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Research on Agentic AI-Driven Automation and Collaboration in Full Architectural Design Workflow for Personalized Spatial Generation Based on User Behavior Perception

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Abstract: Architectural design has long relied on experience, and there is often a gap between the design intent and the actual implementation of the project. This study focuses on two main lines of autonomous intelligent AI intervention in architectural design, namely full-process collaboration and personalized space generation, and examines the possible paths for reconfiguring the design process. It reviews the application of generative adversarial networks, diffusion models, and large language models in architectural planning, scheme layout, and structural optimization, and combines the practical cases of domestic architectural design enterprises from 2024 to 2026 to discover that the AI integration system based on BIM as the data hub is bridging the information gap between concept generation and construction drawing output. Generative AI enables space design to gradually break free from the limitations of standardized modular constraints, and user intentions can directly participate in the iterative generation of spatial schemes through natural language interaction. The promotion of technology also faces problems such as inconsistent data standards, insufficient algorithm interpretability, and a shortage of interdisciplinary talent. It can be promoted collaboratively from three aspects: institutional norms, technological research and development, and talent cultivation, to provide a reference for the intelligent transformation of the architectural design industry.

Keywords: Autonomous intelligent AI, Full process of architectural design, Human-machine collaboration, Building Information Modeling, Personalized space generation.

1. Introduction

For a long time, architectural design has followed an approach dominated by experience and hand-drawn drawings. The transformation of creativity into engineering relies on the personal judgment of architects, and the coordination of multiple trades depends on the exchange of information through two-dimensional drawings. There is often a deviation between the design intention and the final construction effect, and construction rework has become a persistent problem in the industry. In March 2025, the Ministry of Housing and Urban-Rural Development of the People's Republic of China issued the "Technical Code for Intelligent Construction (Trial)" (Jian Ban Shi [2025] No. 14), integrating BIM, artificial intelligence and other technologies into the construction industry, and defining intelligent construction as "a construction method formed by the deep integration of new-generation information technologies and industrialized construction technologies, where human and machine collaborate". For the first time, the state-level document has combined BIM and AI. This policy tendency has opened space for the employment of technology. But the real application of AI to architectural design is still subject to the coordinated growth of three aspects, i.e., institutional systems, technology and talent cultivation.

The application of AI in architectural design is not only a replacement of one tool by another. Parametric design is an automated direction, but, it is limited by the specified algorithm framework. Generative AI based on large language models and diffusion models has demonstrated the ability to understand ambiguous semantics and produce creative visual outputs, and can build a channel between abstract concepts and specific technologies. The consensus in the industry is gradually becoming clear: The positioning of AI is not to replace architects' aesthetic judgment and safety control, but to compress uncertainties into the range that engineering specifications can accommodate in human-machine collaboration [1].

The actual advancement faces multiple obstacles. Professor Ma Zhiliang from Tsinghua University warned that when developing specialized large models for architecture, attention should be paid to assessment to prevent "hallucination" risks; research has also confirmed that generative AI in the field of architecture may have false content infiltrating safety information. In addition, the data formats of design, construction and supply have long been inconsistent, and information is scattered across different carriers, forming "data islands", and National People's Congress representative Feng Yuan proposed this during the 2025 National People's Congress and Chinese People's Political Consultative Conference sessions. Examining the internal logic and practical constraints of AI's involvement in architectural design, and exploring paths that are in line with technical laws and industry realities, has become an important topic that both academia and industry are jointly facing.

2. The Capability Boundaries of Autonomous Intelligent AI in Architectural Design

To understand how AI functions in architectural design, it is necessary to clarify what it can and cannot do in this field. Autonomous intelligent AI is different from traditional software that executes fixed instructions–it has an internal cognitive chain from perception to decision-making and then to generation. The bottom layer is supported by computer power and data, the middle layer is driven by algorithm models, and the top layer is applied to specific design conditions for its effect. This architecture describes the role of AI in the design of architecture–it does not replace the designers in making judgments but aids in some aspects [2].

Large multi-modal models trained on large scale text and picture data may have already associated natural language descriptions with design parameters in semantic understanding and information transformation. A designer who says "I want a tea room with Eastern Zen style" may have it parsed by artificial intelligence into exact specifications like materials, lighting, color and spatial proportions, turning rather abstract thoughts into measurable signs computers can handle. This is particularly crucial in the early phases of requirements communication–goals that would have previously required multiple confirmations may now be aligned in advance in a limited timeframe. Breaking past this step, the communication cost between designer and client will be substantially decreased and the recurrent drawing revision stages may be cut as well.

