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Assessing the applicability of international AI practices in construction management: A systematic review with implications for Vietnam

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Abstract: This study systematically reviews 94 journal articles published between 2000 and 2024 to examine the application of artificial intelligence (AI) in construction management (CM). The review focuses on AI's role in managing quality, time, and cost, which are critical factors for project success. The findings reveal a growing trend in AI adoption, particularly in areas such as scheduling and quality control. However, the use of AI for on-site CM, especially in Vietnam, remains limited and underexplored. This research aims to assess international AI practices and their potential applicability to Vietnam, analyzing how these technologies could improve efficiency, accuracy, and safety in construction projects. The implications of these findings suggest that embracing AI technologies could lead to enhanced project outcomes in Vietnam's construction industry by optimizing quality management, improving scheduling efficiency, and better controlling costs.

Keywords: Artificial Intelligence (AI); Construction Management (CM); Quality Management; Schedule Management; Cost Management.

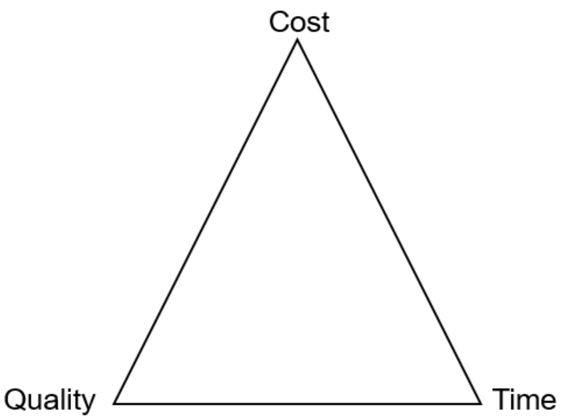
1. Introduction

Defining project management has been a subject of ongoing discussion since the 1950s. Söderlund [1,2] identified Gaddis [3] as the first to define project management, emphasizing the completion of projects within specified timelines, budgets, and requirements. Atkinson [4] and Ke and Ma [5] highlighted three key factors—time, quality, and cost—which became known as the "Iron Triangle" in project management. This concept was further explored by Zid et al. [6], who linked project success to the accurate identification of these "Iron Triangle" values.

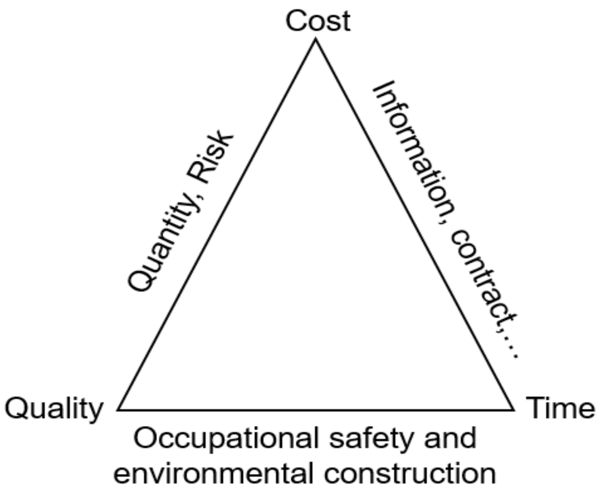
In construction projects, adherence to schedule, cost, and quality, often called the "iron triangle," is widely recognized as the primary determinant of success [7]. Al-Ageeli and Alzobaee [8] sought to identify both criteria and factors that significantly influence project success. Their findings highlighted "quality," "time," and "cost" as the three most critical success criteria among ten identified. Similarly, El-Maaty et al. [9] emphasized the "iron triangle" as a prevalent measure of project performance. Aggor et al. [10], grounding their research in the "iron triangle," scientific management, and strategic management theories, investigated the implementation of construction projects with a focus on time, quality, and cost. They noted that these success factors are often overlooked by construction project management professionals in developing countries. More recently, Kumar et al. [11] identified 10 factors that influence construction management (CM) success: scope, time, cost, resources, stakeholders, quality, risk, procurement, communication, and integration. Their work re-affirmed the continuing importance of the traditional "iron triangle" (cost, time, quality).

In Vietnam, CM involves overseeing various entities and processes related to construction activities, as specified in Decree No. 06/2021/ND-CP and No. 15/2021/ND-CP. This includes managing quality control, construction progress, cost management, safety protocols, and adherence to design specifications to ensure that projects are completed safely, on time, and within budget [12,13]. These areas emphasize the importance of quality, time, and cost in achieving successful CM. Decree No. 06/2021 further specifies a 12-step CM process [12]. The third step, concerning the construction contractor's management responsibilities, highlights the contractor's focus on quality, time, and cost to ensure the successful fulfillment of the construction contract with the investor [12]. Ultimately, the success of CM, whether from the perspective of the investor, contractor, or consulting unit, hinges on these three factors—quality, time, and cost – mirroring the "iron triangle" concept in CM.

The Vietnamese government is increasingly emphasizing the use of information technology in CM. Investors and contractors are encouraged to adopt information technology applications and solutions for CM activities [14]. This includes using electronic formats for construction logs and pre-acceptance test records, along with digital signatures on these documents, in compliance with electronic transaction laws. These guidelines are detailed in Circular No. 10/2021/TT-BXD [14], which provides further instructions on implementing Decree No. 06/2021/ND-CP and Decree No. 44/2016/ND-CP [15].



(a) In project management,



(b) In construction management,

Fig. 1. Illustration of the Iron Triangle: (a) in project management and (b) in construction management

Artificial intelligence (AI), which is a prominent global trend with diverse applications across numerous industries, is also increasingly relevant to the field of CM [16]. The term AI, originating in the 1950s, is recognized for its potential to transform the execution of construction projects [16]. In this study, AI is defined as systems or algorithms capable of performing tasks that require human-like intelligence, including learning from data and making informed decisions. The distinction between AI applications and general digital technologies is important; while tools such as 3D modeling, 4D simulations, and UAVs are significant digital technologies that enhance project efficiency and can be used as inputs for AI solutions in CM, they do not possess the adaptive capabilities inherent to AI. Current applications of AI in CM include contract management through large language models and generative design via Building Information Modeling (BIM), which allows for the exploration of numerous design alternatives. Additionally, integrating BIM with Geographic Information Systems (GeoBIM) facilitates the creation of digital twins for operational management. However, the application of AI specifically for on-site CM is still developing and requires further investigation. The growing use of AI in the construction industry, specifically in CM, is evident in studies published in journals such as Automation in Construction, Journal of Management in Engineering, Journal of Soft Computing in Civil Engineering, Applied Soft Computing, Journal of Construction Engineering and Management, Journal of Asian Architecture and Building Engineering, and Advanced Engineering Informatics.

This paper offers a systematic literature review concerning AI applications in CM, with a particular emphasis on the on-site management of construction works. This review analyzes existing research to determine trends, identify areas requiring further investigation, and suggest potential avenues for future research in this area. This review primarily focuses on international research contributions regarding AI applications in CM, with an emphasis on assessing their relevance and potential implementation within the Vietnamese context. By examining how AI is employed to manage quality, time, and cost in construction projects, the insights gained from international studies provide a framework for understanding how AI technologies can be applied to address specific challenges faced by the Vietnamese construction sector, such as improving project efficiency and quality management.

