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Computational Bibliometric Analysis of Artificial Intelligence in the Construction Industry Research

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ABSTRACT

The objective of this study is to employ bibliometric analysis to investigate the utilization of artificial intelligence in the construction sector. AI is not merely a novel technology governed by specific regulations, but rather a force that is integrated into everyday life. In this industry, artificial intelligence (AI) is a form of technology developed to see the development of construction projects carried out effectively, efficiently, and safely. The VOSViewer mapping is used to analyse bibliometric data on artificial intelligence in the construction industry. The reference manager application is used to obtain research data. We use the words "artificial intelligence" and "construction industry" as data search keywords for this research. We search for data from 2013 through 2023. The results show that the study on artificial intelligence in the construction industry obtained 997 relevant articles published between 2013 and 2023. In addition, the results of research on artificial intelligence in the construction industry have seen a drastic drop from 2021 to 2023. Artificial intelligence in the construction industry was the most published in 2020, with 227 articles published. This research shows how important bibliometric analysis is to obtaining information about this phenomenon. The study is prospectively intended to help and be a reference for scientists and researchers in conducting and defining research topics, especially those related to artificial intelligence and the construction industry.

Keywords:
Bibliometric analysis; Artificial intelligence; Construction industry

1. Introduction

The construction industry is a very important sector for the development of a country [1]. The construction industry offers many benefits, such as renovations of infrastructure that can improve the quality of life as well as access to a range of public services [2]. The construction industry has always been a sector that requires a lot of labour and resources to complete projects on time and at an appropriate cost [3]. The construction industry is known for its field of work in resource planning as well as in terms of risk management and logistics, but often experiences cost inflation and contract

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disputes [4]. The construction industry is unable to fully leverage and integrate the latest existing technologies, such as automation and robotics, due to various obstacles [5]. Over time, technological developments and various innovations have been emerging and facilitating the work in this construction industry [6].

This increasing technological development also requires humans to follow and understand the existence of the term "Internet of Things", which is a container for collecting information, as well as "Artificial Intelligence", which acts as a machine that analyses something related to the information collected by the IoT [7]. I is an evolution in finding, living, learning, communicating, and working that can identify problems and create solutions for the benefit of humans and society [8]. Artificial intelligence (AI) is not just a new technology that requires a rule; it is a power to use in everyday life [9,10]. In this industry, "Building Information Modelling" (BIM) has become one of the technologies developed to see the development of construction projects carried out effectively, efficiently, and safely [11]. This shows that AI has already been widely used and has a good impact in the world of the construction industry [12].

With the emergence of artificial intelligence, often referred to as AI, the way construction companies operate has changed, allowing them to improve efficiency, productivity, and safety in the implementation of projects [13]. AI has a variety of applications in the construction industry [14]. One of the most promising areas is in the planning and design stage. By considering various factors such as materials, labour, and environmental impact, AI-powered algorithms have helped reduce waste, optimize resources, and minimize costs in construction projects [15].

A bibliometric study is a methodology that can enhance the field of research because it can assist researchers in analysing and determining the appropriate methodology and journal for their research [16-19]. VOSViewer is a Java program that can be downloaded and used freely. The software is used to visualize references and quotes in the form of keywords [20]. Thus, bibliometric study is an important method of highlighting and enhancing a particular field, one of which is the field of the construction industry.

The research aims to find out about AI in the construction industry through bibliometric analysis by mapping data using VOSViewer from 2013 to 2023. To find data from 2013 to 2023, the keywords were derived from the relationship between "artificial intelligence" and "construction industry". Every year, research on artificial intelligence and the construction industry is increasing, although in 2015 and 2017 there was a decline. This shows the importance of bibliometric analysis related to artificial intelligence and the construction industry, with the hope of helping and being a reference for determining research topics. The research focuses on the topics of artificial intelligence and the construction industry [21].

