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Application of Landscape Design Optimization Algorithm Based on Big Data in CAD Platform

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Abstract. This article employs a hybrid approach encompassing both theoretical and empirical research. Initially, a comprehensive review of literature and case studies is conducted to map out the current applications and future trends of big data in landscape design. Subsequently, a model for optimizing landscape design algorithms using big data is devised, and its performance is benchmarked against suitable algorithms. Furthermore, the study explores the integration of big data with CAD platforms, enabling the implementation of these optimization algorithms within the CAD environment. The practical utility and efficacy of this research are validated through real-world application examples. The experimental findings underscore the notable impact of the optimization algorithm when applied to CAD platforms. A comparative analysis of design schemes, both pre-and post-optimization, reveals significant enhancements in aesthetic appeal, functionality, and cost-efficiency. Additionally, the algorithm demonstrates robust efficiency and stability, making it well-suited for practical landscape design tasks. Overall, this research successfully introduces a big data-driven landscape design optimization algorithm to CAD platforms, facilitating automated optimizations and intelligent adjustments to design proposals. This innovation represents a substantial advancement in enhancing landscape design productivity, cost reduction, and industry-wide innovation.

Keywords: Big Data; Landscape Design; Optimization Algorithm; Ant Colony Optimization Algorithm; CAD Platform
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1 INTRODUCTION

With the swift advancement of information technology, big data has steadily permeated diverse sectors, emerging as a pivotal catalyst for innovation, transformation, and upgrading, which provides a new way of display and experience for landscape design. Big data can help us gain a deeper understanding of the interaction between ecosystem services and human activities. By analyzing data on human activities such as tourism, agricultural activities, urbanization processes, etc., we can better understand the impact of humans on ecosystems and the feedback of ecosystems on human life. Through big data analysis, we can quantitatively evaluate the economic value of these services and provide stronger support for decision-makers [1]. Barreto et al. [2] explored how to optimize the virtual reality environment, improve design quality, and enhance user experience through a CAD-based creative system for landscape design. Based on optimized CAD floor plans, use VR technology to achieve visualization of three-dimensional landscapes. Designers can preview landscape effects in real time in a virtual environment and perform interactive operations such as roaming, zooming, and rotating. Through real-time feedback and collaborative design tools, communicate and collaborate with relevant personnel such as customers and construction parties in real-time. This adjustment and optimization method can reduce the cost of later modifications and adjustments, and improve design efficiency and satisfaction. In the realm of landscape design, where traditional approaches often hinge on the designer's expertise and instincts, addressing the escalating complexity of design demands and the varying preferences of users poses a challenge. With the acceleration of urbanization, the quality and changes of urban green spaces have become a focus of attention for the public and decision-makers. Google Earth Engine (GEE), as a powerful geographic data processing and analysis tool, provides the possibility. Chen et al. [3] utilizing the Google Earth engine, can quickly map the quality of urban green spaces. Firstly, obtain urban green space information through satellite remote sensing data, including the type, area, vegetation coverage, etc. of the green space. Then, utilizing the image processing and analysis capabilities of GEE, these data are processed and classified to extract green space information. Finally, integrate this information onto the map to generate a distribution map of urban green space quality. In addition to rapid mapping of urban green space quality, Google Earth Engine can also be used for annual dynamic evaluation. By obtaining years of satellite remote sensing data, it can monitor and analyze changes in urban green spaces. In the future, we look forward to seeing more innovative CAD-assisted intelligent technologies applied in landscape design practice, contributing to creating a better living environment. Through CAD-assisted intelligent technology, designers can quickly create three-dimensional terrain, buildings, and vegetation models. Using artificial intelligence algorithms, the software can automatically optimize model structure, and improve rendering speed and visual effects, allowing designers to preview landscape effects more intuitively. CAD-assisted intelligent technology can process and analyze a large amount of geographic, climate, population and other data, providing a scientific basis for landscape design. Through data mining and pattern recognition, designers can better understand the characteristics of the site and develop reasonable design strategies. Combining machine learning technology and CAD-assisted intelligent technology, designers can learn their creativity and style, and automatically generate design solutions. Designers can adjust and optimize according to their needs, thereby improving design efficiency and innovation [4]. Consequently, exploring ways to harness big data to elevate the intelligence, personalization, and sophistication of landscape design has surfaced as a prominent research focus.

Urban green space, as an important component of the urban ecosystem, is of great significance in improving the urban environment and maintaining ecological balance. Hassanpour et al. [5] proposed an evaluation method based on an ant colony optimization algorithm. This method can comprehensively consider various factors such as vegetation types, spatial layout, and ecological functions in green spaces, providing new ideas for the ecological structure evaluation of urban green spaces. In the evaluation of the ecological structure of urban green spaces, we have constructed an evaluation index system that includes multiple aspects such as vegetation diversity, spatial layout rationality, and ecological function completeness. These indicators can comprehensively reflect the ecological structure of urban green spaces and provide basic data for subsequent evaluations. It transforms the evaluation problem of urban green space ecological structure into a multi-objective optimization problem and uses an ant colony optimization algorithm to find the optimal solution. By using an ant colony optimization algorithm, the weights of each evaluation indicator are determined to reflect their importance in the overall evaluation. Urban greening and construction are increasingly receiving attention. As an important component of urban ecosystems, the quantitative estimation of the volume of live vegetation is of great significance for evaluating the level of urban greening and ecological service functions. Huang et al. [6] proposed a novel quantitative estimation model for urban area active vegetation volume. Intended to improve estimation accuracy and efficiency, providing a scientific basis for urban greening planning and management. In order to reduce computational complexity and data storage, it adopts an octane data structure to manage and optimize voxels. By constructing an octree, efficient indexing and querying of voxels can be achieved, thereby improving computational efficiency. Based on the octree data structure, traverse all voxels and accumulate their volumes to obtain an estimated volume of live vegetation for the entire urban area. Analyze and compare the estimation results to evaluate the accuracy and reliability of the model. Big data typically encompasses a vast array of information that surpasses the capture, management, and processing capabilities of standard software tools within defined timeframes. It constitutes a substantial, rapidly expanding, and varied informational resource that demands innovative processing techniques to bolster decision-making, enhance insight and discovery, and optimize processes. This study aims to delve into landscape design optimization algorithms grounded in big data and integrate them into CAD platforms, facilitating more efficient and precise design enhancements. By extracting valuable landscape design insights and user preferences embedded within big data, this endeavour anticipates offering fresh perspectives and methodologies for landscape design, thereby propelling innovative progress within the industry.

