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Research on the Application of Three-Dimensional Virtual Reality Technology in Landscape Architecture Design

Abstract: - This study investigates the depth of and engaging experiences for designers and users could transform conventional landscape architecture design approaches through the use of 3D virtual reality technology. Research assesses the advantages and difficulties of using 3D virtual reality (VR) into landscape architectural practice by means of an extensive analysis of the body of current literature and case studies. The study looks into how 3D virtual reality (VR) technology affects the ideation, imagining, collaboration, and presentation phases of the architecture and landscape process of design. It examines how virtual reality simulations can improve communication among design teams, facilitate client engagement, and enhance decision-making processes. The study also looks at the practical and technical aspects of using 3D virtual reality technologies in landscaping design firms, including hardware requirements, software compatibility, and training requirements. In the end, the research's findings deepen our understanding of how 3D virtual reality technology might revolutionize landscape architecture, practice, and spur creative thinking in design processes.

Keywords:

1. Introduction

The field of landscape architecture is continuously evolving, driven by technological advancements that offer new tools and methods for design innovation [1]. Among these technologies, three-dimensional virtual reality (3D VR) stands out as a promising tool with transformative potential [2]. With its ability to create immersive and interactive environments, 3D VR technology has the capacity to revolutionize the landscape architecture design process, from conceptualization to presentation and implementation [3]. The purpose of this study is to investigate how landscape architectural design uses 3D virtual reality technology and what that means for the industry [4]. By harnessing the capabilities of virtual reality, landscape architects can create realistic and immersive experiences that allow clients, stakeholders, and designers themselves to engage with proposed designs in unprecedented ways [5]. Through virtual reality simulations, designers can visualize spatial relationships, test design concepts, and explore various scenarios, facilitating more informed decision-making and enhancing the overall design quality [6]. Additionally, virtual reality platforms offer opportunities for collaboration and communication, enabling seamless interaction among design team members and fostering greater understanding and consensus among stakeholders [7]. As such, the integration of 3D VR technology holds immense promise for reshaping the landscape architecture design process and unlocking new possibilities for creativity and innovation [8].

The purpose of this study is to investigate how landscape architectural design uses 3D virtual reality technology and what that means for the industry [9]. With the advent of three-dimensional virtual reality (3D VR) technology, the landscape architecture profession is on the brink of a transformative shift [10]. Unlike traditional design methods, which rely heavily on two-dimensional drawings and static models [11], 3D VR offers a dynamic and immersive platform that allows designers to visualize, interact with, and experience landscapes in a whole new way [12]. The purpose of this study is to examine the potential applications of 3D virtual reality equipment in environmental architecture design and how they may affect the field [13]. Landscape architects can produce virtual worlds that offer an accurate and immersive picture of suggested ideas by utilizing virtual reality technologies and platforms. [14]. This immersive experience not only enhances the understanding of design concepts but also enables stakeholders to actively participate in the design process, providing valuable feedback and insights [15]. Moreover, 3D VR technology facilitates iterative design exploration, allowing designers to quickly iterate on ideas [16], test different design scenarios, and evaluate the implications of design decisions in real-time [17]. Additionally, the interactive nature of virtual reality environments fosters

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collaboration among design team members and stakeholders, leading to more informed decision-making and ultimately, better design outcomes. As such, the integration of 3D VR technology has the potential to revolutionize landscape architecture practice, offering new avenues for creativity, communication, and engagement in the design process.

Furthermore, 3D VR technology facilitates collaboration and decision-making by providing a common platform for designers, clients, and other project stakeholders to interact and exchange ideas [18]. Through virtual walkthroughs and interactive design reviews, stakeholders can provide feedback in real-time, leading to more informed design decisions and ultimately, better project outcomes [19]. Additionally, the ability to simulate various environmental conditions and design scenarios in virtual reality allows designers to assess the performance and sustainability of their designs more comprehensively. Therefore, the application of 3D virtual reality technology to landscape architectural work has the potential to transform the design process, encourage creativity, and improve the built environment's overall quality [20].

