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A Literature Review on Development of Real-Time Safety Monitoring of Scaffolding in Construction Site Using Vision-Based Techniques

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Abstract
The construction industry is high-risk, with worker safety as a top priority. This project aims to develop a real-time safety monitoring system for construction sites using vision-based techniques to improve worker safety. A systematic journal analysis was conducted on papers published between 2020 and 2024. After reviewing 32 journal articles, 27 meeting the selection criteria were finalized for analysis. Using VOS viewer, the analysis identified significant contributions in journals such as Applied Sciences, Automation in Construction, and Sustainability, which showed strong impact. Countries with higher-impact journals included South Korea, the United States, and China, with developed nations dominating in total and average citations. Journal analysis provides valuable insights by identifying research trends, uncovering knowledge gaps, and offering a deeper understanding of the field. It also helps guide future research and publication decisions by highlighting the most influential work in construction safety and real-time monitoring systems.
Keywords: *VOS viewer, Applied Sciences, Automation in Construction, and Sustainability*

1. Introduction
Construction site are prone to accidents and even death. Good safety practices prevent accidents and injuries, keep workers healthy, and help projects run smoothly without unexpected delays. Following safety rules also helps companies avoid legal trouble and shows they care about their workers, which improves their reputation. Overall, construction site safety is essential for protecting people, keeping work efficient, and meeting legal standards. Construction sites are inherently high-risk environments with various hazards, making scaffolding safety a critical concern [10]. Recent statistics reveal that falls from scaffolding have increased from 33% to 38% [14], emphasizing the urgent need for effective monitoring. Traditional safety inspections on construction sites are conducted manually, a process that is time-consuming, prone to human error, and often inadequate for detecting unsafe practices in real time [3]. These limitations highlight the need for a more reliable, automated solution to monitor safety compliance continuously and accurately. This approach identifies potential hazards and unsafe behaviors, providing timely notifications to safety officers to prevent accidents before they occur. This automated system not only reduces the likelihood of human error but also ensures that safety regulations are consistently enforced [2][3]. Ultimately, implementing such technology on construction sites enhances overall site safety, mitigates the risks of falls and injuries, and contributes to a safer working environment for construction workers [4] [12].

1.1 Vos Viewer
VOS viewer can be used to construct networks of scientific publications, scientific journals, researchers, research organizations, countries, keywords, or terms. Items in these networks can be connected by co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links. To construct a network, data from Web of Science, Scopus, PubMed, RIS, or Crossruff JSON files can be used [28]. VOS viewer provides three visualizations of a map: The network visualization, the overlay visualization, and the density visualization. Zooming and scrolling functionality allows a map to be explored in full detail, which is essential when working with large maps containing thousands of items. [28] Although VOS viewer is intended primarily for analyzing bibliometric

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networks, it can in fact be used to create, visualize, and explore maps based on any type of network data.

1.2 Methods

To identify research gaps in the existing literature on Development of Real-Time Safety Monitoring of Scaffolding in Construction Site Using Vision-Based Techniques, by conducting a systematic review using VOS viewer. For the analysis 27 relevant journals sourced from Google Scholar and other sources were taken. VOS viewer, a powerful bibliometric software [28], will be employed to visualize and analyze the co-occurrence networks of keywords and authors, revealing clusters of research themes and identifying areas where further investigation is warranted. By mapping the intellectual landscape of the chosen research area, this study aims to contribute to a deeper understanding of existing knowledge, pinpoint areas of under-exploration, and guide future research endeavors towards addressing critical gaps and advancing the field.

2. Results and Discussion

2.1 Systematic Review

The systematic review conducted from the referred journals.

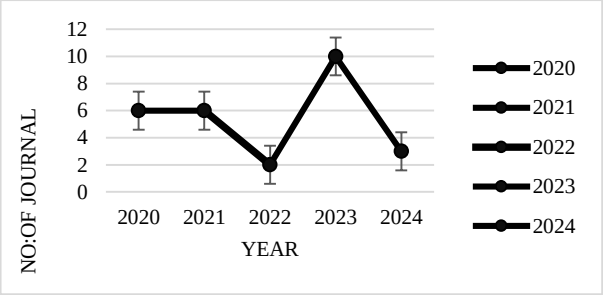


Figure 1 Number of Journal vs year graph

From the graph it was noted that, the no: of journals in 2024 is 3 and the journals based on scaffolding assembly deficiency detection Augmented reality, quality inspection using point cloud technique and YOLO used for personal protection equipment detection.

