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Interactive Landscape Design Based on the Integration of Computer-Aided Design and Virtual Reality

Shuai Yang[1] and Yue Huang[2,3]

[1,2] College of Art and Archaeology, Hangzhou City University, Hangzhou 310015, China, [1]samyang@zju.edu.cn, [2]huanyue@hzcu.edu.cn
[3] College of Computer Science and Technology, Zhejiang University, Hangzhou 310063, China, huanyue@hzcu.edu.cn

Corresponding author: Yue Huang, huanyue@hzcu.edu.cn

Abstract. Using "Zhejiang Poetic Routes" as a case study, this research investigates the utilization of interactive landscape design, which relies on the fusion of computer-aided design (CAD) and virtual reality (VR), in preserving and passing down cultural legacy. The research not only investigates the landscape of Poetic Routes from the perspective of historical stratification from the digital technology level but also puts forward the protection framework of Poetic Routes' historical landscape and the protection method of landscape digital heritage information. The simulation results and user feedback show that using CAD technology to accurately model and combine VR technology to realize interactive landscape design greatly improves the user's immersive experience. The system performance of the proposed method is stable, which can provide a real and vivid experience and also proves the practicability and broad prospects of this method in the protection and inheritance of cultural legacy. Generally speaking, this study not only enriches the theory and practice of cultural legacy protection but also provides new ideas and methods for future research in related fields.

Keywords: CAD Technology; VR; Cultural Legacy Protection; Interactive Landscape Design; Digital Protection System
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1 INTRODUCTION

In interactive landscape design, the breadth and depth of design exploration are crucial for creating landscapes that meet ecological, cultural, and user needs. Han et al. [1] believe that many landscape architects, artists, and architects engaged in human-computer interaction are entering landscape interaction research and design practice. This comes from a 2013 study by Oren Zuckerman and Ayelet Gal-Oz on how TUI(physical user interfaces) enables rich physical feedback and more advanced forms of interaction. Currently, there is an increasing emphasis on using various landscape installations in domestic landscape design projects to enhance site interactivity and create dynamic and experiential urban public spaces. The urban micro-renewal strategy is currently a suitable solution for China's urban renewal process. Urban construction has entered a stage of pursuing development quality through micro renewal from a large-scale incremental development mode. Urban landscape space, as a carrier of people's daily lives, is an important part of urban composition. Urban landscape, as an important component of improving the quality of urban development and the quality of life of residents, faces enormous challenges. Both the progress of urban renewal in China and the actual needs of urban space construction are in line with the long-term urban design goals of improving the quality of urban development and putting people first. The urban renewal model, which was dominated by planning thinking in the past, made it difficult to achieve comprehensive coverage. In terms of humanistic care and social-emotional communication, we need more delicate urban design methods to compensate for the lack of human nature in urban design. With the continuous improvement of China's economic construction level, the spatial layout, industrial structure, and people's cultural level of cities are all keeping pace with the times. Landscape installation is the finishing touch in the overall urban landscape design, as a microelement that is close to the human perspective. It solves the problems brought about by rapid urbanization, such as excessive market-oriented construction of urban public spaces, loss of public attributes of urban landscapes, and aesthetic emptiness and aphasia in urban design. With its rich and diverse formal language, three-dimensional and multi-dimensional interaction methods, and actively guiding public attributes, it can better serve the micro renewal construction of urban public spaces at the micro level of urban landscape design [2]. In the context of interactive landscape design, parametric design not only optimizes the physical form of the landscape but also achieves significant results in behavioural perception. In the evaluation of landscape environmental benefits, after optimizing landscape greening through parameterized design, Han et al. [3] observed a significant improvement in air cleanliness and residential comfort. Applying parameterized software combined with GIS technology to optimize traditional landscape architecture not only enhances the scientificity of design but also enhances the interactivity of design.

Maria [4] believes that the rapid development of digital media technology has promoted urban information exchange, close connection, functional intelligence, and design innovation and has developed towards the direction of system coordination and resource collection. In the virtual environment, the public's operation process and the feedback together constitute the main content of the virtual interactive landscape. Visual virtual interaction means that participants form an interaction in terms of vision and images, and this interaction effect is random and corresponds to vision, which can give participants a feeling of being in the scene. With the development of the times, more and more problems have posed a threat to the psychological or physical health of contemporary people. According to statistics, the number of people in China who are in sub-healthy status has reached 70%, and health and related issues are receiving increasing attention. Visual and auditory perception, as the basic perceptual pathways of individuals, are not only the main ways for individuals to receive information but also important ways for individuals to perceive the environment [5]. Moreover, multiple studies have shown that urban green spaces have a positive effect on individual healing, so it is crucial to fully utilize the healing effects of green space plants and improve the overall health level of urban residents. The environment in which individuals live can greatly affect their health. Research in environmental psychology and other related fields has shown that when the environment has four characteristics: distance, attraction, degree, and compatibility, it has a positive impact on individual recovery. Almost 90% of the human body's sensations are generated through audio-visual effects, so the study of the interaction between vision and hearing, as well as its perceptual impact on individuals and groups, is worth further investigation. Jiang and Zhang [6] used audio-visual interaction as the starting point and aimed to study the healing effect and influencing factors of green plant landscapes for individual physical healing. It clarifies the factors that affect the therapeutic effect and provides methods and reference bases for improving the overall quality of urban green spaces. Firstly, a survey was conducted on 30 locations in three types of urban green spaces in Nanjing to clarify the current status of sound and plant landscapes in the three types of green spaces. Through analysis, it was found that when the sound scene is a situation that individuals prefer, adding visual elements has a relatively low impact on the healing effect of the environment.

