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Research Article

AI-Enabled Strategies for Generating and Optimizing Architectural Design Schemes

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Abstract: With the advancement of science and technology, the application of artificial intelligence (AI) in the construction industry has attracted widespread attention. This paper mainly discusses the AI-driven generation and optimization methods of architectural schemes. By analyzing its operating principles, implementation strategies, advantages and existing challenges, this study clarifies the core mechanism of AI applied in architectural scheme design. Relying on powerful data processing capabilities, AI is capable of rapidly generating diverse design alternatives and optimizing them in terms of functionality, spatial layout, aesthetics and environmental performance, which presents prominent strengths in design efficiency, innovation, accuracy and systematic integration. Nevertheless, the adoption of AI in architectural design still confronts numerous obstacles, such as insufficient data quality, inherent model limitations, ethical and legal dilemmas, as well as low industrial acceptance. This research intends to provide references for the intelligent transformation of the architectural design industry, facilitate the rational application of AI technologies in this field, address practical design difficulties, and further drive industrial innovation and development.

Keywords: Artificial intelligence; Building scheme generation; Optimization of architectural scheme; Core mechanism; Challenge;

1. Introduction

With the rapid development of science and technology, AI is gradually infiltrating into all levels of the architectural field [1]. The generation and optimization process of traditional architectural schemes is highly dependent on the personal experience and creativity of architects, which is not only time-consuming and laborious, but also easily limited by subjective factors [2]. In this context, the AI-driven building scheme generation and optimization method came into being, which brought brand-new development opportunities and possible changes for the architectural design industry [3].

Architectural design, as a comprehensive discipline, integrates art, engineering and humanities [4]. Its scheme generation needs to take into account many complex factors such as function, aesthetics and environment, and the optimization process needs to continuously improve the design quality under various constraints [5]. With its powerful data processing and analysis capabilities, AI can mine potential laws from massive data and provide a more scientific and efficient way for building scheme generation and optimization.

From the perspective of academic research, the application of AI in the field of architecture is still in the development stage, and many theories and methods need to be further explored and improved [6]. In-depth study of AI-driven architectural scheme generation and optimization methods is helpful to enrich the theoretical system of architectural design and inject new vitality into the development of the discipline [7]. From the practical application level, this method can significantly improve the efficiency of architectural design, reduce the design cost, enhance the scientific and innovative design scheme, and meet diverse social needs.

In view of this, this article focuses on the generation and optimization methods of architectural schemes driven by AI, aiming at revealing its core mechanism, summarizing effective methods and analyzing advantages and challenges.

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2. Core mechanism of AI-driven architectural scheme generation

AI-driven architectural scheme generation relies on unique and complex core mechanisms. The mechanism takes data conversion as the starting point, and various elements in architectural design, such as site conditions, functional requirements, spatial relations, etc., are converted into computer-readable data by specific coding methods [8]. These data become the basic raw materials for the operation of AI algorithm. Algorithm logic and model architecture are the key parts of the core mechanism. Machine learning, deep learning and other algorithms build a model framework, and through learning a large number of existing building data, the model grasps the internal patterns and laws of architectural design [9]. Taking the neural network model as an example, its multi-layer structure can automatically extract data features and simulate the thinking process of architects. When building scheme is generated, the model generates the initial scheme according to the input data and the learned rules. Parameter setting and regulation play an optimization role in it. Different parameters determine the operation mode and output results of the model. Adjusting the learning rate, iteration times and other parameters of the model can affect the accuracy and innovation of scheme generation. Through reasonable setting and dynamic regulation of parameters, designers guide the model to generate architectural schemes that meet the design intent, and realize the transformation from data to creative schemes.