The primary foci of this article are diverse and encompass several key areas:

Firstly, it delves into the practical significance and techniques of big data utilization within landscape design, constructing a theoretical foundation tailored for this discipline. Secondly, it ventures into the realm of optimal algorithms tailored for landscape design, such as genetic and particle swarm optimization algorithms, juxtaposing their respective performances. Thirdly, the article investigates the amalgamation of big data with CAD platforms, paving the way for the seamless integration and utilization of optimization algorithms within these platforms. The validity and impact of this exploration are corroborated through empirical applications.

The article's innovative spirit is manifest in several notable ways:

It introduces a pioneering optimization algorithm for landscape design rooted in big data, offering fresh perspectives and approaches to the field. Additionally, it achieves a harmonious blend of optimization algorithms with CAD platforms, elevating both design efficiency and precision. Ultimately, the study's practical relevance and cutting-edge nature are substantiated by real-world applications.

The chapter arrangement of this article aims to systematically expound the theoretical framework of landscape design driven by big data. This article first introduces the importance and specific methods of data collection and then describes the steps and necessity of data processing in detail. Then, through data analysis, it shows how to use advanced technology to extract valuable information from massive data. Finally, in the design application chapter, the key to combining the analysis results with the actual landscape design is emphasized, so as to create a high-quality landscape.

2 RELATED WORK

Augmented reality (AR) technology has brought new perspectives and possibilities to landscape architecture design. By combining AR technology with optimization algorithms, designers can simulate and optimize landscape architecture. Kerr and Lawson [7] discussed how to apply augmented reality technology to landscape architecture design and utilize optimization algorithms for detail optimization. This technology helps to improve the feasibility of design and user satisfaction. Optimization algorithms play a crucial role in landscape architecture design. Through optimization algorithms, designers can optimize the layout, materials, structure, and other aspects of landscape architecture to achieve the best design results. Optimization algorithms can help designers reduce costs and improve sustainability while meeting functional and aesthetic requirements.

Landscape design, as an important component of environmental construction, involves multiple aspects such as ecology, culture, society, and economy. With the increasing demand for environmental quality in society, landscape design is facing more and more challenges. How to achieve the multifunctionality and ecological optimization of landscapes has become an important research topic. The ant colony optimization algorithm, as an intelligent optimization algorithm, provides new ideas for solving this problem due to its characteristics of swarm intelligence and distributed information processing. The ant colony optimization algorithm can find the optimal solution in complex problems by simulating the pheromone transmission mechanism in ant foraging behaviour. In order to address this challenge, the application of landscape design optimization algorithms based on big data in multifunctional landscape design templates is gradually receiving attention. Lavorel et al. [8] explored the potential and impact of this technology in the field of landscape design. Big data refers to a collection of data with a large volume, diverse types, and complex processing. In the field of landscape design, integration, and analysis of data from various aspects such as site environment, user groups, ecosystems, and historical culture. The landscape design optimization algorithm based on big data is a combination of data mining, machine learning and other technologies. This algorithm can automatically extract optimization solutions. The application of this algorithm allows designers to explore more possibilities of design solutions in a short period of time, providing more choices for the final decision.

With the rapid development of technology, advanced technologies such as artificial intelligence, neural networks, and wireless sensor networks are changing our understanding and practice of landscape design and land planning. These technologies provide more scientific and intelligent methods for landscape design, making it more refined, intelligent, and dynamic [9]. Based on neural networks and wireless sensor network technology, intelligent decision-making can be made for landscape design and land planning. For example, neural network technology can be used to simulate and optimize design schemes to achieve optimal design results. Alternatively, machine learning algorithms can be used to evaluate and predict land planning schemes in order to achieve optimal land use outcomes. This will greatly improve the efficiency and accuracy of landscape design. By training neural networks to evaluate the aesthetics of a large number of landscape images, it is possible to automatically calculate the correlation between various landscape features and aesthetics, providing aesthetic guidance for landscape design. This system can collect environmental data in real-time, and use neural networks for data analysis and prediction, bringing unprecedented experiences to our lives and work. In landscape regeneration design, virtual reality technology can present design schemes in an intuitive and vivid way, providing designers and users with a more comprehensive perspective and interactive experience. Traditional cultural elements, as important materials in landscape design, can inject unique cultural connotations and artistic charm into landscape regeneration design [10] Traditional cultural elements are often closely related to specific regions and historical backgrounds. The application of traditional cultural elements in landscape regeneration design helps to showcase regional characteristics and historical memories, making the landscape more distinctive and humane. Many traditional cultural elements emphasize the concept of harmonious coexistence with nature, which has important reference significance for today's ecological and sustainable development. Integrating traditional cultural elements into landscape regeneration design can help achieve multiple goals of ecological protection, cultural inheritance, and sustainable development.

