Optimization Strategy of Architectural Design Based on Data Mining

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Abstract. Optimization strategy formulation based on DM (Data mining) is an important development direction of modern architectural design. It can improve the efficiency and quality of design and reduce the cost of trial and error in design, bringing greater economic and social benefits to the architectural design industry. By combining computer-aided design (CAD) and DM technology, this article puts forward a complete set of architectural design optimization strategies. The specific contents include an in-depth study of CAD and DM's application status and limitations in architectural design. This article discusses how to effectively combine CAD technology with the DM algorithm to realize comprehensive mining and analysis of architectural design data. Specific architectural design optimization strategies are formulated based on the excavated design knowledge. The results fully demonstrate the superior performance of the architectural design optimization system proposed in this article in terms of computational efficiency and stability. At the same time, the efficiency of collaborative design by multi-professional teams using the system proposed in this article is high. It highly evaluates the system proposed in this article in terms of operation convenience, functional satisfaction, and picture fluency. This proves the system's excellent user experience and functionality performance and provides strong support for its wide promotion and use in practical applications.

Keywords: Computer-Aided Design; Data Mining; Architectural Design; Optimization Strategy
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1 INTRODUCTION

With the rapid growth of computer technology, CAD has become a standard tool in the field of architectural design, which greatly improves design accuracy. Virtual reality technology can provide designers with a more realistic and intuitive design experience. Through virtual reality helmets and related software, designers can view, modify, and experience architectural design in a virtual environment. This immersive design approach helps to improve the accuracy of design and the creativity of designers. Bashabsheh et al. [1] explore how to use CAD and virtual reality technology for collaborative design of building structures in order to improve design efficiency, reduce costs, and provide designers with a more intuitive and realistic design experience. In traditional architectural, structural design, designers often rely on two-dimensional drawings and three-dimensional models for communication and collaboration. However, this method has certain limitations, such as inaccurate information transmission and low communication efficiency. The emergence of CAD and virtual reality technology provides new ways to solve these problems. CAD technology provides strong support for the collaborative design of building structures. Through CAD software, designers can create precise 3D models and make real-time modifications and updates. This enables more efficient information transmission and collaboration between different departments and teams, reducing information misunderstandings and repetitive work. However, traditional CAD technology pays more attention to the automation and visualization of design, and how to extract valuable information from massive design data to guide design optimization is still a problem to be solved. The application of CAD (computer-aided design) and data mining technology in the field of architectural design is becoming increasingly widespread. Berseth et al. [2] explored how to use CAD and data mining techniques to explore diverse solutions and achieve better design outcomes through interactive architectural design. Traditional architectural design methods often rely on the experience and intuition of designers, making it difficult to fully consider various factors and possibilities. The emergence of CAD technology enables designers to express and modify designs more accurately, while data mining technology can help designers extract useful information from a large amount of data, providing more references for design. Interactive architectural design can enable designers to communicate and collaborate more effectively with users, other professionals, and more. CAD technology can help designers quickly create and modify design models. Through parameterized and modular design methods, designers can make various attempts and optimizations in CAD software, thereby finding diverse solutions. In addition, CAD technology can also combine artificial intelligence and machine learning techniques to generate and evaluate design solutions automatically, further expanding the possibilities of design. With the popularization and application of CAD (computer-aided design) digital tools, the perception changes in the architectural design process are receiving increasing attention. Ceylan et al. [3] explored the perception changes in architectural design based on CAD digital tool knowledge through case study methods, analyzed the reasons and impacts of their occurrence, and proposed corresponding suggestions. The application of CAD digital tools in architectural design enables designers to design and model more efficiently. However, with the popularization of CAD digital tools, some designers are beginning to realize the changes in design perception. This change manifests as differences in the overall grasp of design, spatial perception, and detail handling. Its aim is to explore in depth the perceptual changes in architectural design based on CAD digital tool knowledge through case studies. In this case, the designer used CAD digital tools for design and modeling. During the modeling process, the designer found that their design perception had changed. Specifically, it manifests as a more accurate grasp of the overall space and a more refined handling of details. Meanwhile, communication and coordination during the design process are also more convenient. In the field of architectural design, DM can help designers find potential design patterns and laws from existing design cases, thus providing optimization suggestions for new designs. Therefore, the combination of CAD and DM technology is of great theoretical significance and practical value for improving the quality and efficiency of architectural design and reducing the cost of trial and error in design.

To meet the needs of beginners in computational design, simplify the CAD operation interface and reduce the learning threshold. Through intuitive interface design and easy-to-understand operating procedures, beginners can quickly get started. Introducing artificial intelligence and machine learning technologies to provide intelligent design assistance for beginners. By analyzing the design intentions and habits of beginners, intelligent algorithms can automatically recommend design solutions and optimization suggestions, improving design efficiency and quality. Chen et al. [4] provide a wealth of architectural design cases for beginners to learn and practice. By imitating the design ideas and methods of excellent cases, beginners can quickly accumulate design experience and improve their design level. Build an online collaboration and communication platform, allowing beginners to share experiences and discuss issues with other designers. Promote the growth and progress of beginners through mutual learning and communication. Establish a continuous learning and feedback mechanism to provide personalized learning suggestions and optimization directions for beginners based on their learning situation and design achievements. Through continuous learning and feedback, help beginners gradually improve their CAD application ability and architectural design level.

