Artificial Intelligence in the Effective Execution Process of Construction Projects in the Future

Abstract

The construction industry currently constitutes 13% of the global gross domestic product (GDP), with projections indicating an 85% increase in value to $15.5 trillion by 2030. The widespread adoption of information technology (IT) has significantly enhanced the integration of disparate data in construction project environments. Consequently, the construction sector including full construction value chain, is undergoing a transformative phase. The increasing investment in artificial intelligence (AI) makes it impossible to keep pace with its rapid advancements. Hence, this study aims to examine the role of AI in facilitating the effective execution of construction projects in the future. This research employs a document analysis approach and scrutinizes 20 relevant papers from both domestic and international scientific databases. Methodologically, this study adopts an applied research approach, and based on the method of data collection, it is considered a descriptive survey method. Therefore, a questionnaire was designed and distributed among 100 experts and practitioners familiar with AI concepts in Tehran for data collection to conduct a census-style field study. Subsequently, Smart PLS software was employed for data analysis. The findings not only validate the model's reliability, validity and fit but also present solutions and pertinent issues related to challenges concerning AI future role in enhancing project execution efficacy.

Keywords: Artificial Intelligence (AI), Effective Execution, Executive Projects, Construction

Introduction

The construction industry faces a multitude of challenges that impede its growth and productivity especially when juxtaposed with more digitally-oriented sectors such as manufacturing (Chui, 2017). Primarily, the digitization of the construction sector has been due to long-term resistance to change (Young et al., 2021). This reluctance to adopt digitization coupled with an excessive reliance on manual methodologies make project management complex and unnecessarily cumbersome (Delgado et al., 2021; Bello et al., 2021). Additionally, the dearth of digital expertise and limited acceptance of technology contribute to cost inefficiencies, project delays, suboptimal performance, uninformed decision-making and reduced safety and productivity standards (Delgado, 2021). It has become increasingly apparent that the construction industry must accept digitization and enhance its technological capacities given the workforce shortages, the impacts of the COVID-19 pandemic and the imperative for sustainable infrastructure development (Young et al., 2021).

Artificial Intelligence (AI), as a prominent digital technology, has significantly enhanced business operations, service processes and industrial productivity across diverse sectors (Aliyo et al., 2023). The acceptance of AI techniques provides automated solutions and offers competitive advantages over traditional approaches (Bello et al., 2021). Various sub-fields within AI including machine learning, natural language processing, robotics, computer vision, optimization and automated planning and scheduling (Nikas et al., 2009), have effectively tackled intricate challenges and facilitated decision-making in real-world scenarios. For instance, the manufacturing industry has witnessed the advent of the fourth industrial revolution (commonly referred to as industry 4.0), which relies on automation, data-driven technologies and advanced AI methodologies. This revolution resulted in substantial enhancements in processes, cost efficiency and production time reduction.

There exists significant potential for its application within the construction sector given the achievements of AI in various industries. AI methodologies offer avenues for process automation, enhancement of project management practices, increasing safety protocols and optimizing resource utilization. Through the utilization of machine learning algorithms, construction enterprises can analyze large datasets to extract valuable insights for informed decision-making processes and predictive maintenance strategies. Moreover, computer vision technologies can assist in quality control and monitoring of construction sites and ensuring compliance with design standards while identifying potential safety risks. Furthermore, optimization algorithms based on AI can simplify construction scheduling, mitigate project delays and enhance overall project efficiency.

However, effective execution of AI within the construction sector faces several hurdles that need to be addressed. These challenges encompass the availability and quality of data, integration with existing systems, ensuring the ethical use of AI and overcoming resistance to change entrenched within the industry. Moreover, there exists a necessity to enhance the skill set of the workforce to accept and leverage AI technologies (Khobragade et al., 2018; Poh et al., 2021).

As a result, the adoption of AI techniques holds promise in mitigating the persistent issues of low productivity and resistance to change within the construction realm. AI has demonstrated its efficacy in other sectors through increasing automation, decision-making ability and overall productivity. Leveraging machine learning algorithms, computer vision capabilities and optimization strategies, the construction industry can overcome its challenges and achieve substantial progress in project management, safety, efficiency and quality performance. However, meticulous attention must be devoted to addressing the inherent complexities associated with AI execution and fostering a culture receptive to technological advancements within the construction domain.

