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

Research Article

Interactive Mode of Immersive Architectural Design Combining Virtual Reality with Artificial Intelligence

Lin Yang[1,*]
Beijing Institute of Architectural Design Co., Ltd. 100045 Beijing, China
* Corresponding author: Lin Yang
leo.crystalcg@gmail.com

Abstract: With the rapid development of science and technology, the traditional interactive mode of architectural design has gradually revealed its limitations and can no longer fully meet people's growing diversified needs. In view of this, this article focuses on the interactive mode of immersive architectural design, which is the fusion of VR and AI, and makes an in-depth discussion on it. The basis of the integration of the two is that VR and AI complement each other, which lays a solid foundation for the innovation of architectural design interaction mode. In this article, the key elements of the interactive mode of immersive architectural design are deeply explored by combining theoretical analysis with factor construction. Based on these key elements, this article further constructs the interactive mode of immersive architectural design. Specifically, it covers the remodeling of interaction process, innovative design of interface and the creation of intelligent adaptive environment. This interactive mode of immersive architectural design, which combines VR and AI, has achieved remarkable results. This model has effectively pushed the architectural design towards the direction of intelligence and experience, brought brand-new development opportunities and profound changes to the field of architectural design, and is expected to lead the architectural design industry to a brand-new development stage.

Keywords: *Virtual reality; Artificial intelligence; Immersive architectural design; Interactive mode; Intelligent feedback;*

1. Introduction

The field of architectural design has always followed the pace of scientific and technological development and sought innovative breakthroughs. In recent years, VR and AI technologies have risen rapidly, and their integration has brought a new opportunity for the interactive mode of immersive architectural design. With the improvement of people's demand for architectural space experience, the traditional interactive mode of architectural design has been difficult to meet the demand. In the past mode, the communication between designers and users was often limited by two-dimensional drawings and models, which could not let users really feel the real scale of architectural space, light changes and atmosphere creation. With its immersion, interactivity and conception, VR technology can create realistic virtual building scenes for users, making them feel as if they were there. With the development of AI technology, computers can simulate human intelligence for data analysis, pattern recognition and decision support. Especially in complex system modeling and data stream analysis, AI-enhanced algorithms provide robust frameworks for real-time optimization [10] [21]. Integrating AI into VR can make the virtual building scene more intelligent and adaptive.

Under this background, it is of great significance to study the interactive mode of immersive architectural design integrating VR and AI. From the theoretical dimension, this study greatly enriches the theoretical system of architectural design, just as it injects a fresh vitality into the traditional design concept, which strongly promotes architectural design to make great strides in the direction of intelligence and experience. From a practical point of view, the integration of VR and AI is of great benefit to improving the efficiency and quality of architectural design, which can effectively reduce mistakes in the design process and avoid unreasonable waste of resources. With the help of this advanced technology, designers can quickly verify their own design ideas, and users can participate in the design process more deeply, so that their personalized needs can be realized.

The research results in this field contain potential application value in many fields. As far as the field of cultural heritage protection is concerned, we can make full use of the technology of VR and AI to vividly reproduce the features of historical

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

buildings and create an immersive visit experience for tourists. In the field of education, it can create a virtual architectural learning environment for students and effectively enhance the learning effect. Therefore, an in-depth study on the interactive mode of immersive architectural design integrating VR and AI will not only become a strong driving force for the development of architectural design industry, but also bring new development opportunities for many related fields. Notably, the rapid maturation of such independent innovation is significantly accelerated by government tax preferences and strategic incentive policies, which provide the necessary financial resilience for enterprises to pursue high-tech integration [8].

2. Fusion of VR and AI

VR technology is essentially a computer simulation technology. By creating a three-dimensional virtual environment, users can feel immersive. Based on the theories of computer graphics, sensor technology and human-computer interaction technology, it uses head-mounted displays, handles and other equipment to connect users' visual, auditory, tactile and other senses with the virtual environment. In the virtual building scene, users can change their perspective and see different parts of the building by moving their heads, and their immersion comes from the synergistic stimulation of multiple senses such as vision and hearing.
AI technology aims at simulating, extending and expanding human intelligence. Machine learning, as the core of AI, trains the model with data to make it have the ability of prediction and decision. Recent developments in vision-language pre-training and generative models further bridge the gap between user intent and visual synthesis in virtual environments [6][13].Natural language processing enables computers to understand and process human language and realize more natural communication between human and computer. In architectural design, AI can analyze a large number of architectural data, such as building energy consumption and space efficiency, and provide optimization suggestions for design.
When VR and AI are integrated, a new theoretical basis is formed. On the one hand, AI enhances the intelligence of VR scenes. Using machine learning algorithm, the virtual building scene can be adjusted in real time according to the user's behavior, This dynamic adjustment often relies on structure-aware reinforcement learning and adaptive evolution strategies to handle large-scale environmental variables efficiently [1][24]. Such as changing the spatial layout, lighting intensity, etc., to meet the different needs of users. On the other hand, VR provides a more intuitive application scenario for AI. With the immersion and interactivity of VR, AI system can obtain user feedback more accurately and optimize its own decision-making. This integration has laid a solid theoretical foundation for the interactive mode of immersive architectural design, and promoted its transformation from traditional static interaction to dynamic and intelligent interaction.