The traditional architectural design process often relies on centralized decision-making and management, which may lead to issues such as information opacity and low collaboration efficiency. With the development of technology, decentralized design methods have gradually become a trend. Through CAD and data mining techniques, designers can more accurately express and optimize design solutions. BIM and blockchain technology provide possibilities for decentralized design. CAD technology can help designers quickly create and modify design models, making the design process more efficient and accurate. Through parameterized and modular design methods, Dounas et al. [5] conducted various attempts and optimizations in CAD software to find the best design solution. In addition, CAD technology can also combine artificial intelligence and machine learning techniques to generate and evaluate design solutions automatically, further expanding the possibilities of design. Data mining techniques can extract useful information from a large amount of data, providing more references for design. By mining historical project data, the application and effects of various design elements under different conditions can be discovered, providing a reference for the design of current projects. By mining user needs, we can better understand and meet their needs. By mining market data, we can understand market trends and competitive situations, providing more business references for design. 3D printing technology has great potential in the field of bone repair. Through CAD technology, personalized bone scaffolds that meet the needs of patients can be accurately designed and manufactured. Data mining techniques can help us extract useful information from a large amount of patient data to optimize stent design. This architectural design method based on CAD and data mining for 3D printing brackets is expected to bring revolutionary breakthroughs to bone repair. CAD technology provides strong support for the design of 3D printing brackets. Entezari et al. [6] used CAD software to create precise 3D models and personalized customization based on patient medical imaging data. Through parameterized and modular design methods, multiple design schemes can be quickly generated and optimized for selection. In addition, CAD technology can also be combined with engineering analysis methods, such as finite element analysis, to simulate and evaluate the mechanical properties of supports. The application of CAD technology has been very mature, covering all stages from preliminary design to detailed design. However, how to make effective use of the massive data generated by CAD has always been a hot and difficult point in research. In the future, with the continuous growth of AI, machine learning, and other technologies, the combination of CAD and DM will become closer. It is expected that there will be more intelligent architectural design auxiliary systems that can automatically extract design knowledge from a large number of data and provide designers with more personalized and accurate design suggestions.

Triangle and mesh are two common CAD design input technologies that have wide applications in architectural design. Triangle technology mainly focuses on the generation and control of architectural form, while mesh technology focuses more on the modeling and optimization of building structures. These two technologies provide designers with powerful tools to better express their design intentions and improve the feasibility and aesthetics of the design. The triangle technique is a method based on mathematical morphology, and its application in architectural design mainly manifests in the generation and control of form. Through triangle technology, Erdolu [7] quickly generates complex architectural forms while also allowing for precise control and adjustment of the forms. This technology provides designers with greater creative space, allowing them to better explore and express design concepts. Triangles and meshes, as CAD design input technologies, not only improve the efficiency and accuracy of design but also have a profound impact on the interactivity of design. Through these two technologies, designers can more intuitively display design results and effectively communicate and coordinate with owners and other professionals. In addition, these two technologies also support real-time interaction and dynamic modification, allowing designers to respond more quickly to various needs and changes. By combining CAD and DM technology, this article puts forward a complete set of architectural design optimization strategies. The specific contents and innovations include: (1) An architectural design optimization system integrating modeling, analysis, and optimization is built. The system makes full use of the advantages of CAD technology in modeling and visualization and, at the same time, plays the role of DM in data analysis and decision support. (2) The system provides data-based decision support for designers by mining historical design data and performance simulation data. This data-driven design method enables designers to optimize the design on the basis of a large number of data, which improves the accuracy of the design. (3) The system provides a flexible design optimization strategy formulation method. Designers can formulate corresponding optimization strategies according to different design needs and goals so that the design can meet the actual needs.

This article is divided into seven sections, and the specific arrangements are as follows:

Section I: Introduction. This article expounds on the research background and significance, research purpose, content and methods, and the structure and arrangement of the paper.

Section II: Related work. The research status and development trend of related technologies are introduced in detail.

Section III: Research on architectural design method and technology based on CAD. An in-depth analysis of the current application and limitations of CAD in architectural design provides a basis for the formulation of subsequent strategies.

Section IV: Research on the optimization strategy of architectural design based on DM. This article discusses how to use DM to extract valuable information and knowledge from massive design data and formulate specific architectural design optimization strategies.

Section V: Design and implementation of architectural design optimization system based on CAD and DM. An architectural design optimization system integrating CAD and DM functions is designed and implemented to provide technical support for practical application.

Section VI: Experimental analysis and application case study. The practicability of the proposed strategy is verified by experiments analyzed and discussed with practical cases.

Section VII: Summary and Prospect. Summarize the main work and achievements of this study, point out its shortcomings, and put forward suggestions for future research.

2 RELATED WORK

In traditional ship and offshore structure construction processes, designers typically rely on drawings and physical models for communication and collaboration. However, this method has certain limitations, such as inaccurate information transmission and low communication efficiency. With the development of 3D CAD and augmented/virtual reality technology, these issues have been effectively addressed. Through 3D CAD data extraction and conversion, design data can be transformed into data in augmented/virtual reality environments, achieving a more intuitive and realistic design and construction experience. 3D CAD data is the core of ship and offshore structural construction. Through 3D CAD data extraction, design data can be exported from CAD software and undergo necessary format conversion. These data can include information such as the geometric shape, material properties, and assembly relationships of ships or offshore structures. The converted data can be used for the development of augmented/virtual reality applications to achieve a more intuitive and realistic design and construction experience [8]. The traditional architectural education model is often limited by geography, resources, and learning time, which makes many aspiring professionals in the construction industry hesitant to pursue it. With the development of CAD and data mining technology, a new educational model has emerged: mandatory virtual design studios for all. This model allows students from all over the world to participate in architectural design through online platforms, breaking the constraints of traditional education and bringing new possibilities to architectural education. Iranmanesh and Onur [9] explored a novel educational model, a nationwide mandatory virtual design studio based on CAD and data mining, and elaborated on its impact on the global transformation of architectural education. Data mining technology provides valuable data support for virtual design studios. By mining and analyzing a large amount of historical project data, students can understand the application and effects of various design elements under different conditions, providing reference for their own design plans. In addition, data mining can also help students understand market demand, technological development trends, and other information, providing guidance for their career planning. Concrete 3D printing is an additive manufacturing technology based on digital model files, which constructs structures through layer-by-layer printing. Compared with traditional building methods, concrete 3D printing has higher design freedom, shorter construction cycles, and better structural performance. However, in practical applications, concrete 3D printing still faces some technical and construction limitations. CAD technology is one of the key tools for achieving 3D printing of concrete. Designers can use CAD software to create 3D models and convert them to STL format for 3D printing. Through the parametric design function of CAD software, designers can quickly adjust the size and shape of the model to meet specific building requirements. In addition, CAD software can also perform structural analysis and optimization to ensure the stability of the printed structure. Data mining technology can provide valuable data support for concrete 3D printing. By mining historical construction data, material performance data, and environmental condition data, we can better understand the patterns and influencing factors of concrete 3D printing. This helps optimize the printing process, improve printing quality, and reduce construction costs. In addition, data mining can also be used to predict future development trends and challenges, providing guidance for further research and practice [10].

