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Optimization of Landscape Design Scheme and Data Mining Based on CAD Data

Shanshan Wu[1] and Shitao Wang[2]

[1]Department of Art and Design, Hefei University of Economics, Anhui, Hefei 230000, China, wakeykey@163.com
[2]College of Public Administration, Nanjing Agricultural University, Jiangsu, Nanjing 210000, China, macgnoir@gmail.com

Corresponding author: Shanshan Wu, wakeykey@163.com

Abstract. Firstly, this article collects and sorts out relevant documents and summarizes and analyzes the application of CAD (Computer Aided Design) technology and DM ((Data Mining) technology in landscape design. Then, a suitable CAD software platform is selected, a landscape design model based on CAD technology is constructed, and the model is verified and preliminarily applied. Moreover, this article uses DM technology to analyze and process CAD data, extract design elements, analyze the relationship between design elements, and optimize the model based on this information. Finally, through case analysis and empirical research, the feasibility and practicability of the optimized landscape design model are verified, and the research results are discussed and summarized. The optimization algorithm shows high accuracy and stability in the experiment, which together form the basis of the algorithm's superior performance. High accuracy ensures that the information or decision provided by the algorithm is reliable, while high stability ensures the consistency of this performance in different situations and multiple uses. Moreover, the optimized scheme of this article has obtained higher assessment in many assessment dimensions, which shows that designers and experts have a positive attitude towards the modified design scheme. This verifies the feasibility and practical value of this research method.

Keywords: Data Mining; Computer-Aided Design; Particle Swarm Optimization; Landscape Design; Design Scheme Optimization
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1 INTRODUCTION

As society progresses and living standards rise, landscape design has become a pivotal aspect of urban planning and construction, garnering increasing attention. Presently, the landscape design industry is shifting from traditional hand-drawn methods toward digital and intelligent designs. CAD technology, renowned for its efficiency and precision, has emerged as a prevalent tool in this domain.

The application of computer vision and deep learning technology in the field of environmental landscape design and planning is becoming increasingly widespread. These technologies provide designers with more efficient and precise tools, making the design process more intelligent. Chen [1] discussed how to apply computer vision and deep learning technologies to environmental landscape design and planning and introduced a system based on these technologies. Deep learning-based 3D reconstruction techniques can generate 3D models based on 2D images or videos. This provides designers with a more realistic and detailed environmental model, which helps them better carry out landscape design. Computer vision technology can help designers automatically identify and classify landscape elements in the environment, such as vegetation types, architectural styles, etc. This helps designers better understand the site conditions and make targeted designs. Deep learning techniques can evaluate and optimize landscape design schemes. This system is based on computer vision and deep learning technology, integrating functions such as data collection, 3D modeling, landscape element recognition, planning scheme evaluation, and optimization. Designers can quickly obtain site data, generate 3D models, and understand the distribution of landscape elements through this system. Utilizing CAD, designers can present their visions more vividly, enhancing both the speed and quality of the design process. Flipped classroom, as an innovative teaching model, is gradually being widely applied in various subject teaching. As a highly practical course, computer-aided landscape design is of great significance in cultivating students' practical skills and innovative thinking. Da et al. [2] explored the application and effectiveness of flipped classrooms based on the Rain Classroom platform in computer-aided landscape design teaching. The computer-aided collaborative design system based on Rain Classroom data provides strong support for landscape architecture design, enabling designers to better utilize color effects. Through the precise expression of data, real-time collaboration, and feedback mechanism of CSCDS, it can achieve a more harmonious, unified, and innovative landscape architecture design.

With the advent of the digital age, the demand for completed model landscape architecture is increasing day by day. However, traditional modeling methods are inefficient and have low accuracy. In recent years, deep learning technology has made significant progress in the fields of image processing and computer vision, providing new possibilities for efficient and accurate modeling of completed model landscape architecture. Han et al. [3] explored how to apply deep learning techniques to scan two drawings to achieve automated modeling of completed landscape architecture models. Deep learning algorithms can effectively extract features from point cloud data, thereby automatically generating finished models. By using convolutional neural networks (CNN) and other algorithms, the surface geometric structure and texture information of buildings can be learned from point cloud data, and high-precision 3D models can be reconstructed. Deep learning techniques can also optimize and enhance the details of generated models. It utilizes technologies such as Generative Adversarial Networks (GANs) to automatically repair and improve the texture and details of the model surface, improving the realism and visual effects of the model.

The parameterized design method based on CAD data can achieve flexibility and controllability in design through parameter adjustment, providing new ideas for the optimization of traditional gardens. Han et al. [4] explored how to apply CAD-based parametric design to the optimization of traditional gardens. Based on CAD data, a parametric model can be established to express the design through the logical relationship between parameters. By setting terrain parameters, it is possible to control the undulating changes of the terrain precisely; by setting vegetation parameters, the distribution and types of vegetation can be reasonably planned. Based on parameterized models, various optimization analyses can be carried out, such as landscape line of sight analysis, spatial streamline analysis, lighting analysis, etc. Through these analyses, problems in traditional gardens can be identified, and corresponding optimization plans can be proposed. The visualization technology based on CAD data can render and display the parameterized models of traditional gardens in real time. Through interactive technology, designers can interact with models, adjust design schemes, and achieve human-computer interaction design patterns. Within the realm of landscape design, DM technology aids designers in comprehending user needs and deciphering the intricacies among design elements, ultimately leading to optimized design solutions. Consequently, the integration of CAD and DM technologies holds immense potential in elevating the scientific rigor and practical applicability of landscape design.

Using CAD data and DM technology to optimize the landscape design scheme can not only improve the design efficiency and quality but also make the design scheme more in line with the needs of users and the actual situation. Specifically, the research significance of this article is embodied in the following aspects: (1) Improving design efficiency: By analyzing and processing CAD data through DM technology, design elements can be automatically extracted, and design schemes can be generated, thus reducing the workload of designers and improving design efficiency. (2) Improve the design quality: DM technology can help designers analyze the relationship between design elements and predict the design effect, thus avoiding potential problems in the design process and improving the design quality. (3) Meet the user's needs: Analyzing and mining the user's needs through DM technology can make the design scheme more in line with the user's expectations and needs and improve the user's satisfaction. (4) Promote the growth of the landscape design field: Combining CAD technology with DM technology can bring new design ideas and methods to the landscape design field and promote innovation and development in this field.

