International Journal of Advanced Technology in Civil Engineering

Volume 2 | Issue 3 Article 3

May 2022

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Recommended Citation

Rustagi, Abhishek and Kaja, Nagaraju (2022) "Applications of AI and ML in Construction Industry," *International Journal of Advanced Technology in Civil Engineering*: Vol. 2: Iss. 3, Article 3.
Available at: https://www.interscience.in/ijatce/vol2/iss3/3

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Applications Of Artificial Intelligence and Machine Learning in Construction Industry

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Absract
Artificial Intelligence is opening up new avenues in the construction industry. Machine learning is an emerging AI research paradigm, and it is important to making buildings "smart." Machine learning technologies have the potential to offer up a plethora of new opportunities in the construction industry, such as site surveillance, automated detection, and intelligent maintenance. The purpose of this study was to examine the new areas where AI and ML are being employed in the construction sector and how their implementation would aid in the improvement of work sites. However, due to the difficulties in collecting annotated data, ML applications face a variety of challenges, especially when applied in a highly complicated building project. This study also looks at how machine learning grew from shallow to deep learning and how it is used in the construction industry. Following the completion of this study, it was determined conclusively that the use of AI and ML in construction projects improves work safety, increases productivity, and so on, and its implications are presently being employed to conduct research around the world.

Key Words
Artificial Intelligence, Construction Monitoring, Intelligent Construction, Machine Learning, Smart Construction

1. INTRODUCTION

Individuals and organisations worldwide spend more than tens of trillions of dollars each year on construction-related activities, with that figure expected to rise by 4.3 percent by 2023. Part of this massive sum of money is spent on, and aided by, technological advancements that affect every aspect of the ecosystem. McKinsey outlined a growing emphasis on solutions that integrate artificial intelligence (AI) and machine learning in its 2020 report, "The Next Normal in Construction: How Disruption is Shaping the World's Largest Ecosystem" (ML).

1.1 Need

For millennia, people have been constructing shelters and buildings, attempting to make construction industry one among the oldest professions. The way buildings are designed, planned, and built, on the other hand, has changed dramatically. For decades, technology has been used in the construction industry to make work more productive and safer.

In recent years, construction firms have incredibly quickly started using (AI) in a variety of ways to render construction extra cost effective and inventive. AI has already proven its value in the construction business, from optimizing work schedules to improving worker safety to monitoring building sites. Since the 1980s, there has been a sustained interest in the topic of artificial intelligence and its applications. Machine Learning and Deep Learning were gradually developed. These are widely used in different industries throughout the world and have lately gained traction in the construction business, enhancing several elements and assisting in building. This research focuses on numerous software advances in the realm of Artificial intelligence and machine learning, as well as their applicability in the construction field.

2. DIFFERENCE BETWEEN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Artificial intelligence (AI) is a broad area of computer science which concentrates on developing intelligent machines capable of doing activities that would normally need human intelligence. Self-driving vehicles, conversation chatbot, e - mail spam detectors, and online streaming recommendations are really a few instances of AI applications.

Machine learning (ML) is a subfield of AI, that uses data and algorithms to imitate how humans learn and improve accuracy over time. Mapquest, traffic prediction, speech recognition, product recommendations, Voice Assistant, stock market trading, and more applications use machine learning without our knowledge.(Middleton, 2021)

3. Applications of AI and ML

3.1. Efficient Designing

Machine learning can enhance design and make them more user-friendly. For example, if a company wishes to tailor its office space according on its unique requirements, ML can anticipate the frequency of usage for each area and provide a design that is appropriate for the people's demands. Figure 1 shows the plan simulations and analysis of it based on various parameters on software created by Autodesk.

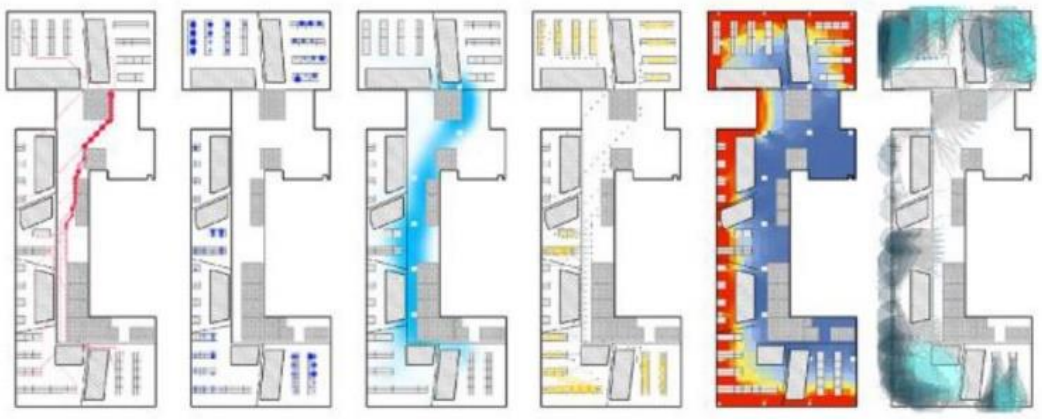

Figure 1: From left to right, each plan is overlaid with a simulation of the following parameters: adjacency preference, work style preference, buzz, productivity, daylight, and views to outside. (Source: Autodesk University)

3.2. Making jobsites safer

The use of ML on building sites has the potential to raise the degree of safety to unprecedented heights. It may be used to detect, analyse, and report any abnormality found.

