructure and avenues for creation of buildings to generate income and facilitate employment creation. It as well contributes to the quality of life for individuals and communities by enhancing access to essential services and promote social wellbeing (Technofunc, 2020). By creating safe and functional spaces, the construction industry enhances the overall wellbeing and happiness of society.

Unfortunately, the construction industry is faced with many challenges, that has hindered its growth and led to extremely low productivity levels when compared with other industries such as; manufacturing. As a matter of fact, the construction industry is one of the least digitalized industries in the world and most stakeholders acknowledge the age long culture of resistance to change. The lack of digitization and overly manual nature of the industry makes the projects management more complex and unnecessarily tedious. The absence of adequate digital expertise and technology adoption within the construction industry has also been linked to cost inefficiencies, projects delay, poor quality performance, un-informed decision making and poor performance in term of productivity, health and safety. Innovation means that construction industry should use all the new and higher available technologies to improve the quality of its core components, to deliver better services and to reduce its environmental impacts (Oladunmoye & Obakin 2023). In recent years, it has become apparent that construction industry must embrace digitization and rapidly improved technological capacity, especially with challenges of existing labor shortages, and need to provide sustainable infrastructures (Abioye *et al.,* 2021). Because of these challenges, opportunities for the use of technological advancement in the construction field has been explored. These advancements range from the use of robotics, 3D printing, augmented reality (Manny, 2023) and finally the use of artificial intelligence to increase the efficiency of the construction process.

Artificial Intelligence (AI) can be defined as the ability of a digital computer or computer-

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controlled robot to perform tasks commonly associated with intelligent beings (Ying, 2022). It is the ability of a computer to behave and interact just the same way a human does. AI has been used across various fields to improve efficiency, cut down on time and increase accuracy. The adoption of AI techniques has helped to enhance automated and provide better competitive advantages as compared to conventional approaches. The subfields of AI such as machine learning, natural language processing, robotics, computer vision, optimization, automated planning and scheduling, have been applied to tackle complex problems and support decision-making for real-world problems (Abioye *et al.,* 2021). AI has significantly helped several important industries such as the manufacturing industry by facilitating the development of new manufacturing models assisted with modern technologies in the domain of intelligent manufacturing (Chaudhuri, S, & Krishnan, 2022). The healthcare sector in diagnostics and medical imaging. AI algorithms can analyze medical images, such as x-rays, CT scans, and MRIs, to detect abnormalities, tumors and other conditions with high accuracy (A, A, & Amalraj, 2023). The finance institution, from algorithm trading to risk management and customer service by reshaping every aspect of finance, offering unparalleled insights, efficiency, and competitive advantage (Divya, 2024). In recent decades, the construction industry has remained one of the low-innovation sectors, exhibiting limited productivity and growth. It is clear that the construction industry lags behind other sectors such as manufacturing, retail, and telecommunications in terms of digitalization (Regona *et al.,* 2022). AI can help automate processes, improve project management, enhance safety measures, and optimize resource allocation. By leveraging machine learning algorithms, construction companies can analyze large datasets to gain valuable insights for informed decision-making and predictive maintenance (Adesola, *et al.,* 2023).

Artificial Intelligence (AI) has begun to be used increasingly in the construction industry for its diverse benefits. AI can analyze data from previous projects and make recommendations for optimal designs, materials, and construction methods. This can lead to cost savings and improved project outcomes. AI can also be used in the construction phase to assist with surveying, quality control, and equipment maintenance tasks (Mohapatr, *et al.,* 2023). The traditional way the construction industry works has slowed down its progress. To fix this, companies are exploring AI to help things run more smoothly and get more done (Yigitcanlar & F, 2020). AI is still very much a growing body of research in the construction industry, with diverse levels of adoption across several countries and different project types. But despite the increasing adoption of AI, there have been issues not yet addressed with its implementation with traditional construction methods, its implementation in developing countries and its long-term effect on construction jobs. Also, the construction industry still faces challenges in fully embracing AI. Many companies are still hesitant due to high implementation costs, lack of digital infrastructure, and the need for specialized training. This is why a comprehensive review is needed; to understand its current trends, its potential impacts and its future directions.

