Analysis of Decision Algorithm Combining Environmental Art Design and CAD Technology

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Abstract. This article mainly explores the application method and effect of big data algorithms combining environmental art design and CAD technology in design decision-making and constructs a design decision support system integrating data collection, processing, analysis, display, and decision support. To comprehensively evaluate the newly developed algorithm system's performance, this article utilizes a range of testing metrics such as system throughput, algorithm execution time, resource utilization, and algorithm complexity. The conducted experiments reveal that the system's response time remains consistent across varying loads, while its throughput stabilizes after a certain level of concurrency, indicating robust concurrent processing capabilities. Furthermore, both the CPU and memory utilization rates of the system are maintained at low levels. In addition, the execution time of different algorithms is significantly different under the same input data, and the execution time of this algorithm is the shortest, which shows that this algorithm has the highest efficiency when dealing with the same task. Through analysis, the system can realize the deep mining and effective utilization of the data related to environmental art design and provide scientific and intelligent design suggestions for designers, thus improving the accuracy and innovation of design.

Keywords: Environmental Art; CAD Technology; Big Data; Design Decision; Deep Learning
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1 INTRODUCTION

With societal advancement and technological development, environmental art design—a confluence of nature, culture, science, and technology—has garnered increasing attention. With the rapid development of technology, computer-aided design (CAD) technology is playing an increasingly important role in landscape design. However, the limitations of traditional CAD technology in handling environmental art and design are gradually becoming apparent. In order to better meet the needs of the landscape industry, a revolutionary technology combining environmental art design with CAD technology has emerged. Choi and Suh [1] discussed the impact and value of this combination in the landscape industry. Through artificial intelligence and machine learning techniques, CAD software can automatically optimize solutions and adjust parameters according to the designer's intentions. This greatly improves the efficiency and accuracy of design, enabling designers to better cope with complex environmental art design tasks. By combining virtual reality (VR) and augmented reality (AR) technologies, designers can perform landscape design in a virtual environment. This allows designers to have a more intuitive experience of the effectiveness of the design scheme, improving the feasibility and practicality of the design. Meanwhile, this technology can also be used for customer display and communication, enhancing their sense of participation and experience. This discipline not only impacts people's quality of life but also reflects societal and cultural standards and aesthetic preferences. With the rapid development of technology, artificial intelligence (AI) has shown strong potential in many fields. The combination of artificial intelligence and CAD technology is changing traditional landscape design patterns in the fields of environmental art design and landscape architecture. Fernberg and Chamberlain [2] provide an overview of this topic, exploring the application, advantages, and development trends of artificial intelligence in environmental art design and landscape architecture. AI can intelligently analyze the structure of landscape architecture, identify potential problems, and propose optimization solutions to improve the stability and safety of the building. The application of artificial intelligence in environmental art design and landscape architecture will become increasingly widespread. In the future, AI may achieve more intelligent design, combined with more innovative technologies such as 5G and the Internet of Things, bringing more possibilities to landscape design. Meanwhile, the widespread adoption and sophistication of CAD technology have equipped environmental art designers with more precise and efficient tools. As an important component of natural ecosystems, the forest landscape's visual quality evaluation is of great significance for ecological protection, tourism development, and other aspects. The traditional forest landscape visual quality evaluation methods mainly rely on manual field inspections and expert evaluations, which are not only time-consuming and laborious but also difficult to achieve large-scale and rapid evaluation. With the continuous development of artificial intelligence technology, the use of artificial intelligence technology for forest landscape visual quality evaluation has become a new trend. Jahani and Rayegani [3] discussed how to use artificial intelligence technology to build decision support systems and evaluate the visual quality of forest landscapes. It utilizes machine learning algorithms to learn a large amount of forest landscape data and establish predictive models. By using pattern recognition technology, classify and recognize the colour, texture, structure, and other aspects of forest landscapes and achieve automatic evaluation of the visual quality of forest landscapes. It utilizes data mining techniques to conduct in-depth analysis of forest landscape data, mining association rules and trends within it. Combining artificial intelligence decision support systems to provide a scientific decision-making basis for managers and decision-makers, optimizing the management and protection of forest landscapes. In the digital and intelligent era, big data algorithms introduce new design possibilities through their robust data processing and analytical capabilities, facilitating personalized, optimized, and intelligent designs.

Environmental art design is an interdisciplinary field that integrates artistic, design, architectural, and ecological knowledge. Computer-aided design (CAD) systems are playing an increasingly important role in various design fields. In the field of landscape design, CAD systems provide designers with convenient and fast drawing tools, making the design process more efficient. Kahlon and Fujii [4] take the design of Japanese rock gardens as an example to explore the framework of concept formation in CAD systems. Japanese rock garden design is a unique landscape design style that emphasizes the harmonious coexistence of natural and artificial elements. In landscape design, CAD systems also assist in design work such as spatial analysis, plant configuration, and landscape element layout. From the above analysis, it can be seen that the conceptual framework formed in CAD systems provides designers with a clear design process, which helps to improve the efficiency and quality of design. After the evaluation and optimization of the plan, use the CAD system to carry out detailed design and improvement in landscape element design and plant configuration. Taking the design of Japanese rock gardens as an example, this framework can help designers better understand the design concepts and characteristics of Japanese rock gardens so as to better apply them to practical design. In recent years, heightened environmental awareness and diverse aesthetic preferences have steered environmental art design towards a more diverse, eco-friendly, and human-centred trajectory. Designers now prioritize practicality, aesthetics, and sustainability to cater to a broader spectrum of users. With the continuous development of technology, 3D printing technology, as an emerging manufacturing technology, is gradually penetrating into various fields. In environmental art design, 3D printing technology also demonstrates enormous potential. Kim et al. [5] explored the potential of 3D printing technology in landscape design and analyzed its application prospects in environmental art design. Traditional manufacturing methods make it difficult to achieve the production of complex structures, while 3D printing technology can easily manufacture complex three-dimensional structures based on digital models. This is very beneficial for the production of complex sculptures, landscape sketches, and other elements in landscape design. 3D printing technology can be customized according to the needs of designers. Landscape design allows designers to create unique design elements based on the special requirements of the project, meeting the needs of customers. In public spaces such as parks and squares, landscape ornaments are indispensable elements. By using 3D printing technology, designers can create unique and interesting landscape pieces, enriching the spatial connotation. In landscape design, architectural models are an important means of expression. Through 3D printing technology, designers can quickly and accurately create building models and better showcase design solutions.

