Optimization of Tourism Scenic Area View Planning and Design Based on Multimodal Fusion

Zhongyuan Yang[1] and Jiaping Chen[2]

[1,2] School of Culture and Tourism, Henan Polytechnic, Zhengzhou 450046, China,
[1]26017@hnzj.edu.cn, [2]chenjiaping@126.com

Corresponding author: Zhongyuan Yang, 26017@hnzj.edu.cn

Abstract. This article presents an optimization model for tourism landscape design under multiple modes. Through multimodal fusion analysis of propagation neural networks, a computer tourism fusion design analysis and optimization system was constructed under multiple datasets. Based on improving rationality, it has enhanced data collection and fusion for optimizing tourism landscape design through computer self-learning. In the process of optimizing the processing mode of computer landscape design, it constructed and analyzed the results of user satisfaction landscape design survey and analysis under the tourism landscape ecosystem. In the process of analyzing the production effect of user landscapes, a multimodal optimization model was used to simulate the effect of landscape design. The proposed multimodal design fusion satisfaction process comprehensively exceeds the traditional concept of fusion optimization models in terms of user statistical satisfaction.

Keywords: Multi-Modal Fusion; Tourism Landscape; Satisfaction; Multimodal Fusion
DOI: https://doi.org/10.14733/cadaps.2025.S3.201-214

1 INTRODUCTION

Rural multimodal landscape design is a very broad concept. This concept originated in geography and refers to a collective term for a rural surface phenomenon or type unit, such as grassland landscape and forest landscape. It has the meaning of scenery, scenery, or scenery. Therefore, the category of landscape design born from luck is closely related to its concept [1]. The development of rural landscape design has gone through a long historical process, during which the clarity and scientificity of its concepts have kept pace with the times and have been continuously supplemented and improved. Modern landscape design and its development not only involve changes in form but also significant transformations in design concepts and traditional ideas. Modern landscape designers believe that landscape design is a comprehensive discipline primarily focused on outdoor environmental construction [2]. In history, the development of landscape design can be divided into early, modern, and contemporary stages. It is a spatial planning that originates from nature and is carried out to meet people's needs [3]. It integrates art, science, culture, and engineering technology and is a highly applied professional discipline. The main research direction of this discipline is to design the environment for human outdoor survival. In summary, this major is designed to address the environmental modification behaviours adopted by humans to adapt to various natural living conditions. Modern landscape design and its development are fundamentally due to the dual impact of industrialization on nature and the human body and mind. The diversified economy requires the participation of other stakeholders, including relevant government departments, developers, investors, or the general public [4]. It is digital technology that can handle various contradictions and interests with ease, make design forms visible, make the design process reversible, and make design methods versatile and multifunctional technical means. In today's social life, especially in the diversified market economy, landscape is no longer the task of landscape designers. Therefore, the conditions that landscape design needs to meet today can no longer be as single as before, considering the diversity of its audience. Under the new global economic and environmental conditions, new design methods are being applied to landscape planning. This method of integrating education with entertainment has been proven effective as it can stimulate students' interest and participation in learning [5].

In the wave of green city design, multidimensional digital models are gradually becoming a key tool for shaping future urban spatial forms. By integrating green city design principles into tourism landscape planning, we can create a tourism environment that is both ecologically beneficial and attractive, satisfying tourists' dual pursuit of natural beauty and cultural depth. Green city design emphasizes the harmonious unity of ecology, economy, and social benefits, while tourism landscape planning is the specific application of this concept in the tourism industry [6]. To more effectively guide tourism landscape planning, some scholars have focused on building a data visualization method system based on nonlinear technology, aiming to optimize the spatial layout and form design of landscape architecture through innovative digital means. We have achieved nonlinear parametric design of actual garden landscape scenes through colour partitioning methods. This method not only breaks the limitations of traditional linear design but also endows landscape spatial forms with richer and more diverse possibilities and higher design efficiency. It can quickly generate multiple design schemes and visually display the spatial effects and potential problems of different schemes through data visualization methods, providing strong decision support for designers [7]. Using nonlinear technology to deeply explore and visualize the spatial form of tourism landscapes. In the analysis of simulation results, it was observed that the proposed nonlinear algorithm significantly improved the efficiency of landscape design. Through data visualization techniques, we can transform complex tourism landscape planning problems into intuitive and easy-to-understand charts and images. The integration of green city design and tourism landscape planning, as well as the application of nonlinear data visualization technology, can help achieve sustainable development of the tourism industry [8].

