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Computer-Aided Design and Applications

Building Multimedia Interactive Landscape Design Platform Based on Genetic Algorithm

Aran Ren[1] and Zhuo Chen[2]

[1,2] College of Design and Art, Harbin University of Commerce, Harbin, Heilongjiang 150028, China
[1]102748@hrbcu.edu.cn, [2]102860@hrbcu.edu.cn

Corresponding author: Zhuo Chen, 102860@hrbcu.edu.cn

Abstract. Landscape design, as a comprehensive discipline, has been deeply influenced by related disciplines, especially computer-aided (CAD) software and computer hardware technology, in its continuous growth. CAD software, with its multifaceted advantages, provides a more direct and efficient means of expressing design effects for landscape design. However, due to the complexity of landscape design and the diversity of design schemes, traditional design methods often face challenges such as time-consuming and difficult optimization. Based on this, this article proposes a CAD landscape design and multimedia interactive platform based on genetic algorithm (GA). This platform fully utilizes the advantages of GA in optimization problems by encoding the design scheme for individual GA and combining it with fitness function evaluation to achieve automated optimization of the design scheme. Meanwhile, by combining multimedia interactive presentation technology, a highly realistic and interactive virtual landscape environment is created to enhance the visualization and communication effects of the design. The experimental results indicate that the construction of the platform not only improves the efficiency and quality of landscape design but also provides users with a richer and more immersive interactive experience.

Keywords: Genetic Algorithm; Computer Assisted; Landscape Design; Multimedia Interaction
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1 INTRODUCTION

Landscape design, a pivotal means for humans to reshape nature and craft captivating living environments, holds ever-growing significance. Ecological landscape geographic planning and design is an important branch of contemporary urban planning and landscape design, aiming to achieve harmonious coexistence between humans and nature through scientific methods and means. Dai and Zhuang [1] discussed the principles, applications, and prospects of ecological landscape geographic planning and design based on genetic algorithms. Firstly, it is necessary to determine the planning objectives and constraints, such as ecological protection, landscape aesthetics, economic benefits, etc. Then, encode the landscape elements within the planning area to form chromosomes. Each chromosome represents a possible landscape pattern scheme. Next, using the selection, crossover, and mutation operations of genetic algorithms, the chromosomes are iteratively evolved. Evaluate chromosomes based on fitness functions and select chromosomes with high fitness to enter the next generation. Simultaneously generating new chromosomes through crossover and mutation operations. After multiple generations of evolution, the chromosome with the highest fitness is ultimately obtained, which is the optimal landscape pattern scheme. By comparing traditional planning methods with planning methods based on genetic algorithms, it was found that the latter has achieved significant advantages in ecological protection, landscape connectivity, and tourist satisfaction. In contemporary society, this field is not merely tethered to aesthetics; it also encompasses the enhancement of ecological environments, intelligent utilization of urban spaces, and the augmentation of human life quality. In order to further improve design efficiency and quality, genetic algorithm, as an optimization search technology, has been introduced into computer-aided drawing programs, bringing new design patterns and methods to indoor architecture education. Denerel and Anil [2] discussed the application and advantages of computer-aided drawing programs in indoor architecture education based on genetic algorithms. In interior architectural design, genetic algorithms can be used to solve complex problems such as spatial layout, material selection, and color matching. By encoding design elements into chromosomes, genetic algorithms can automatically search for the optimal solution among a large number of possible design schemes, greatly improving design efficiency. The program contains a large number of design cases and templates, which students can learn to understand the basic principles and methods of interior design. Through the automated design function of the program, students can quickly master design skills and methods, and improve design efficiency.

Geng and Zhu [3] discussed how to use CAD landscape design and sustainable building technology for landscape design and multimedia interactive management to achieve more efficient, innovative, and sustainable design goals. Sustainable building technology emphasizes environmental friendliness, resource conservation, and ecological balance. By combining it with landscape design, it can achieve a more green and low-carbon landscape effect. Integrating sustainable building technologies such as rainwater harvesting systems and solar energy utilization systems into landscape design can effectively reduce energy consumption and environmental pollution. Meanwhile, choosing local plants and ecological materials can also reduce landscape maintenance costs and improve landscape sustainability. By integrating multimedia elements such as images, sound, and animation, designers can create dynamic and realistic virtual landscapes, allowing customers and stakeholders to have a more intuitive understanding of the characteristics and advantages of design solutions. The intricate process of landscape design encompasses multiple facets, such as terrain manipulation, plant arrangement, architectural construction, and roadway adornment. Its objective is to fashion a landscape that adheres to natural laws while exhibiting cultural nuances within a particular locale through a myriad of design techniques. Traditional garden design is an important component of ancient Chinese culture, and its unique artistic style and profound cultural connotations make it an important source of inspiration for modern urban planning and landscape design. Traditional garden design often involves a large number of parameters and variables, and its optimization process is complex and time-consuming. In recent years, parameterized design based on genetic algorithms has gradually demonstrated its potential in traditional landscape optimization. Han et al. [4] explored the application and advantages of genetic algorithm-based parametric design in traditional landscape optimization. Traditional garden design involves many parameters, such as spatial layout, plant configuration, water body design, etc. These parameters are interrelated and affect each other, making the optimization of landscape design more complex. The parameterized design based on a genetic algorithm can encode these parameters and find the optimal combination of design parameters through the optimization search function of the algorithm. This can not only improve design efficiency but also ensure the rationality and aesthetics of the design scheme. This endeavor necessitates designers to possess profound professional understanding, ample practical experience, and keen creative faculties. Nevertheless, traditional methods often rely on manual drawings and empirical judgments, which are plagued with issues like protracted design cycles and subpar optimization outcomes. These limitations render them incapable of meeting the intricate and diverse demands of modern landscape design.

