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Practice and Challenge of Generative Artificial Intelligence in Architectural Creative Design

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Abstract: Under the background of the rapid development of science and technology, the relationship between generative AI (artificial intelligence) and the field of architectural creative design has become an important topic that has attracted much attention. With the continuous progress of science and technology, generative AI is gradually infiltrating into architectural design. In-depth study on the application of generative AI in this field is of great significance to promote the development of architectural creative design. In this paper, the theoretical basis of generative AI in the field of architectural creative design is deeply analyzed, and the internal logic of its combination with architectural design is explained in detail. At the same time, this paper focuses on the practical mode of generative AI in building concept generation, spatial layout design and shape shaping. Although generative AI has brought new opportunities for architectural creative design, it also faces many challenges in the process of practical application. Based on this, this paper puts forward a series of targeted strategies.

Keywords: Generative Artificial Intelligence, Architectural Creative Design, Practice Mode, Challenge, Coping Strategy.

Disciplines: Intelligent Systems. **Subjects:** Other.

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1 INTRODUCTION

The field of architectural creative design is always in the process of continuous exploration and innovation. With the rapid development of science and technology, generative AI, as a new technology, is gradually infiltrating and reshaping this traditional field. For a long time, architectural creative design relies on the experience, inspiration and creativity of designers. However, the emergence of generative AI has brought new possibilities and development opportunities to this field.

Generative AI relies on deep learning algorithm and has the ability to generate novel content independently. This characteristic coincides with the innovative idea pursued by architectural creative design, which makes it show potential application value in many links of architectural design process. From the initiation of concept to the shaping of form, from the planning of space to the carving of details, generative AI can provide a unique perspective and auxiliary means. This transformative integration aligns with the broader adoption of deep learning models and generative design across creative industries, significantly reshaping sustainable building performance, accelerating design workflows, and redefining traditional architectural practices.[1][2][5][11][20][22]

However, it cannot be ignored that the introduction of new technologies is bound to be accompanied by many challenges. The application of generative AI in architectural creative design not only impacts the traditional design process and methods, but also causes many problems in the aspects of design concept communication, professional knowledge application and design achievement evaluation. In-depth study of these challenges and exploration of effective coping strategies have become an important issue to be solved urgently in the field of architecture.

Exploring the practice and challenges of generative AI in architectural creative design is helpful for architects to better understand and apply this technology, realize design innovation and improve efficiency, and is also of great significance to promote the overall development of architectural design industry. Through theoretical research and practical analysis, the role and orientation of generative AI in architectural creative design are clarified, which provides scientific guidance for its rational application and healthy development and helps architectural creative design to move towards a higher level in the new era.

2 APPLICATION OF GENERATIVE AI IN THE FIELD OF ARCHITECTURAL CREATIVE DESIGN

Generative AI is based on machine learning algorithm,

especially deep learning technology, and aims to generate brand-new and creative content through learning and analyzing a large amount of data. In the field of architectural creative design, its core algorithm principle has become the key element to promote design innovation. These algorithms simulate the process of human cognition and creation, extract patterns and laws from massive building case data, and then provide inspiration and direction for new design. To further enhance these core algorithms, future architectural generative frameworks could incorporate complex logical reasoning from large language models solving situational puzzles and multi-turn entangled instructions.[9][14] Additionally, integrating advanced multi-response regression techniques for handling missing multimodal data, alongside modeling complex physical dynamics like wake oscillators, can fundamentally improve the precision of data-driven design generation.[17][18]

As a subject integrating art and science, the essence of architectural creative design lies in meeting the dual needs of human beings for function and aesthetics through the shaping of space and form. It emphasizes the application of innovative thinking and requires designers to break through the traditional constraints and create unique and meaningful architectural works. This essential feature lays the foundation for the application of generative AI, and the two have internal consistency in pursuing innovation and breakthrough.

