

Dunhuang Dreamscape: A Study and Exploration of Dunhuang Art in Modern Interior Design based on Virtual Reality Technology

Yanxi Su¹, Suzhen Bai¹, Pengfei Deng^{2,*}

¹ Department of Fine Arts, Northwest Normal University, Lanzhou, Gansu 730070, China

² Department of Physics and Electronic Engineering, Northwest Normal University, Lanzhou, Gansu 730070, China

* Corresponding author: Pengfei Deng (Email: 1908396445@qq.com)

Abstract: In the context of the national initiative of the "Belt and Road" policy and the vigorous promotion of cultural soft power, interior design products infused with cultural creativity have emerged as significant carriers of cultural development and heritage. This paper explores the innovative application of virtual reality technology in the field of interior design, with a special focus on the integration of Dunhuang elements in design practices. By combining virtual reality technology with Dunhuang art, a novel paradigm for interior design is proposed, blending ancient murals, patterns, and colors with modern computer graphics technology, infusing spaces with a unique historical charm and cultural significance. From the perspectives of virtual reality technology, inheritance of Dunhuang artistic elements, Dunhuang-style spatial design based on virtual reality, user experience, and emotional resonance, this paper delves into an in-depth exploration. Its aim is to expand innovative paths within interior design, while simultaneously providing new ideas and methods for cultural heritage and spatial perception domains.

Keywords: Dunhuang Art; Modern Interior Design; Virtual Reality Technology.

1. Introduction

Virtual reality technology, as an advanced interactive technology, bridges the gap between the virtual and real worlds, providing users with new experiences [1]. It has shown immense potential and impact in various fields. In recent years, with the continuous evolution of virtual reality technology, people can experience lifelike visual effects, immersive sensations, and emotional resonance in digital environments. In the field of interior design, virtual reality technology is gradually becoming a powerful tool for designers, offering new possibilities to create unique and captivating interior environments [2].

The utilization of virtual reality technology in the interior design process can reduce design costs, enhance user experience, elevate the level of interior design, and improve design efficiency, contributing to the healthy, stable, and sustainable development of the interior design industry. However, to maintain cultural heritage and historical awareness while embracing technological innovation, it's essential to contemplate how to integrate virtual reality technology with traditional culture. This research will focus on the application of Dunhuang artistic elements, exploring the innovative use of virtual reality technology in interior design and how to imbue spaces with deeper emotional significance through the fusion of Dunhuang culture [3].

2. Virtual Reality Technology

Virtual reality technology has made significant strides in the past few years. From interactivity and immersive experiences to emotional resonance, virtual reality technology is reshaping people's perception of the real world. In the field of interior design, designers are now utilizing virtual reality technology for simulation, real-time demonstrations, and adjusting design concepts, in order to better comprehend and meet user needs. Through virtual

reality technology, users are no longer passive observers of design; they can interact, participate, and emotionally engage with the design and its context.

2.1. Virtual Reality Technology Overview

Virtual reality is a technology that constructs three-dimensional virtual worlds using digital processing and sensory techniques. Virtual reality technology can provide sensory stimulation in terms of auditory and visual experiences, creating a sense of immersion. In recent years, virtual reality technology has seen rapid development and has been widely utilized in many fields. Applying virtual reality technology in the process of interior design can bridge the gap between users and designers, facilitating interactive communication between them. This contributes to interior designs that better align with client needs, significantly enhancing the quality and effectiveness of interior design [4]. Virtual reality technology possesses the following characteristics:

(1) Immersiveness

Virtual reality technology possesses an immersive characteristic. Immersiveness primarily refers to the ability of virtual reality technology to provide a sense of being present, commonly referred to as a feeling of "presence." This enables continuous optimization and improvement of design concepts, fostering a significant enhancement in the level of interior design. Concurrently, it facilitates convenient communication and interaction between clients and designers.

(2) Interactivity

Virtual reality technology is interactive. Interactivity is mainly reflected in touch, hearing, visual experience, through the use of certain sensing devices can allow users to produce a more profound experience of objects in the virtual environment. For example, holding objects in a virtual scene gives the user the feeling of actually holding the object, and can also feel the weight of the object itself.

(3) Imagination

Virtual reality technology also has an imaginative character. Virtual reality technology not only presents things in the real world, but also simulates things that do not exist in the imaginary world, bringing users a new experience, allowing users to generate new ideas and inspiration, and promoting users to significantly expand their cognition and improve their imagination. For example, by using virtual reality technology to let users experience the development and changes of the future world, it can lay a good foundation for interior design.

