International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Role of Artificial Intelligence in Construction Project Management

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ABSTRACT

The construction sector occupies one of the major roles within the global economy, and 13% of world GDP currently comes from this industry. It is also expected to expand by 85%, to a value of $15.5 billion by 2030, with demand in China, the United States, and India acting as the major drives. The growth notwithstanding, the sector has been confronting serious problems with regard to arranging and disseminating large quantities of information among subcontractors, contractors, designers, clients, and other stakeholders with efficiency. Information Technology has emerged as a key enabler, thereby integrating scattered data across geographically dispersed projects, transforming the construction value chain.

Artificial Intelligence accelerates this change, and the increasing investment demonstrates the possibility of boosting workforce productivity by 40 percent and doubling economic growth rates annually by 2035. This paper discusses the application of Artificial Intelligence (AI) in Construction Project Management (CPM) and reviews methodologies and applications that have been advanced for the improvement of efficiency and decision-making in the industry. The construction industry is bound to mark a tremendous change by the implementation of Artificial Intelligence (AI), redefining conventional processes and opening up innovation and productivity to new heights.

Keywords: AI-Driven Construction Solutions, Smart Construction Technologies, Automation in Construction Management, Building Information Modeling

1. INTRODUCTION

The construction industry accounts for 13% of the world's GDP and is expected to grow by 85%, reaching $15.5 billion by 2030, promoted by demand of 57% from China, the United States, and India. Global Infrastructure spending is set at $3.4 trillion annually from 2013 to 2030, accounting for 4% of the total GDP. Despite the high level of its economic importance, the industry is beset with problems such as low labor productivity, wastage of resources, and lack of coordination among contractors, designers, and clients. Also, poor communication and fragmented information management add to inefficiency. IT has, however, helped to alleviate some of these issues through better integration and collaboration on distributed projects. Similarly, PMIS provides tools to manage, share, and store project documents

electronically, but few completely integrated systems exist. Virtual Organization concepts provide an enabling infrastructure for electronic collaboration, where geographically distributed teams can access and communicate project data with seamless access.While the industry moves toward "Industry 4.0," in general, digitalization and intelligence are swiftly changing the entire construction value chain from pre-construction to post-construction stages. As a main driver, AI turns this around in CPM by enabling machines to reason, learn, and adapt as would human beings. Investors in Artificial Intelligence, especially machine learning, are making rapid strides to allow the technology to analyze reliable data for intelligent and flexible decisions. With AI, Accenture estimates that annual economic growth rates could triple, and human productivity increase by 40% by 2035-a surefire way it will redefine construction processes. This study looks at AI methodologies and their applications in improving CPM.

2. CONCEPT OF CONSTRUCTION PROJECT MANAGEMENT

Construction project management embraces a series of systematic activities aimed at ensuring that a certain project is appropriately completed within defined parameters of time, budget, and quality. Emerging construction projects have become more complicated and data-driven, and so technologies are being developed to handle and process massive data output, such as BIM and WSN. The information tends to support the efficient application of the AI technique for the complexities of CPM across the entire project lifecycle. The three major phases of CPM are described below, along with the detailed processes:

The **Planning Phase** is the very foundation of a construction project, where overall plans are made which will enable the smooth running of the project. In this stage, plans showing resources, timelines, and budgets for various activities, as well as their dependencies, are elaborated, trying to make the process of construction quicker, less costly, and without wastes. Scheduling plays an important role here, where activities would be distributed chronologically, with dates, resources, and personnel being assigned to them. Also, cost estimation can be useful in predicting what financial and material resources will be required during the project. A well-compiled plan serves as a point of reference throughout the execution of the project, guiding it within budgetary and schedule specifications.

The **construction Phase** succeeds the planning stage, and it is the physical accomplishment of the project. It is during this stage that the actual construction work is done, including jobs like marking the layout, excavations, foundations, structural construction, electrical and plumbing installations, and finishing touches. The project managers are supposed to keep tracking the actual construction in practice by the work according to the plans of the previous phase. This means they have to ensure that whatever defects arise are identified and put right as soon as possible. Similarly, risk management is also their important job responsibility; they are supposed to assess the probable risks to performance, schedule, or budget of the project.

Finally, the **Operations and Maintenance** Phase follows the completion of work at the facility. This phase involves the operational efficiency of the constructed facility for its lifecycle with no failures. The activities undertaken in O&M include preventive maintenance, which entails the early detection and possible prevention of failures, and corrective maintenance, which is performed after failures occur. The aims of O&M are maximizing the facility for functionality, safety, and comfort to the users while maintaining energy norms and environmental standards to long-term sustainability and efficiency. The operation and maintenance phase are crucial since it contributes much to the overall lifecycle cost and performance of the construction project.

