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THE USE OF ARTIFICIAL INTELLIGENCE IN CONSTRUCTION PROJECT MANAGEMENT

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Abstract*. In this article, we analyze the application of artificial intelligence (AI) in construction project management based on current research and practical examples. Our aim is to explore various aspects of AI application in construction, identify its main advantages and capabilities, and evaluate its impact on project management effectiveness and work quality. Through our analysis, we have found that the use of AI in construction project management contributes to process optimization, improved planning and control, and enhanced safety on construction sites. The research also leads to the conclusion that AI has the potential to significantly improve the performance and efficiency of construction work overall.*
Keywords*: project management, artificial intelligence, machine learning, virtual assistant.*

Introduction

In modern construction, the role of artificial intelligence (AI) is becoming increasingly significant and influential. Construction companies are increasingly turning to the application of AI in project management, aiming to optimize processes, increase efficiency, and improve the quality of work.

Artificial intelligence in construction is an innovative technology that has emerged in recent years. AI demonstrates unique capabilities in managing construction projects. For example, machine learning algorithms allow the analysis of vast amounts of data from previous projects, identifying patterns and trends, which in turn helps in predicting the time required for project completion, optimizing budgets, and managing resources.

This completely changes the approaches in construction. Many technologies that seemed like science fiction are now part of the everyday lives of engineers and builders.

The application of AI became the hottest topic of 2023. Seeing the opportunities for automation that AI presents, businesses are increasingly attempting to integrate it into their processes. Construction companies have also caught onto this trend: many are just now realizing that without technology, they will be left in the Stone Age. Despite some inertia in construction, where many rules and documents need to be rewritten before innovations can be implemented, industry leaders have long been working on integrating AI and machine learning into their processes.

Another important application of AI in construction is process automation. Robotic systems can perform many routine tasks, such as monitoring work processes on construction sites, quality control of work execution, and inventory management. This not only increases efficiency but also reduces the risks associated with human error.[1]

Research shows that using AI in construction project management leads to improved safety on construction sites. Automated systems can detect potentially dangerous situations, warn of possible accidents, and minimize risks to workers.

AI-enhanced applications can include advanced project management tools, risk analysis, and optimization of construction processes. AI-based technologies will help improve safety protocols by monitoring in real-time and analyzing events. And using AI in the design and planning stages will help to more efficiently utilize resources and make economically efficient decisions.

According to Deloitte, artificial intelligence and advanced data analysis technologies can provide cost savings on construction projects of 10–15%. They will help streamline the project verification process. And teams will be able to make more accurate estimates, thereby "reducing budgets and deviations from deadlines by about 10–20%. Moreover, the design time will be reduced by 10–30%.[2]

The impact of artificial intelligence is incredibly significant: by 2032, the forecasted value of artificial intelligence in the construction market is projected to reach $151.1 billion. Therefore, this article is dedicated to discussing the role of artificial intelligence in construction project management. We will examine various aspects of its application and analyze its influence on productivity, safety, and the effectiveness of construction activities.

Methods and Materials.

AI is already contributing significantly to generative design. It can analyze thousands of drawings, using them as a starting point, and then generate its own concepts based on the knowledge embedded by developers. AI has the capacity to expand the boundaries of traditional design by introducing unconventional concepts with innovative elements. Architects select the optimal design, and based on sketches, a three-dimensional model is created. [1,2]

Today, advanced technologies are already being utilized in the construction industry:
BIM technologies are employed to create digital twins of the planned projects. A BIM model facilitates efficient interaction between project disciplines, enhances the quality of design decisions, eliminates clashes, and provides a structured dataset for planning and construction.

Project management systems enhance the productivity of project teams through automated planning, progress analysis, and forecasting.

Construction monitoring systems provide reliable data on the condition of structures during both construction and operation stages, allowing for timely detection of deformations and prevention of potential failures.

Video analytics technologies alert about possible violations on construction sites regarding compliance with construction and installation work norms, labor safety regulations, and fire safety. Smart devices monitor the condition of construction equipment, machinery, or personnel.

Nowadays, no complex and large-scale project can proceed without BIM technology, which enables the creation of interactive three-dimensional models of structures at every stage of the construction process. This helps to identify conflicts at the design stage, reduces the number of necessary changes on the construction site, cuts costs, and assists in meeting deadlines. The synergy between BIM and AI aids in addressing numerous construction challenges.[3]

Construction teams establish connections and sequences in 3D models, while AI tools are used to create various simulations of project implementation schedules, complex infrastructure tasks requiring optimization of various parameters. With AI, different scenarios can be explored.