With the acceleration of urbanization, the problems of landscape erosion and connectivity are becoming increasingly prominent. In order to better understand and solve these problems, we introduced the big data ant colony optimization algorithm and used the CAD platform for modelling. Michalek et al. [11] explored the application of this technology in modelling the relationship between erosion and connectivity in urban landscapes. The erosion of urban landscapes mainly refers to the phenomenon of natural landscapes being damaged and degraded during the urbanization process. This erosion not only includes the loss of land resources but also the destruction of ecosystems and water pollution. The connectivity of urban landscapes refers to the connection and flow between various elements in the landscape, including ecological flow, human flow, and logistics. Good connectivity helps maintain the ecological balance of the landscape and improves the quality of life for urban residents. Taking a certain city as an example, we used big data and colony optimization algorithms to model the erosion and connectivity of urban landscapes. Through the analysis of historical data, we identified the main factors affecting landscape erosion and connectivity and simulated them on a CAD platform. By comparing the results of different schemes, we have identified the best urbanization strategy to reduce landscape erosion and improve connectivity. Shan and Sun [12] discussed the importance of auxiliary applications and detail optimization of computer virtual reality technology in landscape design. In the initial stage of landscape design, designers can use computer virtual reality technology for conceptualization and visualization. By creating elements such as terrain, buildings, and vegetation in a virtual environment, designers can quickly explore and try different design solutions to better understand the design intent and effects. During the scheme evaluation phase, designers can use virtual reality technology for simulation and analysis. By simulating the distribution of lighting and pedestrian flow at different time periods, designers can evaluate the feasibility and effectiveness of the plan, thereby optimizing and improving it. In the detail stage of landscape design, virtual reality technology can help designers better handle detail issues. For example, designers can accurately simulate and adjust the types, quantities, and layout of plants to ensure the ecological balance and aesthetics of the landscape.

With the acceleration of urbanization, the demand for three-dimensional urban landscape design is increasing day by day. In order to meet this demand, geographic information systems (GIS) based on optimization algorithms have gradually become an important design tool. Shan and Sun [13] discussed how to use GIS for three-dimensional urban landscape design and evaluation, in order to improve design quality and efficiency. Geographic Information System (GIS) is a computer system used for processing and analyzing geographic data. Through GIS, we can digitize and visualize three-dimensional urban elements such as terrain, buildings, and vegetation. GIS-based optimization algorithms can provide designers with powerful analytical tools to help them simulate and optimize landscape design in virtual environments. GIS-based landscape analysis tools can help designers conduct an in-depth analysis of landscapes, such as visibility analysis, lighting analysis, spatial layout analysis, etc. These analysis results can provide an important reference basis for landscape design. Designers can use GIS platforms to evaluate and compare different landscape design schemes. By simulating and analyzing the effects of different schemes, designers can find the best design scheme and optimize the details. Ant colony optimization algorithm, as an intelligent optimization algorithm that simulates the foraging behaviour of ants in nature, has strong robustness and adaptability and has received widespread attention. Song and Jing [14] discussed the application prospects of ant colony optimization algorithm integrated software technology in landscape design. This algorithm simulates the pheromone transmission process of ants and searches and optimizes in the solution space. Ant colony optimization algorithm has strong robustness and adaptability and can perform well in scenarios such as multi-objective, multi-constraint, and complex problems [15] 3D CAD software provides powerful modelling tools that designers can use to create elements such as 3D terrain, buildings, vegetation, etc. Through real-time rendering and visualization techniques, designers can preview landscape effects in a virtual environment to better understand the design intent and effects. 3D CAD software supports parametric design, and designers can change the shape, size, and position of design elements by adjusting parameters. This parameterized design method can improve the flexibility and adjustability of the design, and reduce repetitive labor and errors. Through 3D CAD software, designers can perform landscape analysis, such as visibility analysis, lighting analysis, spatial layout analysis, etc. These analysis results can provide an important reference for landscape design, helping designers better understand the characteristics and needs of the landscape.

These investigations offer valuable insights and hands-on expertise for integrating big data into landscape design. Nevertheless, the exploration of optimization algorithms for landscape design, rooted in big data, is still nascent, presenting numerous obstacles and quandaries. Chief among these is the efficient handling and interpretation of extensive and multi-faceted landscape datasets. Another significant hurdle is the seamless merger of optimization algorithms with CAD platforms to attain automated design enhancement. Consequently, this article carries substantial theoretical weight and practical relevance, and is anticipated to spark further advancements and innovations within the landscape design domain.

3 BIG DATA AND BASIC THEORY OF LANDSCAPE DESIGN

3.1 Basic Principles and Methods of Landscape Design

Landscape design is a comprehensive art science which involves aesthetics, ecology, psychology, and other disciplines. Some basic principles and methods should be followed in landscape design. See Table 1-3 for details.

Project	*Content description*
Aesthetics	Provide visual appeal, artistry, and cultural connotation.
Ecology	Protect, restore, and enhance the natural environment and ecosystem.
Psychology	Consider human behaviour, perception and comfort.
Other subjects	Geography, history, architecture, etc.

Table 1: Landscape design concept.