The rapid development of digital technology is undergoing profound changes in the field of urban and tourism landscape planning. Focusing on the practice of parametric design in tourism landscape planning, through design exercises and simulation calculations, this paper explores in depth its application technology in panoramic structural layout and expands the analysis of its efficient, universal, multi-objective, sustainable, and optimized characteristics. Parametric design, as an important tool in the field of digital age design, achieves automation and intelligence of the design process by defining design parameters and their interrelationships. In tourism landscape planning, parametric design not only simplifies the tedious manual operations in traditional design. In this context, the integration of computer-aided planning technology, parametric design, and multi-objective optimization strategies has brought unprecedented efficiency improvements, methodological innovations, and changes in thinking patterns to tourism landscape planning [9]. Through algorithm optimization, the design scheme can better adapt to complex and changing site conditions and diverse functional requirements [10]. Combining multi-objective optimization strategies can further optimize the design scheme, achieve a balance between ecological protection and tourist experience, and enhance the overall quality and value of the tourism landscape. Analyzing actual design cases demonstrates the specific application of parametric design in tourism landscape planning.

Within the tourism landscape design field, advancements in science and technology, alongside the diversification of tourist needs, have prompted increased scholarly attention towards the application of emerging technologies. Combining multimodal fusion technology with CAD can bring a new perspective to the design of the tourism landscape. By integrating multi-modal data, designers can fully understand the current situation of the tourist landscape, tourists' needs and market trends, to make more scientific and reasonable planning and design decisions. With the powerful function of CAD technology, designers can transform their design intentions into concrete design schemes more quickly and accurately. This article aims to explore the optimization method of tourism landscape design based on multimodal integration and provide a useful reference for the development of this field through theoretical research and practical exploration.

2 RELATED WORKS

The concept of "tourist landscape" emerged in the 1970s and 1980s, referring to the scenic spots, entertainment venues, and tourism services available for viewing and enjoyment within a region. The joint development of a comprehensive tourism village environment, services, entertainment, cultural dissemination, and other aspects forms a tourist destination with functions such as sightseeing, vacation and leisure, and expanding horizons. When evaluating the quality of a tourist landscape (rural tourism landscape), it is usually based on the comprehensive scores of the "Service Quality and Environmental Quality Evaluation System," "Landscape Quality Evaluation System," and "Tourist Opinion Evaluation System." Rural tourism landscape refers to the natural scenery, pastoral landscapes, architecture, and culture that are highly localized within rural areas, serving as attractions for rural landscapes. It can be seen that in the development of rural tourism landscapes or tourist attractions, in addition to the rational development of rural tourism resources, supporting infrastructure and entertainment facilities should be built for them. Considering this comprehensively, it can meet the tourism needs of tourists in terms of entertainment, food, accommodation, transportation, shopping, and tourism, as well as promote the sustainable development of the tourism industry. Scientificity requires planners to use scientific methods and techniques for landscape design. These two principles provide theoretical support for Xia and Ma [11] to introduce multimodal fusion technology and CAD. Multimodal fusion technology is a new type of information processing method that comprehensively and accurately describes and explains complex real-world phenomena by integrating and analyzing different datasets. In tourism landscape design, multimodal data includes geographic information system (GIS) data, tourist feedback, social media images, and videos. These datasets provide different perspectives on tourism landscapes, tourist demand, and market trends, providing a rich and comprehensive foundation for designers' work.

In tourism landscape planning, it is crucial to make reasonable use of natural conditions such as terrain and climate, promote plant diversity, and enhance landscape appreciation value and ecological functions. Xu and Wang [12] designed an intuitive and user-friendly human-computer interaction interface to ensure that users (including tourism landscape planners, horticulturists, and tourists) can easily access the database and efficiently filter and query according to their own needs. However, in current tourism landscape design, designers often lack awareness of local plant species. This leads to a single plant configuration or poor plant growth conditions, limiting the overall charm and sustainable development of the landscape. The development and application process of this system first focuses on comprehensively collecting and organizing detailed data on common plants in major gardens and tourist landscapes at home and abroad and constructing a rich and accurate database of garden plants. Therefore, introducing computer-aided systems for garden plants has become an innovative measure. This system not only serves traditional garden design but also demonstrates enormous potential in tourism landscape planning. Therefore, based on the unique environment of tourist attractions, scientifically selecting and optimizing the configuration of plant species is the core issue in improving the quality of tourism landscape planning. Yan [13] integrates advanced information technology and ecological principles, aiming to help planners accurately match and optimize plant species based on specific environmental conditions, achieving dual improvements in both ornamental and functional aspects. This database not only covers the biological characteristics and growth habits of plants, but also records in detail their ornamental features, cultural significance, and various uses in gardens, providing solid data support for tourism landscape planning. Users can input specific features of the planned area (such as soil type, rainfall, temperature range, etc.) and expected landscape effects through the system interface. The system will intelligently recommend the most suitable plant species and planting suggestions based on this information.