The combination of parametric-assisted design and multimedia interaction technology has brought new innovative practices for landscape design and sustainable landscape education. Hsu and Ou [5] discussed the application of this innovative practice in landscape design and its role in promoting sustainable landscape education. Through parameterized design assistance, designers can establish mathematical models for landscape design, transforming design elements such as terrain, vegetation, water bodies, etc. into editable parameters. The combination of parametric-assisted design and multimedia interactive technology has brought more innovative and practical teaching methods to sustainable landscape education. Through parameterized design tools, teachers can guide students to participate in the process of landscape design, allowing them to explore different design schemes and effects by adjusting parameters. Especially with the emergence of CAD design software, landscape designers have been provided with more efficient and accurate design tools. In landscape architecture design, the application of big data not only improves the efficiency and accuracy of design but also provides designers with more innovative possibilities. Hu et al. [6] focused on exploring the spatial form of digital nonlinear landscape architecture design based on computer big data, analyzing its advantages, challenges, and future development trends. The digital nonlinear design emphasizes the fluidity and continuity of space, breaking the fixed spatial division and boundaries in traditional architectural design. Through big data analysis and digital simulation, designers can create more free and coherent spatial forms, allowing people to feel the beauty of flow and change within them. Digital nonlinear design based on big data can handle a large number of design variables and parameters, generating complex and diverse spatial forms. These forms not only have rich visual effects but also can meet different functional needs and aesthetic standards.

Compared to traditional manual drawing, CAD technology has the characteristics of accuracy, speed, and convenience, which can greatly improve design efficiency and quality. Designers can use CAD software for terrain modeling, plant configuration simulation, light and shadow analysis, etc., in order to more intuitively display the design effect and timely discover and modify problems in the design. However, although CAD technology has achieved significant results in the field of landscape design, it still faces some challenges. Owing to the intricate and multifaceted nature of landscape design challenges, traditional optimization techniques often struggle to attain the globally optimal solution, resulting in unsatisfactory convergence outcomes. Consequently, there is a pressing need to delve into more efficient and intelligent optimization algorithms to enhance the efficacy and quality of landscape design. GA, an optimization technique that mimics natural evolution, possesses the benefits of robust global search capabilities and high resilience, offering novel perspectives for tackling optimization issues within landscape design. GA utilizes encoding design schemes, treating them as individuals, and evaluates them through fitness functions, enabling the automated optimization of these schemes. In the realm of landscape design, GA finds application in diverse areas, including terrain optimization, plant configuration refinement, and path planning, assisting designers in swiftly discovering solutions that fulfill specific criteria. Furthermore, as multimedia technology continues to evolve, interactive presentation techniques have demonstrated significant potential in landscape design. By integrating 3D modeling, rendering, and interactive methods, we can craft highly realistic and interactive virtual landscapes. This virtual setting not only enhances designers' comprehension and anticipation of design performance in real-world environments but also offers users an immersive experience, deepening their understanding and appreciation of the designs. Given this backdrop, this article introduces a GA-based CAD landscape design and multimedia interactive presentation platform. This platform leverages the strengths of GA in optimization challenges and harnesses the unique features of multimedia interactive presentation technology, striving to achieve efficiency, intelligence, and interactivity in landscape design.

The innovation of this article is as follows:

(1) This article introduces GA into landscape design optimization, breaking through the limitations of traditional optimization methods. GA, with its strong global search ability and high

robustness, provides new solutions for landscape design optimization problems, achieving automated optimization of design schemes, and greatly improving optimization efficiency and effectiveness.

(2) This article innovatively integrates CAD technology with multimedia interactive presentation technology, which not only enhances the visualization effect of design but also enhances the interaction experience between users and design solutions.

(3) This article constructs a GA-based CAD landscape design and multimedia interactive presentation platform, which not only integrates advanced algorithms and technologies but also provides a user-friendly interface and interaction mode, making it more convenient and efficient for designers and users to carry out landscape design work.

This article first introduces the background and significance of the research and then explores the application of GA and CAD in landscape design. Next, we will provide a detailed description of the overall platform construction and algorithm process, and verify its effectiveness and feasibility through experiments. Finally, in the conclusion section, the main findings and innovative points of this article are summarized, and future research directions and suggestions are pointed out.