AI Adoption in Construction

The adoption of AI in the construction industry has been considerably low (Blanco *et al.,* 2018) when compared to its adoption in other industries. But over the last decade, construction processes have begun to be increasingly carried out by AI or a certain level of an integration of AI. The recent growing adoption of AI in organizations has been encouraged due to its deluge of data and strong computational capacity (Zebec & Stemberger, 2020), with organizations believing that its adoption will help maximize their business value in terms of increasing their business value in the areas of revenue growth, cost reduction and operational efficiency (AlSheibani *et al.,* 2020).

(Ransbortham *et al.,* 2017) conducted a study that proved 80% of companies considered AI a strategic opportunity and 85% considered it a strategy for gaining competitive advantage over their rivals. However, some organizations struggle with effective adoption of AI due to lack of proper understanding of its technologies and application (Fountaine *et al.,* 2019) and many fail to realize its full benefits despite investing in it due to poor application of the technologies.

Common AI Technologies Used in Construction

AI's different components such as machine learning, deep learning, Chabot, neural network, virtual assistance can fundamentally reshape business processes. They also make explain that artificial intelligence has made significant progress with machine learning, especially with its latest development; deep learning which relies on neural network processing to perform operations and

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actions that exceed human actions in terms of speed and relevance.

The adoption of Artificial Intelligence comprises both AI technologies and AI capabilities. AI technologies are the techniques and tools used in the implementation of artificial intelligence in an organization (Lichtenthaler, 2019) and they include machine learning (ML) or deep learning, natural language processing (NLP), computer vision, expert systems, planning and scheduling, and speech synthesis systems (Afiouni, 2019; Lichtenthalar, 2019). Although machine learning applications dominate research interest, other AI technologies can be combined with it to provide solutions to problems, such as chatbots combining neural language processing with machine learning providing human comprehension and response to the chatbots (Castillo *et al.,* 2020). AI and its components are reshaping the construction processes (Kuzey *et al.,* 2020), and helping companies with their operations and with reducing costs of predictions. (Agrawal *et al.,* 2018)

Critical Evaluation of AI Applications in Construction

Al-Sheibani *et al.,* (2018) noted that firms adopting artificial intelligence have a strong propensity to grow as this data-based technology would expand their economies of scale arising from a larger data available at the firm. But, although artificial intelligence is still far from equaling human intelligence, it is extremely effective in performing specific tasks in an organization.

There are some start-ups that offer applications relevant to scheduling and image recognition which is important to construction processes. Using historical data in addition to human-inputs, algorithms can consider millions of alternatives for project delivery and continually enhance the schedules. Image recognition can identify unsafe workers and aggregate this data to inform future training and education priorities. However, any AI algorithm is based on training rather than programs, which means that algorithms need a certain amount of data to perform at the level of humans. Obtaining large data sets is today considered as a limitation for many building companies (Chui *et al.,* 2018). AI may help the construction industry overcome the industry's greatest challenges, including costs, scheduling and safety (Blanco *et al.,* 2018). However, even though the construction industry in the starting phase of the digital transformation, and few projects have actually implemented AI.

Future Directions and Potential Impacts

The future of AI shows improved productivity, quality, and safety on the jobsite (Clavero, 2018). (Bharadwaj, 2018) predicted great future potential for AI in construction. Future improved adoption of artificial intelligence in the construction industry and its processes can improve speed, efficiency and mitigate future challenges tremendously.

AI in Construction Processes

AI has helped improve and transform construction processes with its new technologies such as autonomous machinery, robotics, and Machine Learning (ML).

Robotics and Automation in Construction:
Regarding autonomous machinery and robotics, robots such as Hadrian X and SAM100 have helped in transforming masonry work, significantly reducing labor time (Bock and Linner 2017). Also, automated bulldozers, cranes and other vehicles could facilitate consistency and continually productive work. There is already significant focus on self-driving freight and personnel transport, but potential advantages go further (Parveen, 2018). There are already many companies producing robotic bricklayers. In the future, such robots could build structures in extreme or inhospitable environments and lower human involvement in dangerous tasks on site (Parveen, 2018).

In terms of application of drones for site monitoring and surveying, drones can be used for site monitoring and when equipped with AI technologies can be used additionally for data collection that can be analyzed using AI algorithms. The use of the drones also reduces the need for workers to enter hazardous environments. Examples of such platforms are Buildots and Doxel. Deploying drones and drone mapping software such as Drone Deploy drastically cuts down the time to gather accurate surveys maps and aerial images of a jobsite. This can be used to track progress without having to be on the jobsite. Additionally, the aerial images provide project managers with an additional perspective to identify issues and conflicts they may not view from the ground (Parveen, 2018).