Bibliometric analysis is widely recognized as well-established research method in informatics, especially in evaluating the research performance of researchers dan the universities [22]. Choosing nodes and links for a bibliometric study can vary based on the desired focus. Nodes can represent a variety of things, including authors, journals, subject categories, or individual articles [23]. Bibliometric studies are used to determine the body of knowledge in a field of study, look at the conceptual framework, and create the framework of a social network for that field of study [24].

The study of artificial intelligence (AI) therefore spans a number of academic disciplines, including information science, logic, cognition, thinking, systems, and biology. Applications include pattern recognition, machine learning, natural language processing, and knowledge processing. [25]. AI has potential to benefit the construction industry in a variety of ways, including reducing cost overruns, improving safety on the job site, and streamlining project management procedures [26].

Planning, constructing, and maintaining structures including buildings, roads, bridges, and other infrastructure are all part of the construction industry [26]. This industry, which includes numerous

tasks like architectural design, the purchase of supplies and equipment, project management, construction, as well as maintenance and rehabilitation, is essential to the growth and development of a nation. Other professionals and skilled employees employed in the building sector include architects, engineers, project managers, craftspeople, and other construction workers [27]. Building information modelling (BIM) and artificial intelligence (AI) have begun to play an important role in enhancing efficiency, productivity, and safety in the construction sector in recent years [28].

2. Methodology

The data used in this research is collected using the reference manager application Publish or Perish (PoP). The Publish or Perish (PoP) function is to review the literature, especially on the keyword topics we choose. Detailed information for the use of publish or Perish is described in previous research conducted by Al Husain *et al.,* [29]. It is then processed using the computational method of mapping visualization by the VOSViewer application with bibliometric analysis [30]. Every journal article data indexed by Google Scholar as well as having matches with the search themes required in this research is backed up into a file used in the use of VOSViewer [31]. Detailed information for the use of VOSViewer is presented in the literature [32,33].

In this study, only articles related to artificial intelligence in the construction industry were selected for analysis. These articles were published in Google Scholar-indexed journals from 2013 to 2023. Google Scholar was chosen as the source of data collection because of its open-source nature and wide scope in indexing publications. The keyword used for the search was "Artificial Intelligence, Construction Industry," and the search results were stored in two files, *.ris and *.csv. Automated analysis using the VOSViewer application and manual analysis using Microsoft Excel were used to process the data. Data mapping was conducted after the data selection process to analyse developments, research trends, and other fields and terms often associated with artificial intelligence research topics in the construction industry. Finally, the data was analysed to examine the development of research on artificial intelligence in the construction industry.

3. Results

3.1 Artificial Intelligence for Construction Industry Publication Development

The search for publication data on artificial intelligence in the construction industry resulted in 997 articles. Titles and abstracts were used as references to match the data with the chosen research topic, which is "artificial intelligence in the construction industry". A research matrix was created with the number of citations for research on artificial intelligence in the construction industry indexed in Google Scholar during a ten-year period from 2013 to 2023. The total number of research citations was 85,791, with an average citation per article related to this study of 86.05 and an average citation per year of 8,579.10. Articles on artificial intelligence in the construction industry have an h-index of 136 and a g-index of 241. The h-index value reflects the level of productivity and impact of the research conducted [34], with higher h-index values indicating more advanced research in the field [35].

Based on the analysis of the articles with the most citations, one of the most frequently cited is the article entitled "Why are there still so many jobs? The history and future of workplace automation," which has a total of 3,490 citations and was published in 2015. Table 1 shows detailed information for the most cited articles.