Principle	*Content description*
Functionality	
Practicability	Meet the basic use functions and user needs of the site.
Comfort	Provide a pleasant environment and facilities to meet the requirements of ergonomics.
Ecology	
Environmental protection	Minimize the interference and damage to the natural environment.
Sustainability	Use renewable, low-impact, and long-life materials and technologies.
Aesthetics	
Visual attraction	Create pleasing and fascinating visual effects.
Cultural expression	Reflect regional culture and historical characteristics.

Table 2: Landscape design principles.

Step	*Content description*
Site survey	Make a detailed site investigation, including the natural environment, soil, vegetation, climate, etc.
Demand analysis	Communicate with users and interested parties to define design objectives and requirements.
Conceptual design	Formulate preliminary design concepts and directions.
Scheme design	Refine the design concept and formulate multiple alternatives.
Scheme assessment	Review the scheme with users and interested parties to determine the final design direction.
Rendering	Making landscape effect maps with 3D modelling and rendering software
Construction drawing	Draw detailed construction drawings according to the final scheme.
Project coordination	Communicate and coordinate with the construction party, suppliers and other relevant parties.

Field supervision	Conduct on-site supervision and guidance during the construction process.

Table 3: Landscape design process.

3.2 The Theoretical Framework of Landscape Design Driven by Big Data

In the realm of landscape design, big data's application value manifests itself in several key ways:

Firstly, big data serves as a repository of abundant design references. By amassing and scrutinizing a substantial corpus of landscape project data, user behaviour patterns, and environmental indicators, designers gain a more holistic understanding of prevailing design trends, user preferences, and environmental nuances. This wealth of data underpins and informs the design process.

Secondly, big data enhances designers' comprehension of site-specific characteristics. Leveraging high-resolution remote sensing datasets and geographic information systems, designers can undertake quantitative analyses of the site's topography, geomorphology, vegetation coverage, and hydrological features with greater precision. This detailed understanding lays a more solid foundation for design interventions.

Thirdly, big data optimizes landscape design decision-making. By establishing a data-driven decision-making framework, designers can objectively evaluate and compare multiple design proposals, thereby enhancing the rationality and impact of their design choices.

Link	*Describe*	*Main contents and tasks*
Data collection	Collect relevant big data resources by technical means.	Project data: Collect data related to landscape design projects.
		User data: data to understand users' needs, preferences and behaviours.
		Environmental data: data on the natural environment and climate of the site.
		Data sources: Internet, sensors, remote sensing satellites, etc.
Data processing	Preprocessing the collected data.	Data cleaning: removing duplicates, errors and incomplete data.
		Data integration: integrating data from different sources.
		Data formatting: converting data into a format suitable for analysis.
Data analysis	Use technical means to analyze and mine data.	Statistics: Use statistical methods to analyze data.
		Machine learning: Mining patterns and associations in data by using machine learning algorithms.
		Extracting information: extracting valuable information and knowledge from data.
Design application	The results of the analysis are applied to landscape design.	Design scheme formulation: based on the analysis results, a preliminary design scheme is formulated.
		Scheme optimization: design schemes iteratively according to feedback and optimization objectives.
		The final result is to form a high-quality landscape that meets the needs of users and site characteristics.

Table 4: Theoretical framework of landscape design.

The theoretical framework of landscape design driven by big data mainly includes four links: data collection, data processing, data analysis, and design application, as shown in Table 4.

4 REALIZATION TECHNOLOGY OF LANDSCAPE DESIGN ON CAD PLATFORM

4.1 Integration Technology of Big Data and CAD Platform

CAD platform is the core tool for landscape designers to design, which provides rich drawing, editing and rendering functions and can support the whole process from conceptual design to construction drawing. In landscape design, the CAD platform usually includes several main functional modules as shown in Figure 1:

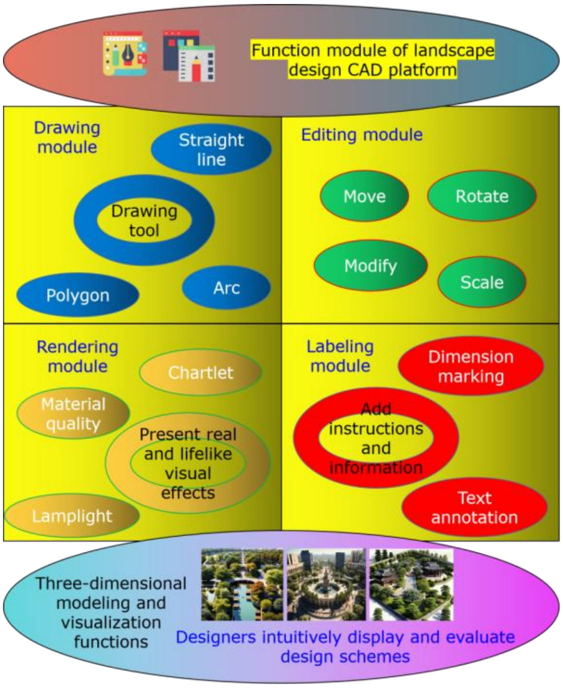


Figure 1: Function module of CAD platform.

To achieve the seamless amalgamation of big data with CAD platforms, three pivotal technical challenges must be tackled: data format conversion, data interface integration, and data transmission proficiency. Addressing these challenges is paramount for ensuring a harmonious collaboration between big data and CAD systems.

Initially, to resolve the issue of data format conversion, this article introduces a robust data conversion framework. This framework is capable of recognizing and manipulating big data from diverse sources and formats, converting them into standard CAD-compatible formats like DWG and DXF. Advanced data analysis and conversion techniques are employed to guarantee data integrity and precision during the transformation process. Moreover, to align with CAD's stringent data accuracy requirements, the framework incorporates data cleansing and correction functionalities, further enhancing data quality.

