How Artificial Intelligence Changed the Construction Industry in Safety Issues

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PZ Razi[1], **SK Sulaiman**[2],**MI Ali**[3], **NI Ramli**[4], **MSH Saad**[5], **O Jamaludin**[6], **SI Doh**[7]
[1,2,3,4,5,6,7] Faculty of Civil Engineering Technology, University Malaysia Pahang, Lebuhraya Tun Razak, 26300, Gambang, Kuantan, Pahang

Abstract. In recent years, the development of machine learning in construction as well as the preparation of appropriate software aims to provide improved solutions to potential safety hazards and risks within the construction environment. However, the fatalities and injuries in construction sites still happened frequently, and the high numbers of accidents and casualties make construction work the most hazardous occupation. This study aims to analyze the prioritize of artificial intelligence (AI) important factors in construction safety using the AHP method. Construction safety practitioners were selected as the respondent. The hierarchy was established consisting of five (5) factors, which were subsequently categorized into twelve (12) sub-factors. With 25.43 percent, jobsite was determined to be the most significant AI element in construction safety, followed by technology component with 25.37% and human error with 22.76%. The subfactors that prioritize are noticed to safety officers when workers disregard safety on the construction site with 69.21%, cloud computing technique, inspecting, controlling, and training with 60.04%, and AI in construction safety can predict the possible issues with 14.29%. The findings of this study can help software developers in determining the level of priority for the use of AI in the safety aspect of construction sites.
(keywords : Artificial Intelligence (AI); construction; safety; risk; hazard)

1. Introduction

Artificial intelligence, or AI, is a broad field of computer science concerned with the development of intelligent robots able to do activities that traditionally require human intellect. It plays a crucial role in assisting construction supervisors to minimize accidents, maintain project efficiency, and dramatically improve operational safety. In recent years, it has been evident that the construction sector is embracing digitization and quickly upgrading its technical capability, particularly in light of labour shortages, the COVID-19 outbreak, and the need to develop sustainable infrastructures. The use of artificial intelligence and related subfields to construction-specific problems. Among other applications, machine learning has been used for health and safety monitoring, cost calculation, supply chain and logistics process enhancements, and risk prediction. It is considered that AI's potential may provide both short- and long-term benefit. AI is a potentially valuable tool for construction safety. Given the anticipated advantages of better safety and decreased costs, artificial intelligence in construction safety will continue to evolve [1].

Construction has been regarded as one of the riskiest industries, where the number of fatal accidents exceeded in many developed countries without a significant downward trend. Numerous kinds of research have revealed that safety issues are tied up with hazardous working conditions and the lack of supervision, emphasizing the necessity of construction management for safety guarantee and accident prevention [2]. By using data to help identify patterns and determine the root cause of an accident, incident or near miss, AI systems in construction are aiming to prevent accidents by giving workers the tools to predict and thus, prevent accidents, and most importantly, fatalities. Since manual checking may cause some errors, real-time detection of behaviours of the workers may help to reduce accidents in the

construction sites. With the help of AI (Artificial intelligence) safety in construction sites can be monitored at ease [3].

The opportunities of AI are believed can offer both short and long-term value. AI can be a useful technology in construction safety. Figure 1 shows some of the advantages and limitations of the subfields of AI in the construction industry. Similar advantages across all the subfields include increased cost and time savings, improved safety, better accuracy, and overall increased productivity. Some of the limitations of AI subfields in construction includes incomplete data, high initial cost of deployment, data and knowledge acquisition issues. Given its expected benefits of increased safety and reduced costs, AI in construction safety will continued to develop [1].