AI acceptance and execution in the construction industry have been limited despite the potential advantages of AI in improving safety measures and achieving sustainability objectives (Delgado et al., 2021; Chien et al., 2020). Many research papers have been published on the application of AI and its subbranches to solve specific construction challenges. For example, machine learning techniques have been used for health and safety monitoring, cost estimation, optimization of supply chain logistics and prediction of risks (Rao et al., 2021). Robotics has found application in different fields like site monitoring, performance evaluation, off-site assembly and the management of construction materials, factory and equipment (Yao et al., 2017). Knowledge-based systems have been employed for tender evaluation, conflict resolution, risk and waste management and sustainability assessment (Ganiyu et al., 2020; Ajayi et al., 2020). However, the construction industry is still one of the least digitized sectors and striving for widespread acceptance of AI and other digital technologies despite these endeavors.

Some studies have highlighted different problems that impede the widespread acceptance of AI in the construction sector like cultural barriers, high initial deployment costs, concerns related to trust and security, talent shortages, limited computational capabilities and inadequate internet connectivity. However, considerable knowledge gaps exist regarding research trends in AI applications, future opportunities and acceptance barriers within the construction domain. To address these gaps, it is important to critically examine the following research questions:

1- What are the specific domains within the construction industry where AI finds application.

2- What future opportunities exist for execution of AI in the construction industry?

3- What key obstacles hinder the acceptance of AI in the construction sector.

As a result, conducting a critical review of AI applications in the construction is essential for comprehending current trends, identifying growth opportunities and recognizing widespread acceptance barriers.

The main goals of this research are as follows:

1- Conduct a comprehensive review of existing AI applications and its sub-fields in the construction industry.

2- Identify areas and potential opportunities for increasing AI execution in construction.

3- Identify and analyze challenges which affected AI acceptance in the construction industry.

This study represents a substantial step towards addressing the lack of information surrounding AI within the construction. It provides fundamental insights into AI, including its various types, components and sub-fields and then delving into its execution within the construction sector. This study elucidates the potential advantages of AI acceptance via critical examining the applications, opportunities and associated challenges and helps inform future strategies for successful integration of AI in the construction industry.

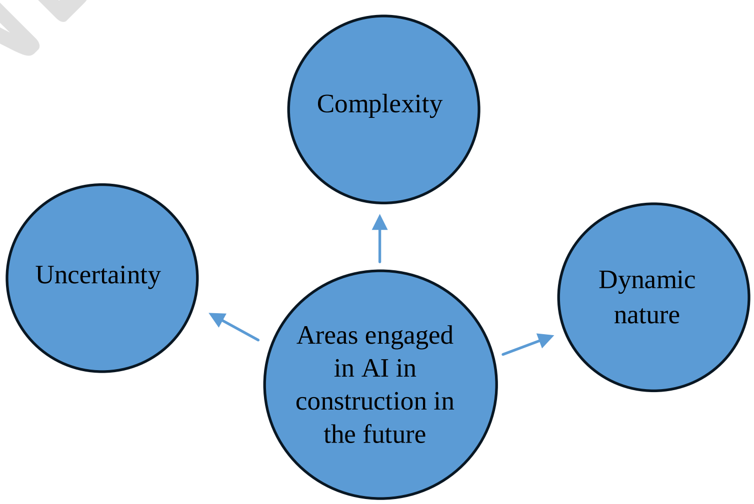
Literature review

The study and execution of laws governing actions of human reason lie at the heart of the field of AI. Over the past fifty years, this subject has transcended boundaries and has far-reaching implications. Currently, this technology is employed in a wide spectrum of applications including expert systems, knowledge-based systems, database-driven intelligent systems and smart robotic systems. Expert system has been named as the “information and decision-making management technology of the twenty-first century” and represents the oldest and most extensive field within AI. In the field of civil engineering, many issues, particularly in engineering design, construction management and program decision-making are affected by numerous uncertainties that are not only solvable through mathematical, physical and mechanical computations but also depends upon them. Experiences of practitioners attest to this fact, especially concerning engineering design, construction management and program decision-making. For instance, when discussing the design of engineering projects, construction project management and decision-making processes for planning, many challenges arise due to various uncertainties. These pieces of information and experiences are not just logically deficient but also inaccurate and managing them with conventional methods is impractical due to their lack of precision (Kork et al., 2023).