Secondly, regarding data interface integration, this article devises a tailored data interface strategy. This strategy meticulously considers the unique features and demands of CAD platforms, ensuring seamless integration with external data repositories. Through these interfaces, CAD systems can seamlessly acquire and update the freshest data from external sources in real time. Additionally, the interface design prioritizes data security and stability, safeguarding against unauthorized access and data breaches.

Lastly, to address data transmission proficiency, this article leverages a suite of efficient data transmission protocols and compression technologies. These technologies optimize transmission speeds while minimizing the risks of delays and losses, all while preserving data quality. By streamlining the data transmission workflow, this article ensures swift loading and seamless utilization of big data assets within CAD environments, fostering a more convenient and productive workspace for designers.

By conquering these three technical obstacles—data format conversion, data interface integration, and data transmission proficiency—the seamless integration of big data and CAD platforms becomes a reality. This integration empowers designers with a potent tool for effortlessly accessing and utilizing big data resources within their CAD ecosystems, significantly elevating the efficiency of landscape design and unlocking new horizons for innovation and optimization.

4.2 Embedding and Implementation of Optimization Algorithm in CAD Platform

Integrating an optimization algorithm within the CAD platform enables automatic refinement and intelligent adaptation of design schemes, thereby enhancing both design efficiency and quality. Here's how to achieve algorithm integration:

Algorithm Choice: Selecting a suitable optimization algorithm demands consideration of the design problem's unique traits, requirements, and the CAD platform's computational capabilities. Common choices include genetic algorithms, simulated annealing, particle swarm optimization, and ACO (ant colony optimization). Each finds application across diverse design scenarios: genetic algorithms, for instance, excel at addressing continuous or discrete variable optimization, mimicking natural selection and genetic mechanisms. Simulated annealing excels at combinatorial optimizations, navigating around local optima to find the global best. Particle swarm optimization mimics the social behaviour of birds or fish to tackle continuous variable challenges, while ACO solves combinatorial problems like the travelling salesman or vehicle routing, drawing inspiration from ants' pheromone-based foraging.

In this article, the algorithm is determined according to the actual design problems and requirements. Because the design problem is a combinatorial optimization problem, this article considers adopting the ACO algorithm. The pheromone released on the path i,j after the ant k moves from the i point to the j point is defined as follows:

$$\Delta\tau_{ij}^{k} = L_j - L_i \frac{Q}{L_{sum}} \tag{1}$$

The amount of pheromone released by ants is related to the difference in accumulated deflection and deformation between j point and i point. Reward the top L ants before pheromone update; By enhancing the pheromone concentration on shorter paths, we aim to expedite the process. Additionally, to safeguard against the algorithm getting trapped in local optima, the volatilization factor is set at a comparatively elevated level, ensuring that the pheromone concentration remains within the designated $\left[\tau_{\min}, \tau_{\max}\right]$ range. The updated formula is as follows:

$$\tau_{ij}^{ef}\ t+1 = 1-\rho\ \tau_{ij}^{ef}\ t + 1-r+1 \sum_{r=1}^{l} \Delta\tau_{ij}^{ef}\ t \qquad if\ 0 < Lr \le l \tag{2}$$

Where l is the number of ants selected and rewarded, and the smaller the number of ordered ants, the higher the information concentration of rewards.

In the realm of multi-objective optimization, an absolute best solution is nonexistent, as the merits and demerits of any given solution are relative. When considering the ant i, whose directional movement is pending selection, its Pareto dominance must be contrasted with that of every other ant in the colony. Subsequently, its optimization probability, denoted as P_j, is delineated as follows:

$$P_j = \frac{\theta_j \delta_{ij}}{\sum_{j=1}^{m} \theta_j \delta_{ij}}, j \neq i, j = 1,2,\cdots,N \tag{3}$$

$$\delta_{ij} = 1 / d_{ij} \tag{4}$$

Where d_{ij} is the distance between the current ant i and the ant j. According to roulette, the location of the selected ant j is taken as the optimization direction of the current ant i. When selecting the sources in each generation, this article will determine the number of selected sources according to the population size and fitness function. Once the number of sources is determined, the next step is to clarify the distance between the sources. Therefore, this article innovatively designs an adaptive distance calculation formula:

$$D_{\min}\ t = \frac{D_0}{T^\beta} \tag{5}$$

In this context, $D_{\min}\ t$ represents the smallest distance between the central points of the t generation's source individuals, while D_0 denoting the shortest distance between the center points of the initial generation's source individuals. β serves to adjust these center point distances dynamically based on the algebraic progression. Experimental findings suggest that β typically falls within the range of [0.15,1] for optimal results. The step-by-step process of the algorithm is visually represented in Figure 2.

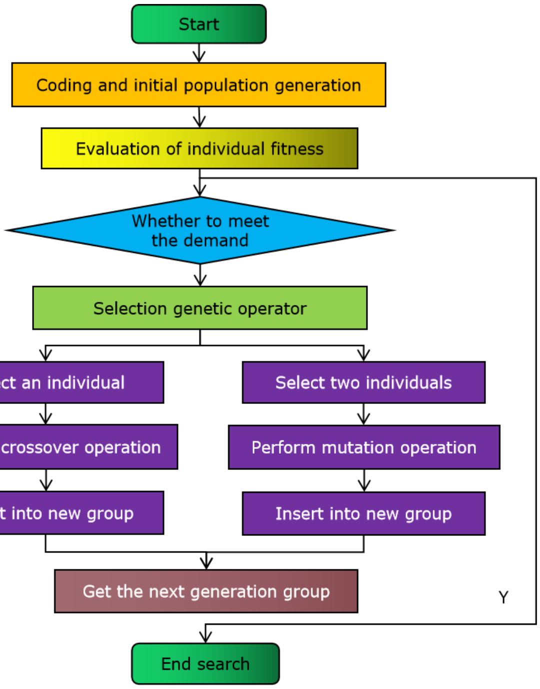


Figure 2: Algorithm flow chart.