With the vigorous development of the social economy and the rapid advancement of computer software and hardware technology, computer technology is playing an increasingly important role in various industries, including tourism landscape planning. In recent years, with the continuous innovation of landscape design computer graphics software, these advanced tools are gradually becoming new engines for the development of tourism landscape planning applications. On the vast stage of tourism landscape planning, computer-aided software has become an indispensable assistant for interior decoration, advertising creative design, and urban tourism planning due to its accuracy, efficiency, and comfortable user experience. They can not only simulate natural and cultural landscapes with extremely high accuracy but also seamlessly integrate virtual design with the real world through virtual reality (VR) technology, bringing unprecedented immersive experiences to tourism landscape planning. Although computer technology has made significant progress in the field of landscape design, its application and development speed in tourism landscape planning are relatively lagging behind, and further exploration and promotion are needed. Yang [14] By comparing and analyzing the unique advantages and potential limitations of different computer-aided software, a detailed software selection guide is provided for industry practitioners. This immersive virtual reality experience is like presenting a landscape painting directly to participants, greatly enhancing the influence and appeal of the planning scheme, and allowing planners and stakeholders to more intuitively feel and participate in the planning process. These software not only excel in creative expression, spatial layout, and material texture simulation in landscape design but also provide customized solutions based on the special needs of tourism landscape planning. Zhang and Deng [15] also pay attention to the latest developments in the process of tourism landscape planning, especially how to use digital tools supported by computer technology to optimize and innovate the planning process. From data collection and analysis, and program design to implementation monitoring and evaluation, each step will explore how computer technology can help tourism landscape planning develop more scientifically, efficiently, and sustainably.

Due to the systematic nature of the application of smart technology in rural tourism landscapes, there is an inevitable connection between specific smart technologies. Based on real-time monitoring, add a positioning function to strictly control the number, duration, and location of tourists in the scenic area, and real-time regulate and predict the flow of people at landscape nodes. For example, integrating video surveillance technology with GPS technology has multiple functions such as image processing, image analysis, resource management, media distribution, storage management, and alarm services. By combining the advantages of different technologies, targeted solutions can be given to specific problems in rural tourism landscapes while endowing landscape space and facilities with functional complexity. Evacuate personnel based on the comparison between the capacity of the scenic spot and the actual capacity to avoid excessive pedestrian flow. At the same time, tourists can learn about the distribution of nearby staff through mobile devices, and once they get lost or encounter other situations, they can communicate with the staff. It can be seen that whether it is a single technology or a combination of technologies, the application of smart technology greatly enhances the functionality of rural tourism landscapes and improves the work efficiency of management departments. The data transmission equipment of rural tourism scenic spots mainly uses the Internet, mobile Internet, wireless network communication technology, Internet of Things and other transmission smart technologies.

3 APPLICATION OF MULTIMODAL FUSION TECHNOLOGY

3.1 Multi-Modal Data Acquisition and Processing

Rescue personnel can also obtain the location of tourists through GPS positioning, providing necessary materials and rescue for stranded tourists, further reducing the probability of accidents in the scenic area. When video surveillance detects a disaster, locate the camera position to take emergency action. Realize the communication and analysis of various data and then utilize diverse multimedia, user terminals, and other devices to output, thereby ensuring the stable operation of the work system and the effective dissemination of landscape information. Nowadays, by applying wireless network transmission technology to rural tourism landscapes, tourists can access the internet anytime and anywhere within the scenic area and obtain the information they are interested in. The information electronic devices in the scenic area are all connected through wireless networks, providing information such as weather, attractions, and transportation, thereby further improving service quality. It is the application of smart technology that has changed and expanded the way information is disseminated, broken the traditional service model, and achieved information-based, data-driven, and diversified scenic area services. For example, in some rural areas, weak mobile phone signals often occur due to terrain reasons, making it difficult for tourists to stay in touch with the outside world on time when they encounter danger. Table 1 shows some examples of multimodal data acquisition, including different data modes, data sources and corresponding acquisition methods.

Data Modality	*Data Source*	*Collection Tools/Techniques*	*Preprocessing Steps*	*Storage Format*
Image	Satellite Remote Sensing	High-resolution Camera	Image Correction, Cropping, Enhancement	JPEG/PNG
	Aerial Photography by Drone	Camera Mounted on Drone	Image Stitching, Denoising, Color Correction	TIFF/JPEG
Text	Tourist Feedback	Online Survey Forms	Text Cleaning, Tokenization, Stop Word Removal	CSV/TXT
	Online Reviews	Social Media Crawler	Sentiment Analysis, Keyword Extraction	JSON/XML
Sound	Environmental Sound Effects	Environmental Recording Equipment	Noise Reduction, Sound Recognition, Feature Extraction	WAV/MP3
	Tourist Voices	Microphone Array	Sound Source Localization, Speech-to-Text	AIFF/FLAC

Table 1: Multimodal Data Collection and Processing Details.

3.2 Multi-Modal Data Fusion Method

Multi-modal data fusion involves effectively integrating data from diverse modes to extract more comprehensive and accurate information. In tourism landscape planning, multimodal data fusion methods primarily encompass feature fusion and decision fusion. Table 2 provides a comparison between these two multimodal data fusion approaches.

