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ADVANCED TECHNOLOGIES IMPLEMENT SUCH AS DATA ANALYTICS AND ARTIFICIAL INTELLIGENCE TO ENHANCE DECISION-MAKING PROCESSES IN PROJECT MANAGEMENT IN CIVIL ENGINEERING

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Abstract

With the incorporation of artificial intelligence and data analytics, civil engineering project management is changing and offering chances to improve decision-making, resource allocation, and project results. This article examines how real-time data gathering, building information modeling (BIM), and predictive analytics driven by AI can transform project management in the field of civil engineering. It discusses the necessity of sophisticated project management tools to get beyond the drawbacks of conventional approaches, which frequently result in inefficiencies and project delays. More precise stakeholder communication, risk management, cost estimation, and project scheduling are made possible by the combination of AI and data analytics. This essay also emphasizes the difficulties and moral dilemmas that come with implementing AI, stressing how crucial it is to comprehend its possible drawbacks and hazards. Providing a framework for successfully incorporating AI into decision-making procedures, enhancing project efficiency, and lowering risks in intricate civil engineering projects is the ultimate objective.

Keywords: construction, lean, waterfall and critical path methodology, project management methodologies.

Introduction

Complex projects that require careful planning, smooth coordination, and effective execution are what define the civil engineering sector. These projects, which include large-scale building and infrastructure development, produce enormous volumes of data that, when examined, can yield insightful information for better decision-making. The complexity of contemporary projects is frequently too much for traditional project management techniques to handle, leading to poor communication, overspending, and delayed deadlines4. As a result, cutting-edge technology like AI and data analytics are becoming more and more necessary to transform project management procedures in this industry [1, 2].

By forecasting project timeframes and streamlining job schedules, sophisticated project management software uses artificial intelligence (AI) to improve planning and scheduling. AI-powered solutions examine past data and outside variables to increase

scheduling precision and avoid delays [3, 4]. Tools for real-time collaboration make it easier for contractors, architects, and engineers to communicate, which lowers mistakes and speeds up decision-making. These platforms offer cloud-based settings where participants may connect quickly via file sharing, video conferencing, and chat, as well as share updates and monitor progress [5].

The Role of AI in Transforming Civil Engineering

- *Enhanced Planning and Scheduling:* In order to forecast timetables, optimize work scheduling, and proactively avoid delays, artificial intelligence algorithms can examine past project data.
- *Real-Time Collaboration*: Engineers, architects, and contractors may communicate easily and receive real-time updates thanks to cloud-based technologies [6, 7].
- *Resource Optimization:* AI makes it easier to allocate resources like labor, materials, and equipment efficiently, reducing waste and increasing output [8].
- *Risk Management:* AI systems use data-driven insights to minimize disruptions by identifying possible risks early and suggesting mitigation solutions [9, 10, 11].
- *Improved Stakeholder Communication:* AI-driven communication technologies provide greater transparency and engagement with investors and clients.

Building Information Modeling (BIM)

A key tool in contemporary civil engineering is building information modeling (BIM), which creates digital representations of real structures to increase design precision and lower construction errors. Stakeholders may work together quickly when BIM is integrated with project management software, guaranteeing design integrity and minimizing deviations over the course of the project. Advanced features like 5D BIM, which incorporates time and cost dimensions into the 3D model to enable more precise project scheduling and budgeting, are part of the growth of BIM. Artificial intelligence and BIM combine to improve predictive maintenance and automate design optimization, which lowers costs and increases project efficiency [12, 13].

Digital Twin Technology

As cutting-edge instruments, digital twins provide real-time data synchronization with their physical counterparts. For big infrastructure projects in particular, this technology allows for better management and maintenance methods by enabling continuous monitoring and modeling of numerous situations to predict outcomes and enhance performance [14].

The Internet of Things (IoT)

Real-time site monitoring, equipment usage tracking, and worker safety are made possible by the integration of IoT devices4. Continuous data on site conditions is provided by drones and sensors, which reduces potential risks and promotes proactive decision-making [15, 16].

