Design Research on Three-dimensional Light and Shadow Technology in the Cre-ation of Warm Atmosphere in Urban Cultural Space

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Abstract. This thesis examines the potential of three-dimensional design and light and shadow technology to create a warm and healing atmosphere and reinforce the expression of urban culture in the scene design of "Yuanndu Impression". In the research process, we constructed a three-dimensional scene space of Weifang, the city of Yuandu, through 3D modelling technology. We then explored the mutual influence of colour, material and other elements with light and shadow effects in the scene design, focusing on the lighting design and the realisation of light and shadow effects. Finally, we adjusted and outputted the rendering settings. The results demonstrate how these elements can be organically combined to create a warm atmosphere. This study offers new insights and methodologies for scene design, with the objective of fostering the integration of related technologies in the domain of urban cultural communication.

Keywords: 3D scene, lighting design, warm atmosphere, urban culture.

1 Introduction

1.1 Research Background

Light is a medium in which the visual senses play an important role [1]. Not only does it bring light into the virtual world, it also gives life and soul to the 3D scene through its unique language of light and shadow. Light and dark possess multiple qualities, extend across space, blend the representational and the non-representational, and meld sensation, affect and emotion[2]. Therefore it is not only the basis of visual perception, but also an important tool for shaping space, creating atmosphere and expressing urban culture.

Firstly, light and shadow have a central role in shaping space in 3D scene design, and are the basis for forming visual information [3]. They are the source of all modelling, whether it be colour or darkness, and the change of light and shadow is of no consequence[4]. The manipulation of light and shadow allows for the creation of a three-dimensional space with depth and three-dimensionality, thereby enhancing the viewer's sense of immersion[5]. Secondly, light and shadow are of equal importance in

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shaping the atmosphere, creating an ambience for the entire scene, enhancing the depth and sense of hierarchy, and deepening the viewer's understanding and emotional response to the scene. Finally, light and shadow are an effective means of expressing urban culture, which can demonstrate the distinctive cultural and historical heritage of a city in three dimensions. The distinctive rhythm of urban light and shadow enables the viewer to gain a more profound comprehension and emotional response to the city's cultural identity.

In this context, how to use and design light and shadow to create a specific atmosphere as well as express urban culture has become an important research direction in 3D scene design.

1.2 Research Purpose

The objective of this study is to investigate more effective techniques for the design of light and shadow to create a warm atmosphere. Despite the advent of digital technology, the emotional impact of light and shadow in three-dimensional scene design is frequently underestimated, resulting in a subtle discrepancy between the virtual and the tangible. The ultimate objective of art is to elicit recognition and emotional resonance in the audience [6]. Light and shadow not only shape the three-dimensional space, but also impart unique emotional qualities to the scene[7]. Consequently, this project examines the intrinsic connection between light and shadow and the emotional impact of a scene, with the objective of creating a warm, comfortable and engaging atmosphere through the use of various light and shadow techniques.

Additionally, this study focuses on integrating light and shadow design with urban cultural space to contribute to urban cultural heritage. By employing digital media art design methods, we can enrich the city's cultural image with deeper heritage[8]. Urban cultural elements will be fully integrated into the design to vividly reflect the city's unique charm. Through the interplay of light and shadow, we aim to showcase the city's history and modernity, tradition, and innovation, providing new perspectives for cultural communication and image shaping.

In summary, on the one hand, this study will explore more effective light and shadow design techniques to provide effective inspiration for 3D scene design to create a warm atmosphere. On the other hand, it promotes the deep integration of light and shadow design and urban cultural space, enriches the cultural image of the city, and is committed to cultural heritage [9].

2 Design Process

2.1 Reproduction of Urban Cultural Elements in 3D Modelling

Throughout the 3D modelling process, respect and understanding of the city's culture is crucial. As shown in Fig. 1, each object and element in the scene is precisely constructed through the use of professional modelling tools such as Maya and 3ds Max, and on the basis of a holistic concept. Firstly, it should be ensured that the buildings in

the picture material match the scene buildings in style and details. On the basis of pursuing authenticity, elements of urban culture should be incorporated to accurately convey the cultural concept of the city. Attention should be paid to the hierarchical nature of structural organisation, dividing the complex model into a number of small parts or elements. This facilitates editing and ensures that the details of the city's cultural elements are reproduced.