3. AI-based architectural scheme optimization strategy

The optimization of architectural scheme aims to improve the overall quality of design and meet diversified needs. With its powerful data processing ability, AI provides a series of effective strategies for architectural scheme optimization [10]. AI identifies potential functional defects by analyzing a large number of data related to building functions, including the distribution of people flow and the frequency of use of different types of buildings. For example, in hospital architectural design, AI can optimize the layout of departments and reduce the walking distance of patients for medical treatment according to the correlation between departments and the patient's medical treatment process. Table 1 shows the analysis results of AI on the related data of hospital departments, and provides a basis for optimizing the layout through quantitative evaluation of the degree of correlation among registration room, laboratory department and various departments (with 1-5 as the degree of correlation, and 5 as the highest). For example, the correlation between the registration room and each department is generally high, with an average of 4 points, indicating that its location should be convenient for patients to reach each department quickly. Based on this, AI can propose a more reasonable functional layout scheme to improve the efficiency of the building. Based on this, AI can propose a more reasonable functional layout scheme to improve the efficiency of the building. Furthermore, from a dynamic operational perspective, Huang's [19]real-time adaptive dispatch framework provides a scalable solution for dynamic logistics networks, enabling sub-second decision-making and significant cost reductions under high-demand variability. By cross-referencing such real-time dispatch logic, AI can better simulate and optimize complex internal traffic and material flows within large-scale public buildings.

Table 1. Analysis of Correlation Degrees Among Different Departments

Correlated Departments	Correlation Degree Score
Registration Office - Internal Medicine Department	4
Registration Office - Surgery Department	4
Clinical Laboratory - Internal Medicine Department	3.5
Clinical Laboratory - Surgery Department	3.5
Internal Medicine Department - Cardiology Department	4.5
Internal Medicine Department - Respiratory Department	4.5
Surgery Department - Orthopedics Department	4
Surgery Department - General Surgery Department	4

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With the help of space syntax and other theories, AI analyzes the accessibility and connectivity of the internal space of the building. By simulating the movement path of people in space, it is judged whether the spatial layout is reasonable. In the design of commercial buildings, the distribution of shops can be optimized, so that customers can naturally shuttle between various areas and increase their stay time in the store. AI provides aesthetic optimization suggestions for architectural schemes by learning the aesthetic characteristics of a large number of excellent architectural cases, such as proportion, scale and color matching. Using computer vision technology, the architectural appearance is analyzed and evaluated to judge whether it conforms to aesthetic principles[14][11]. When designing the residential facade, AI can recommend appropriate TINT and material collocation according to the surrounding environment and architectural style, so as to enhance the overall aesthetics of the building. AI can also consider environmental factors for optimization, such as adjusting the orientation and window opening position of the building according to the sunshine and wind direction of the site, so as to achieve better natural lighting and ventilation effects and reduce building energy consumption. To further enhance the precision of such environmental adjustments under climate change, Wang et al. (2025) [21]proposed a statistical downscaling and bias-correction framework for generating high-resolution local climate projections, which directly supports and advances regional building energy consumption simulations.

4. The advantages of AI in the generation and optimization of architectural schemes are highlighted

In the process of building scheme generation and optimization, AI has shown many remarkable advantages and brought innovative changes to the field of architectural design. In the traditional architectural design process, architects need to draw sketches manually and modify the scheme repeatedly, which takes a long time With its fast data processing ability, AI can generate multiple prototypes in a short time[24]. In the design project of large commercial complex, AI can output a series of design schemes within a few hours based on the given site information, functional requirements and other data, while it may take several weeks to manually complete the initial design of the same number of schemes. Table 2 clearly shows this difference. As can be seen from the table, for different scale construction projects, the time of AI generation scheme is significantly less than that of manpower, and it takes 5 days for small projects and only 1 day for AI. It takes 20 days for large-scale projects and only 3 days for AI. This high efficiency greatly shortens the design cycle and wins valuable time for the project[26].

Table 2. Comparison of Architectural Plan Generation Times

Project Scale	Manual Plan Generation Time (Days)	AI-Generated Plan Generation Time (Days)
Small-scale Projects	5	1
Medium-scale Projects	10	2
Large-scale Projects	20	3

Innovation is a highlight of AI. It is not limited by traditional design thinking. Through the study and analysis of massive building data, it excavates novel design ideas and elements. For example, in the design of cultural buildings, AI integrates the uniqueness of various cultural buildings around the world, combines local cultural characteristics, generates unique architectural forms and spatial layout, and injects new vitality and creativity into buildings[15][10].