2. Materials and Methods

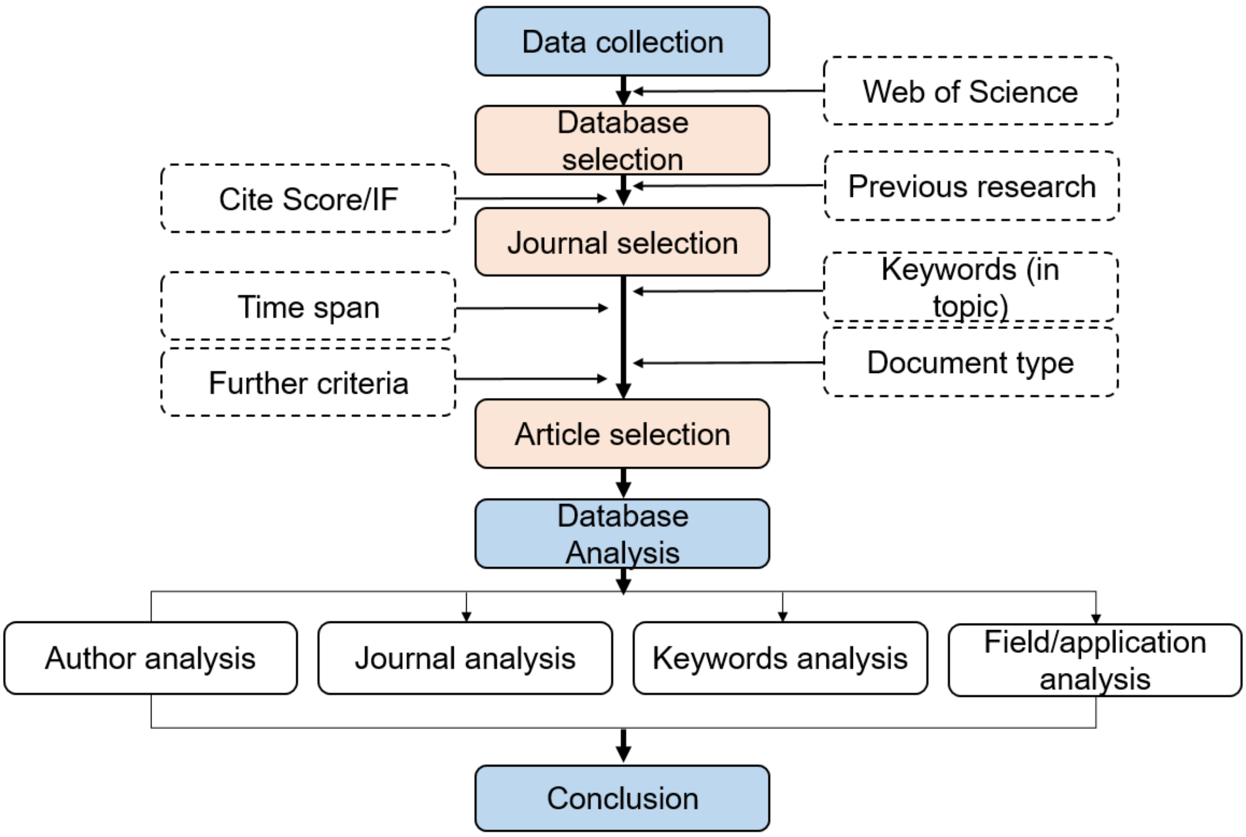


Fig. 2. Flowchart of the proposed research methodology in this study

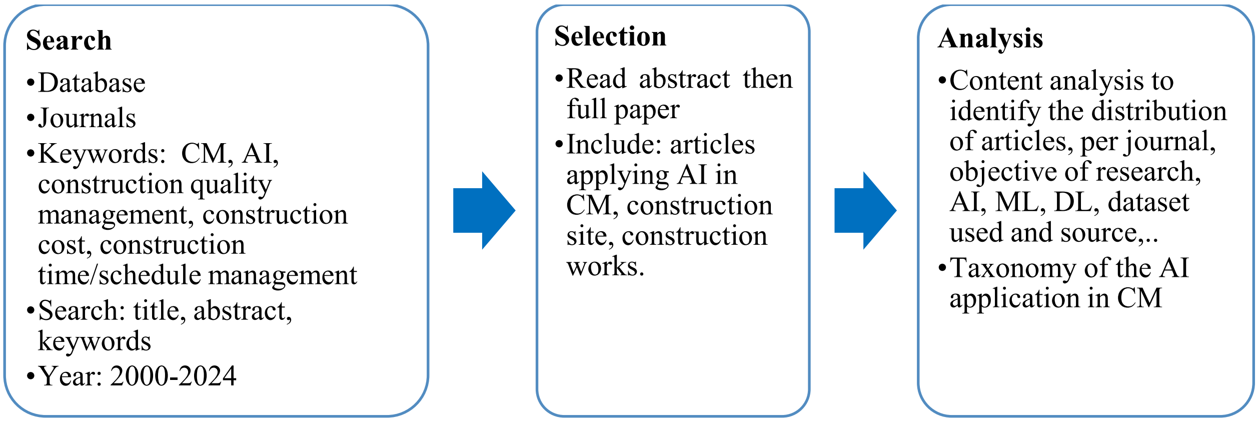


Fig. 3. Illustration of the systematic literature review process

Table 1. The journal databases used in the review process in this study

Journal	Papers
Advanced Engineering Informatics	5
Applied Soft Computing	1
Architectural Engineering and Design Management	1
Automation in Construction	24
Canadian Journal of Civil Engineering	1
Computer-Aided Civil and Infrastructure Engineering	1
Computers in Industry	1
Conference	20
Expert Systems with Applications	1
Frontiers in Built Environment	1
IEEE Internet of Things Journal	1
International Journal of Managing Projects in Business	1
International Journal of Project Management	1
International Journal of Remote Sensing	1
ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences	1
Journal of Architectural Engineering	1
Journal of Asian Architecture and Building Engineering	1
Journal of Computing in Civil Engineering	16
Journal of Construction Engineering and Management	6
Journal of Information Technology in Construction	1
Journal of Management in Engineering	1
Journal of Management in Engineering	1
Journal of Soft Computing in Civil Engineering	1
Multidimensional Systems and Signal Processing	1
Organization, Technology and Management in Construction 2020	1
Smart and Sustainable Built Environment	1
The Journal of Applied Science and Technology Trends (JASTT)	1
PhD Thesis	1

Various methods exist for conducting literature reviews. Among these, scientometric analysis is particularly effective in visualizing key structures and trends within a substantial body of literature, based on factors such as authorship, keywords, and references [17]. In this study, a three-stage process was employed, consisting of: (1) data collection, (2) scientometric analysis, and

(3) discussion and conclusion. The research methodology is outlined in Fig. 2.

Data gathered from each study included author(s), keywords, source (journal title), year of publication, AI techniques employed, data type, dataset used and its source, and other relevant information. Systematic literature review (SLR), as shown in Fig. 3, serves to identify, evaluate, and synthesize the findings of all pertinent studies on AI applications in CM [18],[19]. The proposed approach provides a comprehensive overview of the current state of knowledge in this domain. This SLR process resulted in 94 journal articles published between 2000 and 2024, as shown in Table 1.

The extent to which AI is recognized and applied in CM can be assessed by determining the number of publications appearing annually in reputable scientific journals. Fig. 4 illustrates the progress made in AI implementation in the CM over time. Although advancements in AI and machine learning (ML) implementation within the construction sector have been evident over the years, the application of AI specifically for on-site CM remains limited [20]. Notably, the highest number of articles on AI in CM during the study period occurred in 2009. While the number of articles increased from 4 in 2010 to 10 in 2021, it subsequently decreased to 2 in 2022 before rising again to 5 in 2023. This fluctuation may be attributed to a lack of focus on research concerning the management of quality, time, and cost. This identified research gap could encourage further investigation into AI applications in CM, particularly within the scope of on-site CM, where AI has the potential to assist contractors in managing various aspects, such as quantity, quality, progress, time, labor safety, and risks.

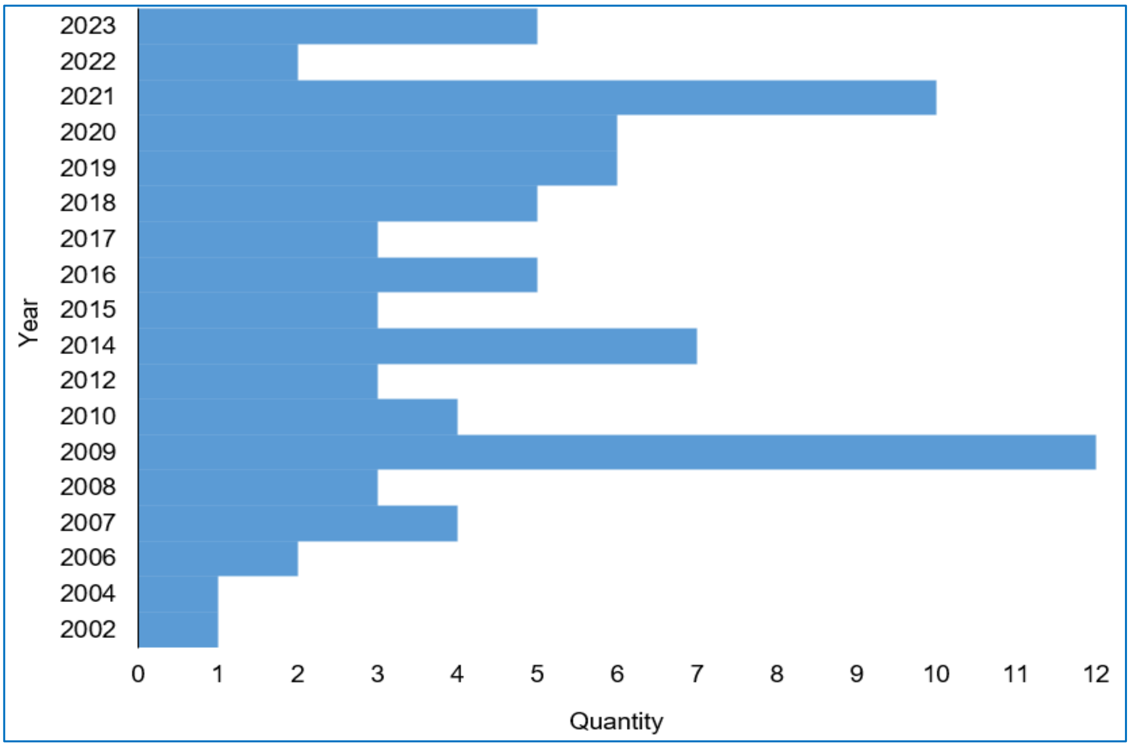


Fig. 4. Annual distribution of published articles on AI applications in CM

3. Results of scientometric analysis

3.1. Construction management or the management of construction works

CM, or the management of construction works, encompasses the complete process of overseeing a construction project on site, from its initiation to completion. This involves managing aspects such as scheduling, quality, cost, safety, resources, and communication to ensure project completion within the allocated time, budget, and according to established standards. An overview of AI applications in CM in Table 2 and Fig. 5.

Table 2. Summary of articles related to construction management

No	Journal	IF*	Authors	Year	Field/Application
1	Automation in construction	9.6	Pan and Zhang [16]	2021	AI application in CM
2	Automation in Construction	9.6	Dave et al. [21]	2016	The algorithmic and entropic scope of AI in CM
3	Automation in Construction	9.6	Asadi et al. [22]	2020	Evidence of Internet of Things (IoT) applications and related standards contribute to improving CM activities
4	Automation in Construction	9.6	Goodrum et al. [23]	2006	UAS applications for controlling progress, quality, safety, and other activities in CM
5	Advanced Engineering Informatics	8.0	Rebolj et al. [24]	2008	Use of Unmanned Aerial Vehicles/Unmanned Ground Vehicles (UAV/UGV) to collect data for surveying, monitoring, and inspecting activities at construction sites.
6	Applied Soft Computing	7.2	Pham and Luu [25]	2023	Using the mutation–crossover slime mold algorithm (MCSMA) to balance time, cost, quality, and continuity of work in CM.
7	Journal of Management in Engineering	5.3	Irizarry et al. [26]	2016	UAS applications for controlling progress, quality, safety, and other activities in CM
8	Journal of Soft Computing in Civil Engineering	4.5	Kulkarni et al. [27]	2017	ANN applications in CM include cost, risk, occupational safety, bidding, labor productivity, and construction equipment
9	Journal of Construction Engineering and Management	4.1	Akinci et al. [28]	2006	Laser scanners and radio frequency identification to model and analyze the impact of technology on data collection and transfer processes at construction sites.
10	Journal of Construction Engineering and Management	4.1	Lacouture et al. [29]	2009	Using Fuzzy mathematical models and the critical path method for multi-objective optimization when constrained by time, cost and material.
11	Journal of Construction Engineering and Management	4.1	Chan et al. [30]	2009	Using Fuzzy technology in CM, including: decision making; performance; evaluation/assessment; and modeling
12	Sustainability	3.3	Wu et al. [31]	2020	System dynamics (SD) applications in risk management, waste management, energy management, and construction productivity
13	The Journal of Applied Science and Technology Trends (JASTT)		Nguyen and Nguyen [32]	2021	Overview of AI applications in ML techniques to manage building costs, schedules, risks, safety, and energy needs
14	Thesis		Nagatoishi [33]	2023	The Space Construction Decision Framework (SCDF) supports cost, schedule, and resource optimization.
15	Technology and Management in Construction 2020	Conf.	Eber [34]	2020	The algorithmic and entropic scope of AI in CM
16	ISARC Conference	Conf.	Yoon et al. [35]	2006	RFID technology application model for progress measurement and CM