However, the presence of AI entails a set of unique advantages and can facilitate the resolution of complex issues at an expert level by mimicking the expertise of specialists. Within the field of civil engineering, there exists a set of potential application areas ready for leveraging a diverse array of AI capabilities.

It is anticipated that as the capabilities of AI continue to grow, AI methodologies will evolve into the next digital frontier. These methodologies will possess the capacity to adeptly transform vast volumes of data into valuable insights which led to a high degree of automation and intelligence across industries and commerce. However, despite the significant growth of engineering data within construction projects, the adoption of AI approaches in the construction sector lags behind. Consequently, there exists a pronounced interest in using various AI methodologies within the realm of effective execution of construction projects. This interest is driven by the desire to capitalize on the lucrative opportunities presented by the digital evolution with the ultimate goal of bolstering productivity and profitability within the industry (Pan et al., 2021).

Benefits of AI in Construction Project Management



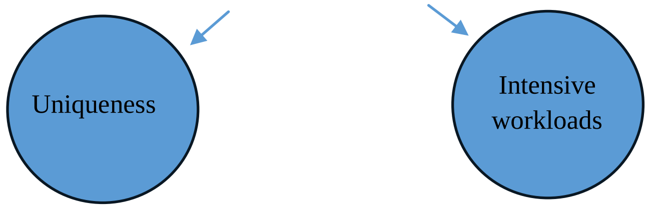


Figure 1- Benefits of AI in effective execution of construction projects

The Digital Age

It is crucial to emphasize that Building Information Modeling (BIM) stands as the principal catalyst for the digitization of the construction industry. In recent years, MIB has undergone significant advancements beyond mere 3D modeling in terms of its ability to provide a set of information for the entire project lifecycle (Tang et al., 2020). BMI has the potential to act as a backbone of the digital realm with AI capabilities and thereby accelerating the digitization of relevant information for intelligent construction. BIM not only provides a platform for collecting vast volumes of data encompassing all project facets but also facilitates real-time sharing, exchange and analysis of data to enable timely communication and collaboration among diverse stakeholders. This functionality is facilitated through BIM which when integrated with AI, serves as a pivotal mechanism for automating and enhancing the construction process. Data originates from the BIM system. The integration of BIM and AI holds promise for transforming traditional paper-based tasks into online administrative functions. It can provide information that is both efficient and effective in terms of project management and thereby serving as a distinctive feature. An additional advantage is that it can utilize the data available in BIM for real-time analysis. This enables quick responses to simplify processes, shorten operation times, reduce costs, mitigate risks, optimize personnel deployment and other objectives (Bilal et al., 2016).

Automation

Project management Project management can become more technically automated and objective through the integration of AI. Traditional construction management methodologies often rely on manual observations and operations which are prone to judgment errors and complex mistakes. Research has demonstrated that AI-driven solutions offer a viable means to surmount many constraints associated with conventional construction management. For instance, machine learning algorithms are used at intelligently processing vast datasets to unveil previously undiscovered insights. Moreover, these algorithms find integration within project management software to facilitate automated data analysis and decision-making processes. The insights derived from such advanced analyses empower managers to attain a deeper comprehension of the construction project, formalize implicit knowledge accrued from prior project experiences and identify project challenges through data-driven approaches. This capability is made feasible by the insights derived from advanced analytical techniques. Furthermore, drones and sensors play a pivotal role in automatic data collection, capturing images and videos of the construction site, environment and progress for comprehensive site monitoring (Van, 2018).

Enhancing Productivity

Ai methodologies offer significant potential for optimizing various aspects within the construction domain. Particularly, these techniques can play a pivotal role in addressing optimization challenges aimed at ensuring the efficient and effective execution of construction projects. For instance, AI enables the development of novel methodologies such as process mining which yields valuable insights into the intricacies of the construction process. Process mining facilitates several advantageous activities including the monitoring of critical workflows, prediction of deviations, identification of latent bottlenecks and extraction of collaborative behavior patterns (Aziz et al., 2014). Leveraging newly acquired information is essential to the successful completion of projects and holds promise for guiding the optimization of the construction execution process.