2.2. Application Significance of Virtual Reality Technology in Interior Design

Virtual reality technology mainly refers to a novel technology that integrates multimedia, computer graphics, digital processing, and sensor technologies. By employing computer equipment, it constructs simulated environments, and through various types of sensor devices, users are immersed in these simulated scenarios, enabling natural interaction with the environment. The utilization of three-dimensional simulation techniques within virtual reality technology facilitates a comprehensive representation of the overall status of interior design projects. This enables clients to fully and intuitively understand the completed project effects, construction processes, and overall project conditions.

Compared to any other form of textual expression or animated presentation, virtual reality technology offers superior results, characterized by freedom, imagery, and vividness. Firstly, virtual reality technology allows stakeholders to fully experience the authenticity and reliability of the design, offering a dynamic and comprehensive view of the interior design process. Secondly, it simplifies the presentation of relatively complex structures, making them more intuitively understandable, and supports iterative design through human-computer interaction. Finally, traditional renderings often look impressive but do not necessarily reflect the actual decorative outcome. However, designs showcased using virtual reality technology can achieve over 90% similarity between the decorative and design effects [5]. By employing virtual reality technology, clients are immersed in a three-dimensional space, providing an immersive experience.

2.3. Application of Virtual Reality Technology in Interior Design

2.3.1. Showcasing Spatial Effects

With the continuous development of socio-economic and scientific technologies, people's material standards of living have greatly improved compared to the past. Simultaneously, stricter demands have been placed on living environments. Traditionally, interior design often adhered to a rigid structure, with limited diversity in decoration styles and forms. However, the integration of virtual reality technology into interior design is changing this landscape. It enables a growing diversity in interior decoration styles, facilitating a shift away from traditional design constraints. Through virtual reality technology, users can experience the post-renovation effects, allowing for necessary modifications and changes based on their preferences [6]. Meanwhile, through the use of intelligent cameras to capture design outcomes, users can optimize and enhance relevant furniture, home decor, and material purchases according to their specific needs. The application of virtual reality technology in showcasing architectural interior design spaces significantly

enhances both the quality and efficiency of interior design work.

2.3.2. Creating Dynamic and Continuous Spaces

In the process of architectural interior design work, it is essential to fully consider various factors such as building materials and color combinations in order to achieve an ideal design solution. Traditional interior design often utilizes animated presentations to showcase design outcomes to users. However, this approach merely provides auditory and visual stimuli, failing to offer users a comprehensive and three-dimensional experience of the design's effects. Through the application of virtual reality technology, it becomes possible to create relatively dynamic and continuous spaces for users. This allows users to experience multi-sensory stimuli and a sense of immersion, presenting them with a realistic spatial environment that effectively meets their real-world needs [7].

2.3.3. Dynamically Editing of Design Elements

By employing virtual reality technology, design elements can be dynamically edited. Relevant interior design professionals can optimize and modify design elements. Simultaneously, they can compare different design elements and select the most optimal ones. In the process of architectural interior design work, strict control over building height should be maintained. To achieve effective control over building height, it is necessary to consider the real conditions of different areas scientifically. Simultaneously, strengthening protection of the surrounding environment is crucial. Through the use of virtual reality technology, interior design plans can be modified and switched at any time. Timely and effective adjustments can also be made to building heights. This aids design professionals in making comparisons among design options, enabling them to develop the most optimized and rational design solutions [8].

3. The Inheritance and Innovative Integration of Dunhuang Elements in Interior Design

The brilliance of Chinese civilization shines brightly, and Dunhuang art, as a dazzling gem in the treasure trove of Chinese culture, has provided a significant impetus for Chinese civilization to embrace the world. As a strategic cornerstone of China's cultural confidence, Dunhuang mural elements possess unique artistic features. They seamlessly blend traditional culture with artistic design, embodying a profound sense of time, space, and history. In this era of advocating cultural self-confidence, we aspire for the cultural atmosphere of our living spaces to be imbued with our national identity. Hence, this section will expound on the development and application of traditional Dunhuang art in modern interior design. Through the exploration of Dunhuang art's cultural, commercial, and aesthetic values, we will analyze and contemplate the prospects, design methods, and techniques of integrating Dunhuang decorative patterns into contemporary interior design. This discussion not only highlights the significance of traditional elements in modern design but also deepens people's understanding and awareness of Dunhuang art.

3.1. Prospects and Outlook of Dunhuang Art in Interior Design

From a cultural perspective, the patterns, colors, compositions, and motifs in Dunhuang murals are incredibly

rich in symbolism [9]. They not only satisfy contemporary aesthetic needs in interior spaces but also contribute to enhancing the general public's artistic appreciation. The artistic design of Dunhuang cave murals provides modern designers with a wealth of artistic resources and design inspiration, be it in overall composition or the application of mural colors [10].



