Optimization of Personalized Indoor Space Layout Driven by Artificial Intelligence

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Abstract. This article explores the application of artificial intelligence in personalized indoor space layout optimization. With the rapid development of artificial intelligence technology, its potential in the field of interior design is increasingly prominent. This study aims to analyze how artificial intelligence can optimize personalized spatial layout through data-driven methods. The article first introduces the application background of artificial intelligence in interior design, and then discusses in detail key technologies such as data collection and processing, machine learning algorithm application, and personalized layout generation. Through case analysis and effectiveness evaluation, this article demonstrates the actual effects of artificial intelligence driven layout optimization, and discusses its advantages and limitations. The research results indicate that artificial intelligence technology can significantly improve the personalization and efficiency of indoor space layout, providing new directions for the future development of the interior design field.

Keywords: Artificial Intelligence; Interior Design; Individualization; Spatial Layout; Optimization Algorithm; User Experience.

1. Introduction

With the improvement of people's living standards and the increase of personalized needs, the interior design industry is facing new challenges and opportunities. Traditional interior design methods often rely on designers' experience and intuition, making it difficult to meet the increasingly diverse needs of users. The rapid development of artificial intelligence technology provides new ideas for solving this problem. By utilizing big data and machine learning algorithms, artificial intelligence can analyze user preferences and generate personalized spatial layout plans, thereby improving design efficiency and quality.

This study aims to explore the application of artificial intelligence in personalized indoor space layout optimization. By analyzing the specific application methods of artificial intelligence technology in interior design, evaluating its effectiveness, and discussing future development directions. This study not only contributes to promoting the application of artificial intelligence technology in the field of interior design, but also provides new solutions for improving user satisfaction.

2. The Application Background of Artificial Intelligence in Interior Design

Traditional interior design methods mainly rely on designers' experience and intuition, with long design cycles, high costs, and difficulty in meeting users' personalized needs. Designers usually need to communicate with clients multiple times and repeatedly modify design plans, which results in low efficiency. However, the introduction of artificial intelligence technology has brought revolutionary changes to interior design. Through machine learning algorithms and big data analysis, AI can quickly process large amounts of design data, identify user preferences, and generate optimized spatial layout solutions [2]. For example, AI can predict the design styles and layout styles that users may like by analyzing their historical data.

The application of artificial intelligence in interior design is mainly reflected in efficiency improvement, personalized satisfaction, and user experience optimization. Firstly, AI can quickly generate multiple design solutions, significantly reducing the design cycle. Secondly, by analyzing user data, AI can generate personalized designs that meet the diverse needs of users. Finally, the

combination of AI and virtual reality technology allows users to intuitively experience the design effect before construction, greatly enhancing their sense of participation and satisfaction.

3. Key Technologies for Optimizing Personalized Spatial Layout Driven by Artificial Intelligence

Data is the foundation for the effective operation of AI algorithms. Artificial intelligence systems need to collect users' basic information, lifestyle habits, aesthetic preferences, and other data, while processing a large number of interior design cases and spatial layout schemes. The quality and diversity of data directly affect the effectiveness of AI generation solutions. High quality data can help AI understand user needs more accurately, thereby generating design solutions that better meet user expectations.

Machine learning algorithms are the core of artificial intelligence driven layout optimization. Common algorithms include Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), and Reinforcement Learning. Convolutional neural networks (CNNs) are mainly used to analyze interior design images and identify spatial relationships; Generative Adversarial Networks (GANs) are used to create new layout schemes and generate diverse designs; Reinforcement learning improves design quality by continuously trial and error optimizing layout schemes. These algorithms are capable of identifying complex spatial relationships and generating personalized designs that meet user needs.

Based on user data and machine learning algorithms, AI systems can generate multiple layout schemes and continuously improve them through optimization algorithms. For example, genetic algorithms are used to optimize space utilization and generate efficient layouts; Multi objective optimization algorithms are used to balance different user needs and generate comprehensive optimal solutions [3]. These technologies enable AI to generate personalized spatial layouts that are both aesthetically pleasing and practical, meeting the diverse needs of users.

4. Case study: Practice of Optimizing Spatial Layout Driven by Artificial Intelligence

4.1 Residential Space Layout Optimization Case

In a high-end residential project, the AI system generates various personalized spatial layout schemes by analyzing the household structure, living habits, and aesthetic preferences of residents. Residents can use virtual reality technology to intuitively experience the effects of different solutions and provide suggestions for modifications. The AI system continuously optimizes the plan based on feedback and ultimately generates a design that satisfies residents. This case demonstrates the practical application effect of artificial intelligence in optimizing residential space layout, significantly improving design efficiency and user satisfaction.