Subfield	Advantages in construction	Limitations in construction
Machine Learning	- Relevant predictive and prescriptive insights - Increased efficiency - Cost savings - Improved safety - Efficient utilisation of resources - Reduced mistakes and omissions	- Incomplete data - Learning from streaming data, dealing with high-dimensional data, scalability of models and distributed computing
Computer Vision	- Faster inspection and monitoring - Better accuracy, reliability and transparency - Cost effective - Increased productivity - Increased safety	- Total scene understanding - Action recognition of equipment and/or workers - Improvement of tracking accuracy and effective visualisation of tracking results.
Automated Planning and Scheduling	- Cost savings due to improved processes e. g. logistics - Increased productivity - Reduced planning effort - Simplified monitoring and control - Optimal plan and schedules	- Mostly expensive to implement - Could be Complex - Knowledge representations for needed models, monitoring issues, integration issues, synthesis techniques, etc.
Robotics	- Increased safety - Increased productivity - Improved quality - Better reliability and accuracy - Faster and more consistent than humans	- High initial costs - Potential job loss due to automation - Maintenance and repair costs - Unstructured work environment
Knowledge-based systems	- Easy access to relevant information - Easy to update - Ability to explain reasoning behind solution - Consistency and availability - Can work with incomplete information - Clear logic	- Intellectual property protection and security issues - Knowledge acquisition issues - Knowledge validation issues
Natural Language processing	- Increased productivity - Cost effectiveness - Time efficiency - Improve communication among stakeholders	- Appropriate representation of fragmented, extended and errorful language - Speech recognition issues such as construction site noise, homonyms, accent variability, etc. - Data privacy and security issues
Optimisation	- Increased productivity due to optimised processes - Increased efficiency - Cost and time savings	- Requires significant computing power - Scalability issues

Figure 1. Advantages and limitation of AI subfields in construction

2. Literature Review

Previous research particularly in Artificial Intelligence in construction safety were reviewed.

2.1. Safety Issues in Construction Industry

On-site safety is described as the absence of hazard or the elimination of situations that are lethal. Construction accidents annually harm or kill thousands of construction workers. Accidents are unexpected occurrences, which break the sequence of events. Thereby a loss in the production of the company occurs [2]. Even for the most seasoned construction worker, construction sites are inherently hazardous. Accidents continue to occur and will continue to occur owing to the nature of the job and the many dangers construction workers confront. The system, environment, and individual engaged in construction operations are to blame for accidents [3]. Nonetheless, [4] conducted a bibliometric

examination of the safety culture topic. They reviewed several research conducted between 1900 and 2015. According to them, the importance of occupational health and safety (OHS) has increased tremendously over the last decade, and human factors have become essential when addressing the safety culture [4].

2.2. Artificial Intelligence (AI)

The goal of Artificial Intelligence is for computers to be able to do human-like tasks, hence relieving humans of menial tasks and reducing human expenses. Therefore, the connection with the building sector will further accelerate the intelligence growth of engineering management. The rising usage of artificial intelligence (AI) in construction engineering and management in recent years is mostly attributable to the technology's promise for enhancing construction performance and efficiency [5]. [6] connected AI to the transformation of the construction sector. Nevertheless,[7] explored a multitude of AI applications in building use cases. In addition, he discussed its applicability in additive manufacturing (3D printing) [8].

2.3. Important of Artificial Intelligence in Construction Safety

As artificial intelligence evolves, so do its abilities to improve safety standards while predicting incidents before they happen. Using artificial intelligence, safety monitoring systems may sift through vast quantities of visual data to detect personnel and circumstances that do not comply with safety standards. Field reporting software enables foreman to input job-site activities or alerts concerns such as keeping key project stakeholders apprised in real-time even when they are not on-site [6].AI can be an invaluable tool in all sorts of business endeavours. When it comes to processes like data analysis and safety protocols, machine learning is the future. For instance, AI programs can assist with the visual analysis of a construction site, providing real-time data collated from cameras and other sensors throughout the location. This can provide vital information on potential hazards, accident likelihood, and similar key points to help plan for worker safety. This information is invaluable not only at the inspection stage but also as work progress and hazards emerge. AI can easily monitor progress in any given area and keep tabs on the responsible workers.

