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Research on Visualization and Interactive Design of Plant Configuration Virtual Reality in the Context of Digitalization

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Abstract: This study aims to explore the application of digital technology in landscape design, focusing on the research of virtual reality visualization and interactive design in the process of plant configuration. Through an in-depth analysis of digital technology, the study outlines its important role in landscape design, especially in the application of plant configuration. The current application status of virtual reality technology in landscape design is discussed, as well as how interactive design can enhance user experience and participation. Furthermore, the achievements and challenges of digital technology in landscape design are summarized. Finally, it proposes future research directions and suggestions, aiming to provide new ideas and methods for practice and research in the field of landscape design and promote the further application and development of digital technology in landscape design.

Keywords: Digitalization; Plant configuration; Virtual reality; Visualization; Interactive design

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1. Introduction

In today's digital era, digital technology is playing an increasingly important role in various fields, including the field of landscape design [1]. The rapid development of digital technology has provided landscape designers with more tools and methods to create more innovative, sustainable, and aesthetically valuable designs [2]. In landscape design, plant configuration is a crucial aspect that not only affects the appearance and aesthetic value of the landscape but also directly relates to its ecological benefits and functionality [3]. Therefore, how to effectively configure plants has become one of the important challenges faced by landscape designers.

With the development and popularization of virtual reality (VR) technology, an increasing number of landscape designers have begun to introduce VR visualization and interactive design into the process of plant configuration [4]. Virtual reality technology provides a new way for designers to simulate and observe the appearance, growth, and interaction with the surrounding environment of plants in a virtual environment [5]. Interactive design allows users to participate in the design process, adjusting the position, type, and quantity

of plants, as well as their interaction with other elements, thus achieving more personalized and flexible plant configuration schemes.

This study aims to explore the issues related to virtual reality visualization and interactive design of plant configuration under digitalization. By exploring the current application of virtual reality in landscape design, discussing the impact of interactive design on user experience and participation, and comparing digital plant configuration methods with traditional methods, we hope to provide new ideas and methods for practice and research in the field of landscape design. This study aims to promote the further application and development of digital technology in landscape design.

2. Related concepts

The application of digital technology in landscape design has become a popular research topic in recent years. With the continuous advancement of computer and virtual reality technologies, digital tools and platforms have become important supporting tools for landscape designers in their daily work [6,7]. In terms of plant configuration and landscape design, digital technology not only provides designers with more design resources and tools but also provides more room for innovation and creativity.

Virtual reality technology, as an important branch of digital technology, has gradually received attention in the application of landscape design. Through VR technology, designers can create realistic virtual environments, enabling users to immerse themselves into the design schemes and adjust and evaluate plant configurations, landscape effects, and more in real time [8,9]. In recent years, more and more studies have begun to explore the application potential of virtual reality technology in landscape design, as well as its impact on design decisions, user experience, and design effects.

Interactive design also plays an important role in plant configuration and landscape design. Interactive designs emphasize user participation and experience, allowing users to directly participate in the design process and achieve personalized and customized design schemes through interaction with the system. In terms of plant configuration, interactive design can enable users to more flexibly adjust the position, type, and quantity of plants, thus achieving plant configuration schemes that better meet personalized needs and design goals.

In short, digital technology plays a pivotal role in landscape design, and this is primarily demonstrated in the application of virtual reality technology and interactive design in plant configuration and landscape design. However, there are still many unresolved issues and challenges, such as the cost and technical limitations of virtual reality, user experience and learning curves of interactive design, etc. Therefore, further research is needed to explore the application and best practices of digital technology in landscape design, further driving the innovation and development of landscape design.

3. Application status and development trend of digital technology in landscape design

The application of digital technology has become increasingly widespread in the field of landscape design, encompassing various aspects from design tools to the design process itself. Digital technology has not only revolutionized the way landscape designers create and visualize their ideas but also enabled more efficient collaboration and decision-making.

