[1]Yuanyuan Ji

Movie Scene Simulation and Rendering Based on Virtual Reality Technology

Journal of Electrical Systems

Abstract: - Movie scene simulation and rendering with virtual reality (VR) technology have emerged as a game-changing method in the film industry, providing filmmakers with unparalleled creative opportunities and immersive storytelling experiences. This article investigates the use of VR technology in movie scene simulation and rendering, with a focus on sophisticated modelling techniques and rendering methods. Filmmakers can effectively control scene complexity and enhance rendering speed by utilizing VR-based modelling approaches such as multi-resolution decomposition and level of detail (LOD) rendering. These modelling techniques enable the development of highly complex and realistic virtual worlds, allowing filmmakers to bring their creative visions to life with unparalleled precision. In addition, VR-based rendering technologies, such as viewpoint-based geometric chunking rendering, improve frame rates and overall scene rendering quality, resulting in a seamless and immersive watching experience for audiences. Using VR technology, filmmakers can push the boundaries of traditional filmmaking, create fascinating cinematic experiences, and reimagine narrative in the digital age. This research explores the revolutionary impact of VR technology on movie scene simulation and rendering, emphasizing its potential to change the way films are created, seen, and appreciated by audiences throughout the world. Finally, they compare and assess the scene effect, LOD detail level, and interactive experience effect before and after simplification. scene design for virtual reality technologies generally scores 5-6 on each of the measures, whereas common technology's scenario design usually gets 3 to 4, showing whether the scenario design of virtual reality technology works properly.

Keywords: Virtual Reality (VR), Light model, Morphing techniques, Scene design.

I. INTRODUCTION

Virtual Reality (VR) technology has transformed many industries, including the film and entertainment sectors. Movie scene simulation and rendering employing VR technology provide filmmakers and consumers with unsurpassed immersive experiences. This introduction discusses the fundamental characteristics and ramifications of using virtual reality to create and visualize movie scenes [1].

Virtual Reality technology involves the production of a simulated environment that either mimics real-world events or generates wholly novel universes. It uses powerful computer-generated imagery (CGI), immersive sound effects, and interactive components to transport people to virtual places. VR technology enables filmmakers to construct and envision elaborate scenes with incredible realism [2]. Using VR, filmmakers may replicate complicated scenarios ranging from historical events to futuristic landscapes, allowing for imaginative storytelling [3].

Rendering in VR is the technique of creating lifelike graphics within virtual environments. VR's superior rendering techniques allow for the development of breathtaking images with realistic lighting, textures, and effects, boosting the whole cinematic experience. The use of VR technology in movie scene simulation and rendering has important ramifications for the film business [4]. It gives filmmakers new opportunities for storytelling, interactive storylines, and audience participation. Furthermore, continual improvements in VR technology and software continue to push the limits of what is possible in cinematic immersion. As VR technology advances, the possibilities for movie scene simulation and visualisation expand exponentially, promising to transform the way films are created, experienced, and loved [5].

This introduction lays the groundwork for delving into the deep nuances and breakthroughs in movie scene simulation and depiction using Virtual Reality technology. This work explores the use of virtual reality to model film and animation scenes, construct lighting models, identify texture pattern coordinates, and replace features through texture mapping [6]. The scene is produced using a local rendering approach called scene chunking [7]. It is clipped into 100 sub-scene cells of 10*10 using a regular grid, and every node is displayed using Viewpoint-based geometrical chunking. The Morphing technique simplifies and smoothes the scene. The study compares the impact of scene simplification and LOD detail levels on GEQ, feel of existence, and visually and

[1] *Corresponding author: Jiaxing Nanyang Polytechnic Institute, Jiaxing, Zhejiang, 314000, China, yoyo12282024@163.com

emotionally impact in designing scenes for films and animations using virtual reality versus conventional approaches [8].

II. Literature Survey

Hu et al [9]. employed a dynamic method to model animation trees. They recreated realistic branches using images and films, calculated leaf parameters utilizing the Fourier transformation and applicable the information to a simpler structure to generate tree animations.