2.2 Analysis of Journals Using Vos Viewer

For the analysis, 27 journals were considered

2.3 Journal Co-Authorship Network

The Journal Co-Authorship Network in VOS viewer visualizes collaborations among authors within a specific journal. By mapping authors as nodes and their co-authorships as edges, it reveals patterns of collaboration, identifies key researchers, and highlights trends, offering insights into research dynamics and networking opportunities within the academic community is shown in fig.2

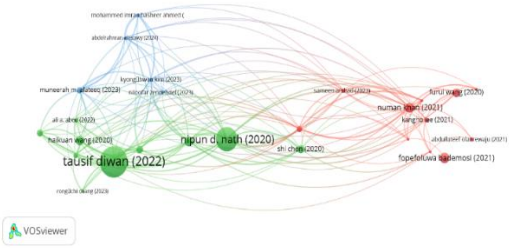
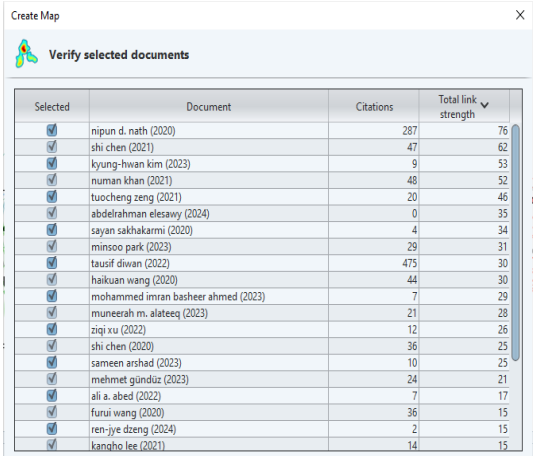


Figure 2 Network Visualization for Journals Using Vos Viewer

The map visualizes collaboration among researchers from 2020 to 2024, with node size reflecting publication influence, indicating the impact of individual researchers or research groups. The colors of the nodes represent different thematic focuses, while the connecting lines illustrate co-authorship patterns; thicker lines denote stronger collaborations based on the number of joint publications. Two prominent nodes specifically highlight the influence of YOLO (You Only Look Once) detection, representing key contributors who have significantly advanced this technology and its applications. By analyzing these patterns, stakeholders can identify leading researchers, emerging trends, and opportunities for future collaboration in the rapidly evolving fields of computer vision and machine learning is shown in **fig.3**


Create Map

Verify selected documents

Selected	Document	Citations	Total link strength
☑	nipun d. nath (2020)	287	76
☑	shi chen (2021)	47	62
☑	kyung-hwan kim (2023)	9	53
☑	numan khan (2021)	48	52
☑	tuocheng zeng (2021)	20	46
☑	abdelrahman elesawy (2024)	0	35
☑	sayan sakhakarmi (2020)	4	34
☑	minsoo park (2023)	29	31
☑	tausif diwan (2022)	475	30
☑	haikuan wang (2020)	44	30
☑	mohammed imran basheer ahmed (2023)	7	29
☑	muneerah m. alateeq (2023)	21	28
☑	ziqi xu (2022)	12	26
☑	shi chen (2020)	36	25
☑	sameen arshad (2023)	10	25
☑	mehmet gündüz (2023)	24	21
☑	ali a. abed (2022)	7	17
☑	furui wang (2020)	36	15
☑	ren-jye dzeng (2024)	2	15
☑	kangho lee (2021)	14	15

Figure 3 Journal with Citations and Total Link Strength from Vos Viewer

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2.4 Journal Network Based on Concept

Concept-based visualization in VOS viewer focuses on representing relationships between terms based on their co-occurrence in data, like scientific literature. It groups related concepts visually, often with clusters and distances to show topic proximity, enabling easier exploration of research trends, term relevance, and interconnected ideas in large datasets is sown in **fig.4**

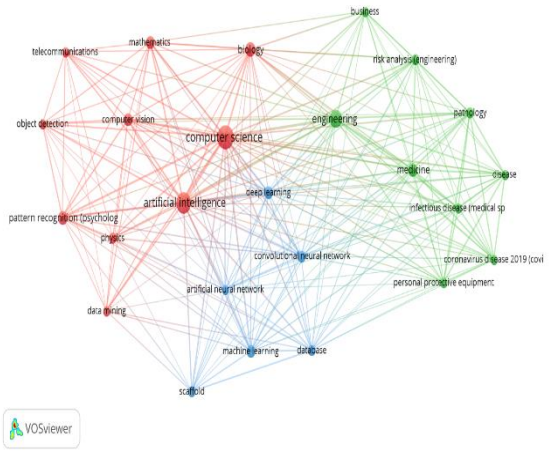

Figure 4 Network Visualization Based on Concept in Journals Using Vos Viewer

The "Red" colour represents the object detection, "Blue" colour is for scaffolding and "Green" for PFAS.