3.1. Design tools and software applications

In the current landscape design field, many professional design software and tools have been widely adopted

to meet the various needs of designers. Among them, software such as AutoCAD, SketchUp, and Lumion are favored by landscape designers. These pieces of software provide a variety of functions, including but not limited to plan drawing, 3D modeling, rendering, and animation production, significantly improving design efficiency and quality. For example, AutoCAD, as a classic computer-aided design (CAD) software, is used to create precise plans and construction drawings, helping designers plan and layout landscape elements. SketchUp is known for its simple and easy-to-use interface and powerful 3D modeling capabilities, allowing designers to quickly create and edit landscape models. In addition, Lumion, as a professional landscape rendering software, can transform design schemes into realistic images and animations, helping designers vividly present their design concepts [10-12].

With the continuous development of technologies such as VR, augmented reality (AR), and artificial intelligence (AI), design tools and software will gradually integrate these emerging technologies, providing designers with richer and more intuitive design experiences and tool support. For example, future design software may combine VR technology to provide designers with an immersive experience in their own designs, allowing better spatial and proportional perceptions. At the same time, with the application of AI technology, design software may have more intelligent functions, such as automated design suggestions, intelligent model optimization, etc., thereby improving design efficiency and quality. In addition, the design tools and software may also develop towards meeting personalized needs and workflows, providing customized features and interfaces, so that each designer can find the most suitable tools and methods for themselves. In summary, the development of future design tools and software will allow more innovation and possibilities for landscape designers, helping them create better designs.

3.2. Data collection and analysis technologies

The application of data collection and analysis technologies such as Geographic Information Systems (GIS), remote sensing, and laser scanning in landscape design has become increasingly widespread. These technologies provide designers with abundant information such as terrain and landform data, vegetation distribution, and other foundational information, strongly supporting the development and implementation of design proposals [13].

For instance, GIS technology can utilize satellite imagery and geographic data to conduct spatial analysis and visualization of sites, assisting designers in understanding the terrain, soil, water systems, and other aspects of the site. Remote sensing technology can capture large-scale geographic information, such as vegetation types and coverage, through aerial photography or satellite remote sensing, providing designers with comprehensive vegetation distribution data. Additionally, laser scanning technology can quickly and accurately capture terrain data and building structures, providing designers with high-precision terrain and landform information.

The integration of these data collection and analysis technologies into the landscape design process not only enhances the accuracy and efficiency of design but also allows designers to make informed decisions based on a comprehensive understanding of the site context. This, in turn, contributes to the creation of more sustainable and effective landscape designs.

With the continuous development of data collection and analysis technologies, there is a trend towards greater accuracy and efficiency. Among them, drone aerial photography technology will become one of the important means of data collection. With its strong flexibility, low cost, and high data acquisition efficiency, drones can capture high-resolution images and conduct terrain surveying and mapping of larger areas, providing landscape designers with more detailed and accurate data support.

Furthermore, high-precision Global Positioning Systems (GPS) will also be widely used, enabling precise positioning and quantitative analysis of sites, providing landscape designers with more precise spatial data. In addition, with the continuous development of AI and big data technologies, processes like data collection and

analysis will become more automated and intelligent. Designers can quickly extract and analyze large amounts of geographic information data through data mining and pattern recognition, providing more scientific and accurate bases for design decisions.

The integration of these advanced technologies into the landscape design workflow will significantly improve the quality and efficiency of design proposals. Designers will be able to make more informed and evidence-based decisions, leading to the creation of more sustainable, effective, and innovative landscape designs.

3.3. VR and AR technologies

VR technology has found application in the field of landscape design. Designers can utilize VR technology to create realistic virtual environments, allowing an immersive experience of the design proposals. Through VR head-mounted displays, such as VR glasses, users can immerse themselves in the virtual landscape environment and enjoy a 360-degree panoramic view of the design.

This technique provides a completely new way for designers to present and communicate their proposals, greatly enhancing users' understanding and perception of the design. It allows stakeholders, clients, and other interested parties to visualize and explore the design in detail, leading to better comprehension and feedback. As a result, VR technology has the potential to revolutionize the landscape design process, making it more interactive, engaging, and effective.

In the future, the application of virtual reality (VR) technology in the field of landscape design will further develop and become more widespread. Firstly, the technology will continue to evolve towards higher simulation fidelity and interactivity. With the continuous advancement of hardware and software technologies, the visual and auditory effects of virtual reality environments will become more realistic and immersive, further enhancing users' sense of immersion and participation.