Jiang et al [10]. evaluated designing an animation using computer graphics concept and advised reforming instructional methods for improved results. The paper discusses the current state of movie animation movement design and manufacturing, including its characteristics and master methods. This paper discusses common animation problems and solutions, as well as the differences in design and performance across different forms of animation. It focuses on motion animation design and production, emphasizing movement, exaggeration, force, and rhythm.

Wang et al [11]. proposed using optical positioning techniques for precisely identifying the camera and character places, as well as Inertia pose sensors may record numerous character poses for real-time virtual filmmaking and simultaneous movement capturing.

Xu [12]. developed a 3D face modelling system that uses the LBF algorithm to identify capabilities, Gabor capabilities for score matched as well as convolutional neural networks for reconstruction.

Ren et al [13]. used machine learning and computer vision to analyse large amounts of animated movie data. The work uses computer vision and machine learning technology as a foundation to investigate new methods and methods for implementing cinema visual expression and presents appropriate thinking to encourage the innovative growth of movie visual expression on the strategic level.

Tsai et al [14]. constructed a digital multimedia animation system, studied its features and evolution history, and developed animation design concepts and procedures.

Pan et al [15]. explored the effect of virtual reality technology on designing animation and developed a gesture detection method for a human-computer communication system.

III. Methodology

A. Modelling techniques using virtual reality

1) Lighting model: Lighting modelling is a critical component of 3D object modelling. Lighting sources may be characterized as directed, point, or aggregated. The sun is an example of a directed light source, which produces light in parallel from an endless distance. Since this light point has no place, it has an countless series and maintains its strength as distance increases. A point source produces light in every direction with identical intensity as the light generated from a point source. To adjust light intensity from a point source, we often utilize the opposite side of a quadratic equation.

2) Model material: Material describes an object's texture and how it interacts with light. The creator offers 64 materials and allows for customisation to fit specific demands. Customized materials are characterized by their transparency, reflectivity, diffuse light colour, ambient light colour, radiant light colour, and reflective light colour. Transparency and reflectivity are set numerically, while the other parameters are described in terms of colour, allowing for colour editing. The metallic texture of a material is determined by its reflectance, with higher values indicating a brighter reflection. Transparency refers to a material's degree of transparency and how it exhibits its glass properties. Ambient light is low-intensity and comes from all directions. Its colour remains constant. When diffuse light hits an item, it scatters in all directions, resulting in uniform colour reflection. Reflected light is the colour of light projected by a mirror, typically white. Emitted lights are the homogeneous luminosity of the thing on its own.

3) Textured mapping: Textured refers to the surface features of a thing. Adding texture to a virtual object enhances its realism. Texture mapping can provide a visual effect without requiring more data, making it suitable for virtual reality. To generate colour textures, first define the texture pattern's coordinate region and then transfer points on the item's surfaces to points within the texture area, also known as mapping. The textured mapping tool applies textured to a landscape design. Environmental mapping enhances the realism of virtual scenes.

B. Image alignment for scene design using multi-resolution decomposition.

Image alignment in scene creation using multi-resolution deconstruction is a technique that divides images into multiple sizes or resolutions. Each scale gives a distinct level of precision, allowing for more precise adjustments during the alignment process. To maintain coherence and consistency in scene design, images are aligned by comparing related features or structures across these resolutions. This method not only improves visual quality by removing artefacts, but it also increases total image clarity. Furthermore, it enables the creation of efficient alignment algorithms, resulting in faster scene processing and optimization.

C. Approach for rendering virtual reality scenes.

1) Scene chunking-based approach for local rendered and proximity control: It describes dependent on the scene chunking, a local rendering strategy that streamlines the rendering process while also simplifying node positioning and adjacency planning. The approach separates the scene into 100 sub-scene cells using a regular grid, each 10*10 in size. Each sub-cell is numbered and saved according to its location, as well as the model data it includes. Each node uses viewpoint-based geometric chunking rendering to decrease the number of models rendered every frame. When looking for nearby nodes, each node generates a list of nodes situated inside the nine sub-scenes that surround its centre, known as neighbour nodes. This technique only allows for the synchronous transfer of information between neighbouring nodes, reducing information transmission and improving system scalability.