3. TYPICAL FEATURES OF CONSTRUCTION PROJECT MANAGEMENT (CPM)

Construction Project Management is a complex process; it coalesces the integrated workflow of tasks along a fixed timeline. It is also based on specific constraints. Recent studies elucidate that CPM features five unique characteristics, namely:

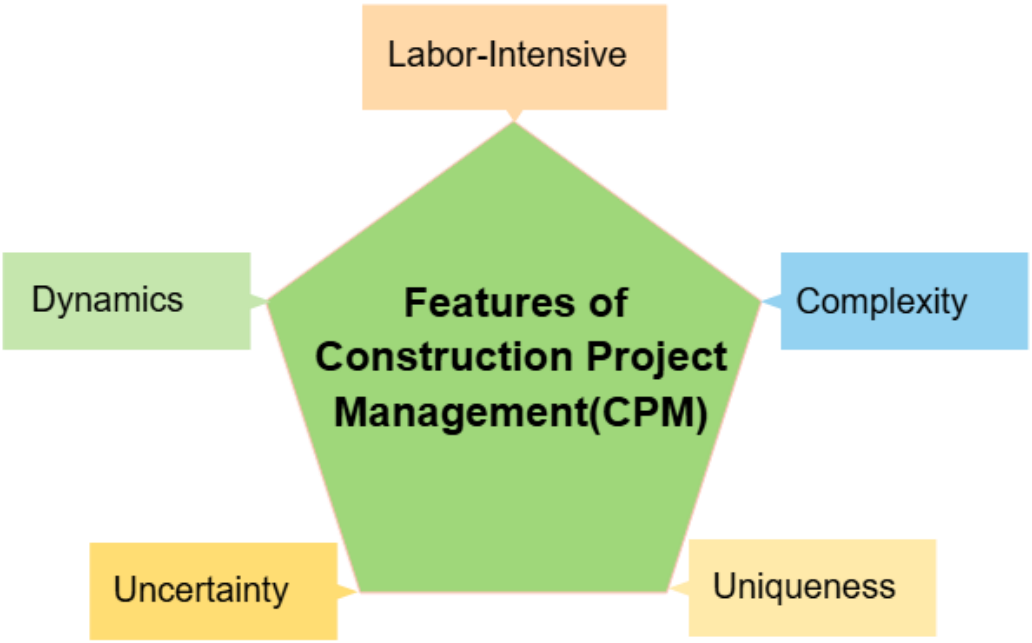


Fig: Features of Construction Project Management (CPM)

3.1 Labor-Intensive: Most construction projects require a great dependency on labor, and the labor element may cost as high as 30% of the project cost. The need for skilled labor has been on the rise; this requires widespread training programs to satisfy. The industry is increasingly automating its functions to reduce dependency on unskilled manpower by integrating more technology for better efficiency, productivity, and site safety.

3.2 Dynamics: Construction projects, although very much planned for, are nonetheless prone to changes along the way. For this reason, factors such as design errors, environmental factors, financial setbacks, and other scope changes may affect the plan. Effective CPM works around flexible approaches toward such changes and allows timely adjustments in order to keep the project current.

Complexities can be related to either the tasks or the people. Various factors need to be considered: security, environment, materials, and weather, among many others. More recently, increasing layers of complexity have been added due to high technologies such as BIM and IoT. Further, the construction project is also multidisciplinary in nature, which includes many complex interactions between workers, stakeholders, and processes, making coordination imperative for any smooth execution.