It is important to minimize unnecessary actions, revisions, and non-essential discussions as these may lead to potential delays and hinder effective collaboration. By minimizing these aspects, strategic decisions can be made promptly to troubleshoot issues in their early stages which lead to enhanced operational efficiency and also helps prevent the need for more time-consuming and costly adjustments in subsequent stages. A diverse range of optimization algorithms exists that each acting as a powerful tool for developing convincing architectural designs and establishing an optimal balance between time, money and quality (Fazeli et al., 2019). Additionally, AI robots is increasingly being integrated into construction sites to perform repetitive and routine tasks such as bricklaying, welding and tiling. This integration aims to liberate human laborers for more complex responsibilities and reducing the manual labor required for these tasks. They operate continuously and tirelessly at a consistent speed and level of quality. This shows the importance of deploying intelligent machinery effectively which ultimately ensures efficiency, productivity and profitability.

Reducing Risk

In environments characterized by high unpredictability, AI demonstrates remarkable capabilities in monitoring, analyzing, evaluating and predicting potential risks related to safety, quality, efficiency and cost within teams and work areas. This capacity has been accepted to identify, assess and prioritize accepted risks (Seo et al., 2015). A variety of AI methods including probabilistic models, fuzzy theory, machine learning and neural networks have been employed to learn from data collected on construction sites in order to find interdependencies of causes and incidents and to measure the probability of occurrence. Furthermore, AI has been used assessment of failure event as well as qualitative and quantitative risk severity to enhance safety in construction sites. AI-driven robots can effectively overcome the limitations of traditional risk analysis such as ambiguity and vulnerability deriving from professional experience and mental judgment. In addition, they are capable of doing so using a variety of statistical modeling and simulation techniques. As a result, AI-based risk analysis has the potential to provide useful and predictive insights into important issues. These insights can help project managers prioritize potential risks quickly and make proactive decisions against preventive actions to reduce risks. Simplifying operations at the workplace, improving employee training and ensuring timely and budget-conscious project completion are examples of efforts to reduce risk. In other words, AI offers an exciting potential for early detection of faults which can help prevent undesirable breakdowns and incidents in complex workflows. Moreover, robots can undertake hazardous tasks and thus reducing the number of individuals who need to be involved in dangerous areas.

Computer Vision

In the evaluation of civil infrastructures, labor-intensive and unreliable traditional visual inspections have progressively been replaced by automated and reliable computer vision techniques. Deep learning strategies, in particular, have been at the forefront of the latest advancements in computer vision technology. These methodologies use extensive learning processes to interpret, evaluate and comprehend image and video data. Computer vision serves two primary purposes in civil infrastructure assessment: inspection and surveillance. These applications hold the potential to comprehensively, rapidly and reliably enhance complex construction tasks and assess structural conditions (Aibem and Laria, 2016). By reducing the need for human presence in hazardous conditions, computer vision contributes to enhanced safety protocols. Inspection programs facilitated by computer vision encompass tasks such as self-damage detection, recognition of structural components, identification of hazardous behaviors and condition assessment. Surveillance programs offer a non-contact approach to quantitatively understand infrastructure conditions. This includes estimating strain, displacement, fracture dimensions and other relevant parameters. Vision-based approaches in civil engineering and management (CEM) are characterized by their relative cost-effectiveness, foundational nature, constructiveness and accuracy. These methodologies effectively translate image data into practical information for assessing structural health and ensuring construction safety.

Methodology

This study adopts an applied research approach, and based on the method of data collection, it is considered a descriptive documentary method

Initially, a comprehensive review of existing literature related to the limited study on the role of AI in the effective implementation of construction projects in the future along with similar studies will be conducted. Subsequently, hypotheses will be formulated based on the research title and objectives through field studies. Considering the fourfold methods of theoretical perspective, namely extending or improving existing theories, comparing different theoretical perspectives, examining specific phenomena using different theoretical perspectives and finally investigating documented and repetitive phenomena in a new environment and conditions, the present research falls into the fourth group. In this study, content analysis will be used as the research method.

