Innovation in Environmental Art Design Based on CAD and Multimodal Data Fusion

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Abstract. This article integrates the development of model information based on environmental art design. The experiment carefully validated the innovative environmental art design effect of a multimodal dataset through a comprehensive model. We conducted a comprehensive performance evaluation and analysis of CAD and various multimodal information platforms and constructed a technology fusion mining approach based on a large amount of data. The research results indicate that the proposed model has creative practicality and strong design value in terms of innovative application value. This significantly improves design efficiency and model-quality construction. Among different design schemes, its application effect in visual impact has obvious advantages. In the multimodal integration and fusion process of the model, these research results have greatly improved the design efficiency and quality of EAD.

Keywords: Environmental Art Design; CAD Technology; Multi-Modal Data Fusion; Creative Design
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1 INTRODUCTION

In contemporary society, EAD has garnered significant attention for its innovative and developmental potential as a crucial means of enhancing people's quality of life and shaping city imagery. Advancements in science and technology have introduced new possibilities for EAD through the fusion of CAD and multimodal data technologies. In the current context of interdisciplinary integration, urban renewal, and diversified artistic works, this article attempts to apply Gadamer's theory of artistic experience to the research of design strategies for interactive landscape installations by combining relevant theories such as interactive design, narratology, and semiotics. Some scholars believe that from the beginning of landscape installation design, designers consciously use the artistic experience of the personality subject to construct the structural characteristics and spiritual connotations of the design work, which runs through the entire design process [1]. Aim to integrate the theory of artistic experience into the design process of interactive landscape installations, to fully expand the designer's horizontal and vertical design perspectives and depth. To better serve the long-term goal of improving urban environmental quality and effectively enhancing people's happiness index. By analyzing and refining Gadamer's theory of artistic experience, we aim to explore its feasibility for application in interactive landscape installation design theory and transform it into a concrete and accessible system design theory. The purpose of endowing interactive landscape installations with richer spiritual and cultural connotations and practical usage functions. The research results have made up for the scarcity of design theory research in interactive landscape installations, providing theoretical support for the design of contemporary interactive landscape installations from an interdisciplinary perspective. It provides a reference cognitive schema for the interpretation of contemporary artworks under the rapid development of the Internet and digital technology, further transforms it into the design mode and theoretical framework of interactive landscape installations, and proposes design strategies based on this [2]. At the same time, enriching the spiritual and cultural connotations of landscape installations can stimulate people's reflection and enhance the connection between people and the city. Based on the new strategy of urbanization development in China, we aim to improve the design level of interactive landscape installations, optimize the overall appearance of urban landscapes, and enhance the public's sense of belonging, experience, and happiness toward urban life. Inspire the vitality of the venue and even the urban space, rely on the artistic appeal of the installation to promote the emergence of cultural and economic activities, and thus drive the diversified development of the city. This achievement not only provides innovative evaluation tools for the field of environmental art design, but also valuable references for future landscape design, planning, and management. The design concept of promoting harmonious coexistence between humans and nature has been deepened and expanded in practice.

The limitations of time and resources often become the main constraints for environmental art designers to unleash their creativity and imagination. In the wave of computer-aided design, design exploration has always been a key link in driving innovation, but traditional goal-oriented and performance-driven systems often struggle to fully cover every corner of the design space. Especially in environmental art design, the comprehensive consideration of nature, culture, and functionality makes design exploration more complex and multidimensional. Given the lack of effective analysis of this complex design space tool in the current literature, we propose an innovative research path [3]. By building a customized large-scale architectural image database, which not only has a high degree of visual diversity but also aims to cover a wide range of potential environmental art and design data spaces. In the testing, it explored various supervised disentanglement schemes, and through in-depth analysis and comparison, revealed the structural differences of different potential spatial design features, providing designers with a new perspective to deeply understand the internal logic of the design space. By accurately analyzing the design space, the system can intelligently recommend diverse design solutions, helping designers achieve more efficient, comprehensive, and creative design exploration under limited time and resource conditions [4]. To overcome this limitation, computational design methods, as a powerful tool, are gradually demonstrating their infinite potential in the field of environmental art and design. Some scholars have delved into a new perspective that shifts from an epistemological perspective to explaining the essence of environmental art and design concepts in space. Intended to utilize advanced disentanglement representation learning techniques, whether supervised or unsupervised, to analyze and deconstruct the conceptual space of environmental art and design. Meanwhile, the unsupervised interpretation scheme has also demonstrated its ability to automatically recognize and separate design features, bringing more autonomy and flexibility to design exploration. Looking to the future, our long-term vision is to open a door to infinite creativity for environmental art designers through such innovative design systems [5].