At the scheme generation level, diffusion models and generative adversarial networks provide different views from the human thinking style. AI doesn't invent schemes via "thinking" but by extracting the distribution of characteristics from a massive number of existing cases, then thorough probability sampling under particular limits, combining to produce new combinations [3]. This mechanism determines that it is more suitable for early exploration of schemes–providing designers with a reference pool beyond their personal experience, and then having humans judge which directions are worth deepening. However, the quality of the generated results ultimately depends on the coverage and quality of the training data. If the data is biased or missing, even if the generated schemes are diverse, they are difficult to truly implement. This is also the most intractable hurdle when this type of technology moves from the laboratory to actual engineering. The data deficiency directly affects the usability of AI-generated results in real projects, and this bottleneck is difficult to completely solve in the short term. The data deficiency is only one end of the problem; the more difficult issue is that these data are constantly attenuated and distorted during the transmission process, which is a consequence of the fragmentation of traditional processes.

3. From Fragmentation to Continuity: The Inner Logic of Full-Process Automated Collaboration

The pain point of the traditional architectural design process lies in the fragmented state of information transmission. Different specialties and each stage rely on intermittent delivery and review to connect with each other. Each time the information is sent there is a chance of attenuation and distortion.

The "Technical Code for Intelligent Construction (Trial)" requires breaking the information isolation to enable data integration during the complete life cycle of building projects. The core innovation of the autonomous intelligent AI-driven full-process collaboration is the development of a continuous and feedbackable data flow. This rationale is physically embodied by BIM [4]. In 2025, the Ministry of Housing and Urban-Rural Development issued the "Technical Code", making use of BIM, AI and other data models as carriers to advance digital delivery of design results, promote efficient data sharing among all disciplines and all participants, and explore AI-assisted design, to move toward data-driven systematic integrated design.

AI is not simply to make one process more efficient but it is more like a glue that combines multiple specializations. In the conceptual design stage, existing research has transformed hand-drawn floor plans into structured BIM models through a multi-agent framework. After the sketches are processed by AI, visual digital information is generated, making the transmission of design intentions transparent between the team and the owner, and the errors caused by misinterpretation are reduced accordingly.

In the scheme refinement stage, the collaborative effect of AI is more reflected in the pre-judgment and automatic resolution of cross-disciplinary conflicts. Systems such as structure, HVAC, and water supply and drainage need to be arranged orderly within a limited space. The overlapping review of two-dimensional drawings is unable to detect all hard clashes, and thus construction changes occur frequently. After AI intervention in the BIM environment, the system can automatically execute collision detection based on the preset rule library. Existing research has proposed a multi-agent AI BIM coordinator based on a large language model, which can complete spatial reasoning, component creation, and collision detection through natural language interaction. Existing studies have shown that the combination of BIM technology and machine learning can effectively enhance the automation level of collision detection. A study took a certain tertiary hospital project in Shihezi as an example. After applying BIM technology for MEP coordination, it achieved a 75.6% reduction in the pipeline collision rate [5]. Once the "inspection–feedback–correction" closed-loop is automated, designers can free themselves from the cumbersome review process and devote more energy to spatial conception. The potential of full-process automated collaboration in reducing non-value-added costs in the industry has thus been preliminarily verified.

4. Paradigm Transformation: Generative AI-Driven Personalized Spatial Generation Logic

If the entire process collaboration addresses the issue of efficiency, then the personalized spatial generation brought about by generative AI touches upon the very essence of design value. Over the past few decades, industrialization and standardization have dominated the construction industry, and the uniform supply of space was an inevitable result of the pursuit of efficiency in that era. The application of AI technology is changing this situation, allowing spatial design to gradually break away from the "one-size-fits-all" model.

The generation of personalized space is a process from demand description to data matching and then to scheme output. When a user says, "I want a sunny reading corner suitable for solitude", the information contained in this statement can be broken down into specific parameters such as window orientation, room depth, surface material sound absorption coefficient, etc. Consumers may input their preferences for kind and style of house, and EasyHome Design's AI design tool can immediately generate many schemes in 3D for them to pick from. For the purpose of matching, AI will draw upon local datasets like libraries of dwelling types, libraries of furniture components, local sunlight and meteorological data, etc. [6]. The "Kujiale" platform has accumulated more than 360 million product material models, covering the house type information of nearly 90% of the new commercial residential buildings in the country in the past five years. According to these constraints, the generative model suggests many layout options.