Secondly, VR technology will integrate more closely with design tools and software. Designers will be able to create virtual models using professional design software and then present them to users through VR technology, allowing users to intuitively experience the effects and atmosphere of the design proposals. Additionally, VR technology can be integrated with other technologies such as GIS and remote sensing to provide designers with a more comprehensive and intuitive design experience and communication platform.

Moreover, VR technology has the potential to revolutionize the design review and approval process. Stakeholders, clients, and other interested parties can virtually walk through the proposed landscape and provide feedback in a more intuitive and engaging manner. This not only improves communication but also saves time and resources by identifying issues early in the design phase.

Overall, the integration of VR technology into the landscape design workflow promises to bring about significant advancements in design quality, user experience, and project efficiency. As the technology matures and becomes more accessible, it is expected to play a pivotal role in shaping the future of landscape design.

3.4. Sustainability and ecological design

The application of digital technologies in sustainability and ecological design has been increasingly highlighted. Designers have been utilizing digital tools such as ecological modeling simulations and environmental impact assessments to evaluate and optimize the environmental benefits and sustainability of their design proposals. Through ecological modeling simulations, designers can simulate the impact of different design proposals on ecosystems, predict changes in vegetation growth, water cycling, and animal and plant habitats, and adjust their designs accordingly to achieve optimal ecological benefits. Meanwhile, environmental impact assessment tools

help designers evaluate the impact of their designs on environmental resources, ecosystems, and communities, enabling them to develop design strategies that align with sustainable development goals [14].

More extensive applications of digital technologies will be expected in sustainability and ecological designs. Firstly, more bioinformatics, ecology, and AI technologies will be introduced to provide a more comprehensive and precise analysis of the complexity and diversity of ecosystems. This will provide designers with more scientific and sustainable design solutions and methods. For example, bioinformatics can assist designers in conducting deep analysis of biological systems such as plants, animals, and microorganisms, understanding their interactions and ecological functions, and guiding vegetation selection and ecosystem construction in landscape design.

Secondly, digital technologies will further enhance the comprehensiveness and complexity of sustainability and ecological design. Designers will not only consider the ecological benefits of individual projects but also the interactive relationships between projects and their surrounding environments, as well as the overall balance of ecosystems. Through systematic design and planning, they aim to restore and enhance ecological systems.

In short, the integration of digital technologies in sustainability and ecological design represents a significant step towards achieving more environmentally friendly and sustainable landscapes. As these technologies continue to evolve, they hold the potential to revolutionize the landscape design industry, leading to more harmonious and resilient ecosystems that benefit both humans and nature.

3.5. User participation and social interaction

Digital technologies have already begun to facilitate user participation and social interaction in landscape design. An increasing number of design projects are inviting public engagement and social media interactions to involve users in the design process, providing designers with additional feedback and opinions. Public participation can be achieved through workshops, public hearings, online surveys, and other methods, enabling users to suggest and provide feedback on design proposals. Social media has also emerged as an essential platform for designers to communicate and interact with users, where they can share design concepts, obtain feedback, showcase project progress, and enhance transparency and public engagement.

The application of digital technologies in user participation and social interaction will further intensify in the future. Firstly, AI technologies will be leveraged to create intelligent user engagement platforms and social design communication forums. AI can be used to analyze and process user feedback and opinions and extract key information to aid designers in making informed decisions. Additionally, design communication platforms will become more intelligent and interactive, enabling real-time exchanges and discussions between designers and users. This will facilitate the sharing of design ideas, problem-solving, and collaborative exploration, fostering deep interaction and co-creation among designers, users, and society.

Secondly, digital technologies will provide more diverse methods and channels for user participation and social interaction. Beyond traditional public engagement and social media interactions, digital technologies can utilize VR, AR, and online platforms to offer users more intuitive and engaging participation experiences, sparking creativity and resonance.

In conclusion, the integration of digital technologies in user participation and social interaction represents a pivotal step towards creating more inclusive and responsive landscape designs. As these technologies continue to evolve, they offer immense potential to transform the design process, making it more democratic, interactive, and innovative. This, in turn, can lead to landscapes that are not only aesthetically pleasing but also deeply connected to the needs and aspirations of the community.