The application of CAD intelligent technology not only simplifies the design process and improves design efficiency, but more importantly, it endows designers with unprecedented creativity and accuracy, enabling them to explore and realize the infinite possibilities of environmental art design in unprecedented ways. In the current field of environmental art design, traditional landscape design methods are often limited to surface-level layout planning, failing to fully explore and showcase the deep beauty and spatial potential of scene elements [6]. The research focuses on the three core links of terrain design, planning and layout, and plant planting. Using the intelligent toolset of AutoCAD, it achieves a comprehensive and multi-angle display from two-dimensional concepts to three-dimensional scenes. Especially the neglect of refined treatment of plant diversity and landscape spatial complexity has led to a lack of ecological richness and spatial utilization efficiency in the design results. Given this, some scholars have delved into the innovative application of computer-aided design (CAD) technology, especially combining the intelligent functions of AutoCAD, in environmental art design, aiming to improve the comprehensive quality of landscape design through technological means [7]. On this basis, a plant landscape spatial coordination planning model was constructed, which fully considers the ecological habits, visual aesthetics, and scientific spatial layout of plants, aiming to achieve a harmonious coexistence between ecology and art. Furthermore, the study utilizes image library functionality to integrate rich colour and texture attributes into 3D visual reconstruction models, enabling landscape spaces to not only have a high visual impact but also contain profound cultural connotations and ecological wisdom. Integrating advanced 3D graphics engines, not only enhances the realistic rendering of landscape elements but also enables precise simulation and optimization of every detail in the design process [8]. The comparative analysis results show that compared to traditional and other modern design methods, the method proposed in this study performs well in key indicators such as graphic refresh rate, visual brightness, and visual contrast, significantly improving the visual quality of design results.

Initially, this article reviews the development status and trends in related research fields through a literature analysis. Subsequently, it constructs an EAD model based on CAD and multimodal data fusion, elucidating its specific application in the design process. Ultimately, the model's validity and practicability are verified through experimentation. The novel contributions of this study include: proposing an EAD model based on the fusion of CAD and multimodal data; achieving effective application of multimodal data in EAD; and enhancing the efficiency and quality of EAD.

2 RELATED WORK

EAD is a multifaceted discipline encompassing architecture, aesthetics, psychology, and other fields. Its theoretical framework encompasses spatial layout, colour coordination, material selection, and more. As society evolves and people's aesthetic perceptions shift, EAD continues to develop and innovate. Currently, the primary trends in EAD involve emphasizing humanized design, ecological protection, and pursuing innovation and individuality. These trends offer extensive scope and opportunities for the integration of CAD and multimodal data fusion technology in EAD. Presently, CAD technology is extensively utilized in EAD, demonstrating significant advantages in three-dimensional modelling, rendering, and simulation. Concurrently, multimodal data fusion technology is advancing, with its application maturing in areas such as image processing, speech recognition, natural language processing, and more.

In the context of environmental art design, the multifunctionality of pixel level and landscape level deeply reflects the subtle perception and response of ecosystem services to landscape composition, fragmentation status, and their interactions. This multifunctionality is not only reflected in the resilience and health of ecology but also profoundly affects the artistic conception and emotional depth conveyed by environmental artworks. Lavorel et al. [9] can alleviate the negative impact of high-intensity utilization to a certain extent through meticulous planning and design. In diverse landscapes with moderate land use intensity, the clever complementarity between vast grasslands and space provides a rich natural foundation for environmental art design, supporting the realization of multiple ecological functions and the integration of aesthetic expression. As land use intensity increases, although it inevitably puts pressure on all ecosystem services, thereby reducing overall multifunctionality, environmental art and design can play a unique buffering and regulatory role in this process. Although this may come at the cost of sacrificing some entertainment functions, especially in exquisite landscape design, this balance and trade-off are particularly important. Specifically, from the perspective of environmental art and design, moderate fragmentation of the landscape is not entirely a disadvantage. On the contrary, it may provide new opportunities for key ecological processes such as nitrogen conservation and pollination. They are interdependent and complementary, jointly constructing the ecological foundation and aesthetic framework of mountains and rivers. However, this synergistic effect is not without costs, especially when balancing with entertainment functions. Li [10] cleverly balances ecological needs with human activity space needs to ensure their harmonious coexistence. It is worth noting that the interactions between ecosystem services are particularly sensitive to changes in land use intensity, as any small adjustments can have a significant impact on specific ecosystem services. In addition, the five regulatory ecosystem services have shown strong synergies in environmental art and design. The degree of landscape fragmentation, as an important regulatory factor in this process, not only affects the intensity of interaction but also provides rich creative space for environmental art design.

With the vigorous development of digital technology, urban planning and design, especially landscape planning and planar architectural layout in the field of environmental art design, are undergoing profound changes. The core of this transformation lies in the deep integration of computer-aided planning technology, especially the combination of parametric design and optimization strategies, which has brought unprecedented efficiency improvement, design innovation, and expansion of thinking patterns to environmental art design. Designers can evaluate the feasibility, economy, and ecological benefits of design schemes through quantitative analysis, ensuring the practicality and sustainability of design results while satisfying aesthetic pursuits. Wu and Yan [11] focus on parameterized design methods in environmental art design practice, deeply exploring their application in multi-objective optimization problems, aiming to reveal the operational wisdom and practical skills of parameterized planning technology in panoramic environmental art layout. More importantly, parameterized design includes strict logical algorithms and data analysis support, making the design process more scientific and reasonable. Through a series of design practice cases, clear design goals were set, and a large number of simulation calculations and data analysis methods were used to conduct a detailed analysis of the entire process of parameterized landscape architecture design. This design method greatly improves the flexibility and responsiveness of the design, enabling environmental artworks to better adapt to complex and ever-changing on-site conditions and ecological needs. Xu and Wang [12] flexibly adjust design parameters such as form, colour, material, etc. during the creative process to achieve dynamic optimization and precise control of design schemes. In the context of environmental art design, parametric design not only demonstrates its efficiency and universality, but also highlights unique advantages such as multi-objective collaboration, sustainability, and continuous optimization. Xu and Jiang [13] believe that the AI-based Art Design and Teaching (AI-ADT) approach in universities has improved their ability to adapt to AI-guided art education. It has established intelligent teaching methods and improved the art knowledge and environment guided by artificial intelligence in art education. The widespread application of artificial intelligence in design education has become a development trend. The art and design industry should recognize and actively adapt to this development trend.