The executive steps of the current research are as follows:

1- Literature review (subject literature review)

2- Extracting structures, variables and factors related to the research topic

3- Designing measurement tools

4- Preliminary field studies

5- Modification and adjustment of measurement tools

6- Field data collection

7- Analysis of collected data and hypothesis testing

8- Conclusion and presentation of recommendations and suggestions

Among the fourfold data collection tools which include referring to documents and archives, interviews and questionnaires, this research will utilize the method of referring to documents and archives.

Results and Discussion

In the construction industry, AI applications have increasingly moved toward on the areas such as machine learning, optimization, robotics and automated planning and scheduling. Machine learning has received significant attention because of its potential for addressing workforce shortages and skill gaps while optimization techniques contribute to enhanced productivity. Robotics, has also significant progress in construction industry by introduction of 3D printing and exoskeletons. However, natural language processing remains relatively unexplored within the industry.

Recent advancements in AI applications within construction have been impacted by new technologies like quantum computing, internet of things (IoT), cybersecurity and blockchain. Quantum computing shows potential for improving practical AI applications with its accelerated problem-solving capabilities. Integration of IoT with AI enables real-time monitoring, tracking and energy efficiency in construction processes. However, the growing reliance on interconnected systems and digital technologies raises concerns about cybersecurity risks in the construction sector. Although, blockchain technology has applications in areas such as risk management and financial services its potential within construction is still being explored.

Generally, AI has the capability of transforming the construction sector by enhancing efficiency, productivity and decision-making processes. Continuous research and progress in various AI sub-fields coupled with their integration with new technologies will continue to shape the future applications of AI in construction.

To gain insights into the current status of AI in the construction industry it is important to understand the main sub-fields of AI that are widely employed in this domain. Some AI sub-fields which have applications in construction industry include:

1- Machine learning: Machine learning involves the development and application of computer programs that learn from data or historical experiences to predict outcomes, control systems or generate models. It includes different techniques like supervised learning (decision-making based on labeled datasets), unsupervised learning (identifying patterns in unlabeled datasets), reinforcement learning (learning by interaction with the environment) and deep learning (employing neural networks for advanced pattern recognition).

2- Computer vision: Computer vision aims to replicate human visual capabilities by enabling machines to comprehend and interpret digital images or videos. This involves image capture, algorithmic processing and analysis to support decision-making in different construction tasks.

3- Automated planning and scheduling: Automated planning includes selecting and sequencing actions to achieve specific objectives while scheduling entails allocating time and resources to achieve those objectives. AI techniques such as search algorithms, optimization methods and genetic algorithms are used to deliver solutions for complex planning and scheduling problems.

4- Robotics: Robotics includes the design, construction, operation and maintenance of advanced robotic devices that capable of performing physical tasks. Robots interact with the environment through sensors and actuators and machine learning methods like reinforcement learning are commonly employed to solve learning problems in robotics.

5- Knowledge-based systems: Knowledge-based systems utilize existing knowledge for decision-making processes. They typically have a knowledge base, an inference engine and a user interface. These systems emulate mimic human decision-making within specific domains and include expert systems, rule-based systems, intelligent tutoring systems and DBMS with intelligent interfaces.

6- Natural language processing: Natural language processing centers on developing computational models that mimic human language capabilities and has applications on machine translation, text processing, speech recognition and information retrieval. Natural language processing tasks comprise part-of-speech labeling, named entity recognition and semantic role labeling.

7- Optimization: Optimization comprises making optimal decisions within defined limitations to achieve the best results and it has developed with the advancement of AI. This mathematical field typically use metaheuristic algorithms such as genetic algorithms and particle swarm optimization.

Table 1- Advantages and limitations of AI sub-fields in construction

Sub-field	Advantages	Limitations	Reference
Machine Learning	Predictive and prescriptive insights	Incomplete data	Delgado et al. (2021)
	Increased efficiency	Learning from data streams, dealing with high-dimensional data, scalability of models and distributed computing	Young et al. (2021)
Computational vision	Faster inspection and monitoring	Complete scene understanding	Bello et al. (2021)
	Better accuracy, reliability, and transparency	Improvement in tracking accuracy and effective visualization of tracking results	Ganiyu et al. (2020)
Planning and automated planning	Cost savings due to improved processes (e.g., logistics)	Primarily expensive execution	Delgado et al. (2021)
	Higher productivity	May be complex	Young et al. (2021)
Robotics	Increased safety	Initial high costs	Nikas et al. (2007)
	Higher productivity	Potential job loss due to automation	
	Improved quality	Maintenance and repair costs	
Knowledge-based systems	Easy access to relevant information	Protection of intellectual property and security issues	Delgado et al. (2021)
	Easy updates	Knowledge acquisition issues	
Natural language processing	Higher productivity	Speech recognition issues such as construction site sounds, homonyms, dialectal variations, etc.	Rao et al. (2021)
	Cost-effectiveness	Privacy and data security issues	
Optimization	Increased productivity due to optimized processes	Requires significant computational power	
	Increased efficiency	Scalability issues	