Environmental art design occupies an important position in the field of architecture, aiming to create both beautiful and practical architectural works through innovative design concepts and techniques. Among them, the biomimetic folding mechanism, as a new type of architectural design element, brings new possibilities for environmental art design with its unique structure and function. Krner et al. [6] explored the application of biomimetic folding mechanisms in environmental art design and architecture, as well as how to integrate design and manufacturing through computer-aided design (CAD). The biomimetic folding mechanism can achieve the lightweight of building structures and improve their strength and stability. Meanwhile, by optimizing the folding method, it is possible to effectively reduce the use of building materials and lower construction costs. Biomimetic folding mechanisms can achieve dynamic changes in architectural space through folding and unfolding. This design approach can provide more possibilities for the spatial layout inside the building and meet different functional requirements. The design of biomimetic folding mechanisms has a unique visual effect, which can bring a unique appearance and aesthetic value to buildings. This design approach can attract people's attention and enhance the identity of the building. Landscape planning and design is a complex process that requires consideration of many factors, such as environment, culture, society, and economy. Traditional planning methods often rely on the experience and intuition of designers, lacking quantitative analysis and optimization. However, traditional genetic algorithms overlook the intuition and experience of designers, leading to a lack of innovation in design solutions. In order to solve this problem, interactive genetic algorithms have emerged, which combine the intuition of designers and the optimization ability of genetic algorithms, providing new ideas and methods for landscape planning and design. The Li and Sharma [7] interactive genetic algorithm can be used to optimize the species, quantity, and distribution of plants to improve the ecological benefits and landscape effects of plant communities. Designers can choose and adjust the configuration schemes generated by algorithms based on their own aesthetic perspectives and experience. Interactive genetic algorithms can help designers allocate landscape resources reasonably, such as roads, lighting, leisure facilities, etc., to meet functional requirements and save costs. During this process, designers can make decisions and adjustments to the optimization results of the algorithm based on actual situations.

Big data algorithms, capable of mining and analyzing vast datasets, uncover hidden correlations and patterns, greatly aiding design decisions. In the design's initial stages, these algorithms assist designers in understanding user needs and market trends, guiding design directions. During the design process, they optimize and refine schematics for improved practicality and scientific rigour.

Post-completion, big data algorithms assess design impact, providing valuable insights for future projects. The core objective of this piece is to investigate the integration of big data algorithms with environmental art design and CAD technology in the context of design decision-making. By undertaking this examination, we aim to establish a design decision support system rooted in big data algorithms, enhancing both the speed and excellence of environmental art design. Furthermore, this article delves into the possibilities and impediments of big data algorithms within environmental art design, offering valuable insights for future scholarly endeavours. In the process of research, this article will face the following core problems: How do we effectively collect and process the data related to environmental art design? How do we combine big data algorithms with CAD technology to support design decisions? How do we assess the effect and value of big data algorithms in design decisions?

Innovation:

Fusion of big data algorithm and environmental art design: The big data algorithm is systematically introduced into the field of environmental art design, which provides data-driven decision support for traditional design methods, thus improving the accuracy and innovation of design.

Construction of design decision support system: A design decision support system integrating data collection, processing, analysis, display, and decision support is constructed. The system can realize the deep mining and effective utilization of data related to environmental art design and provide scientific and intelligent design suggestions for designers.

Practical Application and Validation: While theoretically discussing the utilization of big data algorithms in environmental art design, this article further substantiates the system's viability and efficacy through concrete project implementations and validations.

Chapter Outline:

Introduction: Presents the backdrop, aims, and significance of the research, along with its underlying questions and hypotheses.

Literature Survey: Delves into the current research landscape and future trends, laying the theoretical groundwork and references for this study.

Methodology: Details the research setup, data acquisition and processing techniques, algorithm selection, and refinement strategies, as well as the system's development and deployment process.

Experimental Findings and Interpretation: Unveils the outcomes of data analysis, affirming the research hypothesis and evaluating the system's performance and real-world impact.

Design Decision Support System: Elucidates the system's structure, functional components, interactive design, and its application and feedback within practical settings.

Closing Thoughts and Outlook: Capsulates the research accomplishments and contributions, highlights any limitations, and charts out future research paths, along with recommendations and aspirations for subsequent studies.

2 RELATED WORK

The application of Building Information Modeling (BIM) in the field of environmental art and design is becoming increasingly widespread. However, for the loading of large-scale WebBIM environment art and design scenes, scheduling and managing resources efficiently has become an urgent problem to be solved. The CEB collaborative multi-granularity interest scheduling algorithm, as a new type of scheduling algorithm, aims to solve this problem. Li et al. [8] provided a detailed introduction to the principle, implementation process, and application scenarios of the algorithm. The CEB collaborative multi-granularity interest scheduling algorithm is based on collaborative filtering and multi-granularity partitioning principles and achieves intelligent scheduling and management of resources by analyzing user interests and resource characteristics. This algorithm first divides user interests into multiple granularities, then uses collaborative filtering algorithms to find similar users, and finally schedules based on user interests and resource characteristics. It utilizes collaborative filtering algorithms to identify other users with similar interests as the target user, providing a reference for subsequent resource scheduling. The CEB collaborative multi-granularity interest scheduling algorithm is suitable for loading various large-scale WebBIM environment art and design scenes. In addition, this algorithm can also be applied in fields such as gaming and film production, providing creators with more efficient resource scheduling and management methods. With the rapid development of big data technology, its application in various fields is also becoming increasingly widespread. In the design of garden plant environments, the application of big data provides designers with richer and more accurate data support, which helps to improve the scientific and practical nature of the design. Li [9] discussed the application of a big data-based landscape plant environment design and analysis system. By utilizing big data analysis techniques, the collected data can be analyzed in depth to uncover valuable information related to landscape plant environmental design. By analyzing the growth of different plants, it is possible to identify plant species that are suitable for specific environments. By analyzing climate change trends, it is possible to predict the future impact of the environment on plant growth. Based on the analysis results of big data, designers can design garden plant environments more scientifically. Select appropriate plant species based on soil composition and climate characteristics; Design a reasonable plant configuration based on ecological habits. The application of a big data-based landscape plant environment design and analysis system provides designers with more scientific and accurate design support. Through the application of big data technology, designers can better understand the relationship between the environment and plants and improve the rationality and adaptability of their designs.