There is a solid theoretical basis for the combination of generative AI and architectural creative design. The architectural design process itself has certain logic and regularity, which can be expressed and analyzed in a data-based way, which is consistent with the data processing ability of generative AI. Generative AI can quickly process and integrate a large amount of information, provide diverse design ideas, and make up for the limitations of human designers in information processing and creative expansion. This complementary relationship promotes the integration of the two in theory and opens up a new path for the development of architectural creative design.

3 PRACTICAL MODE OF GENERATIVE AI IN ARCHITECTURAL CREATIVE DESIGN

Generative AI is playing an important role in the field of architectural creative design with a variety of practical modes, profoundly changing the traditional design process and methods. In the process of building concept generation, generative AI plays the role of creative inspiration. It provides designers with novel design concepts and breakthrough points through the study of multi-source data such as massive architectural cases, works of art and natural forms [10]. For example, the algorithm based on GAN can generate unique architectural images and guide designers to break through conventional thinking. Designers can input keywords of specific themes, styles or functions, and the generative AI will generate a series of conceptual sketches accordingly, which will inspire designers and broaden design ideas.

In the aspect of architectural space layout design, generative AI shows strong optimization ability. It can comprehensively consider the functional requirements of buildings, user behavior patterns, spatial streamline and environmental factors, and quickly generate a variety of reasonable spatial layout schemes. Figure 1 shows in detail the comparison of three spatial layout schemes (Scheme A, Scheme B and Scheme C) generated under different parameter settings in terms of space utilization ratio, rationality of functional zoning, convenience of traffic streamline and other indicators. From the data in the table, it can be seen that scheme B has achieved 75% space utilization rate, clear functional division and the most concise and smooth traffic flow line, which has obvious advantages over other schemes. Through such comparative analysis, designers can intuitively evaluate the advantages and disadvantages of different schemes, choose the most suitable spatial layout, or further optimize and adjust on the basis of generating schemes. At a macro urban scale, such optimized architectural spatial layouts must increasingly interface with smart city topologies. This includes accommodating dynamic task prioritization for edge AI, autonomous vehicle routing constraints, and the rebalancing of EV sharing systems within critical urban infrastructure.[3][8][10][19]

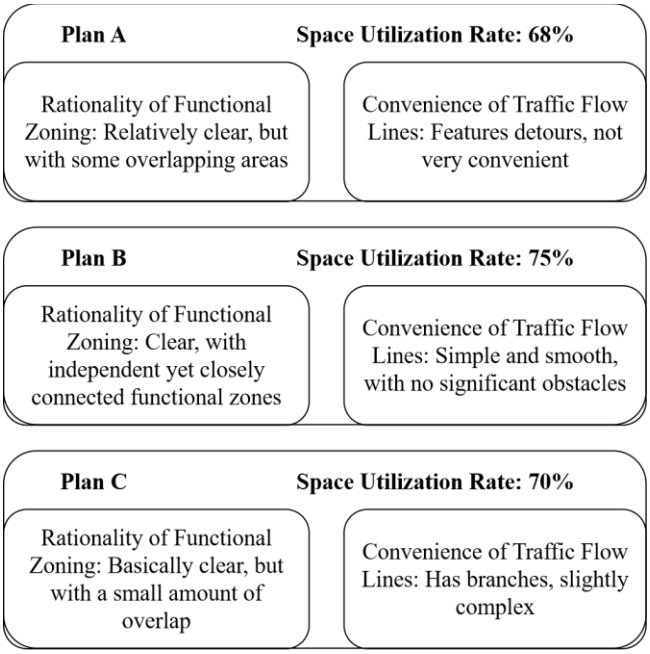

FIGURE 1. COMPARATIVE ANALYSIS OF SPATIAL LAYOUT PLANS GENERATED BY GENERATIVE AI

In the process of architectural form shaping, generative AI gives designers more freedom and innovation possibilities. With the help of parametric design and machine learning technology, it can generate complex and changeable architectural forms according to preset rules and conditions.

