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ARTIFICIAL INTELLIGENCE IN CONSTRUCTION AND LANDSCAPE DESIGN: APPLICATIONS IN PLANNING, SCHEDULING, AND ENGINEERING TO INCREASE EFFICIENCY

ШТУЧНИЙ ІНТЕЛЕКТ У БУДІВНИЦТВІ ТА ЛАНДШАФТНОМУ ДИЗАЙНІ:
ЗАСТОСУВАННЯ В ПЛАНУВАННІ, ПРОЕКТУВАННІ ТА ІНЖЕНЕРІЇ ДЛЯ
ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ

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Abstract. *The construction and landscape industries face numerous challenges: from rising costs, frequent delays and low productivity to a number of issues related to the rational use of resources and compliance with environmental standards. This article reviews the application of artificial intelligence (AI) technologies to automate the planning process, development of work schedules and engineering tasks in order to increase project efficiency. It also provides an analysis of modern approaches to design: from machine learning and data analysis of project BIM models to generative design methods. Examples of automated work scheduling and resource optimization, digital planning of construction and landscaping projects, and the use of AI in the design and visualization of construction objects are considered. The article shows that the implementation of AI allows you to reduce planning errors, shorten project deadlines and reduce costs, increasing the accuracy of forecasts and flexibility of management. The article summarizes the main scientific achievements in this field and offers recommendations for the effective integration of AI in construction and landscape design.*

Keywords: *artificial intelligence, machine learning, construction, landscape design, planning, work schedule, BIM, resource optimization, efficiency.*

Introduction

Modern digital methods, in particular artificial intelligence (AI) technologies, open up new opportunities to improve the efficiency of these processes. In many industries, AI has already proven its ability to increase productivity, accuracy and safety of work [1][2]. In construction, AI directions, such as machine learning, computer vision and robotics, are gradually being introduced to automate key tasks. In particular, robotic systems already perform routine operations, and algorithms analyze large amounts of design data. In this context, a systematic review of existing research and practices becomes relevant, which is the purpose of this article: to show how modern AI methods are applied to work schedules, project planning and engineering tasks, as well as what benefits they provide in terms of saving time, resources and costs.



Literature review

In recent years, the problem of inefficiency in construction projects has attracted significant attention from scholars. For example, a study by Abioye et al. (2021) highlights that the pace of digital adoption in construction is the lowest among other industries, namely due to the gap in standards and divergence in methodologies [1]. At the same time, they note that AI methods (machine learning, image analysis, robotics) have already proven their ability to increase productivity and safety at sites in other industries, so their potential in construction promises significant benefits [1].

In this regard, a number of reviews and analytical works have been conducted. Pan and Zhang (2021) summarized the role of AI in construction engineering management, showing the explosive growth of publications in this field over the past decade. The authors noted a gradual shift in focus from expert systems to BIM, digital twins, and ML approaches aimed at automating design and risk management [2]. Similarly, Chong et al. (2025) study proves that the integration of BIM and AI allows for the creation of dynamic schedule management schemes and risk prediction systems, which significantly improves the quality of project planning.

The trend of implementing AI is occurring at various stages of construction. For example, generation of work schedules, support of engineering solutions and maintenance. In particular, automated scheduling systems based on machine learning have shown the possibility of reducing the time for preparing plans by up to 30% compared to traditional approaches [3]. At the same time, researchers also note some problems: data fragmentation, high initial investments, insufficient staff qualifications and ethical issues remain limitations to the widespread use of AI [3][5].

Artificial Intelligence Methods in Construction

To develop the industry, it is necessary to describe the methods that help achieve the goals. AI in construction is most often implemented through machine learning (ML), deep learning (neural networks), genetic algorithms, optimization methods, and also new generative approaches (LLM, GAN, etc.). For planning and optimizing schedules, ML models are often used to analyze past project data, predict delays and resource conflicts [2][6]. Genetic algorithms work well when optimizing many criteria



(when time, cost, resources need to be taken into account), which is important under unstable conditions, such as unpredictable delays [6]. Artificial neural networks, especially recurrent (RNN) and convolutional (CNN), are effective for recognizing patterns in time series and construction images (monitoring progress by photo) [1][6].

