Immersive Interactive Design of Digital Films Based on Virtual Reality Technology

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Abstract. The 21st century is an era of rapid development in information technology, and the advancement of virtual reality technology has brought transformative impacts to film and television arts. As the seventh category of art, film and television art has been closely related to science and technology since its inception. Combining virtual reality technology with film and television art can present more distinctive features in artistic expression. Based on virtual reality technology, this article delves into the concept and practice of immersive interactive design in digital film and television, aiming to analyze the specific applications of virtual reality technology in immersive interactive design for digital film and television, and explore its development trends and challenges. It is hoped that this article can provide new ideas and directions for the development of film and television arts.

Keywords: virtual reality technology; digital film and television; immersive experience; interactive design

1. Introduction

With the rapid development of information technology, virtual reality technology is gradually infiltrating the field of digital film and television, bringing unprecedented immersive interactive experiences to the audience. As a form of modern art, digital film and television is constantly exploring the intersection of technological innovation in order to achieve richer and deeper artistic expressions[1]. Against this backdrop, immersive interactive design for digital film and television based on virtual reality technology has emerged as a research hotspot in the field of film and television arts.

Rudolf Arnheim, a German-American art theorist and psychologist, believes that visual thinking can be divided into two parts: thinking and perception, which complement each other. In the perceptual part, images can be created at different levels of abstraction. The images in visual perception activities are mainly aimed at grasping and capturing interesting and meaningful forms, and further perceiving the essence and most prominent structural features of the observed object[2]. The Gestalt principle further points out that people's judgment of movement does not depend on rational thinking and analysis, but on direct visual perception. That is to say, viewers can make perceptual judgments instantly when observing images without going through a complex processing process[3].

Therefore, the immersive interactive design of digital film and television with the help of virtual reality technology can be approached from the core perspective of visual thinking,

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emphasizing a user-centered design philosophy. Throughout the design process, whether it is macro-level color matching and style positioning or micro-level graphic symbols and font design, they can all constitute key elements of visual composition in user experience design. Based on this, this article takes digital film and television as the research object and carries out immersive interactive design based on virtual reality technology, aiming to summarize relevant experiences and bring certain inspiration to the development of the film and television industry.

2. Principles of Digital Film and Television Design Based on Virtual Reality Technology

2.1 Principle of Flow Immersion

In the field of digital film and television, immersive experience, as an emerging mode of creation and appreciation, is gradually becoming a research hotspot. This experience relies not only on technological innovation but also involves the deep excavation and expression of humanities and arts. The theory of flow immersion suggests that when viewers are fully engaged in an activity, they can experience a high degree of pleasure and enter a state of forgetfulness. Therefore, in digital film and television creation, creators need to carefully construct plots, scenes, and sound effects, striving to guide viewers into this state and achieve an immersive viewing experience, creating a virtual environment that is almost indistinguishable from the real world for the audience. At the same time, creators also need to focus on the audience's sense of immersion from the interactive experience of installation art. For instance, when wearing VR equipment, creators should ensure that the audience does not feel discomfort but instead feels immersed in the film's scenes, experiencing every detail and movement.

2.2 Principle of Multimodal Interactive Design

In the design of immersive interaction for digital film and television, creators need to ensure that the audience's interaction with the virtual world is natural and intuitive. Therefore, in the design process, firstly, through the integration of multiple senses, it brings comprehensive sensory stimulation to the audience, enabling them to understand and experience film and television content more deeply. For example, in film and television works, the combination of visual effects, sound effects, and motion design creates an immersive atmosphere that makes the audience feel as if they are in the film. Secondly, multimodal interactive design also focuses on the interaction between the audience and the film and television content. The audience can interact with the film and television works through physical movements, voice commands, and other methods, thereby changing the plot direction or obtaining more information. This interactive approach not only increases the audience's participation but also makes the film and television works more attractive and interesting. Thirdly, multimodal interactive design emphasizes a people-oriented design philosophy, requiring creators to fully consider the audience's needs and experiences in the creative process, designing with the audience at the center. Fourthly, creators also need to focus on the communication and exchange between the audience and the film and television content, ensuring that information

can be accurately and effectively transmitted, enabling the audience to interact with the film content more easily and freely during the viewing process[4].