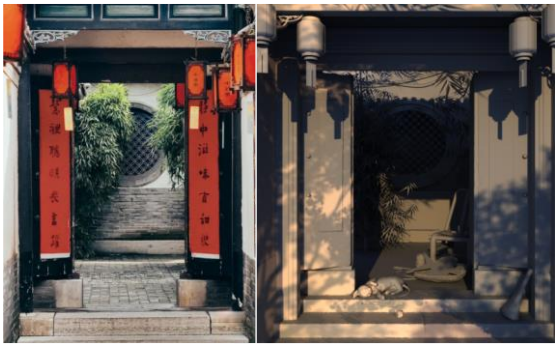

Fig. 1. Pictorial information and modelling reduction

2.2 Expressions of Warmth in Materials and Colours

When constructing a 3D scene, the matching of materials and colours is an important factor in shaping the image. Firstly, the use of metal materials should be minimised to avoid giving a cold visual impression; at the same time, the reflectivity of the materials should be reduced and the roughness of the surface of the objects should be optimised in order to reduce strong refraction and reflection and make the scene softer. The increase in roughness makes the material closer to reality, adding warmth and vividness and texture to the scene. Secondly, the colour palette should be dominated by warm tones and focus on the harmony of warm and cold tones. This combination of colours makes the scene more warm and emotional and infectious.

2.3 Lighting Design in the Warmth of the Atmosphere of the Creation of Techniques

Lighting design and the realisation of warm light and shadow effect is the research focus of this paper, and it is also the key to build a warm atmosphere. In order to create a light and shadow effect with a sense of warmth and atmosphere, after practical testing and innovation, the following four methods were finally adopted:

2.3.1 Lighting Positions and Lighting Angles

Three-dimensional scene production process, the layout and application of lighting is an important part[10]. The outdoor three-dimensional scene is mainly based on natural light, which is sun light, the location of the light and the angle of the light in the three-dimensional scene design plays a crucial role.In the project practice: the use of

45-degree angle lighting can enhance the atmosphere of the scene, make people feel comfortable and relaxed, and let the viewer better feel the cultural context conveyed by the city. In addition, choosing a sunset light angle of less than 45 degrees, avoiding the strong light at noon, will enhance the expression of the scene's emotion and create a comfortable and warm feeling of light.

2.3.2 Application of Warm Colours

For the application of warm colours, there are two main aspects, on the one hand, lighting, warm lighting is more likely to make people feel warm, comfortable and pleasant. With HDR, on the other hand, the warm light is matched with the HDR display effect to make the light more realistic. When using DHR, remember the first choice to create the dome light and copy the already created HDR instance to the dome light. The direct light channel in the V-Ray rendering gets the lighting information, which makes the calculation of the direct light more accurate, the lighting effect is better, and it directly affects the sense of realism and atmosphere of the screen.

2.3.3 Soft Light Factor

Soft light is a fundamental element in the creation of a warm atmosphere and the addition of emotional depth to a scene. In previous projects, a greater focus was placed on the investigation of the interaction between light and the elements within the scene, with a particular emphasis on the strategic addition of tree branches to cast shade over the path of light, thereby enhancing the light and shadow effects.

In the current project, we have further intensified our pursuit of light and shadow aesthetics. It was demonstrated that a combination of shadow mapping techniques based on the addition of path occlusion was able to tightly integrate the subtle changes in light and shadow with the emotional expression of the scene. However, in order to maintain a sense of realism and enhance the expression of the city's culture, it was necessary to make precise adjustments to the shadow positions.

2.3.4 Creating a Hazy Image

In this project, two technological tools were employed to create a picture effect with a warm atmosphere and emotional depth. Firstly, volumetric fog was used to simulate the Tyndall effect, producing a hazy effect that allows soft diffusion of light, resulting in a richly layered and warm atmosphere. Secondly, an innovative atmospheric device was introduced to enhance the bokeh effect and deepen the haze. This device simulates atmospheric conditions, adding volumetric fog and adjusting parameters like turbulence type and noise threshold to achieve the desired picture effect. The result is a strengthened spatial sense and a hazy, defocused visual effect, as shown in Fig. 2.