The purpose of this study is to establish a landscape design model through CAD data and optimize the model by using DM technology. The chapters of the article are arranged as follows:

Section I: Introduction. This article introduces the development status of landscape design, the application of CAD in landscape design, and the importance of DM technology in optimizing design schemes. The necessity and potential value of optimizing landscape design schemes by using CAD data and DM technology are expounded. Summarize the main steps, methods, and technical routes of the research.

Section II: Theoretical basis and literature review. Reviewing the growth of CAD technology and its application cases in landscape design; Explain the basic concept, technology, and application of DM in related fields. This article summarizes the research progress of landscape design scheme optimization, points out the shortcomings of current research, and discusses the innovations of this study.

Section III: Construction of landscape design model based on CAD technology. Determine the basic principles of model design and meet the functional requirements; Select appropriate CAD software and auxiliary tools to build the model; Describe the steps and methods of building the model in detail.

Section IV: Optimization of landscape design model based on DM. Select the appropriate DM method according to the research objectives; preprocess CAD data to extract key features for analysis; design the optimization method for the landscape design model.

Section V: Case analysis and empirical research. Select the appropriate landscape design case as the research object and explain the data source. The optimized model is used to analyze the case and show the optimization effect.

Section VI: Conclusion and Prospect. Summarize the main findings and conclusions of this study; Explain the contribution and practical significance of this study to the field of landscape design; Admit the shortcomings of the research, and put forward the direction and suggestions for future research.

2 THEORETICAL BASIS AND LITERATURE REVIEW

By utilizing computer big data technology, in-depth analysis of the spatial form of landscape architecture can be conducted. Hu et al. [5] discovered the potential relationship between spatial form and environmental factors through data mining and machine learning techniques, providing a basis for design. Digital nonlinear landscape architecture design utilizes parametric design methods to associate spatial form with design parameters. By adjusting parameters, real-time changes in spatial form can be viewed, providing designers with more design freedom. Optimization algorithms based on computer big data can optimize the spatial form of landscape architecture. Through simulation technology, designers can preview the spatial form effects under different conditions for decision-making. Taking a city park as an example, the designer utilized computer big data technology to perform digital nonlinear design on the landscape architecture of the park. First, through data collection and analysis, understand the environmental factors around the park; Then, use parametric design methods to establish a spatial form model; Next, preview the effects of different design schemes through simulation techniques; Finally, use optimization algorithms to adjust and optimize the design scheme.

With the advent of the digital age, the application of computer-aided design (CAD) in the field of landscape planning is becoming increasingly widespread. As a new design method, parameterized models can achieve flexibility and controllability in design by adjusting parameters. Jia [6] discussed how to use computer-aided design methods to construct parameterized models for landscape planning. A parametric model is a method of expressing design through the logical relationship between parameters. It can use parameterized models to precisely control the height, slope, curvature, and other parameters of the terrain, achieving the refinement of terrain design. Through parameterized models, the distribution range and growth conditions of vegetation can be defined, achieving a reasonable layout of vegetation. Through parameterized models, the location, size, and other parameters of landscape facilities can be determined to meet functional requirements while maintaining overall aesthetics. Taking the landscape planning of a certain park as an example, a parameterized model is used for computer-aided design. First, set relevant parameters based on the functional requirements and terrain conditions of the park. Then, use modeling software to construct a parameterized model and make adjustments and optimizations. Next, use the rendering function to view the effects from different angles. Finally, based on the results of the effectiveness evaluation, the scheme is selected and further designed. Landscape design is not only about aesthetics but also about ecology, functionality, and social culture. In the digital age, computer-aided design (CAD) technology provides powerful tools for landscape design. Lavorel et al. [7] explored how to construct a multifunctional landscape design template based on CAD data, combined with the concept of landscape ecology, to achieve a sustainable and humanized urban environment. CAD technology provides infinite possibilities for landscape designers with its precise drawing, modeling, and data analysis capabilities. Designers can create 3D models through CAD software for simulation analysis of lighting, line of sight, pedestrian flow, etc., in order to better understand the performance and effectiveness of design schemes. In addition, CAD data also provides detailed and accurate guidance for the subsequent construction phase. Taking a city park as an example, the designer used CAD software to create a three-dimensional terrain model and carried out vegetation planning based on the principles of landscape ecology. Through simulation analysis, the designer successfully achieved the natural collection and purification of rainwater while utilizing solar energy to provide some energy for the park. In addition, the design of the park fully considers people's needs and provides abundant leisure facilities.

Urban landscape design faces many challenges, such as limited land resources, protection of the ecological environment, and the diverse needs of urban residents. Traditional linear design methods make it difficult to deal with these complex problems, while nonlinear scientific theory provides new ideas for solving these problems. Liu et al. [8] explored how to use computer-aided design (CAD) nonlinear theory to simulate multidimensional urban landscape design parameters. It simulated the evolution of urban spatial layout using nonlinear models and predicted the impact of different design schemes on urban development. Simulating the operation process of urban ecosystems, such as the water cycle and biological migration, through nonlinear models provides a basis for ecological protection and restoration. Simultaneously, nonlinear models are utilized to predict the behavior patterns of urban residents under different landscape designs in order to meet their diverse needs. Taking a city park as an example, using CAD nonlinear theory to simulate multidimensional landscape design parameters. Firstly, obtain terrain, vegetation, and other data on the park's location through GIS technology. Secondly, ecological models to simulate the operation of park ecosystems. In the field of landscape design, machine learning technology provides designers with more efficient and accurate design tools. Liu et al. [9] explored how to apply machine learning technology to the landscape design of Hlai ethnic villages and introduced a machine learning-based landscape design visualization system. It utilizes machine learning algorithms to extract and classify the features of

Hlai ethnic villages. By using image recognition technology, automatically identify features such as architectural style and vegetation type, providing a basis for landscape design. It optimized the landscape spatial layout of the Hlai ethnic village based on machine learning optimization algorithms. Through simulation techniques, designers can preview the effects of different layout schemes for decision-making purposes. A machine learning-based visualization system can render and display the landscape design scheme of the Hlai ethnic village in real time. Through interactive technology, designers can interact with the system and adjust design plans. Designers can quickly obtain relevant data about the Hlai ethnic village, understand site characteristics, adjust and optimize spatial layout through this system, and view the effect of design schemes in real time through visualization technology.