More and more designers and researchers are paying attention to the application of bionics in architecture. The biomimetic folding mechanism, as a design technique that combines natural biological forms with architectural structures, has unique advantages and charm. Through computer-aided technology, we can design and manufacture biomimetic folding mechanisms more efficiently and accurately. Using CAD technology, Krner et al. [11] quickly constructed a geometric model of a biomimetic folding mechanism in a computer. By simulating and analyzing the morphological characteristics of organisms in nature, they can obtain inspiration and transform it into architectural structures. In addition, by using parametric design methods, it is possible to optimize the bionic folding mechanism to improve its stability and functionality. Computer-assisted technology provides strong support for the application of biomimetic folding mechanisms in architecture. Efficient and precise design through CAD, as well as rapid and precise manufacturing through CAM, can better realize the value of biomimetic folding mechanisms in architecture. In architectural design, the combination of CAD and data mining technology provides designers with broader ideas and more efficient design tools. Livshits et al. [12] explored how to use CAD and data mining techniques to simulate the starting point of architectural design in order to provide designers with a new interdisciplinary design method. CAD technology can provide strong support for architectural design, especially in the design starting stage. Through CAD software, designers can quickly create and modify design models and view design effects in real time. In addition, CAD technology can also assist designers in design optimization, such as material selection, structural analysis, etc., to ensure the feasibility and economy of the design. Combining CAD and data mining techniques can form an interdisciplinary design approach. The advantage of this method is that it can combine the artistic and scientific aspects of design, making it more reasonable and feasible. Through CAD technology, designers can use the information obtained from data mining to design quickly and accurately. Meanwhile, the results of data mining can also be continuously updated and optimized during the design process.

With the increasing scale and complexity of construction projects, traditional one-on-one design methods can no longer meet the needs of the modern construction industry. Therefore, the network architecture collaborative design system has emerged, which can achieve real-time collaboration between multiple specialties and teams to improve design efficiency and quality. As a mature CAD software, Auto CAD has good openness and scalability, providing strong support for the implementation of network-building collaborative design systems. Ma et al. [13] explored how to use Auto CAD to design a networked architectural collaborative design system and analyzed its advantages and challenges. Auto CAD provides rich collaborative design tools such as references, blocks, external references, etc., making it convenient for designers to carry out collaborative work. These tools can achieve real-time updates and synchronization of design data, improving design efficiency and accuracy. In the collaborative design system of network architecture, Auto CAD supports flexible permission control mechanisms. Administrators can set different access and editing permissions as needed to ensure the security and confidentiality of design data. In the construction industry, CAD-based robot assembly systems are gradually becoming a key technology for achieving automation, precision, and efficient construction. Pane et al. [14] explored a system architecture for CAD-based robotic building assembly with sensor-based skills and analyzed its advantages and challenges. The CAD-based robot assembly system combines computer-aided design, robotics technology, and sensor technology, bringing tremendous changes to the construction industry. This system achieves automated and precise building assembly through precise 3D modeling, path planning, and control algorithms. The introduction of sensor technology further enhances the perception and adaptability of the system, enabling it to perform efficient operations in complex environments. This sensor-based CAD-based robot building assembly system has many advantages. Firstly, it can achieve automated and precise assembly, improving construction quality and efficiency. Secondly, by introducing sensor technology, the system can adapt to complex and ever-changing environments, improving the reliability and safety of operations.

With the rapid development of information technology, digital enterprises have become an important trend in the construction industry. Roman et al. [15] explored how to integrate the data flow of the construction project lifecycle to create a digital enterprise based on Building Information Modeling (BIM). By analyzing the importance of data flow in construction projects, the advantages of BIM technology, and the characteristics of digital enterprises, we will propose a feasible implementation strategy. Construction projects are complex and diverse, involving multiple stakeholders and a large amount of data and information. Traditional project management methods often struggle to effectively integrate this data, leading to information silos and inefficient communication. Digital enterprises based on BIM can integrate and manage project lifecycle data through a unified data platform. This not only improves project management efficiency but also helps to reduce costs, reduce risks, and improve engineering quality. In the architecture, engineering, and construction (AEC) industry, the use of CAD (computer-aided design) and data mining techniques for building information modeling has become a common practice. CAD technology enables designers to quickly create and modify designs, greatly improving design efficiency. Data mining can help designers better understand project data and make more effective decisions. CAD and data mining techniques can help team members collaborate better. Designers can share and edit designs in CAD software, while data mining can help teams better understand project data and improve decision-making efficiency. Although CAD and data mining are very useful in building information modeling, they cannot completely replace human judgment and experience. Sometimes, the analysis results of technology and data may not fully reflect the actual situation or consider human factors [16].