To enhance landscape design, a prime focus is on optimizing the path layout. Genetic algorithms and cross-mutation techniques should be strategically implemented.

$$v_{k+1} = c_0 v_k + c_1 \left(p_{best_k} - x_k \right) + c_2 \left(g_{best_k} - x_k \right) \quad (6)$$

Among the techniques employed, $c_0 v_k$ stands out as a mutation method rooted in genetic algorithms. Additionally, two crucial elements have been incorporated: the ants' ability to intersect with both the present solution and the extreme values on a global and individual scale. Once this intersection occurs, a fresh position emerges as the outcome. Subsequently, the ultimate shortest path is determined by referencing this newly acquired position.

Algorithm embedding and implementation:

Interface development: develop the corresponding interface on the CAD platform to interact with the optimization algorithm. These interfaces can receive the design parameters, constraints and other information of the CAD platform, and can feed back the optimization results to the CAD platform.

Algorithm integration: The ACO algorithm is integrated into the CAD platform. Furthermore, the algorithm is modified and adjusted to meet the environment and needs of the CAD platform.

Parameter configuration and modification are essential to fine-tune the algorithm's operation. This involves aligning the algorithm's parameters with the unique attributes and demands of the design challenge. Key parameters include population size, iteration count, crossover likelihood, mutation probability, and others. It's crucial to note that the chosen configurations for these parameters significantly impact the algorithm's overall performance and outcome.

Test and verification: Apply the embedded optimization algorithm to the actual design problem and test and verify it. By comparing the performance and effect of different algorithms, the most suitable algorithm is selected for use.

Through the above steps, the embedding and application of the optimization algorithm in the CAD platform can be realized so as to realize the automatic optimization and intelligent adjustment of the design scheme.

4.3 User Interface Design and Interactive Experience Optimization

The user interface is an important medium for designers to interact with CAD platforms, and its design quality and interactive experience directly affect designers' work efficiency and satisfaction. In order to optimize the user interface design and interactive experience, this article takes the following measures: (1) Interface layout optimization: reasonably arrange the position and size of interface elements, so that designers can quickly find the required functions and operations. (2) Simplify the operation process: simplify the complicated operation process, reduce unnecessary clicks and inputs, and improve the work efficiency of designers. (3) Perfect feedback mechanism: provide designers with timely and accurate operational feedback to avoid misoperation and mistakes. (4) Customization support: provide personalized interface customization function to meet the preferences and needs of different designers. Through these optimization measures, the user interface of the CAD platform can be more friendly, easy to use, and efficient, thus improving the designer's work experience and satisfaction.

5 APPLICATION PRACTICE OF LANDSCAPE DESIGN OPTIMIZATION ALGORITHM BASED ON BIG DATA ON CAD PLATFORM

5.1 Data Preparation and Application Case Selection

In the data preparation stage, all kinds of data related to these cases are collected, including site environment data, user behaviour data, design element data and so on. These data come from multiple channels, such as remote sensing satellite images, geographic information systems, social media platforms, etc., which ensure the comprehensiveness and accuracy of the data. Next, these data are preprocessed and format converted, so that they can be successfully imported into CAD platform and optimization algorithm. Pretreatment is beneficial for facilitating the swift convergence of algorithmic models. Common techniques employed for data normalization include the following:

$$y_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \tag{7}$$

$$y = 2 \times \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} - 1 \tag{8}$$

Within the given context, $x_{\max}, x_{\min}$ denotes the extrema (both maximum and minimum) values within the sampled dataset. x_i refers to a specific i sample datum amidst the dataset, while y_i signifies the normalized outcome of the sampled data. This article opts for the normalization approach outlined in formula (8), which aims to remap the values within the [-1,1] range. This, in turn, facilitates a swifter convergence of the multi-objective ACO algorithm.

In order to verify the practical application effect of landscape design optimization algorithms based on big data on CAD platforms, this article carefully selected several representative landscape design cases. These cases cover different types of landscape spaces, including urban parks, residential green spaces and commercial squares, aiming at comprehensively evaluating the applicability and optimization effect of the algorithm in different scenarios. The design of the city park is shown in Figure 3.