2. Related work

Li, R. and Xu, D., [21] creates a new simulation technique for garden landscape distribution that was based on virtual reality and three-dimensional images. Initially, a methodical research approach utilizing three-dimensional images was showcased for the arrangement of landscape gardens. Based on the relationships between various coordinate systems at a given angle of view, a camera pose matrix was generated. Following SURF feature point identification on the landscape garden image, the aforementioned feature points were matched and grouped. Second, the three-dimensional reconstruction of the landscape garden image was accomplished utilizing the recognized image feature points. By the usage of virtual reality technology and the results of the reconstruction process, the three-dimensional picture analysis of the reasoning of environment arrangement was completed.

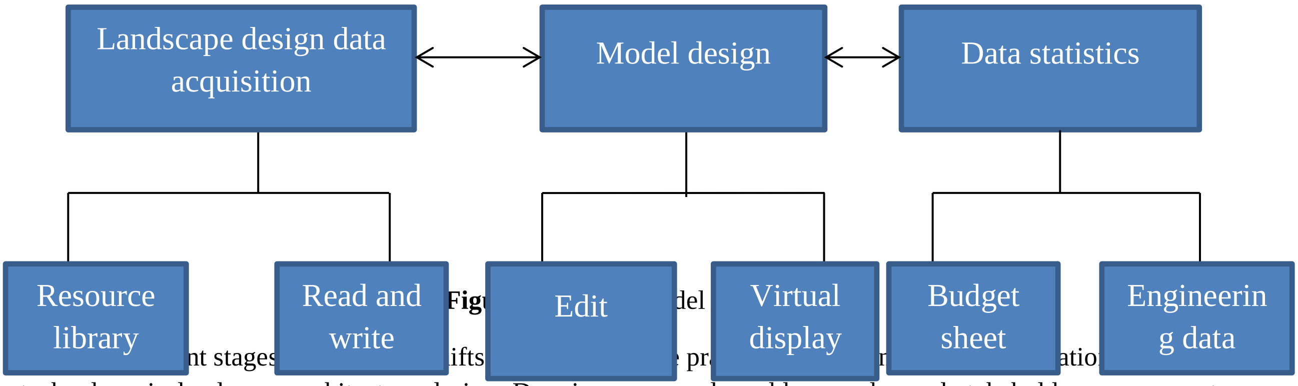
Using virtual reality technology, a new landscaping design effect simulating system was created by Shan, P. and Sun, W., [22]. The overall framework of the system consisted of the user interface layer, program layer, and display layer. In which the hardware, including inputs, displays, primary controls, and acquisition devices, could be selected depends on the structure of the system; system software was made to execute the main program in accordance with this framework. This paper's approach to landscape design was predicated on three-dimensional visual processing technologies. During the design stage, a 3D landscape image could be pre-processed to remove unnecessary and noisy data. Subsequently, the visibility of the architectural landscape image may be improved and 3D landscape image characteristics enhancement could be achieved by applying a certain technique.

In order to raise the degree of digitalization in landscape design, Li, Z., et al. [23] taught of used computer augmented reality (AR) in landscape training. First, a description of the likelihood of related fundamental technologies was given. Second, various phases of the use of augmented reality in the design of landscapes were explored, and also used the virtual modelling tool Sketch Up, the specific scenarios were described and shown. Finally, the advantages and features of virtual reality applications were discussed, and the state of the technology's application in teaching landscape architecture at universities was assessed. The application findings showed that Sketch Up modeling might finish the computerized modelling of plants, buildings, and various other aspects, and that using computerized virtual reality into university landscape architecture courses may considerably boost teaching efficacy.