3.6. Education and training applications

The application of digital technologies in landscape design education and training is becoming increasingly prevalent. Tools such as online education platforms and virtual laboratories have made landscape design knowledge and skills more accessible to students and academic professionals. Online education platforms offer a diverse range of course resources, including video tutorials, online lectures, and course materials, enabling students to engage in self-directed learning based on their interests and needs. Virtual laboratories, on the other hand, provide a practical learning environment where students can conduct landscape design experiments and simulations, deepening their understanding and application of theoretical knowledge.

The further development of education and training applications will be more intelligent and personalized. Firstly, the integration of VR and AR will enable richer and more intuitive learning experiences and interactive teaching methods. VR can provide students with an immersive experience in virtual landscape designs, allowing them to interact with design elements and experience the design process and outcomes in real time, thus deepening their understanding and mastery of landscape design theory and practice. AR, on the other hand, can overlay virtual content onto the real world, providing students with a more authentic and concrete learning experience. For example, during outdoor field trips, AR can be used to display design plans and effects, helping students understand and evaluate the actual impact of their designs.

Secondly, education and training applications will increasingly focus on personalized learning and teaching. With the aid of AI, education platforms can intelligently recommend suitable learning resources and courses based on students' learning styles and needs. Personalized learning paths and plans can be created and targeted learning guidance and feedback can be provided, thereby enhancing learning efficiency and outcomes.

In conclusion, the integration of digital technologies in landscape design education and training represents a significant step towards making learning more accessible, engaging, and effective. As these technologies continue to evolve, they offer immense potential to revolutionize the way we approach education and training, making it more responsive to the needs of students and professionals alike.

4. Evaluation and comparison of the comprehensive effect of digital technology in plant configuration design

4.1. Effect of virtual reality visualization on plant configuration

4.1.1. Real-time visualization

Through VR technology, designers and users can observe the effects of plant configuration schemes in real time in a virtual environment. This real-time visualization allows users to understand the appearance and effects of different plant configuration schemes more intuitively, enabling timely adjustment and optimization. Real-time visualization not only improves design efficiency but also communication and understanding between designers and users.

4.1.2. User participation and experience

VR visualization provides a participatory experience for users, enabling them to be more directly involved in the process of plant configuration. By manipulating the elements in the virtual environment, users can adjust the location, variety, and number of plants, as well as the interaction with other elements, thus achieving personalized and customized design solutions. This user engagement and experience not only enhances the user's sense of participation and satisfaction but also improves the quality and acceptability of the plant configuration solution.

4.1.3. Design decision support

VR visualization technology provides designers with a powerful design decision support tool. By simulating and observing the effects of different plant configuration schemes in a virtual environment, designers can more accurately evaluate the pros and cons of their designs and make more informed decisions. This design decision support not only improves the design efficiency but also reduces the risk and uncertainty in the design process.

4.1.4. Effect evaluation and optimization

Through VR visualization technology, designers can fully evaluate and optimize the effect of plant configuration solutions. Problems and shortcomings in the plant configuration scheme can be discovered and fixed in real time. This allows for continuous improvement in the quality and sustainability of the plant configuration scheme, thus achieving the best results in the landscape design.

To sum up, the application of virtual reality visualization in plant configuration has a remarkable effect, which not only improves the design efficiency and quality but also enhances the user's sense of participation and experience. Virtual reality visualization technology provides powerful design tools and decision support for landscape designers and provides an important guarantee for the optimization and realization of plant configuration schemes.

4.2. Analysis of the impact of interactive design on user experience and sense of participation

4.2.1. Enhancing user participation

Interactive design enables the user to participate directly in the process of plant configuration by manipulating the elements in the virtual environment to achieve personalized and customized design solutions. Users can freely adjust the location, type, and number of plants, as well as the interaction with other elements, so as to achieve a plant configuration scheme that aligns with individual needs and design goals. This freedom and flexibility enhance user engagement and initiative.