Landscape design and planning in the process of urbanization need to fully consider environmental factors, especially soil erosion and connectivity issues. Soil erosion may lead to land degradation, decreased biodiversity, and increased flood risk, while connectivity is related to the health of ecosystems and the maintenance of biodiversity. Michalek et al. [10] explored the application of Particle Swarm Optimization (PSO) in modeling the relationship between soil erosion and connectivity in urban landscapes. Particle swarm optimization is an optimization algorithm based on swarm intelligence, which simulates the social behavior of organisms such as bird and fish schools to find the optimal solution to the problem. In urban landscapes, PSO can be used to construct models to simulate the dynamic relationship between soil erosion and connectivity. This model can help us better understand the impact of urbanization on the ecological environment and provide a scientific basis for landscape design and planning. By utilizing the PSO algorithm, we can construct a connection model between soil erosion and connectivity in urban landscapes. This model will comprehensively consider the effects of terrain, vegetation cover, rainfall, and other factors on soil erosion and connectivity. In rural environmental landscape construction, VR technology can provide a risk-free and comprehensive preview experience, helping designers and decision-makers better understand and evaluate design schemes. Sun et al. [11] explored how to apply virtual reality technology to rural environmental landscape construction. Through VR technology, villagers can experience landscape design schemes firsthand. This not only enhances the understanding and participation of villagers in planning but also helps designers obtain broader feedback. VR technology can provide training for villagers in environmental protection and landscape construction, helping them understand the importance of sustainable development and how to practice these concepts in their daily lives. Taking a certain rural area as an example, designers use virtual reality technology for environmental landscape design. Firstly, collect site data through on-site inspections and measurements. Then, use this data to create a 3D model in VR software for scheme design. Subsequently, the villagers experienced the design scheme through VR devices and provided feedback. The rural environmental landscape construction based on virtual reality technology is an innovative planning method. It not only improves the efficiency and quality of design but also enhances the sense of participation and belonging of villagers.

Digital landscape design has become an important means of urban planning and construction. As a new computing model, edge computing provides new opportunities and challenges for digital landscape design. Wu and Yan [12] discussed the application and mechanism of edge computing in digital landscape design. Using edge computing technology, it can collect and process various data needed for landscape design in real-time, such as terrain, vegetation, climate, etc. Through edge computing, the landscape is simulated and predicted in real time to adjust and optimize the design scheme in time. Based on the data analysis and processing capability of edge computing, it provides intelligent decision support for designers and improves design efficiency and quality. Take the digital landscape design of a city park as an example. By using edge computing technology, designers can collect and process various data in the park in real-time, such as soil moisture, air quality, pedestrian flow distribution, etc. Based on these data, designers can conduct real-time simulations and prediction adjustments and optimize design schemes. Meanwhile, through intelligent decision support, designers can better understand the ecological conditions and tourist needs of the park and improve the scientific and rational design. In landscape design, plants, as important design elements, play a crucial role in creating visual effects and ecological functions of the landscape. The color effect can especially directly affect people's visual perception and psychological reactions. However, in practical landscape design, especially low-cost plant landscape design, effectively utilizing color effects is often a major challenge. The Computer Assisted Collaborative Design System (CSCDS) provides a new solution to this challenge. Xu and Wang [13] discussed how to achieve color effects in low-cost plant landscape design under CSCDS. CSCDS can simulate the growth process and color changes of plants, helping designers anticipate the final landscape effect in the early stages and better adjust design plans. The color effect is an important visual element in landscape design, which plays a crucial role in creating the atmosphere and effect of the landscape. Rich visual effects can be created through reasonable color matching while also reflecting the theme and style of the design. It utilizes the principles of color psychology to influence people's emotions and psychological reactions through color, thereby achieving better landscape effects.

Environmental landscape art design is an important bridge connecting humans and nature. With the advancement of technology, computer-aided design (CAD) is playing an increasingly important role in landscape design. Yu et al. [14] explored how to use CAD data for dynamic nonlinear parameterized environmental landscape art design in order to achieve more natural and harmonious design effects. Dynamic nonlinear parametric design is a computer-based architectural design method that utilizes parametric techniques to adjust and optimize the design dynamically. Taking the landscape design of a certain park as an example, the designer uses CAD data for dynamic nonlinear parametric design. Firstly, accurately simulate terrain, vegetation, water bodies, etc., through 3D modeling; then, use parameterization techniques to set different dynamic response mechanisms, such as vegetation growth, dynamic changes in water flow, etc. Finally, through data analysis and optimization, the design scheme is improved and optimized. The dynamic nonlinear parameterized environmental landscape art design based on CAD data provides designers with a new design concept and method. By utilizing CAD data and parameterization techniques, designers can better simulate natural forms, consider human needs, and achieve dynamic adjustment and optimization of designs. Zhang and Deng [15] discussed how to achieve color effects in landscape architecture design using CAD data-based CSCDS. Using CAD data, designers can create three-dimensional models that intuitively express design intentions, providing a foundation for the application of color effects. CAD data provides accurate measurement information, allowing designers to more accurately grasp the color relationship between buildings and their surrounding environment. Through the rendering function of CAD software, designers can preview the color effects of the design and adjust and improve the design scheme in a timely manner. CSCDS supports multiple people to edit online simultaneously, allowing designers to discuss and adjust color schemes in real time, achieving better color matching. Through parameterized design, designers can more accurately control the use of colors, achieving more harmonious and unified color effects. Taking the landscape architecture design of a city park as an example, the designer used CSCDS based on CAD data for design.

