

# AI-enabled Rendering Technology for the Construction and Development of Dunhuang Virtual Pavilion

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**Abstract:** This paper focuses on the use of AI technology to assist in the construction of digital scenes in Dunhuang Research Institute, which realizes the roaming of tourists in virtual scenes through image recognition and semantic analysis of massive digital image data, and explores the possibility of AI-assisted rendering of virtual museums. Using AI technology, tourists can observe the uniqueness of each cave within the cavern and its rich content from any angle, and obtain an immersive travel experience. The study fully utilizes the new generation of information technology to build a virtual scene platform of Dunhuang Mogao Grottoes, which comprehensively presents the history, cultural value and artistic value of Dunhuang Mogao Grottoes through the comprehensive integration and display of a variety of digital resources. Focusing on digital media and virtual reality technology, through the use of artificial intelligence technology and the comprehensive integration of related digital resources, to build a complete set of virtual reality ecosystem, and explore the realization of multi-source data fusion of Dunhuang cultural communication.

**Keywords:** AI; Dunhuang; Virtual Pavilion; Rendering; Comprehensive Integration.

## 1. Introductory

Dunhuang, a treasure trove with a long history, is rich in artistic, historical and cultural values. In the context of the digital era, the rapid development and wide application of artificial intelligence (AI) technology has opened up new paths for the protection, research and dissemination of cultural heritage. Especially for world cultural heritage sites such as the Mogao Grottoes in Dunhuang, Northwest China, its rich mural and sculpture resources not only carry profound historical and cultural values, but also raise higher protection and research requirements. With the application of technologies such as virtual reality (VR), augmented reality (AR), and AI, Dunhuang art has the opportunity to provide an immersive cultural experience for the public through digitization, as well as more in-depth research tools for scholars.

## 2. Background and Value of the Study

### 2.1. Background and Significance of AI-assisted Interior Rendering

The continuous development of science and technology has led to the widespread application of artificial intelligence (AI) in many fields, of which indoor rendering is an important part. Traditional rendering methods tend to take longer and invest more in labor costs when dealing with complex scenes. However, with the aid of AI deep learning algorithms for indoor rendering, AI technology is able to automatically recognize and process images and related data, thus improving rendering efficiency and quality. In addition, AI can continuously optimize the rendering effect according to the user's needs and feedback, bringing users a more realistic and personalized visual experience. AI-assisted indoor rendering can shorten the rendering time while improving the image quality and reducing the error rate caused by human intervention. AI-assisted interior rendering can shorten rendering time while improving image quality and reducing

the error rate caused by human intervention. It can independently analyze user behavior and collect feedback data to provide designers with accurate optimization suggestions and market forecasts, helping the interior design industry better realize digital transformation.

### 2.2. The Goal and Value of Dunhuang Virtual Scene Construction

The Dunhuang Virtual Scene Construction Project is dedicated to utilizing artificial intelligence technology to recreate the history and culture of Dunhuang and provide an immersive cultural experience for users around the world. The project requires the use of computer vision, deep learning and other AI technologies to conduct high-precision modeling and simulation of historical buildings, murals, cultural relics, etc., so that users can freely explore the virtual scene and feel the charm of Dunhuang history and culture. The project will allow users to freely explore the virtual scene and experience the charm of Dunhuang history and culture.

With the help of AI technology, we can deeply analyze user behavior and make fine adjustments to the virtual scene to improve the user experience. At the same time, the Dunhuang project, with the help of modern science and technology, shows the world a magnificent picture of ancient charm. The project has been a great success.

### 2.3. AI-assisted Virtual Scene Innovation at Dunhuang: Cross-border Collaboration and Market Potential

Dunhuang is a world cultural heritage that attracts a large number of tourists every year. Traditional tours are limited by the protection of cultural relics, and in order to better meet the needs of cultural dissemination and tourists, the Dunhuang Virtual Scene has emerged. Through virtual reality technology, tourists can understand and appreciate the cultural relics and history of Dunhuang in a comprehensive way without touching the physical objects, injecting scientific and technological vitality into the development of the tourism