***Impact factor in May 2024**

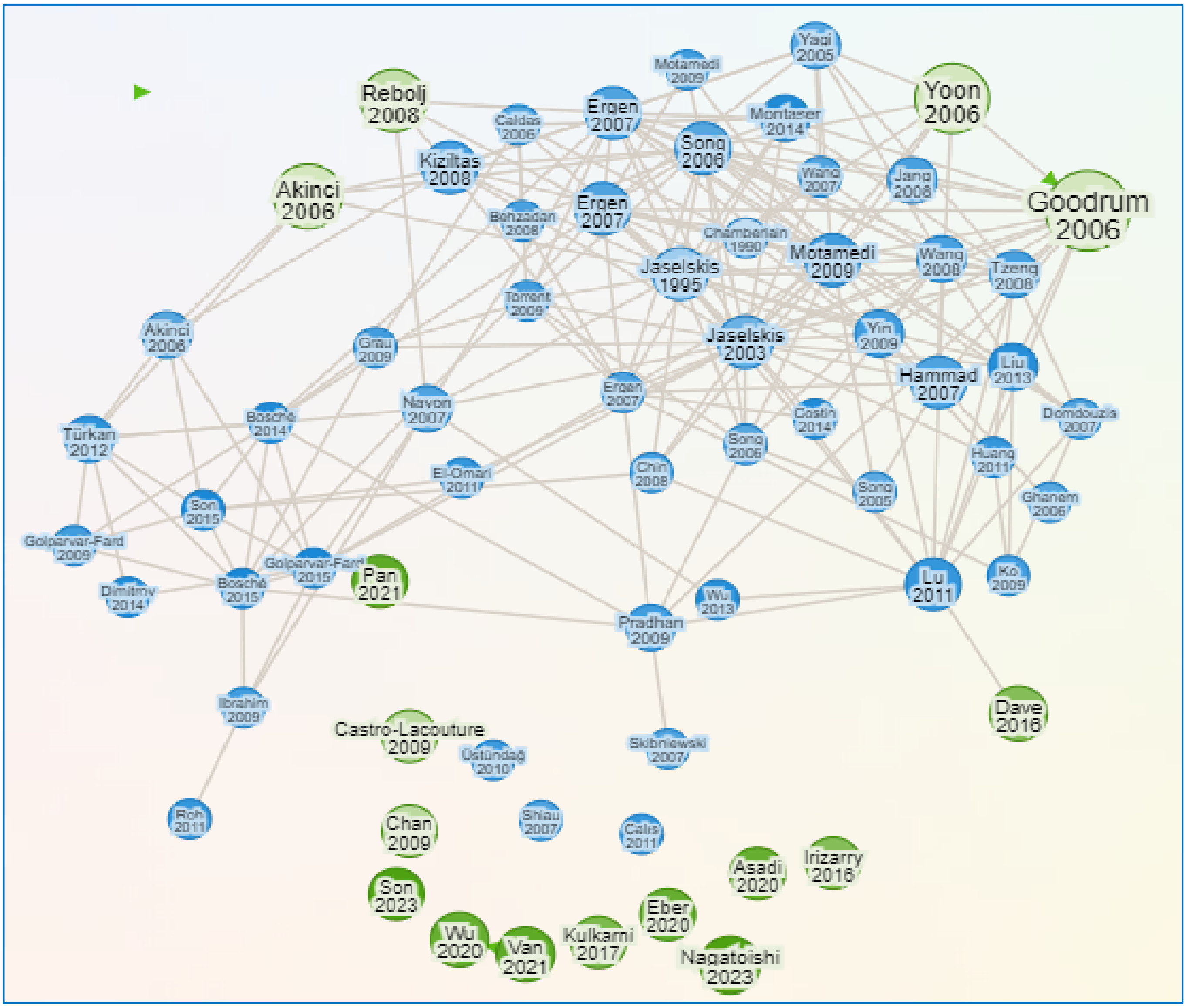


Fig. 5. Network diagram of authors from the literature review AI application in CM

Most of the articles reviewed appear in journals with high impact factors, such as Automation in Construction (IF 9.6) and Advanced Engineering Informatics (IF 8.0). This suggests that the topic of AI in CM is attracting increasing attention in reputable publications. However, some articles are also published in journals with lower impact factors, indicating that the research is disseminated through a variety of outlets and reached a broad audience. Many of these articles were published in recent years, particularly after 2016, which reflects the growing interest and development in AI applications for CM. Earlier articles published in 2006 and 2008 demonstrate the foundational work on which current research builds. Automation in Construction has the largest number of articles on this topic, consistent with its focus on technology and automation in the construction industry. The articles also appear in various other journals, including those specializing in management, soft computing, and specific areas of construction engineering, indicating the interdisciplinary nature of this research.

The articles examined use various AI algorithms and techniques, including machine learning, deep learning, fuzzy logic, and computer vision (CV). This range of approaches reflects the diverse ways in which AI can be applied to address CM challenges. The tools and methodologies employed in the reviewed articles include laser scanning, RFID, UAVs, and simulation models, which demonstrate the practical applications of AI in CM. The articles cover various CM applications, including quality management, progress monitoring, risk management, cost estimation, and safety management. This breadth of applications highlights the potential of AI to improve many aspects of construction projects.

Overall, a trend toward increased complexity in AI applications for CM is observed, with a shift from basic automation to more sophisticated tools for decision-making and optimization. Further research is needed on integrating AI with other construction technologies, such as BIM, and on developing standardized AI solutions for CM. Future research could address the challenges of data acquisition and processing in CM, and the ethical and societal implications of AI in the construction industry.

3.2. Construction schedule/time management

Table 3. Summary of articles related to construction schedule/time management

No	Journal	IF	Authors	Year	Field/Application
1	Automation in Construction	9.6	Zhang and Arditi [36]	2013	Laser scanning technology
2	Automation in Construction	9.6	El-Omari and Moselhi [37]	2009	Barcodes, 3D laser scanning, RFID, photogrammetry, multimedia, and pen computing tools
3	Automation in Construction	9.6	Kim et al. [38]	2013	4D CAD model
4	Automation in Construction	9.6	Son and Kim [39]	2010	3D Auto
5	Automation in Construction	9.6	Leung et al. [62]	2008	Integration of long-range wireless networking, network cameras, and web-based collaboration platform.
6	Automation in Construction	9.6	Ekanayake et al. [57]	2021	CV
7	Automation in Construction	9.6	Martinez et al. [63]	2021	Integrating DL algorithms and finite-state machines into existing footage captured by closed-circuit television (CCTV) security cameras.
8	Automation in Construction	9.6	Zhang et al. [58]	2009	CV
9	Automation in Construction	9.6	Shahi et al. [69]	2013	Ultra Wideband (UWB) positioning system based on onsite 3D marking
10	Computers in Industry	8.2	Omar et al. [52]	2018	Automatic monitoring system
11	Advanced Engineering Informatics	8.0	Dimitrov and Fard [66]	2014	A vision-based material using the joint probability distribution of responses from a filter bank, principal Hue saturation-value color values, and multiple one-vs.-all kernel support vector machine classifier.
12	Advanced Engineering Informatics	8.0	Ibrahim et al. [59]	2009	CV
13	Advanced Engineering Informatics	8.0	Lei et al. [40]	2019	CNN-based 3D patch registration
14	Expert Systems with Applications	7.5	Hajdasz [53]	2014	The MoCCAS intelligent system
15	Smart and Sustainable Built Environment	5.5	Johansen et al. [70]	2021	Real-time location sensing systems (RTLS)

No	Journal	IF	Authors	Year	Field/Application
16	Journal of Computing in Civil Engineering	4.7	Shahi et al. [41]	2015	High-frequency autonomous technologies, such as three-dimensional (3D) imaging and ultra-wideband (UWB) positioning
17	Journal of Computing in Civil Engineering	4.7	Fard and Mora [55]	2007	Semi-automatic vision
18	Journal of Computing in Civil Engineering	4.7	Golparvar-Fard et al. [42]	2009	4D Simulation Model Overlaid on Time-lapse Photographs
19	Journal of Computing in Civil Engineering	4.7	Hui and Brilakis [60]	2013	UAV
20	Journal of Information Technology in Construction	4.4	Golparvar-Fard et al. [71]	2009	D4AR–A 4-dimensional augmented reality model
21	Creativecommons licenses/Advances in Multimedia	4.0	Wang and Hu [72]	2023	Deep learning-based AI
22	Frontiers in Built Environment/construction management	2.2	Zhao et al. [56]	2021	Real-time indoor resource positioning based on low-energy Bluetooth
23	Journal of Asian Architecture and Building Engineering	1.5	Kim et al. [64]	2009	RFID systems and on-site robots
24	Journal of Architectural Engineering	0.4	Shih and Wang [43]	2004	Long-Range Three-Dimensional Laser Scanner
25	Construction Research Congress 2014: Construction in a Global Network	conf.	Maalek et al. [44]	2014	Cameras, LiDAR, and 3D range imaging
26	ISARC 2016	conf.	Ishida [45]	2016	Kinect 3D image sensors
27	Sustainability	3.3	Ko and Han [67]	2017	Regression, neural network, and autoregressive moving average models
28	ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences	conf.	Bognot et al. [47]	2018	Unmanned aircraft systems (UAS), 4D planning models, and GIS analysis
29	Sustainability	3.3	Ali et al. [68]	2020	iVR (Interactive Voice Response)
30	Infrastructures	2.7	Zhang and Arditi [48]	2020	Terrestrial Laser Scanning
31	Sensors	3.4	Jacob-Loyola et al. [61]	2021	UAVs
32	ISARC 2018	conf.	Pushkar et al. [49]	2018	Three-Dimensional Laser Scanner
33	CME25: Construction Management and Economics: past, present, and future	conf.	Golparvar-Fard et al. [50]	2007	Time-lapse photographs in 4D
34	Construction Research Congress 2009: Building a Sustainable Future	conf.	Golparvar-Fard et al. [51]	2009	D4 AR — 4D Augmented Reality — Models