2 RELATED WORK

In landscape planning, parameterized models can convert landscape elements such as terrain, vegetation, and water bodies into editable parameters. By adjusting these parameters, designers can quickly generate multiple design schemes and compare and optimize them. This method not only improves design efficiency but also generates more diverse and innovative landscape forms. Jia [7] explored the computer-aided design method of multimedia interactive landscape planning parameterization model and analyzed its advantages and value in practical applications. Designers can use multimedia interaction technology to create virtual landscape scenes for real-time operation and simulation. This interactive design approach not only allows designers to more intuitively experience the effect of the design scheme but also allows for timely adjustment of design parameters based on user feedback, achieving dynamic optimization of the design. 3D visualization technology is playing an increasingly important role in landscape design with its unique advantages. Jiang and Zhang [8] discussed the application of 3D visualization in multimedia interactive displays in landscape design and analyzed its impact and contribution to landscape design practice. In landscape design, 3D visualization technology can present the creativity and concepts of designers in a three-dimensional form. At the same time, it can also provide designers with a more intuitive experience and understanding of design solutions. At the same time, by adjusting parameters such as lighting and materials, simulation of different scenes and atmospheres can also be achieved, providing designers with more design ideas and inspiration.

In landscape planning and design, interactive genetic algorithms automatically generate multiple design schemes by simulating natural selection and genetic processes. Li and Sharma [9] selected, modified, and optimized landscape design through human-computer interaction. Traditional landscape planning and design often require designers to spend a lot of time and effort manually designing and adjusting. Interactive genetic algorithms can automatically generate multiple design schemes that meet the requirements based on preset rules and constraints. These schemes, under the optimization of algorithms, usually have better overall effects and higher design quality. As a key component of urban planning and design, the generation process of landscape design plans requires comprehensive consideration of various factors such as terrain, vegetation, water systems, architecture, etc., in order to achieve the unity of ecology, aesthetics, and practicality. Nisztuk and Myszkowski [10] complement the advantages of different evolutionary algorithms, overcome the limitations of a single algorithm in solving complex problems, and improve the search efficiency and global optimization ability of the algorithm. The automatic generation of landscape design plans involves the optimization and coordination of multiple factors, such as terrain undulations, vegetation distribution, building layout, etc. These factors are interrelated and affect each other, making design problems complex and difficult to handle. The hybrid evolutionary algorithm can comprehensively consider multiple factors and find the optimal solution that meets the requirements by combining the advantages of different evolutionary algorithms.

CAD (Computer Aided Design) multimedia interactive integration software technology has gradually become an important tool in the field of landscape planning and design. This technology integrates multiple media forms such as images, sound, animation, etc., providing designers with a more intuitive and comprehensive design experience, thereby promoting innovation and development in landscape planning and design. Song and Jing [11] discussed the application prospects of CAD multimedia interactive integration software technology in landscape planning and design. CAD multimedia interactive integration software technology can significantly improve the efficiency and quality of landscape planning and design. CAD multimedia interactive integration software technology provides more diverse means for the display and communication of landscape planning and design schemes. In addition, this technology can also achieve interactive display methods, allowing viewers to freely explore virtual scenes, enhancing their perception and understanding of design solutions. With the acceleration of urbanization, urban landscape ecosystems are facing more and more challenges. Among them, how to effectively carry out green design and optimize urban green structures has become one of the current research hotspots. The computer-aided greening design based on genetic algorithms provides new ideas and methods for solving this problem. Sędzicki et al. [12] studied the green structure in urban landscape ecosystems, which refers to the overall structure formed by natural elements such as green spaces, vegetation, and water bodies in urban spaces. Optimizing green structures can not only improve the ecological environment quality of cities but also enhance their aesthetics and the quality of life of residents. Computer-assisted greening design based on genetic algorithms can achieve sustainable development of urban landscape ecosystems by optimizing green structures.