industry. ai can also be used for the digital protection of cultural relics to realize the complete inclusion and permanent preservation of cultural relics, or to provide tourists with intelligently guided tours. . Assessing the market potential of AI applications in Dunhuang's virtual scene can be done in a variety of ways. First, market research is used to understand the actual application of virtual reality technology in the tourism industry and to understand the acceptance of AI tour guide services by tourists . Study successful cases to assess the potential value of AI in Dunhuang's virtual scene. For example, the Pure Land on Earth exhibition scenario lasted six months and showcased the Eastern Pure Land world of the Medicine Master Glazed Light Buddha on the north wall of Grotto 220. Highly recognized by the market and positive feedback . The market prospects of AI in Dunhuang virtual scenes need to take into account both technology and market demand. the application of 5G and virtual reality technology gives AI a broader market space. Intelligent services such as AI tour guides have become a development trend. Cross-border cooperation and innovation are crucial to maximize market potential. The combination of AI and virtual reality/augmented reality technology has given a new visual experience to interior rendering. The research on digital visual design reengineering and application of Dunhuang murals has provided contemporary designers with a wealth of innovative ideas and unique aesthetic materials, as well as a channel for value sharing for global cultural exchange and dissemination The research is also a channel for global cultural exchange and dissemination of value sharing. Cross-border cooperation includes the integration of technology and art, business model innovation, such as the development of cultural and creative products and services, as well as virtual tour guide services, etc. . Cross-border collaboration of AI in indoor rendering and Dunhuang virtual scenes brings new opportunities for education and training, such as building virtual classrooms and learning platforms. International exchanges and cooperation is an important means to promote cross-border collaboration in AI, including collaborative research and development of advanced technologies and demonstration of results with international research institutes and institutions of higher learning. In particular, advances in virtual reality (VR), augmented reality (AR), and digital restoration technologies are being utilized to innovate Dunhuang's virtual scenes, which will not only provide an immersive experience for a wider audience, but also play an important role in preserving and transmitting this world cultural heritage.

### **3. Technology Development: The Empowering Relationship of AI Technology in Interior Rendering**

#### **3.1. Development of AI Technology for Interior Rendering**

The application of AI technology in the field of interior rendering is constantly updated and iterative. Through training, AI can independently adjust the rendering parameters, applied to automate the layout and design of the scene, improve the rendering efficiency, ensure the real sense of the environment experience at the same time, realize the automation of the layout and design of the interior scene, improve the efficiency of the designer's work. . Artificial Intelligence technology advances, indoor rendering relies on

data and algorithms. AI perfect, provide more realistic visual experience, understand the scene semantic information, rendering effect in line with the environment atmosphere and emotion. Combined with VR/AR technology, AI will open up new possibilities for interior rendering.

#### **3.2. Advantages and Challenges of AI-assisted Interior Rendering**

AI can assist in interior rendering, produce high-quality results efficiently, and improve design performance. Designers can devote themselves to the core of creativity and design, and leave the complicated mechanical tasks to the computer to complete.AI can be automatically optimized according to the designer's preferences and style, so that the rendering effect is closer to the original intention. However, there are challenges in practice, such as the need for a large amount of data resources, high technical threshold, data quality and algorithm accuracy impact. Therefore, we should strengthen the research and application of AI technology, improve algorithm accuracy and computational efficiency, reduce cost and elasticity cost, and emphasize data quality monitoring and management to improve service quality.

#### **3.3. Practical Examples of AI in Interior Rendering**

Artificial intelligence has made significant breakthroughs in the field of interior rendering. For example, the image rendering technology framework can directly synthesize multi-angle virtual images without the need for 3D models. AI can learn the logical relationship between data and repair shape data to realize clear and realistic image and scene rendering. AI analyzes customer preferences and living habits to provide customized design solutions to increase efficiency and improve indoor environments.AI also extends capabilities in lighting simulation, material simulation, etc., so that designers can more accurately adjust their design solutions. AI can also expand its capabilities in lighting simulation and material simulation, allowing designers to more accurately adjust their designs.

### **4. Scene Analysis: Construction and Status of Dunhuang Virtual Scene**

#### **4.1. Background and Objectives of Dunhuang Virtual Scene Construction**

Dunhuang is a world heritage city that attracts millions of tourists every year. However, due to the increase of tourists, Dunhuang's cultural relics are under pressure to be protected. For this reason, the Dunhuang municipal government put forward the idea of building a virtual scene, with the application of virtual reality technology, we can realize the digital restoration and reproduction of historical scenes, to provide tourists with a richer travel experience. At the same time, the virtual scene can also provide more accurate three-dimensional data model for academic research, in-depth excavation of the connotation and value of Dunhuang culture. The virtual scene can also provide a more accurate 3D data model for academic research, deeply excavating the connotation and value of Dunhuang culture.

