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Advancements in Real-Time Incident Reporting for Construction Sites: A Literature on NLP Applications

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Abstract

Construction site incidents show growing concern based on data collected by the International Labour Organization which demonstrates rising frequency of incidents along with severe consequences. The evaluation of research between 2020 and 2024 outlines existing practices, difficulties and prospective uses of NLP and AI to revolutionize incident reporting procedures. The review examines three major sections about present-day operations and Natural Language Processing applications while also analyzing Artificial Intelligence-based severity assessment methods. Through the Litmap system identified a significant problem in connecting NLP technology with immediate incident data entry. A method to analyze site-specific data by conducting surveys uses NLP speech recognition technology alongside AI tools that perform report assessment along with severity classification to develop a real-time alert system. This approach seeks to offer useful information that both enhances safety protocols and enables better decisions at the same time. NLP and AI work together to strengthen occupational safety by assessing sites more efficiently thus lowering accident frequencies and resulting in better safety results. This system provides the potential to lower both accidents and near-miss incidents dramatically during its implementation phase.

Keywords: *Automated Incident Reporting, AI, NLP, Construction Site Safety Management, Litmap, Speech Recognition.*

1. Introduction

Construction industry faces substantial difficulties from hazardous site conditions which exist across all building worksites. Recent data reveals a concerning increase in construction site incidents, emphasizing the urgent need for improved safety practices and more efficient response mechanisms. Traditional reporting systems, often reliant on manual methods, are slow and inefficient, leading to delays in addressing critical safety issues. These inefficiencies are compounded by fragmented communication channels, decentralized safety data, and challenges such as language barriers and unclear instructions, which further hinder effective risk management. A centralized, real-time incident reporting system has the potential to bridge these gaps, enabling faster communication, improved awareness, and quicker responses to safety hazards. Advanced technologies like Natural Language Processing (NLP) and Artificial Intelligence (AI) offer transformative solutions to these challenges. NLP enables the conversion of voice reports into text, automating documentation and reducing reliance on manual data entry. Similarly, AI-powered systems can analyze incident data, classify severity in real time, and assist safety managers in prioritizing high-risk situations for immediate action. This literature review explores the current state of incident reporting in the construction industry, highlighting prevalent practices and the limitations that persist. It delves into the role of NLP and AI in enhancing incident reporting systems, focusing on their ability to streamline data collection, improve reporting accuracy, and support real-time decision-making. By examining existing studies and identifying gaps in the integration of these technologies, this chapter underscores the need for innovative solutions to

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enhance safety practices in construction environments. [1-5]

1.1. Incident Reporting

Construction sites must have effective incident reporting systems to document and analyze all workplace accidents together with their injuries and potential dangerous situations. The reporting process includes a comprehensive documentation of time-based information and place-related data along with observations from witnesses and suspected reasons behind the occurrence. The documented information enables risk analysis for safety purposes which results in risk prevention and enhanced safety procedures. Hazard identification becomes more efficient together with quick response time through reporting thereby minimizing the occurrence of the same events. Construction sites rely on incident reports for both adherence to regulations and personnel accountability purposes.

1.2. Natural Language Processing

Functional systems under Natural Language Processing (NLP) utilize artificial intelligence to generate interfaces which process human language and computer systems. Machines gain ability through NLP to understand natural language while making useful interpretations of it. The major NLP applications consist of language translation as well as sentiment analysis and text summarization and speech recognition systems. Through its combination of linguistics and machine learning NLP facilitates computers to analyze large natural language datasets thus becoming useful for applications such as chatbots along with virtual assistants and automated reporting.

1.3. AI Severity Classification

AI severity classification is the process of using artificial intelligence models to categorize incidents or issues based on their level of severity, such as high, medium, or low. This classification helps prioritize responses, enabling quicker action on more critical incidents while optimizing resource allocation. The AI model, often using techniques like machine learning or NLP, analyzes data such as text descriptions, contextual information, and historical patterns to determine the severity level. In driven severity systems. Complex research construction, severity classification can enhance safety by rapidly identifying high-risk incidents, supporting proactive measures, and improving overall risk management.

1.4. Lit Map

Researchers use the visualization and mapping platform LitMap to efficiently structure their academic research analysis processes. The program offers straightforward discovery capabilities for trends and research gaps as well as link detection which enables researchers to conduct more organized and knowledgeable reviews.

2. Literature Review

Researchers have studied the implementation of text mining alongside natural language processing (NLP) for construction purposes in incident reporting and safety analysis activities [1, 3, 11, 14]. Research teams use NLP techniques for both construction accident classification and extraction of important information from accident story records [11, 14, 15]. Research indicates that joining NLP with AI technology presents a method for construction safety-management enhancement through real-time incident reporting and predictive analytics systems [7, 9]. Research evidences that text mining and NLP operate successfully in spotting common yet minimal construction safety problems [5]. Research has investigated the application of NLP and artificial intelligence in maritime incident reporting to develop better transcription abilities while enhancing incident analysis possibilities [10]. Research shows that NLP should integrate with Building Information Modeling (BIM) to boost construction safety management according to the findings of [13]. The increasing attention toward NLP applications in construction emerges from a scientometric study which demonstrates scholar interest mainly concentrated on safety and risk management aspects [13]. Research shows that the construction safety field actively explores NLP and Artificial intelligence tools for incident reporting and safety analysis and predictive tools [1, 3, 7, 11, 14]. This review uses LitMap to group studies based on three main subjects which include present incident reporting practices and Natural Language Processing roles and computer-relationships emerge through this visual framework

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which demonstrates both technological development patterns and vacant spaces especially within immediate incident documentation procedures. AI-driven severity classification becomes visible through LitMap due to its chronological presentation across multiple studies that shows the path of development. The method allows for both thorough and organized assessment that addresses construction site challenges along with their safety opportunities. LitMap simplifies research analysis because it showcases how NLP and AI technology should transform safety procedures and decision systems in construction sites. Table 1 shows Category of Entities Identified from Literatures for AI Training.