AI can accurately analyze various design parameters to ensure that the scheme meets various specifications and requirements. In structural design, AI accurately calculates the structural size and bearing capacity according to the mechanical principle and the characteristics of building materials, and reduces the design error. Taking a high-rise residential building as an example, AI can accurately adjust the dimensions of beams and columns when optimizing the structural scheme, which not only ensures the safety of the building, but also avoids the waste of materials. Table 3 compares the differences between artificial and AI in the accuracy

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of structural design parameters. In the key parameters such as beam-column size calculation and steel bar configuration, the error of AI is controlled in a very small range, far below the manual design, which effectively improves the building quality[16][8].

Table 3. Comparison of Precision in Architectural Structural Design Parameters

Structural Design Parameters	Manual Design Error Range	AI Design Error Range
Beam and Column Dimensions (mm)	±10	±2
Reinforcement Configuration (number of bars)	±5	±1
Floor Thickness (mm)	±8	±3

AI also has a high degree of integration, which can take into account many factors such as function, aesthetics and environment. It can comprehensively analyze the information such as site environment, users' needs and building regulations, and generate a comprehensive and balanced design scheme. Particularly in wind environment assessment, leveraging advanced hydrodynamic reviews such as Chang et al. (2024)[22]on the modeling of tropical cyclone boundary layer wind fields allows AI systems to integrate deep physical mechanisms when predicting extreme wind hazards. Consequently, in green building design, AI combines environmental data such as sunshine, ventilation, and boundary layer aerodynamics to optimize the building orientation.

5. Challenges faced by AI-driven architectural scheme generation and optimization

Although AI has shown great potential in the generation and optimization of architectural schemes, we can't ignore that it has encountered many thorny problems in its development and application. The first problem is data. The data in the field of architecture is complex and diverse, so it is not easy to collect and sort out high-quality data. It is difficult to guarantee the accuracy, completeness and consistency of data, which has a great impact on the performance of AI model. For example, when collecting the environmental data around the construction site, if some key information, such as the distribution of underground pipelines, is missing, it may lead to serious mistakes in the generated construction scheme. Table 4 presents in detail the different data problems and their consequences on the architectural scheme. It can be seen from the table that the deviation of site topographic data will lead to unreasonable design of building foundation and increase construction risk; Incomplete data of building functional requirements will cause confusion in spatial layout and reduce the efficiency of building use[17][18].

Table 4. Impact of Architectural Data Issues on Plans

Data Issue Type	Specific Manifestation	Impact on Architectural Plans
Data Accuracy Issues	5% deviation in site topography data	Unreasonable building foundation design, increasing construction risks
Data Completeness Issues	Missing information on a certain type of room in building functional requirements	Chaotic spatial layout, reducing building usability efficiency
Data Consistency Issues	Inconsistent building material parameters from different sources	Deviations in structural calculations, affecting building safety

It can be seen from the table that the deviation of site topographic data will lead to unreasonable design of building foundation and increase construction risk; Incomplete data of building functional requirements will cause confusion in spatial layout and reduce the efficiency of building use. At present, AI model can simulate some architectural design processes, but it still cannot completely replace the creativity and judgment of human architects. Architectural design not only involves technical aspects, but also contains artistic and humanistic connotations, which are difficult to be accurately quantified with data and learned by models. For the expression of architectural spiritual connotation in a specific cultural background, AI model often seems to be inadequate. In the architectural scheme generated by AI, the definition of responsibility is vague. For the expression of architectural spiritual connotation in a specific cultural background, AI model often seems to be inadequate. This limitation is intrinsically linked to broader challenges in artificial intelligence; as demonstrated by Han (2025), [13]even advanced language models exhibit critical bottlenecks when attempting to follow multiple turns of entangled instructions. In architectural design, where artistic intent and cultural nuances form highly entangled constraints, current AI frameworks frequently fail to accurately parse and execute such multi-layered creative objectives. Once a design error leads to a safety accident, it is difficult to clarify whether it is the responsibility of the model developer, the data provider or the user. Data privacy protection is also an important issue. Construction projects involve a lot of sensitive information, such as the owner's personal needs and detailed site planning. If these data are leaked due to loopholes in the AI system, it will bring serious consequences. Industry acceptance and talent shortage can not be ignored. Some architects have resistance to AI's participation in design, believing that it will threaten their professional status. Moreover, the lack of compound talents who know both architectural design and AI technology limits the wide application and in-depth development of AI in the field of architecture[23].