3. Methodology

The questionnaire was the primary instrument for the main survey and the design was based on an examination of the literature of relevant factors and sub-factors from the construction safety industry and experts from the construction safety industry. The study will be analyzed by adopting the Analytical Hierarchy Process (AHP). This study first conducted a focus and systematic search of literature review on the topic of Artificial Intelligence (AI) in safety construction issues. From the search, the important factors of AI in safety construction were retrieved and developed via the hierarchy diagram in Figure 2. Figure 2, the AHP diagram shows important factors reflected to AI adoption in construction safety. Each factor obtained from the searching and reviewing literature on the topic of Artificial Intelligence (AI) in safety construction issues. Among the factors that reflected to the prominent factors of AI adoption in construction safety were budget [9], communication, human error, Jobsite [8] and technologies [3].

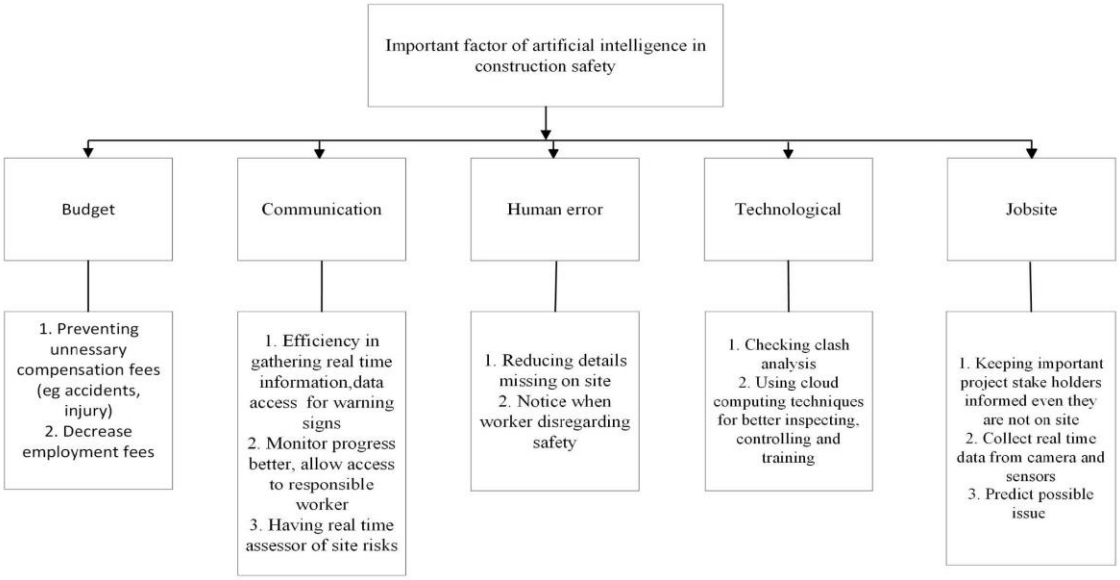

Figure 2. AHP Hierarchy Diagram.

In the main survey, the questionnaire administration technique employing the web-based questionnaire. For selected experts in the construction safety sector, a web-based questionnaire strategy was used. The operational definitions used in the questionnaire were clearly explained to respondents. In AHP, the decision issue is often subdivided into a hierarchy of subproblems that may be separately analysed. The components of the hierarchy may relate to any aspect of the decision issue. Experts provide a numerical scale to each pair of options Ai, Aj after the construction of the hierarchy (Table 1).

Table 1. Numerical Index [9]

Numerical scale	Definition	Verbal explanation
1	Equal significance of the two elements	Two elements contribute equally to the property
3	Low significance of one element compared to another	Experience and personal assessments favor one element slightly over another
5	Strong significance of one element compared to another	Experience and personal assessments favor one element strongly over another
7	Confirmed dominance of one element over another	One element is strongly favored and its dominance is borne out in practice
9	Absolute dominance of one element over another	The evidence favoring one element over another appears irrefutable
2,4,6 and 8	Intermediate values between two neighbouring levels	The assessment falls between two levels
Reciprocal (1/x)	A value attributed when activity is compared to activity j becomes the reciprocal when j is compared to i	