3 CONSTRUCTION OF LANDSCAPE DESIGN MODEL BASED ON CAD TECHNOLOGY

Since the birth of CAD technology in the 1960s, it has become an indispensable tool in various design fields. The growth of CAD technology has experienced the transformation from 2D drawing to 3D modeling, from single function to integration and intelligence. Early CAD systems were mainly based on simple graphics processing and storage technology. Later, with the rapid growth of computer technology, CAD systems gradually integrated complex geometric modeling, engineering analysis, optimization design, and other functions.

In the field of landscape design, the application of CAD has also experienced a similar evolution. Designers began to use CAD software to draw 2D graphics such as plans, elevation, and sections and gradually developed to use 3D CAD technology to create realistic scene simulations and dynamic demonstrations. Moreover, it also introduces how to improve the modeling efficiency, ensure the model accuracy, and optimize the design scheme. Through CAD technology, landscape designers can express their design intentions more intuitively and communicate with customers and team members more effectively. In addition, CAD technology also promotes the cross-integration of landscape design and other related fields, such as the application of architectural information model technology in landscape design.

DM involves extracting subtle, undisclosed, yet beneficial information from substantial datasets. It integrates knowledge and techniques from statistics, machine learning, database systems, and various other fields. In real-world scenarios, DM assists users in unearthing the inherent connections and patterns within data, thereby aiding decision-making processes. The application of DM technology spans numerous domains, including financial risk mitigation, marketing strategies, and medical diagnostics. While its utilization in landscape design may be comparatively niche, it harbors immense untapped potential. This method first extracts design knowledge from historical design cases by using DM technology and then automatically optimizes the design scheme by combining it with a multi-objective optimization algorithm. In addition, DM can also help landscape designers better understand user needs and market trends and improve the pertinence and innovation of design schemes.

As the landscape design industry continues to expand, refining design approaches has emerged as a pivotal research topic. Both domestic and international scholars have extensively delved into optimizing landscape designs, primarily concentrating on several key areas. Firstly, aesthetic-based optimization techniques aim to enhance the visual appeal of designs by refining the arrangement and integration of landscape components. Secondly, ecological principles guide optimization methods that prioritize the ecological functions and Sustainability of landscapes. Thirdly, intelligent algorithms, such as genetic algorithms and Particle Swarm Optimization (PSO), mimic natural optimization processes to identify the most effective design solutions. Their case studies underscore the significant role and practical value of parametric modeling and simulation analysis in refining landscape designs. These investigations offer theoretical foundations and practical insights for optimizing landscape design strategies. However, there are still some shortcomings in the optimization research of landscape design schemes at present. For example, most of the existing research focuses on the realization of a single optimization goal but lacks in-depth research on multi-objective optimization problems. In addition, the existing optimization methods often face challenges such as large amounts of calculation and unstable optimization effects when dealing with complex landscape design problems. Therefore, this study aims at improving Innova.

In light of the limitations present in current research, this study introduces several notable innovations: First, this study combines CAD technology with DM technology, provides rich design information by using CAD data, and optimizes the landscape design scheme by analyzing these data and extracting useful information through DM technology. Secondly, this study will comprehensively consider multiple optimization objectives, such as aesthetics, ecology, and economy, and establish a multi-objective optimization model to find the optimal design scheme. Finally, this study will use advanced intelligent optimization algorithms to deal with complex landscape design problems and improve the efficiency and stability of optimization. These innovations are expected to provide new ideas and methods for the optimization of landscape design schemes. When building a landscape design model based on CAD technology, it is necessary to make clear the basic principles of model design and the functional requirements to be met. These principles and requirements will guide the whole model construction process and ensure that the final model can meet the needs of practical application. See Table 1 for details.

Fundamental principle	*Analysis*	*Function requirement*	*Analysis*
Accuracy	The model must be able to accurately reflect all elements in landscape design to ensure the accuracy of the design scheme.	Programme presentation	The model should be able to visually display the design scheme, including floor plan, elevation plan, 3D effect map, etc., which is convenient for designers to communicate with customers and other team members.

Flexibility	The model needs to be flexible, can adapt to different types and scales of landscape design projects, and is convenient for designers to adjust and modify.	Data analysis	The model should be able to support statistical analysis of design data, such as area calculation and material estimation, and provide a basis for design decisions.
Usability	The model should be easy to understand and operate so that designers can use the model efficiently for design work.	Scheme optimization	The model should be able to support the optimization of the design scheme, such as automatically adjusting the layout and optimizing materials, so as to improve the design efficiency and quality.

Table 1: Basic principles and functional requirements.

Moreover, choosing appropriate CAD software and auxiliary tools for model construction is very important. When choosing, you need to consider the function, performance, ease of use, compatibility, and price of the software. Commonly used CAD software platforms, such as AutoCAD, SketchUp, and Rhino, all have powerful modeling and drawing functions that can meet the needs of landscape design. In addition, you can also choose some professional landscape design plug-ins or extension tools, such as Landscape Design Software and Vectorworks Landmark, which provide specific functions and tools for landscape design and can further improve design efficiency. The function of a scene assembler is to assemble semantic 3D scenes. The module takes the 3D scene ID requested by the user as input, analyzes the user's request, finds the corresponding ontology from the model ontology library, and then assembles the target scene model. The process is shown in Figure 1.