With the rapid development of technology, artificial intelligence (AI) is playing an increasingly important role in landscape design. Especially in environmental analysis and edge-driven technology, AI has brought unprecedented opportunities and challenges to landscape design. Ma et al. [10] explored how to utilize soft multimedia technology based on environmental analysis and edge-driven AI to achieve artistic landscape design. Environmental analysis is an important part of landscape design, which involves an in-depth understanding of terrain, climate, vegetation, hydrology, and other aspects. Edge-driven AI refers to the processing and analysis of AI being carried out near the data source, thereby reducing the time and cost of data transmission and processing. In landscape design, edge-driven AI can be used for real-time monitoring and data analysis, providing designers with timely and accurate environmental information. Artistry is one of the core goals of landscape design. Soft multimedia technology based on environmental analysis and edge-driven AI can help designers better achieve artistic landscape design. The field of landscape design and land planning is facing a technological revolution. Traditional landscape design and land planning methods often rely on manual investigation and empirical judgment, which is not only inefficient but also difficult to cope with complex and changing environmental conditions. However, with the rise of neural networks and wireless sensor network technology, there is an opportunity to build an intelligent environmental landscape design and land planning system, achieving more accurate and efficient design and planning. Peng [11] discussed how to use neural networks and wireless sensor network technology to achieve intelligent environmental landscape design and land planning. Intelligent environmental landscape design and land planning based on neural networks and wireless sensor networks are innovative methods with broad application prospects. By utilizing the deep learning and pattern recognition capabilities of neural networks, as well as the real-time monitoring capabilities of wireless sensor networks, we can achieve more accurate and efficient environmental landscape design and land planning.

Landscape environmental art design plays an important role in modern architecture. It is not only the art of beautifying the appearance of buildings but also the key to creating a comfortable and harmonious living environment. Especially in the design of the front and back yards of buildings, it is a challenging task to cleverly utilize landscape elements to create a courtyard landscape that is in harmony with the architectural style. In recent years, deep learning has achieved significant results in fields such as image processing and natural language processing and has also brought new ideas and methods to landscape design. Senem et al. [12] explored how to use deep learning techniques to generate artistic and practical landscape designs for the front and back yards of buildings. As the entrance space of a building, the front yard is an important place to showcase the architectural style and characteristics. By utilizing deep learning techniques, we can generate artistic and practical front-end landscape designs based on factors such as architectural style and the surrounding environment. Generate ground paving, plant configuration, water features, etc., that are coordinated with the architectural style through GANs. Popular design elements and layout methods are extracted through CNN analysis of successful courtyard design cases. Optimize the design layout through RL to achieve automated configuration. In the field of environmental design and architecture, the embedded steady-state principle is an important concept that emphasizes the need to fully consider the stability and sustainability of the environment during the design process. This principle is not only applicable to architectural design but also has a profound impact on environmental art design. Showkatbakhsh et al. [13] explored the evolutionary design process of embedded steady-state principles and how they affect the adaptation of architectural forms and environmental art design. The principle of embedded steady-state states that a design should be coordinated with the surrounding environment and able to adapt to changes in the environment. This design philosophy emphasizes sustainability and stability by optimizing design elements to better adapt to the environment, thus achieving long-term stability and sustainability. In architectural design, priority should be given to selecting renewable, recyclable, and low-energy building materials. These materials can not only reduce energy consumption and environmental pollution but also adapt to changes in the environment and improve the stability of buildings.

With the continuous development of technology, computer-aided design (CAD) software is playing an increasingly important role in landscape planning and design. However, a single CAD software still has limitations in certain aspects. Integrating CAD with other software has become a trend to better meet the needs of designers. Song and Jing [14] explore the application prospects of integrated software technologies such as CAD, SketchUp, and PS in landscape planning and design. The graphical interface of software such as SketchUp and PS is more intuitive and easy to operate, which can help designers better express their design intentions. Through the rendering and post-processing functions of this software, designers can create more exquisite and realistic renderings, enhancing the expressive power of their designs. By integrating CAD with software such as PS, designers can utilize the data analysis function of PS to process and analyze design data, extracting valuable information related to landscape planning and design. These pieces of information can provide decision support for designers, enhancing the scientific and practical nature of their designs. Coastal landscape environmental art design is a complex art form that requires careful consideration of multiple aspects, such as the natural environment, cultural background, and ecological protection. With the continuous development of technology, the application of virtual reality (VR) technology and intelligent algorithms in environmental art design is becoming increasingly widespread. Wang [15] explored how to utilize these technologies for coastal landscape environmental art design. By utilizing virtual reality technology, designers can simulate real coastal landscape environments in computers, thereby more intuitively experiencing and evaluating the feasibility and effectiveness of the design. This technology can reduce design costs, shorten design cycles, and improve design efficiency. Through virtual reality technology, designers can interact in real-time with the virtual environment, and modify and adjust their designs. This interactive design approach can improve the flexibility and adjustability of the design, enabling designers to better meet customer needs. Virtual reality technology allows designers to observe design effects from multiple perspectives discover and solve potential problems. This multi-angle observation method helps improve the precision and completeness of the design.

With the rapid development of artificial intelligence (AI) technology, its applications in various fields are becoming increasingly widespread. In the field of landscape design, AI technology provides designers with new creative tools and ways of thinking, making landscape design more diverse and personalized. Ceramic art, as an important component of traditional Chinese art, has unique aesthetic value and profound cultural connotations. Wang [16] explored how to leverage AI technology to maximize the application beauty of ceramic art in landscape design. Using AI technology to conduct data mining and analysis on the history, style, and craftsmanship of ceramic art, delving into the inherent laws and innovative points of ceramic art, and providing inspiration for landscape design. Through AI algorithms and computer simulation technology, intelligent optimization of the layout, proportion, colour, and other aspects of ceramic elements in landscape design is carried out to improve the rationality and aesthetics of the design. By utilizing virtual reality (VR) technology, ceramic art is combined with landscape design to present design results in an immersive manner, allowing audiences to better experience the application beauty of ceramic art in landscape design. The combination of AI and CAD technology in the fields of environmental art design and landscape design has brought unprecedented opportunities and challenges to design. In order to adapt to this development trend, it is particularly important to build an artificial intelligence-driven landscape design teaching platform based on the combination of environmental art design and CAD technology. Yang et al. [17] explored how to build such a teaching platform and analyzed its role and value in landscape design teaching. The artificial intelligence-driven landscape design teaching platform that combines environmental art design with CAD technology is an innovative teaching tool. The platform can simulate real project scenarios, allowing students to improve their ability to solve practical problems in practice.