In the field of architecture, digital archiving can not only record building entities but also archive people's perceptual experiences. Tai et al. [17] explored how to use computer-aided methods to digitally archive the perception experience of architectural space and analyzed its advantages and challenges. Architectural space is an important component of human life, carrying people's emotions, memories, and culture. Over time, many architectural spaces with historical and cultural value gradually disappear. Therefore, digital archiving of the perception experience of architectural space is of great significance. Computer-assisted methods provide an effective means to achieve this goal. Virtual reality technology can create virtual environments similar to the real world, allowing people to experience architectural spaces firsthand. By capturing information such as people's behavior, expressions, and speech in virtual environments, their perceptual experiences can be digitally recorded and analyzed. It utilizes multimedia technology to interactively display digitally archived materials, enabling viewers to have a more intuitive understanding of the history, culture, and perceptual experience of the architectural space. Interactive displays can enhance the audience's sense of participation and immersion. CAD (Computer Aided Design) technology is an indispensable tool in the field of construction engineering, and modeling technology is the core of CAD technology.

Traditional modeling techniques often struggle to cope with complex and ever-changing building structures, thus requiring a more efficient and accurate modeling method. The modeling technology based on extended graphs and polymorphic models has emerged in this context. Build corresponding extension diagrams based on the actual needs of the construction project. The expansion diagram should include sufficient nodes and edges to express all the details of the building structure. Define corresponding attributes for the nodes and edges of the extended graph, such as position, size, material, etc. These attributes will be used to describe the physical characteristics of the building structure. When there is a change in the building structure, the expansion plan should be updated accordingly, and its consistency should be maintained. In addition, regular maintenance should be carried out on the extension diagram to ensure its completeness and accuracy. When the form of the building structure changes, the polymorphic model should be transformed accordingly, and its parameters should be updated. In addition, regular maintenance should be carried out on polymorphic models to ensure their integrity and accuracy [18].

3 ARCHITECTURAL DESIGN METHOD AND TECHNOLOGY BASED ON CAD

3.1 Basic Principles and Methods of Architectural Design

In the field of architectural design, CAD technology has become an indispensable tool for designers. It can create, modify, analyze, and optimize digital models so that designers can complete design tasks more quickly and accurately. CAD systems usually include modeling, rendering, animation, simulation, and other functions, which can improve the design quality. The growth of CAD has gone through the process of going from two-dimensional to three-dimensional, from static to dynamic, and from linear to nonlinear. Nowadays, with the continuous progress of computer technology, CAD technology has been able to achieve advanced functions such as modeling, multi-disciplinary collaborative design, and performance-based design of complex building shapes. Architectural design is a complex and comprehensive process involving art, technology, economy, society, and other aspects. In architectural design, designers need to follow some basic principles and methods to ensure the quality and feasibility of design. These principles and methods include:

(1) Functional requirements and spatial layout: Designers need to fully understand the functional requirements of buildings and users' behavior patterns and rationally plan the spatial layout to ensure the practicality and comfort of the space.

(2) Architectural form and aesthetics: Architectural design needs to consider the aesthetic value of architectural form and shape the aesthetic feeling of architecture by means of form, proportion, and color so that it is in harmony with the environment and has a unique personality.

(3) Structural safety and stability: Designers need to ensure the structural safety and stability of buildings and reasonably select structural forms and materials to meet the requirements of earthquake resistance and wind resistance.

(4) Green building and sustainability: In modern architectural design, green building and sustainability have become important design principles. Designers need to consider the energy efficiency, resource utilization, and environmental impact of buildings so as to realize the harmonious symbiosis between buildings and the environment.

3.2 Advantages and Limitations of CAD in Architectural Design

The use of CAD technology in architectural design has been very common. CAD technology can easily create complex building shape models, such as surface modeling and parametric design. These models can accurately express the designer's intention and provide an accurate digital basis for subsequent design, analysis, and manufacturing. At the same time, CAD technology can be combined with performance-based design methods for architectural design. Designers can use CAD software to simulate and analyze the performance of building models, such as structural analysis and energy consumption simulation, to verify and optimize the design scheme. Generally speaking, the use of

CAD in architectural design has brought many advantages, but there are also some limitations. See Table 1 for details.

Project	*Superiority*	*Limitations*
Design efficiency and quality	CAD technology can greatly shorten the design cycle, reduce the cost of trial and error, and improve the accuracy and reliability of design.	Designers are required to have higher skills, and they need to have certain computer skills and professional knowledge. It takes time and cost to learn and master relevant skills.
Multi-specialty collaborative design	CAD technology can realize the construction of a multi-professional collaborative design platform, facilitate communication and cooperation among various professions, and improve design efficiency and quality.	There are problems with data compatibility and interoperability, and different CAD software may adopt different data formats and standards, which may bring troubles and challenges to designers.
Modify and optimize the design scheme.	Using CAD technology in architectural design can easily modify and optimize the design scheme and improve the flexibility and innovation of design.	There is a high demand for computer hardware, which requires high-performance CPUs, large-capacity memory, and professional graphics processors, which may increase the design cost and cycle.

Table 1: Advantages and limitations.

4 OPTIMIZATION STRATEGY OF ARCHITECTURAL DESIGN BASED ON DM

4.1 Application of DM Algorithm in Architectural Design Optimization

DM can be used for performance optimization in the architectural design stage. Through the mining and analysis of architectural performance data, performance bottlenecks are found, and optimization suggestions are put forward. In addition, DM can also be used for architectural design decision support, providing designers with a data-based decision-making basis. Different DM algorithms can be selected to deal with the demand for architectural design optimization. By choosing the appropriate DM algorithm, we can dig and analyze the architectural design data deeply, find the laws and patterns, and provide decision support for design optimization.