2.3 Principle of Emotional Design

The core of emotional design lies in taking the user as the center and deeply exploring and satisfying their emotional needs. Based on the principle of emotional design, the immersive experience of digital film and television can be divided into three levels: visceral, behavioral, and reflective. The visceral level focuses on the appearance and initial effects of the product, the behavioral level focuses on the performance and usability of the product, and the reflective level focuses on the audience's feelings, emotions, and cognition towards the product. By integrating the design of these three levels, precise scene reproduction, role performance, and sound design can be achieved. During the film and television production process, creators need to trigger emotional resonance among the audience using relevant technologies, enabling them to experience the emotions and stories conveyed by the film more deeply, thereby enhancing their emotional experience and making it more memorable and profound[5].

2.4 Principle of Personalized Customization

Digital film and television immersive interactive design based on virtual reality technology should support personalized and customized experiences. Creators can analyze the audience's preferences and behaviors to provide them with personalized viewing content and interactive methods. The audience can adjust the parameters of the virtual environment according to their needs, choose their preferred viewing mode and difficulty, and thereby obtain a more personalized immersive experience.

2.5 Principle of Smoothness

Virtual reality technology needs to process a large amount of image, sound, and data information to achieve a high-quality immersive experience. If the technical implementation is not smooth, the quality and stability of the entire virtual environment will be affected. Therefore, in digital film and television design, it is essential to ensure that the audience's actions and interactions in the virtual world can proceed smoothly, avoiding any interruptions to the sense of immersion and providing users with a more realistic and coherent immersive experience[6].

3. mmersive VR Interaction Design in Digital Filmmaking

3.1 Scene Construction in Digital Filmmaking

In the immersive VR interaction design of digital filmmaking, scene modeling serves as a crucial foundation for building the virtual world. This process not only requires designers to possess profound three-dimensional modeling skills but also a deep understanding of the artistic nature of digital filmmaking. This design, focusing on immersive interaction, mainly involves trigger conditions, animations and sound effects during the interaction process, as well as feedback after interaction. Consequently, this design allows audience members to interact with the virtual scene in multiple ways based on multimodal interaction technology.

In terms of the specific process, firstly, a detailed analysis and planning of the scene are conducted based on the project overview and plot requirements of the digital film. This includes determining the spatial layout, lighting effects, color schemes, and other elements to ensure that the virtual scene realistically recreates the atmosphere and emotions required by the plot. Secondly, during the modeling process, this design utilizes geometric processing to create highly realistic virtual objects and scenes. Detailed attention is paid to scene details such as texture mapping and material rendering to enhance the visual quality of the scene. By simulating the effects of natural and artificial light sources, a realistic lighting atmosphere is created for the scene, further enhancing the audience's immersion. Finally, this design optimizes the virtual scene using VR technology to reduce scene complexity, ensuring smooth operation on VR devices and thereby improving rendering speed and interactive performance.

3.2 Texture Mapping for Character Models in Digital Filmmaking

Texture mapping is a crucial technique for enhancing the realism of character models, involving the mapping of images (textures) onto the surface of three-dimensional models. In the production of character models for digital filmmaking, this design divides the model into multiple grid blocks, each representing a part of the model, such as the head, body, limbs, etc. Each block can undergo independent texture mapping. As shown in Figure 1, taking the head as an example, this design subdivides it into parts such as the face and hair, and selects or creates corresponding texture images for each part. Through UV mapping technology, the relevant texture images are accurately mapped onto the corresponding grid blocks, ensuring that the textures align with the geometric shape of the model's surface.