2) Mahalanobi-based Algorithm for Ensuring Entity Uniqueness: The Mahalanobi-based Algorithm for Ensuring Entity Uniqueness is a mechanism for ensuring the uniqueness of entities within a system. It uses the Mahalanobis distance, a statistical measure that takes into account correlations between variables, to determine how similar entities are. The algorithm finds each entity's uniqueness within the system by examining its traits or attributes and computing their Mahalanobis distances. Entities with comparable characteristics will have shorter Mahalanobis distances, indicating a greater possibility of being duplicates. The algorithm then uses control mechanisms to ensure uniqueness, such as rejecting entities with Mahalanobis distances less than a specific threshold or taking corrective action to settle conflicts. This approach allows for effective control of entity uniqueness, lowering the risk of redundancy and inconsistency in the system while maximizing resource use and improving overall system performance.

D. Hybrid Simplification Technology for Scene Design using Virtual Reality.

1) Error metrics: Error metrics measure the largest angular divergence between a node location and its corresponding representation in the recorded image.

2) Transformations between geometry and texturing: To convert geometry to texture, divide the model into areas and apply different operations to each. Figure 1 illustrates the spatial partition boxes for each section.

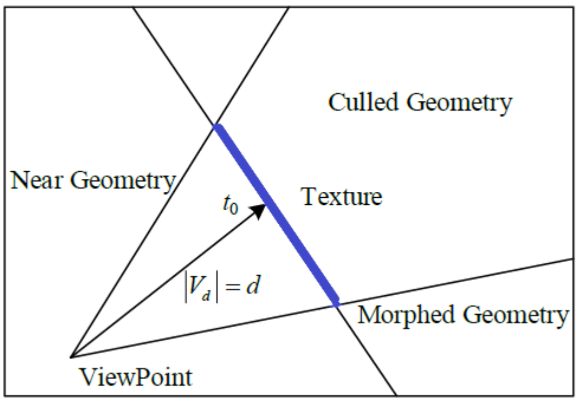

Fig 1: Model segmentation.

The textured measurements are parallel to the screen's dimensions. The texture should not be gradually projected to geometric coordinates while the initial changeover from geometry to texture. Next geometry will be displayed straight on the texture plane.

3) Morphing method in seamless transitions: The morphing approach creates distinct points and similarities among the real geometry and projected point on the textured area. It then tries to introduce the relationship between these points. Fig 2 depicts the graphical morphing process.

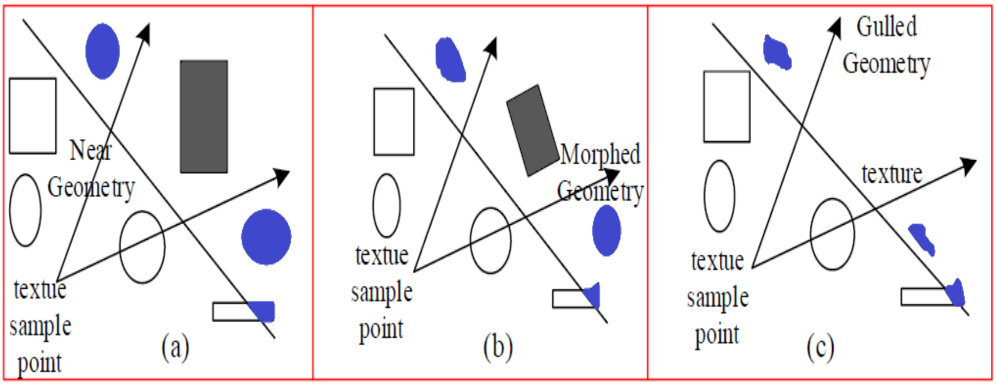

Fig 2: Morphing procedure.

The user manually enters the first points corresponding to the original image, which are subsequently gathered in a plane. The coordinates inside every triangle is going to be automatically created in the distant future.

IV. Results

A. *Analysis of virtual reality scene design in movie and TV animations.*

1) Analysis of virtual scenes before and after simplification: In the simulated situation, the model's graphic effects before and after simplification of the partially intercepted film and animation scene is compared. There is no obvious difference between the models in the static visual map, which has a good visual effect. In addition, there is no significant difference between the visual effect of the simplified model and the original model after adding textures, which shows that texture mapping can be an effective means to reduce the amount of mesh data while maintaining a realistic appearance. After the simplification process, the rendering efficiency of the whole scene was significantly improved. At this point, not only the realism of the graphics is maintained, but also the real-time nature is satisfied, which is a more feasible method. Table 1 shows the summary of the experimental data of scene simplification.