Figure 1. Zaojing Pattern in Dunhuang Art

As shown in Figure 1, the pattern layout in Dunhuang art is unified, colors are harmonious, and figures possess graceful postures. Layers of cloud and lotus patterns surround the scenes, with warm colors like deep red and earthy hues dominating the composition, complemented by sky blue and black-and-white as secondary colors. If modern virtual reality technology is integrated into interior design, as illustrated in the example, it would enhance the overall impact, breathing new life into Dunhuang art.

In contemporary interior design, Dunhuang elements can be applied to various scales, from large-scale interior murals to small home decorations, furniture embellishments, and wall hangings. Designers can either extract individual elements for reconstruction or exaggerate and transform them, imbuing them with fresh cultural significance. Incorporating traditional patterns in modern design not only increases product value and enriches cultural content but also significantly contributes to the inheritance and development of traditional culture [12].

From a business perspective, the rapid development of cultural and artistic IP and the cultural and creative industries has seen remarkable success in cross-industry collaborations with Dunhuang culture. Dunhuang not only attracts artists but also draws a significant number of tourists. The surrounding infrastructure, cultural exchanges, and leisure and entertainment facilities in the vicinity of Dunhuang City are relatively lacking. Therefore, the development of modern interior design in Dunhuang is particularly crucial. In the field of environmental art and design, the exploration of colors from Dunhuang decorative patterns, combined with modern aesthetic design concepts, can be applied to various types of spaces, such as themed cultural and creative spaces, commercial venues, and exhibition spaces. Designers, with

their unique aesthetic perspectives, integrate Dunhuang's rich traditional culture to create spaces that meet diverse needs, significantly promoting the development of Dunhuang's artistic and cultural creative industries. This approach achieves a cooperative and mutually beneficial relationship between art and business.

3.2. Design Exploration of Dunhuang Art in Interior Spaces

3.2.1. Principles of Color Redesign

In the rapidly changing times, people's sensitivity to color is also evolving rapidly. Taking the Cave 329 of the Early Tang Dynasty (as shown in Figure 2) as an example, the predominant color is green, in contrast to the Sui Dynasty period, where there is more usage of colors, mostly in cool tones, resulting in a richer color hierarchy and presenting an elegant and fresh quality. Cave 320 of the Flourishing Tang Dynasty (as shown in Figure 3) is dominated by colors such as earthy red, vermilion, deep red, stone blue, stone green, blue, and ochre. The color brightness has a good rhythm while maintaining an overall sense, exhibiting a natural transition and distinct layers [13].

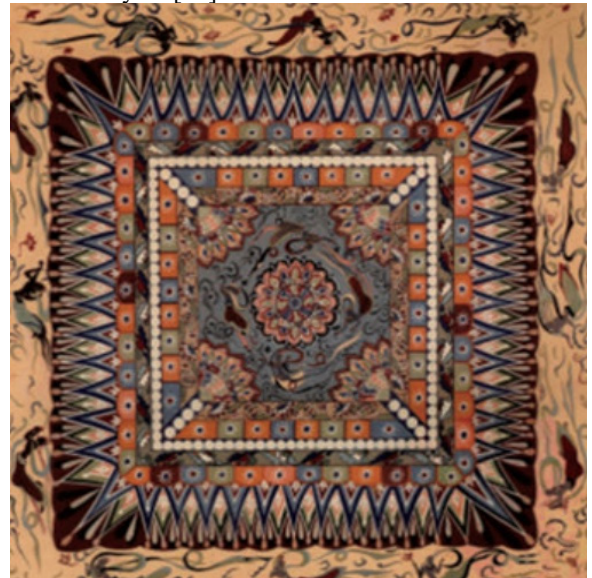


Figure 2. Cave 329 Zaojing Pattern of the Early Tang Dynasty



Figure 3. Cave 320 Zaojing Pattern of the Flourishing Tang Dynasty

For the redesign of Dunhuang colors, one should start by respecting traditional culture and fully exploring its symbolic significance. The principles of color extraction, contrast, and application scale should be grasped. Dunhuang decorative patterns present a variety of color combinations, such as the excellent examples of zaojing patterns, pingqi patterns, and chevron patterns from the Sui-Tang and Song-Yuan periods. In contemporary interior space design, skillfully incorporating these color palettes imparts unique cultural significance and charm to the space, creating a distinct Dunhuang-style color palette.