Fusion Method	*Fusion Stage*	*Main Algorithms/Techniques*	*Advantages*	*Limitations*	*Applicable Scenarios*
Feature Fusion	Early	Deep Learning (CNN, RNN, etc.), Feature Concatenation	Fully Utilizes Complementarity, Enhances Information Richness	High Complexity of Fusion Algorithms, Large Computational Load	Requires Highly Integrated Information Representation
		Multiple Kernel Learning, Joint Feature Selection	Effective Handling of High-Dimensional Data	May Introduce Noise and Redundant Information	
Decision Fusion	Late	Weighted Averaging, Voting Mechanism	Considers Advantages of Each Modality, Enhances Decision Reliability	May Neglect Fine Differences Between Modalities	Independent Decisions from Each Modality
		Bayesian Fusion, Fuzzy Logic	Handles Uncertain Information	Requires Large Amounts of Annotated Data for Training	

Table 2: Comparison and selection of multimodal data fusion methods.

4 OPTIMIZATION MODEL OF TOURISM LANDSCAPE DESIGN

Smart navigation scene is the full application of the Internet, Internet of Things, GPS, multimedia, augmented reality, and other technologies in the field of traffic navigation. The smart navigation scenarios in rural tourism landscapes include "real-life navigation" and "electronic navigation signs" that provide maps and guidance services for tourists. In terms of the presentation form of scenic area maps, traditional paper flat maps can clearly show the geographical outline of scenic areas and the distribution status of scenic facilities, but their navigation function is not obvious, and they do not have real-time and practicality. The operation process of the real-life navigation system is very simple. Tourists only need to open the scenic area app and turn their phone camera towards the actual scene. If you want to go to a certain position on the screen, tap the icon to change the navigation route directly. After the tourist opens the app point their phone at the road, and a little penguin will appear on the screen as a GPS guide to lead the tourist to the scenic area. The walking movements of penguins are captured through motion capture technology to achieve a perfect reproduction of their actual walking posture. Therefore, many rural tourism landscapes will use mobile reality navigation systems that combine 3S technology and augmented reality technology in scenic area maps, and tourists can use their mobile phones to navigate routes at any time.

Restaurants, shops, etc. are labelled, and all icons are coloured according to different functional categories, allowing visitors to intuitively understand surrounding information. In addition, the view interface will display important scenic spot information and public service facilities on the screen. The "intelligent real-time commentary" that provides automatic explanation services and the "smart parking lot" that provides convenient parking services provide tourists with comprehensive traffic information services. At this point, the relevant image information will be associated with geographic information and directional navigation will be carried out based on the real scene. Tourists can follow the arrow direction to reach their destination. Through high-tech, we provide tourists with transportation information, scenic area maps, route navigation and other services to ensure the quality of scenic area services and the safety of tourists' travel.

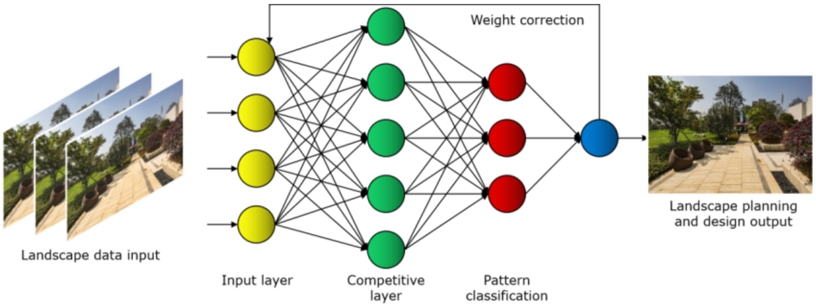

Figure 1: Model structure of self-generating system.

Finally, the ACO decision optimization module is used to further optimize the design results of BPNN, and fine-tune the design results of BPNN by simulating the optimization algorithm of ant colony foraging behavior, to find a better design scheme and further improve the scientificity and rationality of the design.

To calculate the boundary M of the landscape function type C_j, follow this method:

$$\beta_0, \beta = \arg\max C_j \ \ where Y_j \left(\beta_0 + \sum_i \beta_i y_{ij} \right) \geq C_j \tag{1}$$

The formula includes β_0, β, which serves as both a constant and a weighted variable for computing the landscape functional characteristics y_{ij} while Y_j representing the classification state of landscape functional types.

The accuracy of the recognition results for landscape functional areas is verified and evaluated using quantitative indicators derived from the confusion matrix, considering both overall recognition accuracy and specific functional area types. Additionally, the Kappa coefficient formula is used for the recognition of landscape functional areas.

$$K = \frac{P_o - P_e}{1 - P_e} \tag{2}$$

P_o signifies the ratio of accurately classified samples of each function type to the overall sample count, whereas P_e indicates the ratio of the product of the actual count of each function type and the classified sample count to the square of the total sample count.

This process uses image segmentation technology to divide the landscape image into regions or objects and extract their own artistic style characteristics. Figure 2 shows the detection window of landscape art features.

Figure 2: Landscape feature detection window.