4.2 Formulation of Architectural Design Optimization Strategy Based on DM

In this article, the formulation of an architectural design optimization strategy based on DM includes the following steps: firstly, collect and sort out relevant architectural design data, including historical design data and architectural performance data. Then, choose the appropriate DM algorithm to process and analyze the data and find the laws and patterns. Then, according to the mining results, the corresponding optimization strategies are formulated, including the adjustment of design parameters and the optimization of the design process.

In the optimization of architectural design, this article adopts a clustering algorithm for the classification of architectural design styles. Set data set:

$$X = \ x_1, x_2, x_3, \ldots, x_n \tag{1}$$

Among them, X has m clusters R and X is clustered to finally get the classification set:

$$C_1, C_2, C_3, \ldots, C_m \tag{2}$$

The above set meets the following conditions:

$$C_1 \neq \Phi, \quad i = 1,2,3,\ldots,m \tag{3}$$

$$\bigcup_{i=1}^{m} C_i = X \tag{4}$$

$$C_i \cap C_j = \Phi, \quad i \neq j, \quad i,j = 1,2,3,\ldots,m \tag{5}$$

Randomly choose k sample points from the given sample set and designate them as the cluster centers. The mathematical expression for this process is as follows:

$$d\ x,C_i = \sqrt{\sum_{j=1}^{m} x_j - C_{ij}{}^{2}} \tag{6}$$

Where x is the data object, C_i is the i cluster center, and m is the dimension of the data object. x_j And C_{ij} are the j attribute values of x and C_i. Calculate the sum of squares of errors of the whole data set, and the formula is as follows:

$$S = \sum_{i=1}^{k} \sum_{x \in C_i} \left| d\ x,C_i \right|^2 \tag{7}$$

Suppose that in the transaction set, the confidence of rule $A \Rightarrow B$ is c, and if D contains both transactions A and B, the probability is c; This is the conditional probability $P\ B,A$, and the formula is as follows:

$$Support\ \mathrm{A \Rightarrow B} = P\ A \cup U \tag{8}$$

$$Confidence\ \mathrm{A \Rightarrow B} = P\ B \middle| A \tag{9}$$

The appearance of itemset A is independent of the appearance of itemset B. If:

$$P\ \mathrm{A \cup B} = P\ A\ P\ B \tag{10}$$

The appearance of itemset A depends on the appearance of itemset B. The correlation between A and B is measured by the following formula:

$$Corr_{AB} = \frac{P\ \mathrm{B|A}}{P\ \mathrm{B}} = \frac{P\ A \cup B}{P\ A\ P\ B} \tag{11}$$

Evaluate and filter the mined association rules to determine which rules are meaningful and practical. Evaluation indicators can include support, confidence, promotion, and so on. Filter out those rules that have guiding significance for architectural design. The filtered association rules are applied to the actual architectural design. Designers can adjust design parameters according to these rules to optimize building performance. At the same time, these rules can be further verified and improved through the monitoring and feedback of the actual building performance.

The formulation of an optimization strategy is a complex decision-making process involving many factors and objectives. This article mainly considers the following four factors: (1) The functional requirements of the building: This is the basis of the design, including the purpose of the building, the number of people to accommodate, and the equipment requirements. The optimization strategy must ensure that the design scheme meets these basic functions. (2) Spatial layout: Reasonable spatial layout can improve the efficiency and comfort of buildings. DM can analyze successful spatial layout cases in historical design and extract applicable design principles. (3) Structural safety: The structural safety of the building is very important, and the optimization strategy needs to ensure that the structural integrity is not sacrificed in the design process. DM can identify the key factors affecting structural safety and formulate corresponding optimization measures. (4) Green building: The optimization strategy should focus on how to reduce energy consumption, improve resource utilization efficiency, and reduce the impact on the environment. Through the optimization strategy based on DM, the quality and efficiency of architectural design can be significantly improved.

5 DESIGN AND IMPLEMENTATION OF ARCHITECTURAL DESIGN OPTIMIZATION SYSTEM BASED ON CAD AND DM

5.1 System Overall Architecture Design

The overall architecture design of the architectural design optimization system based on CAD and DM needs to fully consider the functional requirements, performance requirements, and scalability of the system. In this article, the system architecture adopts a hierarchical design, including a data layer, algorithm layer, application layer, and user interface layer. The algorithm layer provides algorithm support related to DM and CAD, including the DM algorithm and CAD modeling algorithm. The application layer realizes the core functions of the system, including design optimization and performance analysis. The user interface layer provides a friendly user interface, which is convenient for users to operate and view the results. See Figure 1 for the overall architecture of the system.

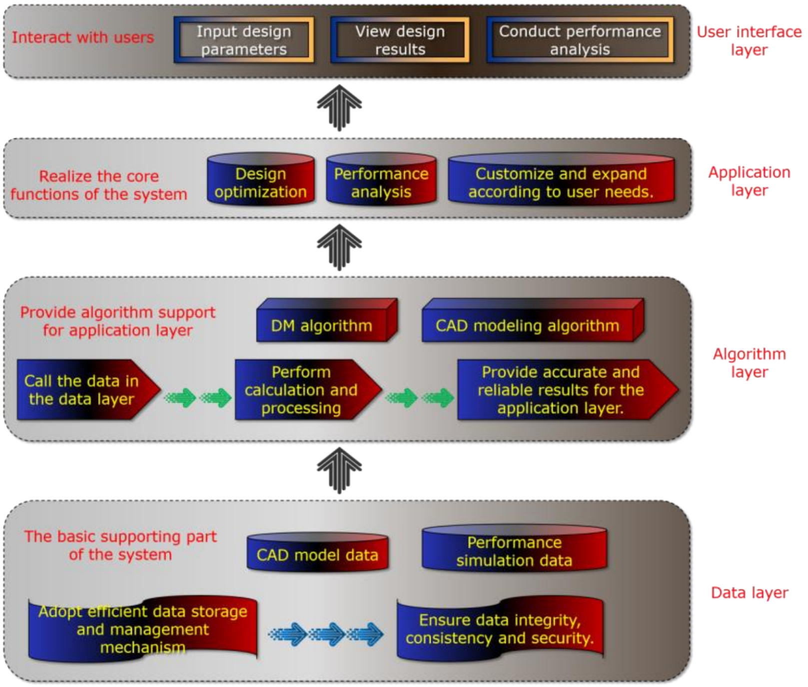

Figure 1: Overall system architecture.