Digital BIM (Building Information Modeling) models occupy a special place in modern methods. Thanks to BIM, there is a lot of data about objects: building geometry, material details, methods of work. If you combine BIM with AI, you get a single source of knowledge about the project, which simplifies the analysis and verification of solutions [6]. For example, AI modules can automatically find problems in a 3D model at the design stage, suggest corrections or assess energy consumption or stability of structures [6]. If you add robotic systems, such integration significantly simplifies the performance of routine tasks: robots can independently perform the same or dangerous operations according to the BIM model, increasing accuracy and safety [6].

AI applications in planning and scheduling

One of the most important areas of application of AI in construction is the automation of planning and scheduling. Traditional tools (Gantt, CPM) have static algorithms, while ML-based systems are able to take into account the complex dynamics of the project. The use of historical data and real indicators allows you to predict possible shifts in deadlines and promptly compensate for them [2][3].

For example, generative methods (such as models based on large neural networks) can automatically create optimized plans. Such algorithms learn from many years of data and object parameters, and then generate schedules taking into account resource constraints and probable risks [2][4]. Experimental studies have shown that the implementation of an AI-based automated planning system can reduce the time for preparing schedules by up to 30% [3], reduce the number of conflicts with resources, and increase the accuracy of predicting delays. For example, ALICE Technologies and nPlan use Bayesian networks and optimization algorithms to dynamically update plans in real time [2][3].

AI is also useful for strategic planning of construction projects. Automated



systems analyze initial data (geodesy, budget, equipment, weather) and suggest better options for resource allocation and work sequences. For example, the combination of BIM and geographic information systems (GIS), enhanced by AI, provides a powerful platform for spatial planning. Using BIM + GIS helps to take into account topography, climate, transport accessibility and other factors, and ML algorithms model the best scenarios with this data [6]. Such solutions reduce the chance of errors in assessing conditions on the construction site.

Application of AI in engineering design and landscape design

In the creation of structures and landscape planning, AI is used to develop, analyze and optimize solutions. The concept of "landscape design" refers to both urban planning of external space and landscaping and improvement of territories.

In engineering design, AI helps in generative design: algorithms generate hundreds of layout and construction options taking into account given constraints (weight, materials, loads). The most effective options are then selected for detailed development, which reduces the number of iterations compared to manual methods. For example, in construction, artificial neural networks are already used to optimize metal frames and reinforced concrete elements, predict the strength of materials based on complex parameters, and automatically check standards [6]. This significantly reduces the likelihood of design errors and ensures high quality projects [7]. (See Figure 1)

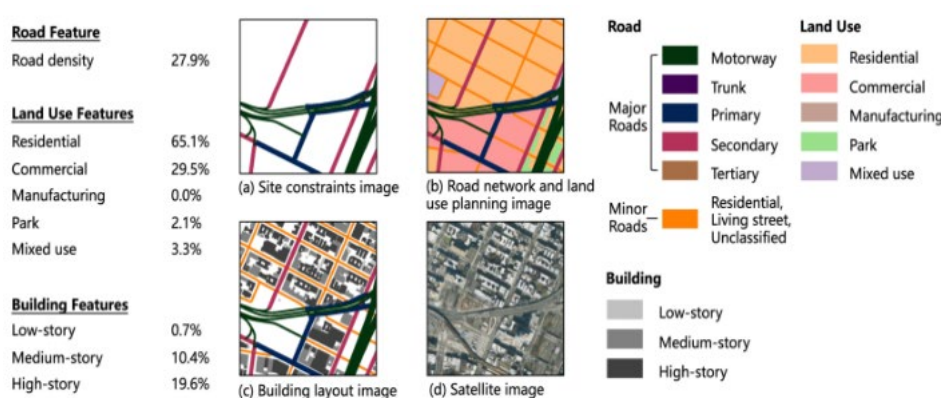


Figure 1 - Computer model of the landscape created using an artificial intelligence tool