Given a landscape environment W, with boundary WSB, and all polygon obstacle areas denoted as Q_i, then:

$$W = WSB, Q_1, Q_2, \cdots, Q_m \tag{3}$$

m represents the count of polygonal obstacle areas. Singular value decomposition (SVD) is a versatile algorithm applicable to any matrix decomposition. For instance, if the data input size to the fully connected layer is $u \times v$ and the weight matrix is W, the output data of the fully connected layer can be calculated using the formula:

$$y = Wx \tag{4}$$

The computational complexity is u, v. When a W pair is decomposed using singular values and W is approximated by the first t significant eigenvalues obtained from the decomposition, the decomposition formula is given as follows:

$$W = U \sum V^T \approx U \sum_t V^T \tag{5}$$

U denotes a u, v -dimensional orthogonal matrix. $\sum_t$ Represents a diagonal matrix corresponding to the first t values in the original diagonal matrix W, with a dimension of $t \times t$. V Signifies an $v \times t$ -dimensional orthogonal matrix.

Neural networks and traditional regression analysis share a similarity in their objective: both aim to find the best function fit by minimizing model error. The model fitting error is expressed as follows:

$$E = Y - f\ X \tag{6}$$

Since the deviation term's value is consistently 1, its weight has an equivalent effect to the constant term in the regression model. Analogously, a network with a hidden layer resembles a nonlinear regression model, and a hidden layer is represented by the following formula:

$$y = G\left(\sum_{j=1}^{k} \beta_j G\left(\sum_{i=1}^{m} \gamma_{ji} x_i\right)\right) \equiv f\ x, \phi \tag{7}$$

G denotes the transformation function for both the hidden and output layers in a neural network. h represents the number of neurons in the hidden layer, while m signifies the count of input units. β_j Refers to the weights between output neurons and hidden layer neurons, and γ_{ji} denotes the weights between hidden layer neurons and input neurons. ϕ Encompasses all relevant weights within the network, x_i represents the input value, and y is the output value.

In the enhancement scheme, we focus on studying the strategy of combining global and local pheromone updating, with further optimization of the global updating formula to enhance scientific and innovative design.

By integrating ACO's rapid global optimization capabilities with the neural network's extensive mapping abilities, this novel model exhibits strong global search and optimization prowess while accurately mapping and expressing the complex characteristics of tourism landscape design.

Some ants depart from set I_{pi} and adhere to specific path rules to locate elements within all sets in sequence, ultimately discovering the food source. The path selection rule involves a set I_{pi}, all ants $k\ 1,2,\cdots,M$, and the random selection of the j element with a predetermined probability, calculated using the following formula:

$$prob\ t_j^k\ I_{pi} \ = t_j\ I_{pi}\ / \sum_{\mu=1}^{N} t_u\ I_{pi} \tag{8}$$

When constructing a line R_t, R_c, the time and cost and compare their values to determine the better line $Rbetter$, and subsequently update the pheromone of the superior line:

$$\tau\ i,j\ = 1-\mu\ \tau\ i,j\ + \mu\tau_0 \tag{9}$$

μ denotes a parameter ranging from 0 to 1, while τ_0 representing the initial pheromone concentration. In the intricate context of tourism landscape design, it is crucial to employ a local updating method for pheromone processing.

5 CASE ANALYSIS

This method fully harnesses the benefits of multimodal fusion technology, effectively integrating data from different modes to produce more realistic and detailed landscape effects. Additionally, the learning capabilities of BPNN and the optimization prowess of ACO ensure that the design outcomes align closely with actual requirements, enhancing the scientific and rational design.

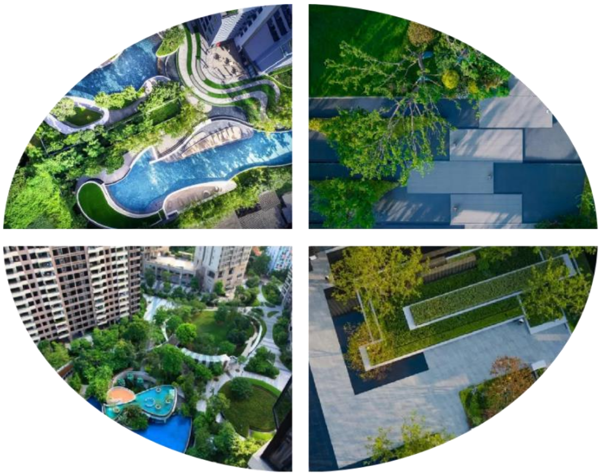

Figure 3: Landscape effect of this method.

Figure 3 shows the landscape effect of this method In contrast, the effect diagram of landscape planning by traditional methods (without ACO optimization) is relatively rough and simple, as shown in Figure 4. Traditional methods often rely on the designer's personal experience and subjective judgment, lacking systematicness and scientificity. Therefore, it is often difficult to achieve the ideal effect in the design effect, and it can not meet the diverse needs of tourists.

Figure 4: Landscape effect of traditional method design.