Zhang, X., et al. [24] investigated the implementation strategy of an online gardening system and built a virtual environment modeled after the historic city of Yangcheng. On the computer platform, we investigate and put into practice a medium-complexity virtual traveling system with more extensive roaming features. With a focus on virtual system application and the use of virtual reality modeling technologies, a desktop-style simulated garden simulation system was developed by the Quest3D software platform. The experimental results showed that the GPU-accelerated sketching method based on GLSL is viable and that it significantly improves the sketching frame rate of 3D garden landscape greenery scenes with minimal scene data. Many types of 3D were displayed using the Open Space Scene Graph (OSG) graphics rendering engine.

3. System model

A complex system model is depicted in Figure 1 of research on the use of three-dimensional in nature virtual reality (3D VR) technology for landscape architectural design. Initially, the investigation delves into the theoretical underpinnings of landscape architecture principles and the immersive capabilities of VR technology. By synthesizing insights from environmental psychology, human-computer interaction, and VR studies, a theoretical framework is constructed to guide the integration of 3D VR tools into landscape design processes. Research presents a methodical framework for the creation and assessment of 3D virtual reality landscape architectural design tools. This includes the creation of software platforms that facilitate terrain modeling, vegetation placement, lighting simulation, and interactive user experiences. Through case studies and user feedback, the effectiveness and usability of these tools are assessed, providing empirical validation and insights into their practical implications for design practice.



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… nt stages … ifts … pr … r … atio … technology in landscape architecture design. Drawing upon real-world examples and stakeholder engagement, the research investigates the impact of VR-enhanced design processes on project outcomes, stakeholder collaboration, and communication. By analyzing the strengths and limitations of integrating 3D VR tools, the research offers critical insights into their potential benefits and challenges. Furthermore, the study discusses implications for professional practice, education, and future research directions, thereby contributing to the advancement of landscape architecture as a field that embraces emerging technologies for sustainable and innovative design solutions.

3.1 Using Three-dimensional in nature Virtual Reality Technology in the Design of Landscape Architecture

In order to grasp the present state of research as well as identify knowledge gaps, the approach for the study on the software of three-dimensional in nature virtual reality (3D VR) technologies to environment architecture design starts with a thorough assessment of the literature. Subsequently, clear research objectives will be established to guide the direction of the study. Following this, a methodological framework will be developed, outlining specific data collection methods, analysis techniques, and ethical considerations. The research will involve both qualitative and quantitative data collection approaches, including interviews, surveys, and observations. Designers and stakeholders will interact with virtual reality models and simulations of proposed landscape designs to evaluate design concepts and provide feedback. To find patterns, correlations, and trends, data analysis will include the statistical examination of quantitative data and a thematic examination of qualitative data. The results will be analyzed in light of the study's goals, offering important new information about the efficiency and effects of 3D virtual reality on the processes and products of landscape architectural design.

Furthermore, the research will validate and verify the findings through peer review, expert consultation, and triangulation of data sources to ensure the reliability and credibility of the research outcomes. A thorough grasp of the use of 3D virtual reality (VR) technology in landscape architecture design will be made possible by this continuous method of gathering, analyzing, and interpreting data. This will also provide insights into the potential benefits of VR technology for improving stakeholder engagement, design visualization, and decision-making processes. Ultimately, the proposed methodology aims to advance knowledge in the field of landscape architecture by exploring innovative approaches to design communication and visualization facilitated by three-dimensional virtual reality technology.