That is to say, the soundscape experience lays the foundation for the therapeutic effect, but in noisy sound environments, visual landscapes can have a more significant impact on the environment. Secondly, by analyzing the soundscape characteristics of each type of green space, the soundscape characteristics and plant landscape composition of the three types of green spaces are summarized, and then computer technology is used to synthesize soundscapes with these characteristics as corresponding auditory materials for the experiment.

The aim of this study is to construct an interactive knowledge chain landscape design platform through a visual programming language, virtual reality parametric modeling, and 3D printing practice activities by integrating CAD and VR technology. This platform can not only examine the characteristics of the times and the succession process of the "Zhejiang Poetic Routes" cultural belt from the perspective of historical stratification but also gain insight into the internal laws and dynamic relations of the generation and evolution of poetry. Through the multi-layer link system platform of GIS tools, the real landscape can be infinitely layered in time scale and multi-dimensions, and the time depth and multi-dimensional information of poetry and landscape can be reflected in more detail. Under this background, the research has two main objectives: first, to create a framework for the protection of the historical landscape of the Poetic Routes cultural belt and to integrate poetry culture into modern life; The second is to establish the information protection method of landscape digital heritage in "Zhejiang Poetic Routes" cultural belt and provide necessary decision-making tools for protecting cultural legacy by using digital information technology. These studies it is expected to build a design strategy system based on public participation, which has the characteristics of landscape space of Poetic Routes, integrates economic, ecological, and social benefits, and promotes the overall inheritance of landscape space of Poetic Routes.

The follow-up content will first build a framework for the protection of the historical landscape of the Poetic Routes cultural belt, reproduce the historical culture in a digital way, and explore ways to integrate poetry culture into modern life. Then, the information protection method of landscape digital heritage in the "Zhejiang Poetic Routes" cultural belt will be established, and the strategy of using information technology to protect and manage cultural legacy will be put forward. Finally, by integrating the above research, a design strategy system of public participation is constructed, aiming at promoting the inheritance of Poetic Routes landscape space and realizing the integration of economic, ecological, and social benefits.

2 THEORETICAL FRAMEWORK AND TECHNICAL BASIS

In interactive landscape design, the application of software plays an important role in research. For example, users are allowed to adjust land use intensity and fragmentation level in real-time through the interface. Observe how these changes affect multifunctionality at the pixel level and landscape level. Especially in heterogeneous landscapes with moderate land use intensity, we found that vast grasslands and spatial complementarity can support the provision of multiple ecosystems. Lavorel et al. [7] simulated the interactions between six key ecosystem services (ES) on different terrains, from plains to mountainous areas, with a particular focus on spatial sensitivity differences. The sensitivity of these six ecosystem services to landscape composition, fragmentation, and their interactions is clearly demonstrated, enabling users to understand the complexity and dynamics of ecosystem services intuitively. In the simulation process, four different land use intensity treatments were set, including intensive (>30% land use), extensive or protected (<30% land use), and moderate intensity use (>40% land use but maintaining a certain natural area). The rapid transformation and development of society will inevitably drive a shift in people's needs for life. The simple visual stimulation and assimilation of landscape styles can no longer meet people's needs for community-shared space landscapes. People who are busy in cities are gradually beginning to pay attention to the homecoming attributes that communities should have. Zhang and Deng [8] emerged from three major backgrounds: the increasing demand for interactive and experiential landscapes driven by social transformation, the important impact of the concept of shared space on community construction, and the problems existing in community landscape development. Through field research, the data collected from the "Community Shared Space Interactive Experience Landscape