To further corroborate the efficacy of the refined method, a user satisfaction rating experiment was conducted. As illustrated in Figure 5, the results reveal that the proposed method surpasses the traditional approach considerably in terms of user satisfaction. This superiority stems from the enhanced method's ability to comprehensively consider tourists' needs and preferences, and seamlessly integrate tourists' feedback, social media images and videos, and other pertinent information into the design using multimodal fusion technology, ultimately enhancing tourists' satisfaction and overall experience.

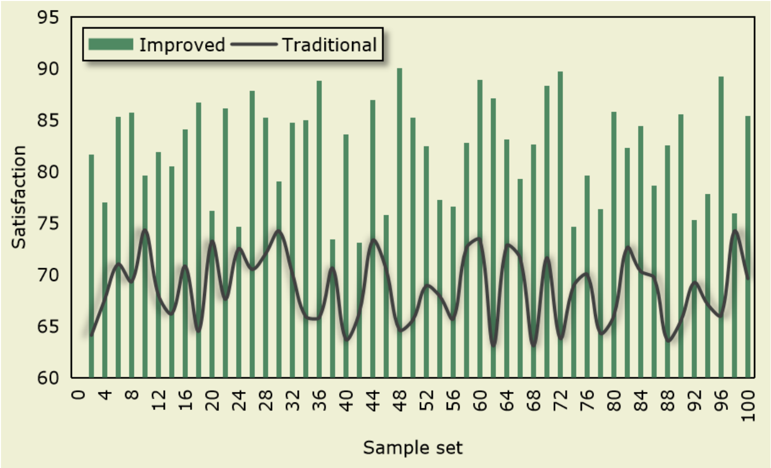

Figure 5: User satisfaction score.

Furthermore, this study conducted a scoring experiment to evaluate design performance. The reason why rural tourism landscapes are deeply loved by people is not only because of the beautiful natural rural landscapes but also because of the unique customs, and historical and cultural background of rural areas. It is precisely because of the accumulation of time that rural tourism landscapes have a unique charm. And these cultures and legends, as a kind of "artwork", need to be protected and spread in the form of dissemination. Therefore, in most rural tourism landscapes, historical and cultural exhibition halls, museums, village history museums, and other forms are often used to explain and display the local cultural background. But for ancient villages and historic villages with profound historical and cultural heritage, it is difficult to vividly convey cultural connotations through traditional display methods such as text and images. Therefore, compared to traditional exhibition halls, smart exhibition halls that use multimedia, virtual reality, panoramic projection, sensing and other technologies are more conducive to the display and development of rural tourism landscapes. The smart exhibition hall scene usually includes two forms of display: digital display and virtual experience, presenting display information in various forms to tourists, suitable for rural tourism landscapes that require cultural, natural, and historical display.

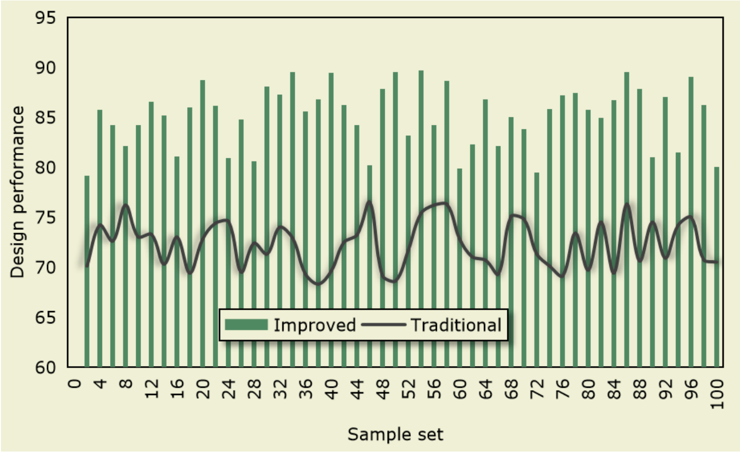

Figure 6: Design performance score.