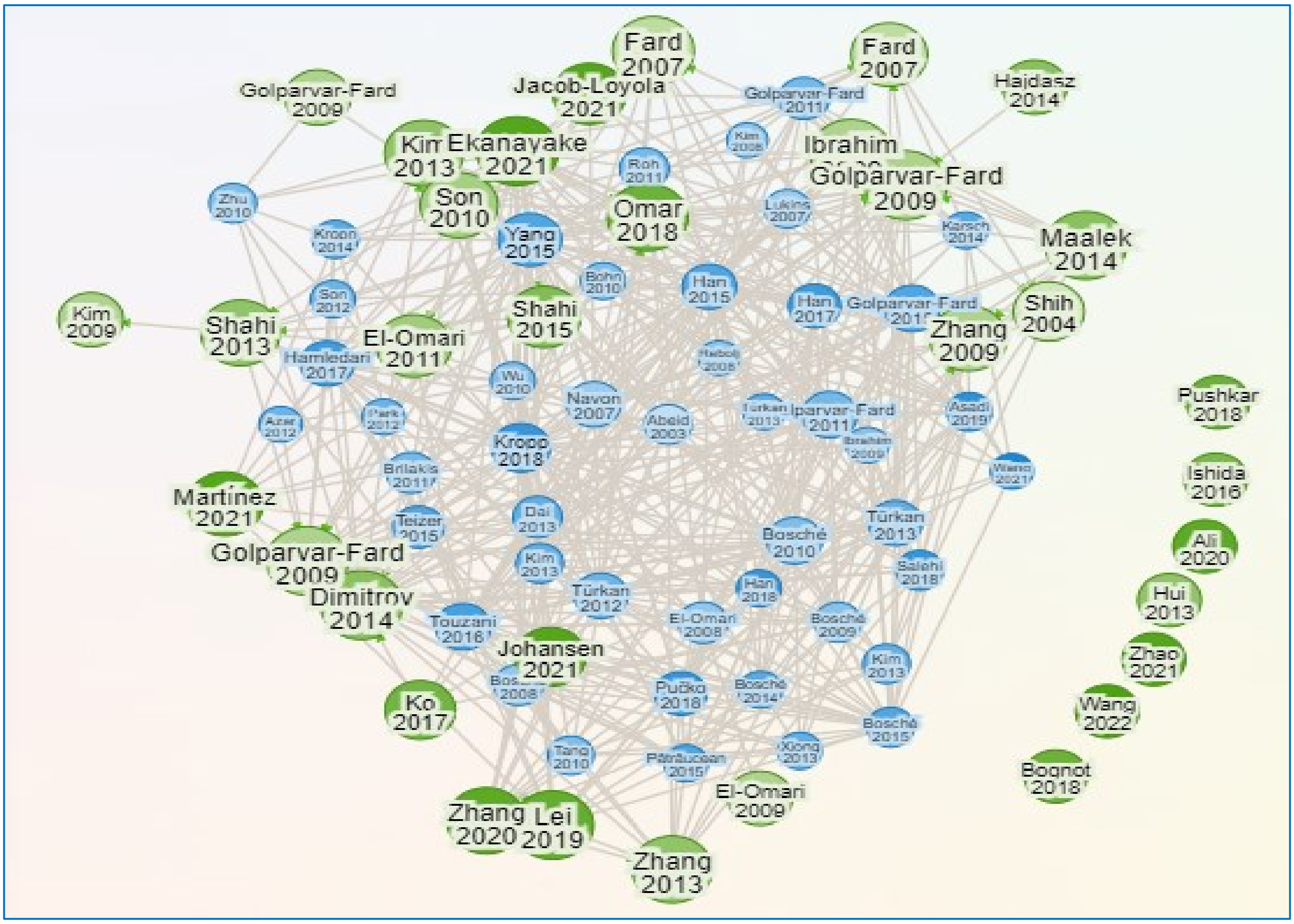


Fig. 6. Network diagram of authors from the literature review on AI application in construction schedule/time management

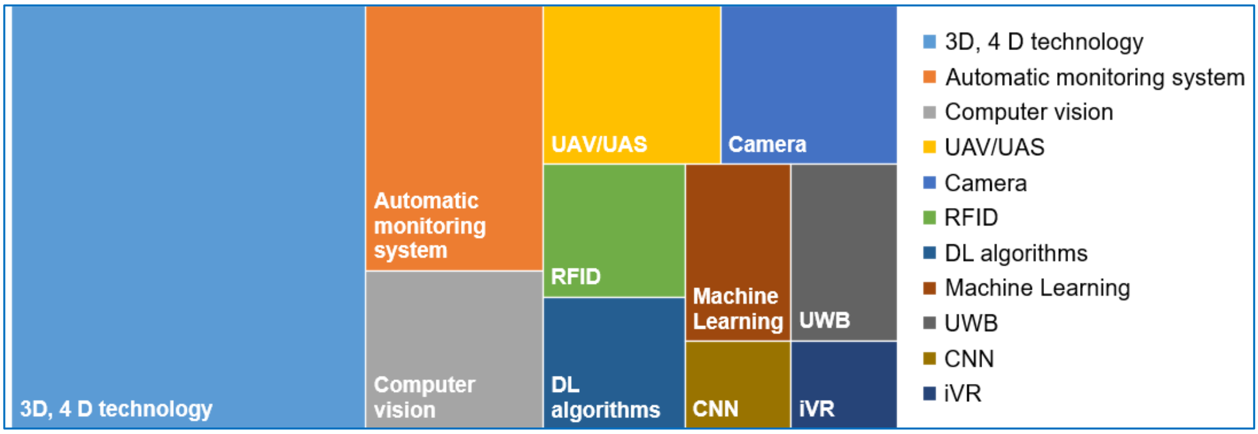


Fig. 7. Overview of AI applications in construction schedule/time management

Several research articles have explored AI applications in construction schedule/time management. Specifically, 3D and 4D technology applications have been identified in 16 studies [36–51]. Automatic monitoring systems have been addressed in 5 studies [52–56]. CV [57–59], UAVs/UASs [47,60,61], and camera applications have also been examined [44,62,63]. RFID [37, 64], deep learning algorithms [63,65], ML [66, 67], and UWB [42,49] were implemented in 2 studies. In addition, CNN [40] and iVR [68] were addressed in one study. These applications are summarized in Figs. 6 and 7.

Table 3 presents an overview of research on

AI applications for managing construction schedules and time. The table categorizes this research by journal, impact factor, authors, year of publication, and specific area of application. The articles included in the table were published in various journals with different impact factors. The presence of articles in high-impact journals, such as Automation in Construction, suggests that this is an area of growing research interest. Publication dates range from 2004 to 2023, indicating ongoing activity in this field.

Many articles on this topic are published in Automation in Construction, which is consistent with the journal's focus on technology and automation in the construction industry. Articles also appear in journals focused on computing, specific construction engineering fields, and other relevant fields, reflecting the interdisciplinary nature of this research.

The research summarized in the table uses a variety of AI algorithms and techniques, including 3D/4D modeling, CV, ML, and deep learning. The tools and methodologies employed include laser scanning, RFID, UAVs, cameras, and simulation models, demonstrating the practical applications of AI in CM. The applications addressed in this research include progress monitoring, automated data capture, and site activity tracking, highlighting the potential of AI to improve construction scheduling.

Future trends in applying AI to construction schedule/time management suggest increasing integration with Building Information Modeling (BIM). This integration allows dynamic, real-time updates of 4D models. AI-powered predictive analytics can also be used to anticipate potential delays and proactively optimize schedules. Wider use of CV and deep learning algorithms is expected for automating progress monitoring and identifying safety hazards. Drones and autonomous robots may become more common for tasks such as site documentation, inspection, and data collection, leading to improvements in efficiency and safety.

Further research is required to develop AI algorithms that can handle the complexities of construction environments and manage unstructured data. It is also important to investigate the ethical and societal implications of AI in construction, including potential workforce displacement and data privacy concerns. Standardized AI solutions and best practices should be developed to encourage wider adoption and ensure consistent results in construction schedule/time management. The role of AI in optimizing resource allocation, managing supply chains, and improving communication and collaboration among project stakeholders also requires further exploration.

3.3. Construction quality management

Table 4. Summary of articles related to construction quality management

No	Journal	IF	Authors	Year	Field/Application
1	Automation in Construction	9.6	Cao and Le [103]	2019	Deep fully convolutional neural network
2	Automation in Construction	9.6	Kim et al. [96]	2014	Terrestrial laser scanning
3	Automation in Construction	9.6	Teizer et al. [73]	2010	3D laser scanning
4	Automation in Construction	9.6	Wang [106]	2008	RFID
5	Automation in Construction	9.6	Zhou et al. [97]	2021	Terrestrial laser scanning (TLS).
6	Automation in Construction	9.6	Wang et al. [98]	2016	Terrestrial laser scanning (TLS).
7	Automation in Construction	9.6	Lin and Fang [87]	2013	CV
8	Automation in Construction	9.6	Kim et al. [91]	2021	Terrestrial laser scanning (TLS) based ML
9	Automation in Construction	9.6	Akanmu and Okoukoni [92]	2018	Swarm nodes

No	Journal	IF	Authors	Year	Field/Application
10	Automation in Construction	9.6	Akinci et al. [99]	2006	Sensor systems and integrated project models
11	Computer-Aided Civil and Infrastructure Engineering	8.5	Nishikawa et al. [81]	2011	Multiple Sequential Image Filtering
12	IEEE Internet of Things Journal	8.2	Wu et al. [101]	2023	Blockchain-Based Onsite Activity Management
13	Advanced Engineering Informatics	8.0	Golparvar-Fard et al. [93]	2013	Multiclass Support Vector Machine (SVM)
14	Journal of Management in Engineering	5.3	Wu et al. [102]	2021	Hyperledger Fabric (HLF), IoT và blockchain
15	Journal of Computing in Civil Engineering	4.7	Azar [88]	2015	CV
16	Journal of Computing in Civil Engineering	4.7	Gong and Caldas [89]	2012	CV
17	Journal of Computing in Civil Engineering	4.7	Liu [74]	2014	2D image processing and 3D scene reconstruction
18	Journal of Computing in Civil Engineering	4.7	Tang et al. [75]	2010	Laser Scans and Algorithms
19	Journal of Computing in Civil Engineering	4.7	Giri et al. [76]	2014	Laser Displacement Sensor (LDS)
20	Journal of Computing in Civil Engineering	4.7	Hajian and Broandow [77]	2012	3D laser scanning
21	Journal of Computing in Civil Engineering	4.7	Zhu and Brilakis [82]	2010	Image/video recognition via edge detection and Hough transform
22	Journal of Computing in Civil Engineering	4.7	Gong and Caldas [90]	2009	CV
23	Journal of Computing in Civil Engineering	4.7	Zhu and Brilakis [83]	2012	Image recognition and the Hough transform.
24	Journal of Computing in Civil Engineering	4.7	Golparvar-Fard et al. [78]	2009	D4AR
25	Journal of Computing in Civil Engineering	4.7	Yang et al. [84]	2014	Surveillance cameras
26	Journal of Computing in Civil Engineering	4.7	Xu et al. [108]	2020	3D laser scanning and kNN
27	Journal of Construction Engineering and Management	4.1	Yang et al. [94]	2019	Wearable Smartphone System
28	Journal of Construction Engineering and Management	4.1	Zhu and Brilakis [100]	2009	Machine Vision
29	Journal of Construction Engineering and Management	4.1	Atherinis et al. [79]	2018	RFID and virtual -3D
30	International Journal of Remote Sensing	3.1	Teza et al. [109]	2007	TLS and the Iterative Closest Point (ICP) Algorithm
31	Multidimensional Systems and Signal Processing	1.7	Cao et al. [85]	2015	Audio signal processing and ML algorithms.