Note: Related references for the benefits and limitations of each sub-field are listed in the reference column.

This research has identified challenges that affect the adoption of AI in the construction industry, shown below:

Explanation of Cultural and AI Issues

The construction industry has been slow in adopting new technologies because of the risky and costly nature of construction processes. Traditional methods are favored over less reliable technologies. To encourage acceptance, AI technologies must demonstrate usability and undergo thorough testing across various construction projects. Furthermore, the use of explainable AI is crucial for building trust in AI systems. Construction professionals should comprehend how AI systems make decisions which can reached through means like local model explanations and layer-wise communication dissemination.

Security

While AI has the potential to enhance security and detect intrusions, it also presents a target for exploitation by hackers and cybercriminals. Mistakes in construction processes can have substantial results for quality, cost and time which impact the overall project schedule and jeopardizing worker safety. To reduce security risks, strategies such as adversarial machine learning should be employed. Further research is required to address security concerns associated with emerging AI technologies including computer vision and robotics.

Talent Shortage

There exists a shortage of engineers in AI with the requisite skills to drive AI advancement across various industries including construction. Identifying experienced AI engineers within the construction sector to develop customized solutions for specific industry problems is a challenging task. Addressing this shortage requires increased investment in training and collaboration between construction experts and AI researchers.

High Initial Costs

Although the benefits of AI-based solutions in construction are undeniable, the initial execution costs of AI technologies such as robotics can be prohibitively high. In addition, maintenance needs must also be taken into account. This presents a difficulty for subcontractors and smaller companies in the construction industry. Determining cost-effectiveness and return on investment in decision-making for AI technology adoption is paramount. With the increasing prevalence of these technologies, it is expected that prices will decrease and make them more feasible for smaller companies.

Ethics and Governance

Building public trust in AI technologies relies on widespread, transparent and agile governance. Ethical considerations are essential to prevent potential risks and guarantee equity in the construction sector. Regulations should address issues such as decision-making in uncertain conditions and uphold justice in the construction industry. Establishing ethics in AI systems and implementing safety engineering practices are significant steps in addressing these challenges.

Computational Power and Internet Connectivity

Construction sites are often located in remote areas and suffer from unreliable power sources, telecommunications and internet connectivity. This poses a challenge for AI tools reliant on these resources such as robots and site monitoring systems. Hence, real-time computations and communications may be disrupted. As a result, solutions must be devised to ensure efficient operation in spite of restricted connectivity and power outages. The emergence of technologies such as GF and GD communications might assist in addressing these problems.

Model Testing Using Structured Linear Relationships

In this stage, to assess the conceptual model and ensure the presence or absence of causal relationships among research variables as well as evaluation of the fit between observed data and the conceptual research model, a research model was tested using structural equation modeling. The outcomes of the testing are shown in the following chart.