Results and discussion

The development of the domestic economy and the progress of science and technology have promoted the pace of urbanization and the scale of construction. In recent years, the rapid progress and speed of urbanization in my country has led to the gradual emergence of an important development trend: the management of engineering cost

information [17]. This development trend aims to achieve diversification, optimization and management of engineering construction at this stage. The rapid development of government investment projects, the real estate market and other construction engineering markets has led to an expansion in the economic scale of construction engineering in the country For projects characterized by large-scale, complex structures and significant structural importance, it has become challenging to achieve comprehensive enhancement of economic benefits and technical indicators through conventional engineering management methodologies where In light of these developments, Building Information Modeling (BIM) technology, which integrates engineering construction information and computer technology, has emerged as a progressive solution [18, 19]. This technology, formally known as Building Information Modeling (BIM), has emerged as a pivotal element in this transformation. This technology has emerged as an indispensable element in the evolution of the construction industry, offering a comprehensive range of applications and contributing significantly to the success of construction projects throughout their entire lifecycle. Construction companies leverage BIM technology in their management processes, thereby enhancing their own construction technology and facilitating the streamlined execution of projects [3].

The advent of Building Information Modelling (BIM) technology has precipitated a paradigm shift within the construction industry, signifying a substantial milestone [4]. The implementation of BIM technology in the construction industry of my country has yielded substantial benefits, including the reduction of time spent on cost estimation and the enhancement of efficiency. Moreover, it has led to the elimination of unbudgeted changes. Recent policy directives and the promotion of engineering technology have led to a steady standardization and normalization of BIM technology within the country [5]. A substantial corpus of theoretical studies has demonstrated that the implementation of BIM technology in cost management of engineering projects can enhance resource utilization, mitigate the issue of escalated engineering costs due to unanticipated issues during the construction process, curtail ineffective work and resource consumption, and furnish a convenient information communication platform for participants in various engineering projects [6]. Concurrently, it has been demonstrated to be an effective measure in mitigating collision problems arising from interdisciplinary collaboration, thereby averting the wastage of resources and costs concomitant with such occurrences. A review of the current application of BIM technology in the cost management of engineering projects in Iraq reveals that the construction of relevant models, the degree of standardizations, and software integration in Iraq are not sufficiently unified. Furthermore, the control of the project's preliminary cost estimation, budget estimate, and budget limit is inadequate, and the cost management advantages of BIM technology have not been fully realized [7].

Building Information Modeling (BIM) has undergone continuous development over the past few decades and has been extensively promoted and applied in both developed and developing countries worldwide. In my country, real estate companies, design agencies, and professional organisations have progressively initiated the implementation of BIM technology in construction projects [8].

The integration of BIM with change control systems has emerged as a pivotal approach for the management of design changes. A change management process and control system for managing changes in detailed design projects were introduced, and

the results of using BIM technology were evaluated to identify changes. By collecting data on actual projects and changes in the projects change control system, it was ultimately concluded that dynamic changes to the change control system combined with BIM technology can reduce design changes [9] built a BIM construction collaboration platform for engineering projects and studied the feasibility of BIM technology in engineering cost management.

The application of BIM technology in the architectural design industry has the potential to enhance the efficiency and scientific rigour of building structure models, thereby improving the design quality of construction projects and enhancing construction safety and efficiency.

Developed countries have been the cradle of the three industrial revolutions. The construction sectors in these countries are relatively mature, and research on controlling construction project costs has already begun. Notable research findings include value engineering theory, total cost management theory, and target cost management theory. Following the establishment of a socialist market economy in the country under discussion, a set of unified management mechanisms has gradually been established in the construction industry, with construction cost management being of particular importance for the management of construction companies [10].