Designers can precisely control the generation process of architectural form by adjusting algorithm parameters, such as geometric shape, proportional relationship and topological structure. Generative AI can also simulate the laws of natural growth, mechanical principles, etc., create architectural forms that conform to structural logic and have unique aesthetic value, break the limitations of traditional architectural modeling, and make architecture more expressive and recognizable.

4 CHALLENGES FACED BY GENERATIVE AI IN ARCHITECTURAL CREATIVE DESIGN

Generative AI generates design results based on data and algorithms, and lacks deep emotional understanding and humanistic care for design concepts. Architectural design is not only a material creation to meet functional requirements, but also a carrier of culture, emotion and values. Table 1 shows the communication of the design concept of the same building project. As can be seen from the table, human designers can integrate local historical and cultural elements into the design, take "inheritance and innovation" as the concept, and show respect and emotion for the site through unique spatial sequences and architectural symbols. Although generative AI can generate a design that meets the functional requirements, it is obviously insufficient in embodying the design concept of "place spirit". It simply lists the common elements of similar buildings and lacks in-depth cultural interpretation and emotional resonance. This makes the design results difficult to arouse the emotional resonance of users, and can not really realize the effective communication of design concepts.

TABLE 1. COMPARISON OF DESIGN CONCEPT COMMUNICATION BETWEEN DESIGNERS AND GENERATIVE AI

Comparison Target	Design Concept Explanation	Specific Manifestation Methods	Understanding and Expression of Site Culture
Human Designers	Inheritance and innovation, respecting the historical and cultural aspects of the site while integrating modern functional requirements	Combining traditional building materials with modem structures, designing unique spatial sequences, and employing local characteristic architectural symbols	Conducting in-depth research on the historical and cultural aspects of the site, demonstrating emotions and respect for the site through spatial layout and architectural forms
Generative Artificial Intelligence	Meeting functional requirements and referencing similar architectural styles	Combining spaces according to functional modules and using common architectural styling elements	Simply listing common elements of similar buildings, lacking in-depth interpretation and unique expression of the site culture

With the application of generative AI in design, the role of designers is changing. Traditional architectural design depends on the designer's profound professional knowledge, such as architectural mechanics, materials science, laws and regulations, etc. However, generative AI can automatically generate a preliminary design scheme, which makes some designers rely too much on technology and ignore the accumulation and promotion of professional knowledge. This may lead to problems in structural safety and material feasibility, although the design is creative. There are difficulties in the evaluation of architectural design results in generative AI. Because the design results generated by generative AI are innovative and unique, the traditional evaluation criteria are difficult to fully apply. How to establish a scientific and reasonable evaluation system that adapts to the characteristics of new technology has become the key. At present, the lack of unified and clear evaluation criteria makes it easy to be subjective and arbitrary when judging the quality of design results, which affects the healthy development of architectural design industry.

5 STRATEGIES AND PROSPECTS FOR COPING WITH THE CHALLENGES OF GENERATIVE AI

In order to balance the application of technology and humanistic care, designers should strengthen their own dominance of design concepts. On the basis of creative inspiration provided by generative AI, the cultural connotation, social significance and emotional needs of users behind the design project are deeply explored. Figure 2 shows the integration of humanistic elements in two similar architectural design projects. Project A, led by designers, fully combines local community culture and residents' living habits, and sets up a number of public communication spaces in the architectural layout. The exterior of the building adopts colors and textures with regional characteristics to enhance residents' sense of belonging and identity. Project B relies too

much on generative AI. Although it meets the basic functions, it lacks the consideration of humanistic elements, the spatial layout is cold, and the appearance lacks regional characteristics. By comparison, designers should actively guide the output of generative AI, making it a powerful tool to convey humanistic care, rather than being dominated by technology.