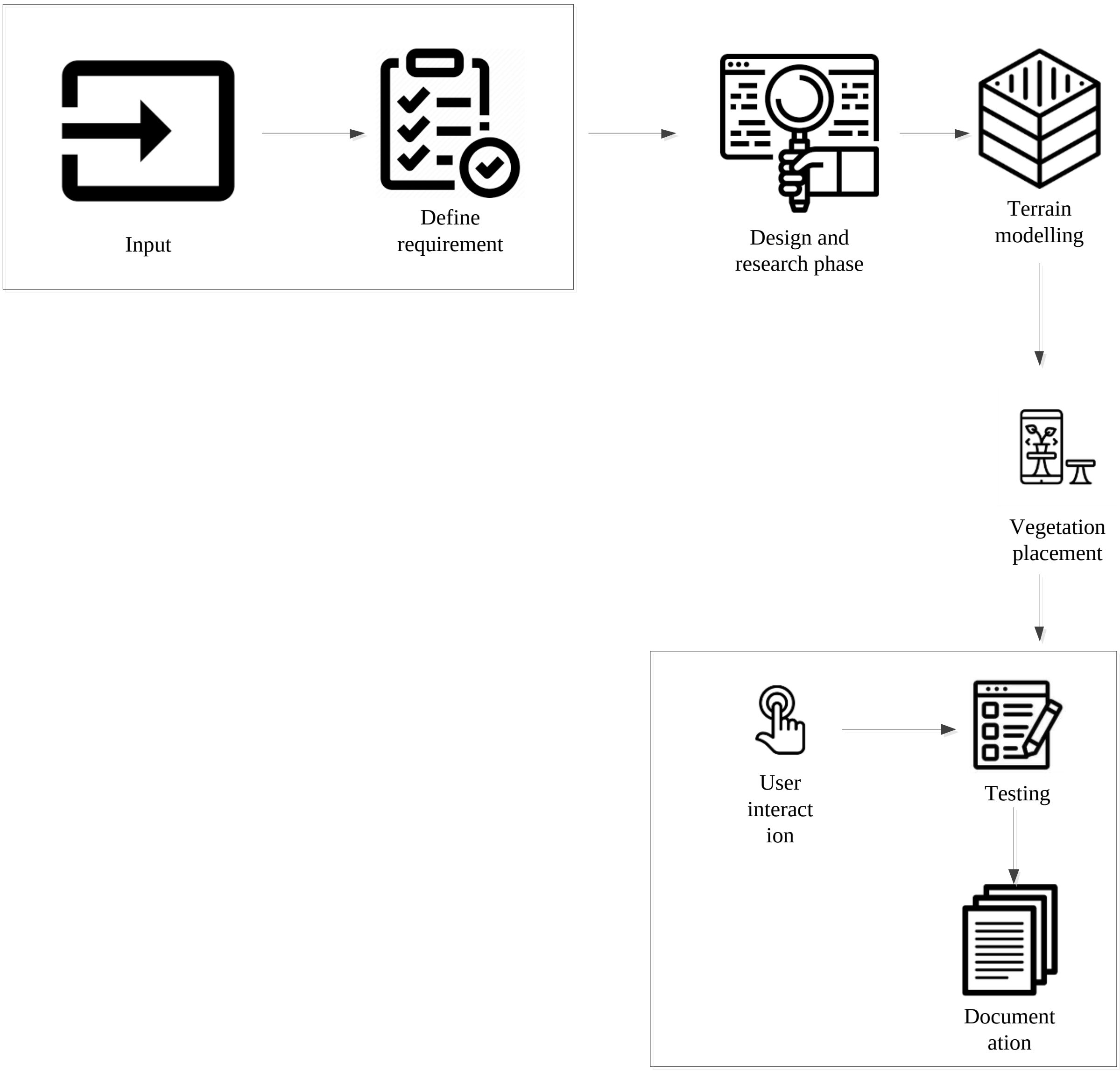

Figure 2. Designing landscape architecture with three-dimensional virtual reality technology

3.2 Application of three-dimensional virtual reality technologies to landscape architecture design

A cohesive grouping of points that connect between the surrounding cloud point clouds models is generated by examining the reflected points inside the nearby point cloud models of several landscaping gardens in the same image. By resolving the optimum alignment transformation among the point cloud sets, incorporating the entire landscape garden with the local point cloud model, and producing an extensive three-dimensional graphic representation of the landscape garden, the three-dimensional image evaluation of the landscape garden's rational distribution can be finished. The process of taking pictures of landscape gardens is as follows: the images in the landscape garden image set E are contained in the point cloud models and, respectively. The number of matching point clouds designates the points in the three-dimensional image to be projected onto the landscape garden scene image plane. It also calculates the pixel coordinates of the landscape garden image and the partial and whole point clouds, respectively, that are projected onto the landscape garden scene image K, positional coordinates of the spot.

