Postprint: Analysis of 3D Animation Application in Frontier Film and Television Special Effects Technologies Through "Avatar"

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Abstract

Three-dimensional (3D) technology is currently undergoing rapid development, significantly impacting the evolution of the film industry. Both animated productions such as *Toy Story* and feature films like *Avatar* have comprehensively applied 3D technology throughout their filmmaking processes, thereby fully actualizing its potential. Three-dimensional cinema provides audiences with a visual spectacle while equipping creators with advanced technologies for computer-generated (CG) character creation, cinematography, and display systems.

Full Text

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Viewing the Application of 3D Animation in Cutting-Edge Film Visual Effects from *Avatar*

Abstract: 3D technology is in a period of rapid development and has profoundly influenced the film industry. Both the animated film *Toy Story* and the movie *Avatar* have fully integrated 3D technology into their production, harnessing its value to the fullest extent. 3D films provide audiences with a visual feast while offering creators advanced CG character production techniques, shooting technologies, and display technologies.

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1. The Specific Meaning of 3D Technology and 3D Film

1.1 The Concept of 3D Technology

3D stands for "Three Dimensions," where "Dimension" represents a dimension. "Three Dimensions" generally refers to three dimensions. A three-dimensional description of an object typically includes length, width, and height to form what we call a "solid." Thus, every solid object in three-dimensional space includes three attributes: length, width, and height. In 通俗 terms, 3D is the opposite of two-dimensional planar objects with only length and width.

When humans view objects with both eyes, the distance between the two eyes causes them to see objects from different angles. If one eye is covered, the visual effect differs significantly from binocular vision. In fact, viewing with both eyes can present perception in three dimensions—vertical, horizontal, and depth—forming stereoscopic vision and mapping everything in real space to our eyes in a three-dimensional form.

1.2 The Meaning of 3D Film

3D film differs technically from traditional film in many ways. During shooting, 3D film employs new shooting methods based on optical principles. When watching 3D films, audiences need to wear special stereoscopic glasses; otherwise, due to the polarized light technology used in 3D films, many images cannot be viewed properly. After wearing glasses made with polarizing filters, the polarizing effect of light creates a stereoscopic visual experience. People define this type of film that provides an immersive stereoscopic experience as 3D film. 3D film presents stereoscopic effects by superimposing two different images and utilizing the difference between left and right eye vision and the brain's image processing capabilities. Through polarizing filters in 3D glasses, the light received by the left and right eyes is distinguished: the left eye can only see images shot from the left side during filming, and the right eye can only see images shot from the right side. After the images are transmitted to the brain, they are processed into stereoscopic images.

For film creators, the category of 3D film is not limited to the above content. All films that apply 3D technology should be called 3D films. For example, the animated film *Toy Story* applied 3D film technology during production, making it a type of 3D film as well.

2. The Application Scope of 3D Technology in Film Production

2.1 Script Discussion

For a film like *Avatar*, reasonable and meticulous planning must be conducted before shooting begins. It is necessary to understand the director's main creative requirements while also communicating with relevant technical staff and preparing the required equipment. Whether the film script can ultimately be approved largely depends on whether the production process can perfectly present the images conceived by the director and achieve the desired picture quality. Cameron once stated that when *Avatar* was in the conceptual stage, the technology at that time was completely incapable of realizing the images he envisioned.

2.2 Concept Design and Storyboard Production

Concept design includes characters, props, and 2D scenes, thereby determining the overall style and color tone of the film. Storyboards are created through shot-by-shot filming based on the script, depicting corresponding plots through activities of 2D scenes, architecture, and other 镜头. The work of these two stages provides sufficient visual references for later 3D film production.

2.3 3D Model Design

The design of 3D models is crucial for 3D films themselves. 3D models constitute the most important visual components of an entire 3D film, including the 3D production of scenes and characters. The entire process is completed by technical personnel using relevant software.

2.4 3D Scene Construction

In the process of establishing 3D scenes, there are two main technical methods that can meet the requirements, which are also the two most commonly used approaches. First, using computer software's 3D scene modeling technology to complete the production of 3D scenes. This method has significant drawbacks: firstly, the workload is enormous, making it difficult to complete in a short time, and the technical requirements are relatively high, increasing overall production costs. Secondly, the images produced using computer software have significantly reduced realism, with overall low picture quality that shows a clear gap compared to real filmed footage.

The second method involves using 3D tracking technology for shooting. Real scenes are first shot with a camera, then post-processed with a computer to restore them into computer models. Compared to scenes made purely with computer software, this model of constructing 3D scenes requires relatively less workload, which is beneficial for controlling film costs. At the same time, because it shoots real scenes, the picture quality is very strong, and the realism is

incomparable to computer simulation software. Additionally, during the shooting process, 3D photography techniques can be integrated into the footage, which greatly benefits post-production 3D visual effects and can lay the foundation for later production.

2.5 Texture Mapping and Lighting Effects Production

Lighting effects production is handled by lighting artists who meticulously depict materials to establish the overall color tone of CG scenes, then use lighting effects to render each shot.