#### **4.2. Application Areas of AI in Dunhuang Virtual Scene Construction**

AI is widely used in the construction of Dunhuang virtual

scenes, including scene modeling, texture mapping, light rendering and dynamic simulation. Using deep learning technology to extract and classify features of Dunhuang murals, a high-precision Dunhuang virtual scene model can be quickly generated to show a virtual scene with historical and cultural characteristics. AI technology plays a key role in texture mapping, light rendering and dynamic simulation. AI technology plays a key role in texture mapping, lighting rendering and dynamic simulation, which can automatically complete the texture mapping and mapping of Dunhuang murals to enhance the realism of the virtual scene. Through machine learning to study the lighting characteristics, it enhances the adaptability of lighting rendering to the virtual scene. In addition, it realizes the dynamic simulation of the virtual scene to enhance the sense of immersion and realism.

### **4.3. Evaluation of AI for Optimization in Interior Rendering**

AI technology has achieved remarkable results in the field of interior rendering. In order to comprehensively evaluate its effect, a comprehensive evaluation system needs to be constructed. The evaluation indexes include rendering time, image quality, realism and details and other aspects. User surveys can understand the degree of satisfaction and acceptance of users of AI rendering results. The analysis model can deeply study the application of AI technology in interior rendering and optimize the shortcomings. Effect evaluation and optimization are the core aspects to achieve this goal.

## **5. Technology Convergence: Application and Development of AI in Indoor Rendering and Dunhuang Virtual Scene Construction and Dilemmas**

### **5.1. Cross-domain Application Exploration of AI with Interior Rendering and Dunhuang Virtual Scene**

The importance of intelligent interactions cannot be overstated, and therefore, intelligent user-centered interactions have become especially critical. Today, a single computer can depict thousands of nuances on thousands of objects. While integrating the values of human-centeredness, justice and harmony, and sustainable development into intelligent subjects, it is also necessary to change the traditional forms of expression of cultural commodities, and to enhance the level of product intelligence from the user's perspective, which will be a great change[12] The Dunhuang culture, as a model of excellent Chinese culture, provides a solid support for our national self-confidence. The use of digital technology has an inestimable value for the wide dissemination and in-depth promotion of Dunhuang culture. In order to satisfy the public's desire for novel ways of viewing exhibitions, we should actively promote the widespread application of virtual reality technology in museum exhibitions and set up a number of virtual reality experience exhibition halls to enhance the public's interactive experience.[13] In order to meet the needs of virtual scenes and users, we should actively promote the wide application of virtual reality technology in museum exhibitions, and set up a number of virtual reality experience exhibition halls to enhance the interactive experience of the public. In order to

satisfy the virtual scene and users' needs, the requirements of supply-side equipment and network environment must be taken into account. Artificial intelligence technology provides innovative solutions to this challenge, helping to reduce the burden on the network and equipment.

### **5.2. Continuous Innovation of AI Technology and Deep Integration of Indoor Rendering and Dunhuang Virtual Scene**

When logging into the Dunhuang scene on the PC, integrating inputs from multiple rendered frames preserves details and eliminates visual distortion. The deep learning supersampling technique helps reduce the burden on the device by predicting and filling in details during rendering. However, the technique involves a large number of computational operations that can impact device performance. Using advanced techniques such as Deep Learning Supersampling (DLSS) increases frame rate and produces high-quality images, ensuring that image quality is optimized. Increased image resolution can be achieved by "computing" with AI technology. DLSS is a deep neural network that learns from large amounts of image data and accurately predicts high-quality image pixels, filling in the details and textures of the original image. It improves frame rate and enhances the user experience, optimizing the user's graphic design and visual enjoyment experience. DLSS's AI rendering technology uses NVIDIA's Neurographics Framework, NGX, which is capable of rendering tens of thousands of high-resolution images offline to train a deep neural network, resulting in a qualitatively better gaming experience. The latest DLSS2.0 technology delivers image quality comparable to the original resolution while rendering only one-quarter to one-half of a pixel, reducing the burden on the device and dramatically increasing the frame rate. DLSS2.0 technology improves the resolution and frame rate of the game screen, providing a smoother, more detailed viewing experience for visitors. On the PC platform, the technology can improve the frame rate of the pavilion by approximately 2.6 times.[14] on the PC platform.

#### **5.2.1. Stylistic Migration and Content Creation of Generative Adversarial Network (SRAGAN) in Dunhuang Virtual Scene**