The design power distribution has been adjusted in this technique. Instead of being passive recipients of spatial arrangements, inhabitants may come to recognize the development of spatial forms trough daily language. Xinhua News Agency reported that the "Xinzhujia" platform allows users to upload their own house plans and write down their expectations for the living space, and the system can generate a complete design rendering in just a few seconds. Academic research also provides data support–the practice of generative AI-assisted interior design shows that the entire process cycle can be compressed from four weeks to two weeks, the number of scheme iterations can increase from three to eight, and user satisfaction can be raised from 80% to 95% [7]. It is worth noting that personalized space design still has clear boundaries; structural safety, fire evacuation, and accessibility design, etc., these hard requirements must be controlled by certified architects. What AI can do is to provide more possibilities in terms of aesthetics and functionality while meeting safety redundancy. In the past, designers did the design for users; now designers collaborate with AI to assist users in completing their own spatial expression.

5. Realistic Barriers: Systemic Factors Constraining the Deep Integration of AI

However, the aforementioned capabilities have not been fully realized in actual projects. The implementation of autonomous intelligent AI in the entire process of collaboration and personalized generation still faces many systemic constraints. According to a research, the present use of AI in real estate and construction is largely at the "praised but not commercially successful" stage [8].

The first challenge to be overcome is data silos. To train AI models, construction data has to be high quality, accurately tagged and regularly prepared. However, in practice, the data standards of design institutes, construction units and material suppliers are not united, and drawings, models and texts are scattered in multiple systems, and the circulation is problematic.Representative Feng Yuan pointed out that architectural design involves multiple specialties such as architecture, structure, and mechanical and electrical engineering, and the data sources are numerous and the formats are diverse, which significantly affects the effectiveness of model training. Most current engineering standards are written in natural language, making it difficult for machines to directly read them. AI has difficulty understanding compliance requirements and is prone to errors when generating automatic reviews and schemes, and the reliability of automatic review and scheme generation also decreases.

Algorithm opacity essentially means insufficient explainability. The contradiction between algorithm opacity and engineering safety is another obstacle for the implementation of AI. The decision-making process of generative AI is like a "black box", making it difficult for people to understand the basis for its results. Most AI modeling methods have problems such as opaque modeling processes, output results that cannot be directly edited, and lack of semantic information. while AI proposes a structural plan, engineers cannot follow the rationale like they do while reading conventional calculation manuals. The duty allocation difficulty is caused by the "unclear" feature [9]. Feng Yuan suggested the need to explain the responsibility and authority of algorithm developers, design units and practical engineers. She also claimed there are still no proper laws and restrictions.

And not to mention the talent disparity. "There is a serious lack of interdisciplinary talents who are proficient in both civil engineering and AI", stated Feng Yuan. This is not being picked up by the university system of training. Industry studies say the sector has to actively react rather than passively respond to problems including unequal standards, complex system integration and a scarcity of staff. At the same time, some practitioners are skeptical or even resistant to AI. An expert stated that the biggest challenge at present is not technology, but the transformation of people's concepts–some designers are accustomed to traditional methods and are reluctant to make changes voluntarily.

6. Path Analysis: Towards a Future of Deep Human-Machine Collaboration

The shift in mindset is just the beginning. To truly implement autonomous intelligent AI in the field of architectural design, a practical and systematic approach is needed. Among them, data standardization is the first problem to be addressed.

National People's Congress representative Feng Yuan proposed that the industry should accelerate the digital transformation of engineering standards, enhance the machine-readable nature of national mandatory provisions, and ensure the smooth flow of data among different entities. Internationally, ISO 23387:2025 has systematically stipulated the data templates for building information models, providing a reference for unified data structures and achieving machine interpretability. Industry authorities can refer to this framework and work with leading enterprises to promote the formation of a common building data exchange format, gradually breaking down information barriers at each stage. If the data infrastructure is accessible and standard enough, artificial intelligence can better understand the particular demands of different circumstances based on universal design [10].

The development of specialized intelligent agents is a crucial step in the usage of AI. General large models have difficulty in tackling hard engineering problems. "The generic huge models are still far from being applied in the domain of architecture", said Ma Zhiliang, a professor at Tsinghua University. Specialized large model creation method includes demand analysis, data processing and model design. Some previous articles have attempted to pair PINNs with BIM for the performance prediction and optimization of structures such as bridges. The advantage of specialized models is that it incorporates the mechanical principles and the regulatory constraints in the generation process, therefore, accomplishing a trade-off between the AI creativity and the physical determinism [11]. In the work process, the "Tiangong AI Review Platform" has started to investigate the mode of multi-agent preliminary review + manual re-review, and the machine review time for common schemes has been controlled within 10 minutes. The industry has gradually reached a consensus: AI output can only be used as a reference, and the final design documents still require the signature and seal of registered architects or engineers.