Source: [7]



In landscape design, AI is used to analyze environmental and social data to create balanced landscaping projects. Computer vision algorithms process satellite imagery and sensor data to classify land use and monitor vegetation changes. Combined with ML, this allows for the development of irrigation models that automatically adjust irrigation based on soil moisture and weather conditions [4]. Intelligent irrigation systems can learn optimal irrigation schedules for different plant species, reducing water consumption and labor costs [7]. AI tools also help in selecting plant species according to the climatic and soil conditions of the site, generate landscape plans taking into account prospective cultivation, and create visualizations of projects. This improves the quality of design solutions and significantly saves designers' time. (See Fig. 1)

The construction of parks and green areas uses the same BIM+AI technologies as in buildings. Robot manipulators can lay lawns, place landscape elements or plant plants according to automatic plans. This significantly speeds up large landscaping projects. AI also monitors the condition and safety of the territory: image-analyzing systems can track the movement of people or the state of lighting in parks, warn of danger and help with space management [4][6].

AI models help designers quickly explore outdoor space plans. In addition, such models quickly improve them. Another study shows how generative AI increases the efficiency of design creation in urban and landscape planning [7]. AI tools allow architects to instantly analyze a multitude of possible design scenarios and choose the most optimal solution.

Discussion of results

In general, the implementation of AI in construction and landscape design projects shows significant productivity gains. According to various studies, AI-based systems can significantly reduce the duration of project preparation and reserve resources more effectively than traditional methods [3]. For example, in cases of adaptive planning, the risk of delays and cost estimates are significantly reduced due to the prediction of potential problems and automatic restructuring of schedules [3]. In landscape design, AI algorithms have helped to optimize the use of water and fertilizers, as well as



improve the quality of design and reduce the cost of maintaining green areas [4]. (See Table 1)

Table 1 - Main applications of artificial intelligence and their impact on construction efficiency and landscape.

Branch	Approach	Efficiency
Construction planning	BIM + AI (ML optimization)	Reduction of schedule delays by ~30–40%; acceleration of decision-making by ~30%
Structural design	Generative AI	Approximately 30–40% faster project iteration; approximately 20% material savings
Landscape design and planning	Generative design (computer vision/ML)	Faster project research; wide choice of design methods; reduction of design time by approximately 30–40%

Source: Author's own development

At the same time, the implementation of AI solutions is associated with certain difficulties. The key barriers have been identified as data heterogeneity (project data is often stored in different formats and its quality is unpredictable), high costs of implementing and configuring systems, and lack of staff training [3][5]. For example, implementing BIM+AI requires significant investments in model preparation and sensor integration on site, which may be prohibitive for small companies. In addition, engineers and managers are often not ready for new approaches and tools: without training, it is difficult to accept the benefits of intelligent systems [3][5].

On the other hand, many scholars emphasize that AI should serve as an auxiliary tool, not a complete replacement for humans [3]. For example, Umoru (2025) concludes that AI can serve as an “important complement” to schedule management, but its use must be approached responsibly and strategically [3]. That is, the best results can be achieved by automating routine tasks while simultaneously upgrading employees' skills to work with new systems.



Conclusions

The article analyzes the main areas of use of artificial intelligence in construction and landscape design, in particular in planning, scheduling and execution of engineering tasks. It is concluded that modern AI technologies can significantly increase the efficiency of construction project management. The use of machine learning and generative design ensures the rapid creation of optimized plans and constructive solutions. The integration of BIM and computer algorithms facilitates the analysis of project data and the identification of problems at the early stages. Robotic systems controlled by AI automate similar or dangerous operations on the site, which increases the accuracy of work and occupational safety.