In order to ensure that the images reconstructed by the super-resolution model still have clear textures, we adopt an image super-resolution reconstruction model based on coordinate attention generative adversarial network. The model is further optimized by introducing a multi-scale coordinate attention module, which improves the model's ability to capture information at all levels of the image by paying careful attention to feature maps at different scales. Meanwhile, the model employs the coordinate attention mechanism to enhance the feature screening function of the residual network, and performs two rounds of upscaling and downscaling operations within the CR module. During the feature fusion process, an adaptive weighting module is introduced, which is capable of dynamically adjusting the weights according to the importance of each feature map, further enhancing the fineness and accuracy of image reconstruction. In addition, the model adopts a large number of long and short hop connections to accelerate the convergence speed of the network, which solves the problem of gradient disappearance during the training process. The algorithm simplifies the model parameters and improves the

computational efficiency while maintaining high quality image reconstruction. Experiments show that compared with other algorithms, the algorithm performs better in PSNR and SSIM metrics, and the images are clearer and brighter[15]. Display design requires a lot of time, manpower, material resources and creative ability, and most of the display designs are currently designed and drawn out manually, which is inefficient and of poor quality. However, with generative AI mapping technology, images can be automatically recognized, processed and labeled for faster and more efficient creative

output. Display designers have the ability to speed up the design process by using generative AI mapping technology to produce high-quality images, videos, and dynamic scenes, while also reducing the cost of labor and time required in manual drawing and design. The graphics generated using AI techniques are more aesthetically pleasing and personalized. Therefore, this paper presents some suggestions to utilize AI technology for exhibition planning in order to increase the likelihood of successful exhibitions[16].

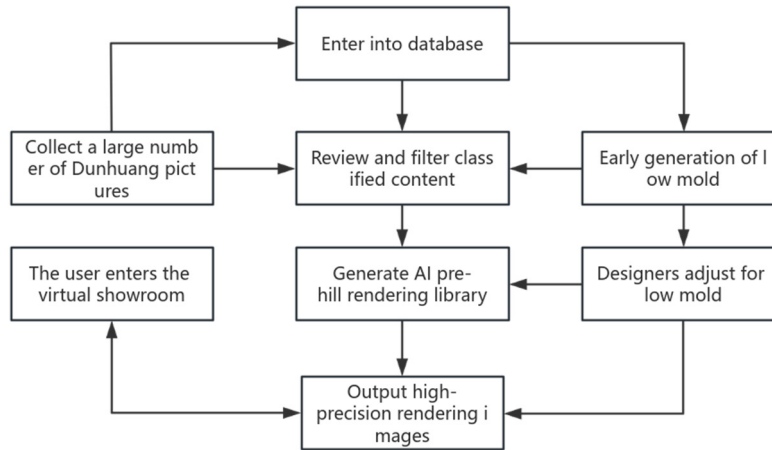


Fig 1. The optimized model

### 5.3. Ethical Challenges and Responses to AI Technology in Interior Rendering and Dunhuang Virtual Scenes

Cultural enterprises have adopted AI technology to produce their own cultural commodities, with insufficient attention paid to the quality of their products, leading to the increasingly serious phenomenon of homogenization of works. Intelligent recommendation algorithms are unable to judge the value of texts, and factors such as insufficient data and balanced values of algorithms make it possible for AI technology to produce bias, which in turn induces the proliferation of "vulgar" information. In this context, a solution based on data protection is proposed for various data types. To address the legal gaps and insufficient copyright protection, it is recommended to strengthen legislative protection.[17]. In the context of AI technology applied to indoor rendering and Dunhuang virtual scenes, it is necessary to carry out the corresponding institutional innovation and construction. First, strengthen the construction of the copyright system, improve the legal system of science and technology-oriented cultural industry, and ensure that intellectual property rights are fully protected. Secondly, clarify the rights and obligations between AI technology designers, users and regulators to ensure that the legitimate rights and interests of all parties are fully respected. Finally, integrate the public safety of technology application, reduce the problem of unclear responsibility in the accountability gap mechanism, and create a favorable environment under the rule of law for the application of AI technology in indoor rendering and Dunhuang virtual scene[18].

## 6. Conclusion

The international cultural industry continues to develop and grow, promoting the continuous generation and construction of cultural spaces. The emergence of virtual exhibition space not only expands the scope of cultural dissemination, but also brings the audience a more free and flexible way of experience. The traditional relationship between the audience and the performance has been transformed and reshaped, the audience's viewing space has been newly defined, and the interactive relationship has been reconstructed. The virtual exhibition space transcends the boundaries of time and place, realizing cross-regional, time-independent cultural transmission, education and research activities. Online exhibitions and cultural activities have exploded, contributing to the rapid rise of new business models for museums. In the post-epidemic era, the challenges facing virtual exhibition spaces are not only limited to the convenience and user base of the Internet, but also include fierce competition that coexists with opportunities. This study explores the use of AI technology to assist indoor rendering technology in the construction of virtual scenes at Dunhuang. By using AI technology, within the framework of ethical environment, we can explore more possibilities of virtual pavilions to realize the protection and innovation of cultural heritage. We can expand the ways of space creation and highlight the core spirit of cultural space, so that it can carry more far-reaching influences and meanings and become a carrier of collective memory.

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