Landscape architecture, as an important carrier of environmental art design, carries multiple functions such as ecological balance, cultural inheritance, social interaction, and aesthetic enjoyment. By comprehensively utilizing these technologies, a virtual garden has been constructed that integrates ecological beauty, cultural charm, social emotions, and artistic sense. Based on the above research background, Zhang and Deng [14] chose interactive landscape installations as the research object, art experience theory as the research entry point, and based on the current situation and needs of urban renewal in China, explored the breakthrough point of the innovative design of interactive landscape installations. Firstly, the core concepts of interactive landscape installations and artistic experience theory were sorted out using literature analysis and interdisciplinary methods, and the correlation between the two in terms of design aesthetics, design thinking, and design spirit was summarized. Then, the cognitive methods of art experience theory were analyzed and combined with the design process of interactive landscape installations, summarizing the application framework of art experience theory in interactive landscape installation design. Finally, based on the correlation characteristics, design patterns, and application frameworks between interactive landscape installations and artistic experience theory, design strategies for interactive landscape installations were proposed [15]. The theory of artistic experience is an alternative interpretation to subjective aesthetics, which can help us gain a deeper understanding of the essence of artistic works in the increasingly diverse development of art. Specifically, starting from four dimensions of social empowerment, technological innovation, cultural creativity and inheritance, and physical perception, this study provides new design methods for interactive landscape installations in the context of urban renewal in China and stimulates innovation vitality. Then, based on case studies, the main design patterns of interactive landscape installations in China were summarized, providing a realistic model for the formation of design strategies. Applying it to the design theory of interactive landscape installations can not only bring forth new ideas but also extract objective and authentic design elements from a wide range of artistic works and endow the installations with innovative vitality. It can also deeply integrate art and interactive landscape installations at the levels of society, technology, culture, and perception, thereby better serving the development path of urban renewal in China.

3 CONSTRUCTION OF EAD MODEL

By integrating the theoretical algorithm research results of this article, a fully functional and stable prototype system for large-scale 3D urban scene visualization has been developed. Spatial indexing is an effective method for solving the problem of landscape geographic information data retrieval and scheduling. This article discusses the index organization structure for three common types of data in urban 3D scenes, including 3D models and massive building models. The integration technology of vector data and terrain was studied. The urban spatial data engine is the foundation of urban 3D GIS applications. This chapter studies and designs the architecture of a large-scale urban geographic spatial data engine. The demand analysis is detailed in Table 1:

No.	*Demand Item*	*Description*
1	Solution to Design Inefficiency	The model needs to integrate CAD technology to provide precise and efficient design tools.
2	Breakthrough in Creative Expression Limitations	The model should have a flexible design idea generation mechanism to provide diversified creative inspiration and solutions.
3	Implementation of Accurate Design Effect Evaluation Function	The model needs to combine multi-modal data fusion technology to provide an accurate evaluation of design effects.
4	Powerful Data Processing Capability	The model should be able to efficiently process data from different modalities to support the innovation and practicality of design.
5	Flexible Design Idea Generation Mechanism	The model should automatically generate diversified design solutions based on designer input and requirements.
6	Accurate Design Effect Evaluation Function	The model should accurately evaluate the effect of design solutions and provide quantitative indicators and visual displays.

Table 1: Demand analysis table.

The overall architecture design of this model is divided into four main levels: data acquisition layer, data processing layer, design creativity generation layer, and design effect evaluation layer (as shown in Figure 1). The data acquisition layer is responsible for collecting data related to EAD from different sources and forms. The data processing layer integrates and analyzes the collected data by using multi-modal data fusion technology. Based on the processed data, the design creativity generation layer generates innovative design schemes through CAD technology. Finally, the design effect evaluation layer evaluates and optimizes the generated design scheme.

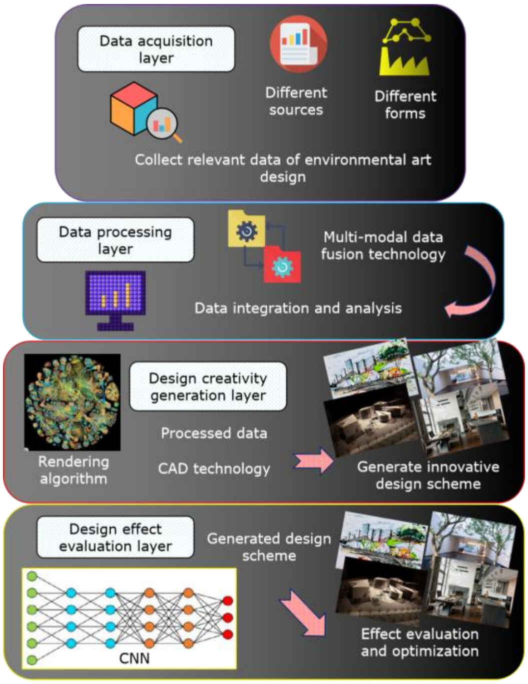

Figure 1: Overall architecture diagram of the model.