Teams also create 5D models, adding information regarding financial expenditures to these models. As AI tools continue to evolve in 2024, we can expect their deeper integration in the design and construction planning stages, providing more advanced modeling capabilities. The field

of AR is experiencing explosive growth, and integration with AI and BIM opens up fascinating possibilities.[4]

The "digital twin" technology enables predicting the development of a situation at a facility for decades ahead. Making changes to one part of the digital twin allows tracking the impact of these adjustments on the object itself and the surrounding environment. Such an approach helps identify "pitfalls" and errors at the design stage.

Augmented reality provides the opportunity to test the future building in various conditions before its construction. Using AI in the design and planning stages can lead to more efficient resource utilization and economically viable solutions.

Experts note that about 20% of time is spent on data search. AI provides access to connected data across the platform and enables quick retrieval of the required information in a user-friendly format. Real-time predictive analytics will significantly enhance decision support every day, both on-site and in the office. For instance, AI can forecast material deliveries, optimize routes, and delivery schedules, taking into account multiple factors. This reduces costs and downtime.[5]

AI applications may encompass advanced project management tools, predictive analytics for risk assessment, and optimization of construction processes. The synergy of BIM, AI, and construction management tools could lead to a revolution in design, planning, cost management, material selection, labor optimization, and quality control.

You can experience how digital solutions streamline construction management and help efficiently organize all processes. The application structures all project data, storing drawings and BIM model data that can be accessed in just a few clicks.

All processes are highly automated: it's enough to create templates for different processes once, and then fill out any documentation in just a few clicks. Our clients save up to 7 hours per week on reporting.

Construction progress can be monitored online, directly from mobile devices: tasks are created and assigned to responsible parties. Photos, videos, and precise locations can be added to them. As tasks are completed, the data is entered into the system and immediately visible to all team members. All updates are reflected in the system online and analyzed by the system in the form of charts and diagrams.

Additionally, data from sensors on-site, when configured appropriately, can be fed into Plan Radar for further processing. This automates construction monitoring. Such an approach links the construction site and the office: all data can be tracked directly from a smartphone.[6]

Intelligent monitoring systems can track quality at all stages of construction. Sensors and cameras record process parameters, while AI analyzes the data and identifies deviations.

For example, during concreting, AI monitors the conformity of the concrete composition to specified parameters, as well as the temperature and humidity on-site. During bricklaying, it tracks the verticality of the structure, the thickness of joints, and the strength of the mortar. Machine vision systems verify the visual quality of surfaces. If defects are detected, AI immediately alerts builders, enabling them to promptly rectify the defects and avoid serious consequences in the future. The integration of BIM with AI also opens up new and interesting possibilities for enhancing efficiency at all stages of a building's lifecycle. BIM data combined with machine learning can enable companies to improve efficiency and make more rational decisions beyond the design stage.

Artificial intelligence can diagnose the operation of building engineering systems. Sensors monitor the performance parameters of heating, ventilation, and electrical systems. Based on this data, AI detects faults and predicts breakdowns. AI plans preventive maintenance to prevent serious breakdowns. It calculates the optimal frequency of servicing and minimizes repair costs for building owners [8]

2.1 Challenges in AI Implementation

The bright prospects presented by the application of artificial intelligence (AI) remain rather elusive for many companies. The adoption of AI requires changes in approaches, employee training, and adaptation of business processes, which not all companies are prepared for. The implementation of AI necessitates shifting the focus of project teams from task execution to defining processes, selecting tools, and making data-driven decisions. Structured data is critically important for the successful implementation of AI.

Concerns exist regarding data confidentiality and the preservation of intellectual property when using AI. With the advancement of AI, questions arise regarding data confidentiality, security, and ethical use. Who will manage all the information, who will be responsible for its provision, collection, control, management, and dissemination throughout the environment? These are all questions that become relevant with deeper AI integration.

AI will not replace people on the construction site but will significantly change office processes, such as document preparation, information retrieval, and data analysis. In recent years, the construction industry has already begun experimenting with AI: research, training, launching pilot projects, and automating operations to enhance competitiveness in the market.