Survey Questionnaire" was analyzed using SPSS software for dimensionality reduction. It was found that residents have a high level of attention to four aspects of the community landscape: behavioural needs, regional emotions, perceptual satisfaction, and diversity. Therefore, the interactive and experiential landscape in community shared spaces should serve as a social bridge between residents, in line with the trend of technological development, and optimize the role of the landscape. By combining observation methods to obtain user profiles, the main pain points in current community shared space landscape design are summarized. It creates three major strategies: perceptual perception of community shared space landscape and exploring regional emotions of community shared space landscape. Aiming at the pain points of interactive experiential landscape in community shared spaces, propose to achieve multifunctional diversification of community shared space landscape. And verify the feasibility of the strategy through design evaluation, providing design reference value for new communities and old-day renovation communities. This interactive experience not only helps designers collect user feedback but also stimulates user creativity and imagination, providing more inspiration for design. With the increasing reliance on digital tools in the field of landscape design, existing software is now capable of efficiently implementing vegetation design and its widespread application in urban planning and architecture. Sędzicki et al. [9] proposed an innovative theoretical model for automatic plant selection and possible changes in green scenes. This model can not only be integrated into the design process in the early stages of conceptual design but also allow designers and stakeholders to participate and modify the design in real-time through an interactive interface. Its research is not only satisfied with the current situation but also proposes a complex digital greening selection and design method based on new parameter spreadsheets, further promoting the development of interactive landscape design. Modern high-tech comprehensive software has been widely used in landscape design, not only greatly improving design efficiency, but also providing landscape planning designers with more intuitive and in-depth creative ideas and expression tools. Song and Jing [10] used CAD software to draw floor plans, conduct spatial layout planning, and generate accurate design drawings. Through the interactive interface of SketchUp, designers can adjust model parameters in real-time, observe the effects of different design schemes, and provide more inspiration and choices for design. Designers can use PS software to post-process renderings, enhance the visual effects of the images, and highlight the characteristics and highlights of the design. Use the software to create virtual landscape environments, allowing users to experience immersive experiences through virtual reality technology (VR) or augmented reality technology (AR). This interactive experience not only allows users to have a more intuitive understanding of design solutions but also collects their feedback and provides designers with more directions for improvement.

In terms of applying computational methods to interactive landscape design, during the Renaissance, architects cleverly utilized the principles of perspective projection and geometric distortion to increase the depth of the building's illusory space, thus planning a multi-view layout and anticipating the final appearance of the building during construction. Tai [11] adopted an advanced computational method to simulate the perspective projection of architectural distortions observed in the Lin Family Building and garden in order to explore the underlying reasons and expected visual effects. They are also designed to create a magnified presentation of architectural elements in oblique views, integrating them with the landscape background to form a continuous scrolling picture. This mathematical principle of linear perspective not only explains the causal relationship of geometric distortion in Renaissance architecture but also provides new perspectives and inspiration for modern interactive landscape design. This technique is vividly reflected in the Lin Family Building and garden, unfolding from the panoramic view of the Octagonal Pavilion, showcasing the harmonious coexistence of classical architecture and natural landscapes. In order to deeply explore the mechanism of digital landscape design and enhance the interactive experience of users in the process of building a digital landscape platform, Wu and Yan [12] proposed a novel interactive digital landscape design scheme based on mobile edge computing. Meanwhile, by combining Roberts edge detection and Laplace operator, we have achieved high-level stable preservation of landscape images, ensuring the clarity and stability of the images during the interaction process. Its design scheme adopts discrete elevation calculation technology, aiming to preserve the framework of landscape design images and ensure accurate restoration of three-dimensional landscapes. Through edge computing, they can process data near the data source, greatly reducing the delay of data transmission and thus providing users with a smoother, real-time interactive experience. Through simulation experiments, the effectiveness of an interactive digital landscape design scheme based on mobile edge computing is verified.

With the rapid development of the social economy and the continuous innovation of computer software and hardware technology, computer technology has shown extensive application potential in multiple fields. Although computer-aided design software has achieved significant results in landscape design, its pace in practical application in landscape planning and development is relatively slow. Interactive landscape design provides users with an immersive experience through advanced technologies such as virtual reality (VR) and augmented reality (AR), allowing designers to interact more intuitively with design solutions, thereby better understanding and grasping the details of the design. Xu and Wang [13] will provide an overview of the current situation and development trends of landscape design and delve into the process and technology of interactive landscape design. In the landscape architecture industry, computer-aided design software has become an indispensable tool for landscape designers due to its accuracy, efficiency, and convenience, greatly promoting innovation and development in areas such as interior decoration, advertising design, and urban planning. Yu et al. [14] delved into the application of a three-dimensional participatory geographic information system (PGIS) based on a virtual globe in supporting public participation in spatial planning processes, with a particular focus on its potential in interactive landscape design. In landscape design, the handling of detailed elements can often bring unexpected effects. Through 3D CAD technology, designers can more accurately control parameters such as size, material, and position of detail elements, achieving more refined design effects. For example, in the design of landscape sketches, designers can use 3D CAD software to model and render the sketches and add appropriate materials and lighting effects to make the sketches more vivid and interesting. Meanwhile, by adjusting parameters such as the size and position of the sketch, it is possible to achieve perfect integration with the surrounding environment [15].

3 HISTORICAL STRATIFICATION INVESTIGATION OF "ZHEJIANG POETIC ROUTES"

3.1 Relevant Research of Poetic Routes Landscape Overview

"Zhejiang Poetic Routes" is a landscape belt bearing a profound historical and cultural legacy. It meanders through the beautiful mountains and rivers in Zhejiang Province, connecting many historic cultural attractions in series. This route not only witnessed the travel and creation of countless literati but also carried rich historical and cultural information and regional characteristics. There are various types of landscape elements here, such as strange peaks and rocks, clear springs and waterfalls, old houses in ancient villages, temples, and pavilions, and every place is full of poetry and painting.