4.2.2. Improving the user experience quality

Interactive design provides users with a more intuitive, flexible, and personalized design experience. Through simple operations, users can quickly understand the effects of different plant configuration schemes, and adjust and optimize the design scheme in time. This real-time feedback and adjustment mechanism allows the users to experience the effects and changes of the design scheme more intuitively, thus improving user satisfaction and acceptance of the design scheme.

4.2.3. Promoting user participation and communication

Interactive design not only enables users to participate in the process of plant configuration but also facilitates communication and exchange between users. Users can discuss and collaborate in the virtual environment, explore different design options and schemes, and make decisions through interaction and feedback. This process of participation and communication not only enhances the interaction and cooperation between users but also promotes the understanding and trust between designers and users, thus providing more room for the optimization and realization of design schemes.

In summary, interactive design has a positive impact on the user experience and sense of engagement. By enhancing user experience and promoting communication and exchange between users, interactive design provides a more flexible, personalized, and effective design scheme for plant configuration, and offers more design choices and participation opportunities for landscape architects and users.

4.3. Comparison and analysis between the digital plant allocation method and the traditional method

4.3.1. Efficiency and flexibility

The digital approach utilizes VR technology to simulate the effects of plant configuration schemes in real time and allows users to make rapid adjustments and optimizations in the virtual environment. Designers can try different plant combinations and layout schemes easily, thus improving design efficiency and flexibility.

Traditional plant configuration methods often need to be carried out in a field environment, and designers need to conduct several field surveys and experiments before they can determine the final plant configuration scheme. This method is time-consuming and non-flexible.

4.3.2. Quality and evaluation

The digital method can simulate the effect of the plant configuration scheme in real time. Through real-time feedback and adjustment in the virtual environment, designers can evaluate the pros and cons of various design choices in time and make targeted optimizations and improvements.

Traditional plant allocation methods usually need to be carried out in a field environment, and designers can only evaluate the effect of design schemes through field observation and experimentation. The evaluation process of this method is subjective, and it is difficult to fully take into account the influence of various factors, making it prone to bias and misjudgment.

4.3.3. User participation and experience

The digital approach utilizes VR technology to enable users to participate in the process of plant configuration directly. By manipulating the elements in the virtual environment, users can adjust the location, variety, and number of plants, as well as the interaction with other elements, thus achieving personalized and customized design solutions.

The traditional plant configuration method is usually completed by the designer alone, and the user can only understand the design scheme through the designer's explanation and demonstration. This method has low user participation and poor experience, and it is difficult to meet users' personalized needs and design preferences.

There are obvious differences between the digital plant allocation method and the traditional method in terms of efficiency, quality, and user participation and experience. Through VR technology, the digital method improves the design efficiency and quality, enhances the user's sense of participation and experience, and provides a new idea and method for the optimization and realization of plant configuration.

5. Summary

This research explores the innovative application of digital technology in the field of landscape design, especially the theory and practice of integrating VR visualization and interactive design in the process of plant configuration. Through an in-depth analysis of the connotation of digital technology and its key role in landscape design, the traditional methods of plant allocation are effectively expanded and upgraded.

This study reviews the current application of digital technologies, especially virtual reality technologies, in landscape design, revealing how these technologies are reshaping designers' workflows and user experiences. The introduction of virtual reality technology allows designers to simulate and evaluate the effects of plant configurations in an unprecedented way, leading to more informed decisions at an early stage of design. At the same time, the application of interactive design further enhances the user's sense of participation and

satisfaction, making the design process more democratic and personalized. A comparison is made between the digital plant allocation method and the traditional method, and the advantages and limitations of digital technology are discussed. Although digital technology has brought a lot of convenience and innovation to landscape design, how to overcome its cost and technical limitations, as well as how to balance the relationship between user experience and design effect, still requires further research.

This study provides strong theoretical support and practical guidance for the digital transformation in the field of landscape design. Through an in-depth analysis of the application status and development trend of digital technology in plant configuration, the study provides designers with new ideas and methods to promote landscape design to achieve greater breakthroughs and development in the digital era. In the future, with the continuous progress of technology and in-depth research, it is believed that digital technology will play a more important role in landscape design and contribute to creating a more beautiful and sustainable living environment.

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Disclosure statement

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