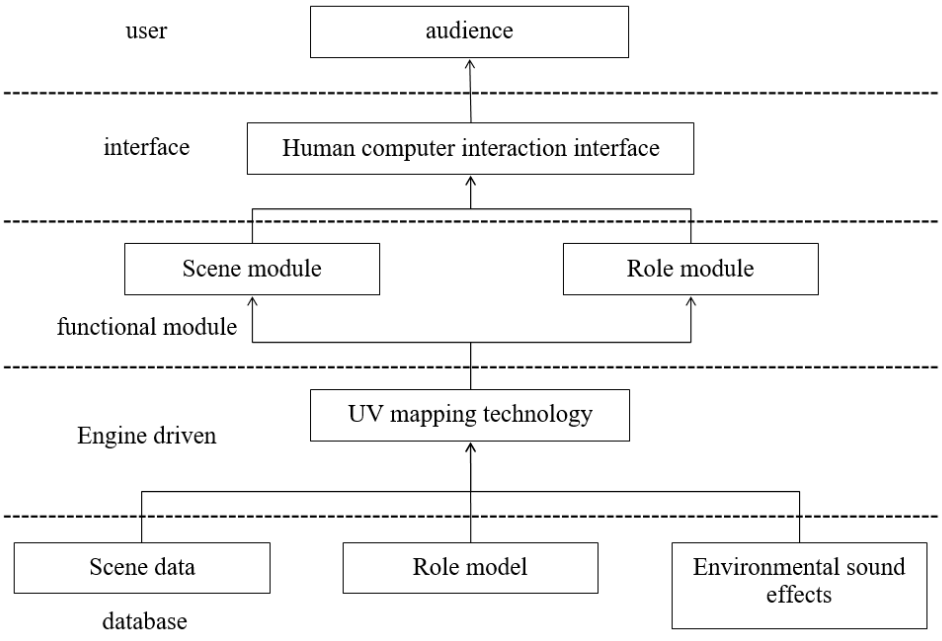

Figure 1 Implementation derivation of texture mapping technology

After dividing the model into blocks, a refinement process is applied to the triangular mesh of each block. For instance, in the texture mapping of the face, to capture the subtle changes in skin texture, this design eliminates sharp edges and adds more triangular meshes to capture finer details. This allows for a more precise representation of skin texture and quality during the texture mapping process. When viewers engage with the film using interactive equipment, they can utilize technologies such as gesture recognition, voice recognition, and eye tracking to enrich their interactive experiences.

3.3 Sound Design in Digital Filmmaking

The experimental evaluation metrics employed in this paper include Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and the coefficient of determination (R2). MAE reflects the true error and is desirable to be as small as possible. RMSE, on the other hand, accumulates errors and is more sensitive to outliers. The formulas for MAE and RMSE are presented in Equations 1 and 2, X_i respectively, where represents the predicted label of a sample, and Y_i represents the actual label of a sample.

$$MAE = \frac{\sum_{i=1}^{n} \left| X_i - Y_i \right|}{N}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} \left(X_i - Y_i \right)^2}{N}}$$

The coefficient of determination (R^2) represents the degree of fit and adaptability of the regression model. A higher value indicates better model performance, with the predicted data curve closely approximating the actual data curve. The formula for R^2 is shown in Equation 3:

$$R^2 = 1 - \frac{\sum_{i=1}^{N} \left(\hat{e}_i - e_i \right)^2}{\sum_{i=1}^{N} \left(e_i - \overline{e}_i \right)^2}$$

In this equation, $\hat{e}_i$ denotes the predicted label of a test sample, e_i represents the actual label, and $\overline{e}_i$ is the average of the actual labels in the test set.

Based on the above approach, comparisons of experimental results using machine learning models, deep learning models, various emotion-based features, and mainstream models reveal that the combination of the CLDNN_BILSTM model with fused features enables a scientific design of emotions in digital film sound effects. This facilitates a deeper understanding of the plot and character emotions for the audience during interactions, creating a more realistic and engaging digital filmmaking experience that immerses the audience and delights them with the joy of interacting with the virtual world.