Table 1: Overview of Research Data for Scenario Simplification.

Place Name	No. of models	No. of noodle sheet	Peripheral state	FPS	Graphical enhancements
Unique scene	24700	266400	Static	34	High realism, poor real-time.
			Dyna-mic	19	
Simplify scene	23500	178700	Static	35	Great realism along with excellent real-time performance
			Dyna-mic	30	

In simplistic situations, static and dynamic states have slightly differing frame rates, although not considerably so. This is due to the lower data complexity, which gives the system more processing time for smoother image rendering. Frame rates vary greatly in the original scenario due to the machine's difficulty in uploading and displaying large volumes of data. This difficulty frequently causes screen slowness, especially during contextual actions. As the user's viewpoint changes, different sceneries are loaded and shown, resulting in an uneven image with reduced smoothness.

2) Level of Detail (LOD) comparison: The Level of information (LOD) approach is employed for rendering models with different degrees of information in real-time. As the viewing distance lowers, the model's detail level adapts to preserve the highest visual fidelity. Unity3D's built-in LOD tool is used to customize scene models at four different degrees of detail. As the camera travels with the user, models lose complexity and detail as the camera distance rises, with LOD0 to LOD3 indicating increasing degrees of detail degradation. LOD2 preserves the object's overall contour, whereas LOD3 indicates the farthest camera distance, hiding the model to conserve system resources. To prevent screen flickering during model state transitions, the LODbias parameter in Unity3D's LOD correctness panels serves as a storage unit, with a value of 15 in this study ensuring stability and smoothness when switching models.

B. Experience interaction analysis

The research included 10 highly educated persons aged 22-35 who did not have prior experience with virtual reality equipment. After a 5-minute preparation period, 10 participants were able to participate in the CAVE experience simultaneously without assistance. The event ended with the completion of a questionnaire.

1) GEQ Experiences and Sensing Effect Assessment: In this research, they use a traditional experiences question to examine the sense of immersion, fluency, competence, challenge, good and negative emotions, and restlessness/annoyance. Richter's five-point scale was used to rate the experience as 0-not at all, 1-a little, 2-the medium, 3-good, and 4-very good. The average score for each dimension can indicate the experience effect of that dimension. In this research, we use *s* to represent the average score attained for each item over 10 questionnaires. *i* represents the question number. *j* represents the questionnaire serial number. The average score for each question is calculated using equation (1).

$$S_t=\sum_{j=1}^{10} a_{if}, i = 1,2,3,\cdots 33 \quad \ldots\ldots\ldots\ldots (1)$$

The research discovered high mean scores for immersion (3.96), positive emotion (3.56), mind flow (3.46), and competence (4.86) aspects, while challenge (0.7), negative emotion (0.1), tension (0.10), and concern (0.1) dimensions scored low. The virtual environment, with its extensive high-definition and field-of-view coverage stereoscopic imageries, closely resembles real-life settings, contributing to excellent immersion ratings. Fig 4 displays the average score for every aspect of the GEQ experience.

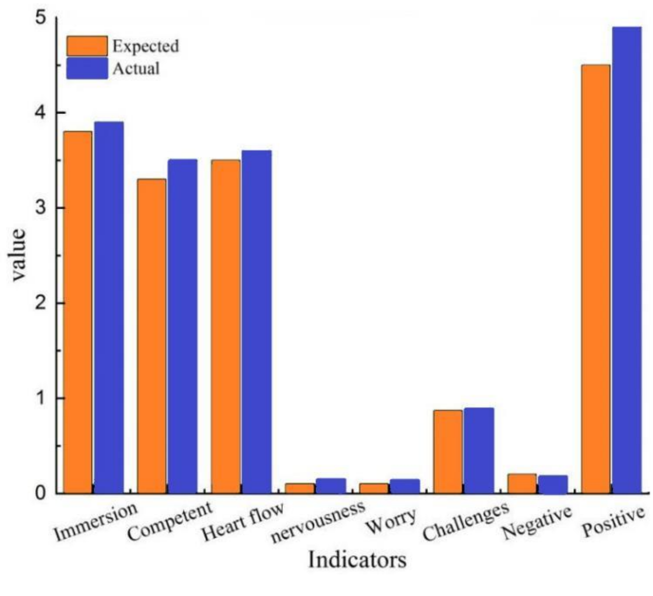

Fig 3: The average scores for every aspect of GEQ experiences.