Table 1
Artificial intelligence in the construction industry publication data

No	Authors	Title	Year	Cites	Refs
1	DH Autor	Why are there still so many jobs? The history and future of workplace automation	2015	3490	[36]
2	LD Xu *et al.,*	Industry 4.0: state of the art and future trends	2018	2532	[37]
3	AG Frank *et al.,*	Industry 4.0 technologies: Implementation patterns in manufacturing companies	2019	1790	[38]
4	S Mullainathan and J Spiess	Machine learning: an applied econometric approach	2017	1689	[39]
5	J Wang, Y Ma *et al.,*	Deep learning for smart manufacturing: Methods and applications	2018	1236	[40]
6	D Acemoglu and P Restrepo	Automation and new tasks: How technology displaces and reinstates labour	2019	1001	[41]
7	YK Dwivedi *et al.,*	Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy	2021	951	[42]
8	S Grigorescu *et al.,*	A survey of deep learning techniques for autonomous driving	2020	936	[43]
9	Y Liu *et al.,*	Materials discovery and design using machine learning	2017	795	[44]
10	A Gatt and E Krahmer	Survey of the state of the art in natural language generation: Core tasks, applications and evaluation	2018	777	[45]

Figure 1 depicts the development of research published in the indexed journal Google Scholar on artificial intelligence in the construction industry. Research on artificial intelligence in the construction industry has shown fluctuations from 2017 to 2023. The number of publications increased from 26 articles in 2013 to 29 articles in 2014, and further to 42 articles in 2015 and 48 articles in 2016. In 2017, the number of publications declined to 44 articles. However, from 2018 to 2020, the number of publications dramatically increased from 87 articles in 2018 to 151 articles in 2019, and further to 227 articles in 2020. However, between 2021 and 2023, the number of publications drastically dropped from 223 articles to 99 articles, and in 2023, only 23 articles were published, with a possibility of further increase this year. The development of research on artificial intelligence in the construction industry serves as a basis for future research on artificial intelligence in the building industry. The current research trends on artificial intelligence in the construction industry are still relevant for future studies.

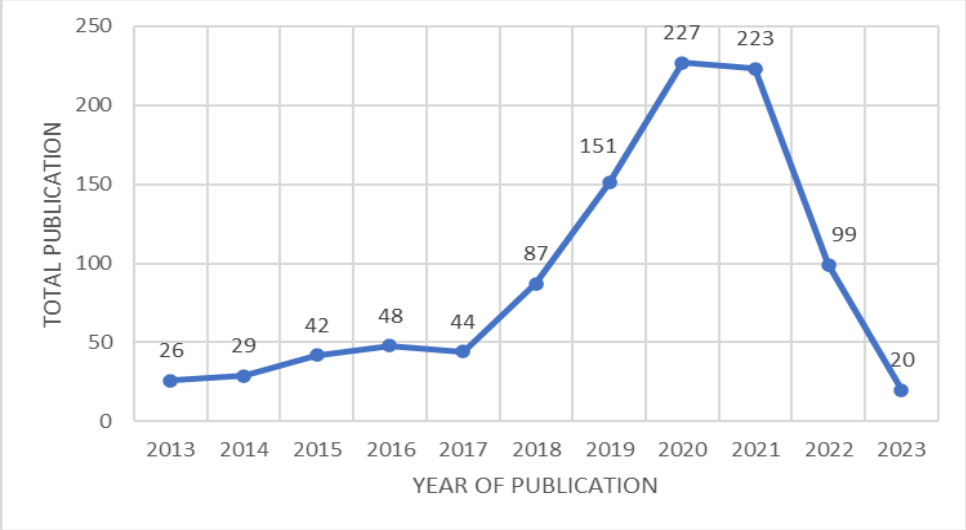

Fig. 1. Artificial intelligence in the construction industry publication development

3.2 Artificial Intelligence in the Construction Industry Publication Mapping Visualization

Based on the mapping results, 7,882 related terms were found in research on artificial intelligence in the construction industry. We determined the number of occurrences of terms that appeared at least 5 times, resulting in 250 terms being included. Then, we selected the most relevant 76% of these terms, resulting in 190 terms being used for mapping visualization. The selection of these terms was based on their relevance and importance to artificial intelligence research in the construction industry.

Figure 2 shows the visualization of the network of publications on artificial intelligence in the construction industry from 2013 to 2023. The mapping visualization displays a network between the visualized terms (Yu *et al.,*; Ospina-Mateus *et al.,*; Pinto *et al.,*). and groups or clusters them. The terms related to research on artificial intelligence in the construction industry are divided into 8 clusters.