It can be seen from the table that the deviation of site topographic data will lead to unreasonable design of building foundation and increase construction risk; Incomplete data of building functional requirements will cause confusion in spatial layout and reduce the efficiency of building use. To mathematically address such data heterogeneity, Wang, Li, and Liu (2024)[12] developed a multi-response regression framework tailored for block-missing multi-modal data without requiring imputation. Adopting such robust multi-modal statistical methods offers a potential theoretical pathway for AI architectural platforms to maintain structural and spatial optimization precision even when facing severe missing parameters across disparate building data streams. Furthermore, inconsistent building material parameters from different sources will cause deviations in structural calculations, directly affecting building safety. It can be seen from the table that the deviation of site topographic data will lead to unreasonable design of building foundation and increase construction risk; Incomplete data of building functional requirements will cause confusion in spatial layout and reduce the efficiency of building use. Furthermore, inconsistent building material parameters from different sources will cause deviations in structural calculations, directly affecting building safety and the stability of the entire project lifecycle. To systemically mitigate these risks during the material sourcing and construction phases, Huang′s resilience index framework enables quantitative measurement of supply chain recovery dynamics, offering policymakers a data-driven tool to monitor system stability and evaluate disruption response strategies[20].

6. Conclusions

In this article, the generation and optimization methods of architectural schemes driven by AI are deeply explored, the core mechanism is revealed, and the advantages and challenges are analyzed, which provides a comprehensive view for the intelligent development of architectural design industry. The research shows that the AI-driven building scheme generation relies on data conversion, algorithm model and parameter control. In the process of generation, the architectural design elements are transformed into data, the model is built by machine learning and other algorithms, the scheme is generated according to the input data, and the optimization results are adjusted by parameters. In terms of scheme optimization, it covers many dimensions such as function, spatial layout, aesthetics and environment, and achieves the goal of comprehensively improving design quality.

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AI has obvious advantages in building scheme generation and optimization. Efficiency greatly shortens the design cycle, innovatively breaks through the limitations of traditional thinking, accuracy ensures that the scheme meets the specification requirements, and integration takes into account various factors, bringing new vitality and possibility to architectural design. But it can't be ignored, and its application faces many challenges. Data problems, such as accuracy, completeness and consistency, are difficult to guarantee, which affects the performance of the model; The limitations of the model make it impossible to completely replace the creativity and judgment of human architects. In addition, the definition of ethical and legal responsibilities is vague, and there are concerns about data privacy protection; Industry acceptance needs to be improved, and the shortage of compound talents also limits its development.

In order to promote the wide application of AI in the field of architecture, a multi-pronged approach is needed. Relevant departments should strengthen data management and improve data quality; Continuously improve the model algorithm to enhance its function and adaptability; Clarify ethical and legal norms and protect the rights and interests of all parties; Strengthen personnel training and build a professional team that knows both architecture and AI. In this way, we can give full play to the advantages of AI and push the architectural design industry into a new era of intelligence.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The author(s) declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

References

[1] *Hasançebi, O. (2008). Adaptive evolution strategies in structural optimization: Enhancing their computational performance with applications to large-scale structures. Computers & structures, 86(1-2), 119-132.*

[2] *Cao, B., Fan, S., Zhao, J., Tian, S., Zheng, Z., Yan, Y., & Yang, P. (2021). Large-scale many-objective deployment optimization of edge servers. IEEE Transactions on Intelligent Transportation Systems, 22(6), 3841-3849.*

[3] *Wang, C. (2025). Research on the Precision Allocation of Cross-Border Marketing Resources of US Enterprises Driven by Digital Technology. Innovation in Science and Technology, 4(11), 7-13.*

[4] *Meunier, L., Rakotoarison, H., Wong, P. K., Roziere, B., Rapin, J., Teytaud, O., ... & Doerr, C. (2021). Black-box optimization revisited: Improving algorithm selection wizards through massive benchmarking. IEEE Transactions on Evolutionary Computation, 26(3), 490-500.*