CAD is a process of designing with computer technology. It involves the use of specialized software to create, modify, analyze, and optimize various aspects of the design. In landscape design, CAD technology is widely used in terrain modeling, vegetation layout, road, and hard landscape design, and many other aspects. Through CAD software, designers can complete the design task more accurately and efficiently and realize the visualization and optimization of the design scheme at the same time. VR represents a computational technology capable of generating and enabling the exploration of virtual worlds. Through simulating human senses, including audio-visual and tactile perceptions, it immerses users in an ultra-realistic three-dimensional virtual setting. In the field of cultural legacy protection, VR technology has great potential. It can reconstruct historical scenes, reproduce the original appearance of cultural legacy, and provide users with a brand-new and immersive experience.

Interactive landscape design emphasizes the interactive relationship between landscape and people, aiming at creating a spatial environment that can respond to users' behaviours and provide diversified experiences. In interactive landscape design, designers need to fully consider users' needs and behavior patterns and use advanced technical means to realize the interactivity and dynamics of the landscape. This study applies the idea and method of interactive landscape design to the protection and inheritance of the cultural legacy of "Zhejiang Poetic Routes," aiming at creating a real and vivid interactive experience environment for users through the integration of CAD and VR technology.

3.2 Historical Stratification Analysis Method

Historical stratification analysis is a method to reveal the historical evolution of landscape by studying cultural remains in different historical periods. In the historical stratification investigation of the "Zhejiang Poetic Routes" landscape, this article uses digital technology to analyze the landscape along the route.

Firstly, this article analyzes the spatial distribution of historical sites along Poetic Routes by using a geographic information system. By overlaying the data layers of different historical periods, we can clearly see the distribution of cultural relics in each period and their relationship. Secondly, this article uses remote sensing technology and drone aerial photography to obtain high-resolution image data. These data not only help us to observe the present situation and characteristics of the landscape more intuitively but also provide important basic data for the subsequent historical stratification analysis. Finally, combined with historical documents and archaeological excavation results, this article deeply excavates and sorts out the history and culture along the Poetic Routes. By comparing the cultural relics and landscape characteristics in different historical periods, we can reveal the historical evolution process and regional cultural characteristics of the "Zhejiang Poetic Routes" landscape.

3.3 Landscape Digital Protection Framework

Aiming at the protection requirements of the historical landscape of "Zhejiang Poetic Routes", this section puts forward a digital protection framework for the landscape. The framework defines the protection objectives, principles and measures, aiming at providing strong support for the long-term preservation and sustainable development of the Poetic Routes landscape.

Protection objectives: this article is committed to protecting the historical and cultural relics and natural landscape resources along the Poetic Routes and inheriting and promoting the regional cultural characteristics of Zhejiang; Furthermore, we also hope to enhance the public's awareness and protection awareness of cultural legacy through digital means. Protection principle: adhere to the principles of authenticity, integrity, and sustainability. That is to protect the historical authenticity and style integrity of the Poetic Routes landscape while ensuring its sustainable development and sustainable use. Protection measures: This article takes various measures to protect the landscape of Poetic Routes. First of all, we established a perfect landscape database and information management system by using digital technology and realized the comprehensive record and dynamic monitoring of landscape resources. Secondly, we have strengthened the planning management and the construction of laws and regulations along the line, ensuring the rational utilization and effective protection of landscape resources. Finally, we have improved the public's awareness and participation in the landscape of Poetic Routes through publicity, education and tourism development.

4 INTERACTIVE LANDSCAPE DESIGN PRACTICE BASED ON CAD AND VR

4.1 Implementation of Fusion Technology

It is a complex and delicate process to integrate CAD design with VR technology to realize interactive landscape design. This process requires a deep understanding of CAD design and its core role in landscape design. CAD design provides a solid foundation for landscape design with its accurate drawing and modelling functions. Through CAD, landscape elements such as topography, vegetation, and buildings can be accurately drawn, and detailed design drawings can be generated.

In this study, CAD and GIS technology are closely combined, and the landscape building components along "Zhejiang Poetic Routes" are fully digitized. Through high-precision CAD modelling, these unique architectural elements are successfully converted into digital format and accurately assembled and presented on the computer. Not only does this process achieve the virtual duplication of landscape designs, but it also immerses users in the charm and complexities of ancient buildings through a digital medium. Furthermore, it digitally preserves and oversees the artful specifics, structural traits, utilitarian functions, and installation steps of these edifices. For a visualization of the GAN model derived from landscape space modelling, refer to Figure 1.

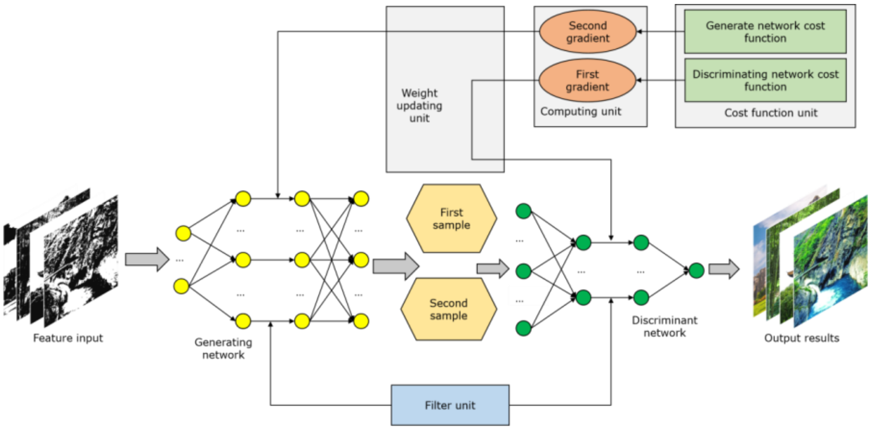

Figure 1: GAN model for landscape spatial modelling.