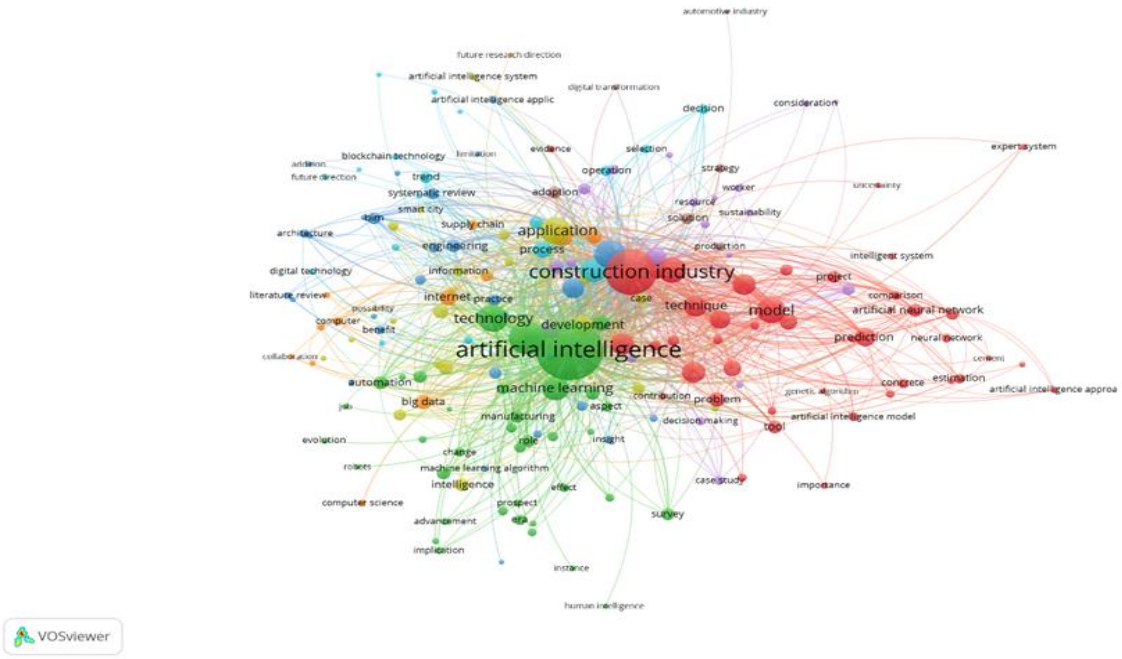

Fig. 2. Network visualization of artificial intelligence in the construction industry publication

Table 2 shows the distribution of clusters in the mapping research analysis on artificial intelligence in the construction industry.

Table 2
Cluster mapping analysis

Cluster	Colour	Items	Items
1	Red	43	Algorithm, analysis, ann, approach, artificial intelligence approach, artificial intelligence method, artificial intelligence model, artificial intelligence technique, artificial intelligence tool, artificial neural network, cement, company, comparison, compressive strength, concrete, construction cost, construction industry, construction project, contribution, data, estimation, evidence, genetic algorithm, importance, intelligent system, methodology, model, neural network, optimization, performance, prediction, prediction model, problem, productivity, project, researcher, study, support vector machine, technique, tool, uncertainty, world