The cultivation of talents is needed to provide long-term support for the above changes. Feng Yuan suggested that architectural universities should add an "architecture + AI" interdisciplinary program to reserve interdisciplinary talent from the source. For in-service engineers, enterprises should establish a systematic AI training mechanism. Feng Yuan pointed out that current industry training mostly stays at the software operation level, which restricts the efficiency of technology transformation. Only by fully integrating creative decision-making with AI computing power can the intelligent transformation of architectural design truly form an internal driving force.

7. Conclusion

Do the aforementioned paths work in practice? The analysis of this study indicates that AI-driven full-process collaboration and personalized space generation are driving architectural design from segmented tasks towards integrated operations. The integration of BIM and AI effectively bridges the data gap between conceptual design and construction drawing output, while generative AI enables spatial design to break away from the single supply mode of standardized modular constraints. Both of these approaches have shown some initial effectiveness in improving design efficiency and enhancing user engagement in real life cases.

But there are a number of constraints to technological implementation. The challenges restricting the popularization of artificial intelligence (AI) technologies are uneven data standards, poor interpretability of algorithms, uncertainty in safety responsibility, and lack of interdisciplinary skills. Currently, the practices are mostly restricted to front-end functionality such as scheme development and conflict detection. Open questions remain in back-end issues such as automatic generation of construction drawings and fully professional collaborative design. Industry studies indicate that AI in architecture is primarily "praised but not commercially successful", suggesting a gap still exists between technical promise and practical usefulness.

Institutional efforts should be accelerated to transform engineering standards into machine readable representations and to define legal limitations of design responsibility. Ideally, we should be designing bespoke models that address the specific needs of the building sector–marrying the generative talents of AI with technical certainty. At the level of talents, the barriers between civil engineering and artificial intelligence should be broken and interdisciplinary abilities should be cultivated.

AI will radically change the practice of architecture, but it will not replace architects. Artificial intelligence can analyze data, generate schemes and conduct initial compliance screening, but the esthetic judgment, value evaluation and inventive leadership are still the domain of designers. There is an initial outline for the human-machine collaboration framework and the boundaries are constantly moving with the advancement of technology. Institutional building, technology breakthroughs and educational innovation follow up in a coordinated manner, which ensures the smooth progress of the intelligent transformation of architectural design.

References

[1] Li, C., Zhang, T., Du, X., Zhang, Y., & Xie, H. (2025). Generative AI models for different steps in architectural design: A literature review. Frontiers of Architectural Research, 14(3), 759–783.

[2] Hegazy, M., & Saleh, A. (2023). Evolution of AI role in architectural design: between parametric exploration and machine hallucination. MSA Engineering Journal, 2(2), 262–288.

[3] Zhuang, X., Zhu, P., Yang, A., & Caldas, L. (2025). Machine learning for generative architectural design: Advancements, opportunities, and challenges. Automation in Construction, 174, 106129.

[4] Shehzad, H. M. F., Ibrahim, R. B., Yusof, A. F., Khaidzir, K. A. M., Iqbal, M., & Razzaq, S. (2021). The role of interoperability dimensions in building information modelling. Computers in Industry, 129, 103444.

[5] Wang, C. (2026). Application of BIM Technology in the Pipeline Comprehensive Construction Process of Hospitals. Brick-tile, (1), 93–95. [In Chinese]

[6] Lee, J. K., Jeong, H., Kim, Y., & Cha, S. H. (2024). Creating spatial visualizations using fine-tuned interior design style models informed by user preferences. Advanced Engineering Informatics, 62, 102686.

[7] Wang, S. Y., Su, W. C., Chen, S., Tsai, C. Y., Misztal, M., Cheng, K. M., … Chen, M. Y. (2024, May). Roomdreaming: Generative-AI approach to facilitating iterative, preliminary interior design exploration. In Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems (pp. 1–20).

[8] Memon, S. A., Shehata, W., Rowlinson, S., & Sunindijo, R. Y. (2025). Generative artificial intelligence in architecture, engineering, construction, and operations: A systematic review. Buildings, 15(13), 2270.

[9] Zhan, J., Fang, W., Love, P. E., & Luo, H. (2024). Explainable artificial intelligence: Counterfactual explanations for risk-based decision-making in construction. IEEE Transactions on Engineering Management, 71, 10667–10685.

[10] Lee, Y. C., Eastman, C. M., & Solihin, W. (2021). Rules and validation processes for interoperable BIM data exchange. Journal of Computational Design and Engineering, 8(1), 97–114.

[11] Chen, J., & Bao, Y. (2025). Multi-agent large language model framework for code-compliant automated design of reinforced concrete structures. Automation in Construction, 177, 106331.