3.2.2. Application of Dunhuang Art in Soft Furnishings

Integrating Dunhuang Culture into Soft Furnishing Design. For instance, the iconic Dunhuang red can be incorporated into the design of chairs and coffee tables, where the cushions are in red while the rest remains in natural wood color, creating a series of unique furniture pieces. Another approach is to distill and combine the essence of a specific Dunhuang cave and apply it to the design of cushions and wall art. This design technique isn't about simple borrowing; it involves a modern reinterpretation that is harmoniously blended with Dunhuang art. Embracing the essence of Dunhuang culture requires designers to thoroughly understand and learn its intrinsic nature, while enhancing their artistic cultivation. Delve deeply into Dunhuang decorative motifs, master the principles of coordination and arrangement, and achieve the goal of preserving Dunhuang culture. Innovative redesign rooted in Dunhuang culture is crucial to create artworks that are not only accurate but also capable of continuing the legacy and development.

3.2.3. Integration of Dunhuang Art and Space

The Dunhuang Mogao Caves offer us a perception of openness, inclusivity, equality, and development. Over the course of more than a millennium, Dunhuang Mogao Cave culture has embraced the Buddhist beliefs of both the ruling elites and common people of various dynasties. This multi-generational transmission through diverse methods represents the developmental state of traditional culture. When considering the redesign of Dunhuang decorative patterns, it's important to contemplate how we can more appropriately integrate our understanding of Dunhuang culture into living spaces, infusing them with the environment, topography, and beliefs.

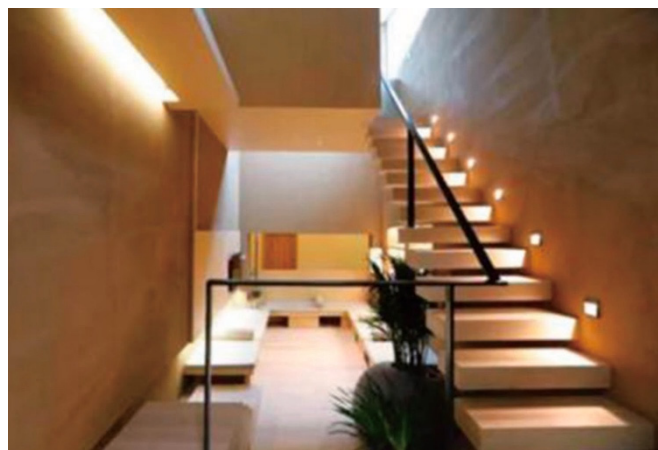


Figure 4. Example of Yulin Grottoes Renovated Space

For instance, in the transformation project of the Beilin Grottoes Visitor Center, the interior space is free-flowing and

boundary-less, allowing people to sit on the floor. Traditional decorations and furniture are absent. Instead, using ergonomic principles, earthen blocks of heights 35cm, 70cm, and 105cm are creatively stacked to accommodate different visitor behaviors like standing, sitting, and leaning. The interior employs locally sourced materials like yellow earth walls, and the architectural design features openings that seamlessly connect the indoor and outdoor spaces, achieving a harmonious blend. The creation of ambiance transcends mere appearances; it should be conceived from the perspectives of functional form and practical needs to achieve a seamless integration with the space (as shown in Figure 4).

4. Dunhuang-Style Space Design in Virtual Reality

By seamlessly integrating virtual reality technology with Dunhuang elements, a whole new artistic experience has been created. Designers have infused Dunhuang elements with digital vitality using computer graphics technology, resulting in unprecedented diversity and vitality. In a virtual reality environment, users can immerse themselves in exploring Dunhuang culture, engaging intimately with art, and generating personalized emotional resonance. This design not only preserves ancient culture but also represents an innovative endeavor to combine culture with technology, offering an unparalleled journey of artistic exploration.

4.1. Creating an Immersive Dunhuang-Style Experience

Dunhuang murals, as treasures of world art, have achieved a remarkable level of mastery not only in painting techniques but also encompass profound philosophical contemplation and religious beliefs. By incorporating Dunhuang elements into modern virtual interior design, designers in the digital age breathe new life into these ancient patterns and colors. Through computer graphics technology, the geometric patterns of murals can be deconstructed, reassembled, and rearranged, resulting in unprecedented artistic effects. For instance, designers can use virtual reality installations to allow viewers to interact with virtual murals in soft lighting, enabling them to appreciate not only the beauty of the murals but also to delve deeper into the rich cultural significance conveyed by the patterns through interactive means. This interactive experience will enable audiences to engage with art in a fresh way, gaining a more profound appreciation of the charm of Dunhuang culture.