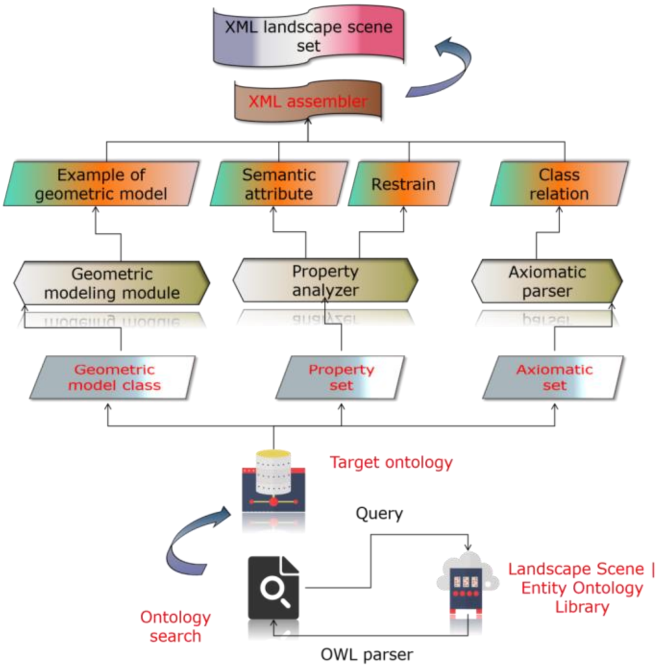

Figure 1: Flow chart.

The model-building process in this article is a systematic and detailed work. Firstly, the basic data of landscape design projects, such as topographic maps and vegetation distribution maps, are collected from various channels, and these original data are preprocessed, such as format conversion and coordinate registration, to ensure their compatibility with CAD software. Then, using the 3D modeling technology of CAD software, the terrain model is carefully constructed according to the terrain data to reproduce the real natural elements such as mountains and water bodies. Subsequently, according to the distribution information and characteristic parameters of vegetation, the vegetation model is created in detail in the software, including rich kinds of trees, shrubs, and vast grasslands [13]. In addition, according to the specific requirements of the design scheme, this article also accurately constructs 3D models of various buildings and facilities, such as elegant pavilions and unique sculptures, in a CAD environment. Finally, these independently constructed model elements are organically integrated to form a comprehensive and coordinated landscape design model, and the overall scheme is carefully adjusted and optimized according to the aesthetic principles and functional requirements of the design to ensure that the final design scheme is not only beautiful and practical but also fully meets the requirements and standards of the project.

After the model is built, the feasibility and practicability of the model are verified by cases and experiments. In this article, some typical landscape design cases are considered, and the design practice is carried out by using the constructed model. By comparing the actual design scheme with the model output results, the accuracy and reliability of the model are verified. Moreover, this article invited other designers and experts to evaluate and provide feedback on the model in order to improve it further. Through the verification and application of this step, it can be ensured that the constructed landscape design model has practical application value.

4 OPTIMIZATION OF LANDSCAPE DESIGN MODEL BASED ON DM

In the process of optimizing the landscape design model, choosing the appropriate DM method is the key. Considering that the goal of this study is to extract useful information from CAD data to optimize the design scheme, this article will use historical design data to train the classification model and predict the performance of the new design scheme to guide the design decision. Before DM, preprocessing and feature extraction of CAD data are essential steps. Pretreatment includes data cleaning, format conversion, and standardization to ensure the quality and consistency of data. Feature extraction involves extracting key features that are meaningful for analysis from the original data, such as the type, size, and location of design elements. At this stage, the design model is decomposed and reconstructed by using the built-in functions and custom scripts of CAD software, and the key features for subsequent analysis are extracted. These features will be used as the input of the DM algorithm, which will directly affect the quality and accuracy of optimization results.

Aiming at the characteristics and optimization objectives of the landscape design model, this article designs a special optimization algorithm. Based on the extracted feature data, the optimization algorithm uses the design patterns and relationships found by the DM method to adjust and optimize the design scheme automatically or semi-automatically. PSO is an optimization algorithm inspired by the study of the foraging behavior of birds. Assuming n particles are traveling at a fixed velocity within an-dimensional space, let us denote their population X .

$$X = X_1, X_2, \cdots, X_n \tag{1}$$

The location of the i particle can be described as:

$$X_i = x_{i1}, x_{i2}, \cdots, x_{iD} \tag{2}$$

The speed of the i particle is represented as:

$$V_i = v_{i1}, v_{i2}, \cdots, v_{iD} \tag{3}$$

Determine the fitness score pertaining to X_i based on the objective, and its personal peak value stands at:

$$P_i = (p_{i1}, p_{i2}, \cdots, p_{iD}) \tag{4}$$

The overall maximum (or minimum) value within the entire population, known as the global extremum, is:

$$P_g = (p_{g1}, p_{g2}, \cdots, p_{gD}) \tag{5}$$

The revised equations for calculating the velocity and position of the particle are as follows:

$$v_{ij}(t+1) = wv_{ij}(t) + c_1 r_1 (p_{ij}(t) - x_{ij}(t)) + c_2 r_2 (p_{gi}(t) - x_{ij}(t)) \tag{6}$$

$$x_{ij}(t+1) = x_{ij}(t) + v_{ij}(t+1) \tag{7}$$

$$i = 1, 2, \cdots, n; j = 1, 2, \cdots, d \tag{8}$$

In this context, w it serves as the inertia weight.

In the optimization of landscape design model based on DM, PSO can be used to find the best design scheme. The following are the specific steps:

Initialize particle swarm: In this step, it is necessary to determine the size of the particle swarm, that is, the number of particles, as well as the initial position and speed of each particle. Under the background of landscape design model optimization, each particle can represent a potential design scheme, and its position can be regarded as a combination of design parameters (such as vegetation type, layout mode, etc.). Speed represents the moving direction and step size of the design scheme in the search space.

Design Evaluation Criteria: The fitness function serves as a metric for assessing the caliber of each particle, effectively gauging the adequacy of the design approach. In refining the landscape design model, this function aligns with distinct design goals and limitations, encompassing aesthetics, ecology, and economy. Assessing the fitness value of each particle determines whether the present design aligns with the prescribed standards.

Particle Adjustments: Guided by the PSO principles, particles adapt their velocity and position, drawing from their personal best positions and the collective's historical optimum. In the context of landscape design optimization, this translates to refining each design approach based on its individual and global peaks, ultimately seeking a superior design.