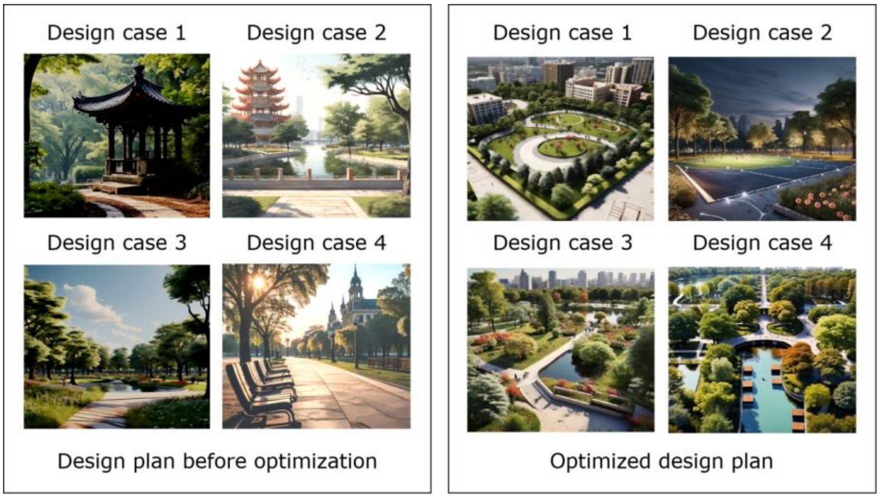


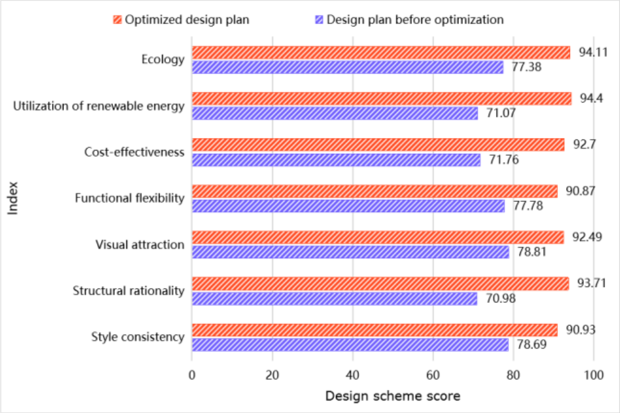
Figure 3: Urban park design.

The green space design of the residential area is shown in Figure 4. The design of the commercial plaza is shown in Figure 5. Figure 6 shows the user's rating results. The assessment results show that compared with the design scheme before optimization, the design scheme after application of the optimization algorithm has been significantly improved in aesthetics, practicality and ecology. These enhancements not only elevate the overall quality of the design plan but also more effectively align with users' needs and aspirations. Furthermore, to impartially evaluate the impact of the optimization algorithm, this article incorporates a comprehensive array of quantitative and qualitative metrics to assess the landscape design outcomes holistically. The rate of convergence for the algorithm is visually represented in Figure 7.

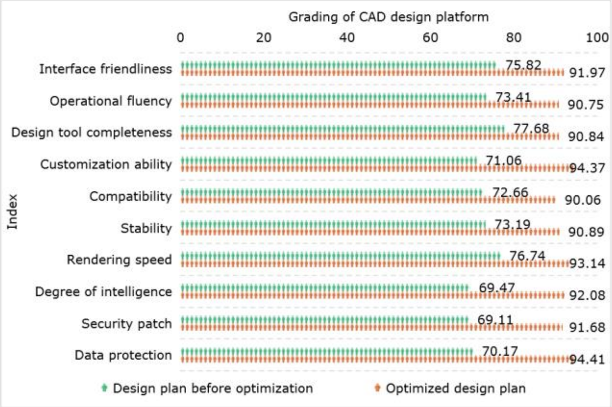
Figure 4: Green space design of the residential area.

Figure 5: Commercial plaza design.

In terms of convergence rate, the algorithm attained a converged state within a brief timeframe. This underscores the remarkable efficiency of the optimization algorithm in tackling landscape design challenges, enabling it to identify near-optimal solutions within constraints of time. This is particularly significant in practical landscape design scenarios, where designers often face stringent deadlines. A graphical representation of the algorithm's execution efficiency is presented in Figure 8.



6(A) Design scheme score



6(B) Grading of CAD design platform

Figure 6: User's rating results.

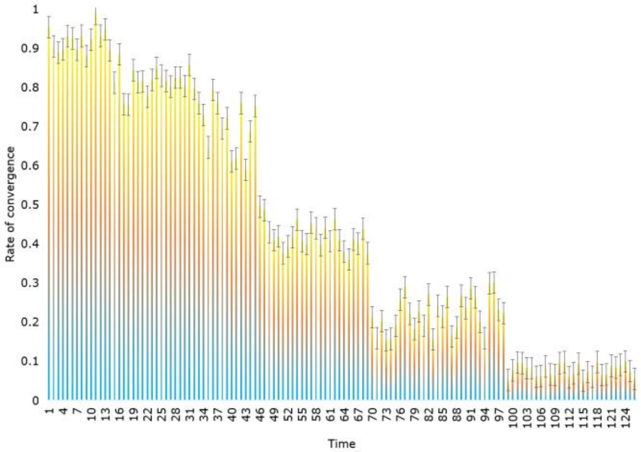


Figure 7: Convergence rate of the algorithm.

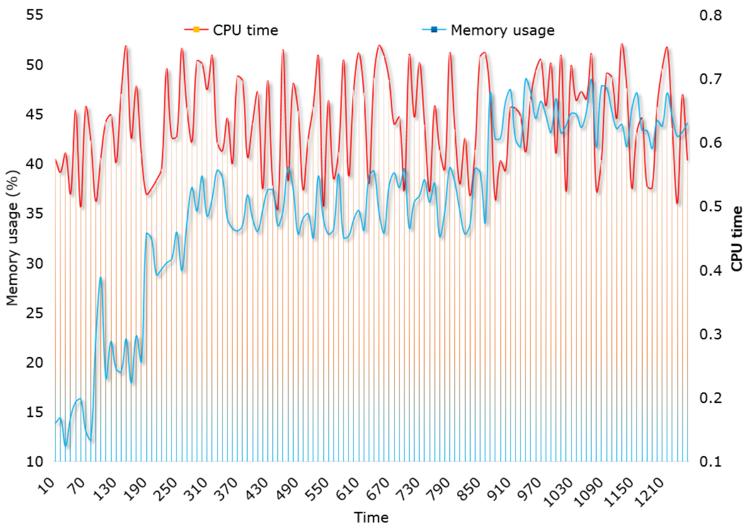


Figure 8: Operational efficiency of the algorithm.