Quality Control in Construction Using AI:
AI and Machine Learning are used for Defect Detection. AI systems significantly reduce costs associated with post-construction defect repairs. They provide real-time feedback and can detect

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cracks in concrete, misaligned beams, or improper installations, using drones or on-site cameras (Li *et al.*, 2019).

Another use for AI is the AI-Enhanced Material Testing and Predictive Maintenance. AI powered technologies and systems can optimize material usage by reducing waste and improving sustainability in construction. AI can offer predictive and material testing abilities.

Safety Management in Construction Using AI: AI is used for Hazard Detection and Risk Management. AI- driven safety systems have been able to significantly reduce accident rates through the identification of risks in real-time and alerting the site supervisors to take immediate preventive action.

AI for Sustainability in Construction

Sustainability has become a major focus in several industries, the construction industry included, as saving the planet has become a popular goal. It is evident that the revolution of AI has led to significant process improvements, cost-efficiency, reduced production times, improved safety and helped to achieve firms' sustainability goals (Abioye *et al.*, 2021).

AI Designs that Reduce Energy Consumption and Improve Sustainability AI in Building Information Modeling (BIM) for Energy-Efficient Designs: AI-driven BIM tools can enable the creation of energy efficient designs through modifications that can help reduce heating, cooling, and lighting while still prioritizing human comfort. AI models can multi-task and identify the most energy efficient options to take, reducing the risk of costly modifications later on.

AI for Passive Design Optimization: Some AI powered tools can improve passive heating and cooling, thereby reducing the need for the installation of mechanical systems needed to enhance human comfort, significantly lowering energy consumption and carbon footprints of buildings.

AI in Material Optimization for Green Construction Practices: AI in Selection of Sustainable Material. AI powered tools and platforms, such as One Click LCA, can compare and contrast the sustainability qualities of different materials and help in the recommendation of alternatives that are more beneficial to the environment.

AI in Reducing Material Waste and Enhancing Efficiency: Since AI can optimize amounts and types of construction materials, AI can also reduce material waste by up to 20% in some large-scale projects.

AI in Lifecycle Analysis and Promoting Circular Construction Models: AI-Enhanced Lifecycle Analysis (LCA). With the integration of AI in construction processes, there is an increased chance of accuracy and speed of lifecycle assessments, helping professionals identify opportunities and reduce buildings' impact on the environment right from the onset. Also, AI can help assess several sustainability scenarios significantly faster than traditional LCA methods.

AI in Circular Construction Models: There is an increasing use of AI in the design of modular buildings, using components that can be disassembled and recused for future projects, contributing to a circular economy of materials. AI therefore has the potential to shift construction processes towards a low-carbon future through efficient use of resources and provision of real-time feedback concerning sustainability metrics.

Impact of AI on the Construction Workforce

While AI has deep advantages on the workforce, there have been issues about this technology affecting the need for human labor and its accompanied skills requirements.

The Role AI in Influencing the Need for Labor and Skills in the Construction Industry

Automated Tasks and Influence on the Demand for Labor: AI has replaced low skills and manual intensive labor with more specialized roles that involve technical expertise (Bock and Linner 2016). It is also important to consider the fact that AI-driven machines can operate 24 hours in day without limitations like human fatigue, thereby increasing productivity. But the rapid adoption of AI in construction processes can lead to unemployment especially where up skilling and reskilling programs are not in place.

Shift in Skill Requirements for Construction Jobs: In the future of construction workforce, there will be a blend of technical and analytical skills (Blanco et al. 2018), and construction workers will need to learn to collaborate with AI technologies in order to optimize workflows. This would help construction workers that successfully acquire necessary digital and technical skills as they will be able to advance in their careers due to the benefits associated with the implementation of AI technologies. On the other hand, this would be

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really terrible for low-skilled construction workers who don't have the resources or the time to acquire these skills.

Creation of New Job Categories: The emergence of AI technologies has created new job opportunities in several industries including the construction industry. AI is creating jobs that blend traditional construction methods with new technological approaches.

Training of Construction Workforce their Upskilling

Need for Upskilling in AI-Driven Construction Processes: To effectively collaborate and align with AI technologies and systems, it is important that construction workers at all levels should receive suitable training because upskilling programs for AI technologies can lead to a more efficient, knowledgeable and safety-conscious workforce. But unfortunately, smaller construction firms may not have the available resources for upskilling of their workers, making the gap between large and small firms even wider in relation to the implementation of AI technologies.