But at the same time, the research results indicate the need to address the challenges posed by today: the process of data standardization, personnel training and a gradual transition from traditional design methods to automated ones. In the absence of large-scale input data and regardless of the quality of the algorithms, maximum efficiency results, unfortunately, are still difficult to achieve. That is why it is recommended to combine intelligent tools with carefully planned project creation strategies.

Thus, the use of AI in graphic design, planning, and engineering contributes to the further development of “smart” construction and landscaping processes. As a result, comprehensive AI solutions can significantly reduce project time and resource costs, increase management flexibility, and ensure higher quality of the final product.

References

1. Abioye, SO, Oyedele, LO, Akanbi, L., Ajayi, A. (2021) Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, 44, 103299. URL: https://www.researchgate.net/publication/355102329_Artificial_intelligence_in_the_construction_industry_A_review_of_present_status_opportunities_and_future_challenges (in English)
2. Pan, Y. and Zhang, L. (2021) Roles of artificial intelligence in construction



engineering and management: A critical review and future trends. Automation in Construction, 122, 103517. URL:

https://www.researchgate.net/publication/347441718_Roles_of_artificial_intelligence_in_construction_engineering_and_management_A_critical_review_and_future_trends (in English)

3. Umoru, C. (2025) AI and Construction Project Schedules Efficiency: A Review. International Journal of Scientific Research and Modern Technology, 4(6), pp. 89–94.

URL:https://www.researchgate.net/publication/395636240_AI_and_Construction_Project_Schedules_Efficiency_A_Review (in English)

4. Xing, Y., Gan, W., Chen, Q., Yu, PS (2025) AI-Generated Content in Landscape Architecture: A Survey. AI Open. URL:

https://www.researchgate.net/publication/383460736_Artificial_Intelligence_in_Landscape_Architecture_A_Survey (in English)

5. Al-Sinan, MA, Bubshait, AA, Aljaroudi, Z. (2024) Generation of Construction Scheduling through Machine Learning and BIM: A Blueprint. Buildings, 14(4), 934.

URL: <https://www.mdpi.com/2075-5309/14/4/934> (in English)

6. Chong, H.-Y., Yang, X., Goh, CS, Luo, Y. (2025) BIM and AI Integration for Dynamic Schedule Management: A Practical Framework and Case Study. Buildings, 15(14), 2451. URL: <https://www.mdpi.com/2075-5309/15/14/2451> (in English)

7. He, M., Liang, Y., Wang, S., Zheng, Y., Wang, Q., Zhuang, D., Tian, L., Zhao, J. (2025) Generative AI for Urban Design: A Stepwise Approach Integrating Human Expertise with Multimodal Diffusion Models. arXiv. URL: <https://arxiv.org/html/2505.24260v1> (in English)

Анотація. Будівельна та ландшафтна галузі стикаються з численними проблемами: від зростання витрат, частих затримок і низької продуктивності до ряду питань, пов'язаних з раціональним використанням ресурсів і дотриманням екологічних стандартів. У даній статті розглянуто застосування технологій штучного інтелекту (ШІ) для автоматизації процесу планування, розробки графіків робіт та інженерних завдань з метою підвищення ефективності проекту. Він також забезпечує аналіз сучасних підходів до проектування: від машинного навчання та аналізу даних проектних BIM-моделей до генеративних методів проектування. Розглянуто приклади автоматизованого планування робіт та оптимізації ресурсів, цифрового планування проектів будівництва та озеленення, використання AI при



проектуванні та візуалізації об'єктів будівництва. У статті показано, що впровадження AI дозволяє зменшити помилки планування, скоротити терміни виконання проектів і знизити витрати, підвищивши точність прогнозів і гнучкість управління. У статті узагальнено основні наукові досягнення в даній галузі та запропоновано рекомендації щодо ефективної інтеграції AI в будівництво та ландшафтний дизайн.

Ключові слова: штучний інтелект, машинне навчання, будівництво, ландшафтний дизайн, планування, графік роботи, BIM, оптимізація ресурсів, ефективність.