Smartvid.io, a machine learning technology, leverages visual and sound data from construction sites to detect safety issues, allowing for safety briefings to minimize high danger and enhance overall safety on building sites. (Newmetrix, n.d.)Figure 2 shows an interface of how the Smartvid.io application.

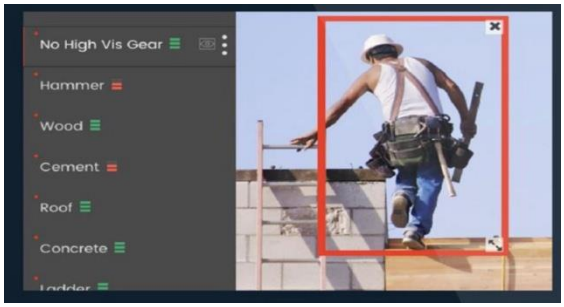

Figure 2: Smartvid.io can automatically add the tags

3.3. Assessing and Mitigating Risks

The use of Machine Learning has enabled risk assessment faster and more reliable. Construction projects are often complicated and create a large quantity of data, which ML systems may mine for precise and thorough risk evaluations.

Construction IQ, an Autodesk solution, assists projects in managing and reducing risks on a daily basis, as well as improving performance in real time. The program has been subjected to millions of construction issues and sightings, inspections statistics, building information models, modification orders, and project results, allowing it to recognize hazards and provide actionable insights. (Autodesk, 2022) Figure 3 is from Construction IQ showcasing list of subcontractors and a list of their safety issues.

Figure 3: The IQ application shows a list of subcontractors on a project and a breakdown of their safety issues by the "fatal four" categories (*Construction IQ | BIM 360 | Autodesk Knowledge Network*, n.d.)

3.4. Increasing overall productivity

When Machine Learning is utilized in a building project, it boosts productivity. The software monitors and manages the daily operations on construction sites such as brick laying, concreting, plumbing services, electrical services, HVAC services, flooring, roofing amongst other things.

Triax Technologies Inc.'s "IoT-enabled Spot-R Solution" has been assisting teams with real-time employee management. Users may review the present location of workers directly in both 3D models and wireframe thanks to this technology. This information is then made available to machine learning algorithms, which may track performance and recommend specific changes. (Triax, 2022)

3.5. Equipment's Predictive maintenance

There are now end-to-end systems that employ machine learning and sensors to identify and warn businesses about changes in machinery vibrations and temperatures, with no prior machine learning or cloud experience necessary. These solutions enable construction businesses to remotely maintain and upgrade their fleet of devices without ever having to physically touch them.

3.6. Anomaly Detection using computer vision

To improve quality at building sites, companies are turning to computer vision to enable faster and more precise flaw detection. ML offers low-cost, high-accuracy anomaly detection solutions that can process thousands of photos per hour to find faults and aberrations, and then report the images that differ from the standard so that appropriate action can be taken.

3.7. Forecasting to improve Supply Chain efficiency

By evaluating time-series data and offering accurate projections, machine learning can assist construction companies in anticipating the future, decreasing operating expenses and inefficiencies, ensuring increased resource and product availability, delivering products faster and cutting prices.

3.8. Cost Overrun Prevention and Improvement

On larger projects, even the most efficient construction teams face cost overruns. Machine learning can be used by AI to better schedule realistic timetables from the start, learning from the data such as project or contract type, and including parts of real-time training to improve skills and team leadership.

3.9. Construction in Remote Location

Construction goes faster when structures may be partially erected off-site and then completed on-site. The idea of deploying smart robots and artificial intelligence to complete this distant assembly is novel. A wall can be built on assembly line while the human workers concentrate on finishing other works.

3.10. Construction using 3D Printing

Advanced additive manufacturing processes will be incorporated into mass manufacturing systems, bringing with them a new degree of speed and customization, as well as the potential to address difficult manufacturing challenges while simultaneously serving as a separate system for bespoke manufacture. In Figure 4 we can see the use of AI with various aspects in construction.