3 INNOVATIVE APPLICATION OF CAD TECHNOLOGY SUPPORTED BY BIG DATA ALGORITHM

3.1 The Combination of Big Data Algorithms and Environmental Art Design

Environmental art design stands as a profoundly interdisciplinary field, encompassing various domains like architectural design, interior design, landscape design, and urban planning. The basic principles of environmental art design mainly include humanized design, functional design, aesthetic design, and sustainable design. These principles together constitute the foundation of environmental art design and guide designers on how to balance practicality and aesthetics in the creative process and how to consider the interactive relationship between human behaviour psychology and the environment. In terms of design principles, environmental art design emphasizes the principles of integrity, coordination, comfort, and innovation (as shown in Table 1).

Design Philosophy	*Definition and requirements*
Principle of integrity	The design works to maintain unity and harmony in form, colour, and material, creating an overall aesthetic feeling.
Principle of coordination	The integration of design works with the surrounding environment ensures that the design style is in harmony with the environment.
Comfort principle	Pay attention to the convenience and comfort of design works in the use process and provide a good use experience.
Innovative principle	On the basis of following tradition, we dare to try new design concepts and techniques to promote the innovation and development of design.

Table 1: Design Philosophy.

Aesthetic standards are an indispensable part of environmental art design, which reflects the cultural level and aesthetic trends of society. People's aesthetic standards will also be different under different geographical, ethnic, and cultural backgrounds. Therefore, designers need to have keen insight and rich cultural literacy in order to grasp and embody these aesthetic standards in design accurately.

The relationship between the environment and people is one of the core issues in environmental art design. The environment not only provides the material basis for human survival and development but also has a far-reaching impact on human psychology and behaviour. Therefore, in environmental art design, designers need to fully consider people's needs, behaviour, and psychological characteristics and create design works that conform to the principles of ergonomics, behavioural psychology, and aesthetic psychology. Moreover, designers also need to pay attention to the feedback effect of the environment on people, improve the environmental quality, and enhance people's quality of life and happiness through design means.

CAD technology is one of the indispensable tools in environmental art design. Its development process has experienced the transformation from two-dimensional drawing to three-dimensional modelling, from single function to integrated system. As computer technology continues to evolve and gain widespread adoption, CAD technology has emerged as the go-to tool for designers to craft designs, produce renderings, and develop construction drawings. This encompassed procedures like data gathering, preprocessing, feature extraction, and model development, with the model's efficacy being substantiated through illustrative examples. In the realm of environmental art design, CAD technology finds its niche applications, primarily encompassing the areas outlined in Figure 1.

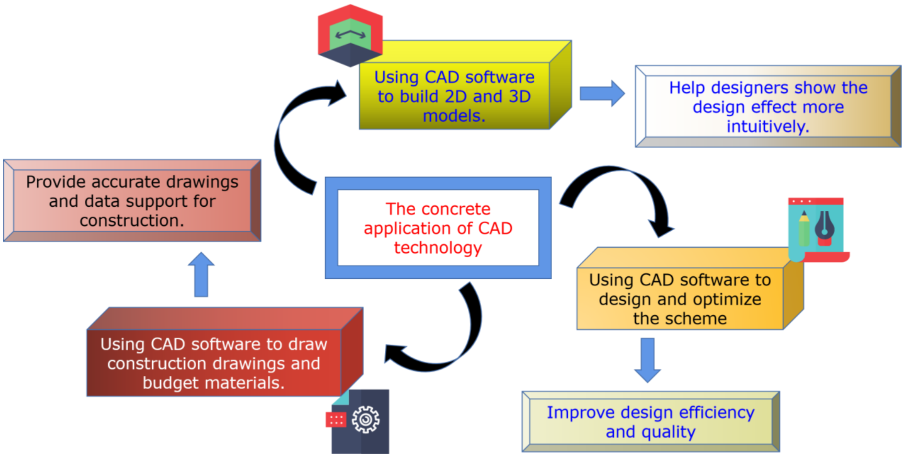

Figure 1: The concrete application of CAD technology.

Big data denotes a vast array of data sets that surpass the capabilities of conventional software tools to capture, manage, and analyze within a set timeframe. The arsenal of big data analysis algorithms encompasses classification, clustering, association rules, prediction, and optimization algorithms, each with distinct strengths and applications. In the context of environmental art design, these algorithms can be employed in various ways: classification algorithms can segment and pinpoint user needs; clustering algorithms can categorize and contrast design concepts; association rule algorithms can unravel the relationships between design elements; prediction algorithms can anticipate design trends and future evolutions; and optimization algorithms can refine and enhance design proposals. In the realm of environmental art design, the utilization of big data algorithms offers designers a fresh viewpoint and toolbox. The integration manifests primarily in three ways: Firstly, big data algorithms facilitate a deeper comprehension of user preferences and market dynamics, guiding design positioning. Secondly, they enhance the design process by optimizing and refining schemes, ensuring both scientific rigour and practical applicability. Lastly, these algorithms evaluate and provide feedback on the design's impact, serving as valuable experience and reference for future endeavours. As technological advancements continue, CAD technology and big data algorithms are increasingly becoming seamlessly integrated. This integration is reflected not only in the complementarity of technology but also in the innovation of design thinking and methodology. CAD technology provides accurate modelling and visualization tools for environmental art design, while big data algorithms provide powerful data support and analysis for design decisions. The combination of the two enables designers to create on the basis of more comprehensive and in-depth data insight, which improves the accuracy and innovation of design.

3.2 The Integration of CAD Technology and Big Data Algorithm

The application scenarios of big data algorithms in environmental art design are diverse and far-reaching. During the initial design phase, big data algorithms facilitate precise identification and targeting of user needs, guiding the overall design direction. Throughout the design process, these algorithms intelligently refine and enhance the design scheme, boosting both efficiency and quality. Post-completion, big data algorithms quantify and evaluate the design's impact, offering valuable feedback for further refinement. CAD data plays a pivotal role in this analytical process, harbouring rich geometric, material, and illumination information that serves as a crucial data source for big data analysis. By mining and analyzing this data, designers gain deeper insights into the design's performance and characteristics, revealing potential issues and areas for improvement leading to targeted optimizations.

Table 2 highlights the key ways in which big data algorithms augment and extend the capabilities of CAD technology, including but not limited to enhanced data processing, improved design accuracy, and expanded analytical capabilities.