4. Implementation of Immersive VR Interaction in Digital Films and Television

To delve deeply into the difficulty of digital film and television interaction under immersive interactive design using VR technology, this article invited 30 digital film and television professionals from the local film viewing association to watch movies in both immersive interactive design and conventional 3D cinemas. Subjective surveys were conducted to collect data on interaction difficulty, and the results are presented in Figure 2.

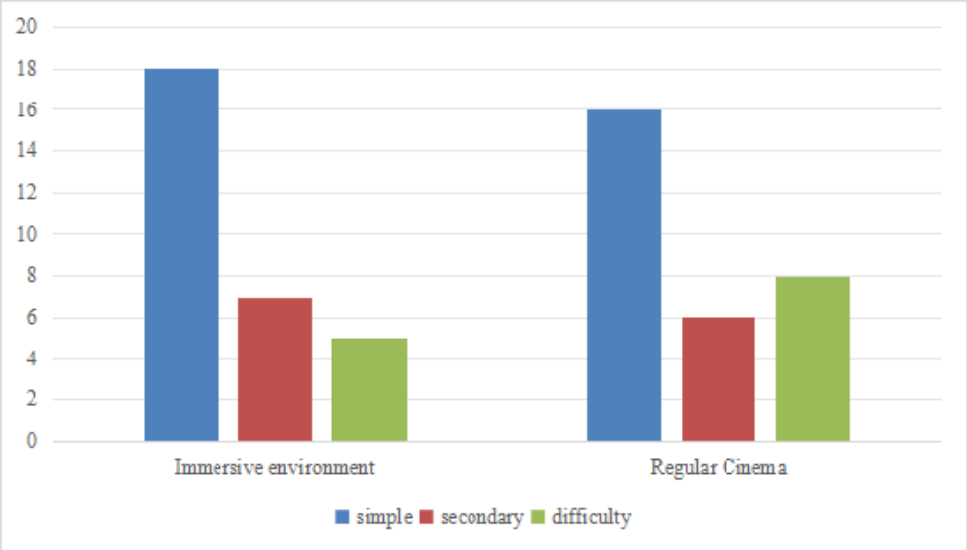

Figure 2: Comparison of Interaction Difficulties in Different Scenarios

Firstly, it was observed that in the immersive environment, 18 designers considered the difficulty of using VR technology for immersive interactive design to be simple, accounting for 60%. This indicates that in an immersive environment, the design logic and operation methods of VR technology are more intuitive, helping designers to quickly get started and efficiently complete their design work. Additionally, 7 designers rated the interaction difficulty as moderate, accounting for 23.3%, while only 5 designers considered it difficult, accounting for 16.7%. In contrast, in a conventional cinema, 16 designers rated the interaction difficulty as simple, accounting for 53.3%, slightly lower than in the immersive environment. This suggests that although VR technology can be used in conventional cinemas, it may lag behind the immersive environment in terms of operational convenience and intuitiveness. Meanwhile, 6 designers rated the interaction difficulty as moderate, accounting for 20%, similar to the immersive environment. However, it is noteworthy that 8 designers considered the difficulty of using VR technology for immersive interactive design in a conventional cinema to be challenging, accounting for 26.7%, significantly higher than in the immersive environment.

Based on these findings, the experimental results indicate that VR technology indeed possesses a lower interaction difficulty and good interaction effects in immersive interactive

design. Especially in an immersive environment, its advantages become more apparent, significantly enhancing designers' operational experience and work efficiency. Therefore, in future digital film and television practices, we can further promote and apply VR technology, especially in immersive environments, to fully leverage its advantages and improve design quality and efficiency.

5. Conclusion

In summary, this experimental comparative analysis provides strong data support for the difficulty of digital film and television interaction using VR technology in immersive interactive design. Through in-depth analysis of the experimental results, we can better understand the application advantages and challenges of VR technology in different interactive environments, providing valuable references for future digital film and television practices.

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