Training Programs for Technical and Digital Skills: Recently, construction companies have begun to collaborate with institutions to focus on AI as it has begun to take preeminence in the industry. Even workers that are past institutional-level schooling can learn about these technologies at their own pace as the virtual training environment is a popular method for up skilling.

Government Initiatives for the Development of the Workforce: There have been various government-backed programs that have been put in place to provide financial support for upskilling of workers in AI technologies (Mahmood *et al.*, 2021). These can ensure a more equitable distribution of opportunities in AI- enabled construction projects.

Successful AI applications in construction (Case studies)

Case Study 1: AI in Determining the Optimal Sequence for Kōkua Facade Installation Using ALICE

Company: Hawaiian Dredging Construction Company (HDCC)

AI Technology: ALICE, an AI-powered construction optioneering platform

Methodology: Hawaiian Dredging Construction Company (HDCC), Hawaii's largest general contractor, undertakes diverse projects in sectors like hospitality, residential, institutional, and infrastructure. For the $88 million Kōkua senior housing project in downtown Honolulu, HDCC faced challenges due to the site's proximity to adjacent buildings, restrictive logistics, and a one-way street with traffic constraints. ALICE was employed to optimize facade installation sequencing. The platform generated thousands of scenarios to identify the most efficient approach, visualizing plans with 5D modeling and enhancing scheduling flexibility.

Key Outcomes:

- Reduced Rework and Waste: Digitization minimized material waste and site rework, promoting sustainability.
- 17% Reduction in Project Duration: Optimized sequencing helped mitigate delays and enhanced adaptability to unplanned changes.
- Cost Savings: Labor and equipment costs decreased by 14% and 12%, respectively.
- By leveraging ALICE, HDCC digitized construction processes, significantly improved efficiency, and achieved adaptability for future projects.

Case Study 2: AI Transforming Construction Processes in the "Office of the Future"

Project Overview: The *Office of the Future*, a groundbreaking project by the Dubai Future Foundation, is the world's first fully 3D-printed office building. Completed in 2016 in Dubai, UAE, the 250-square- meter structure was printed in 17 days using advanced AI-integrated 3D printing technology.

AI Technology: AI and 3D Printing Integration

Design: AI-driven generative design tools explored hundreds of architectural variations, optimizing stability and reducing material waste (Xie & Liu, 2014).

Construction: AI algorithms guided precise layer-by-layer 3D printing, minimizing human intervention and errors (Sepasgozar *et al.*, 2016).

System Integration: AI streamlined the installation of mechanical, electrical, and plumbing (MEP) systems, enhancing efficiency and reducing post-construction modifications (Dubai Future Foundation, 2016).

Key Outcomes:

- Time Savings: The structure's main body was printed in 17 days, with installation and finishing completed in 48 hours (Dubai Media Office, 2016).

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- Material Efficiency: Layer-by-layer printing eliminated waste, supporting the UAE's sustainability goals. Cost Reduction: 3D printing cut construction costs by 50–70% (Dubai Media Office, 2016).
- Design Flexibility: Enabled intricate architectural designs at lower costs (Winsun Global, 2016).

Challenges

Technical Barriers: Scaling 3D printing for larger structures remains challenging due to size and material constraints (Sepasgozar *et al.*, 2016).
Regulatory Resistance: Building codes require updates to integrate such technologies (Ernstsen *et al.*, 2020).
Workforce Training: Retraining is essential to handle advanced technologies effectively (Sepasgozar *et al.*, 2016).

Challenges and Barriers to AI Adoption in Construction

The construction industry has begun to gradually embrace AI technologies in its various sectors. But despite the fact that these technologies propose several benefits, there are still several challenges and barriers that hinder the adoption of AI in the industry. The construction industry is currently the least digitalized industry due to a prolonged resistance to change, making it much more difficult to adopt the new technologies and methods (Young, D., Panthi, K., & Noor, O. 2021).

The lack of digitalization in the construction industry and its continued reliance on manual processes have made the management of projects more complicated and unnecessarily difficult. This obsolete way of working has potentially slowed down progress and created more challenges than needed (Delgado, J. M. D., & Oyedele, L. 2021).