In the fields of architectural design and landscape planning, computer simulation technology has become an important tool for analyzing geometric distortions. Tai [13] introduced how to use computer simulation projection to analyze the geometric distortion of scholar gardens in courtyards and gardens, and explored its significance in practical applications. In architectural design and landscape planning, computer simulation projection technology can be used to predict and evaluate the visual effects and geometric distortions of design schemes under different conditions. As a typical garden space, the geometric form and layout of scholar gardens in courtyards and gardens are crucial for the overall visual effect. By using computer simulation projection technology, we can conduct an in-depth analysis of the geometric distortions in these two garden spaces. By establishing three-dimensional models of the courtyard and scholar garden, it is possible to simulate the projection effects from different perspectives. This includes the angle of sunlight exposure at different time points and the perspective of different observation points. By simulating the projection effects under different conditions, it is possible to clearly observe the geometric changes in the garden space from different perspectives. Xu and Wang [14] discussed the color effects and applications of low-cost plant landscape design in CAD systems. The CAD system provides powerful technical support for plant landscape design by integrating various design software, databases, and collaborative tools. Designers can use these tools to quickly generate design proposals, make real-time modifications and optimizations, and communicate and collaborate efficiently with team members. This system greatly enhances the flexibility and innovation of design, making low-cost plant landscape design more feasible. In plant landscape design, color is one of the important visual elements. Through reasonable color matching and application, different atmospheres and styles can be created, enhancing the visual effect of the landscape. Low-cost plant landscape design also has significant effects on color application. Zhao [15] discussed the application of 3D CAD in landscape design and analyzed how to improve design effectiveness through hierarchical detail optimization. 3D CAD technology can perform various analyses on landscape design schemes, such as spatial layout analysis, line of sight analysis, lighting analysis, etc. These analyses help designers identify problems and shortcomings in their designs, and then optimize and improve them. In addition, by simulating the landscape effects under different seasons and weather conditions, designers can also predict long-term changes in the garden space, ensuring the sustainability and adaptability of the design. 3D CAD technology provides powerful interactive design capabilities, allowing designers to modify and adjust design elements in real-time in a 3D environment, and observe the effects of modifications. In the process of 3D modeling, attention should be paid to the representation of details, such as the morphology of vegetation and the texture of buildings. Meanwhile, selecting appropriate materials and textures is also the key to improving design effectiveness. Through precise modeling and material selection, garden design schemes can be made more realistic and vivid.

The advancement of landscape design intricately intertwines with the backing of computer technology and sophisticated algorithms. Employing these algorithms in tandem with CAD tools enables the attainment of innovation, optimization, and efficiency in landscape design, thereby fostering the sustainable growth of the industry. CAD, when paired with cutting-edge algorithms, can lead to remarkable advancements in landscape design, driving the industry's constant evolution and progress. Looking ahead, as technology continues to innovate and its application fields broaden, landscape design is poised to embark on an even more promising journey of growth.

3 CAD AND GA

3.1 CAD

CAD software is a mode of graphic design that utilizes the internal graphic functions of a computer and employs relevant technologies. This software can greatly help relevant designers and assist them in completing their design work. From a deeper perspective, CAD software is more like a data system that integrates multiple functions and enables interaction between graphics. It is mainly based on interactive computer systems, continuously composing and analyzing the display, terminals, and current graphics-related content. In the landscape design industry, the application of CAD technology has become particularly important. In the traditional landscape design process, designers often rely on hand drawing to express their overall design ideas. However, the process of drawing hand-drawn drawings is not only complex but also extremely inconvenient to modify once there are errors. The introduction of CAD design software has completely changed this situation.

In landscape design, CAD technology mainly focuses on landscape drawing and some auxiliary calculations. Designers can use CAD software to reproduce hand-drawn drawings on a computer and further modify and optimize them through various functions of the software. Integrating computer technology with hand drawing not only streamlines the design process, enhancing its speed and convenience, but also significantly boosts the precision and overall effectiveness of the designs. Furthermore, CAD design software boasts a comprehensive array of functionalities and tools, encompassing terrain modeling, plant configuration, and building layout among others. These features empower designers to realize better their creative visions (illustrated in Figure 1).

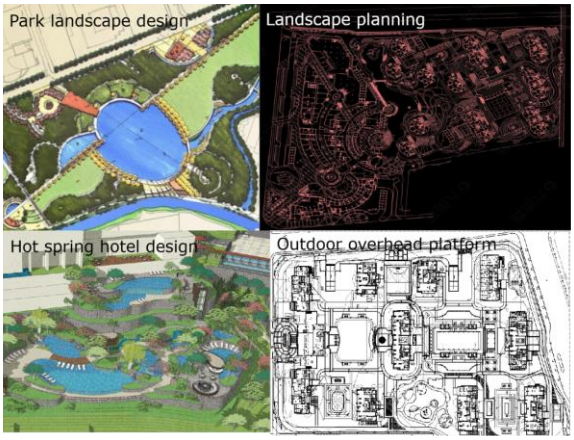

Figure 1: Application of CAD in Landscape Design.

For instance, the terrain modeling capability allows designers to replicate the intricate contours and variations of the landscape accurately. Similarly, the plant configuration function assists in selecting the most appropriate plant species and layout techniques, while the architectural layout function ensures an aesthetically pleasing and functional building arrangement. The utilization of CAD software in landscape design not only elevates the efficiency and quality of designs but also expands the creative horizons and opportunities for designers.

3.2 GA

GA, as an algorithm that simulates biological evolution mechanisms for global optimization search, has demonstrated its powerful optimization capabilities in multiple fields in recent years. Compared with traditional optimization methods such as the gradient descent algorithm, GA has significant advantages: it does not require the calculation of the gradient of the objective function and relatively low requirements for the concavity and convexity of the objective function. These characteristics make GA perform well in handling complex and nonlinear optimization problems. In the realm of landscape design, the utilization of GA holds vast promise and untapped potential. This intricate process encompasses a multifaceted array of factors and objectives, necessitating careful deliberation on the harmonious integration and equilibrium among diverse elements like terrain contours, vegetative cover, architectural layouts, and aquatic features. Traditional optimization methods often find it difficult to fully consider these factors, leading to difficulty in achieving optimal design solutions. The global search capability of GA enables it to find better design solutions in complex design spaces.