5.2 Integration and Implementation of CAD and DM Module

In this system, the integration of CAD and DM modules is the key link. First, choose the appropriate CAD software and DM tools to ensure their compatibility and interoperability. Then, CAD software and DM tools are integrated through the API interface. In the stage of integration, data transmission format, data conversion, and other issues need to be considered. At the same time, it is necessary to preprocess and postprocess the CAD model to meet the needs of the DM algorithm.

In order to meet the complexity and diversity requirements of an architectural design optimization system, this article divides the whole system into several relatively independent but interrelated functional modules according to functional logic. This modular design is not only conducive to the development and maintenance of the system but also improves its scalability and flexibility.

CAD modeling module

Function definition: Provide users with a friendly modeling interface and support the creation, editing, and saving functions of 2D and 3D building models.

Input and output: the input is a manual operation by the user or import of external CAD files; The output is a complete building model file.

Algorithm flow: receiving user input →, building model →, real-time rendering →, outputting model file.

Interface design: intuitive operation interface, providing modeling toolbar, property window, and real-time preview window.

DM module

Function definition: Mining historical design data and performance simulation data to extract valuable information and patterns.

Input and output: the input is the design data in the historical database; The output is the mining design rules, trends, or patterns.

Algorithm flow: data preprocessing →, selecting appropriate mining algorithms (such as association rules, clustering, classification, etc.) → mining data, → outputting results.

Interface design: provides DM parameter setting, result display, and export functions.

(3) Design optimization module

Function definition: based on the CAD model and DM results, provide designers with optimization suggestions or automatically optimize design schemes.

Input and output: the input is the CAD model and DM result; The output is the optimized design scheme or suggestion.

Algorithm flow: receiving CAD model and DM results →, applying optimization algorithm →, outputting optimization scheme.

Interface design: displays the comparison effect before and after optimization and provides the functions of adjusting optimization parameters and saving the scheme.

(4) Performance analysis module

Function definition: simulate and analyze the performance of architectural design schemes, such as structural strength, energy consumption, lighting, etc.

Input and output: the input is the design scheme; The output is the simulation results of various performance indicators.

Algorithm flow: loading design scheme → selecting performance analysis items → carrying out simulation calculation → outputting results.

Interface design: display the simulation results in the form of charts and support the simultaneous comparison and export of multiple performance indicators.

In the stage of designing these modules, this article pays special attention to the interaction and cooperation between modules. For example, the model file output by the CAD modeling module can be directly used by the DM module and design optimization module, while the performance analysis module can receive the optimized design scheme for simulation analysis. Furthermore, to guarantee the stability and dependability of the system, this paper takes into account mechanisms for exception handling, data backup, and recovery during the design phase. This ensures that the system can swiftly resume normal operation in case of any issues.

5.3 System Implementation and Testing

After completing the system design and module division, the system is implemented and tested. In the stage of implementation, it is necessary to follow the standards and specifications of software development to ensure the quality and maintainability of the code. Tables 2- 4 show the results of the unit test, integration test, and system test.

Test type	*Test target*	*Number of test cases*	*Pass quantity*	*Number of failures*	*Success rate*	*Remarks*
Unit testing	Verify the function and performance of each module.	150	140	10	93.3%	Partial boundary conditions are not completely covered.

Table 2: Unit test results.

Test type	*Test target*	*Number of test cases*	*Pass quantity*	*Number of failures*	*Success rate*	*Remarks*
Integration testing	Verify the interface and data flow between modules.	80	75	5	93.8%	There is a small problem in interface data transmission.

Table 3: Integration test results.

Test type	*Test target*	*Number of test cases*	*Pass quantity*	*Number of failures*	*Success rate*	*Remarks*
System testing	Verify the function and performance of the whole system.	50	48	2	96.0%	There is a performance bottleneck in a specific configuration.

Table 4: System test results.

6 VISUAL PRESENTATION AND CASE ANALYSIS

To assess the efficacy and applicability of the architectural design optimization system leveraging CAD and DM, this segment conducts experimental analysis. The experimental design includes selecting suitable experimental objects, determining experimental parameters, and setting the experimental environment. In the experimental method, quantitative analysis and qualitative analysis are combined, including the measurement of performance indicators and the survey of user satisfaction. Figure 2 shows the computational efficiency of the system.

According to the data in Figure 2, we can see that the system shows high computational efficiency under different task scales. It clearly shows the advantages of this method. Traditional methods often rely on designers' experience and trial and error, which may take longer to achieve the optimization goal. The system in this article greatly accelerates the design optimization process by combining CAD and DM technology. Figure 3 shows the stability of the system.

According to Figure 3, compared with the traditional architectural design system, the system proposed in this article has obvious advantages in stability. The traditional system will be unstable or collapse in the face of complex or abnormal situations, but the system in this article ensures stable operation in various situations through advanced algorithms and robust design. The experiment records the time required for multi-professional teams to use the system for collaborative design, as shown in Figure 4.