Strengthen and expand	*Details*	*Influence on CAD technology*
Operating efficiency and stability	Using big data algorithms to optimize the underlying architecture of CAD software and reduce the consumption of computing resources and memory.	Designers can perform modelling, rendering, and other complex operations more smoothly and quickly, reducing the risk of software crashes or jamming.
	Load common tools and functions in advance through predictive models to reduce waiting time.	Improve the user experience so that designers can focus more on design work than software operation.
Data analysis and visualization	Integrate big data analysis tools to analyze design data in real time and provide key indicators and trend prediction.	Designers can more accurately assess the effect of the design scheme, such as structural strength, hydrodynamic performance, and so on.
	Use visualization technology to transform complex data into intuitive charts and models to help designers better understand the data.	Strengthen the designer's comprehensive understanding of the design scheme and support faster and more intelligent decision-making.
Intelligent design assistant tool	Provide automatic optimization functions and automatically adjust design parameters according to design requirements and constraints.	Reduce the time for designers to manually adjust parameters and improve design efficiency.
	Use machine learning algorithms to provide intelligent recommendations for designers, such as material selection and design style.	Inspire the creativity of designers and provide new design inspiration and direction.
	Realize automatic checking of design rules to avoid design errors and conflicts.	Improve the design quality and reduce the need for subsequent modification and rework.

Table 2: Overview of the enhancement and expansion of big data algorithm to CAD technology.

4 CONSTRUCTION AND PRACTICE OF DESIGN DECISION SUPPORT SYSTEM

4.1 System Architecture and Functional Design

The construction of the design decision support system should start from the overall system architecture and functional design. An ideal design decision support system must encompass the essential functionalities of data gathering, processing, analysis, visualization, and decision support.

These features should be seamlessly integrated within a cohesive system architecture to guarantee efficient system performance and user-friendliness (as illustrated in Figure 2).

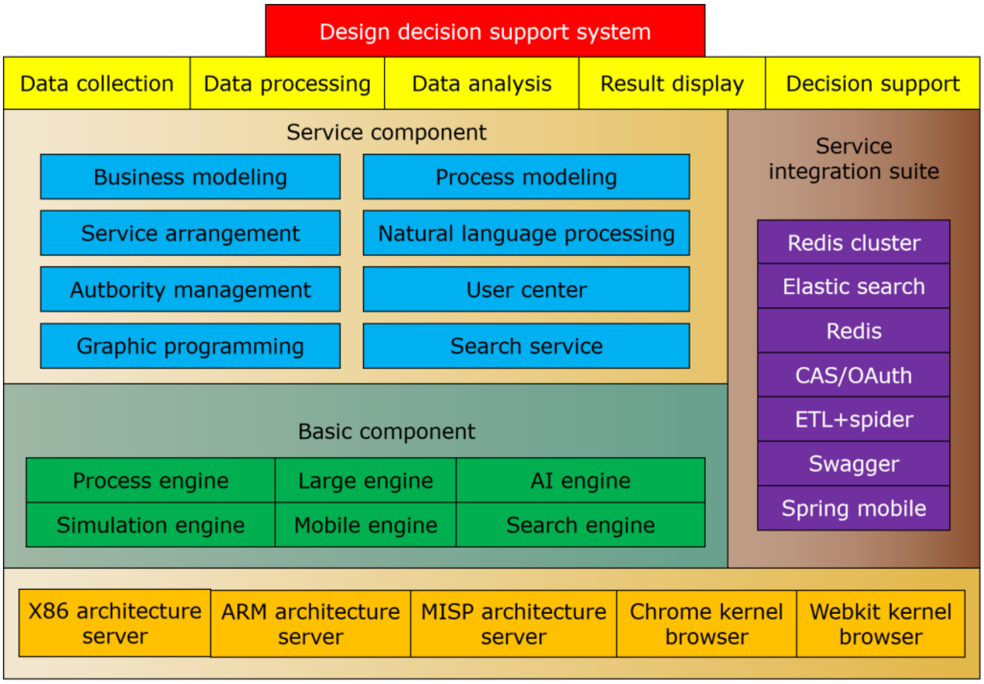

Figure 2: System architecture.

The overall framework is the "skeleton" of the system, which determines the contact mode and data flow direction among the components of the system. In the design decision support system, the overall framework usually includes a data layer, processing layer, analysis layer, presentation layer, and decision layer. The data layer is responsible for collecting and storing the original data; The processing layer performs preprocessing operations such as cleaning, integration, and conversion of the data; The analysis layer uses big data algorithms to deeply analyze and mine the data; The presentation layer visually presents the analysis results to users in the form of charts, reports and so on; The decision-making layer provides design decision-making suggestions for users according to the analysis results.

In the division of functional modules, the design decision support system usually includes a data management module, data analysis module, visualization module, and decision support module. The data management module is responsible for data storage and management; The data analysis module provides a variety of big data algorithms for users to choose and use; The visualization module presents the analysis results to the user in an intuitive way; The decision support module provides users with design optimization and decision suggestions according to the analysis results. In addition, the interaction design of the system is also very important, and good interaction design can improve the user experience and work efficiency.

4.2 The Implementation of Big Data Algorithm in the System

Big data algorithms constitute the backbone of design decision support systems. During system implementation, it's crucial to choose the right big data algorithm and tailor it to the system's specific needs. Given the nuances of environmental art design, algorithms adept at handling unstructured data like images and texts are often preferred. Furthermore, enhancing system efficiency and stability demands optimization and fine-tuning of the algorithm's performance.

When selecting a big data algorithm, factors like applicability, accuracy, and efficiency come into play. Applicability gauges the algorithm's ability to tackle real-world system challenges; accuracy assesses the reliability of its analytical outputs; and efficiency determines if its runtime aligns with the system's real-time demands. With these considerations in mind, algorithm parameters and models can be refined to boost overall performance.

Based on these insights, this article opts for the WNN within the DL (deep learning) framework as its primary algorithm. WNN flexibly adopts probability classification functions based on whether the problem is classification or regression. The probability values are derived using a standard equation formulated as follows:

$$\sigma_j = p(y = j|x) = \frac{e^{x^{T_{w_j}}}}{\sum_k^k e^{x^{T_{w_k}}}} \tag{1}$$

$$j \in [0,1,\cdots,k] \tag{2}$$

Where: k is the number of categories. $p(y = j|x)$ It is the probability that, given the observed value x and the weight w_j, the category j is the correct category in the k category. In the context of function approximation, the excitation function for each neuron takes the form of a wavelet-based nonlinear function. Typically, the signal $f(t)$ can be represented using the subsequent discrete wavelet formulation:

$$f = \sum_{m,n\in Z} \langle f,\psi_{m,n}\rangle \psi_{m,n} \tag{3}$$

Among them, the wavelet series $\{\psi_{m,n}(t)|m,n \in Z\}$ constitutes the framework of $L^2(R)$. In this way, the single hidden layer feedforward neural network with a wavelet basis as the action function can be used to represent the signal function $f(x) \in L^2(R)$. WNN structure is shown in Figure 3.