No	Journal	IF	Authors	Year	Field/Application
32	Architectural Engineering and Design Management		Ahsan et al. [95]	2011	Mobile Technologies
33	Applied Sciences	2.5	Lee et al. [104]	2022	Deep Learning-Based PC
34	Buildings	3.1	Razveeva et al. [105]	2023	CNN, U-Net and LinkNet.
35	ISARC 2016	conf.	Kim et al. [110]	2016	CV
36	International Symposium on Automation and Robotics in Construction 19th (ISARC)	conf.	Akinci et al. [107]	2002	RFID
37	CIB World Building Congress 2019	conf.	Al-Adhami [86]	2019	Extended Reality (XR) technology
38	Electronics	2.6	Giri et al. [76]	2017	Laser Displacement Sensor (LDS)
39	IOP Conference Series: Materials Science and Engineering	conf.	Petrov and Hakimov [80]	2019	4D Visual Modeling

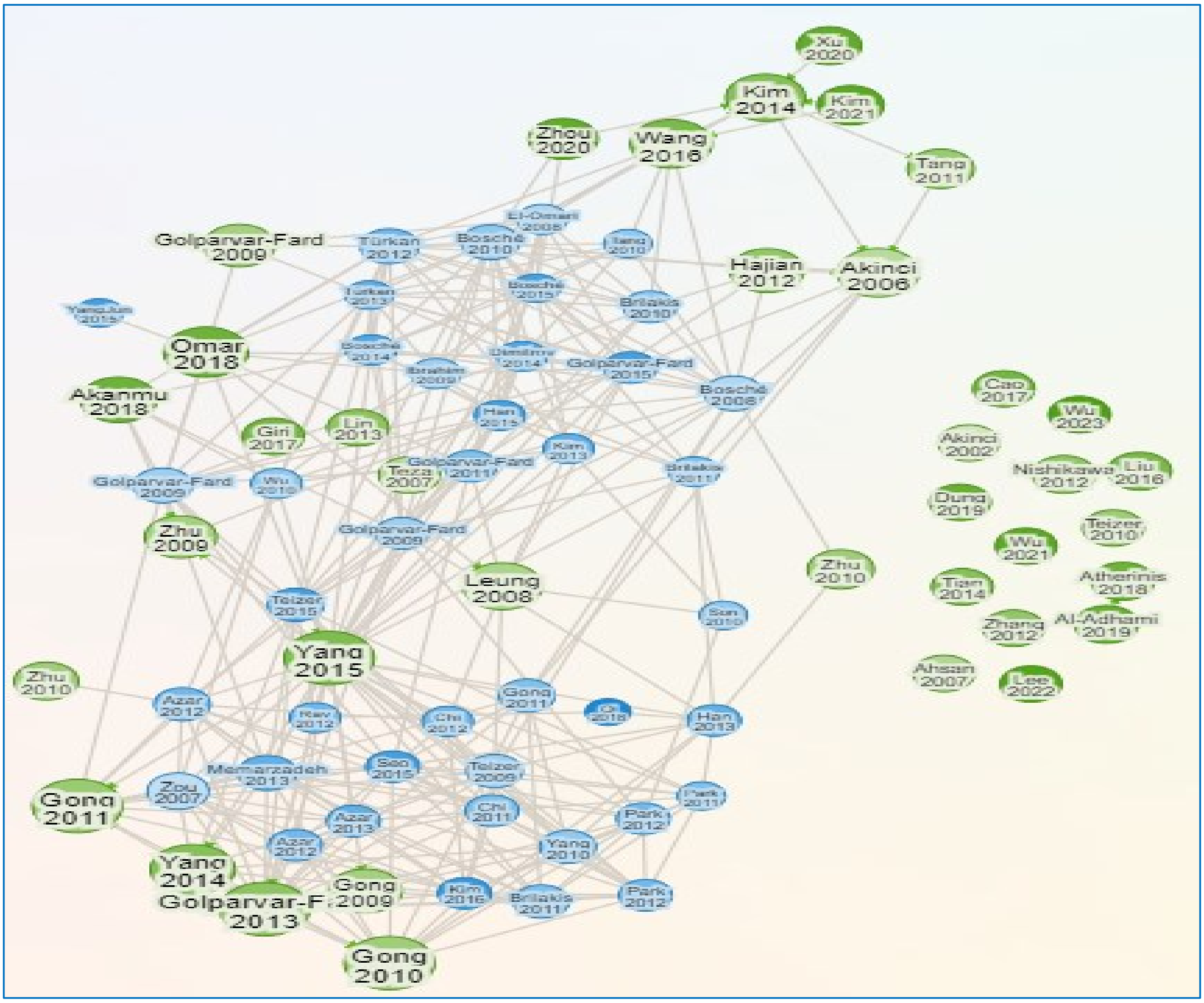


Fig. 8. Network diagram of authors from the literature review of AI applications in construction quality management

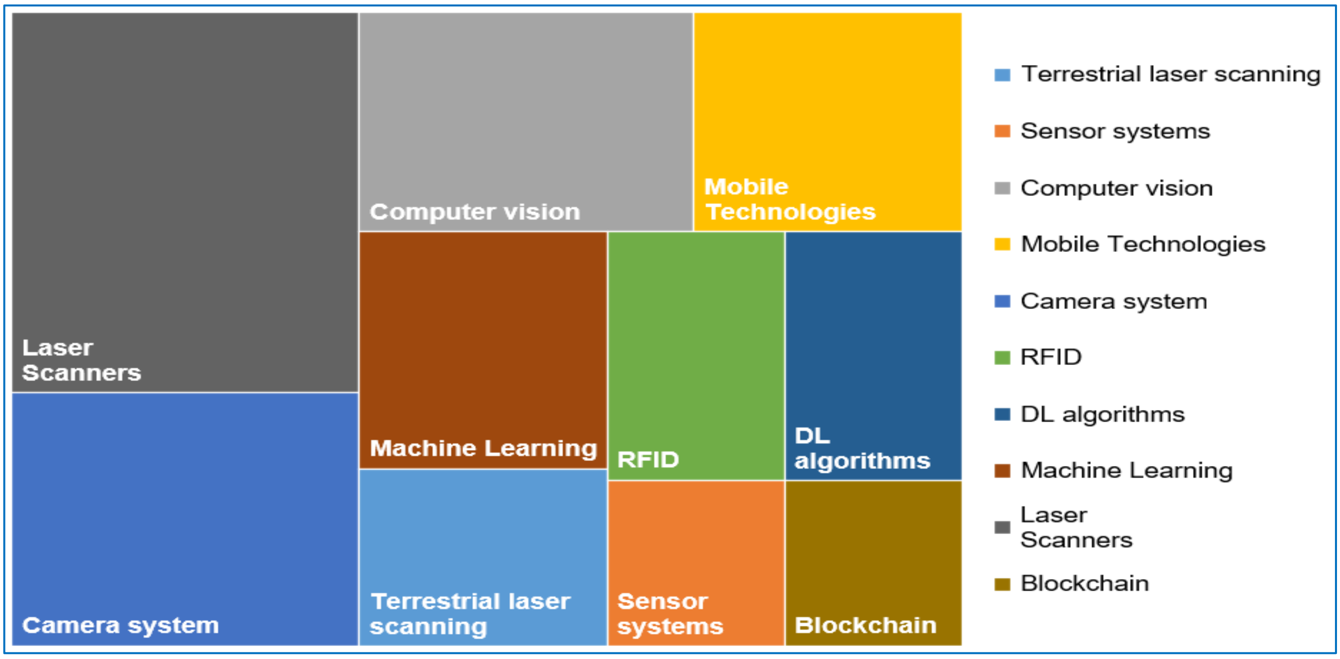


Fig. 9. Overview of AI applications in construction quality management

AI is becoming increasingly important for construction quality management. Laser scanners were used in 9 of the reviewed studies [73–80]. Camera systems have been used in 6 projects [81–86]. CV was employed in 5 research projects [87–90]. ML [85,91–93] and mobile technologies [94,95] were each used in 4 topics. Other technologies used include terrestrial laser scanning [91,96–98], sensor systems [99,100], blockchain [101,102], deep learning algorithms [103–105], and RFID [79,106,107]. These applications are illustrated in Table 4 and Figs. 8 and 9.

Table 4 summarizes research on AI applications in construction quality management. This research was categorized by journal, impact factor, authors, year of publication, and species, which are sources of many publications on this topic. Articles also appear in journals focused on computing, specific construction engineering fields, and other relevant fields, reflecting the interdisciplinary nature of this research. The research summarized in the table uses various AI algorithms and techniques. The tools and methodologies employed include cameras, sensor systems, blockchain, and RFID. Applications addressed in the research include quality assessment, crack detection, and surface defect inspection, highlighting the potential of AI to improve quality control in construction.

Future construction quality management trends are oriented toward increased automation. This may include the greater use of deep learning and CV for quality assessment and defect detection. The integration of AI with BIM could allow for real-time quality assessment and feedback during construction. AI-powered wearable technologies and mobile devices could assist workers with quality checks and issue identification on site. Blockchain technology can enhance transparency and traceability in quality management. Further research is required to develop AI algorithms that can adapt to the changing conditions of construction environments and variations in materials and quality. The use of AI to predict and mitigate potential quality issues before they occur warrants further investigation. Standardized, AI-based quality assessment metrics and reporting systems should be developed. Further research should explore how AI can optimize quality inspection schedules while ensuring compliance with relevant standards.

3.4. Construction cost management

Table 5. Summary of articles collected on construction cost management

No	Journal	IF	Authors	Year	Field/application
1	Automation in Construction	9.6	Bansal and Pal [111]	2007	Use of AreView, ArcView, 3-D visualization, 3-D view of building for building cost estimation and visualization
2	International Journal of Project Management	7.4	Chou [112]	2011	Use of Monte Carlo simulations to evaluate stochastic processes and choose input probability distributions to test hypotheses and determine correlations between simulated variables.
3	International Journal of Managing Projects in Business	3.9	Afzal et al. [113]	2019	Use of AI method for cost-risk assessment
4	Canadian Journal of Civil Engineering	1.1	Ji et al. [114]	2011	Use of the concept of Euclidean distance and genetic algorithm to develop a CBR cost estimation model for construction projects
5	ICCIKE 2023	conf.	Patil and Bhaumik [115]	2023	Use of IoT-enabled systems to reduce construction costs through safety management, vehicle and material fleet management, and progress monitoring on site