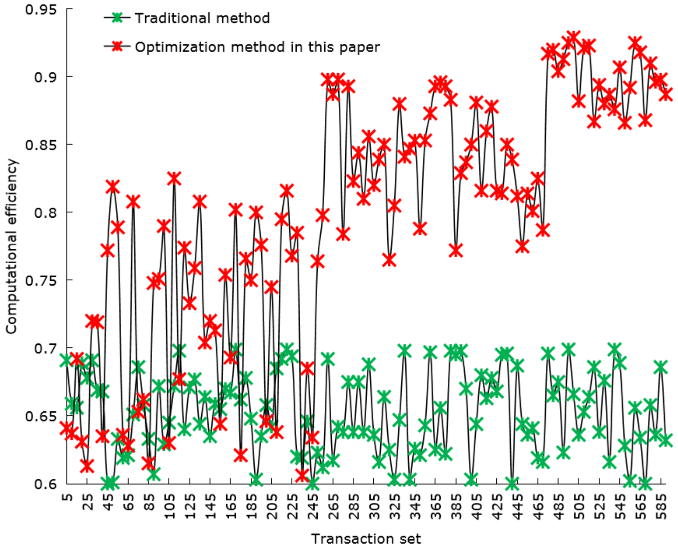

Figure 2: Computational efficiency of the system.

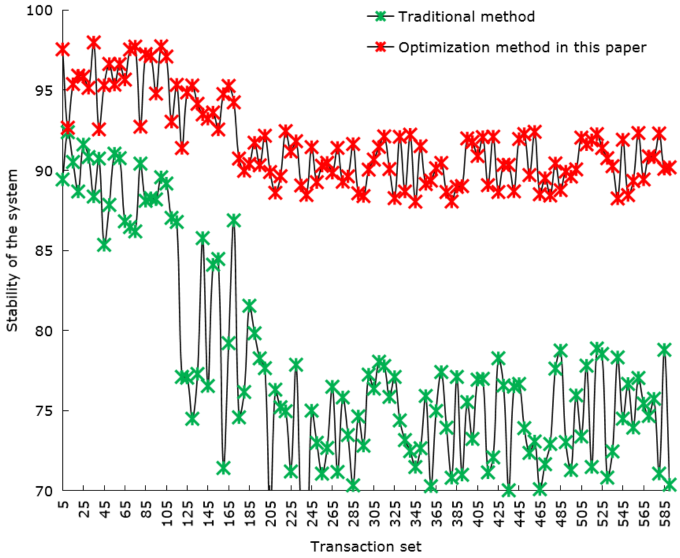

Figure 3: Stability of the system.

According to the data in Figure 4, it takes a short time for multi-disciplinary teams to use the system for collaborative design, which is basically between 30 minutes and 55 minutes. This shows that the system can significantly improve the efficiency of collaborative design. The traditional collaborative design stage often needs a lot of time on communication and coordination, but the system proposed in this article enables team members of different majors to collaborate more efficiently by providing a unified platform and tools. Figure 5 shows the scores of multi-professional teams on the system's operation convenience, function satisfaction, and picture fluency.

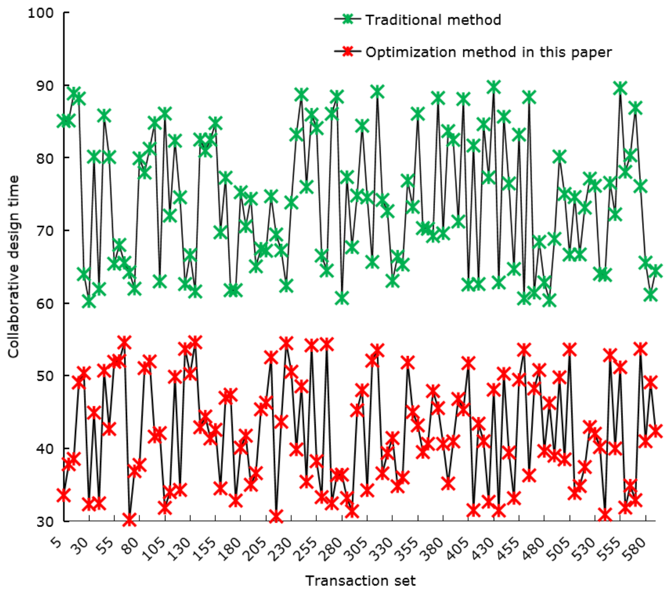

Figure 4: Collaborative design time.

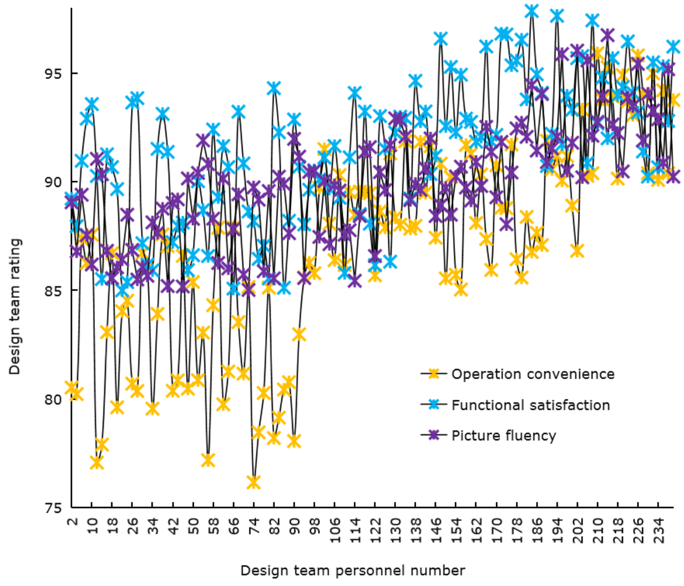

Figure 5: Design team rating results.

The results in Figure 5 fully demonstrate the positive evaluation of the system proposed in this article by multi-professional teams in terms of operation convenience, functional satisfaction, and screen fluency. This serves as evidence not only for the system's superiority in terms of user experience and functionality but also lends credence to its extensive applicability within the architectural design industry.