Technological Limitations

Availability and Quality of Data

A major challenge hindering the adoption of AI in the construction industry is that the industry does not have adequate access to consistent and high-quality historical data. For AI to be able to make predictions, automate processes and improve decision making, it relies heavily on the existence of large amounts of historical data. But inconsistency in the quality of data in the industry reduces the effectiveness of AI applications (Cao et al. 2021).

Limited AI System Integration and Interoperability

Developing AI solutions that are compatible with industries' standards can help with resolving integration issues (Eastman *et al.*, 2018). But these AI systems must be flexible enough (customizable) for the variations associated with projects, which at a large scale can be quite difficult to implement (Shen *et al.*, 2019).

Data protection and privacy

In an age of ubiquitous and massive collection of data through digital communication technologies, the right to protection of personal information and the right to respect for privacy are crucially challenged. Both physical AI robots as part of the Internet of Things, as well as AI soft bots that operate via the World Wide Web must comply with data protection regulations and not collect and spread data or be run on sets of data for whose use and dissemination no informed consent has been given (Parveen, 2018).

High Initial Investment

This is more of a challenge to smaller firms as there is the need for large upfront costs even though there is a guaranteed long-term savings through AI increasing the efficiency and reducing labor costs of projects. Without a clear evidence of quick return on investments, many firms are skeptical of AI's financial benefits, especially when market profit margins are already thin. But despite the initial costs, firms that adopt AI early could achieve a competitive advantage with all the advantages associated with its implementation.

Cost of Workforce Training and Upskilling

Many construction workers lack the technical skills needed to work with AI technologies and this requires a significant amount of investment in training them (Mahmood *et al.*, 2021). Smaller firms are mostly affected by this because of the financial pressure they already face but prioritizing upskilling improves productivity and job satisfaction among the workers, reducing labor turnover.

Resistance to Change within the Construction Industry

Cultural and Organizational Resistance

A lot of construction workers and professionals are skeptical about the potentials of AI in the industry. They view it as a disruptive technology that could only cause complications and not improve them. This resistance is usually based off the lack of understanding about the workings of AI technologies and its associated benefits. Even when they sometimes recognize its potential

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benefits, they refuse to implement it due to fears of the complexity of its integration into existing workflows.

Change Management Workflow Concerns
Construction workers are often apprehensive about AI technologies believing it will reduce the need for human labor resulting in massive layoffs. The failure to carry workers along during the early stages of the AI adoption could lead to significant pushbacks from the workforce, delaying or halting its implementation. Firms therefore should adopt proactive approaches to change in management and involvement of workers in the AI adoption process to see successful technology integration.

Legal and Ethical Issues Surrounding AI in Construction

Regulatory Uncertainty
There have been so many questions raised about liability in relation to AI, especially when the automated systems make decisions that can potentially cause errors or accidents, and until clearer regulations are established, firms may be hesitant to adopt AI technologies. A clearer regulatory environment could encourage firms to adopt AI through the reduction of future legal repercussions.

Human Dignity
The principle of human dignity as the recognition of the inherent human state of being worthy of respect, must not be violated by 'autonomous' technologies. It also implies that there have to be (legal) limits to the ways in which people can be led to believe that they are dealing with human beings while in fact they are dealing with algorithms and smart machines. A relational conception of human dignity which is characterized by our social relations requires that we are aware of whether and when we are interacting with a machine or another human being, and that we reserve the right to vest certain tasks to the human or the machine (Parveen, 2018).

Future Directions of AI in Construction
In the future (a few years from now in fact), the construction industry, from the look of things and advancements made in technology, is expected to undergo substantial progress. Artificial Intelligence (AI) is set to revolutionize the entirety of the construction industry as there is an increasing demand for better efficiency, sustainability, and safety that traditional practices fail to sufficiently meet.

Developing AI Technologies in the Future of Construction

Machine Learning and Predictive Analytics
Machine Learning (ML) has been a major tool for the significant advancement of AI. It allows systems to learn from historical data without so much programming from the part of the user. In the construction industry, ML algorithms use historical data to predict outcomes for future projects, thereby improving the processes. It can be used to anticipate project delays, using historical data like the weather, available workforce, etc. all to help project managers make good and beneficial decisions (Abioye *et al.*, 2021).