It may seem surprising, but the issue of using AI for project management has been around for over 30 years. In 1987, a landmark article by William Hosley titled "Applications of Artificial Intelligence for Project Management" was published. That same year, under the auspices of NASA, a study on the effectiveness of AI methods in project management was completed. Meanwhile, there has been a proliferation of solutions, which can be broadly divided into two classes:

1. Virtual project manager assistants.
2. Artificial intelligence in project management systems [9]

In 2017, Allan Rocha and Ricardo Vargas introduced PMOtto – a personal virtual project manager assistant service that combines chatbot functionality with interfaces for interacting with project and project portfolio management systems, such as Microsoft Office 365 Project Online. Project participants can freely communicate with PMOtto via smartphone or web chat, report task status, inform about risks, and request necessary information. PMOtto recognizes speech and text, converting them into commands for information systems. Additionally, PMOtto can provide project implementation recommendations based on machine learning results and implemented algorithms. Developers claim that PMOtto embodies a combination of various profiles with over 20 years of project management experience.

Construction IQ (formerly known as Project IQ) is an intelligent assistant for construction projects using the Autodesk BIM 360 platform. Using machine learning methods, Construction IQ collects and analyzes data on the quality and safety of construction objects, potential project risks, etc. For example, it identifies tasks with a high probability of delays and other risks. Construction IQ extracts information from project records, observation and audit results, technical assignments, contractor reports, and other project documents. All this is used to identify, analyze, and prioritize

project risks. The risk analysis results performed by Construction IQ are presented to users in Project Home – a unified window displaying key project information, including work progress, an interactive object model, camera data, etc. [10]

This list of examples by no means exhausts the growing influence of artificial intelligence on project management. However, the question of replacing a project manager with artificial intelligence is hardly relevant. Artificial intelligence frees up time from routine and technical tasks, allowing project managers to focus on less formalized areas such as communication and expectations management, conflict resolution, strategic planning, etc. Furthermore, implementing artificial intelligence requires a sufficiently high level of project management culture and discipline. Artificial intelligence works with data, and this data must be reliable and provided in a timely manner.

3. Results

AI and BIM technologies today enable the creation of interactive 3D models of constructions at every stage of the construction process, identifying conflicts even during the design phase, reducing the need for changes at the construction site, lowering costs, and helping to meet deadlines [11].

The application structures all project data, including drawings and BIM model data, which can be accessed with just a few clicks. This facilitates efficient project management since all data is available in a user-friendly format [12].

All processes are executed with maximum efficiency: it's enough to create templates for various processes once, and then fill in all documentation with just a few clicks [13]. This saves up to 7 hours per week on report creation, significantly increasing work productivity [9].

Construction progress can be monitored online, directly from mobile devices: tasks are created and assigned to responsible parties. Photos, videos, and precise locations can be added to them. As tasks are completed, data is entered into the system and immediately visible to all team members. This allows for prompt responses to changes and deficiencies, enhancing the quality of project work.

All updates are reflected in the system online, and analysis is conducted through graphs and diagrams. This enables efficient process control and identification of problematic areas, leading to increased work efficiency.

AI provides access to connected data across the platform and enables quick retrieval of necessary information in a user-friendly format. This reduces time spent searching for data and enhances work productivity.

The application structures all project data, storing drawings and BIM model data that can be accessed in just a few clicks. All processes are highly automated: it's enough to create templates for various processes once, and then fill in any documentation with just a few clicks. Our clients save up to 7 hours per week on report generation. This helps reduce time spent on report preparation and increase work productivity.

AI allows for the creation of interactive 3D models of constructions at every stage of the construction process, identifying conflicts even during the design phase, reducing the need for changes at the construction site, lowering costs, and helping to meet deadlines.

Experts note that approximately 20% of time is spent on data retrieval [11]. AI provides access to connected data across the platform and enables quick retrieval of necessary information in a user-friendly format. Real-time predictive analytics will significantly enhance decision

support every day, both on the construction site and in the office. For instance, AI plans material deliveries, optimizes routes, and schedules deliveries considering multiple factors. This reduces costs and downtime. AI applications may include advanced project management tools, predictive analytics for risk assessment, and optimization of construction processes.

The synergy of BIM, AI, and construction management tools could revolutionize design, planning, cost management, aid in material selection, optimize labor, and quality control.