Iterative Refinement: This process involves repeatedly implementing the aforementioned steps, enabling the particle swarm to navigate the search space efficiently in pursuit of an improved design. Once a satisfactory design is located, the algorithm halts its iterations and presents the most optimal design solution.

After completing the model optimization, the optimization results are analyzed and discussed in detail. This includes comparing the differences between the design schemes before and after optimization in aesthetics, ecology, and economy, evaluating the effectiveness and stability of the optimization algorithm, and discussing the significance and value of the optimization results in practical application.

5 CASE ANALYSIS AND EMPIRICAL RESEARCH

In order to verify the practicability and effect of the optimized landscape design model, this study carefully selected several representative landscape design cases as the research object. These cases cover landscape design projects of different scales and types (parks, residential areas, commercial areas, etc.), which have certain universality and reference values. In terms of data sources, it mainly relies on public landscape design databases, professional magazines, design competition-winning works, and other channels. Moreover, this article also cooperated with some landscape design companies and obtained valuable data accumulated by them in actual projects. These data include design drawings, renderings, construction documents, etc., which provide rich materials for this study. In the process of case analysis, first, the basic data of each case are sorted and summarized to ensure the accuracy and consistency of the data. Then, the optimized landscape design model is applied to analyze the case. Specifically, the key design features in the case are extracted by using DM technology, and these features are input into the optimization model to generate the optimized design scheme.

In order to show the optimization effect intuitively, the design schemes before and after optimization are compared and analyzed in various ways. In this article, contrast charts and effect diagrams are made to show the improvement of the optimized scheme in terms of aesthetics, ecology, and economy from the visual and data levels. The design scheme before and after optimization is shown in Figure 2 and Figure 3.

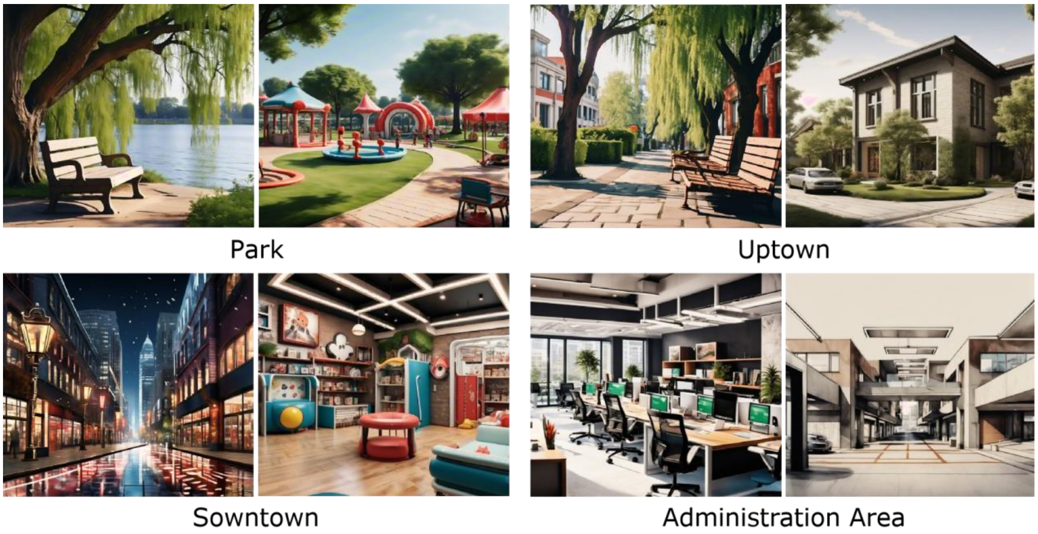

Figure 2: Design scheme before optimization.

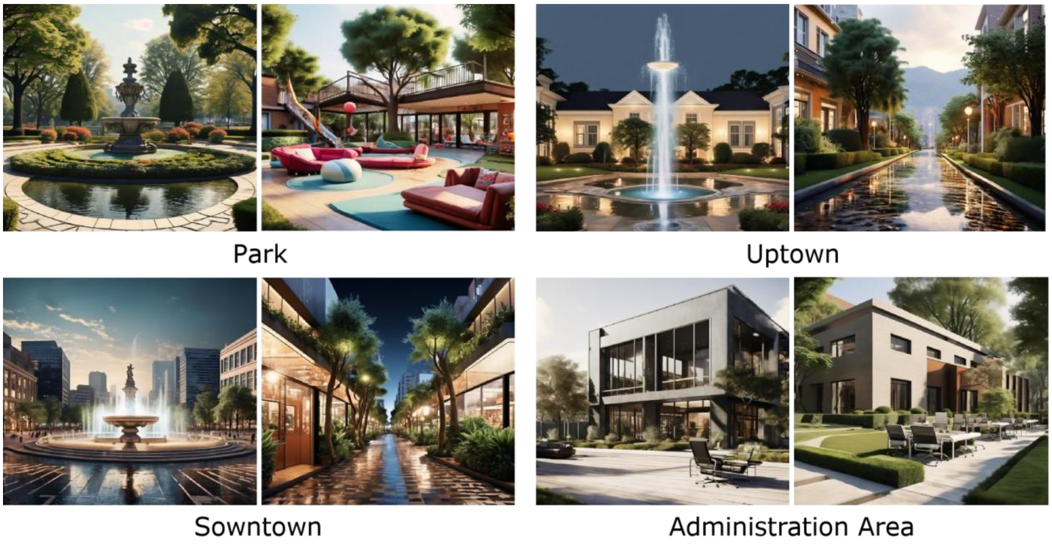

Figure 3: Optimized design scheme.

In this section, 756 users are invited to rate the two design schemes above, and the results are shown in Figure 4.