Additionally, the 3D model accuracy and realistic behaviour of virtual characters improve immersion. The interesting and colourful animation exercises energized participants, resulting in greater mind flow scores as they grew immersed and lost sight of time. The task's clarity and interest resulted in low tension/annoyance levels, but the challenge segment gave a few negative feelings.

2) Evaluation of the impact of proscenium: The experience of presence in virtual reality is based on both visual cues and active engagement with the virtual environment and learning tasks. This computational depiction of absorption in VR movies and TV focuses on 4 aspects: realism, equipment environment, hearing and observability, which score the maximum. Visual realism is enhanced by factors such as thorough coverage of the equipment area and high-definition imagery, while auditory immersion is improved by 3D sounds. However, tactile feedback is still a weaker aspect due to fewer tactile context sequences, indicating space for growth. Overall, adaptation/immersion and authenticity have high average values, indicating a substantial presence. While the device quality and expected consistency scores are reasonable, greater user familiarity with virtual reality interactions can improve operational efficiency.

3) Analyzing the impact of emotional and visual experiences: Visual appeal and ease in virtual reality cinema and animation refer to the aesthetic and comfort elements of the virtual experience. Emotional experience refers to users' feelings, attitudes, moods, and empathy while interacting with virtual animations. Exploration includes consumers' proclivity for critical thinking and continued exploration after seeing virtual animation. According to feedback on the visual and emotional effects of virtual reality in film and television, virtual reality-based scene design beats traditional scene design in the sense of realism, richness, comfort, visual beauty, exploration, novelty, satisfaction, and interaction. Visual element richness is higher in virtual reality-based scene design, with an average of 4.2 compared to 3.6 in traditional scene design. Virtual reality-based scene design succeeds in both visual aesthetics and comfort, with ratings above 4, indicating significant advantages over traditional design. Viewpoint, colour, material, and performance interactions also receive higher scores in virtual reality-based scene design, ranging from 5 to 6, compared to roughly 3.4 in traditional design.

V. Discussion

The study's findings show that using virtual reality (VR) technology in movie and animated scene design provides considerable benefits and advances in visual aesthetics, emotional engagement, and user interaction. The study found that VR-based scene designs exceed traditional methods in the sense of realism, richness, visual attractiveness, interaction, comfort, exploration, novelty, and enjoyment. Notably, VR-based scene designs had greater visual element richness scores and outstanding evaluations for visual aesthetics and comfort, demonstrating VR's ability to generate immersive and visually appealing environments. Moreover, VR-based designs excel in promoting user involvement, with aspects such as viewpoint, colour, material, and performance interactions scoring much higher compared to traditional designs. These findings highlight the revolutionary potential of VR technology in improving the overall quality and engagement of film and animation experiences. Furthermore, the study reveals that VR-based scene designs stimulate users to explore and think critically, resulting in greater engagement and enjoyment. Overall, the findings highlight the practical benefits and positive impact of adopting VR technology into film and animation production, opening the door to more immersive and captivating narrative experiences in the future.

VI. Conclusion

This research highlights the substantial benefits and revolutionary power of virtual reality (VR) technology in cinema and animation scene creation. Creators may improve visual aesthetics, emotional engagement, and user interaction by using immersive VR-based designs, resulting in more captivating and immersive audience experiences. The study found that VR-based scene designs outperformed traditional methods in the sense of realism, richness, visual attractiveness, interaction, comfort, exploration, novelty, and enjoyment. Furthermore, VR-based designs promote user exploration and critical thinking, resulting in greater levels of engagement and happiness. These findings highlight the practical benefits of adopting VR technology into film and animation production, providing filmmakers and animators with new tools and strategies to enhance their storytelling and create more immersive and fascinating experiences. As VR technology advances, we may expect more developments in movie scene simulation and visualization, which will eventually shape the future of filmmaking and entertainment. The use of VR technology has enormous promise for improving the creative process and providing exciting cinematic experiences to audiences throughout the world.