The integration of AI into the construction industry requires changes in approaches, staff training, and adaptation of business processes. AI will shift the project team's efforts from task execution to process definition, tool selection, and data-driven decision-making. Successful AI implementation critically depends on data structuring. Concerns exist regarding data confidentiality and intellectual property preservation when using AI. With the development of AI, questions of data confidentiality, security, and ethical use of AI arise. Who and how will manage all information, who will be responsible for its provision, collection, control, management, and distribution throughout the environment? These are all questions that will become relevant with deeper AI implementation [15]

Artificial intelligence (AI) won't replace humans on construction sites, but it will drastically change office processes, such as documentation compilation, information retrieval, and data analysis. In recent years, the construction industry has already begun experimenting with AI: conducting research, training, launching pilot projects, and automating operations to enhance competitiveness in the market. AI enables the creation of interactive three-dimensional models of structures at each stage of the construction process, identifying conflicts during the design phase, reducing the need for on-site modifications, cutting costs, and helping meet deadlines.

The application organizes all project data, including drawings and BIM model data, which can be accessed with just a few clicks. All processes are highly automated: templates are created once for various processes, making it possible to fill out any documentation with just a few clicks. Our clients save up to 7 hours a week on reporting. Construction progress can be monitored online directly from mobile devices: tasks are created and assigned to responsible individuals. Photos, videos, and precise locations can be added to tasks. As tasks are completed, the data is entered into the system, and all team members are immediately notified. All updates are reflected in the system online, with analysis provided in the form of graphs and diagrams.

AI can analyze thousands of drawings, using them as a starting point to form its own concepts based on developers' knowledge. It can expand the boundaries of traditional design by introducing non-standard concepts with elements of innovation. BIM models enable effective interaction between project disciplines, improve the quality of design decisions, and eliminate clashes. Project management systems increase the productivity of project teams through automatic planning, progress analysis, and forecasting. Construction monitoring systems provide reliable data on the condition of structures during construction and operation, allowing timely detection of deformations and prevention of potential failures [16]

Video analytics technologies warn of possible violations at the construction site regarding compliance with construction and installation work norms, labor safety rules, and fire safety. Smart devices monitor the condition of construction equipment, machinery, or personnel. The synergy of BIM and AI helps solve many construction problems. Construction teams establish relationships and sequences in 3D models, while AI tools are used to create various project schedule simulations, solve complex infrastructure tasks, and optimize various parameters.

With AI, various scenarios can be explored. Teams also create 5D models, adding financial expenditure information to these models. As AI tools develop in 2024, we can expect their deeper integration in the design and construction planning stages, providing more advanced modeling capabilities.

The AR sphere is experiencing explosive growth, and integration with AI and BIM opens up exciting possibilities. The "digital twin" technology enables prediction of site developments decades ahead. Changes made to one part of the digital twin can track the impact of these adjustments on both the object and the surrounding environment, helping identify pitfalls and errors at the design stage.

Augmented reality allows testing future structures in various conditions before construction begins. The use of AI in the design and planning stages can lead to more efficient resource utilization and economically viable solutions.

AI provides access to connected data across the platform and quickly retrieves the required information in a user-friendly format. Real-time predictive analytics significantly improves decision support every day, on-site and in the office. For example, AI plans material deliveries, optimizes routes, and delivery schedules considering multiple factors, reducing costs and downtime. AI applications may include advanced project management tools, predictive analytics for risk assessment, and optimization of construction processes.

The synergy of BIM, AI, and construction management tools can lead to a revolution in design, cost management, material selection, labor optimization, and quality control. Some examples of applications that can be used to structure data for a project in the construction industry include BIM (Building Information Modeling) software, project management software, and document management systems. BIM software, such as Autodesk Revit, creates a 3D model of a building and integrates data about the building's design, materials, and construction schedule. This data can then be used to create detailed plans, schedules, and cost estimates. Project management software, such as Microsoft Project, helps to plan, organize, and manage resources for a project. It can track progress, manage tasks and deadlines, and provide real-time updates on the status of a project. Document management systems, such as SharePoint, provide a centralized location for storing and sharing documents, drawings, and other project-related information. These systems can also include features for version control, search, and collaboration.

Additionally, there are also AI-based applications that can be used to structure data for a project, such as PMOtto, a virtual personal assistant for project managers that uses machine learning algorithms to provide recommendations and insights on project execution, and Construction IQ, an AI-powered solution that can analyze project data and identify potential risks and issues before they become problems.

It is important to note that these applications should be integrated with each other and with other systems used in the construction process, such as ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) systems, to ensure that all data is accurate, up-to-date, and easily accessible to all stakeholders.[17]

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