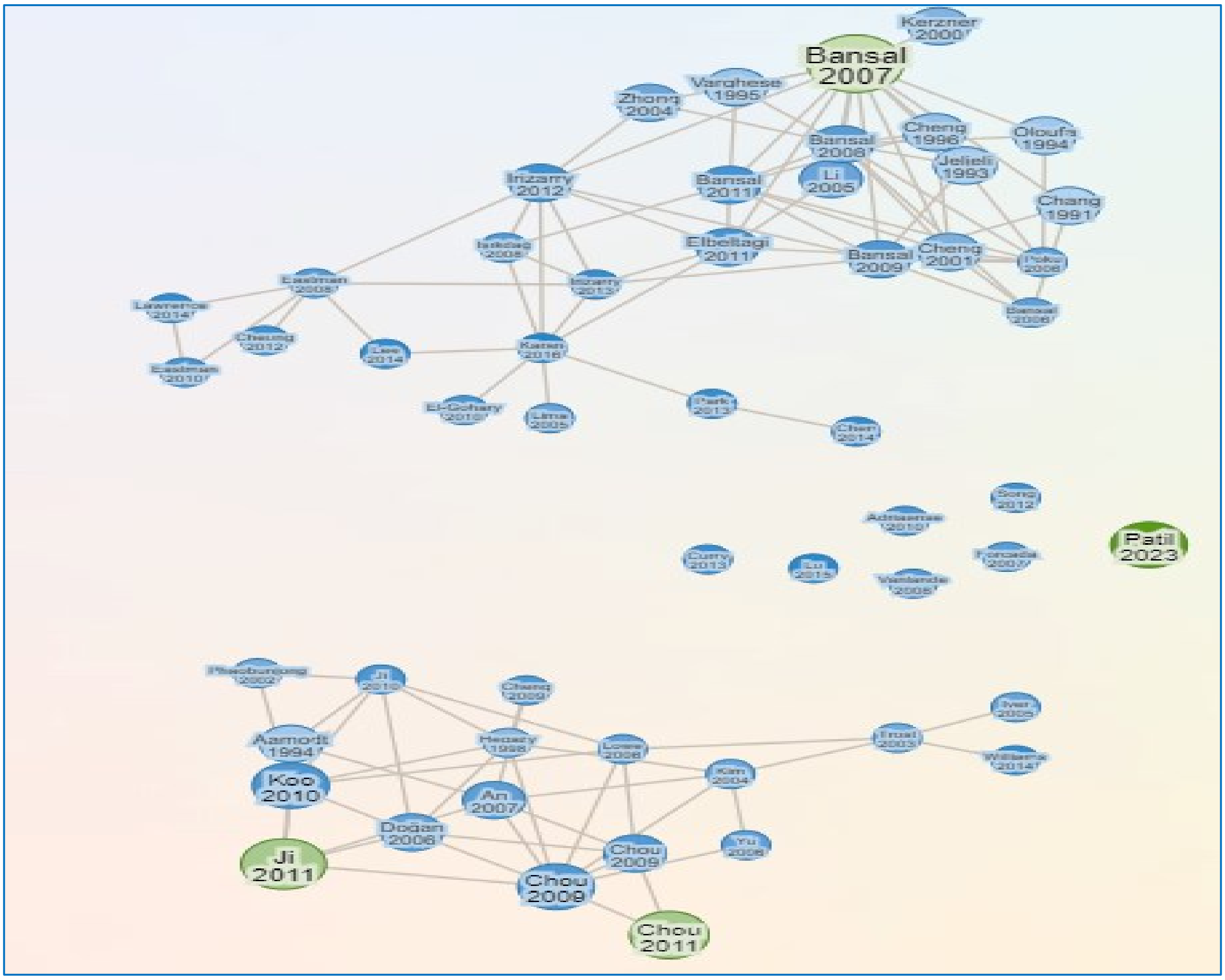


Fig. 10. Network diagram of authors from the literature review of AI applications in construction cost management

Construction cost management helps ensure that construction investment goals are met effectively. Construction costs should be calculated accurately and comprehensively for each project and construction package in accordance with design requirements, construction conditions, and market prices. The application of AI in this field remains limited. Some studies have explored the use of ArcView, 3D visualization, and 3D building views for building cost estimation and visualization. The use of Euclidean distance and genetic algorithms to develop CBR cost estimation models for construction projects has also been investigated. The use of IoT-enabled systems to reduce construction costs through safety management, vehicle and material fleet management, and on-site progress monitoring has also been studied. These studies are summarized in Table 5. Fig. 10 presents a network diagram of authors from a literature review on AI applications in construction cost management. In the future, AI-based cost management applications may help construction contractors achieve their goals more efficiently.

Future construction cost management projects may involve the creation of more sophisticated AI algorithms. These algorithms can be used to predict and control costs while considering factors such as material prices, labor costs, and market fluctuations. Integrating AI with BIM could allow for real-time cost tracking and analysis, which would help with proactive cost control measures. AI-powered platforms may also be developed to assist with tendering, procurement, and contract management, improving efficiency and transparency in cost-related processes. Further research should focus on developing AI algorithms that can adapt to changing economic conditions and project-specific requirements. The ethical implications of AI in cost management, such as potential biases in cost estimation and allocation, should also be investigated. Standardized AI-based cost management frameworks and best practices can be developed to ensure consistent and reliable cost control across construction projects.

3.5. Discussion

In the network diagram figures, nodes represent authors, and the connections between them indicate co-authorship relationships. The inclusion of years alongside authors' names provides a timeline of their contributions, helping to identify trends in research activity over time. The size of each node reflects its degree centrality, which indicates the prominence or influence of an author based on the number of connections within the network. Large nodes without visible connections may represent influential authors whose works are widely cited but not directly linked to co-authorship within this dataset. This explanation clarifies the structure and significance of the network diagrams presented in the study.

Based on the provided references, Table 6 summarizes the tasks, types of input data, and outputs related to AI applications in CM. This table integrates examples from the reviewed studies to clarify how AI technologies are applied across different CM tasks. AI applications in CM utilize various types of input data specific to each task, resulting in outputs that improve operational efficiency and decision-making processes. In quality management, laser scanning is frequently employed to detect surface defects and ensure dimensional accuracy. Camera systems provide high-resolution images for crack detection and quality inspections. Additionally, sensor systems gather real-time structural or environmental data, and blockchain technology is used to enhance transparency and traceability in quality control. For schedule and time management, UAVs capture aerial imagery for visual progress tracking. RFID tags facilitate real-time tracking of materials and equipment, while 3D/4D models incorporate spatial and temporal data for dynamic schedule updates. In cost management, IoT-enabled systems generate real-time data on material usage and equipment operation to optimize resource allocation, while historical cost databases support predictive models for cost estimation. These outputs—ranging from defect maps to optimized schedules and precise cost predictions—lead to practical improvements such as enhanced quality control, reduced delays, and improved resource utilization in construction projects.

Table 6. Summary of CM tasks along with inputs and outputs related to AI techniques

CM Task	Input Data	AI Techniques/Tools	Outputs	References
Quality Management	Laser scanning data	Computer Vision (CV), Deep Learning	Crack detection, defect mapping, surface quality assessment	[72–79], [102–104]
	Camera images	Convolutional Neural Networks (CNN), Image Processing	Automated quality inspection reports	[80–85], [86–89]
	Sensor systems	Machine Learning (ML), Blockchain	Real-time monitoring of structural integrity	[98–101]
	Mobile technologies			
Schedule/ Time Management	UAV-captured images	CV, ML	Progress tracking, activity recognition	[56–60]
	RFID data	RFID-enabled systems	Real-time material and equipment tracking	
	3D/4D models	Simulation Models	Dynamic schedule updates, delay prediction	[35–50]
	Time-lapse photographs			
Cost Management	IoT-generated data	Predictive Analytics, Case-Based Reasoning (CBR)	Cost estimation, optimization of resource allocation	[110–114]
	Historical cost databases			
	Market price indices			

4. Conclusion

AI has the potential to automate and accelerate learning, reasoning, and perception from large datasets in CM. This capability can be applied to various engineering projects, each with unique characteristics. In recent years, AI has demonstrated promise in improving efficiency, accuracy, and safety within the construction industry. AI's ability to analyze extensive datasets enables a deeper understanding through three fundamental steps: data acquisition and preprocessing; data mining using appropriate models; and knowledge discovery and analysis. Different AI-related approaches can benefit CM in terms of automation, risk mitigation, efficiency improvements, and enhanced decision-making.

This systematic literature review has examined relevant research published over the past 24 years concerning various applications of AI in CM, particularly focusing on the management of construction works on-site. The findings indicate that while advanced AI technologies possess significant potential, their adoption within the construction industry has been relatively slow. In Vietnam, the application of AI in the construction sector is still emerging, with its use in on-site CM remaining limited.

The implications of these findings for the Vietnamese context are noteworthy. As Vietnam continues to develop its construction industry, embracing AI technologies could lead to improved project outcomes by optimizing quality management, enhancing scheduling efficiency, and better controlling costs. The study highlights the need for further exploration of AI applications tailored to local challenges and conditions. Future research directions may include exploring AI's role in risk management, safety management, resource allocation, contract management, and supply chain optimization. By addressing these areas, stakeholders in Vietnam's construction industry can leverage AI to enhance project execution and competitiveness in a rapidly evolving market.

References

[1] J. Söderlund. (2004). Building theories of project management: past research, questions for the future. *International Journal of Project Management*, 22(3), 183-191.

[2] J. Söderlund. (2004). On the broadening scope of the research on projects: a review and a model for analysis. *International Journal of Project Management*, 22(8), 655-667.

[3] P.O. Gaddis. (1959). The project manager, Harvard Business Review. *Harvard Business School Publishing*.

[4] R. Atkinson. (1999). Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management*, 17(6), 337-342.

[5] H. Ke, J. Ma. (2014). Modeling project time–cost trade-off in fuzzy random environment, *Applied Soft Computing*, 19, 80-85.

[6] C. Zid, N. Kasim, A.R. Soomro. (2020). Effective project management approach to attain project success, based on cost-time-quality. International Journal of Project Organisation and Management (IJPOM), 12(2), 149-163.

[7] K.N. Jha. (2013). Success Traits for a Construction Project. *Determinants of Construction Project Success in India, Topics in Safety, Risk, Reliability and Quality*, vol 23. *Springer, Dordrecht*, pp 147-161.

[8] H.K. Al-Ageeli, A.S.J.A. Alzobaee. (2016). Critical Success Factors in Construction Projects (Governmental Projects as a Case Study). *Journal of Engineering*, 22(3), 129-147.

[9] A.A. El-Maaty, A.Y. Akal, S.A. El-Hamrawy. (2018). The Iron Triangle of Projects Management: Quality, Schedule and Cost of Road Infrastructure Projects in Egypt. *J. Calautit, F. Rodrigues, H. Chaudhry, H. Altan (eds.), Towards Sustainable Cities in Asia and the Middle East, Springer International Publishing, Cham*, pp. 1-14.

[10] K. Aggor, L. de Souza, E. Abdalla, F. Somado-Hemazro. (2019). Examining Project Execution on Time, Quality, and Budget within the Ghanaian Construction Industry. *Elixir Project & Quality*, 127, 52688-52700.

[11] V. Kumar, A. Pandey, R. Singh. (2023). Project success and critical success factors of construction projects: project practitioners' perspectives. *Organization, Technology and Management in Construction: An International Journal*, 15(1), 1-22.

[12] Government. (2021). Decree No. 06/2021/ND-CP on quality management, construction and maintenance of construction works.