Terrain is the foundation of landscape design, and its shape and undulation directly affect the overall effect of the landscape. Through GA, the terrain can be optimized to better align with the design intent. Plants are important elements in landscape design, and their variety, quantity, and layout directly affect the visual effect and ecological function of the landscape. GA can help optimize plant configuration. In landscape design, the layout of buildings is also an important optimization problem. GA can help optimize the building layout. By taking the various parameters of the building as the genes of GA and utilizing the global search ability of the algorithm, the optimal layout scheme that meets the design requirements is found. By utilizing its powerful global search capability and low requirements for the concavity and convexity of the objective function, multiple optimization goals can be achieved, including terrain optimization, plant configuration optimization, and building layout optimization.

4 CAD LANDSCAPE DESIGN AND MULTIMEDIA INTERACTIVE PLATFORM DESIGN BASED ON GA

4.1 Platform Design

As computer technology continually evolves and optimization algorithms undergo constant innovation, the integration of CAD software with GA has sparked revolutionary shifts within the landscape design industry. Serving as a cornerstone tool, CAD software boasts robust graphics processing capabilities and design assistance functions, empowering designers to efficiently tackle tasks like terrain modeling, plant configuration, and building layout. Meanwhile, GA, as a global optimization search algorithm, excels at discovering the optimal design solution in intricate design spaces, offering a more scientific and rational approach to landscape design. In CAD landscape design leveraging GA, the optimization mechanism of GA is seamlessly integrated into CAD software. This integration involves encoding design parameters, formulating fitness functions, and executing genetic operations like selection, crossover, and mutation to arrive at the optimal design solution. This approach surpasses the limitations of traditional design methods, enabling a more comprehensive consideration of multiple goals and constraints in landscape design, thus optimizing and enhancing design schemes. Figure 2 shows the encoding process of landscape layout optimization.

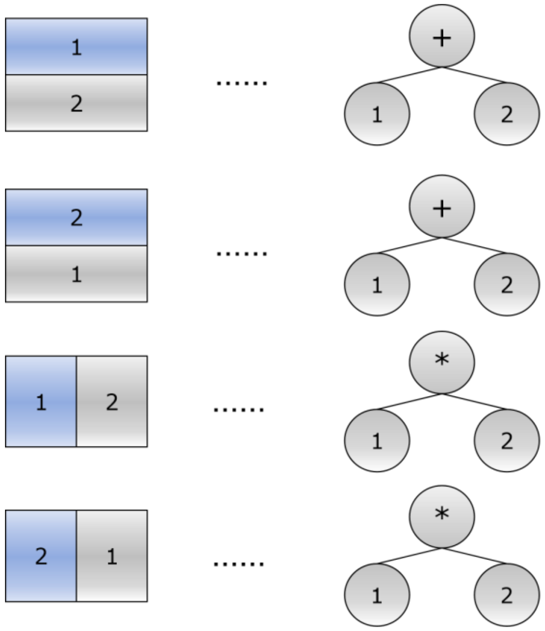

Figure 2: Encoding process of landscape layout optimization.

Meanwhile, multimedia interactive platform design is another important direction for the growth of the landscape design industry. With the rapid growth of information technology, people's demand for landscape design is no longer limited to drawings and models but is more focused on interaction and experience with design. Therefore, building a landscape design platform that can support multimedia interaction has become particularly important. The combination of GA-based CAD landscape design and multimedia interactive platform design can achieve real-time rendering of design schemes, 3D display, and user interaction operations. Designers can upload their own CAD design files through the platform, use GA for optimization processing, and display the optimized design scheme on the platform. Users can browse design solutions, perform virtual roaming and interactive operations, and provide feedback through the platform. This multimedia interactive design approach not only improves the visual effect of the design but also enhances the interaction between users and the design, helping designers better understand user needs and further improve the design scheme.

4.2 Algorithm Principle

In the cognitive process of coupling multi-objective GA, data mapping is a crucial step. The core idea of this mapping process is to convert the data samples generated by the target object into a fixed grid area for further processing and analysis. Through data mapping and deformation processing, a data sample set space suitable for multi-objective GA operations can be constructed. In this space, GA can search and optimize multiple objective functions through operations such as selection, crossover, and mutation, to find the optimal solution or approximate optimal solution that satisfies specific constraint conditions. In theory, under the same coupling condition, any data sample must satisfy both of the following conditions simultaneously:

$$D\ \dot{s} = d \times \frac{\alpha \dot{s}^{2} - 1}{\chi^{2}} \quad (1)$$

$$F\ \dot{s} = f \times \left|\dot{s}\right|^{-\frac{1}{\delta^{2}}} \quad (2)$$

In the formula: $\dot{s}$ represents any data sample, $\dot{s} \in [1, M]$; $D\ \dot{s}$ represents the conditions for coordinated processing; $F\ \dot{s}$ represents the conservation condition of the sample; d represents the coordination coefficient; f represents the conservation coefficient; a represents coupling parameters; δ represents the multi-objective labeling parameter; χ represents data sample mapping permission.