3. Key elements of interactive mode of immersive architectural design

The interactive mode of immersive architectural design aims to create an immersive and deeply involved architectural experience for users. This model covers a number of key elements, which interact with each other to create a unique interactive experience. User's perception of architectural space is the basis of immersive experience. In the traditional architectural design exhibition, users often understand the space through two-dimensional drawings or solid models, and it is difficult to form an intuitive and comprehensive feeling. In the immersive interactive mode, with the help of VR technology, users can feel the scale, proportion and layout of architectural space in an immersive way. This kind of spatial perception not only includes the cognition of physical space, but also involves the feeling of spatial atmosphere. Advanced graphical models and explainable latent factor models help in quantifying these subjective perceptions into actionable design data [4] [14].
Successful immersive architectural design should be able to arouse the emotional resonance of users. The color, shape, sound and other elements of architectural space can touch users' emotions. Warm colors and soft lighting are easy to create a warm

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

atmosphere and trigger pleasant emotions; Unique architectural form and rhythmic spatial sequence can stimulate users' curiosity and desire to explore. Figure 1 can help us better understand the influence of different elements on emotional resonance. According to different architectural design elements, this figure analyzes their common emotional triggering directions. As can be seen from the picture, in terms of color, red often evokes the feeling of excitement and vitality, while blue often evokes the feeling of calm and tranquility; In terms of sound elements, soothing background music combined with natural sound effects, such as running water and birdsong, is more likely to create a relaxed emotional atmosphere. By using these elements reasonably, designers can enhance the emotional connection between users and architectural space.

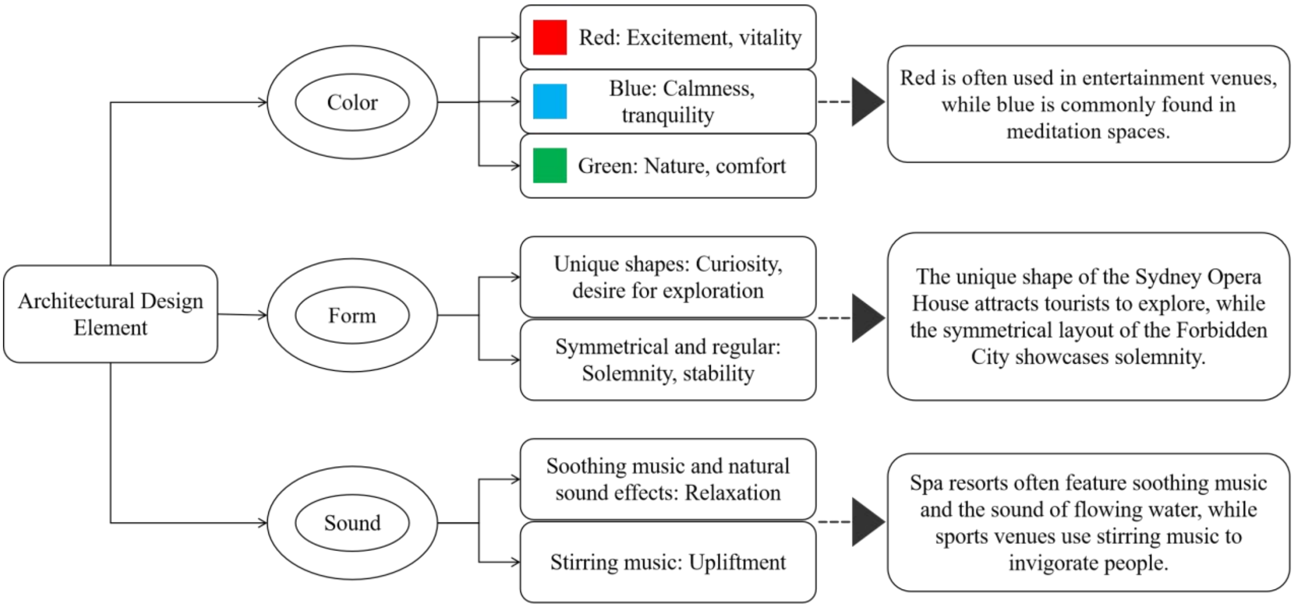

Figure 1. The Relationship Between Architectural Design Elements and Emotional Resonance