As a new display method, the virtual display presents rural history, culture, stories, and backgrounds in a more intuitive and vivid form in rural tourism landscapes, bringing new vitality to rural tourism landscapes. Compared to physical displays, virtual cultural relic displays allow visitors to view exhibits more clearly, up close, and from different perspectives, and can also avoid the danger of cultural relics being broken, stolen, or exposed to damage for a long time. For some important, difficult-to-display, or disappearing historical relics, holographic projection technology can be used to restore the relics, which has a high degree of authenticity. Cultural relics are symbols of the Chinese nation and carriers of regional culture. The rural lifestyle and production methods have gradually modernized over time, and only the primitive rural production and living scenes have true experiential and communicative value. Items placed in this scene from history can appear in the picture, breaking through the limitations of space and time, and integrating history with the present, virtual, and reality more closely, making landscape tourism more interesting. Therefore, virtual reality technology can be applied to the reproduction of historical scenes, allowing tourists to "visit" historical scenes through VR devices and truly experience the village landscape from many years ago. However, presenting ancient scenes through physical objects is somewhat difficult and requires a significant amount of manpower and material resources, and the final presentation effect may also be unsatisfactory. The display of virtual items is not limited to indoor scenes, and visitors can use their mobile phones to point at any designated real scene indoors or outdoors. It can be seen that digital display has great application space in rural tourism landscapes. It breaks the traditional static display method and attracts tourists with its unique fun and interactivity, while also catering to the information input methods of people in today's era. The technology used for virtual item display is augmented reality, which combines virtual objects with real scenes to achieve mixed interaction from the virtual world to the real world. Figure 7 shows the comprehensive score. Rural tourism landscape, as an important carrier of rural scenic culture and aesthetics, has a significant impact on the atmosphere creation and sustainable development of scenic spots. Therefore, smart landscape scenes in rural tourism mainly include interactive experience landscapes, plant scanning recognition, and garden maintenance. Smart landscape is a type of advanced landscape design that upgrades traditional landscapes into more intelligent and information-based landscapes driven by various technologies. It includes diverse display modes that are multifunctional, interactive, and aesthetically pleasing, as well as intensive, digital, and sustainable green management modes. The first two emphasize the interaction between tourists and the landscape, while garden maintenance focuses more on controlling the health status of plants in the scenic area, ensuring that tourists can enjoy a good experience both during participation and appreciation. With the continuous changes in technology and evaluation standards, rural tourism landscape design nowadays pays more attention to issues such as aesthetics, economic experience, and sustainable development. Continuously breaking through the traditional design of smart landscapes through innovative technologies has become the development direction of rural tourism landscapes. The smart landscape in the scenic area pays more attention to the integration of the theme and landscape, the interaction between tourists and the landscape, and the management and maintenance of the greenery in the scenic area.

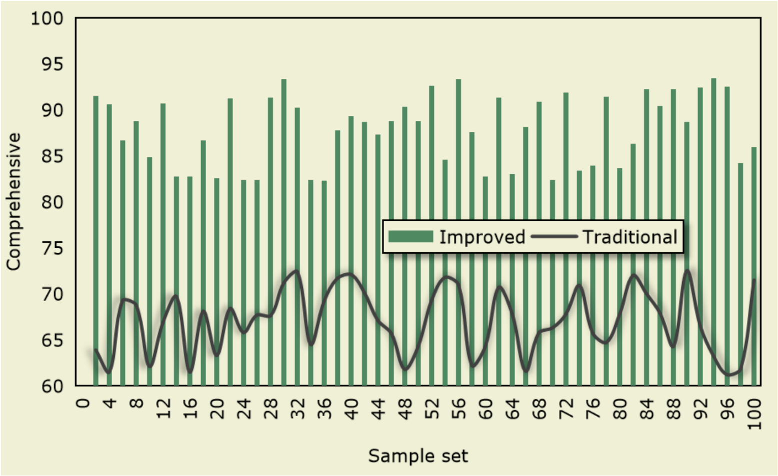

Figure 7: Comprehensive score.

The interactive experiential landscape is one of the most popular forms of landscape development today, serving as a bridge between humans and nature due to its unique experiential and interactive nature. In rural tourism landscapes, interactive experiential landscapes can encourage tourists to interact with the tourism landscape. But with the development of society, communication and interaction between humans and nature, as well as between humans, have gradually been neglected, leading to a lack of awareness of actively getting close to nature and missing out on the beauty of nature. Due to the innate affinity for nature that humans are born with, they are full of longing for natural landscapes, which is also the reason why rural tourism is popular today. The rural tourism landscape endows different rural cultural connotations from the urban landscape. Many tourists go to rural tourism to experience and understand the unique production and lifestyle of the countryside, and diverse technologies enrich the variability of landscape facilities. The design purpose of the interactive landscape experience is to allow people to participate in the landscape and experience the beauty and fun of the landscape in person. Only human participation can truly play the role of interactive landscape, thereby improving the integrity and popularity of the landscape. Through the analysis and research of the technological application and expression forms of interactive landscapes, interactive experiential landscapes are presented through highly attractive forms of expression or cool technologies, utilizing people's living habits and curiosity to guide them to experience and participate in facility interaction. On the other hand, the interaction between tourists and facilities has become a form of shaping landscapes. For example, the two giant water wheels in Lanzhou Garden of Wuhan Garden Expo Park simulate the pedal water wheels used by early people to transfer water from the river to the rice fields. Tourists can understand the production principles of the landscape through interaction, which plays a certain role in popular science education. The water wheels in the park restore the working principle of the original water wheels, and visitors can personally experience the process of manually stepping on the water wheels after learning about it. The educational and entertaining learning experience allows tourists to have a deeper understanding of the wisdom of ancient people.