In the model, CAD technology is mainly used in the creative generation layer of design, which plays a vital role. Through the three-dimensional modelling function of CAD technology, designers can intuitively construct and display design objects in the form of three-dimensional space, which makes the design process closer to the real world and helps designers capture and express their creativity and ideas more accurately.

For instance, rendering a simple scene involving a light source, material, and surface can be represented by the following formula:

$$L_0 \; p,w \; = L_e \; p,w \; + \int_\Omega f_r \; p,w',w \; L_i \; p,w' \; \; w' \cdot n \; d\omega' \tag{1}$$

Among them:

$L_0 \; p,w$ Is outgoing radiance as viewed from a point p in the direction w.

$L_e \; p,w$ Is the direct illumination observed from point p in the direction w.

$f_r \; p,w',w$ Is a bidirectional reflection distribution function (BRDF), which describes the ratio of the radiation brightness of incident radiation $L_i \; p,w'$ reflected from direction w' to direction w to the incident brightness.

w' Is the direction of incident light as viewed from point p in direction w'.

n Is the surface normal?

Ω Is the solid angle of the observation direction w'.

BRDF is a function that describes how the surface of an object reflects light, and it is a key component of the rendering equation. The general form of BRDF is as follows:

$$f_r\left(\omega_i \rightarrow \omega_0\right) = \frac{dL_0\left(\omega_0\right)}{dE_i\left(\omega_i\right)} \tag{2}$$

Among them:

ω_i Is the direction of incident light.

ω_0 Is that the direction of reflected light?

$dL_0\left(\omega_0\right)$ Is the slight increment of radiation brightness of reflected light in the direction ω_0.

$dE_i\left(\omega_i\right)$ Is the slight increment of radiation illumination of incident light in direction ω_0.

CAD technology can automatically adjust parameters and details within the design scheme based on the outcomes of multimodal data fusion. This means that CAD systems can not only be used as a designer's expression tool but also as an intelligent auxiliary tool to help designers complete the design work more accurately and efficiently. Through multi-modal data fusion, CAD systems can integrate data from different sources, such as user feedback, environmental parameters, etc., and automatically optimize the design scheme according to these data to realize the intelligence and personalization of design.

The multi-modal data fusion method is mainly used in the data processing layer of the model. This method extracts key information and features by integrating data from images, sounds, texts, and other sources. Then, these information and features are fused by algorithms and models, and more comprehensive and in-depth data analysis results are obtained. In the model, the realization of multimodal data fusion mainly depends on advanced machine learning algorithms and big data processing technology. The machine learning algorithm utilized is the convolutional neural network (CNN), a widely employed algorithm in image processing. Its core mechanism involves extracting features from images through convolution operations. In CNN, data undergoes processing through multiple layers, including convolution, activation, pooling, and fully connected layers, to achieve feature extraction and classification. For a given input image (or feature map) X and convolution kernel W, the convolution operation can be mathematically expressed as follows:

$$Y = X * W + b \tag{3}$$

Where $*$ stands for convolution operation, b is the offset term, and Y is the output characteristic map.

In practical applications, convolution operations usually involve multiple convolution kernels to extract different features. Therefore, the output feature map y is a three-dimensional tensor, and its depth (or channel number) is equal to the number of convolution kernels. In addition, CNN also includes activation functions, such as ReLU, Sigmoid, and tanh, which are used to increase the nonlinearity of the network. The formula is:

$$\begin{aligned} f(x) &= \max(0, x) \\ f'(x) &= \begin{cases} 1 & if\ x>0 \\ 0 & otherwise \end{cases} \end{aligned} \tag{4}$$

$$\begin{aligned} f(x) &= \frac{1}{1+e^{-x}} \\ f'(x) &= f(x)\left(1-f(x)\right) \end{aligned} \tag{5}$$

$$\begin{aligned} f(x) &= \frac{e^{z}-e^{-x}}{e^{z}+e^{-x}} \\ f'(x) &= 1-f(x)^{2} \end{aligned} \tag{6}$$

The pooling layer serves to decrease the dimension of the feature map, minimize computational requirements, and extract essential features. Typical pooling operations include maximum pooling and average pooling. In a comprehensive CNN model, these layers are stacked to create a deep network, with weights and biases learned through training data to accomplish tasks like image classification and object detection. For the convolution layer, the dimensions of the output feature map can be determined using the following formula:

$$N = \frac{W - F + 2P}{S} + 1 \tag{7}$$

Among them:

N Is the size of the output characteristic graph (assuming that both the input and output are squares).

W Is the size of the input feature map.

F Is the size of the convolution kernel (filter).

P Is the size of padding, that is, the number of layers of zeros added around the input feature map.

S Is the step size, that is, the number of pixels that the convolution kernel slides on the input feature map.