On the basis of the above formula, let A represent the encoding condition of the data sample, β represent the mapping value based on coupled multi-objective GA, $\overline{\overline{S}}$ represent the average value of the data sample, and the data mapping relationship equation is:

$$A = \frac{\sum_{\dot{s}=1}^{M} |\dot{s}|^3 - \beta\left(\overline{\overline{S}}\right)^2}{D\ \dot{s} \times F\ \dot{s}} \tag{3}$$

When designing the optimal layout of the landscape, to ensure that the solution of the data mapping relationship meets the constraint requirements of the coupled multi-objective GA, the values of the coordinated processing condition and the sample conservation condition must both fall within the numerical range of (0,1).

The basic layout features play a crucial role in landscape design, as they provide an intuitive description of the visual layout form of the landscape, reflecting the spatial relationships and overall structure of landscape elements. In the context of multi-user interactive GA applications, higher requirements have been put forward for the setting of landscape nodes. By implementing a landscape node layout that is in the same plane as the coordinate axis, and combining it with the optimization mechanism of multi-user interactive GA, a more scientific, reasonable, and user-oriented landscape design solution can be obtained. The coefficient of landscape node layout based on multi-user interactive GA is represented by O' , and its solution expression is as follows:

$$O' = \frac{1}{q}\sum_{r=1}\left(\frac{\delta\left|e_{\max}^2 - e_{\min}^2\right|}{\gamma^2 \cdot E}\right) \tag{4}$$

In the formula: r represents the derivative vector; $e_{\max}$ represents the maximum value of the plane layout parameters; $e_{\max}$ represents the minimum value of plane layout parameters; δ represents layout planning features; E represents the non-zero guiding quantity in the layout plane; γ represents the layout permission of landscape nodes.

Let ϕ represent the scene vector in the layout environment, $\dot{I}$ represent the planning coefficient, and equation (4) be used to derive the basic layout feature solution expression as follows:

$$U = \phi^2 - 1 \cdot \sqrt{\frac{Q'}{\|\dot{I}\|}} \cdot |\Delta T|^2 \tag{5}$$

The formula ΔT represents the unit layout period.

In adaptive GA, the crossover probability P_c and mutation probability P_m serve as pivotal parameters governing the search process. Their adaptive adjustment is paramount for optimizing algorithm performance and convergence speed. When the fitness of the population is relatively concentrated, indicating a lack of diversity and potential risk of falling into local optima, adaptive GA increases both the crossover probability P_c and mutation probability P_m . Boosting crossover operations enables the algorithm to explore more regions of the solution space while increasing mutation operations generates novel individuals that differ from the current population, enhancing diversity. Conversely, when the fitness of the population is dispersed, suggesting significant differences and diversity among individuals, adaptive GA decreases the crossover probability P_c and mutation probability P_m. This approach maintains the search momentum and prevents undue disruption to the currently favorable state. In essence, the adaptive adjustment of these probabilities allows the GA to balance exploration and exploitation, ensuring both effective coverage of the solution space and efficient convergence towards optimal solutions.

$$P_c = \begin{cases} k_1 \; f_{\max} - f' \; / \; f_{\max} - f_{ave} \; , f' \geq f_{ave} \\ k_2, f' < f_{ave} \end{cases} \tag{6}$$

$$P_m = \begin{cases} k_3 \; f_{\max} - f \; / \; f_{\max} - f_{ave} \; , f \geq f_{ave} \\ k_4, f < f_{ave} \end{cases} \tag{7}$$

The formula $f_{\max}$ represents the highest fitness, f_{ave} denotes the average fitness, f' stands for the fitness value of the individuals exhibiting superior fitness among the crossover group, f represents the fitness of those individuals that produce variation, and $0 < k_1, k_2, k_3, k_4 \leq 1$.

Visualization plays a crucial role in the comparative design process of landscape layout nodes. Through visualization processing, users can intuitively see the spatial relationships, color combinations, and overall style between different layout nodes, thereby better participating in the design process, providing feedback, or further adjusting the design. The visualization processing expression is:

$$K = \frac{1}{\iota}\left|D\right|^2 + \lambda \sum_{l=1}^{+\infty} \bar{h}_l^2 \tag{8}$$

The formula, ι represents the visualization operation coefficient; λ represents the node comparison parameter of GA; l represents the initial value of the node labeling coefficient; $\bar{h}$ represents the cumulative mean of nodes in the layout plane.