4.1.1 Data Collection and User Requirement Analysis

In this project, the AI system first collected basic information of residents through questionnaire surveys and user interviews, including the age, occupation, lifestyle habits, and aesthetic preferences of family members. For example, residents hope that the living room can accommodate gatherings of multiple people while preserving sufficient private space; The kitchen needs an open design for easy interaction with family members; The bedroom requires a quiet and comfortable environment. In addition, the AI system also analyzes the historical data of residents, such as past decoration styles and furniture choices, to predict their possible preferred design styles.

4.1.2 Layout Generation and Optimization

Based on the collected data, the AI system uses Generative Adversarial Networks (GANs) to generate various spatial layout schemes. These plans not only consider functional zoning and flow

design, but also take into account the aesthetic preferences of residents. For example, AI has generated a design scheme that connects the living room and dining room, increasing the transparency of the space; Meanwhile, through clever zoning design, the privacy of the bedroom is preserved. Residents can use virtual reality technology to intuitively experience the effects of different solutions and provide suggestions for modifications. The AI system continuously optimizes solutions based on feedback, ultimately generating designs that satisfy residents.

4.1.3 Effect Evaluation

The successful implementation of this project demonstrates that artificial intelligence has significant advantages in optimizing residential spatial layout. Firstly, AI can quickly generate multiple solutions, significantly shorten the design cycle, and improve design efficiency. Secondly, personalized design and visualization functions greatly enhance user engagement and satisfaction [4]. Residents stated that the AI generated design not only meets their needs, but also provides many innovative designs that they never thought of.

4.2 Commercial Space Layout Optimization Cases

In another commercial office space design, the AI system optimized the spatial layout by analyzing the company's workflow, number of employees, and office equipment requirements. The system not only considers functional zoning and flow design, but also predicts future space demand changes through machine learning algorithms, reserving flexibility for the company's long-term development [5]. This case demonstrates that artificial intelligence also has significant advantages in optimizing commercial space layout and can meet the diverse needs of enterprises.

4.2.1 Data Collection and Requirements Analysis

In this project, the AI system first collected the company's workflow, number of employees, and office equipment requirements through questionnaire surveys and employee interviews. For example, the company hopes that office space can support team collaboration while retaining sufficient personal workspace; The conference room needs to be equipped with advanced video conferencing equipment; The rest area needs to provide comfortable seating and entertainment facilities. In addition, the AI system also analyzed the company's historical data, such as past office space layouts and employee satisfaction surveys, to predict their potential preferred design styles.

4.2.2 Layout Generation and Optimization

Based on the collected data, the AI system uses convolutional neural networks (CNN) to generate various spatial layout schemes. These plans not only consider functional zoning and flow design, but also incorporate the company's aesthetic preferences. For example, AI has generated a design scheme that connects the office area with the rest area, increasing the transparency of the space; Meanwhile, the privacy of the conference room is preserved through clever zoning design. Companies can use virtual reality technology to intuitively experience the effects of different solutions and provide suggestions for modifications. The AI system continuously optimizes solutions based on feedback and ultimately generates designs that satisfy the company.

4.2.3 Effect Evaluation

The successful implementation of this project demonstrates that artificial intelligence has significant advantages in optimizing commercial space layout. Firstly, AI can quickly generate multiple solutions, significantly shorten the design cycle, and improve design efficiency. Secondly, personalized design and visualization functions greatly enhance user engagement and satisfaction [5]. The company stated that the AI generated design solutions not only meet their needs, but also provide many innovative designs that they did not expect.

4.3 Public Space Layout Optimization Cases

In the design of a large shopping center, the AI system optimized the layout of public spaces by analyzing customer shopping behavior, store types, and foot traffic data. The system not only considers functional zoning and flow design, but also predicts future space demand changes through machine learning algorithms, reserving flexibility for the long-term development of shopping centers [5]. This case demonstrates that artificial intelligence also has significant advantages in optimizing public space layout and can meet the diverse needs of customers.

4.3.1 Data Collection and Requirements Analysis

In this project, the AI system first collected shopping behavior, store types, and foot traffic data of the shopping center through questionnaire surveys and customer interviews. For example, shopping centers hope that public spaces can support various activities, such as exhibitions, performances, and promotional events; At the same time, sufficient rest and dining areas need to be reserved. In addition, the AI system also analyzed historical data of shopping centers, such as past public space layouts and customer satisfaction surveys, to predict their possible preferred design styles.

4.3.2 Layout Generation and Optimization

Based on the collected data, the AI system uses Generative Adversarial Networks (GANs) to generate various spatial layout schemes. These plans not only consider functional zoning and flow design, but also incorporate the aesthetic preferences of shopping centers. For example, AI has generated a design scheme that connects public spaces with shops, increasing the transparency of the space; Meanwhile, through clever zoning design, the privacy of the rest area and dining area is preserved. Shopping centers can use virtual reality technology to visually experience the effects of different solutions and provide suggestions for modifications. The AI system continuously optimizes the plan based on feedback and ultimately generates a design that satisfies the shopping center.