Table 1 Category of Entities Identified from Literatures for AI Training

Category	Entities
Safety Terms	• Incident Reporting • Safety Hazards • Safety Risks • Real-Time Reporting • Safety Management • Hazard Classification • Root Cause Analysis • Safety Protocols • Preventive Measures
Job Titles	• Safety Manager • Site Supervisor • Construction Worker • Safety Consultant • Incident Response • Team, Risk Analyst • Health and Safety Officer
Area of Work	• Construction Sites • Site Safety Management • Incident Management • Risk Assessment • Safety Data Collection • Real-Time Safety Monitoring • Safety Compliance

The literature review regarding construction site safety contains key entities which are organized into this table structure. Risk management becomes effective through essential safety terminology that includes incident reporting with hazard classification and safety protocols. Three positions receive specific mention in the table because they bear the responsibility for site safety enforcement: Safety Manager, Site Supervisor and Health and Safety Officer. The three essential areas of work at construction sites concentrate on safety management alongside incident reporting and real-time safety monitoring. The classification system helps organizations understand what elements influence safety conduct and decision processes within construction sites.

2.1. Critical Review

The prevention of future accidents heavily depends on strong safety incident reporting systems which need immediate proper documentation. Construction activity requires automation and new methods to manage incident reporting with high efficiency in the present moment. Safety management improvements together with immediate responses depend on

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automated safety incident reporting systems that maintain efficient alert systems and prompt incident reporting. Through NLP technology developers can both create automatic safety incident reports and recognize repeating near-miss incident patterns. Artificial Intelligence evaluates construction safety results through system assessment of fundamental elements which include human workplace conduct together with environmental conditions. Hybrid supervised machine learning approaches combined with artificial intelligence successfully extract data from documents as a prerequisite to performing relevant information analysis. The literature shows little investigation about NLP and AI integration to support immediate incident reporting. [6-10]

3. Methodology

To conduct a comprehensive literature review, it was essential to define the research scope and objectives clearly. This involved stating the research question, identifying key themes, and specifying the timeframe. Reliable academic databases such as IEEE Xplore, Scopus, and Google Scholar were selected to identify relevant studies. A Boolean search strategy was developed to filter studies based on specific keywords and years. The identified studies were then screened and selected based on inclusion and exclusion criteria. The selected studies were analyzed and categorized into key themes, and the findings were synthesized to identify gaps and emerging opportunities. Finally, the results were presented, and future research directions were discussed to integrate AI and NLP in construction safety. [11-15]

3. Results and Discussion

A review of 25 journals in this research network identified main trends about NLP in incident reporting alongside AI-based severity classification methods. The circle representations in this diagram stand for research papers while their visual size indicates how many times papers have been cited. Citation and conceptual connections between different research papers run along the networking edges. The diagram clusters related papers together based on shared themes or methodologies. Notably, the NLP in Incident Reporting cluster is less densely connected to the AI severity classification cluster. This indicates a research gap in integrating NLP with AI-based incident severity classification. The disparity suggests significant untapped potential for future research. Bridging the gap between real-time incident reporting and AI-driven severity classification is a key area for future research. Integrating NLP and AI can enhance decision-making and improve the efficiency of incident management systems. This integration can contribute to the advancement of AI and NLP applications in real-time reporting. Ultimately, this can make systems more effective in responding to and managing construction site incidents. Figure 1 shows Literature Analysis Using Lit Maps.

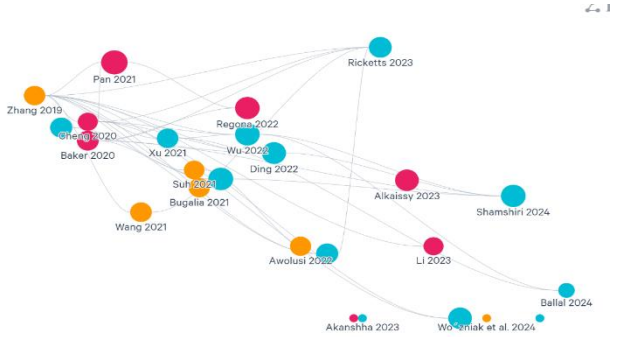

Figure 1 Literature Analysis Using Lit Maps

Conclusion

The integration of NLP and AI into safety incident reporting systems has significant potential to transform construction site safety management. Timely and accurate documentation is critical in preventing accidents, and automation plays a key role in improving the efficiency and accuracy of incident reporting. The integration of NLP technology helps organizations perform automated report creation while finding patterns in near-miss events and improving their safety cultural environment. The combination of NLP-based voice reporting enables immediate data collection which leads to instant reporting while predictive AI models use worker activities and site parameters to take proactive safety actions. The integration of NLP and AI remains inadequate for real-time reporting applications because user-friendly interfaces and AI-based severity classifiers for these systems need

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development. A system development for these needs would enhance documentation precision while streamlining incident responses to better determine incident severity. A holistic solution for safety management will emerge from performance-based predictive AI technology successfully combined with NLP-driven reporting systems. Using AI together with NLP technology within real-time incident reporting systems improves site safety through accelerated correct decision-making and minimizes potential construction site incidents. The integration between these technologies will power incident management systems to become faster while also making them more efficient and data-based. Research in this area during future years will generate safer construction site operations alongside minimized work-related accidents. Research collaboration between practitioners and scholars should focus on developing innovative safety solutions for construction sites because of the present NLP and AI integration deficit.

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