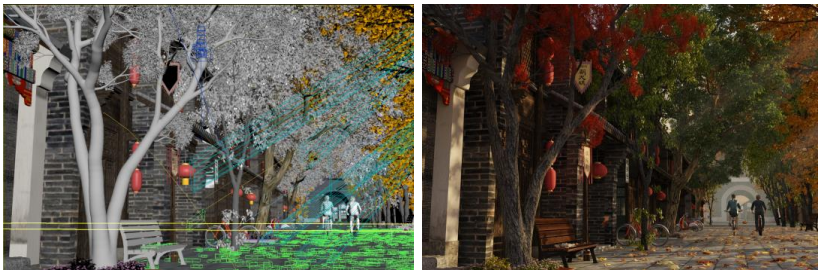

Fig. 2. Fogged light and volumetric fog effects

2.4 Reinforcement of Urban Warmth in Rendering Settings

Before rendering, color presets were fine-tuned based on real-time feedback to achieve a warm atmosphere using film tones. Key parameters like light intensity, dark intensity, linear intensity, and angle were adjusted to optimize the overall visual effect. It was observed that these parameters are interconnected, and adjusting each impacts the visual outcome uniquely, as outlined in Table 1.

Table 1. Relationship between numerical adjustment and screen

Adjustment value	Brilliant intensity	linear strength	linear angle	Dark Intensity	Description of changes
0-0.3 Smaller	brighten	Wider range of bright parts	Wider dark range	Darker	Screen brightens gradually, with large bright areas and dark areas staying dark
0.3-0.6 Medium	Enhanced brightness	Reduced range of highlights	Reduced darkness	Dark areas are brightened	Brightness increases, bright areas shrink, and dark areas change
0.6-1 Larger	Significantly brighter	Small or almost disappeared	Small or almost disappeared dark areas	Significantly brighter	The screen brightens significantly, with dark areas shrinking or almost disappearing

To guide the viewer's focus, emphasis was placed on enhancing bright areas and deepening dark areas. Practical adjustments to image parameters were made as follows: significantly increase dark intensity (0.3-0.6) and slightly raise bright parts intensity (0-0.3) to enhance depth and contrast while maintaining naturalness and brightness. Additionally, a coordinated approach was taken with linear intensity and angle: increase linear intensity to around 0.3 to narrow bright areas, and fine-tune the angle below 0.3 to keep dark areas stable, ensuring overall image balance. Effective adjustment of film tonal parameters not only guides the viewer's eye, but also enhances visual appeal and artistic effect while maintaining naturalness.

3 Design Innovations

Firstly, the application of innovative lighting layouts and light-shadow variations in creating emotional resonance and a warm atmosphere is explored in this paper. It delves into techniques such as softening light and creating a hazy effect in visuals. These innovative lighting design methods significantly enhance the ambiance of scenes, while also elevating the artistic value and expression of urban culture.

Secondly, the innovative integration of the application of urban cultural elements and light and shadow layout promotes the new development of urban culture. This paper closely combines the city's historical and cultural elements with scene design, and at the same time combines three-dimensional design and light and shadow technology to vividly present the city's culture, which enhances the audience's sense of identity and sense of belonging to the city's culture and provides a new way of thinking for cultural inheritance and development.

4 Conclusions

Taking "Yuandu Impression" as an example, this thesis discusses in depth the method of creating a warm atmosphere by light and shadow in scene design based on V-Ray rendering technology. The contribution of this study is to propose the principles of light and shadow design and rendering setup techniques to provide insights for 3D scene design and to promote the application and development of digital media art in urban cultural communication. However, this paper also has some limitations. For example, the practical process may be limited by hardware equipment and software tools, resulting in unsatisfactory performance of light and shadow effects. Future research can further explore the intrinsic relationship between light and shadow and emotion, and cope with the technical limitations to enhance the effect of warm atmosphere.

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