2.6 Animation

Animators can present story content to the audience shot by shot according to specific plot needs. The presentation of story content requires animation. The objects of animation setting are characters or other active scenes. During the setting period, manual keyframe setting or motion capture devices can be used. The choice of setting scheme depends on specific action scenes, but the ultimate goal is to make character expression more vivid. For example, in *Avatar*, director Cameron used advanced technology to carry out motion capture.

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3. The Application of 3D Animation in Film Visual Effects

3.1 3D Shooting Technology

3.1.1 Live-Action Shooting To better shoot real scenes with 3D visual effects, all 3D live-action shooting systems are essential. When director Cameron conducted high-difficulty shooting, he improved the 3D live-action operation, solving the defect in original 3D shooting where difficult shots were hard to achieve due to bulky cameras. 3D live-action shooting is composed of a camera and two high-definition lenses. High-definition lenses are used because they are smaller in volume, convenient to move, and can capture different angles. The camera is larger in volume and very bulky, inconvenient to move, making some angles difficult to reach. However, the camera's stability and picture quality cannot be achieved by high-definition cameras alone. Therefore, the two must cooperate, using their respective advantages to flexibly adjust the camera and high-definition lenses. Using beam splitter filters in conjunction with different digital lenses allows all scenery to directly enter the lens. Under different refraction and reflection paths, two cameras record separately, just like our eyes, providing different visuals and feeding all perspective information to the brain, thus forming three-dimensional vision.

3.1.2 Virtual Shooting System Virtual shooting involves shooting 3D scenes in virtual CG environments using virtual cameras. When shooting, all physical scenes within the scene must first be recorded with a camera. Through

positioning and tracking, after completing scene setup, 3D model software is used for post-production of characters or auxiliary scenes, transforming the real scenes existing in the computer into combined virtual-real scenes. When presenting virtual scenes, virtual cameras should be used more frequently to change different angles and directions.

3.2 3D Image Presentation Technology

To view real 3D scenes in a cinema primarily relies on the technical infrastructure of 3D imaging. The content involved in 3D imaging is quite complex, with both advantages and disadvantages in application. Therefore, when viewing, it is necessary to consider which approach can achieve the best visual effect. Considerations should start with equipment conditions, 3D film data, and other factors. For instance, the well-known *Avatar* uses glasses-type 3D imaging technology in cinemas, specifically polarized 3D imaging technology. The reason is that the 3D shooting technology employed during *Avatar's* production all utilized single-camera dual-lens shooting, where the two lenses function similarly to human eyes. This type of 3D shooting technology generates data formats that are compatible with specialized glasses-type 3D imaging technology. However, glasses-free 3D imaging technology requires comprehensive 3D data information.

In 3D imaging presentation technology, the required equipment can be divided into two categories: The first category is glasses-type 3D imaging presentation technology, where all audience members must wear stereoscopic glasses. These glasses enable the left and right eyes to see different visual images—3D imaging presentation technology is actually based on this principle. The second category is glasses-free 3D imaging presentation technology, which allows audiences to obtain authentic 3D visual presentation without wearing any stereoscopic glasses.

3.3 Post-Production of 3D Visual Effects

3.3.1 Single-Camera Dual-Lens In the movie *Avatar*, director Cameron used the single-camera dual-lens system he developed for 3D live-action shooting. The final images are data files processed through 3D image processing. This processing technology is generally very convenient during post-production.

3.3.2 Dual-Camera Dual-Lens If various files are generated through a dual-camera dual-lens 3D shooting system, they are two synchronized image files corresponding to the audience's left and right eyes. Since the dual-camera dual-lens 3D shooting system generates video that requires post-processing, it is essential to simultaneously import the two video files into the software during post-production, then edit these two video files, involving editing, color grading, creating post-effects, etc. If synchronization is not achieved throughout the production process, not only will the 3D visual effect presentation be greatly compromised, but the 2D visual quality will also decline. Therefore, when saving video files, the 2D video saving method is used. Hence, much of the 2D video

post-production content can be directly adjusted and edited, including EDIUS, Dayang, AfterEffect, Premiere, etc.

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4. Conclusion

In recent years, with the improvement of computer hardware levels and the popularization of 3D animation software, 3D animation technology has been increasingly applied not only in film and television but also continuously expanding in advertising, architecture, medical, teaching, and other fields. Especially with the rise of VR virtual reality technology, 3D animation has shown great potential in the simulation field, making some military and national defense fields increasingly involve 3D animation technology. It can be anticipated that future military training will be as easy as watching a movie, and ordinary audiences walking into cinemas will also be able to experience a highly realistic battle through 3D animation simulation. The war scenes in the movie *Avatar* are still vivid in our memory. This is the visual enjoyment brought to us by 3D technology. If the virtual reality field becomes increasingly mature, this film will bring us not only visual experience but also allow us to walk into the cinema and experience a real war.

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Note: Figure translations are in progress. See original paper for figures.