6 CONCLUSIONS

In exploring new paths for optimizing tourism landscape design, this study creatively introduces the concept of multimodal fusion into the field of rural tourism. This model not only deepens our understanding of multimodal data fusion strategies but also cleverly applies these technologies to the refined design of rural tourism landscapes, achieving a dual leap in design scientificity and artistry. It constructed an optimization model that integrates multimodal data, BPNN (Backpropagation Neural Network), and ACO (Ant Colony Optimization) algorithm. By comprehensively collecting and integrating multimodal data, including multi-dimensional information such as natural environment, cultural history, and tourist behaviour, our model provides unprecedentedly rich materials and profound insights for rural tourism landscape design. The introduction of BPNN further enhances the learning and prediction capabilities of the model, enabling the design process to accurately capture and respond to complex and changing tourism demands. The global optimization feature of the ACO algorithm ensures that the design scheme optimizes the overall landscape layout while taking into account individual beauty, thereby enhancing the overall satisfaction and experience of tourists. The experimental results show that this optimization model based on multimodal fusion has demonstrated significant advantages in rural tourism landscape design. It not only brings the design effect closer to nature and integrates culture but also achieves significant improvements in user satisfaction and design performance. It breaks the limitations of traditional design methods and injects new vitality and creativity into rural tourism landscapes.

Zhongyuan Yang, https://orcid.org/0009-0006-7746-7014
Jiaping Chen, https://orcid.org/0009-0001-6374-490X

REFERENCES

[1] Carbonell, C.-C.; Saorin, J.-L.; Hess, M.-S.: Spatial Orientation Skill for Landscape Architecture Education and Professional Practice, Land, 9(05), 2020, 161. https://doi.org/10.3390/land9050161
[2] Dmitry, C.: Basin approach as a tool for landscape assessment and planning, Current Landscape Ecology Reports, 7(2), 2022, 15-23. https://doi.org/10.1007/s40823-022-00069-4
[3] Hong, L.; Hong, Y.-L.; Wei, L.; Guo, J.-J.; Zhong, L.: Application of flipped classroom based on the rain classroom in the teaching of computer-aided landscape design, Computer Applications in Engineering Education, 28(2), 2020, 357-366. https://doi.org/10.1002/cae.22198
[4] Hu, S.; Meng, Q.; Xu, D.; Katib, I.; Aouad, M.: The spatial form of digital nonlinear landscape architecture design based on computer big data, Applied Mathematics and Nonlinear Sciences, 7(1), 2021, 783-790. https://doi.org/10.2478/amns.2021.1.00069
[5] Jia, J.: Computer-aided design method of parametric model for landscape planning, Computer-Aided Design and Applications, 19(S3), 2022, 55-64. https://doi.org/10.14733/cadaps.2022.S3.55-64

[6] Khosravi, R.; Hemami, M.-R.: Identifying landscape species for ecological planning, Ecological Indicators, 99(1), 2019, 140-148. https://doi.org/10.1016/j.ecolind.2018.12.010
[7] Li, J.; Gan, J.: The importance of low-carbon landscape design in rural tourism landscape, Ecological Chemistry and Engineering S, 29(1), 2022, 319-332. https://doi.org/10.2478/eces-2022-0023
[8] Li, G.; Zhu, T.; Hua, J.; Yuan, T.; Niu, Z.; Li, T.; Zhang, H.: Asking images: Hybrid recommendation system for tourist spots by hierarchical sampling statistics and multimodal visual Bayesian personalized ranking, IEEE Access, 7(1), 2019, 126539-126560. https://doi.org/10.1109/ACCESS.2019.2937375
[9] Saroinsong, F.-B.: Supporting plant diversity and conservation through landscape planning: A case study in an agro-tourism landscape in Tampusu, North Sulawesi, Indonesia, Biodiversitas Journal of Biological Diversity, 21(4), 2020, 1518-1526. https://doi.org/10.13057/biodiv/d210432
[10] Tavakoli, M.; Monavari, M.; Farsad, F.; Robati, M.: Ecotourism spatial-time planning model using ecosystem approaches and landscape ecology, Environmental Monitoring and Assessment, 194(2), 2022, 116. https://doi.org/10.1007/s10661-021-09558-1
[11] Xia, B.; Ma, P.-L.: Design and implementation of a computer-aided system for landscaping plant selection, Computer-aided Design and Applications, 18(S1), 2020, 87-96. https://doi.org/10.14733/cadaps.2021.S1.87-96
[12] Xu, F.; Wang, Y.: Color effect of low-cost plant landscape design under computer-aided collaborative design system, Computer-Aided Design and Applications, 19(S3), 2021, 23-32. https://doi.org/10.14733/cadaps.2022.S3.23-32
[13] Yan, Z.: TODIM-VIKOR method for quality evaluation of tourism rural landscape planning with 2-tuple linguistic neutrosophic numbers, Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology, 45(5), 2023, 8249-8261. https://doi.org/10.3233/JIFS-231400
[14] Yang, L.: Salt culture and sports leisure tourism landscape design, Journal of Landscape Research, 11(02), 2019, 70-71+74. https://doi.org/10.16785/j.issn1943-989x.2019.2.015
[15] Zhang, M.; Deng, X.: Color effect of landscape architecture design under computer-aided collaborative design system, Computer-Aided Design and Applications, 19(S3), 2021, 13-22. https://doi.org/10.14733/cadaps.2022.S3.13-22