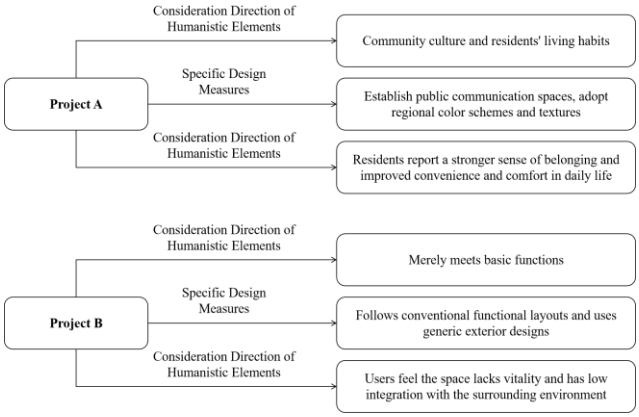

FIGURE 2. COMPARATIVE ANALYSIS OF THE INTEGRATION OF HUMANISTIC ELEMENTS IN ARCHITECTURAL DESIGN PROJECTS

It is very important to improve the collaboration ability between designers and generative AI. The architectural education system needs to keep pace with the times, increase relevant courses, and cultivate students' design ability assisted by AI. Designers themselves should constantly learn new technologies and deeply understand the algorithmic logic and operating mechanism of generative AI in order to better cooperate with it. At the same time, departments can establish interdisciplinary teams, integrate professionals in computer science, architecture, sociology and other fields, give full play to their respective advantages, and jointly promote architectural design innovation. This educational and interdisciplinary evolution in fostering architectural creativity [6] also empowers design firms to commercialize their AI-assisted projects globally. By utilizing data-driven decision-making, architectural enterprises can optimize overseas market growth, achieve precise cross-border marketing allocation, and implement dynamic ROI prediction models for brand exposure on professional networks.[7][13][16][21]

In the future, generative AI will develop in a more intelligent and personalized direction in the field of architectural creative design. With the continuous progress of technology, generative AI is expected to understand the designer's intention more accurately and generate a highly innovative and practical design scheme that fits the design concept. In the evaluation of design results, it is expected to establish a scientific, comprehensive and adaptive evaluation system to ensure the steady improvement of design quality. Generative AI is also expected to be deeply integrated with virtual reality, augmented reality and other technologies, providing designers and users with more immersive design experience and interaction, further expanding the boundaries of architectural creative design and creating more attractive and valuable architectural works.

6 CONCLUSIONS

Generative AI has brought remarkable changes to architectural creative design, showing great potential in practice, but also accompanied by many challenges. From the theoretical basis, its core algorithm is consistent with the essential connotation of architectural creative design, which provides strong support for the combination of the two. In practice mode, whether it is to assist concept generation, optimize spatial layout, or shape unique architectural form, generative AI provides designers with a new perspective and efficient tools, enriching design resources and means. However, it cannot be ignored that the application of generative AI in architectural creative design exposes a series of problems. In the communication of design concepts, the results generated by technology lack humanistic feelings, which makes it difficult for users to resonate. The impact on architectural professional knowledge and skills makes designers face the challenge of role change, which may lead to hidden dangers in design at the technical level. The lack of scientific standards in the evaluation of design results has affected the control of design quality. In order to meet these challenges, it is crucial to balance technology application and humanistic care. Designers should dominate the design concept, deeply integrate humanistic elements into the design, and avoid being dominated by technology. It is also indispensable to improve the collaboration ability between designers and generative AI, which requires the reform of architectural education system and the continuous learning of designers themselves. Through these strategies, it is expected to realize the organic integration of generative AI and architectural creative design.

Looking forward to the future, generative AI will continue to develop in the field of architectural creative design, which is expected to break through the existing limitations, realize more intelligent and personalized design, push architectural creative design to a new height, and inject a steady stream of power into the innovative development of the construction industry. Ultimately, these design advancements will seamlessly integrate with environmental and economic macro-systems. This involves leveraging high-resolution local climate projections to support sustainable building energy simulations [12], while simultaneously utilizing Web3 frameworks, such as multi-chain DAO treasury management and machine learning-based liquidity pricing, for the future commercialization and secure management of digital architectural design assets.[4][15]

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