5 RESULT ANALYSIS AND DISCUSSION

The following experiments will be conducted to verify the performance of the platform in this article. Use the platform proposed in this article to optimize the landscape of a certain city and evaluate people's recognition through satisfaction. From Figure 3, we can see the comparison of people's satisfaction after optimizing the landscape on different platforms. By comparing the landscape satisfaction data optimized on different platforms, it is evident that the landscape optimized on this platform performs more prominently in terms of satisfaction. This result fully demonstrates the effectiveness and advantages of the platform in landscape optimization. Compared to traditional platforms, this platform combines GA, CAD, and multimedia technologies to achieve more precise and efficient landscape optimization. In addition, the improvement in satisfaction also reflects people's recognition and acceptance of the optimized landscape.

Table 1 shows the comparison of people's satisfaction values before and after optimizing different landscapes in the city. From the data in the table, it is clear that after optimizing the platform in this article, people's satisfaction with these landscapes has significantly improved. Comparing the satisfaction values before and after optimization, it can be seen that each landscape has achieved higher satisfaction ratings after optimization. This significant improvement demonstrates the effectiveness of the platform in landscape optimization, which can effectively improve and enhance the quality and attractiveness of urban landscapes. The improvement in satisfaction is not only a numerical change but also reflects people's recognition and love for the optimized landscape.

The root mean square error (RMSE) serves as a metric for quantifying the disparity between observed and true values, thereby rendering it highly suitable for assessing the convergence precision of algorithms.

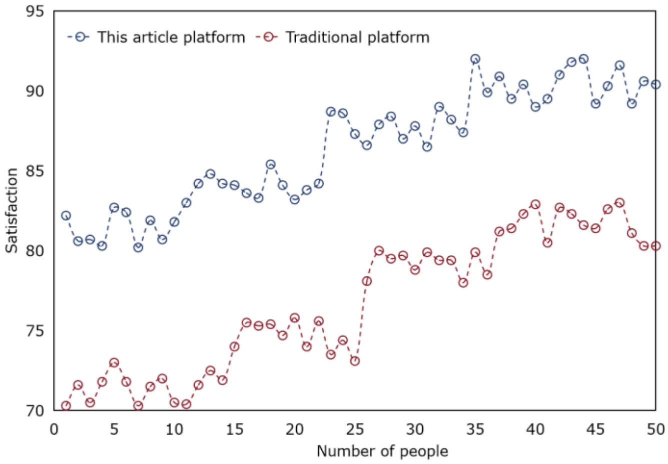

Figure 3: Satisfaction comparison.

Evaluation factors	*Before optimization*	*After optimization*
Greening rate	0.14	0.37
Wide field of vision	0.27	0.58
Leisure level	0.31	0.87
Personalized spatial layout	0.26	0.57

Table 1: Comparison of satisfaction before and after landscape optimization.

A reduction in the number of evolutionary generations translates to a shorter time frame for the algorithm to approximate optimal solutions, ultimately leading to accelerated convergence. Figure 4 compares the experimental outcomes of our approach with those of traditional methods. Evidently, the curve corresponding to our proposed method attains a lower RMSE value with fewer evolutionary generations, indicative of a swifter convergence rate. Conversely, the curve for traditional methods gradually trends towards lower RMSE values as the number of generations increases, revealing a slower convergence rate. This comparison underscores the superiority of our method in terms of both convergence speed and precision.

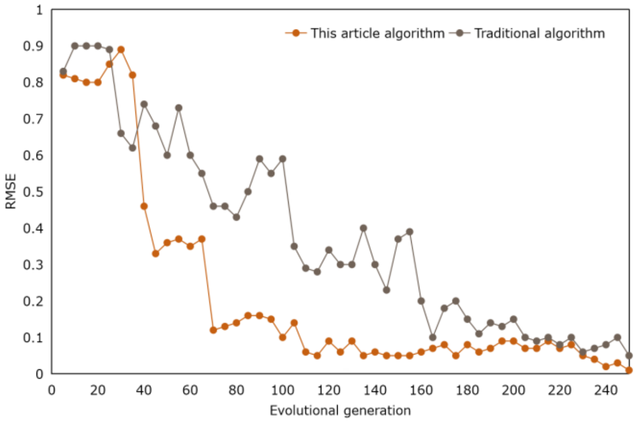

Figure 4: RMSE comparison results.

Figure 5 compares various algorithms based on the likelihood of damaged nodes serving as cluster heads. The illustration reveals that when the proportion of damaged nodes remains low, both algorithms' models exhibit robust security. This indicates that both algorithms can effectively cope with and maintain stable system operation with minimal node damage. However, as the ratio of damaged nodes gradually increases, the algorithm model proposed in this paper shows significant performance advantages and can improve model stability.