In addition, in order to further verify the practicability of the system, several typical architectural design cases are selected for application research in this section. These cases cover different types of buildings and different design requirements, such as houses, office buildings, and public facilities. Figure 6 and Figure 7 show the architectural design cases using the traditional method and the method in this article, respectively.

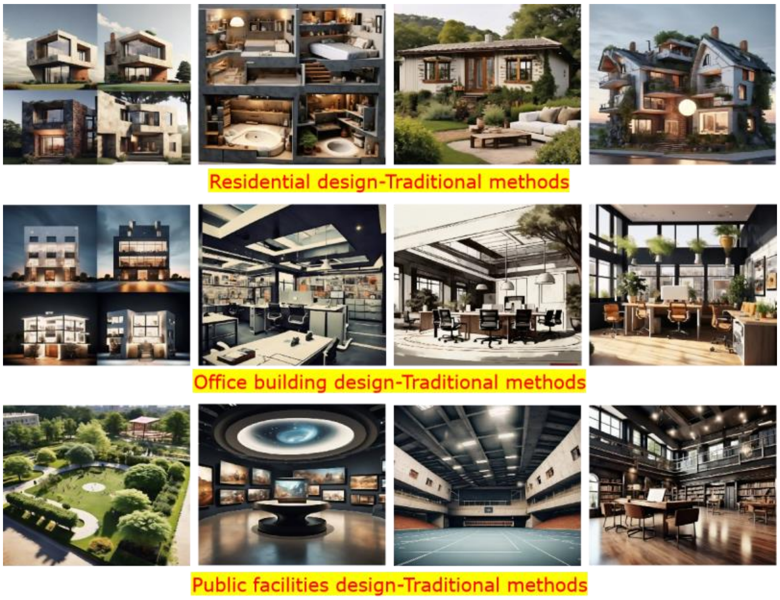

Figure 6: Architectural design traditional method.

Figure 7: Architectural design-optimization method in this article.

For the above architectural design cases, 236 users were randomly invited to score the innovative design scheme, and the scoring results are shown in Figure 8.

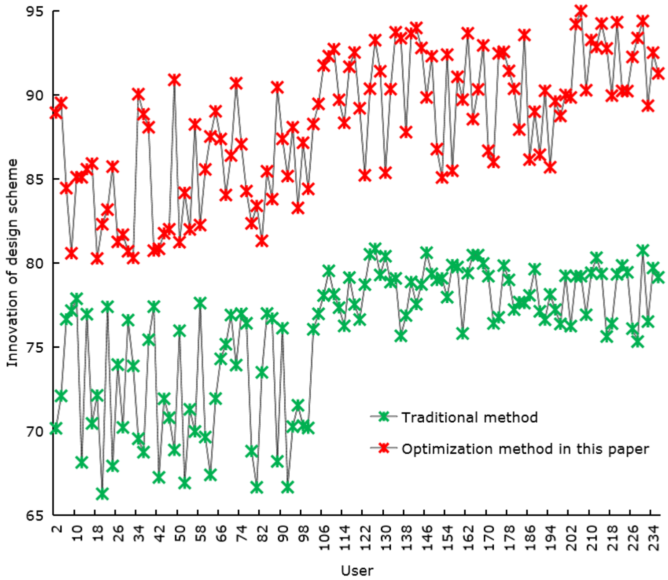

Figure 8: Innovative scoring results of a design scheme.

The innovation score of the traditional method shows a certain distribution range, but the overall score is relatively low. This shows that traditional methods may be innovative in some aspects, but they may be limited by traditional thinking and methods as a whole. In contrast, the design scheme of the optimization method in this article gets a higher score in terms of innovation. The score distribution is more inclined to the high score area, which shows that this method has significant advantages in innovation.

In this section, by comparing the architectural design schemes before and after optimization, it is found that the performance index of the optimized scheme has been significantly improved. At the same time, the optimization strategy based on DM can better explore the design potential and improve the design quality.

7 SUMMARY AND PROSPECT

7.1 Summary of Research Work

This research is devoted to the research and use of architectural design optimization systems based on CAD and DM. By deeply studying the application of CAD technology and DM algorithm in architectural design, this article constructs a system integrating CAD modeling, DM, and design optimization. The system can use historical design data and performance simulation data to provide data-based decision support for designers and improve the quality of architectural design.

During the research phase, this article has accomplished a range of tasks, including the design of the system's overall architecture, the integration and implementation of CAD and DM modules, the segmentation and meticulous design of system functional modules, as well as system implementation and testing. Through experimental analysis and application case study, the practicability of the system is verified.

7.2 Insufficient Work and Prospect

Although some achievements have been made in this study, there are still some shortcomings:

There is still room for further optimization in the selection and application of the DM algorithm. In the future, we can try to adopt more advanced algorithms, such as deep learning, to improve the effect and accuracy of DM.

The user interface and interactive experience of the system need to be further improved to improve the convenience and satisfaction of users.

In the application case study, the architectural types and design requirements involved are not extensive enough. In the future, it can be extended to more types of buildings and more complex design scenes.

In view of the above shortcomings and prospects, this article puts forward the following suggestions for future research reference:

More advanced DM algorithms, such as deep learning and reinforcement learning, are deeply studied and applied to architectural design optimization to improve the optimization effect and accuracy.

Improve the user interface and interactive experience of the system, provide a more friendly and intuitive operation mode, and reduce the learning cost and difficulty of users.

Expand the application scope of the system and apply it to more types of buildings and more complex design scenes to verify the universality and adaptability of the system.

Pay attention to emerging technologies and trends, such as AI, big data, cloud computing, etc., explore their application potential in the field of architectural design, and bring new innovations and breakthroughs to architectural design.

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