The calculation of the output size of the pooled layer is similar to that of the convolution layer, but usually, it does not involve padding (or padding is 0, which does not affect the output size):

$$N' = \frac{W' - F' + 2P'}{S'} + 1 \tag{8}$$

However, in practical application, padding (N_{new} $P' = 0$) is usually not used in the pool layer, so the formula is simplified as:

$$N' = \frac{W' - F'}{S'} + 1 \tag{9}$$

Among them:

N' Is the size of the output characteristic map of the pool layer.

W' Is the size of the input feature map of the pooling layer (usually the same as the output size of the previous convolution layer).

F' Is the size of the pooled window.

S' Is the step size of the pooling operation.

Machine learning algorithms possess the capability to autonomously learn and extract valuable information and patterns from extensive datasets, thereby enhancing the intelligence and efficiency of the multi-modal data fusion process. Big data processing technology provides the ability to deal with massive and diverse data, which enables the model to cope with data challenges from different sources and formats. The combination of the two enables multimodal data fusion to be effectively realized in the model and provides strong data support and analysis capabilities for the design creative generation layer.

4 ANALYSIS OF APPLICATION EXAMPLES AND EXPERIMENTAL RESULTS

4.1 Model Performance Evaluation Experiment

The true value of interactive landscape works lies not in the works themselves but in the process of interactive experience, in which the creation of the works can be realized. Therefore, designers need to take into account the audience experience at the beginning and during the design process, which involves the embodiment of experiential principles in interactive works. Therefore, in designing works, designers are required to consider not only the form of the work, but also the emotional, physiological, and psychological factors of the audience. The designer mentioned here needs to consider the important nodes of audience interaction throughout the entire creative process. On the other hand, for the audience, different moods, environments, and times when experiencing the works already designed by the designer may cause different feelings for the experience, which highlights the true essence of the principle of experientiality. In this variable process, the feedback information is a process of regeneration and redesign for the entire design work, which demonstrates the uniqueness of interactive landscape works.

Figure 2 shows the evaluation of creativity, practicality and aesthetics of the design scheme generated by this model.

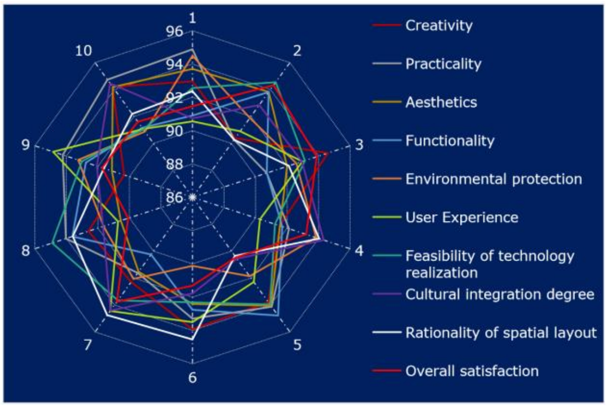

Figure 2: Evaluation index score (The proposed model).

The accuracy of the model is shown in Figure 3.

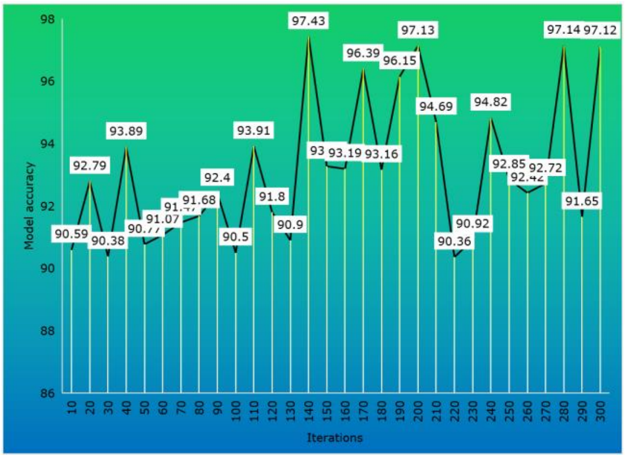

Figure 3: Model accuracy (The proposed model).

Figure 3 shows the accuracy changes of the proposed model during the iteration process, providing us with an important perspective for evaluating model performance. From the graph, it can be seen that as the number of iterations increases, the accuracy of the model shows a certain fluctuation but an overall upward trend. Although the accuracy of the model fluctuates during the iteration process, it remains at a relatively high level overall, reflecting the model's effective fitting ability to data and the stability of its generalization performance. In addition, the maximum model accuracy of 97.43% indicates that the model has achieved high prediction accuracy on specific tasks and can accurately capture patterns and features in the data. The data processing speed of the model is shown in Figure 4.

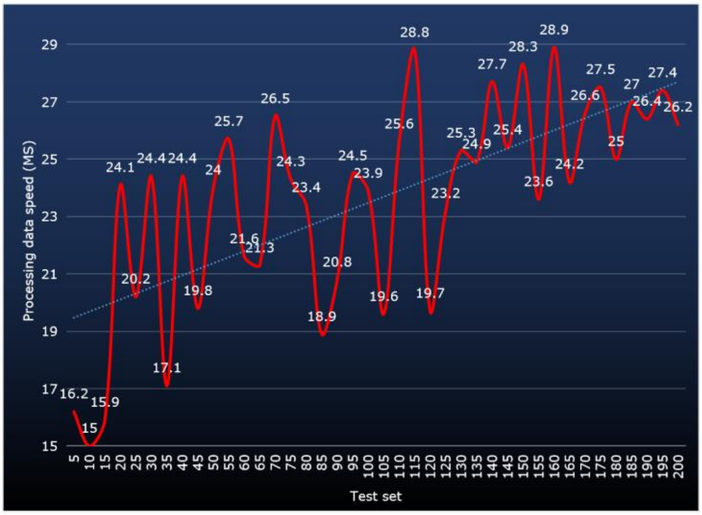

Figure 4: The speed at which the model processes data (The proposed model).