4.3.3 Effect Evaluation

The successful implementation of this project demonstrates that artificial intelligence has significant advantages in optimizing public space layout. Firstly, AI can quickly generate multiple solutions, significantly shorten the design cycle, and improve design efficiency. Secondly, personalized design and visualization functions greatly enhance user engagement and satisfaction [5]. The shopping center stated that the AI generated design solutions not only meet their needs, but also provide many innovative designs that they did not expect.

4.4 Case Study on Optimization of Educational Space Layout

In the design of a university library, an AI system optimized the layout of the library by analyzing students' learning behavior, book types, and foot traffic data. The system not only considers functional zoning and flow design, but also predicts future space demand changes through machine learning algorithms, reserving flexibility for the long-term development of the library [5]. This case demonstrates that artificial intelligence also has significant advantages in optimizing the layout of educational spaces, and can meet the diverse needs of students.

4.4.1 Data Collection and Requirements Analysis

In this project, the AI system first collected data on the library's learning behavior, book types, and foot traffic through questionnaire surveys and student interviews. For example, the library hopes that the learning space can support multiple learning methods, such as individual learning, group discussions, and remote learning; At the same time, sufficient book and rest areas need to be reserved. In addition, the AI system also analyzed historical data of the library, such as past learning space layouts and student satisfaction surveys, to predict their possible preferred design styles.

4.4.2 Layout Generation and Optimization

Based on the collected data, the AI system uses convolutional neural networks (CNN) to generate various spatial layout schemes. These plans not only consider functional zoning and flow design, but also incorporate the aesthetic preferences of the library. For example, AI has generated a design scheme that connects the learning space with the book area, increasing the transparency of the space; Meanwhile, through clever partition design, the privacy of the rest area and discussion area is preserved. Libraries can use virtual reality technology to visually experience the effects of different solutions and provide suggestions for modifications. The AI system continuously optimizes the plan based on feedback and ultimately generates a design that satisfies the library.

4.4.3 Effect Evaluation

The successful implementation of this project demonstrates that artificial intelligence has significant advantages in optimizing the layout of educational spaces. Firstly, AI can quickly generate multiple solutions, significantly shorten the design cycle, and improve design efficiency. Secondly, personalized design and visualization functions greatly enhance user engagement and satisfaction [5]. The library stated that the AI generated design not only meets their needs, but also provides many innovative designs that they did not expect.

Design cycle, and improve design efficiency. Secondly, personalized design and visualization functions greatly enhance user engagement and satisfaction [5]. The hospital stated that the AI generated design not only meets their needs, but also provides many innovative designs that they did not expect.

5. Effect Evaluation and Future Prospects of Artificial Intelligence Driven Layout Optimization

Through the analysis of actual cases, the effectiveness of AI driven layout optimization is mainly reflected in three aspects: efficiency, quality, and user satisfaction. Firstly, AI systems can significantly shorten the design cycle, quickly generate multiple options for selection, and significantly improve design efficiency. Secondly, AI generated design solutions often better meet user needs, improve space utilization, and enhance design quality. Finally, the interactivity and visualization capabilities of AI systems greatly enhance user engagement and satisfaction [4].

Although artificial intelligence has shown great potential in interior design, it still faces some challenges. Firstly, how to ensure that the design solutions generated by AI are creative and artistic, rather than just piling up data, is an urgent problem that needs to be solved. Secondly, the collection and use of user data must strictly comply with privacy protection regulations to ensure data security. These challenges require joint efforts from technology developers, designers, and policy makers to solve.

In the future, the application of artificial intelligence in interior design will be more extensive and in-depth. Firstly, by combining IoT technology, AI can achieve deep integration between smart homes and spatial layout, providing users with a more intelligent living experience. Secondly, through augmented reality technology, users can interact more intuitively with AI systems, adjust design schemes in real-time, and further enhance user experience [5]. The development of these technologies will bring more innovation and possibilities to the field of interior design.

6. Conclusion

This study explores the application of artificial intelligence in personalized indoor space layout optimization. By analyzing key technologies, practical cases, and effectiveness evaluations, we have found that artificial intelligence can significantly improve the efficiency and quality of interior design, meeting the personalized needs of users. Despite still facing some challenges, the application prospects of artificial intelligence in the field of interior design are broad. In the future, with the

continuous advancement of technology, artificial intelligence is expected to become a powerful assistant for interior designers, creating more comfortable and intelligent living and working environments for users.

References

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