2	Green	37	Advance, advancement, analytic, artificial intelligence, aspect, automation, change, cyber physical system, deep learning, education, effect, era, evolution, future, human intelligence, impact, implication, industry, innovation, instance, job, machine learning, manufacturing, manufacturing industry, medicine, prospect, robot, robotic, robots, role, site, society, survey, systematic literature review, technology, transformation, and work
3	Blue	28	Ability, Addition, architecture, artificial intelligence application, benefit, bim, concept, construction, construction sector, database, engineering, information modelling, insight, knowledge, limitation, literature review, machine learning algorithm, organization, perspective, potential, practice, research, section, simulation, systematic review, term artificial intelligence, visual reality, and visualization.
4	Yellow	24	Application, article, artificial intelligence algorithm, artificial intelligence system, artificial intelligence technology, blockchain, case, development, digital twin, effectiveness, efficiency, evaluation, implementation, information, intelligence, level, natural language processing, network, opportunity, possibility, service, smart city, term, and vision.
5	Purple	20	Assessment, building, case study, comparative study, consideration, construction site, control, decision making, demand, feature, framework, integration, intelligent technology, machine, planning, resource, safety, sustainability, utilization, and worker
6	Cyan	19	Big data analytic, blockchain technology, combination, construction management, construction supply chain, critical review, decision, digital technology, digitalization, environment, future direction, operation, process, selection, supply chain management, system, trend, and value
7	Orange	13	3d printing, area, big data, big data, cloud computing, collaboration, computer, computer science, future research direction, information technology, internet, iot, management, and supply chain.
8	Brown	6	Adoption, automotive industry, digital transformation, production, solution, and strategy

Figure 3 displays an overlay visualization of publications related to artificial intelligence in the construction industry. This visualization shows the distribution of research conducted over the years, allowing for updates to the usage of related terms in research [49]. As demonstrated in Figure 3, the majority of research related to artificial intelligence in the construction industry was conducted in 2018 and 2019. The dominant colour of the nodes in Figure 3 ranges from green to yellow.

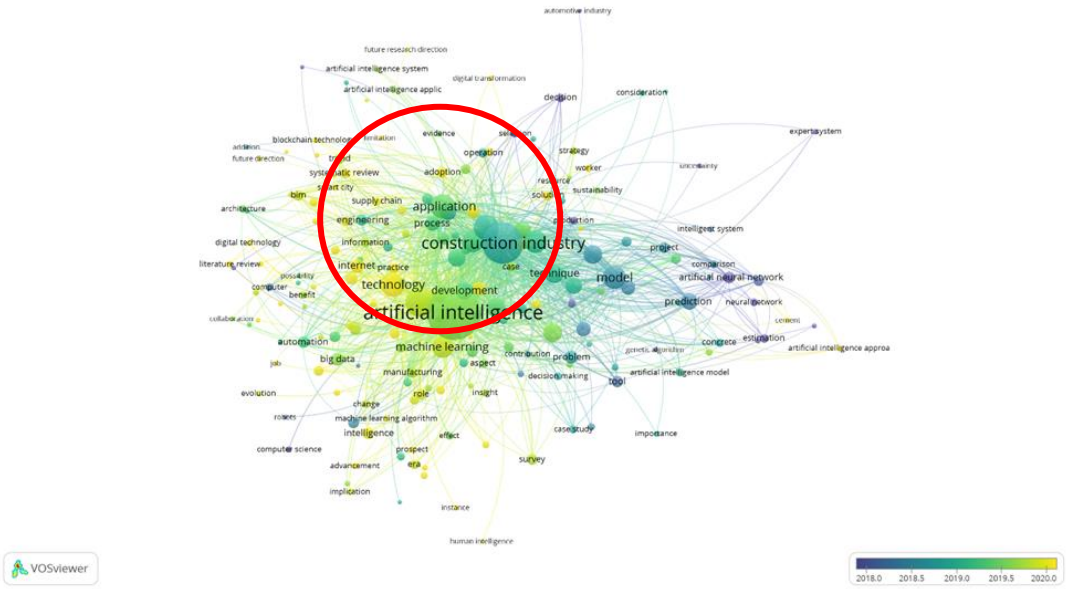

Fig. 3. Overlay visualization of artificial intelligence in the construction industry publication