The horizontal axis of Figure 4 represents the test set, and the vertical axis represents the speed of data processing. It can be seen that the curve gradually increases. The maximum processing speed of the model reached 28.9 milliseconds (ms), indicating that under optimal conditions, the model can process data at an extremely fast speed and provide almost real-time interactive feedback to the audience. The minimum value of 15 milliseconds (ms) also demonstrates the excellent performance of the model when dealing with relatively simple or small-scale test sets. This efficient data processing capability is the key to achieving a smooth interactive experience in interactive landscape works. It can be seen that the design scheme generated by this model has a high score in creativity, practicality, and aesthetics, reaching more than 9 points comprehensively. At the same time, the accuracy of the model is about 91%, and the speed of data processing is fast, reaching about 20 ms.

To comprehensively evaluate the performance of the EAD model based on the fusion of CAD and multimodal data, this section compares it with the KANO model and comprehensively evaluates its performance from the aspects of creativity, practicality, aesthetics, and design efficiency. Figure 5 shows the evaluation of creativity, practicality, and aesthetics of the design scheme generated by the KANO model.

Figure 5, based on the KANO model, comprehensively displays the scores of interactive landscape works on multiple key evaluation indicators, providing a detailed evaluation perspective for the overall performance of the works. From the graph, it can be seen that the work has achieved impressive results in creativity, practicality, aesthetics, functionality, environmental protection, user experience, technical feasibility, cultural integration, rationality of spatial layout, and overall satisfaction. Figure 6 illustrates the accuracy of the KANO model, while Figure 7 depicts its data processing speed.

The horizontal axis of Figure 6 represents the number of iterations, and the vertical axis represents the accuracy of the model. It can be seen from the graph that as the number of iterations increases, the accuracy of the model shows a fluctuating trend, with the lowest accuracy being 55.04% and the highest being 86.51%. This significant improvement in accuracy not only reflects the learning efficiency and stability of the model during training but also proves that designers have successfully improved the predictive ability and accuracy of the model by continuously optimizing algorithms and adjusting parameters.

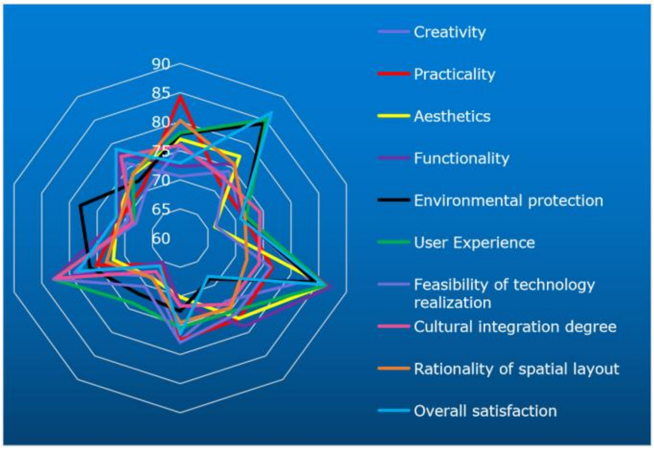

Figure 5: Evaluation index score (KANO model).

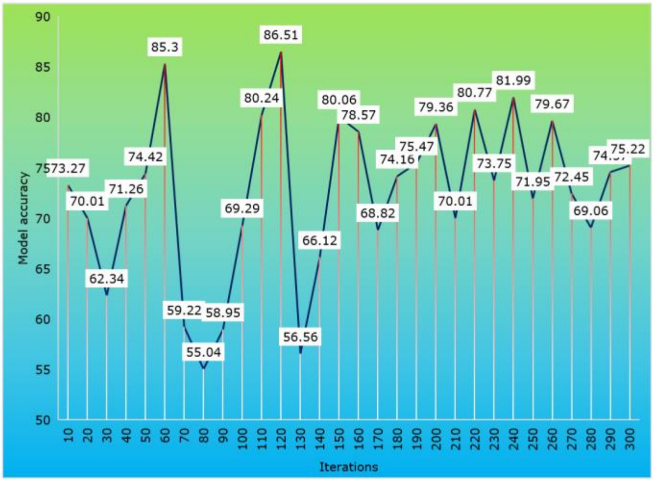

Figure 6: Model accuracy (KANO model).