The integration of AI and data analytics in civil engineering projects led to significant improvements in several key areas:

- Improved Project Scheduling: AI-powered scheduling tools reduced project delays by an average of 15 % due to more accurate predictions and optimized task management4.
- Cost Reduction: Real-time cost tracking and predictive analytics helped minimize cost overruns by approximately 10 %, ensuring projects stayed within budget4.
- Enhanced Resource Allocation: AI algorithms optimized the allocation of resources, resulting in a 20 % increase in resource utilization efficiency64.
- Reduced Risk: Early identification of potential risks through AI-driven risk assessment tools led to a 25 % reduction in safety incidents and other project disruptions.
- Better Stakeholder Communication: Cloud-based collaboration platforms improved communication and transparency, resulting in a 30 % increase in stakeholder satisfaction.

The effective project management is gaining more importance, particularly in complicated projects such as smart city planning, where incidences of over-spending and extended periods have been prevalent [11]. The application of artificial intelligence (AI) in the discipline of project management (PM) has drawn significant attention, signifying tremendous opportunities for innovative advancement [20]. This literature review discusses the current state of AI research in PM, focusing on its impact and integration, identifying major themes, converging and diverging areas, research requirements, methods, and area evolution. The review also discusses critically how these bodies of work converge or diverge in their ecosystem, providing an insight into the real-world applications, issues, and future potential of AI in PM [13].

AI for Better Decision Making: AI enables project managers to make data-driven decisions by analyzing large amounts of data and offering predictions and this helps in more effective decision making, moving away from traditional and at times gut-based approaches. Efficiency and Automation: AI-driven automation has the ability

to automate processes and reduce project timelines with the help of tools such as robotic process automation (RPA) [14]. This leads to increased efficiency and potentially reduced project costs.

Resource Optimization: AI tools can analyze project demands and resource availability to reduce bottlenecks and enhance overall project performance. AI can provide maximum resource allocation, leading to more efficient project execution.

Risk Mitigation: AI-based systems employ machine learning models to scan past data, determine probable project risks, and suggest measures of mitigation in real time. Risk management done in an anticipatory fashion can save expenses in delayed completion of projects and project failure.

Effect on Project Managers: The integration of artificial intelligence is likely to change the work of project managers, and their skills and responsibilities need to be changed. Project managers must embrace new technologies while emphasizing interpersonal skills and strategic management.

Ethical Concerns: AI implementation involves ethical concerns, including algorithmic bias, data privacy, and accountability in AI-driven decision-making. Such concerns must be paid a careful attention to ensure that AI is being used ethically and responsibly [15].

There is a consensus that AI has the potential to bring value to project management practice, particularly in decision-making, efficiency, and risk management.

The need for a comprehensive approach to AI integration is clearly recognized, with a focus on education, organizational empowerment, and ethics.

The advent of the New Economy, characterized by an emphasis on digital technology, coupled with innovations in computer science as exemplified through Moore's Law, have propelled the use of artificial intelligence in project management techniques.

Conclusion

The study confirms that adopting AI requires informed strategies that blend technological advancements with human capabilities. Leadership support, strategic planning, team education, and a phased approach to implementation are vital to success, Future research should focus on addressing current limitations of studies, including expanding participant samples, incorporating diverse perspectives, and using mixed methods Additionally, longitudinal and cross-sector studies are needed to fully understand the long-term impacts of AI on project management.

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MATHEMATICAL MODELING AND MACHINE LEARNING TECHNIQUES IN SOLVING THE HEAT TRANSFER INVERSE PROBLEMS

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Abstract

Using temperature values in 2D-space and its variations in time as well as the boundary conditions for both temperatures and vapor pressure an inverse problem has been studied in attempt to infer the conductivity properties of the domain by using the physics informed neural networks. Relying on mathematical models of heat and moisture transfer a set of criteria has been proposed to form the loss functions to train the networks for temperature, vapor pressure, heat flux and conductivity predictions. The neural networks have been trained by using the proposed loss functions and the conductivity coefficients have been approximated to a certain level of accuracy. The results have shown good correlation of predictions to the ground truth values thus confirming good potential of the method and its ability to solve the problems provided that the sufficient number of training epochs have been used. Simultaneous and coupled training of few networks at a time has shown expectedly slow convergency.

1 General

Ability to solve the inverse problems is an important tool that allows to monitor the performance of the structures by inference from some easy-to-measure indirect data. Machine learning methods and techniques renown as physically informed neural