[13] Government. (2021). Decree No. 15/2021/ND-CP, Detailed Regulations on

Certain Aspects of Investment Project Management in Construction.
[14] The Ministry of Construction. (2021). Circular 10/2021/TT-BXD providing Guidance Decree 06/2021/ND-CP and 44/2016/ND-CP in Vietnam.
[15] Government. (2016). Decree No. 44/2016/ND-CP, details some articles of the Law on occupational safety and sanitation, technical inspection of occupational safety, training of occupational safety and sanitation and monitoring of occupational environment.
[16] Y. Pan, L. Zhang. (2021). Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Automation in Construction*, 122, 103517.
[17] H. Xu, R. Chang, M. Pan, H. Li, S. Liu, R.J. Webber, J. Zuo, N. Dong. (2022). Application of Artificial Neural Networks in Construction Management: A Scientometric Review. *Buildings*, 12(7), 952.
[18] B. Kitchenham, O. Pearl Brereton, D. Budgen, M. Turner, J. Bailey, S. Linkman. (2009). Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, 51(1), 7-15.
[19] R. Khallaf, M. Khallaf. (2021). Classification and analysis of deep learning applications in construction: A systematic literature review. *Automation in Construction*, 129, 103760.
[20] S.D. Datta, M. Islam, Md.H. Rahman Sobuz, S. Ahmed, M. Kar. (2024). Artificial intelligence and machine learning applications in the project lifecycle of the construction industry: A comprehensive review. *Heliyon*, 10(5), e26888.
[21] B. Dave, S. Kubler, K. Främling, L. Koskela. (2016). Opportunities for enhanced lean construction management using Internet of Things standards. *Automation in Construction*, 61, 86-97.
[22] K. Asadi, A. Kalkunte Suresh, A. Ender, S. Gotad, S. Maniyar, S. Anand, M. Noghabaei, K. Han, E. Lobaton, T. Wu. (2020). An integrated UGV-UAV system for construction site data collection. *Automation in Construction*, 112, 103068.
[23] P.M. Goodrum, M.A. McLaren, A. Durfee. (2006). The application of active radio frequency identification technology for tool tracking on construction job sites. *Automation in Construction*, 15(3), 292-302.
[24] D. Rebolj, N.Č. Babič, A. Magdič, P. Podbreznik, M. Pšunder. (2008). Automated construction activity monitoring system. *Advanced Engineering Informatics*, 22(4), 493-503.
[25] V.H.S. Pham, N.Q.K. Luu. (2023). Optimization time-cost-quality-work continuity in construction management using mutation–crossover slime mold algorithm. *Applied Soft Computing*, 147, 110775.
[26] J. Irizarry, D.B. Costa. (2016). Exploratory Study of Potential Applications of Unmanned Aerial Systems for Construction Management Tasks. *Journal of Management in Engineering*, 32(3), 05016001.
[27] P.S. Kulkarni, S.N. Londhe, M. Deo. (2017). Artificial Neural Networks for Construction Management: A Review. *Journal of Soft Computing in Civil Engineering*, 1(2), 70-88.
[28] B. Akinci, S. Kiziltas, E. Ergen, I.Z. Karaesmen, F. Keceli. (2006). Modeling and Analyzing the Impact of Technology on Data Capture and Transfer Processes at Construction Sites: A Case Study. *Journal of Construction Engineering and Management*, 132(11), 1148-1157.
[29] D. Castro-Lacouture, G.A. Süer, J. Gonzalez-Joaqui, and J.K. Yates. (2009). Construction Project Scheduling with Time, Cost, and Material Restrictions Using Fuzzy Mathematical Models and Critical Path Method. Journal of Construction Engineering and Management, 135(10), 1096.
[30] A.P.C. Chan, D.W.M. Chan, and J.F.Y.

Yeung. (2009). Overview of the Application of "Fuzzy Techniques" in Construction Management Research. *Journal of Construction Engineering and Management*, 135(11), 1241-1252.

[31] Z. Wu, K. Yang, X. Lai, M.F. Antwi-Afari. (2020). A Scientometric Review of System Dynamics Applications in Construction Management Research. *Sustainability*, 12(18), 7474.

[32] V.T. Nguyen, Q.T. Nguyen. (2021). Research Trends on Machine Learning in Construction Management: A Scientometric Analysis. *Journal of Applied Science and Technology Trends*, 2(2), 124-132.

[33] M.G. Nagatoishi. Construction Management in Space: Explore Solution Space of Optimal Schedule and Cost Estimate. *Dissertations & Theses, Stanford University*.

[34] W. Eber. (2020). Potentials of artificial intelligence in construction management. *Organization, Technology and Management in Construction: An International Journal,* 12(1) 2053-2063.

[35] S.-W. Yoon, S. Chin, Y.-S. Kim, S.-W. Kwon. (2006). An Application Model of RFID Technology on Progress Measurement and Management of Construction Works. *2006 Proceedings of the 23rd ISARC, Tokyo, Japan*, pp 779-783.

[36] C. Zhang, D. Arditi. (2013). Automated progress control using laser scanning technology. *Automation in Construction*, 36, 108-116.

[37] S. El-Omari, O. Moselhi. (2011). Integrating automated data acquisition technologies for progress reporting of construction projects. *Automation in Construction*, 20(6), 699-705.

[38] C. Kim, B. Kim, H. Kim. (2013). 4D CAD model updating using image processing-based construction progress monitoring. *Automation in Construction,* 35, 44-52.

[39] H. Son, C. Kim. (2010). 3D structural component recognition and modeling method using color and 3D data for construction progress monitoring. *Automation in Construction*, 19(7), 844-854.

[40] L. Lei, Y. Zhou, H. Luo, P.E.D. Love. (2019). A CNN-based 3D patch registration approach for integrating sequential models in support of progress monitoring. *Advanced Engineering Informatics*, 41, 100923.

[41] A. Shahi, M. Safa, C.T. Haas, and J.S. West. Data Fusion Process Management for Automated Construction Progress Estimation. *Journal of Computing in Civil Engineering*, 29(6), 436.

[42] M. Golparvar-Fard, F. Peña-Mora, C.A. Arboleda, S. Lee. (2009). Visualization of Construction Progress Monitoring with 4D Simulation Model Overlaid on Time-Lapsed Photographs. *Journal of Computing in Civil Engineering*, 23(6), 391-404.

[43] N.-J. Shih, P.-H. Wang. (2004). Point-Cloud-Based Comparison between Construction Schedule and As-Built Progress: Long-Range Three-Dimensional Laser Scanner's Approach. *Journal of Architectural Engineering*, 10(3), 98-102.

[44] R. Maalek, J. Ruwanpura, K. Ranaweera. (2014). Evaluation of the State-of-the-Art Automated Construction Progress Monitoring and Control Systems. *Construction Research Congress 2014: Construction in a Global Network*, pp. 1023-1032.

[45] K. Ishida. Construction Progress Management and Interior Work Analysis Using Kinect 3D Image Sensors. *2016 Proceedings of the 33rd ISARC, Auburn, USA*, pp. 314-322.

[46] A. Shahi, J.S. West, C.T. Haas. (2013). Onsite 3D marking for construction activity tracking. *Automation in Construction,* 30, 136-143.

[47] J.R. Bognot, C.G. Candido, A.C. Blanco, J.R.Y. Montelibano. (2018). Building construction progress monitoring using unmanned aerial system (UAS), low-cost photogrammetry, and geographic information

system (GIS). *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* IV–2 41-47.

[48] C. Zhang, and D. Arditi. (2020). Advanced Progress Control of Infrastructure Construction Projects Using Terrestrial Laser Scanning Technology. *Infrastructures*, 5(10), 83.

[49] A. Pushkar, M. Senthilvel, K. Varghese. (2018). Automated Progress Monitoring of Masonry Activity Using Photogrammetric Point Cloud. *2018 Proceedings of the 35th ISARC, Berlin, Germany*, pp 897-903.

[50] M.G. Fard, A. Sridharan, S. Lee, F. Peña-Mora. (2007). Visual Representation of Construction Progress Monitoring Metrics on Time-Lapse Photographs. *2007, Proc. Construction Management and Economics Conference, Reading, UK*, pp 1-9.

[51] M. Golparvar-Fard, S. Savarese, F. Peña-Mora. Interactive Visual Construction Progress Monitoring with D^4 AR — 4D Augmented Reality — Models. *Construction Research Congress 2009: Building a Sustainable Future*.

[52] H. Omar, L. Mahdjoubi, G. Kheder. (2018). Towards an automated photogrammetry-based approach for monitoring and controlling construction site activities. *Computers in Industry*, 98, 172-182.

[53] M. Hajdasz. (2014). Flexible management of repetitive construction processes by an intelligent support system. *Expert Systems with Applications*, 41(4), 962-973.

[54] K.W. Johansen, R. Nielsen, C. Schultz, J. Teizer. (2021). Automated activity and progress analysis based on non-monotonic reasoning of construction operations. *Smart and Sustainable Built Environment*, 10(3), 457-486.

[55] M.G. Fard, F. Peña-Mora. (2012). Application of Visualization Techniques for Construction Progress Monitoring. Computing in Civil Engineering (2007), pp. 216-223.

[56] J. Zhao, E. Pikas, O. Seppänen, A. Peltokorpi. (2021). Using Real-Time Indoor Resource Positioning to Track the Progress of Tasks in Construction Sites. *Frontiers in Built Environment*, 7, 1-18.

[57] B. Ekanayake, J.K.-W. Wong, A.A.F. Fini, P. Smith. (2021). Computer vision-based interior construction progress monitoring: A literature review and future research directions. *Automation in Construction*, 127, 103705.

[58] X. Zhang, N. Bakis, T.C. Lukins, Y.M. Ibrahim, S. Wu, M. Kagioglou, G. Aouad, A.P. Kaka, E. Trucco. (2009). Automating progress measurement of construction projects. *Automation in Construction*, 18(3), 294-301.

[59] Y.M. Ibrahim, T.C. Lukins, X. Zhang, E. Trucco, A.P. Kaka. (2009). Towards automated progress assessment of workpackage components in construction projects using computer vision. *Advanced Engineering Informatics*, 23(1), 93-103.

[60] L. Hui, I. Brilakis. (2013). Real-Time Brick Counting for Construction Progress Monitoring. *Computing in Civil Engineering (2013)*.

[61] N. Jacob-Loyola, F. Muñoz-La Rivera, R.F. Herrera, E. Atencio. (2021). Unmanned Aerial Vehicles (UAVs) for Physical Progress Monitoring of Construction. *Sensors*, 21(12), 4227.

[62] S. Leung, S. Mak, B.L.P. Lee. (2008). Using a real-time integrated communication system to monitor the progress and quality of construction works. *Automation in Construction*, 17(6), 749-757.

[63] P. Martinez, B. Barkokebas, F. Hamzeh, M. Al-Hussein, R. Ahmad. (2021). A vision-based approach for automatic progress tracking of floor paneling in offsite construction facilities. *Automation in Construction*, 125, 103620.

[64] K. Kim, G. Kim, K. Kim, Y. Lee, J. Kim. (2009). Real-Time Progress Management System for Steel Structure Construction. *Journal of Asian Architecture and Building Engineering*, 8(1), 111-118.