The suggested method employs the AHP technique for the paired comparison of significant elements, allowing for the objective ranking of detected factors. The framework offers a decision-making instrument for identifying the significance of AI in building site safety. After the hierarchy has been constructed, experts give a numerical scale to each pair of alternatives based on their influence on

the element at the highest level of the hierarchy. By turning assessments of elements into numerical values, a priority index for each expert's opinion is determined [9]. Then, using the processed weights of the AHP, numerical values are compared, and priority is assigned to significant factor items. This ranking of factor items enables decision makers to distinguish between the most and least important factor items. The suggested architecture facilitates the application of AI on building sites by decision makers [9].

4. Results and Discussion

Using the AHP technique, the purpose of this research is to examine the prioritisation of artificial intelligence-related safety considerations. The created hierarchy consisted of five (5) elements, each of which was further subdivided into subfactors. To assist the expert in conducting pairwise comparisons among the hierarchy's members, reciprocal matrices were developed. Because it employs reciprocal value in matrices, geometric mean is used. Moreover, the ratios of global priorities fluctuate with various normalizations of local priorities when arithmetic mean aggregation is employed, but do not change when geometric mean aggregation is used[10].

Table 2 shows the most prioritized important factors of AI in construction safety are jobsite (25.43%), followed by technology (25.37%), and human error (22.76%). The two least factors are communication (13.79%) and budget (12.64%). Jobsite dominated the ranks largely due to the accidents that frequently happened on-site will delay the project. Prior studies have reported that using AI can make jobsite more productive and safer. Similarly, project managers are able to monitor location-based tasks in a progressive manner. They use face recognition, on-site cameras, and comparative advances to assess labourer productivity and technique conformity [10]. Furthermore, the sub-factors were also ranked, top and bottom three (3) sub-factors will be further discussed. In Table 2, it was shown that the factor of AI gives notice to safety officers when workers disregard safety on the construction site with 69.21%. This study is parallel with [11] findings. A system that warns an operator with a warning message, hence reducing hazards, is an example of an AI technology that focuses on site staff safety. With greater efficiency, AI may contribute to improvements in safety and health, since technologies and robots can be utilised to analyse locations and perform hazardous activities for people.

Table 2. List of Prioritized Weight Factor.

Core Element	Factor Elements (Local Weighted, %), Rank	Factor Sub-Elements (Local Weighted, %)	Global Weighted (%)	Ranking
Important Factor	Budget (12.64), 5	B1, (56.12)	7.09	5
		B2, (43.88)	5.55	9
	Communication (13.79), 4	C1, (2.9)	3.16	12
		C2, (32.94)	4.54	10
		C3, (44.15)	6.09	8
	Human Error (22.76), 3	HE1, (30.79)	7.01	6
		HE2, (69.21)	15.75	1
		T1, (39.96)	10.14	4

Technology (25.37), 2	T2, (60.04)	15.23	2
Jobsite (25.43), 1	J1, (16.43)	4.18	11
	J2, (27.38)	6.96	7
	J3, (56.18)	14.29	3

5. Conclusion

There is no way out of safety issues in construction projects if conventional safety monitoring adopted without embracing new technology to assist the system. Hence, this study is conducted to identify the importance of artificial intelligence (AI) adoption in construction safety. It was found that the most prioritized important factors of AI in construction safety are jobsite (25.43%), followed by technology (25.37%), and human error (22.76%). The two least factors are communication (13.79%) and budget (12.64%). Jobsite dominated the ranks largely due to the accidents that frequently happened on-site will delay the project. From the important factors, safety officers can focus on the factors and consider using AI for the construction site. With greater efficiency, AI may contribute to improvements in safety and health, since technologies and robots can be utilised to analyse locations and perform hazardous activities for people. Based on this study, recommendations that should be explored in the future are:

i. The impact of AI on safety that is related to all phases of the construction stage.

ii. The development of further AI related to safety applications.

iii. The comparison between AI and IoT (Internet of Things) in construction safety issues.

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