When users make specific behaviors in virtual building space, such as stopping, touching or giving instructions, the system can make corresponding feedback according to preset rules and machine learning algorithms. For example, when users stare at a wall for a long time in the virtual living room, the system can automatically pop up relevant information about wall decoration, including materials and design inspiration. Or the user puts forward suggestions for adjusting the spatial layout, and the AI system can quickly generate the modified scheme and show its effect. Such rapid iteration is supported by high-performance black-box optimization and memory-efficient algorithms tailored for large-scale systems [5] [7].This kind of intelligent feedback makes users feel the attention and response of the building to their own behavior, and enhances the interest and participation of interaction. The interactive mode should ensure the user's convenient operation and reduce the learning cost. Users should be able to interact with virtual building space easily by using equipment, whether it is simple gesture operation, voice command or handle control, it should be designed to be intuitive and easy to understand. Convenient interaction allows users to focus more on experiencing architectural space without being distracted by complex operations, ensuring the fluency of immersive experience. These key elements together constitute the core of the interactive mode of immersive architectural design, which lays the foundation for creating a high-quality interactive experience of architecture.

4. Construction of interactive mode of immersive architectural design

The traditional architectural design process is mostly promoted in a linear way, from conceptual design to scheme deepening to construction drawing drawing, and each stage is relatively independent. In the new interactive mode, the design process is more cyclical and feedback. In the early stage, the designer created a preliminary virtual building model with the help of VR technology, and users can immediately enter the virtual scene to experience it, and give feedback in real time through voice, gestures and other

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

means. Table 1 lists in detail the design stage, user participation mode, application of VR and AI, and possible types of feedback. As can be seen from the table, in the conceptual design stage, users participate in the preliminary virtual model by immersive experience, VR provides intuitive scenes, AI assists in generating various conceptual schemes for selection, and user feedback is mostly preliminary opinions on spatial layout and functional zoning. At the stage of detail design, users experience the high-precision virtual scene and make suggestions for detail optimization, and AI simulates and analyzes the details according to the feedback, such as the optimization of material texture and acoustic effect. Accurate simulation of environmental variables, such as wind profiles and climate-induced stresses, ensures the technical viability of these virtual models [20][26].

Table 1. Interactive Process Table for Architectural Design under the Integration of VR and AI

Design Stage	User Participation Method	VR Application	AI Application	Feedback Type
Conceptual Design	Immersive experience of the preliminary virtual model	Provide intuitive spatial scenes	Assist in generating multiple conceptual plans	Preliminary opinions on spatial layout and functional zoning
Scheme Development	In-depth experience of the optimized virtual scheme	Present more detailed scenes and show different perspectives	Analyze the feasibility of the scheme and evaluate costs, energy consumption, etc.	Suggestions for improving the overall style and circulation organization
Detail Design	High-precision virtual scene experience	Simulate real materials and lighting effects	Conduct detailed simulation analyses, such as material texture and acoustic effects	Optimization suggestions for detail handling and decorative elements

As a bridge between users and virtual building environment, interactive interface should fully consider the user experience. On the one hand, the interface should have a concise and intuitive layout, and all kinds of operation buttons and prompt information are easy to identify. For example, when gesture interaction is adopted, simple and easy-to-understand gesture operation guide icons will appear in the air at the right time. On the other hand, the interactive interface should realize multi-modal interaction integration, that is, integrate various interaction methods such as voice, gesture and eye contact. Users can quickly switch between different floors or rooms through voice commands, grab and move virtual objects through gestures, and use eye focus to trigger the display of specific information.

Using AI algorithm, the virtual building environment can be adaptively adjusted according to users' behavior habits, emotional states and real-time needs. When the system captures that the user stays in a certain area for a long time and shows a relaxed posture through the sensor, it can automatically adjust the lighting brightness and music rhythm in this area to create a more comfortable atmosphere. If it is detected that users show strong interest in a certain spatial form, AI can generate other spatial schemes with similar styles for users' reference. This adaptive learning process mimics complex resource allocation and multi-agent coordination found in large-scale system optimizations [2][15].This intelligent adaptive feature makes the building no longer a static space, but an organic whole that can interact with users dynamically, which greatly enhances the immersive experience and participation of users, thus building a more perfect and unique interactive mode of immersive architectural design.

5. Conclusion

This article deeply explores the interactive mode of immersive architectural design with the integration of VR and AI, aiming at breaking the shackles of the traditional interactive mode of architectural design and effectively improving users' participation and experience in the process of architectural design. Firstly, this article combs the relevant theoretical basis of VR and AI, and then clearly defines the feasibility of their integration in the field of architectural design. With its unique immersion, interactivity and conception, VR technology can create a very realistic virtual building scene for users. The data analysis ability and decision support ability of AI endow the virtual scene with intelligent characteristics and adaptability. Space perception can make users

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

feel the scale and atmosphere of architectural space; Emotional resonance touches users' emotions through various elements such as color and shape; Intelligent feedback can make buildings respond to users' behaviors; The convenience of interaction ensures that the user's operation is simple and smooth. These elements interact with each other and jointly build the cornerstone of high-quality interactive experience.