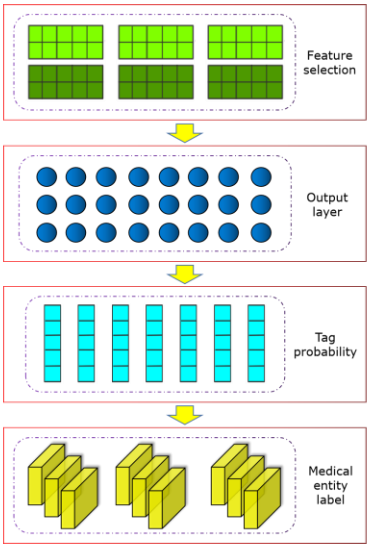

Figure 3: WNN structure.

The input/output relationship of the WNN exhibits nonlinearity, and its hidden layer units possess the capability to closely approximate any continuous real-valued function defined within a compact set, attaining any desired level of accuracy. Therefore, the mathematical model $Z = Z(x,y)$ of the pre-restored object surface is rewritten as:

$$Z = \sum_{i=1}^{N} w_i \phi(a_i x + b_i y + c_i) + w_0 \tag{4}$$

Where N is the quantity of hidden neurons, w_i, a_i, b_i, c_i is the network parameter, and $\phi(\cdot)$ is the nonlinear wavelet node function. p, q This can be obtained by the following formula:

$$p(x,y) = \sum_{i=1}^{N} a_i w_i \phi_i(a_i x + b_i y + c_i) \tag{5}$$

$$q(x,y) = \sum_{i=1}^{N} b_i w_i \phi_i(a_i x + b_i y + c_i) \tag{6}$$

Assuming that $A(i,j)$ is a pixel in the image A, $B(i,j)$ is the corresponding pixel in the image B, and $F(i,j)$ is the pixel in the fused image, there are:

$$F(i,j) = W_a(i,j) \times A(i,j) + W_b(i,j) \times B(i,j) \tag{7}$$

Where $W_a(i,j), W_b(i,j)$ are the weight coefficients of the image A, B, respectively, and the weight coefficients are adjustable. Based on the formulaic definition of image contrast, the directional contrast within the wavelet domain is delineated as:

$$R_j^i = \frac{D_j^i}{C_j} \quad (i = 1,2,3) \tag{8}$$

Where $i = 1,2,3$ represent vertical, horizontal, and diagonal directions, respectively. For images with high frequencies, the directional contrast is computed for every frequency and direction using the aforementioned formula. Subsequently, the wavelet coefficients of the merged image are derived from these directional contrast values:

$$D_{j,G}^i = \begin{cases} D_{j,I}^i & R_{j,I}^i \geq R_{j,I'}^i \\ D_{j,I'}^i & R_{j,I}^i \leq R_{j,I'}^i \end{cases} \quad (i = 1,2,3) \tag{9}$$

Collect all kinds of data related to design, including historical design cases, user needs, market trends, etc. The DL model is trained by using the collected data. By continuously fine-tuning the model parameters, it becomes possible to discern underlying trends and patterns within the data. This article employs the stochastic gradient descent method for optimizing the parameters across the entire network, with the standard gradient descent's objective function defined as follows:

$$\theta = \theta \text{-} \alpha \nabla_\theta J\left(\theta; x^{(i)}\right) \tag{10}$$

Where α is the learning rate, which determines the speed of network convergence.

During the model training phase, a range of optimization techniques are employed to enhance both the efficiency of training and the model's capacity for generalization. Once trained, the DL model can be integrated into a decision support system, offering designers intelligent guidance in their design choices. For example, you can automatically recommend a suitable design scheme according to the design requirements and market trends inputted by users or, according to historical design cases and user needs, predict the design trends that may be popular in the future.

In addition, in the design decision support system constructed in this article, when integrating the DL algorithm, API calling mode is considered. Calling through API is an efficient and flexible way to realize the integration of algorithms and systems. In this way, the design decision support system can call these APIs through network requests to obtain the processing results of the algorithm without embedding the algorithm code directly into the system code. The advantage of this method is that it can keep the system simple. Moreover, it is convenient to update and maintain the algorithm independently.

4.3 System Application and Verification

After the system is built, it needs to be applied and verified in practice. This includes the deployment and implementation of the system and the verification and feedback in the actual design project. Through practical application and verification, we can check whether the function of the system is perfect, whether the performance is stable, and whether it can meet the actual needs of users. Detailed system verification and feedback are shown in Table 3:

Verification project	*Verify subitem*	*Verify the result*	*Feedback details*
Functional integrity	Core function	Pass	All core functions run as expected, without omission.
	Auxiliary function	Pass	The auxiliary functions are complete to meet the use requirements.
	Specific demand function	Pass	The function customized according to the specific needs of users performs well.
Performance Stability	Load test	Pass	Under the condition of high load, the system response time and resource utilization rate are kept within the acceptable range.
	Stress testing	Pass	The system can still run stably under extreme pressure without collapse or significant performance degradation.
	Long run	Pass	After a long period of operation, the performance of the system has not decreased significantly.
User demand satisfaction	User survey	Pass	User research shows that the system meets the actual needs of most users.
	User testing	Pass	During the user testing, no obvious function loss or performance problems were found.
	User feedback collection	Partly pass	Most users gave positive feedback, but a few users put forward some suggestions for improvement.
Security	Vulnerability scanning	Pass	After vulnerability scanning, the system found no known security vulnerabilities.
	Permission control	Pass	The authority of the system is strictly controlled and meets the safety requirements.
	Data encryption	Pass	The system encrypts sensitive data to protect the safety of user data.
Usability	Interface design	Partly pass	The overall interface design is clear, but some users report that some operations are not intuitive enough.
	Operating process	Pass	The system's operation flow is concise

			and easy to use.
	User manual and help	Pass	The user manual and help documents are detailed and provide good support for users.

Table 3: System verification and feedback.

When testing the system performance and algorithm, the data graph can effectively show the test results and performance indicators. The following are the test results of the algorithm part:

System throughput is shown in Figure 4.