Robotics and Automation
Using robots that can help with repetitive tasks efficiently in construction processes shows a very promising future for the application of AI in construction. Also, drones can be used to monitor work on site and collect work data, while minimizing the workers' exposure to the hazardous environment (Jallow *et al.*, 2022).

Natural Language Processing (NLP)
This improves the communication among people on the construction team by using voice-activated project management tools that understand natural language requests. This helps with organization of reports and documents to enable efficient teamwork among stakeholders involved in the project (Wu *et al.*, 2022).
Areas for Advancement of AI in the Construction Industry

Adaptive Architecture
This involves designing buildings that can respond vitally to changing environmental conditions and also to the users' needs. AI technologies can enable this through live data analysis from Internet of Things (IoT) devices which are located within the structures. These technologies can adjust the lighting, heating and cooling to comfortable levels, thereby improving the building's energy efficiency and the users' comfort (Egwim *et al.*, 2024).

Robotics in Construction Processes
This is the combination of robotics and Artificial Intelligence (AI) to renew the construction industry by improving its efficiency, safety and productivity. Robotic systems on construction sites are able to carry out several of complex tasks simultaneously, thereby moving across different job sites on their own, carrying out repetitive tasks, all while adapting to various conditions through AI

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algorithms that learn from historical data (UBC Faculty of Applied Science, 2023).

AI powered machines can also sense potential risks and make immediate decisions to mitigate these risks without the need for human intervention. This can help minimize the constant need for human operators and also the risk of accidents (SafetyCulture, 2023). AI algorithms can also predict failure of equipment, making it possible for proactive maintenance and improvement in project timelines (Trimble, 2023).

These robots and machines also become smarter with each use and refine their performance, suggesting better and more efficient methods to be able to complete their tasks. Combining human capabilities and robotics can bring about a new era in the construction industry, making projects faster and safer (Impakter, 2023). Also, autonomous vehicles can takeover repetitious tasks, allowing the skilled workers to specialize where their skills are actually needed (Cat Rental Store, 2023).

Smart Cities

AI has the potential to develop smart cities through integrating several technologies in order to improve the living conditions in urban environments. These technologies could range from AI controlled traffic systems to energy efficient buildings which can significantly improve the lives of residents (Regona, 2022).

Sustainable Construction Practices

AI can impact sustainability in construction by improving the use of resources and by the reduction of waste generated during construction processes. Machine Learning (ML) algorithms can also analyze the usage of materials and suggest ways to reduce their environmental impacts, while still prioritizing structural integrity and safety (Darko *et al.*, 2020).

AI in the Advancement of Construction and Digital Twin Technologies

Digital Twin Technology

These are virtual duplications of physical resources that can help with live monitoring and analysis of projects throughout their lifecycle. A combination of AI and digital twin technology can improve predictive maintenance based on usage patterns and provided historical data (Rampini & Cecconi, 2022).

Improved Collaboration among Stakeholders

There would be a fostering of collaboration among the stakeholders by the provision of centralized platforms for information sharing and decision making, thereby reducing miscommunication and enabling proper alignment of project goals (Regona, 2022).

Risk Management

AI systems can process historical data to identify patterns and mitigate future challenges and risks. These systems could provide prompt warnings to allow project managers to swiftly take preventive measures so that the project can stick to time and budget, and improve the overall project outcome (Joe G. 2024). Machine Learning (ML) models can also evaluate several risk factors and propose strategies to mitigate the risks.

CONCLUSION

The integration of Artificial Intelligence (AI) in the construction industry has the potential to give the industry a big shift by improving efficiency, productivity, maximizing time, and quick mitigation of challenges that might arise during construction. By embracing the influence of AI in construction, AI can enhance the construction industry. This systematic review of several publications has explored the applications of AI in the construction industry, giving two case studies; the current trends through which AI is currently integrated into construction processes; the potential impacts that this new technology has been recorded to have on construction and the construction workforce; and possible future directions of AI in the construction industry in the coming years.

AI focused developments provide so many benefits that can transform design processes, restructure workflows and enhance resource consumption. But for this to be effective indeed, current perceived challenges have to be overcome to reduce uncertainties with its implementations and promote willingness among the workforce to accept it.

In the future, improvements on AI technologies could help accelerate the adoption of AI in construction processes, thereby revolutionize the construction industry. Despite how promising this future is, it still heavily relies on lots of training and investments.

However, it is important to note that AI will still have to work alongside humans in the industry for many more years to come.

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