The error function for extracting 3D landscape features is delineated as follows:

$$\cos t\ u,v = \left\|u-v\right\| \times \max_{f\in T_u}\left\{\min_{n\in T_{uv}}\ 1 - f\cdot normal\cdot n\cdot normal\ \div 2\right\} \quad (1)$$

In this context, $\left\|u-v\right\|$ denotes the distance between two points, designated as u,v. T_u stands for all triangles neighbouring u, while T_{uv} signifies all triangles that share an edge with uv.

Allow the plane labelled P to intersect the centroid, P', of the closest points K, ensuring that the normal vector, n, fulfills the condition $\left|n\right| = 1$. Consequently, the characteristic vector linked to the minimum eigenvalue M can be interpreted as the normal vector of the point P_i.

$$M = \sum_{i=1}^{K} P_i - P'\ \ P_i - P'^{\ T} / K \quad (2)$$

The angle formed by the normal N_{new} of the triangle and the normal N_{ini} of the original mesh is less than the predetermined threshold ε.

$$\arccos\ N_{new}\cdot N_{ini}\ \le \varepsilon \arccos\ N_{new}\cdot N_{ini}\ \le \varepsilon \quad (3)$$

In this study, a multi-layer neural network model is designed, which uses data from multiple sensors as input information. By training this model, the inherent characteristics and potential laws of data are deeply studied, and then the efficiently fused data are output. This technical means can effectively deal with diverse data types and abnormal data problems, showing superior accuracy and wide applicability. For the model of intelligent perceptual information fusion algorithm in interactive landscape design, please refer to Figure 2 for details.

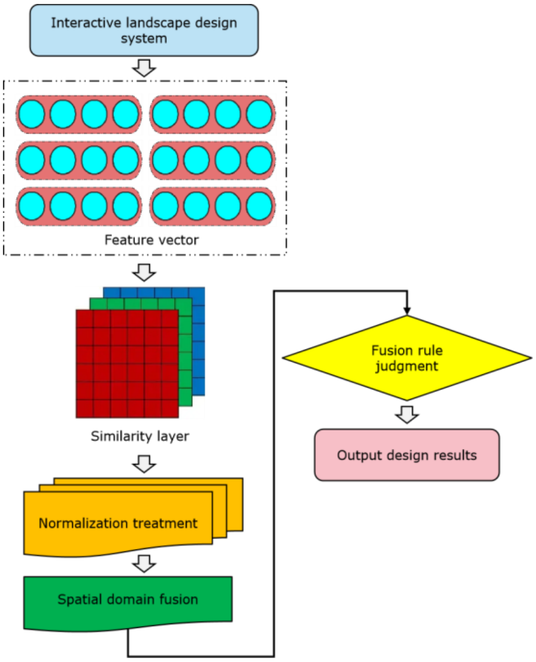

Figure 2: Information fusion algorithm model.

The degree of congestion in a landscape space provides a more accurate representation of the openness of vision in 3D space, expressed as follows:

$$SC_b = \frac{\sum_{i=1}^{n} V_{bi}}{\max H_b \times A} \quad (4)$$

In this context, SC_b signifies the congestion level of the landscape space, V_{bi} corresponds to the i building volume, and $\max H_b$ denotes the peak height of the landscape structures. The intricacy of elements within an image reveals both the hues of the scenery and the variety of its components, formulated as:

$$F = CR \times TY \quad (5)$$

The given formula, CR signifies the count of predominant hues present in the landscape, whereas TY designates the diversity of landscape types.

Optimizing the layout of the landscape constitutes a crucial step in interactive landscape design that is rooted in the amalgamation of CAD and VR technologies. Refer to Figure 3 for an illustration of the coding phase inherent in this optimization procedure, which entails converting design components and their associated parameters into digital codes, thereby enabling computers to comprehend and manipulate them.

Designers will use CAD software to create the preliminary layout of the landscape, which includes topography, vegetation, water, architecture and other design elements. In this process, each element will be given specific attributes, such as location, size, colour, etc., and will be converted into corresponding digital codes. These codes not only define the basic attributes of elements but also provide the basis for their interactive behaviour in a VR environment. Next, these encoded data will be imported into the VR engine for further optimization and adjustment.

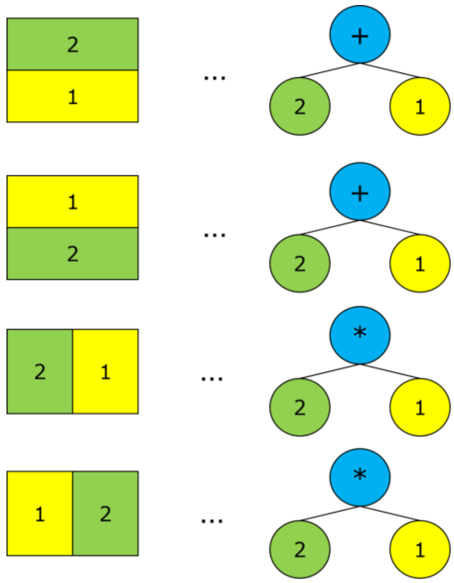

Figure 3: Coding process of landscape layout optimization.