$$y_j = QY_j \tag{1}$$

$$F(Q_{l1}, Q_{l2}) = \| Q_{L1} - (t.Q_{l1}.S + L) \tag{2}$$

Following the determination of Q_{l1} and Q_{l2} geometric centers P_1 and P_2, equation (4) is used to get the translation vector M.

$$M = (P_1 - P_2) + (P - P_1) \tag{3}$$

Equation (4) is used to normalize the coordinates of Q_{l1} and Q_{l2}, without taking the scaling factor into account.

$$S = V.W^U \tag{4}$$

The minimization problem is fixed via the use of Procrustes orthogonal problem theory. When the landscape cloud picture point cloud model is being converted to it, the rotation matrix R needs to satisfy the internal structure's invariance. The ideal rotation matrix R for landscape architecture can be solved via formula (5).

$$Q_2 = t.Q_2.S + M \tag{5}$$

Use formulas (6) and (7) to determine scaling, rotation, and translation. Following the transformation, P_1 point cloud is changed to use P_2 coordinate system.

4. Results and discussion

Urban landscape planning and design is a complex procedure which involves gathering the required fundamental first phase and producing intricate design blueprints. To the application of the design and the remarks made on the preparation of material during the process. Urban planning, which constitutes the conceptual and strategic work of the urban environment, is based on the process of transforming planning objectives as well as planning suggestions into concrete areas. It is clear that as the number of meshes increases, the quantity of triangular fractures progressively reduces, enhancing the visual representation effect. To create the images of the wide grassy areas, choose the Searched Face Set element. The neighboring meadow effect and slope was determined after each coordinate point's points were computed and patterned. The demonstration of three-dimensional picture analysis of the coherence of landscape distribution was carried out using the three-dimensional sensory perspective and the dimension estimation method, respectively.

4.1 Performance evaluation

The performance of the landscape yard imagery's three-dimensional in nature image reconstruction correctness can be assessed by counting the number of characteristic points derived from it; nevertheless, the key factor is the precise alignment of the matching feature value pairs of two landscape garden photos. The two procedures are utilized to align the landscape horticulture image's points of features. As shown in Figures 3 and 4, the performance stability as well as efficacy of the virtual reality technology and three-dimensional photos utilized in this study surpass those of earlier image recognition systems. After the technology for spreading landscape architecture was tested, the connected landscape architectures' rationality indicators improved. This demonstrates how technology can boost linked product sales and trustworthiness. It is discovered that the system satisfies business and user needs in terms of functionality and server cluster performance requirements following evaluation and examination of the outcomes in the aforementioned stages.

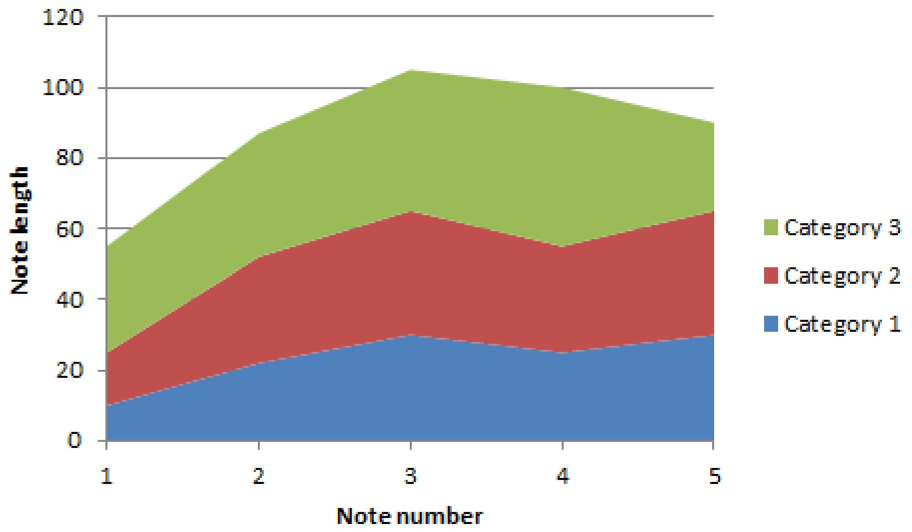

Figure 3. Technical variations in the logical arrangement of landscape architecture