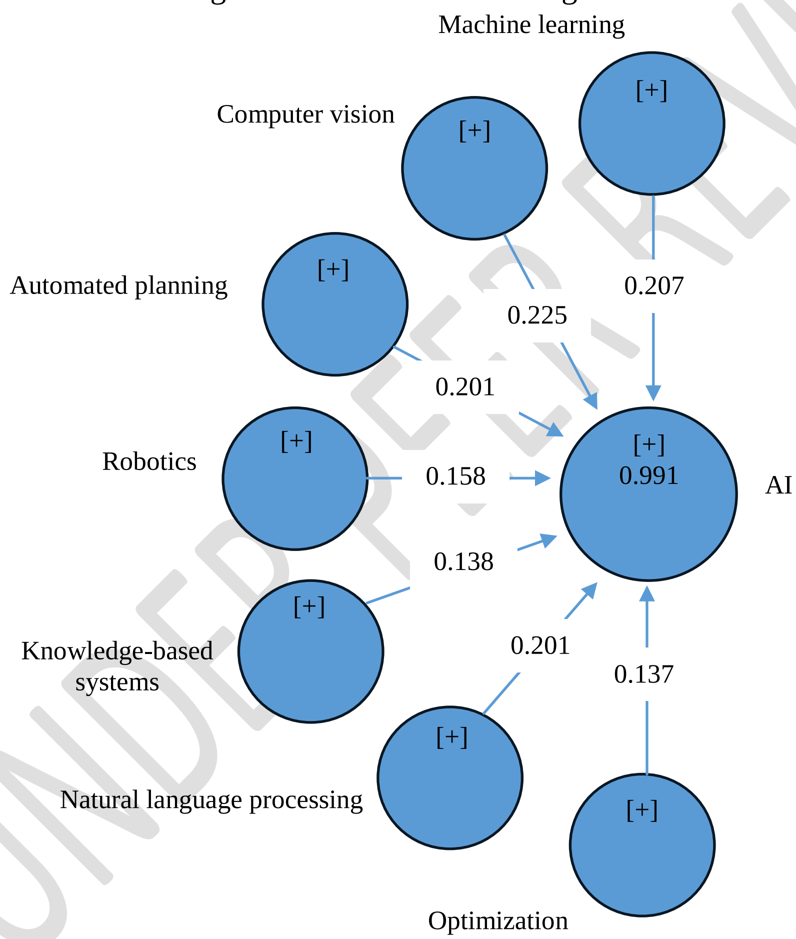
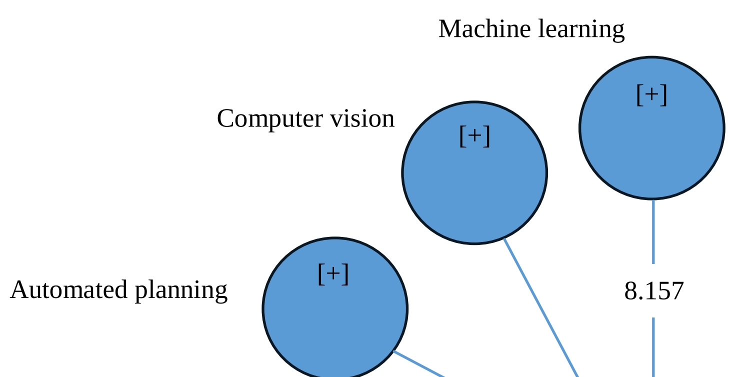