[5] *Loshchilov, I. (2014, July). A computationally efficient limited memory CMA-ES for large scale optimization. In Proceedings of the 2014 Annual Conference on Genetic and Evolutionary Computation (pp. 397-404).*

[6] *Al-Terkawi, L. (2026). Survey on distributed parallel genetic algorithms for large-scale data analysis. Computing, 108(1), 6.*

[7] *Nishad, D. K., Verma, V. R., Rajput, P., Gupta, S., Dwivedi, A., & Shah, D. R. (2025). Adaptive AI-enhanced computation offloading with machine learning for QoE optimization and energy-efficient mobile edge systems. Scientific Reports, 15(1), 15263.*

[8] *Hao, Z. (2025). Task Affinity-Aware Scheduling for Multi-Core Edge Devices in Autonomous Vehicles. Engineering Frontiers, 1(2).*

[9] *Wang, P., Wang, H., Li, Q., Shen, D., & Liu, Y. (2024). Joint and individual component regression. Journal of Computational and Graphical Statistics, 33(3), 763-773.*

ISSN 3107-7657 (Print) ISSN 3107-7657 (Online)

[10] *Lin, A. (2026). Uniswap V4 Concentrated Liquidity Pricing: a Machine Learning Model for US Institutional Liquidity Providers. Journal of Intelligence and Engineering Technology, 1(1), 19-26.*

[11] *Wu, Y. (2026). Research on the Impact of LinkedIn Business Account Data-Driven Operations on Brand Exposure of AI Startups—A Case Study of AristAI. International Academic Journal of Social Science, 2, 27-37.*

[12] *Wang, H., Li, Q., & Liu, Y. (2024). Multi-response Regression for Block-missing Multi-modal Data without Imputation. Statistica Sinica, 34(2), 527.*

[13] *Han, C. (2025). Can Language Models Follow Multiple Turns of Entangled Instructions?. arXiv preprint arXiv:2503.13222.*

[14] *Wu, Y. (2026). Research on Dynamic Prediction Model of Brand Marketing Content ROI Based on Machine Learning. International Journal of Advance in Applied Science Research, 5(2), 31-38.*

[15] *Lin, A. (2026). Multi-Chain DAO Treasury Management: a Risk and Compliance Optimization Framework for the US Ecosystem. Journal of Intelligence and Engineering Technology, 1(1), 11-18.*

[16] *Hao, Z. (2026). Structure-Aware Deep Reinforcement Learning for Latency-Minimal Scheduling of Edge AI Inference on Heterogeneous Cores. Journal of Intelligence and Engineering Technology, 1(1), 50-59.*

[17] *Wang, C. (2025). Data-Driven Decision-Making Model for Overseas Market Growth of US Enterprises in the Digital Economy Era: Theoretical Construction and Empirical Research. Journal of World Economy, 4(6), 58-65.*

[18] *Wang, C. (2026). A Study on Data-Driven Budget Optimization for US Enterprises' Cross-Border Marketing. Frontiers in Management Science, 5(1), 41-46.*

[19] *Huang, S. (2025). Real-time adaptive dispatch algorithm for dynamic vehicle routing with time-varying demand. Academic Journal of Computing & Information Science, 8(9), 108-118.*

[20] *Huang, S. (2025). Measuring supply chain resilience with foundation time-series models. European Journal of Engineering and Technologies, 1(2), 49-56.*

[21] *Wang, J., Kudagama, B. J., Perera, U. S., Li, S., & Zhang, X. (2025). Framework for generating high-resolution Hong Kong local climate projections to support building energy simulations. Physics of Fluids, 37(3).*

[22] *Chang, Y., Wang, J., Li, S., & Chan, P. W. (2024). A comprehensive review on the modeling of tropical cyclone boundary layer wind field. Physics of Fluids, 36(3).*

[23] *Greenberg, I., Sielski, P., Linsenmaier, H., Gandham, R., Mannor, S., Fender, A., ... & Meirom, E. (2025). Accelerating vehicle routing via ai-initialized genetic algorithms. arXiv preprint arXiv:2504.06126.*