By comparing and analyzing the computing resources occupied by the algorithm in the running process, we can find that the optimization algorithm is excellent in running efficiency. It can complete complex computing tasks in a short time while maintaining low resource consumption. This is of great significance for dealing with large-scale landscape design problems or real-time optimization design. The stability test results of the algorithm are shown in Figure 9.

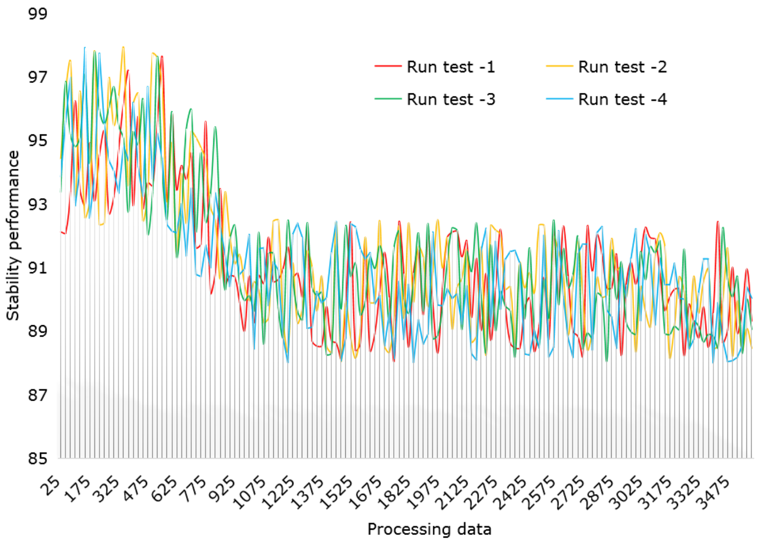


Figure 9: Algorithm stability test.

By running the algorithm many times and observing the stability of the results, it can be confirmed that the optimization algorithm can maintain good performance in different situations. This means that the algorithm is insensitive to small changes in input data and can stably output high-quality design schemes. This is especially important for the complex and changeable environment in actual landscape design.

5.2 Analysis and Assessment of Landscape Design Results

Through in-depth analysis and assessment of the landscape design results of application cases, this article finds that the optimization algorithm based on big data has shown remarkable advantages in many aspects. First of all, in the scheme layout, the optimization algorithm can automatically generate a reasonable and beautiful spatial layout according to the site characteristics and user requirements, which greatly improves design efficiency and quality. Secondly, in terms of plant configuration, the optimization algorithm can intelligently match and combine plants according to their ecological habits and ornamental characteristics, and create a more colourful plant landscape. In addition, in terms of facility configuration, the optimization algorithm can also make intelligent planning and layout according to people's flow and use demand, which improves the convenience and comfort of facility use.

In the process of landscape design, this article always pays attention to collecting users' feedback and suggestions. Through questionnaires, interviews, etc., we know the real feelings and needs of users for the application effect of optimization algorithm; In view of the problems and suggestions put forward in user feedback, this article summarizes them in time and formulates corresponding improvement strategies. First of all, in the performance of the algorithm, we will continue to optimize and improve the searchability and convergence speed of the algorithm and improve the running efficiency and stability of the algorithm. Secondly, the user interface, will further simplify the operation process, improve user-friendliness and reduce the user's difficulty in using and learning costs. In addition, in the application scenario, this article will continue to expand and optimize the application scope and applicable conditions of the algorithm, so that it can better adapt to different types and scales of landscape design projects.

6 CONCLUSIONS

In this study, we delve into the practical application of a landscape design optimization algorithm, rooted in big data, within a CAD platform. By seamlessly blending the optimization algorithm, big data capabilities, and the CAD environment, we achieve significant advancements in the intelligence and automation of the landscape design workflow, thereby elevating both design efficiency and quality.

Our research journey began with a comprehensive overview and classification of optimization algorithms, narrowing down to those most suited for landscape design challenges. Subsequently, we explored the synergies between big data and CAD platforms, unlocking the potential of efficient data processing and utilization. This culminated in the integration of the chosen optimization algorithm into the CAD ecosystem, giving rise to an intelligent landscape design system. The system's real-world effectiveness was then rigorously tested through a practical case study.

Key accomplishments of this endeavour include:

(1) Introducing a novel framework for big data-driven landscape design optimization, offering fresh perspectives and tools for designers.

(2) Establishing a seamless, efficient data exchange between big data resources and the CAD platform, greatly enhancing designers' access to vital data resources.

(3) Successfully embedding the optimization algorithm within the CAD workflow, leading to automated design refinements, intelligent adjustments, and overall improved design outcomes.

(4) Demonstrating the system's real-world impact and usability through a concrete case study, solidifying its role in advancing the intelligence of the landscape design sector.

While our current focus has been on static landscape designs, we acknowledge the growing importance of dynamic landscapes. Looking ahead, as technologies like artificial intelligence and big data continue to evolve, intelligent design stands poised to become a pivotal trend in landscape design. It is imperative for the industry to embrace and nurture these intelligent design technologies to further push the boundaries of design excellence and efficiency.

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