The extreme beauty of the representations is contrasted with a more conventional and authentic actual world through the usage of virtual reality technology in the design plan. In particular, in terms of modeling, architecture, innovation, and communication capabilities, virtual reality technology supports architectural landscape design by allowing designers for reassembling the time and space of the landscape of construction environment in addition to helping them overcome immediate and spatial constraints. The thorough research leads to the conclusion that the approach has shown to be quite stable, essentially guaranteeing accuracy and precision in image recognition. Nonetheless, it is evident from the system access speed that the loading is too sluggish. On the one hand, each picture recognition function has a unique implementation in terms of needs because there are so many distinct types of image recognition functions.

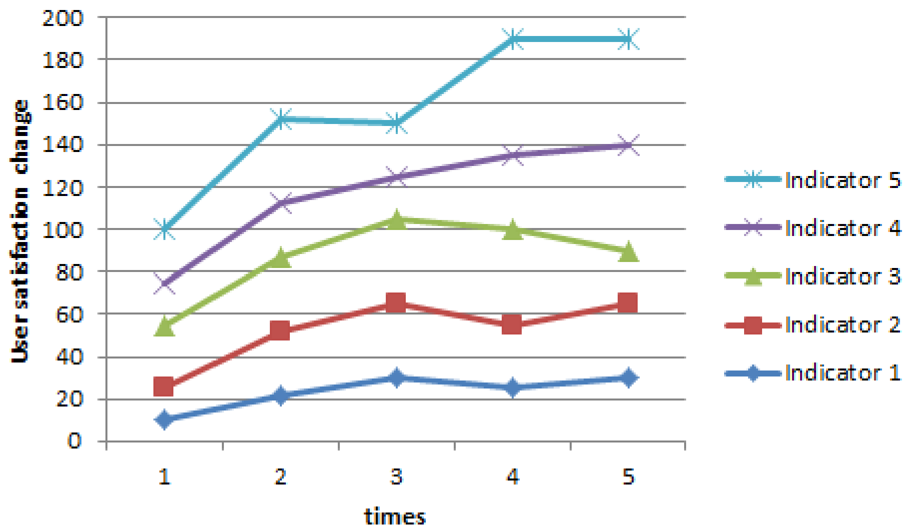

Figure 4. The distribution of landscape architecture under various index systems

5. Conclusion

In conclusion, the research on the application of three-dimensional virtual reality (3D VR) technology in landscape architecture design highlights the immense potential of this innovative tool in revolutionizing the field. Through comprehensive analysis and experimentation, it has been demonstrated that 3D VR technology offers unparalleled opportunities for landscape architects to visualize, conceptualize, and communicate design ideas in an immersive and interactive manner. The utilization of 3D VR technology enables designers to create realistic virtual environments that accurately represent proposed landscape designs, facilitating better understanding and collaboration among stakeholders. Furthermore, the research findings underscore the significant benefits of incorporating 3D VR technology into the landscape architecture design process, including enhanced spatial comprehension, improved design iteration, and increased stakeholder engagement. By harnessing the capabilities of 3D VR technology, landscape architects can streamline the design process, mitigate potential design flaws, and ultimately create more innovative and sustainable landscapes. However, it is essential to recognize that the successful integration of 3D VR technology into landscape architecture practice requires ongoing research, development, and investment in technological infrastructure and expertise. Overall, this research contributes valuable insights into the transformative potential of 3D VR technology in landscape architecture design and sets the stage for further exploration and implementation of innovative technologies in the field. As technology continues to evolve, landscape architects must embrace these advancements to stay at the forefront of design innovation and create landscapes that meet the needs of the present while envisioning the possibilities of the future.

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