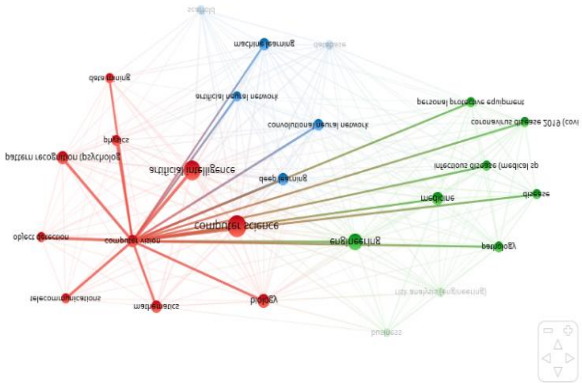

Figure 5 Network Visualization Focusing on Computer Vision Node Using Vos Viewer

From the **fig.5** the node of computer vision and its connections depicted. It has connections with the PPE, ML and other factors and no connection with scaffolding.

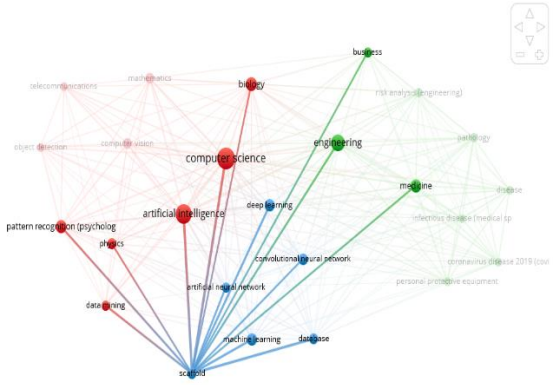

Figure 6 Network Visualization Focusing on Scaffolding Node Using Vos Viewer

From the **fig.6** the node shows the connections of scaffolding. It has one connection with ML and no connection with PPE, computer vision and object detection.

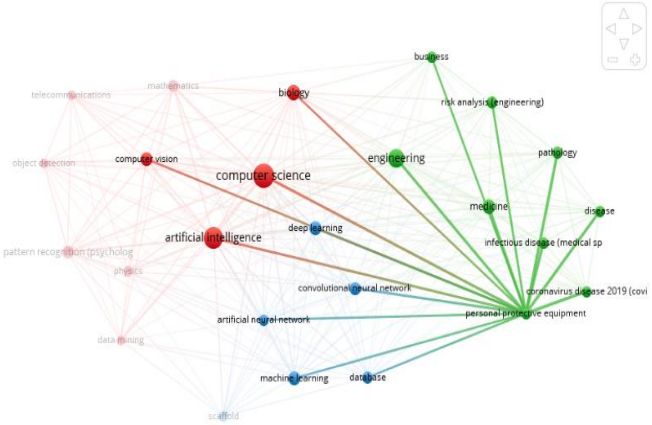

Figure 7 Network Visualization Focusing on PPE Node Using Vos Viewer

From the **fig.7** the Connections of PPE node and it shows connections with ML and computer vision. No connection with scaffolding From the analysis for journals based on concept, the scaffolding and machine learning have one connection and lack of connection with Personal fall arrest system detection. The different nodes in the figures represents the different factors. The most influenced node is AI and Computer science and engineering.

Conclusion

The research literature analysis showed that a dynamic interplay of factors influenced construction site safety. Machine Learning was a critical technology with strong connections to the key safety aspects, such as PPE monitoring. On the other hand,

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scaffolding safety showed little integration with computer vision, and hence, this area is quite open for further research. While connections between PPE and both ML and Computer Vision are evident, integrating these technologies for scaffolding safety challenges such as fall detection and structural stability assessment remains relatively under-explored. This opens up further avenues for research into the full exploitation of ML and Computer Vision to improve scaffolding safety, leading to a safer and more productive construction environment.

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