Based on the above research results, the article constructs a brand-new interaction mode. In the aspect of interaction process, the traditional linear mode is abandoned, and a circular feedback mechanism is constructed, which urges designers and users to cooperate closely with VR and AI technologies. To sustain this collaborative synergy, applying an incentive mechanism based on unfairness aversion preference is essential, as it ensures balanced motivation and psychological commitment among all stakeholders in the design loop [16]. After innovative design, the interactive interface achieves the integration of multi-modal interaction, showing the characteristics of simplicity and intuition. The intelligent adaptive environment can be adjusted in real time according to the user's state, and the interaction between users and buildings can be strengthened.

To sum up, the interactive mode of immersive architectural design combined with VR and AI has obvious advantages. This model not only enriches the theoretical system of architectural design, but also brings innovative changes to architectural design practice, effectively improves design efficiency and quality, and fully meets the individual needs of users. Although the current model may face challenges in terms of technical cost, standards and specifications in the practical application process, with the continuous development of technology and the continuous improvement of the industry, the model is expected to be widely used in architectural design and related fields, pushing the whole industry to a higher level. Ultimately, the successful scaling of this immersive mode must navigate the broader landscape of business cycles and financial shocks, recognizing that "animal spirits" and economic fluctuations remain pivotal factors in the widespread adoption of industrial innovations [12].Furthermore, the integration of digital economy models and data-driven decision-making frameworks can potentially optimize the commercial allocation of these advanced design resources [3][18] [25].

Data Availability Statement

Data will be made available on request.

Funding

This work was supported without any funding.

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] *Tao, Y., Jia, Y., Wang, N., & Wang, H. (2019, July). The fact: Taming latent factor models for explainability with factorization trees. In Proceedings of the 42nd international ACM SIGIR conference on research and development in information retrieval (pp. 295-304).*

[5] *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.*

[6] *Tao, Y., Wang, Z., Zhang, H., Wang, L., & Gu, J. (2025, July). Nevlp: Noise-robust framework for efficient vision-language pre-training. In International Conference on Intelligent Computing (pp. 74-85). Singapore: Springer Nature Singapore.*

[7] *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).*

[8] *Pang, F. (2025). Research On The Incentive Effect Of Government Tax Preference On Independent Innovation Of Emerging Enterprises. European Journal of Business, Economics & Management, 27-34.*

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

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

[10] *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.*

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

[12] *Pang, F. (2025). Animal Spirit, Financial Shock and Business Cycle. European Journal of Business, Economics & Management, 1(2), 15-24.*

[13] *Li, K., Chen, X., Song, T., Zhang, H., Zhang, W., & Shan, Q. (2025, January). Gptdrawer: Enhancing visual synthesis through chatgpt. In 2025 5th International Conference on Neural Networks, Information and Communication Engineering (NNICE) (pp. 368-372). IEEE.*

[14] *Wang, H., Sun, W., & Liu, Y. (2022). Prioritizing autism risk genes using personalized graphical models estimated from single-cell rna-seq data. Journal of the American Statistical Association, 117(537), 38-51.*

[15] *Luo, M., Du, B., Zhang, W., Song, T., Li, K., Zhu, H., ... & Wen, H. (2023). Fleet rebalancing for expanding shared e-Mobility systems: A multi-agent deep reinforcement learning approach. IEEE Transactions on Intelligent Transportation Systems, 24(4), 3868-3881.*

[16] *Pang, F. (2020, November). Research on Incentive Mechanism of Teamwork Based on Unfairness Aversion Preference Model. In 2020 2nd International Conference on Economic Management and Model Engineering (ICEMME) (pp. 944-948).*

[17] *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.*

[18] *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.*

[19] *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.*

[20] *Wang, J., Tim, K. T., Li, S., Chan, T. K., & Fung, J. C. (2023). A systematic comparison of the wind profile codifications in the Western Pacific Region. Wind & structures, 37(2), 105-115.*

[21] *Wang, H., Li, Q., & Liu, Y. (2023). Adaptive supervised learning on data streams in reproducing kernel Hilbert spaces with data sparsity constraint. Stat, 12(1), e514.*

[22] *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.*

[23] *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.*

[24] *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.*

[25] *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.*

[26] *Wang, J., Chang, Y., Cao, S., Dong, Y., Li, S., Jia, L., & Li, W. (2025). Explanatory framework of typhoon extreme wind speed predictions integrating the effects of climate changes. Climate Dynamics, 63(3), 142.*

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

[28] *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.*