Chart 1- Measurement of the overall model in standard mode



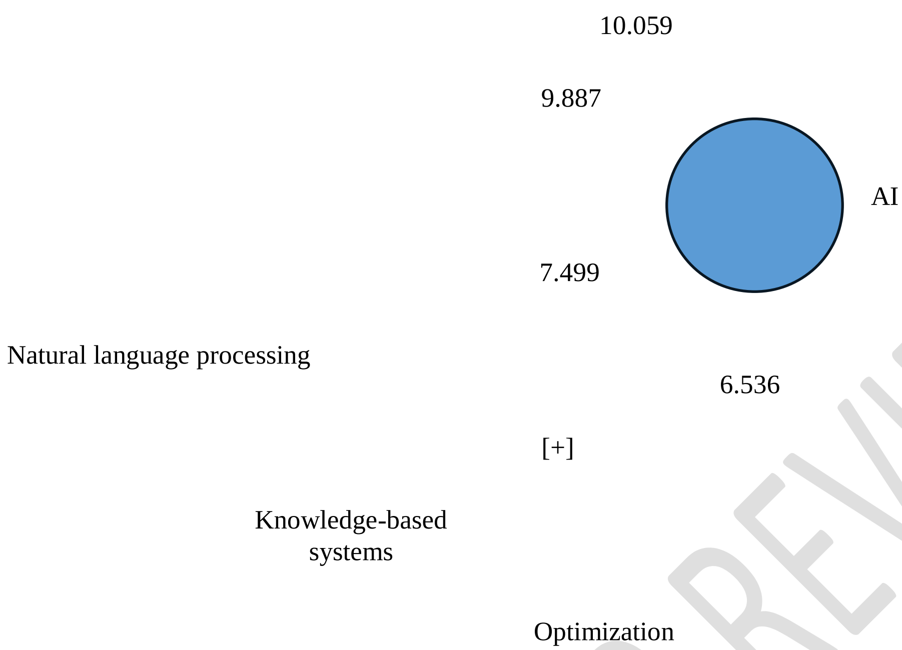


Chart 2- Measurement of the overall model in significance mode

To assess reliability, Cronbach's alpha and composite reliability were utilized. For validity assessment, convergent validity was employed. In addition, model fit was evaluated using the Goodness-of-Fit (GOF) index.

Table 2- Reliability and validity of external Models

variable	CR	AVE	CRO	Fornell-Larcker matrix						
				1	2	3	4	5	6	7
Automated planning	0.884	0.718	0.802	0.847						
Optimization	0.889	0.653	0.735	0.465	0.808					
Robotics	0.827	0.615	0.726	0.504	0.553	0.784				
Knowledge-based systems	0.813	0.596	0.737	0.534	0.553	0.674	0.772			
Natural language processing	0.862	0.675	0.760	0.421	0.586	0.598	0.423	0.822		
Computer vision	0.868	0.686	0.771	0.611	0.518	0.613	0.525	0.569	0.828	
Machine learning	0.77	0.704	0.789	0.563	0.448	0.534	0.513	0.610	0.697	0.839

- If Cronbach's alpha value is higher than 0.7, it indicates acceptable reliability.

- A CR value above 0.7 for each construct suggests adequate internal consistency for the measurement model.
- An AVE value above 0.5 indicates acceptable convergent validity.
- Considering the thresholds of 0.01, 0.25 and 0.36 as values representing weak, moderate and strong fit for the GOF index, achieving 62.0 suggests a strong fit for the model.

Conclusion

AI has the potential to revolutionize the construction industry by enhancing productivity and addressing various challenges. By leveraging the increasing volume of data generated throughout the building lifecycle and integrating it with other digital technologies, AI can enhance construction processes. This aims to explore the application of AI technologies in construction encompassing computer vision, robotics, natural language processing, machine learning, automated planning and scheduling, knowledge-based systems and optimization.

This study utilized a qualitative approach and analyzing publication trends in AI and its sub-fields over the past six decades using a qualitative approach and analyzing publication trends in AI and its sub-fields over the past six decades. The findings categorized AI sub-fields into emerging, mature and matured areas of research in the construction domain. As a result, computer vision, robotics and natural language processing were categorized as emerging technologies, whereas machine learning, automated planning and scheduling were identified as mature technologies and knowledge-based systems and optimization as matured technologies. Additionally, this study established an advertising lifecycle to predict the maturity period of each sub-field.

Although AI technologies have been employed in construction research, the adoption of recent advancements has been somewhat slow. For instance, the widespread utilization of deep learning which capable of delivering more precise predictions compared to conventional machine learning techniques has not been broadly employed. Additionally, this study discovered opportunities and research challenges for AI in construction taking into account emerging trends like BIM, IoT, quantum computing, augmented reality, cybersecurity and blockchain. AI is a leading technology that can bring significant changes to both our work and lives. However, its application in the efficient execution of construction projects which is characterized by uniqueness, compressed schedules, dynamic complexity and uncertainty is still in its infancy. In the foreseeable future, it is expected that the construction industry will rely more on AI and invest more money in it. Various AI technologies will be utilized to train suitable models for successful management of the rapid data generation in the execution of efficient construction projects. It is expected that AI can fulfill promises related to prediction, optimization and decision-making. This enables the traditional construction industry to advance rapidly towards automation and digitization. The most significant findings derived from this comprehensive study are as follows:

i. More academia will focus their endeavors on the construction phase where fewer digital tools and methods are currently being utilized.

ii. The adoption of BIM and machine learning approaches commonly takes place in the execution of efficient construction projects as research in this area heavily emphasizes data analysis and visualization.

iii. While nearly half of the research is allocated to two distinct areas, construction performance management and construction supply chain management and resource optimization, lower than half of the total research volume has centered on these two subjects.

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