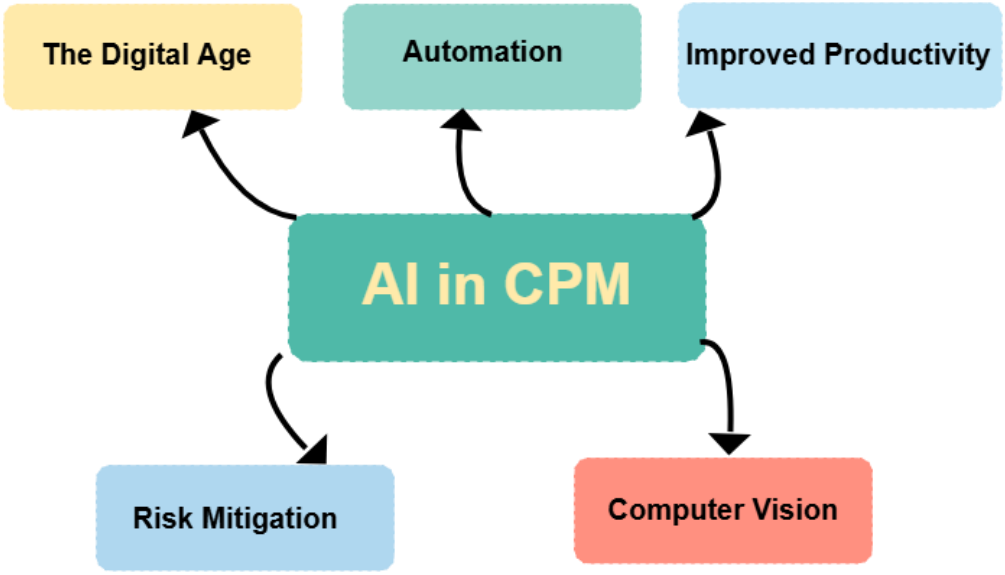
3.3 Uncertainty: Construction projects are inherently fraught with great uncertainty. From the estimation of the timeline of completion to costs involved to uncertainties of ground conditions, changes in weather, and inconsistency in material provided, the risks are always there. Risk identification and mitigation at an early stage may reduce the impact of such uncertainties and enhance the chances of project completion successfully. Also, strategies of CPM need awareness and adaptiveness continuously for handling unforeseen factors occurring during project execution.

3.4 Uniqueness: Every construction project is unique in terms of the client's needs, the magnitude of the work, surroundings, and inhibitions. Unlike other industries, construction projects are not standardized because each project has its own unique set of challenges requiring different mechanisms to accomplish. This uniqueness creates a necessity for teams with a mix of skills and backgrounds to ensure that every project addresses the individuality of each for its successful completion.

3.5 Complexity: Construction projects may be complicated for two major reasons: the nature of the activities involved and the players involved. The activities involved in construction work are labor-intensive, diverse, and interdependent, which creates a high possibility of schedule conflicts and performance glitches. For work to go smoothly, several factors must be considered, including security, environment, weather, workers, and time limits. While BIM, IoT, and the use of new materials facilitate sustainability in modern technologies, because of their inherent nature, they also add to the complexity. Moreover, the involvement of workers with various backgrounds and expertise adds to the complicated interactions and communication that further contribute to the project's complexity.

4. ARTIFICIAL INTELLIGENCE (AI) IN CONSTRUCTION PROJECT MANAGEMENT (CPM)

It exploits human intelligence to solve the complicated problems arising in the construction domain. AI, after five decades of development, has found practical applications in expert systems, smart systems, and robotic systems. In civil engineering, AI can help solve problems regarding engineering design and construction management, along with decision-making in cases of uncertainty and imprecision. AI can even mimic the capabilities of professionals by providing solutions where conventional methods lack the efficiency to solve a problem. While the volume of engineering data is growing rapidly, most AI applications are still underutilized in construction, despite its potential. In addition, with ongoing progress, AI will be able to perform tasks automatically, increasing productivity and profitability of CPM.



Fig; Artificial Intelligence (AI) in Construction Project Management (CPM)

4.1 The Digital Age in Building Construction

The implementation of BIM had changed the building construction industry from mere 3D modeling, to be a platform where data can be shared and analyzed in real time across the project lifecycle. Integrated with AI, BIM allows the automation, real-time analysis, and efficient management of projects, hence streamlining processes, reducing costs, and optimizing personnel allocation.

4.2 Automation:

It automates a lot of tasks involved in managing construction projects and enhances decision-making. Machine learning algorithms sift through vast amounts of data, uncovering insights that help comprehend projects better. Drones and sensors independently track construction progress and provide more accurate, data-driven insights compared to traditional means.

4.3 Improved Productivity:

AI enhances construction processes through process mining, the identification of bottlenecks, and the forecasting of issues. The execution of repetitive tasks by AI-powered robots increases efficiency by reducing labor and improving quality for better project outcomes.

4.4 Risk Mitigation:

AI enhances risk analysis by adopting machine learning and other probabilistic models in predicting and prioritizing safety, quality, and cost risks. The proactive approach helps to mitigate all kinds of risks that occur at construction sites and lead to an accident, which delays projects.

4.5 Computer Vision:

AI-driven computer vision replaces manual inspection with fully automated and reliable visual analysis that detects damage, identifies structural issues, and continuously monitors those conditions in real time. It improves the precision and speed of construction management while improving safety and structural health.

5. CONCLUSION

AI will surely give a massive impact on the construction industry, mainly in data management, decision-making, and process optimization. However, everything is still in the development stage, and future research will be done to improve the AI tools for better phase management of construction. There is a need for research studies to be conducted in areas like construction performance and supply chain management to fully realize the potential of AI in changing the construction industry.

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