[65] H. Wang, Y. Hu. (2022). Artificial Intelligence Technology Based on Deep Learning in Building Construction Management

System Modeling. *Advances in Multimedia*, 2022, 5602842.

[66] A. Dimitrov, M. Golparvar-Fard. (2014). Vision-based material recognition for automated monitoring of construction progress and generating building information modeling from unordered site image collections. *Advanced Engineering Informatics*, 28(1), 37-49.

[67] Y. Ko, S. Han. (2017). A Duration Prediction Using a Material-Based Progress Management Methodology for Construction Operation Plans. *Sustainability*, 9(4), 635.

[68] A.K. Ali, O.J. Lee, D. Lee, C. Park. (2021). Remote Indoor Construction Progress Monitoring Using Extended Reality. *Sustainability*, 13(4), 2290.

[69] A. Shahi, J.S. West, C.T. Haas. (2013). Onsite 3D marking for construction activity tracking. *Automation in Construction*, 30, 136-143.

[70] K.W. Johansen, R. Nielsen, C. Schultz, J. Teizer. (2021). Automated activity and progress analysis based on non-monotonic reasoning of construction operations. *Smart and Sustainable Built Environment*, 10(3), 457-486.

[71] M. Golparvar-Fard, F. Peña-Mora, S. Savarese. (2009). D4AR – A 4-Dimensional augmented reality model for automating construction progress monitoring data collection, processing and communication. *Journal of Information Technology in Construction*, 14, 129-153.

[72] H. Wang, Y. Hu. (2022). Artificial Intelligence Technology Based on Deep Learning in Building Construction Management System Modeling. *Advances in Multimedia*, 2022, 5602842.

[73] J. Teizer, B.S. Allread, U. Mantripragada. (2010). Automating the blind spot measurement of construction equipment. *Automation in Construction,* 19(4), 491-501.

[74] Y.-F. Liu, S. Cho, B.F. Spencer, J.-S. Fan. (2016). Concrete Crack Assessment Using Digital Image Processing and 3D Scene Reconstruction. *Journal of Computing in Civil Engineering*, 30(1), 04014124.

[75] P. Tang, D. Huber, and B. Akinci. (2011). Characterization of Laser Scanners and Algorithms for Detecting Flatness Defects on Concrete Surfaces. *Journal of Computing in Civil Engineering*, 25(1), 31-42.

[76] P. Giri, S. Kharkovsky, B. Samali. (2017). Inspection of Metal and Concrete Specimens Using Imaging System with Laser Displacement Sensor. *Electronics*, 6(2), 36.

[77] H. Hajian, G. Brandow. (2012). As-Built Documentation of Structural Components for Reinforced Concrete Construction Quality Control with 3D Laser Scanning. *Computing in Civil Engineering (2012)*.

[78] M. Golparvar-Fard, F. Peña-Mora, S. Savarese. (2012). Monitoring of Construction Performance Using Daily Progress Photograph Logs and 4D As-Planned Models. *Computing in Civil Engineering (2009)*.

[79] D. Atherinis, B. Bakowski, M. Velcek, and S. Moon. (2018). Developing and Laboratory Testing a Smart System for Automated Falsework Inspection in Construction. *Journal of Construction Engineering and Management*, 144(3), 1439.

[80] I. Petrov and A. Hakimov. (2019). Digital technologies in construction monitoring and construction control. *IOP Conference Series: Materials Science and Engineering*, 497, 012016.

[81] Takafumi Nishikawa, Takafumi Nishikawa, Junji Yoshida, Toshiyuki Sugiyama, Yozo Fujino. (2012). Concrete Crack Detection by Multiple Sequential Image Filtering. *Computer-Aided Civil and Infrastructure Engineering*, 27(1), 29-47.

[82] Z. Zhu, I. Brilakis. (2010). Concrete Column Recognition in Images and Videos. *Journal of Computing in Civil Engineering*, 24(6), 478-487.

[83] Z. Zhu, I. Brilakis. (2012). Automated Detection of Concrete Columns from Visual

Data. *Computing in Civil Engineering (2009)*, 135-145.

[84] J. Yang, P. Vela, J. Teizer, Z. Shi. (2014). Vision-Based Tower Crane Tracking for Understanding Construction Activity. *Journal of Computing in Civil Engineering*, 28(1), 103-112.

[85] J. Cao, W. Huang, T. Zhao, J. Wang, R. Wang. (2017). An enhance excavation equipments classification algorithm based on acoustic spectrum dynamic feature. Multidimensional Systems and Signal Processing, 28, 921-943.

[86] M. Al-Adhami, S. Wu, L. Ma. (2019). Extended Reality Approach for Construction Quality Control. *CIB World Building Congress 2019*.

[87] K.-L. Lin, J.-L. Fang. (2013). Applications of computer vision on tile alignment inspection. *Automation in Construction*, 35, 562-567.

[88] E.R. Azar. (2016). Construction Equipment Identification Using Marker-Based Recognition and an Active Zoom Camera. *Journal of Computing in Civil Engineering*, 30(3), 04015033.

[89] J. Gong, C.H. Caldas. (2012). An Intelligent Video Computing Method for Automated Productivity Analysis of Cyclic Construction Operations. *Computing in Civil Engineering (2009)*.

[90] J. Gong, C.H. Caldas. (2010). Computer Vision-Based Video Interpretation Model for Automated Productivity Analysis of Construction Operations. *Journal of Computing in Civil Engineering*, 24(3), 252-263.

[91] M.-K. Kim, J.P.P. Thedja, H.-L. Chi, D.-E. Lee. (2021). Automated rebar diameter classification using point cloud data based machine learning. *Automation in Construction*, 122, 103476.

[92] A. Akanmu, F. Okoukoni. (2018). Swarm nodes for automated steel installation tracking: A case study. *Automation in Construction*, 90, 294-302.

[93] M. Golparvar-Fard, A. Heydarian, J.C. Niebles. (2013). Vision-based action recognition of earthmoving equipment using spatio-temporal features and support vector machine classifiers. *Advanced Engineering Informatics*, 27(4), 652-663.

[94] Z. Yang, Y. Yuan, M. Zhang, X. Zhao, B. Tian. (2019). Assessment of Construction Workers' Labor Intensity Based on Wearable Smartphone System. *Journal of Construction Engineering and Management*, 145(7), 04019039.

[95] S. Ahsan, A. El-Hamalawi, D. Bouchlaghem, S. Ahmad. (2007). Mobile Technologies for Improved Collaboration on Construction Sites. *Architectural Engineering and Design Management*, 3(4), 257-272.

[96] M.-K. Kim, H. Sohn, C.-C. Chang. (2014). Automated dimensional quality assessment of precast concrete panels using terrestrial laser scanning. *Automation in Construction*, 45, 163-177.

[97] X. Zhou, J. Liu, G. Cheng, D. Li, Y.F. Chen. (2021). Automated locating of replaceable coupling steel beam using terrestrial laser scanning. *Automation in Construction*, 122, 103468.

[98] Q. Wang, M.-K. Kim, J.C.P. Cheng, H. Sohn. (2016). Automated quality assessment of precast concrete elements with geometry irregularities using terrestrial laser scanning. *Automation in Construction*, 68, 170-182.

[99] B. Akinci, F. Boukamp, C. Gordon, D. Huber, C. Lyons, K. Park. (2006). A formalism for utilization of sensor systems and integrated project models for active construction quality control. Automation in Construction, 15(2), 124-138.

[100] Z. Zhu, I. Brilakis. (2010). Machine Vision-Based Concrete Surface Quality Assessment. *Journal of Construction Engineering and Management*, 136(2), 210-218.

[101] H. Wu, H. Li, X. Luo, S. Jiang. (2023). Blockchain-Based Onsite Activity Management for Smart Construction Process Quality

Traceability. *IEEE Internet of Things Journal*, 10(24), 21554-21565.

[102] H. Wu, B. Zhong, H. Li, J. Guo, Y. Wang. (2021). On-Site Construction Quality Inspection Using Blockchain and Smart Contracts. *Journal of Management in Engineering*, 37(6) 04021065.

[103] V.D. Cao, D.A. Le. (2019). Autonomous concrete crack detection using deep fully convolutional neural network. *Automation in Construction*, 99, 52-58.

[104] S. Lee, M. Jeong, C.-S. Cho, J. Park, S. Kwon. (2022). Deep Learning-Based PC Member Crack Detection and Quality Inspection Support Technology for the Precise Construction of OSC Projects. *Applied Sciences*, 12(19), 9810.

[105] I. Razveeva, A. Kozhakin, A.N. Beskopylny, S.A. Stel'makh, E.M. Shcherban', S. Artamonov, A. Pembek, H. Dingrodiya. (2023). Analysis of Geometric Characteristics of Cracks and Delamination in Aerated Concrete Products Using Convolutional Neural Networks. *Buildings*, 13(12), 3014.

[106] L.-C. Wang. (2008). Enhancing construction quality inspection and management using RFID technology. *Automation in Construction,* 17(4), 467-479.

[107] B. Akinci, M. Patton, E. Ergen. (2002). Utilizing Radio-Frequency Identification on Precast Concrete Components - Supplier's Perspective. 2002 Proceedings of the 19th ISARC, Washington, USA, pp. 381-387.

[108] Z. Xu, R. Kang, R. Lu. (2020). 3D Reconstruction and Measurement of Surface Defects in Prefabricated Elements Using Point Clouds. *Journal of Computing in Civil Engineering*, 34(5), 920.

[109] G. Teza, A. Galgaro, N. Zaltron & R. Genevois. (2007). Terrestrial laser scanner to detect landslide displacement fields: a new approach. *International Journal of Remote Sensing*, 28(16), 3425-3446.

[110] H. Kim, K. Kim, H. Kim. Data-Driven Scene Parsing Method for Construction Site Monitoring. *2016 Proceedings of the 33rd ISARC, Auburn, USA*, pp. 943-947.

[111] V.K. Bansal, M. Pal. (2007). Potential of geographic information systems in building cost estimation and visualization. *Automation in Construction*, 16(3), 311-322.

[112] J.-S. Chou. (2011). Cost simulation in an item-based project involving construction engineering and management. *International Journal of Project Management*, 29(6), 706-717.

[113] F. Afzal, S. Yunfei, M. Nazir, S.M. Bhatti. (2021). A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies: Cost overrun in construction projects. *International Journal of Managing Projects in Business*, 14(2), 300-328.

[114] S.-H. Ji, M. Park, H.-S. Lee. (2011). Cost estimation model for building projects using case-based reasoning. *Canadian Journal of Civil Engineering*, 38(5), 570-581.

[115] D.T. Patil, A. Bhaumik. (2023). Efficiency of Internet of Things (IoT)-Enabled Systems in Reducing Construction Cost. *2023 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE)*, pp. 408-413.