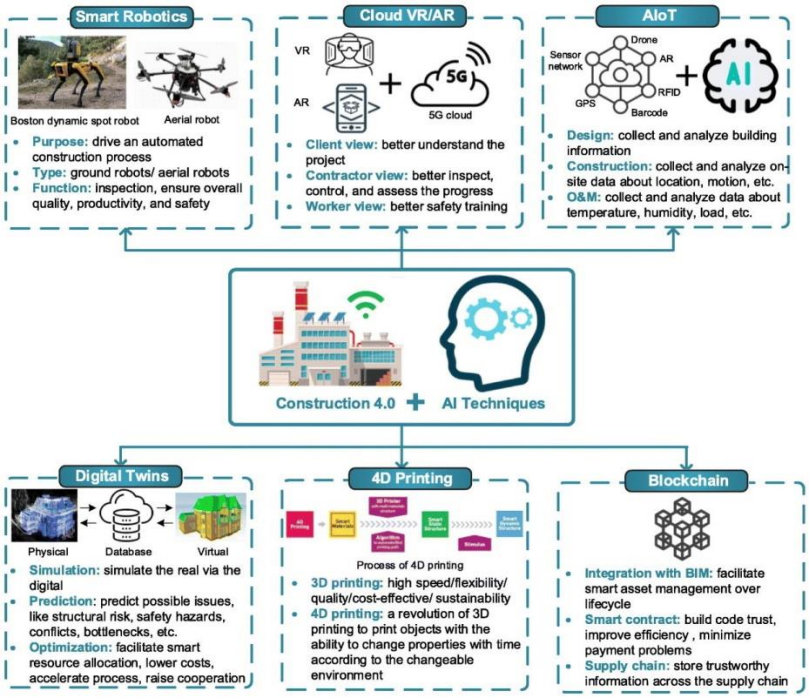

Figure 4: Applications of Artificial Intelligence. (Pan & Zhang, 2021)

3.11. Mitigating Construction Labor Shortages using AI

McKinsey & Company stated in 2017 that AI-enhanced analytics might raise construction businesses' efficiency by up to 50%. This is fantastic news for construction businesses who can't find enough human employees to fill out their project sites, and those enterprises are the norm rather than the exception.

AI-powered robots, such as Boston Dynamics' Spot the Dog, enable project managers to make real-time decisions on numerous job sites, such as whether to relocate workers to other areas of work or to new project locations entirely. Robot "dogs" and GIS enabled Artificial Intelligence drones scan work areas during and after hours to identify pain points.

3.12. Construction Sequences and Task management

AI-based systems may detect possible incompatibilities, delays, and adjustments during the construction process by comparing the digital twin of the structure in BIM cloud to the real tangible representation. Robots and drones are now capable of frequent image acquisition as well as 360-degree laser scanning. These images and measurements provide essential information for the AI to follow the timely growth of the real building vs the design preserved in the BIM cloud.

Furthermore, comparing actual construction phase to the digital twin enables automatic detection of inconsistencies from the actual building design during the construction period. This enables for swift response and, as a result, early troubleshooting. This reduces the need for subsequent, more expensive adjustments (e.g., if pipes or cables have been installed in the wrong location, they can be moved before all walls are plastered). Possible delays and changes may prompt the AI to make an automated updates to the project timeline stored in the BIM cloud. Based on this basis, all stakeholders, including distributors and manufacturers, may be contacted instantly.

3.13. Use of AI after completion of construction

AI may be used for building management long after the construction is finished. Advanced analytics and AI-powered algorithms generate useful insights into the operation and effectiveness of a building, bridge, roads, and nearly anything in the built environment by gathering information about a structure via sensory drone, and other wireless technologies. This means that artificial intelligence may be used to detect growing issues, identify when preventative maintenance is required, and even direct human behavior for maximum security and safety.

3.14. Research

As seen in the graphic, almost majority of Chinese research is focused on building safety management. One plausible explanation is that China is actively investing in building infrastructure, and the government encourages the adoption of modern technologies in the urbanisation process. The total investment in infrastructural development was 2604.05 billion US Dollars in 2018.

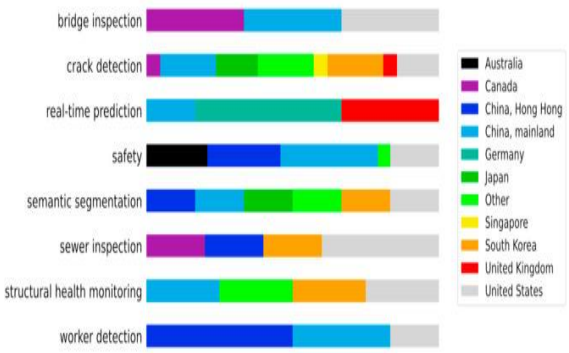

Figure 5: Shows the amount of research done in construction industry using AI and ML (Xu et al., 2021)

4. Conclusion

Since early 2000's, machine learning technology has gradually gained popularity in the construction industry, and it is currently playing a pivotal role in the development of intelligent automation. Many difficulties remain unresolved despite recent improvements in ML research in the building sector. Data gathering and reducing the impacts of site environment are the most difficult tasks. Following a review of the literature, this study recommends that multiple teams collaborate to develop a large and comprehensive dataset using the same annotating criteria in order to ease the data collection difficulty. Presently, most construction researchers employ machine learning to extract or identify features. The main breakthrough is the use of machine learning insights for Rather than improving the algorithms, more discretion is being used. Mastering machine learning techniques and integrating them with unique construction knowledge domains to develop specialized deep network modeling for the construction business might be a future research path. Machine Learning and Artificial Intelligence applications range from better and more efficient designs to safer work sites, automated fabrication, Integrated Building Information Modelling (BIM), post-construction surveys, and research. The applications are real-time and are also used for research and development in a variety of different fields.

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