Figure 7 shows the variation in the data processing speed of the model when dealing with different test sets, which is presented through the KANO model. The horizontal axis of Figure 7 represents the test set, and the vertical axis represents the speed of data processing. The lowest model accuracy is 52 (ms) and the highest is 59 (ms). The data processing speed variation shown in Figure 7 provides important reference information. It reminds designers to pay attention to the data processing capabilities of models in different scenarios when designing interactive landscape works, to ensure that the works can provide a stable interactive experience under various conditions. The results show that the scores of creativity, practicality and aesthetics of the design scheme generated by the KANO model are general, and the comprehensive score is about 7.5. The accuracy of the model is about 79%, and the data processing speed of the model is about 70 ms. Compared with the KANO model, the model proposed in this article can generate more creative, practical and beautiful design schemes, and can greatly improve the design efficiency.

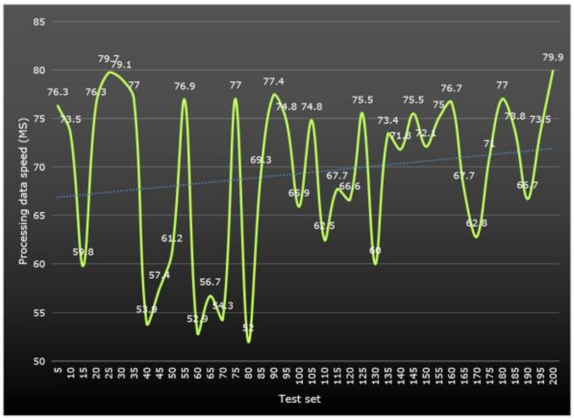

Figure 7: The speed at which the model processes data (KANO model).

Through the above comparison and analysis, this article finds that the EAD model based on the fusion of CAD and multimodal data has obvious advantages in many aspects, especially in creativity and design efficiency. This shows that the proposed model has remarkable innovation ability and practical application effect in EAD.

4.2 Practical Project Application Case

To further validate the practical application effectiveness of the EAD model integrating CAD and multimodal data, this section applies it to a real-world EAD project. The model proposed in this article is utilized to innovate and refine the design scheme, ultimately achieving satisfactory design outcomes. This practical application further confirms the model's practicality and effectiveness in EAD.

In the actual project application, this article obtains the design effect of the EAD model based on the fusion of CAD and multimodal data, as shown in Figure 8.

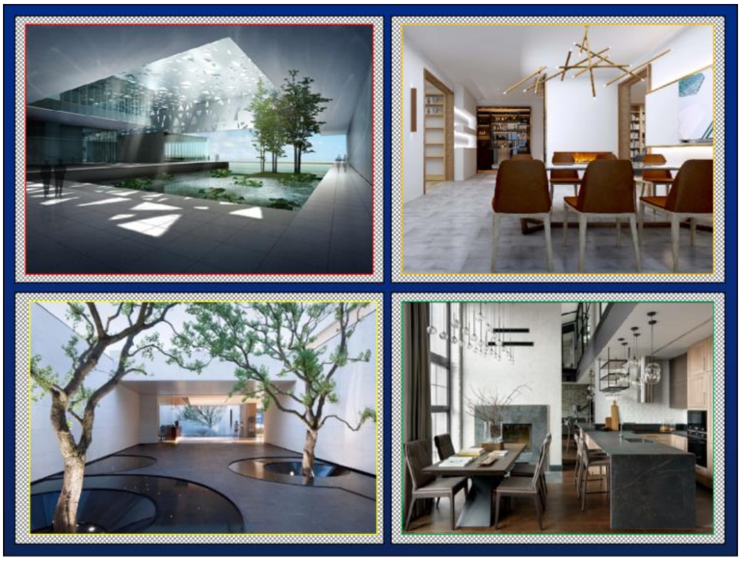

Figure 8: Design effect diagram.

Through professional evaluation tools and methods, this section comprehensively evaluates the creativity, practicality and aesthetics of the design scheme, as shown in Table 2.

Evaluation Index	*Score (out of 10)*
Creativity	9.6
Practicality	9.5
Aesthetics	9.4
Functionality	8.8
User Experience	9.3
Technical Feasibility	8.9
Environmental Friendliness	8.6
Cultural Integration	9.1
Spatial Layout Rationality	9.2
Overall Satisfaction	9.1

Table 2: EAD model design effect evaluation table.

In Table 2, the column "Evaluation Index" lists many aspects of evaluating the design scheme, including creativity, practicality, aesthetics, functionality, user experience, feasibility of technology realization, environmental protection, cultural integration, rationality of spatial layout and overall satisfaction. The "Score (out of 10)" column gives the corresponding score value, with a full score of 10. The evaluation results show that the design scheme generated by this model is excellent in many aspects, especially in creativity and practicality.

At the same time, this section further verifies the feasibility and practicability of the design scheme through user feedback and practical application effect. Users' feedback on the EAD model based on the integration of CAD and multimodal data is shown in Table 3.

User ID	*Feedback*	*Suggestions for Improvement*
User 1	The model significantly improves design efficiency and quality, generating creative and practical design solutions.	Further, optimize the model algorithm to improve data processing speed.
User 2	The design solutions are innovative, but some details need to be refined	Add more practical design functions to enhance the model's detail processing capabilities
User 3	The model is easy to operate, and the generated design solutions meet actual needs with a good user experience.	Add user-defined functions to make design solutions more personalized.
User 4	The model excels at improving design efficiency, but it is hoped that more design material libraries will be added.	Expand the design material library to provide a more diverse selection of design elements.
User 5	The generated design solutions excel in practicality, but the interface layout needs further optimization.	Optimize the interface layout to enhance user interaction experience.
User 6	The overall performance is excellent, but the application effect needs to be improved in some specific scenarios.	Optimize for specific scenarios to enhance the model's applicability in complex environments.