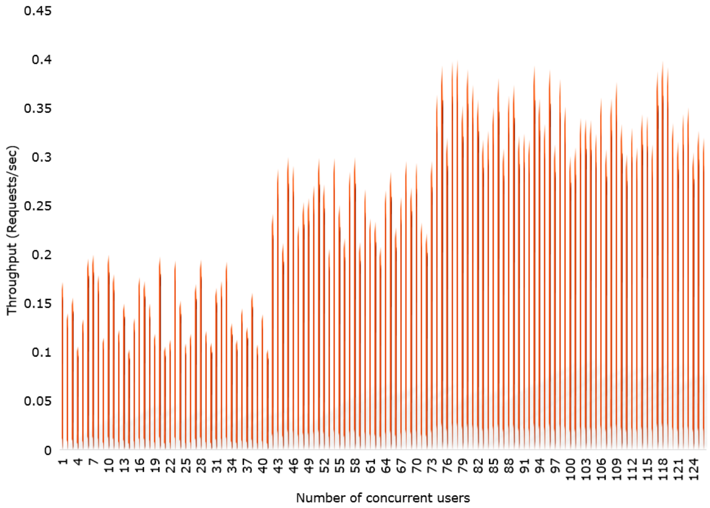

Figure 4: Throughput of system.

Results: Due to the increase in the number of concurrent users, the system throughput showed a trend of rising first and then tending to be stable. This shows that the system can achieve the best performance under a certain quantity of concurrent users, and then the throughput will not increase significantly due to resource constraints or algorithm efficiency problems. In order to improve system throughput, we can consider increasing system resources or optimizing algorithms.

The algorithm execution time is shown in Figure 5.

Results: The execution time of different algorithms is significantly different under the same input data, among which the DL algorithm has the shortest execution time, and the decision tree algorithm has the longest execution time. This shows that the DL algorithm is the most efficient when dealing with the same task, and the decision tree algorithm needs to be further optimized to improve the execution speed.

The utilization ratio of system resources is shown in Figure 6.

Results: During the test, the CPU utilization and memory utilization of the system remained at a low level, while the disk IO utilization was high. This shows that the CPU and memory resources of the system still have more free space, which can support higher load. However, the high utilization rate of disk IO may indicate that the system has a disk read-write bottleneck. In order to improve system performance, we can consider optimizing disk read and write operations, increasing cache, or reducing unnecessary disk access.

The complexity of the algorithm is shown in Figure 7.

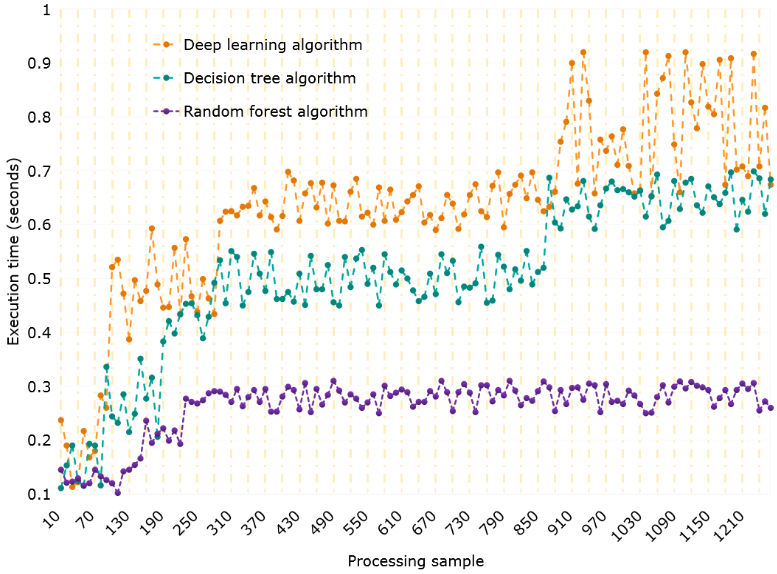

Figure 5: Algorithm execution time.

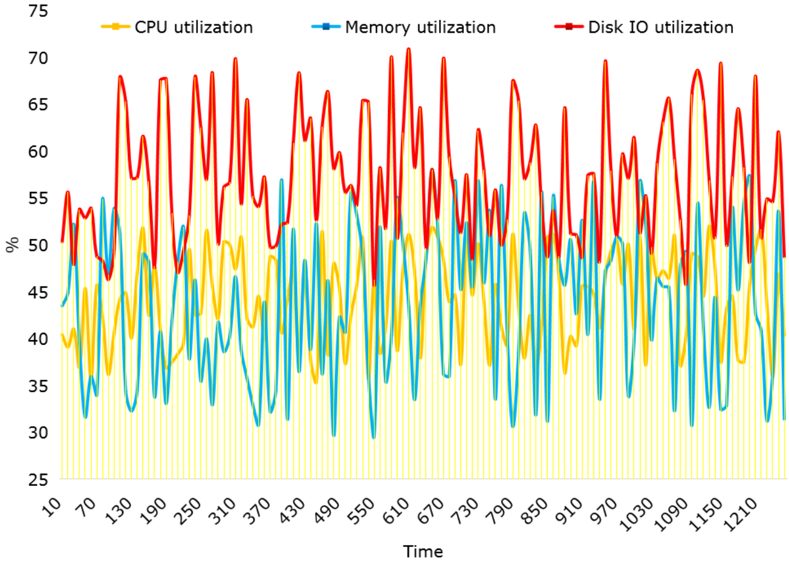

Figure 6: System resource utilization ratio.

Results: With the increase of input data scale, the execution time of the DL algorithm increased linearly, while the execution time of the decision tree algorithm and random forest algorithm increased exponentially. This shows that the DL algorithm has good scalability and can maintain high efficiency when dealing with large-scale data. However, the decision tree algorithm and random forest algorithm have poor scalability and may encounter performance problems when dealing with large-scale data.

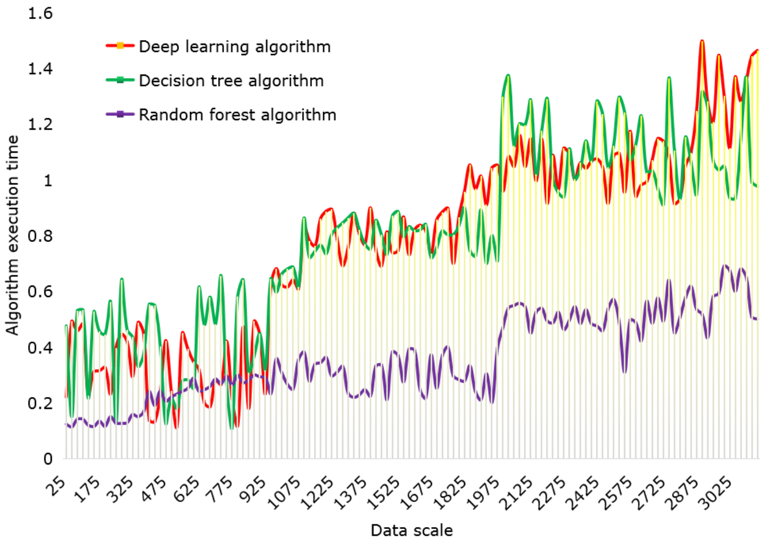

Figure 7: Algorithm complexity.