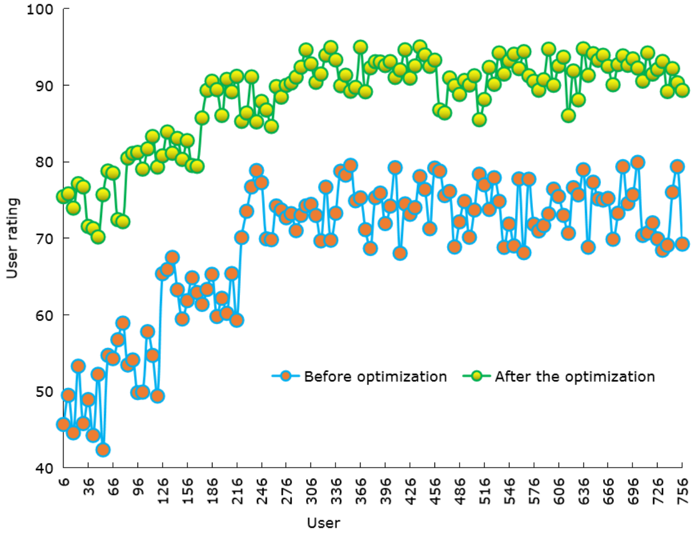

Figure 4: User rating.

The score of the optimized scheme is obviously higher than that of the pre-optimized scheme in all aspects. The optimized scheme gets a higher score, which directly reflects the user's recognition and satisfaction with the design improvement, and at the same time, shows that the optimization work carried out by the design team for the user's needs and feedback is effective. It provides valuable feedback for the design team and points out the direction of continuous improvement in the future. Moreover, this article invited some designers and experts to make multidimensional assessments and feedback on the design scheme before and after optimization, and the results are shown in Figure 5.

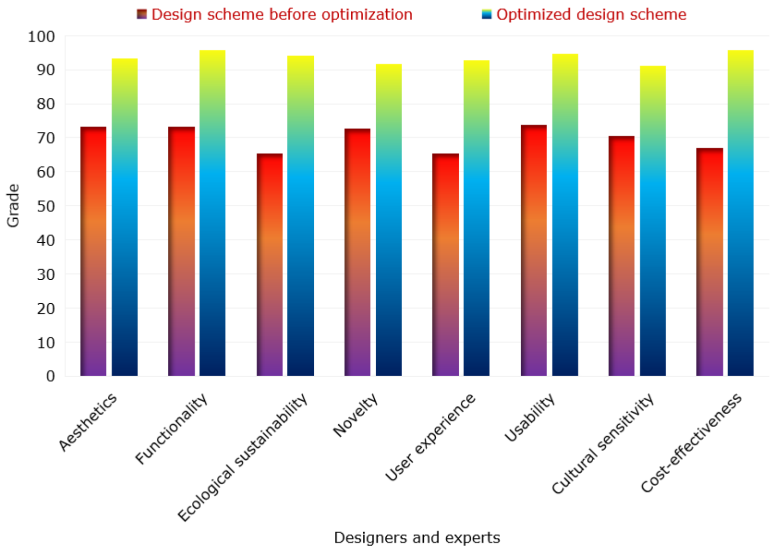

Figure 5: Assessment results.

It is a very important step to invite designers and experts to evaluate and give feedback on the design scheme before and after optimization because they can provide in-depth insights from a professional perspective. Figure 5 shows the assessment results of these professionals on the design scheme, and the optimized scheme has obtained higher assessment in multiple assessment dimensions, indicating that designers and experts have a positive attitude towards the modified design scheme. This recognition not only verifies the professionalism of the design team but also enhances the credibility and acceptance of the change plan in the industry. The accuracy and stability of the optimization algorithm are shown in Figures 6 and 7.

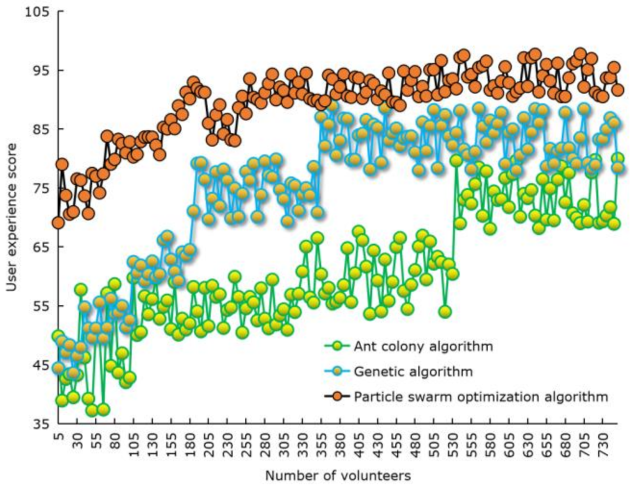

Figure 6: Accuracy of optimization algorithm.

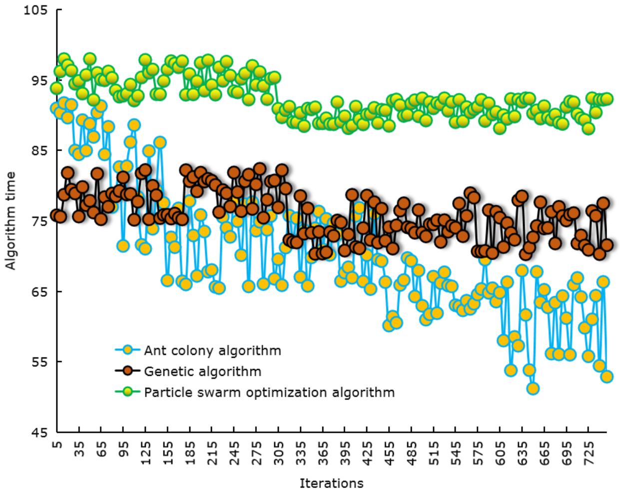

Figure 7: Stability of optimization algorithm.

The experimental findings indicate that the optimization algorithm attains an accuracy level exceeding 93%. This shows that the algorithm can make correct decisions or provide accurate answers very frequently when dealing with related problems. This high accuracy is very important for many application scenarios because it is directly related to the credibility and practicability of the algorithm. Moreover, the results show that the optimization algorithm has high stability. This means that the performance of the algorithm is relatively consistent in different situations or multiple runs, and there will be no big fluctuations. This stability is very important for practical application because it ensures the reliability and predictability of the algorithm.