In the VR environment, designers can intuitively see the effect of landscape layout and make real-time modifications and adjustments as needed. Through reasonable coding, various elements in the landscape can be easily managed and modified, and the layout can be flexibly adjusted and optimized.

To reposition the 3D model, it must be situated within the (x,y,z) coordinate axis. Presuming that $F(x,y,z)$ represents the original 3D model and $I(x,y,z)$ signifies the repositioned model, the corresponding formula is provided below:

$$I(x,y,z) = F(x - m_p, y - m_p, z - m_p) \tag{6}$$

Scaling involves adjusting the size of the 3D model uniformly along all three axes of the coordinate system to prevent geometric distortion. In case the 3D model $F(x,y,z)$ of size $L \times M \times N$ is transformed into a new 3D model $I(x,y,z)$ of size $KL \times KM \times KN$, the process can be mathematically represented by the formula given below:

$$I(x,y,z) = F(\mathrm{int}(c \times x), \mathrm{int}(c \times y), \mathrm{int}(c \times z)) \tag{7}$$

$$c = 1/k \tag{8}$$

When $k>1$, the 3D model shrinks in size, whereas when $k<1$ the 3D model expands.

Develop a perception model for landscape information fusion, and subsequently derive the fitness function of landscape information fusion, expressed as follows:

$$fitness(\vec{x}) = \begin{cases} f(\vec{x}) & If\ feeasible \\ 1 + rG(\vec{x}) & Otherwise \end{cases} \tag{9}$$

Taking into account the grey pixel level f of landscape design and spatial pattern optimization, the grey moment invariant feature decomposition method is employed to construct the resolution model for environmental vision in landscape ecological space:

$$W_{u}\ a,b\ = e^{i2\pi k\ln a}\times\frac{K}{\sqrt{a}}\left\{\left[\left[\frac{ae^{\frac{j2\pi f\min}{a}\ b-b_{a}}}{f_{\min}}-\frac{e^{\frac{j2\pi f\max}{a}\ b-b_{a}}}{f_{\max}}\right]\right.\right.$$
$$\left.\left.+\,j2\pi\ b-b_{a}\left[Ei\ j2\pi f_{\max}\ b-b_{a}\ -Ei\left(\frac{j2\pi f_{\min}}{a}\ b-b_{a}\right)\right]\right]\right\} \tag{10}$$

$$b_{a} = 1-a\left(\frac{1}{af_{\max}}-\frac{T}{2}\right) \tag{11}$$

Herein, $Ei\ \cdot$ signifies the output characteristics of visual information specific to the landscape ecological space environment. By integrating the model recognition technique, landscape design can be effectively implemented.

4.2 Interactive Landscape Design Practice: Taking "Zhejiang Poetic Routes" as the Object

The interactive landscape design example featuring "Zhejiang Poetic Routes" aptly illustrates the allure of CAD and VR technology convergence. In this instance, CAD was initially leveraged to meticulously model and design the landscapes along the "Zhejiang Poetic Routes." These designs encompassed terrain, vegetation, ancient buildings, water systems, and various other landscape components, all of which underwent meticulous planning and refinement (refer to Figure 4).

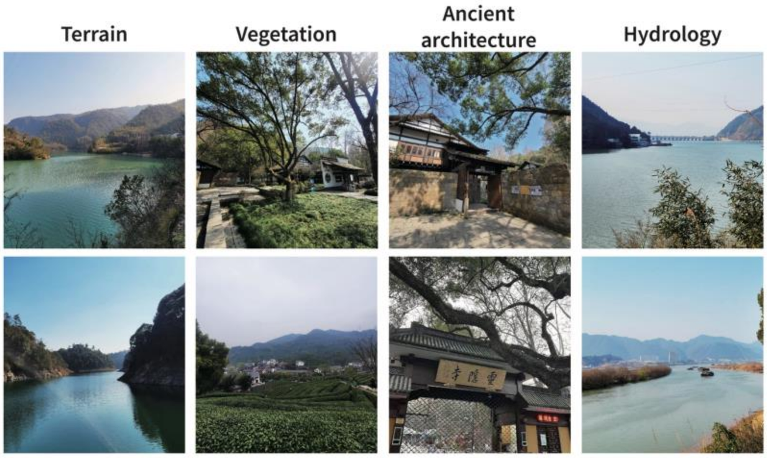

Figure 4: Landscape design task objects.