Virtual reality-based Dunhuang-style interior design offers people a whole new journey of artistic exploration. With high-resolution virtual reality installations, users can immerse themselves in exploring the murals and statues of the Mogao Grottoes, as if transported back into the Dunhuang culture of a thousand years ago. This design is not just a historical reenactment; it's a creative attempt to seamlessly integrate ancient culture with modern technology. For instance, in a virtual Dunhuang library design, users can peruse scriptures on virtual bookshelves and interact with virtual scrolls through gestures, further enhancing their understanding of the depth of Buddhist culture [14].

4.2. Enhancing User Experience and Emotional Resonance

User experience is one of the key issues in the application of virtual reality technology in interior design. Through

virtual reality technology, designers can create immersive environments that allow users to freely explore within virtual spaces. In the context of Dunhuang-style virtual interior design, users become participants and creators of the space, engaging in interactive communication with the virtual environment. For example, users can use gestures to contribute to a virtual mural, leaving their own creative marks within the virtual space. This sense of participation and creative experience further fosters emotional resonance between users and the design, transforming the space from a mere visual experience into a comprehensive interaction of culture and emotions.

5. Conclusion

In today's context of the national promotion of the "Belt and Road" policy and the vigorous development of cultural soft power, interior design products with cultural creativity have become important carriers for cultural development and heritage. Nowadays, Dunhuang culture no longer needs to be confined by traditional ideological barriers; instead, it should innovate based on inheritance. Dunhuang murals, with their vibrant and colorful characteristics, stand as a treasure of world civilization. Leveraging the unique perspectives of designers and their sensitivity to beauty, the integration of Dunhuang's ancient culture with virtual reality technology uncovers more possibilities and creates valuable and meaningful interior design products, ultimately achieving global recognition of Chinese cultural values.

The fusion of virtual reality technology and Dunhuang elements is leading the interior design field into a new wave of innovation. By combining virtual reality technology with Dunhuang culture, we showcase the charm of traditional culture in the digital environment, creating artistic and historical experiences that transcend time and space. This integration not only enriches the creativity and content of design but also constructs a bridge between cultural heritage and technological innovation. Future designers need to master virtual reality technology more proficiently and continuously explore innovative applications, thereby creating deeper and more diverse spatial perceptions and emotional experiences for people.

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References

- [1] Bell J T , Fogler H S .Preliminary testing of a virtual reality based educational module for safety and hazard evaluation training [J]. 2022.
- [2] thomas B H .Virtual Reality for Information Visualization Might Just Work This Time[C]//Wearable Computers, 2001. Proceedings. Fifth International Symposium on.2020.
- [3] Ming-Hao Z .A Research of Monk Poets in Dunhuang in the Tang Dynasty[J].Academic Journal of Jinyang, 2008.
- [4] Rubino F .Virtual reality and surgery[J].Surgical Research, 2022: 1383-1392.
- [5] Hongmin S , Yinjiang J .The Application of Virtual Reality Technology in Interior Design System Development [C]// International conference on construction & real estate management. Department of Computer Science and Technology, Northeast Agriculture University, China, 2007.
- [6] Zi-Hua Q , Chuan-Jin X I .Unique Aesthetic Thinking System and Poetic Aesthetic Theory--On General Characters of the Oriental Aesthetics [J].Journal of Nanjing University (Philosophy, Humanities and Social Sciences), 2003.
- [7] Ahmad R , Gethin D T , Lewis R W .Design Element Concept of squeeze casting process[J].Applied Mathematical Modelling, 2012, 36(10):4760-4788.
- [8] Vaagensmith B , Singh V K , Ivans R ,et al.Review of Design Elements within Power Infrastructure Cyber-Physical Test Beds as Threat Analysis Environments[J].Energies, 2021(5).
- [9] Kang C .The study of the Arrow-shooting Images in the Dunhuang Frescoes[J].Northwest Minorities Research, 2003.
- [10] Cao Y , Li Y , Zhou Q .3D Modeling and Animation Design of Flying Apsaras in Dunhuang Frescoes[J]. 2021.
- [11] Ying W , University N N .The Feasibility Study on the Construction of Cultural Creative Industrial Park That Guided with for Dunhuang Frescoes[J].International Cultural Administration, 2018.
- [12] Di S , Jiawan Z , Rui Z ,et al.Line Drawing Extraction and Computer Aided Copying for Dunhuang Frescoes[J].Journal of Computer-Aided Design & Computer Graphics, 2018.
- [13] Xu X .Interior Design Decoration Simulation Based on Wireless Sensors[J].Microprocessors and Microsystems, 2021, 82 (3):103813.
- [14] Sun X .Green and Ecological Interior Design Based on Network Processor and Embedded System[J].Microprocessors and Microsystems, 2021, 82(9):103911.