References

[1] X. Yuan and H. Huixuan, "The Fusion Method of Virtual Reality Technology and 3D Movie Animation Design," Int. J. Adv. Comput. Sci. Appl., vol. 14, no. 11, pp. 993–1004, 2023, doi: 10.14569/IJACSA.2023.01411101.

[2] L. Kuo, "Emerging Technologies on the Prosperity of Image, Film, and Television," Emerg. Media, Feb. 2024, doi: 10.1177/27523543241229243.

[3] J. Zhang and Y. Feng, "Research on the Creative Performance of Digital Film and Television Works Based on Virtual Reality Technology," Appl. Math. Nonlinear Sci., vol. 9, no. 1, Jan. 2024, doi: 10.2478/amns-2024-0633.

[4] Y. Zhang and I. Weber, "Adapting, modifying and applying cinematography and editing concepts and techniques to cinematic virtual reality film production," Media Int. Aust., vol. 186, no. 1, pp. 115–135, Feb. 2023, doi: 10.1177/1329878X211018476.

[5] Z. Gao, "Application of 3D Virtual Reality Technology in Film and Television Production Under Internet Mode," in Lecture Notes on Data Engineering and Communications Technologies, Springer Science and Business Media Deutschland GmbH, 2023, pp. 341–349. doi: 10.1007/978-3-031-31775-0_35.

[6] Z. Yu, C. L.-P. V. and A. Reality, and U. 2024, "Mapping the Viewer Experience in Cinematic Virtual Reality: A Systematic Review," direct.mit.eduZ Yu, CH LoPRESENCE Virtual Augment. Reality, 2024•direct.mit.edu.

[7] P. Chanpum, "VIRTUAL PRODUCTION: INTERACTIVE AND REAL-TIME TECHNOLOGY FOR FILMMAKERS," Humanities, Arts and Social Sciences Studies, vol. 23, no. 1. pp. 9–17, 2023. doi: 10.14456/hasss.2023.2.

[8] Y. Gao, "The application of digital media art in film and television animation based on three-dimensional interactive technology," Appl. Math. Nonlinear Sci., vol. 9, no. 1, Jan. 2024, doi: 10.2478/amns.2023.2.00313.

[9] S. Hu, Z. Zhang, H. Xie, and T. Igarashi, "Data-driven modeling and animation of outdoor trees through interactive approach," Vis. Comput., vol. 33, no. 6–8, pp. 1017–1027, Jun. 2017, doi: 10.1007/s00371-017-1377-6.

[10] J. Tan, "Evolution of Art Form of Video Animation Design Under the Background of Computer Graphics System Development," DEStech Trans. Soc. Sci. Educ. Hum. Sci., no. ssme, 2017, doi: 10.12783/dtssehs/ssme2017/12947.

[11] Y. Wang, Y. Wang, and X. Lang, "Applied research on real-time film and television animation virtual shooting for multiplayer action capture technology based on optical positioning and inertial attitude sensing technology," J. Electron. Imaging, vol. 30, no. 03, 2021, doi: 10.1117/1.jei.30.3.031207.

[12] L. Xu, "Fast Modelling Algorithm for Realistic Three-Dimensional Human Face for Film and Television Animation," Complexity, vol. 2021. 2021. doi: 10.1155/2021/3346136.

[13] Y. Wan and M. Ren, "New Visual Expression of Anime Film Based on Artificial Intelligence and Machine Learning Technology," J. Sensors, vol. 2021, 2021, doi: 10.1155/2021/9945187.

[14] R. Jiang, L. Wang, and S. B. Tsai, "An Empirical Study on Digital Media Technology in Film and Television Animation Design," Math. Probl. Eng., vol. 2022, 2022, doi: 10.1155/2022/5905117.

[15] X. Liu and H. Pan, "The Path of Film and Television Animation Creation Using Virtual Reality Technology under the Artificial Intelligence," Sci. Program., vol. 2022, 2022, doi: 10.1155/2022/1712929.