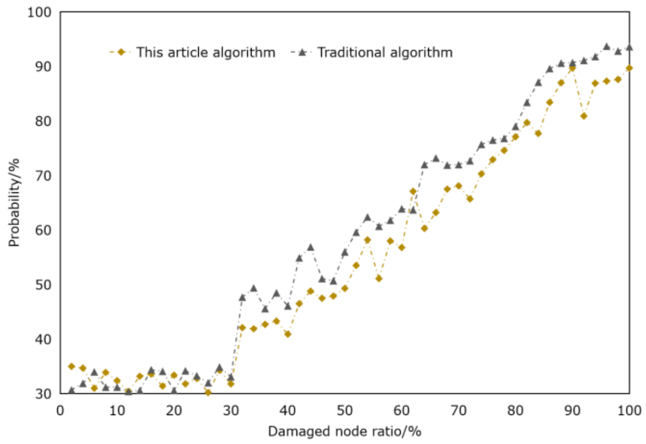

Figure 5: Comparison of the probability of damaged nodes becoming cluster heads.

Figure 6 presents a comparative analysis of energy consumption across different algorithms. Evidently, the algorithm introduced in this paper exhibits notable advantages over traditional methods in terms of energy usage. This superior performance is primarily attributed to the integration of GA within our proposed algorithm, which effectively minimizes redundant data transmission and consequently reduces energy consumption.

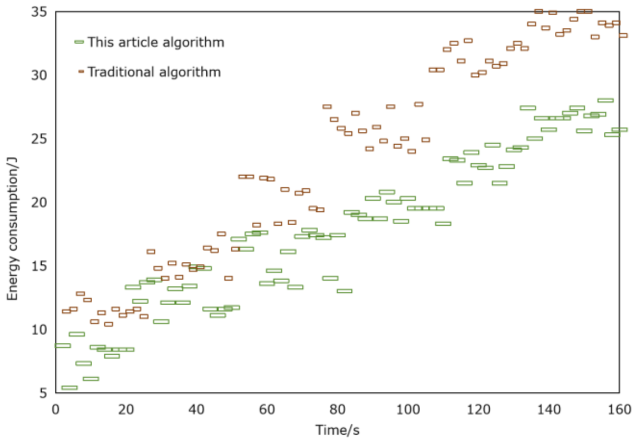

Figure 6: Energy consumption comparison.

Figure 7 shows the comparative data of different platforms in terms of task processing speed. It can be clearly seen from Figure 7 that under the same number of tasks, the processing time of the platform in this article is shorter. This result fully demonstrates the significant advantage of our platform in task processing efficiency. This advantage enables the platform in this article to process a large number of tasks more quickly, improving overall work efficiency. Meanwhile, shorter processing time also means that users can obtain results and feedback faster, enabling them to make faster decisions and adjustments, further optimizing the landscape design process.

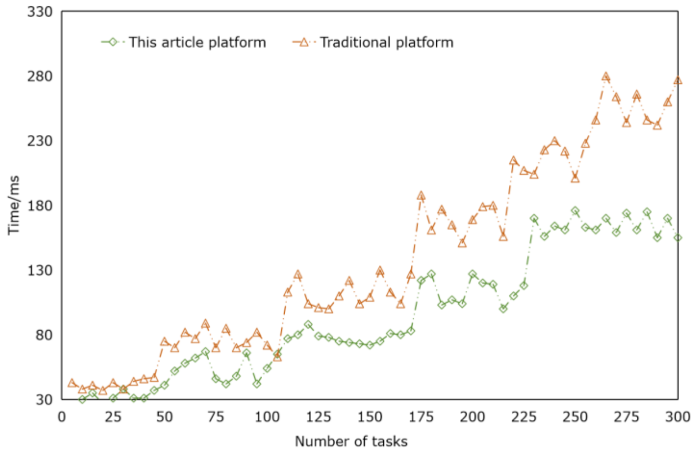

Figure 7: Comparison of task processing speed.

6 CONCLUSIONS

CAD technology, a noteworthy advancement in computer science, offers profound advantages in the realm of landscape design. Its introduction has facilitated smoother communication among designers and boosted collaboration efficiency. As information technology continues to proliferate, CAD technology's application in landscape design is expected to broaden significantly, gradually supplanting traditional manual drawing methods and emerging as the preferred tool in this field, hinting at the vast potential for future use. The CAD landscape design and multimedia interactive platform introduced in this article, grounded in GA, leverages GA's strengths in optimization problems. By encoding design schemes as individual GAs and evaluating them using a fitness function, we achieve automated optimization of the design schemes, thereby enhancing design efficiency. Experimental results demonstrate that this platform not only elevates the efficiency and quality of landscape design but also enhances users' interactive experience, offering a richer and more immersive encounter.

Although this article has achieved certain results in CAD landscape design and multimedia interactive platforms, there are still some shortcomings. The optimization process of GA may be influenced by parameters such as initial population, crossover, and mutation operations. How to determine the optimal parameter settings to further improve the optimization effect is a problem worthy of in-depth research. With the continuous increase and changes in design requirements, the functionality and performance of the platform also need to be constantly updated and improved to adapt to new design requirements.

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Aran Ren, https://orcid.org/0009-0006-3206-0157
Zhuo Chen, https://orcid.org/0009-0000-9772-0634

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