3D Surround Sound Audio and Sound Design for Digital Film and Television Works (Postprint)

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Abstract

Since the film and television industry entered the 21st century, 3D surround sound technology has been widely applied in film and television productions, with its technological development becoming increasingly mature. Both the audio technologies that support 3D surround sound and innovations in sound design have been continuously explored and advanced through creative practice in film and television production, while technical standards and industry norms for 3D surround sound have gradually taken shape. This paper aims to systematically summarize the current mainstream technological development of 3D surround sound and the conventional applications of sound design within this technology, providing reference for relevant researchers and practitioners from both technical and artistic perspectives.

Full Text

Preamble

3D Surround Sound Audio and Sound Design in Digital Film and Television Works

Abstract: Since the 21st century, 3D surround sound technology has been widely applied in film and television works, with increasingly mature technological development. Both the audio technology supporting 3D surround sound and innovative sound design have advanced through practical creation in film and television works, while technical standards and industry norms have gradually taken shape. This paper aims to summarize and organize the current mainstream 3D surround sound technology development and conventional applications of sound design within 3D surround sound technology, providing reference for relevant researchers and practitioners from both technical and artistic perspectives.

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1. Brief Overview of Surround Sound Technology Development

1.1 2D Surround Sound

Since the inception of sound recording and reproduction technology, it has evolved through three stages: monophonic, stereo, and surround sound. The emergence of the first sound film, *Lights of New York*, in 1929 marked the first presentation of sound technology in cinematic works. For some time thereafter, film sound was recorded in monophonic or stereo formats. The earliest experiment with surround sound in film can be traced back to 1938, when Disney's *Fantasia* first employed the company's self-developed "Fantasound" five-channel reproduction technology—comprising left, center, right, left surround, and right surround channels. This technology pioneered all subsequent surround sound technologies, initiating research into surround sound for the film industry. In the following decades, sound developers experimented with 4-channel, 5-channel, 6-channel, and 7-channel surround sound technologies, yet stereo remained the mainstream technology for film sound. The world's first film produced using 5.1 surround sound technology was *Batman Returns* in 1992, while *Toy Story 3* in 2010 was the first to be produced and released using 7.1 surround sound technology. Since then, surround sound technology has been widely applied in film production practice.

Dolby Laboratories has played a pivotal role in the industry throughout the development of surround sound technology. From the 1970s to the 1990s, Dolby Laboratories successively developed Dolby Stereo, Dolby AC-3 (also known as Dolby Digital), and DTS (Digital Theater System) surround sound technologies, gradually promoting their application in cinemas and home theater systems.

The research and development of surround sound technology has spanned decades, and academia categorizes it as single-plane, multi-channel surround sound technology. This single-plane spatial surround sound technology is based on two-dimensional plane space and falls within the category of 2D surround sound technology. In 2D surround sound systems, speakers are distributed in a two-dimensional plane approximately at the listener's ear height. Compared with stereo, 2D surround sound improves the sense of direction for various sound sources and provides better sound clarity, presence, and layering.

However, 2D surround sound also has limitations. In this environment, the optimal listening area is relatively narrow, and listeners in different positions experience significant variations. Moreover, sound localization is not sufficiently clear, sound movement is not smooth enough, the sense of immersion is not strong enough, and there exists inconsistency between the film's visual scenes and the sound.

1.2 3D Surround Sound

3D surround sound, also known as multi-layer, multi-channel surround sound, improves upon 2D surround sound technology by refining the lower-layer audio design and adding a top-layer reproduction system. It not only transmits left-right and front-back sound information in a 2D surround sound field but also conveys vertical height variations of sound within the sound field environment.

Currently, mature 3D surround sound technologies include Dolby Atmos, Barco Auro 3D (Belgium), IOSONO 3D (Germany), China's 13.1 Multi-dimensional Sound system, among others. Dolby Atmos, released by Dolby Laboratories in 2012, is currently the most widely applied and recognized film sound production and reproduction technology in the global cinema market. It was first employed in the film *Brave* in June 2012.

Dolby Atmos is built upon Dolby 7.1 surround sound technology, achieving 3D surround sound effects by improving the number of lower-layer surround speakers in cinemas and adding overhead speaker design, while maintaining compatibility with the 7.1 system.

The speaker layout for Dolby Atmos is as follows:
(1) **Lower-layer surround sound:** Based on the Dolby 7.1 surround sound system, the number of left and right planar surround speakers is increased to compensate for the original deficiencies in sound localization.
(2) **Top-layer surround sound:** Two rows of speakers are added to the cinema ceiling, aligned in a straight line with the rearmost left-center and right-center speakers. The distance between each speaker is maintained at approximately 2-3 meters, aimed at the intersection point of the central listening area's edge line and the cinema's central axis, with the speaker angle adjusted to remain within 30 degrees.
(3) **Behind-screen speakers:** Left-center and right-center speakers are added. The screen speakers are placed at two-thirds of the screen height. Bass speakers should be positioned offset from the room's central axis to prevent standing waves.