Next, these CAD models are imported into the virtual environment by using VR technology. In this virtual "Zhejiang Poetic Routes", users can freely stroll, watch the scenery along the way and experience the interaction with the landscape. For example, when users walk in front of an ancient building, they can view the internal structure and layout of the building through VR technology; When users walk into a forest, they can feel the swaying of trees and the singing of birds. In addition, we have added rich interactive functions to this interactive landscape design example. Users are able to engage with the virtual environment through various devices like handles or helmets, allowing them to interact with elements such as touching virtual trees or operating doors and windows. These interactive capabilities significantly enrich the user's immersive experience, transforming the interactive landscape design of "Zhejiang Poetic Routes" into a captivating virtual tourism endeavour.

4.3 User Experience and Feedback

After the "Zhejiang Poetic Routes" interactive landscape design system was launched, this article collected a large number of users' experiences and feedback. Overall, users' assessment of the system is very positive. They generally believe that it is a brand-new and exciting way to experience "Zhejiang Poetic Routes" through VR technology. Users can not only experience the beauty of Zhejiang's mountains and rivers, and its historical and cultural legacy but also interact with the landscape in a rich way, which gives them a deeper understanding of "Zhejiang Poetic Routes".

Furthermore, users also put forward some valuable improvement suggestions for the system. For example, some users suggested adding more interactive functions and scenic spot introduction information; Some users hope that the system can support multi-person online tours at the same time. These feedbacks provide an important reference for us to further optimize the system. On the whole, the interactive landscape design system of "Zhejiang Poetic Routes" has achieved good practicability and effect assessment results.

5 PROTECTION METHOD AND SYSTEM PERFORMANCE ASSESSMENT OF LANDSCAPE DIGITAL HERITAGE INFORMATION

5.1 Heritage Information Protection Method

The protection of landscape digital heritage information is very important, which is not only related to the inheritance of cultural legacy but also related to the protection of intellectual property rights. In view of this problem, this article adopts a series of protection strategies and implementation methods:

(1) Emphasize the integrity and authenticity protection of information. All digital landscape heritage information needs to undergo strict examination and proofreading to ensure that it accurately reflects the true face of the original landscape. Furthermore, we adopt high-standard data encryption technology to prevent data from being illegally tampered with or stolen.

(2) Pay attention to the long-term preservation and backup of information. By establishing a perfect data storage and backup mechanism, we ensure that all important data can be recovered quickly even in the most extreme cases. In addition, we regularly migrate and update the data to adapt to the ever-developing data storage technology.

(3) Advocating reasonable information sharing and using the mechanism. While protecting landscape digital heritage information, we are also committed to promoting the rational use and dissemination of this information. By establishing a strict authorization and licensing system, we not only protect the rights and interests of information owners but also promote the exchange and sharing of information.

5.2 System Design and Implementation

In order to protect the digital heritage information of the landscape, this section has designed and implemented a comprehensive protection system. This system covers multiple aspects such as data collection, processing, and storage.

In the data collection stage, this article uses high-resolution scanners and professional photography equipment to ensure the acquisition of high-quality raw data; Furthermore, strict monitoring and recording of the collection process were carried out to ensure the integrity and traceability of the data. In the data processing stage, the system utilizes advanced image processing and data analysis techniques to perform denoising, enhancement, and correction operations on the original data. These processing steps not only improve the quality of data but also provide convenience for subsequent storage and retrieval. In the data storage stage, the system has selected stable and reliable storage devices and established multiple backup mechanisms. By adopting distributed storage and fault-tolerant technology, the security and availability of data are ensured.

5.3 System Performance Assessment

In this experiment, precise landscape models were constructed using CAD technology, and these models were transformed into interactive 3D environments through VR technology. Through this approach, a series of interactive landscape design schemes were designed and comprehensively evaluated. Firstly, a detailed landscape design model was created using CAD software, including various elements such as terrain, vegetation, architecture, and water systems. These models not only accurately reflect design details, but also provide basic data for subsequent VR fusion. Next, the CAD model was imported into the VR engine and an interactive 3D landscape environment was constructed. In this environment, users can freely explore the landscape and experience the visual and spatial effects brought by different design schemes.

In order to evaluate the effectiveness of different design schemes, A/B testing and other methods were used in the study, inviting users to experience and compare different design schemes. Quantitative analysis was conducted on the advantages and disadvantages of each solution by collecting user feedback and data. During the iterative optimization phase, adjust the model based on user feedback and actual usage. By continuously optimizing design elements and interaction methods, the performance and user experience of landscape design have been significantly improved.

In order to objectively demonstrate the optimization effect, the accuracy and stability of the model before and after iterative optimization were compared. As shown in Figures 5 and 6, the iteratively optimized model has significantly improved accuracy.

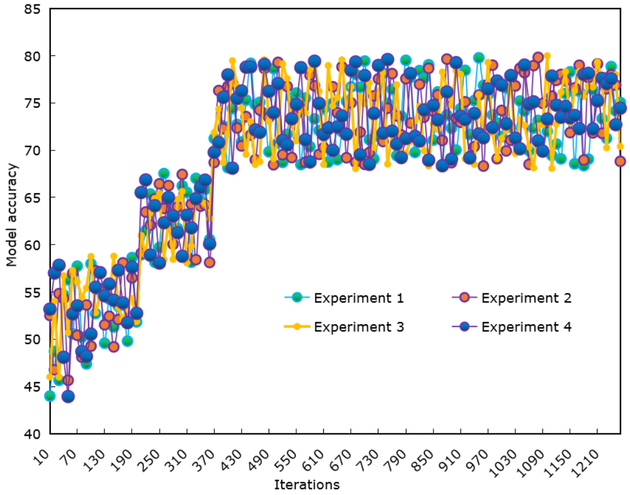

Figure 5: Accuracy before iterative optimization.