Through the analysis of several cases, this section finds that the optimized landscape design model performs well in many aspects. First of all, in terms of aesthetics, the optimized scheme pays more attention to overall coordination and detail handling, making the landscape more pleasing to the eye. Secondly, in the aspect of ecology, the optimized model can automatically adjust the vegetation allocation and water body design and enhance the ecological benefits of the landscape. Finally, in terms of economy, the optimization model effectively reduces the construction cost and maintenance costs through reasonable layout and material selection.

6 CONCLUSIONS

This article constructs a landscape design model based on CAD technology, which can accurately express design elements and design schemes. Moreover, this article uses DM technology to analyze and process CAD data, extract useful information, and optimize landscape design models. Finally, the feasibility and practicability of the optimized landscape design model are verified by empirical research. The main conclusions are as follows:

The construction method of landscape design model based on CAD technology can effectively integrate design elements such as topography, vegetation, and architecture and provide accurate, flexible, and easy-to-use tools for landscape design. DM method plays an important role in the optimization of landscape design models. Through technologies such as classification and prediction, design features can be extracted, design patterns and trends can be found, and design schemes can be optimized automatically or semi-automatically. Through the analysis and empirical study of actual cases, it is verified that the optimized landscape design model has improved in aesthetics, ecology, and economy. This proves the practical value of this research method.

Generally speaking, the methods and conclusions of this study can provide useful reference and guidance for landscape design practice and promote the innovation and growth of the landscape design industry. Although some achievements have been made in this study, there are still some shortcomings and problems that need further discussion: the data source of this study mainly depends on open channels and cooperative companies, and there may be some limitations and deviations. In the future, data sources can be further expanded to increase diversity and comprehensiveness. Meanwhile, there is still room for improvement in DM and optimization algorithms. In the future, we can try to introduce more advanced algorithms and technologies to improve the optimization effect and accuracy.

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Shanshan Wu, https://orcid.org/0009-0008-1429-0412
Shitao Wang, https://orcid.org/0000-0002-5152-3210

REFERENCES

[1] Chen, X.: Environmental landscape design and planning system based on computer vision and deep learning, Journal of Intelligent Systems, 32(1), 2023, 20220092. https://doi.org/10.1515/jisys-2022-0092

[2] Da, H.-L.; Hong, Y.-L.; Wei, L.; Guo, J.-J.; En, Z.-L.: Application of flipped classroom based on the Rain Classroom in the teaching of computer-aided landscape design, Computer Applications in Engineering Education, 28(2), 2020, 357-366. https://doi.org/10.1002/cae.22198
[3] Han, S.; Jiang, Y.; Huang, Y.; Wang, M.; Bai, Y.; Spool, W.-A.: Scan2drawing: use of deep learning for as-built model landscape architecture, Journal of Construction Engineering and Management, 149(5), 2023, 04023027. https://doi.org/10.1061/JCEMD4.COENG-13077
[4] Han, Y.; Zhang, K.; Xu, Y.; Wang, H.; Chai, T.: Application of parametric design in the optimization of traditional landscape architecture, Processes, 11(2), 2023, 639. https://doi.org/10.3390/pr11020639
[5] Hu, S.; Meng, Q.; Xu, D.; Katib, I.; Aouad, M.: The spatial form of digital nonlinear landscape architecture design based on computer big data, Applied Mathematics and Nonlinear Sciences, 7(1), 2021, 783-790. https://doi.org/10.2478/amns.2021.1.00069
[6] Jia, J.: Computer-aided design method of parametric model for landscape planning, Computer-Aided Design and Applications, 19(S3), 2022, 55-64. https://doi.org/10.14733/cadaps.2022.S3.55-64
[7] Lavorel, S.; Grigulis, K.; Richards, D.-R.: Templates for multifunctional landscape design, Landscape Ecology, 37(3), 2022, 913-934. https://doi.org/10.1007/s10980-021-01377-6
[8] Liu, C.; Lin, M.; Rauf, H.-L.; Shareef, S.-S.: Parameter simulation of multidimensional urban landscape design based on nonlinear theory, Nonlinear Engineering, 10(1), 2022, 583-591. https://doi.org/10.1515/nleng-2021-0049
[9] Liu, J.; Wu, X.; Zhang, Y.; Wang, L.: Visualization system of Hlai ethnic village landscape design based on machine learning, Soft Computing, 27(14), 2023, 10001-10011. https://doi.org/10.1007/s00500-023-08196-8
[10] Michalek, A.; Zarnaghsh, A.; Husic, A.: Modeling linkages between erosion and connectivity in an urbanizing landscape, Science of The Total Environment, 764(10), 2020, 144255. https://doi.org/10.1016/j.scitotenv.2020.144255
[11] Sun, B.; Jiang, Y.; Liu, Y.; Wu, X.; Liu, Q.: Rural Environmental landscape construction based on virtual reality technology, Sustainability, 15(23), 2023, 16377. https://doi.org/10.3390/su152316377
[12] Wu, H.; Yan, J.: The mechanism of digitized landscape architecture design under edge computing, Plos one, 16(9), 2021, e0252087. https://doi.org/10.1371/journal.pone.0252087
[13] Xu, F.; Wang, Y.: Color effect of low-cost plant landscape design under computer-aided collaborative design system, Computer-Aided Design and Applications, 19(S3), 2021, 23-32. https://doi.org/10.14733/cadaps.2022.S3.23-32
[14] Yu, C.; Altalbe, A.; Du, N.: Environmental landscape art design using dynamic nonlinear parameterization, Fractals, 30(02), 2022, 2240077. https://doi.org/10.1142/S0218348X22400771
[15] Zhang, M.; Deng, X.: Color effect of landscape architecture design under computer-aided collaborative design system, Computer-Aided Design and Applications, 19(S3), 2022, 13-22. https://doi.org/10.14733/cadaps.2022.S3.13-22