The promotion of Dolby Atmos technology in cinemas has been remarkably rapid. The vast majority of cinemas can upgrade their existing 5.1 or 7.1 sound systems to Dolby Atmos systems. Currently, over 100 film production institutions worldwide have utilized Dolby Atmos technology for post-production mixing on more than 600 films. Dolby Atmos sound systems have been installed in over 60 countries and regions, with more than 1,600 cinema screens equipped

with the technology. This explosive development has played a crucial role in promoting and innovating 3D surround sound technology. Dolby Atmos has become the mainstream technology for cinema surround sound systems, leading the trend and direction of 3D surround sound development in cinemas.

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2. Application of 3D Surround Sound Technology in Film and Television Works

Compared with traditional 2D surround sound technologies such as 5.1 or 7.1, the most significant technical innovation of 3D surround sound is the addition of overhead speaker design, along with improvements to the lower-layer surround sound and behind-screen audio. Sound transmission has evolved from a two-dimensional plane to a three-dimensional space that integrates horizontal, vertical, and depth dimensions. The resulting sound effects are more vivid and realistic, audience immersion is stronger, the overall sound integration is more uniform, sound transmission is smoother and more seamless, and sound design in film and television works has become more creative.

2.1 Sound Effects Design for Screen Objects

Sound effects design represents the most prominent and obvious transformation in creating film and television works using 3D surround sound technology, most directly bringing enormous changes and impact to the audience's auditory experience. The addition of vertical spatial dimension for sound propagation allows sound effects design to be more realistic, detailed, and stunning when integrated with picture scene details.

Static Overhead Sound Effects: Previously, in 2D surround sound technology, sounds above the head could not be authentically reproduced and could only be restored through lower-layer surround speakers. Now, utilizing 3D surround sound technology, common real-life sounds such as rain, thunder, airplane noise, and bird calls that occur above the head can be authentically represented in film scenes.

Dynamic Overhead Sound Effects: This technique authentically reproduces dynamic sound effects occurring above actors' heads in scenes where airplanes, animals, gunfire, and other elements move from far to near, near to far, front to back, or back to front within the film's visual frame.

Combined Dynamic Sound Effects: Sound designers can create various sound trajectory combinations in film scenes, such as from low to high, from left to high then to right, from front to high then to back, matching the dynamic changes of sound effects consistent with the picture scenes.

The sound effects design mentioned above all appear in appropriate positions within the film's visuals and belong to the category of conventional sound effects

design. This type of sound effects design is based on authenticity (sound effects matching visual objects on screen) and centers on the main character in the scene, creating various static and dynamic sound designs for objects appearing within the main character's visual range.

Another type of sound effects design involves virtual sound effects for screen objects. These sound effects are mostly designed for changes in the psychological activities of on-screen characters or for virtualized scene visuals.

Localization of Sound Effects: In previous 5.1 or 7.1 surround sound systems, the static and dynamic localization of sound effects was relatively vague, with rough and unnatural movement trajectories. Dolby Atmos technology features "independent sound source" technology that enables clearer and more accurate localization of sound effects. With careful listening, audiences can capture detailed trajectory changes as sounds move through each speaker.

2.2 Dialogue Design

In the era of 2D surround sound technology, dialogue and narration design was relatively conservative, typically using the center speaker behind the screen for reproduction to ensure audience audibility and intelligibility. With the support of 3D surround sound technology, flashback dialogue segments in films can utilize the four overhead front speakers closest to the screen and the behind-screen center speaker, with appropriate arrangement of direct-to-reverberant sound ratios, allowing listeners to clearly perceive better clarity and intelligibility and easily distinguish it from normal dialogue.

Another common dialogue design approach occurs in scenes with multiple characters on the same screen, where various languages and dialogues interweave. Using the main character's perspective as the axis, with other characters positioned at different orientations relative to the main character, dialogue can be assigned to different surround speakers according to the positions of different characters. This achieves precise localization of dialogue and creates a sense of envelopment, integration, and authenticity for the entire scene's sound. Fully utilizing the charm of 3D surround sound technology, dialogue design becomes more innovative and creative, breaking the previous limitation where film dialogue was always assigned to the center speaker.

2.3 Music Design

Film music scoring should be the element that utilizes 3D surround sound technology the least. Compared with film music reproduction design in the 2D surround sound era, there has been no significant change. Fundamentally, this is because music is a cohesive whole, with recording and production completed in the studio. Most recordings employ a surround sound main microphone pattern combined with auxiliary spot microphones, while reproduction primarily uses the left and right speakers behind the screen and the side and rear wall surround speakers in the cinema. During viewing, the music maintains high

overall integration, and audiences experience a strong atmospheric sense of the film's plot. Attempting to place different instrument tracks in different speakers for reproduction would intensify the destruction of musical integrity and would not conform to the habits and logic of human music appreciation.

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3. Conclusion

The exploration and application of 3D surround sound technology for sound design creation in film and television works remains in its initial stages, with various sound creation techniques and technologies still being continuously explored and summarized. The promotion of 3D surround sound technology in cinemas is relatively mature, having gained recognition from film production institutions and audiences, and will remain the mainstream for sound design creation in film and television works for some time to come.

Dolby Atmos technology has gained widespread recognition among sound design practitioners. Sound designers should leverage their understanding, imagination, and creativity regarding sound art, deeply explore the creative potential of Dolby Atmos technology, and conscientiously create more vibrant film and television works.

[1] Dolby Atmos Official Documentation.
[2] Dolby Surround 7.1 Official Documentation.

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