Table 3: EAD Model User Feedback Table.

In Table 3, the column "User ID" is used to identify six different users, the column "Feedback" records each user's evaluation and opinion on the model, and the column "Suggestions for Improvement" records each user's suggestions for improving the model.

You can see that users generally believe that the model has obvious advantages in improving design efficiency and quality, and the generated design scheme is very creative and practical. At the same time, users also put forward some suggestions for improvement, such as further optimizing the algorithm of the model, increasing the speed of data processing and adding more practical design functions. According to the feedback and suggestions of users, the model will be continuously improved and optimized to better meet the actual needs and improve the innovative ability and practical application effect of EAD.

5 CONCLUSIONS

Integrating CAD and multimodal technology is a complex and ever-changing computer technology that has changed the way humans live their daily lives. Its role in design is becoming increasingly important, and at the same time, new requirements have been put forward for the concept, content, and methods of landscape design. The focus of this article on multimodal digital landscape research is mainly on interactive expression, and it can be said that interactive landscape design will become the dominant direction in future landscape design. It has gradually replaced many jobs while creating new job opportunities, with the continuous maturity and development of multimodal digital technology. The core of digital design lies in the generation, development, and regulation of design through the setting of calculation rules and parameters, achieving optimal design. This technology greatly improves the efficiency and accuracy of design. In the later stage, with the introduction of digital technology and appropriate computer control, the interactivity of environmental landscape art can be maximized, making it possible for both designers and audiences to become "creators" of the work. Design works that have not applied digital technology to interaction design in the past can only reflect the idea of interaction in the final presentation. In addition, the potential of EAD models based on CAD and multimodal data fusion to have a profound impact on the EAD field has been recognized. Landscape design guided by the concept of interaction integrates interactive thinking throughout the entire landscape design process, from preliminary design to final presentation. This change is not limited to its artistic expression, but its greater significance lies in enabling the audience to have a more direct or indirect connection and resonance with the work through interactive means.

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REFERENCES

[1] Bianconi, F.; Filippucci, M.; Seccaroni, M.; Rolando, A.; D'Uva, D.: Machine learning and landscape quality. Representing visual information using deep learning-based image segmentation from street view photos, SCIRES-IT-SCIentific Research and Information Technology, 13(1), 2023, 117-134. http://dx.doi.org/10.2423/i22394303v13n1p117

[2] Chen, J.; Stouffs, R.: Deciphering the noisy landscape: Architectural conceptual design space interpretation using disentangled representation learning, Computer-Aided Civil and Infrastructure Engineering, 38(5), 2023, 601-620. https://doi.org/10.1111/mice.12908

[3] Du, J.: Application of CAD aided intelligent technology in landscape design, International Journal of Advanced Computer Science and Applications, 13(12), 2022, 1030-1037. https://doi.org/10.14569/IJACSA.2022.01312118

[4] Hassanpour, P.; Sayyahnia, R.; Esmaeilzadeh, H.: Ecological structure assessment of urban green space using the landscape approach (case study: Tehran's 22nd district), Environmental Sciences, 18(1), 2020, 187-202. https://doi.org/10.29252/envs.18.1.187

[5] Herrero-Tejedor, T.-R.; Arques Soler, F.; López-Cuervo Medina, S.; de la O Cabrera, M.-R.; Martin Romero, J.-L.: Documenting a cultural landscape using point-cloud 3d models obtained with geomatic integration techniques. The case of the El Encín atomic garden, Madrid (Spain), Plos One, 15(6), 2020, e0235169. https://doi.org/10.1371/journal.pone.0235169

[6] 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

[7] 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

[8] Kim, S.; Shin, Y.; Park, J.; Lee, S.-W.; An, K.: Exploring the potential of 3D printing technology in landscape design process, Land, 10(3), 2021, 259. https://doi.org/10.3390/land10030259

[9] Lavorel, S.; Grigulis, K.; Richards, D.-R.: Templates for multifunctional landscape design, Landscape Ecology, 37(3), 2022, 913-934. https://doi.org/10.1007/s10980-021-01377-6

[10] Li, P.: Intelligent landscape design and land planning based on neural network and wireless sensor network, Journal of Intelligent and Fuzzy Systems, 40(2), 2021, 2055-2067. https://doi.org/10.3233/JIFS-189207

[11] Wu, H.; Yan, J.: The mechanism of digitized landscape architecture design under edge computing, Plos One, 16(9), 2021, e0252087. https://doi.org/10.1371/journal.pone.0252087

[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] Xu, B.; Jiang, J.: Exploitation for multimedia Asian information processing and artificial intelligence-based art design and teaching in colleges, ACM Transactions on Asian and Low-Resource Language Information Processing, 21(6), 2022, 1-18. https://doi.org/10.1145/3526219

[14] 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

[15] Zhao, X.: Application of 3D CAD in landscape architecture design and optimization of hierarchical details, Computer-Aided Design and Applications, 18(S1), 2020, 120-132. https://doi.org/10.14733/cadaps.2021.S1.120-132