The visualization of research density on artificial intelligence in the construction industry is presented in Figure 4. The colour density visualization indicates that the brighter the yellow colour

and the larger the diameter of the circle of a term, the more frequently the term appears [50]. Conversely, the amount of research on a term depends on when the colour on the term fades and approaches the background colour [51]. As shown in Figure 4, there is a significant amount of research on artificial intelligence, the construction industry, development, technology, industry, models, and applications. Artificial intelligence appears the most, with 649 occurrences. This suggests that most of the research is related to artificial intelligence. Dwivedi *et al.,* conducted research on Artificial Intelligence (AI), which provides a multidisciplinary perspective on emerging challenges, opportunities, and agendas for research, practice, and policy. Other research, such as that conducted by Principal *et al.,* [52] and Gunawan *et al.,* [53], also highlight the bibliometric effectiveness of analysing current research trends, which is in line with the findings of this research.

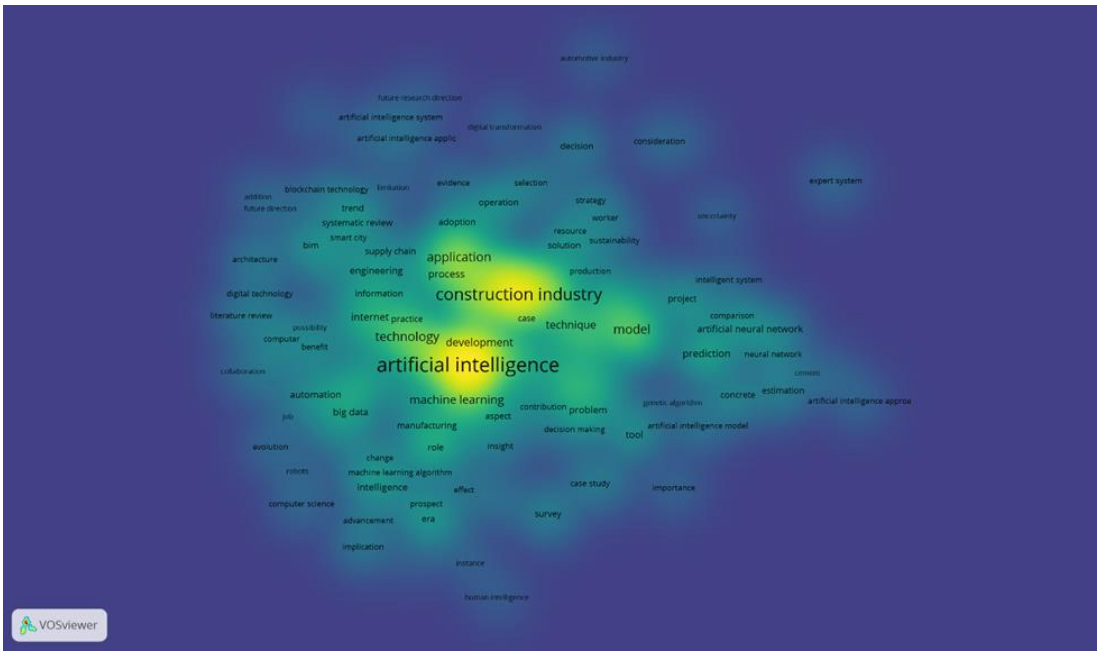

Fig. 4. Density visualization of artificial intelligence in the construction industry publication

4. Conclusions

The study aims to conduct a bibliometric analysis of research on artificial intelligence in the construction industry by combining mapping analysis with VOSViewer software. The Publish or Perish (PoP) 8 reference management application was used to collect data for this research. The data was collected based on the keywords “Artificial Intelligence” and “Construction Industry” and included bibliographic information such as topic, title, keyword, and abstract. The article published between 2013 until 2023, and the total article that relevant to the keyword is 997 articles. The result indicate that the highest number of publications related to Artificial Intelligence (AI) in the construction industry was in 2020. The Analysis revealed a direct connection between construction industry development research and artificial intelligence, as demonstrated by the VOSViewer data. The Study’s findings are expected to provide valuable insights for scientist and researchers as they embark on further research related to artificial intelligence and the construction industry.

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