To sum up, through the test and analysis of system performance and algorithm, this article can draw some improvement suggestions and optimization directions. These suggestions can help improve the overall performance of the system and the efficiency of the algorithm and provide users with a better experience. In addition, this article also collected users' feedback and suggestions, providing a basis for the continuous improvement and optimization of the system (as shown in Table 4).

User number	*Feedback content*	*Suggestion*
001	The system has a fast response speed.	Want to add more customization options?
002	Some interface operations are not intuitive enough.	It is suggested that the interface layout be optimized.
003	The report generation function is very practical.	It is suggested that the report export format be increased.
004	The data import function needs to be improved	Hope to improve the speed and accuracy of data import.
005	The overall performance of the system is good.	No recommendations

Table 4: User feedback and suggestion collection.

5 CONCLUSIONS AND PROSPECT

This article delves into the utilization of big data algorithms within environmental art design, with a particular emphasis on the creation and implementation of a design decision support system. By seamlessly integrating big data algorithms into environmental art design, the article successfully established a fully functional and reliable decision support system. This system adeptly collects, processes, analyzes, and presents pertinent environmental art design data, providing designers with informed and intelligent decision-making assistance.

The key findings of this article are threefold: First, it introduces a harmonious blend of big data algorithms and environmental art design, laying a solid theoretical foundation for their union. Second, it outlines the comprehensive structure and functional components of the decision support system, showcasing the effective utilization of big data algorithms within its framework. Lastly, through rigorous practical applications and validations, the article affirms the system's utility and efficacy in the realm of environmental art design. This contribution signifies the introduction of a novel design approach and methodology, elevating the scientific rigour and intelligence of design practices.

During the course of the research, the article posits a series of hypotheses, which are subsequently validated through rigorous experiments and data analyses. These validations demonstrate that the incorporation of big data algorithms in environmental art design notably enhances design efficiency and quality, optimizes design proposals, and minimizes design costs. Furthermore, the practical implementation of the decision support system attests to its feasibility and impact on real-world projects. Nevertheless, the article acknowledges its reliance on existing data sources and processing techniques, acknowledging potential limitations in data quality and processing speed. Looking ahead, the article aims to expand its data sources and refine its processing methods to further enhance data integrity and processing efficiency.

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REFERENCES

[1] Choi, J.-H.; Suh, J.-H.: Exploring the 4th industrial revolution technology from the landscape industry perspective, Journal of the Korean Institute of Landscape Architecture, 47(2), 2019, 59-75. https://doi.org/10.9715/KILA.2019.47.2.059

[2] Fernberg, P.; Chamberlain, B.: Artificial intelligence in landscape architecture: a literature review, Landscape Journal, 42(1), 2023, 13-35. https://doi.org/10.3368/lj.42.1.13

[3] Jahani, A.; Rayegani, B.: Forest landscape visual quality evaluation using artificial intelligence techniques as a decision support system, Stochastic Environmental Research and Risk Assessment, 34(10), 2020, 1473-1486. https://doi.org/10.1007/s00477-020-01832-x

[4] Kahlon, Y.; Fujii, H.: A framework for concept formation in cad systems: a case study of Japanese rock garden design, Computer-Aided Design and Applications, 17(2), 2020, 419-428. https://doi.org/10.14733/cadaps.2020.419-428

[5] 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

[6] Krner, A.; Born, L.; Bucklin, O.: Integrative design and fabrication methodology for bio-inspired folding mechanisms for architectural applications, Computer-Aided Design, 133(80), 2020, 102988. https://doi.org/10.1016/j.cad.2020.102988

[7] Li, B.; Sharma, A.: Application of interactive genetic algorithm in landscape planning and design, Informatica, 46(3), 2022, 365-372. https://doi.org/10.31449/inf.v46i3.4049

[8] Li, K.; Zhang, Q.; Jia, J.: CEB-collaboratively multi-granularity interest scheduling algorithm for loading large Webbim scene, Journal of Computer-Aided Design & Computer Graphics, 33(9), 2021, 1388-1397. https://doi.org/10.1016/j.jmsy.2022.07.014

[9] Li, Y.: Application of garden plant data query and analysis system based on big data, International Journal of Frontiers in Engineering Technology, 4(2), 2022, 27-32. https://doi.org/10.25236/IJFET.2022.040205

[10] Ma, B.; Dong, Y.; Liu, H.; Cao, Z.: Soft multimedia assisted new energy productive landscape design based on environmental analysis and edge-driven artificial intelligence, Soft Computing, 26(23), 2022, 12957-12967. https://doi.org/10.1007/s00500-021-06155-9

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

[12] Senem, M.-O.; Koç, M.; Tunçay, H.-E.; AS, İ.: Using deep learning to generate front and backyards in landscape architecture, Architecture and Planning Journal (APJ), 28(3), 2023, 1-11. https://doi.org/10.54729/2789-8547.1196

[13] Showkatbakhsh, M.; Kaviani, S.; Weinstock, M.: Evolutionary design processes with embedded homeostatic principles -adaptation of architectural form and skin to excessive solar radiation, Computer-Aided Design and Applications, 18(5), 2021, 914-953. https://doi.org/10.14733/cadaps.2021.914-953

[14] Song, Y.; Jing, Y.: Application prospect of CAD-SketchUp-PS integrated software technology in landscape planning and design, Computer-Aided Design and Applications, 18(S3), 2020, 153-163. https://doi.org/10.14733/cadaps.2021.S3.153-163

[15] Wang, H.: Landscape design of coastal area based on virtual reality technology and intelligent algorithm, Journal of Intelligent & Fuzzy Systems, 37(5), 2019, 5955-5963. https://doi.org/10.3233/JIFS-179177

[16] Wang, M.: Maximizing the beauty of ceramic art application in landscape design under the background of artificial intelligence, Journal of Multimedia Information System, 10(4), 2023, 371-382. https://doi.org/10.33851/JMIS.2023.10.4.371

[17] Yang, X.; Jiang, D.; Liu, M.: Construction and application of a landscape design teaching platform driven by artificial intelligence, International Journal of Web-Based Learning and Teaching Technologies (IJWLTT), 19(1), 2024, 1-16. https://doi.org/10.4018/IJWLTT.336483