The study also compares the stability of the model before and after optimization, as shown in Figure 7 and Figure 8. After iterative optimization, the stability of the model has also been significantly improved.

In the conducted experiment, the landscape design proposal created by conventional methods served as the control group, whereas the interactive landscape design proposal, utilizing the integration of CAD and VR, functioned as the experimental group. Through an assessment of tourist satisfaction, loyalty, and overall experience (detailed information provided in Table 1), it was discovered that the experimental group exhibited substantial superiority in every respect.

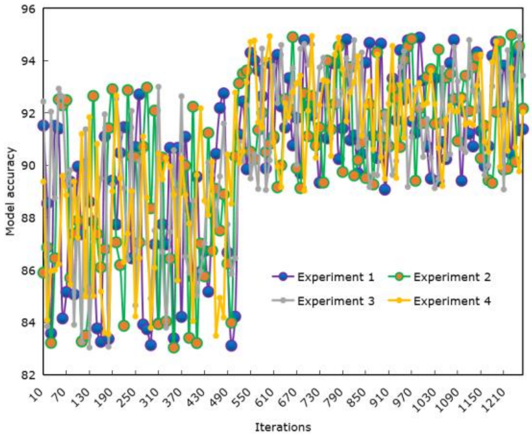

Figure 6: Accuracy after iterative optimization.

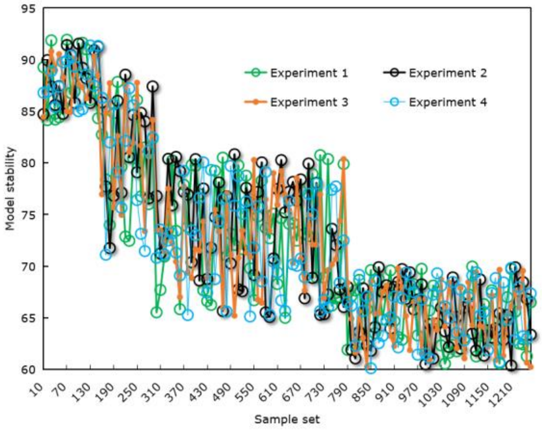

Figure 7: Stability before iterative optimization.

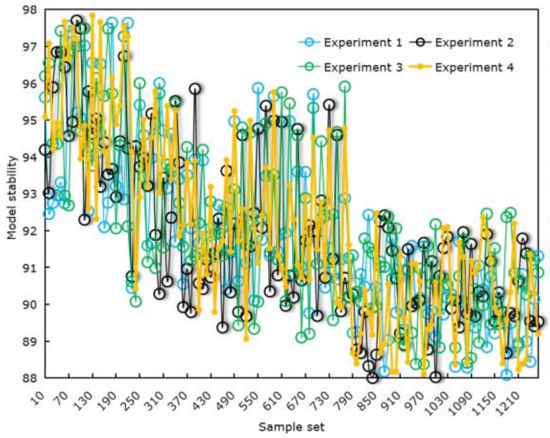

Figure 8: Stability after iterative optimization.

Assessment index	*Experimental group (using model)*	*Control group (traditional design)*
Tourist satisfaction	93.55%	70.63%
Tourist loyalty	88.87%	60.88%
Tour experience (5 points)	4.6	3.3

Table 1: Comparative experimental results.

According to user feedback, the interactive landscape design plan that incorporates CAD and VR integration successfully fulfills user needs while delivering a deeper, more immersive experience. Additionally, users have offered insightful feedback on interaction methods and landscape components, serving as a valuable reference for future refinement.

6 CONCLUSIONS

This study delves deeply into the utilization of CAD and VR technology in safeguarding and transmitting cultural legacy. Through the historical stratification investigation of the "Zhejiang Poetic Routes" landscape, this article reveals the profound historical background and cultural significance of this cultural route. Furthermore, the article successfully practices interactive landscape design based on CAD and VR, which not only enhances users' perception and experience of cultural legacy but also verifies the effectiveness of the integration of these two technologies in the exhibition and dissemination of cultural legacy. In addition, this article also constructs a set of methods and systems for protecting landscape digital heritage information, and through the system performance assessment, it proves its reliability in ensuring the authenticity, integrity and long-term preservation of heritage information.

Looking ahead, further exploration of the application of CAD and VR technology within the cultural legacy field is planned. This involves researching more sophisticated landscape modelling techniques to enhance VR realism and immersion. Additionally, the development of a more intelligent heritage information management system for dynamic monitoring and pre-alarm of cultural legacy is intended. Simultaneously, focus will be placed on the global promotion and application of these technologies, aiming to make a significant contribution to the preservation and continuation of cultural legacy.

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Shuai Yang, https://orcid.org/0000-0003-4757-9358
Yue Huang, https://orcid.org/0000-0003-0729-5318

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