Postprint: Technical Advantages and Key Technologies of Virtual Studio

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Abstract

As a novel television program production technology, virtual studio can not only enhance program quality but also deliver seamless, realistic visuals that integrate virtual and real scenes, providing audiences with stunning sensory experiences. This paper primarily investigates the technical advantages and key technologies of virtual studio, aiming to demonstrate that although these technologies are diverse, they all serve the purpose of enhancing visual realism. Virtual studio technology represents a revolutionary leap forward in television program production.

Full Text

Research on the Advantages and Key Technologies of Virtual Studio Technology

Abstract: As a novel television program production technology, virtual studio not only enhances program quality but also delivers seamless, realistic imagery that blends virtual and physical scenes, providing audiences with stunning sensory experiences. This paper explores the technical advantages and key technologies of virtual studio, demonstrating that while the technologies are diverse, they all serve to enhance visual realism. Virtual studio technology represents a revolutionary leap in television program production.

Keywords: virtual studio; advantages; key technologies

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1. Technical Advantages of Virtual Studio

Virtual studio represents a cutting-edge application of computer technology in television production, offering low production costs, operational convenience, and effective support for creative expression. Its special effects capabilities far surpass those of conventional technologies, enabling the visualization of virtually any imaginable effect and creating a refreshing viewing experience. Typically, virtual studio backgrounds utilize three-dimensional computer-generated imagery rather than simple two-dimensional graphics. Although these backgrounds are virtual, they can be adjusted in real time with convenient operation, achieving true synchronization with camera movements. Virtual studio technology integrates 3D graphics, artificial intelligence, pattern recognition, and computer graphics processing. The vivid scenes viewers frequently observe are often composites of computer-generated 3D virtual environments and actual camera footage, blending reality and illusion so seamlessly that performers and settings merge flawlessly [1].

A virtual studio system primarily consists of cameras, a camera tracking system, computer graphics workstations, and a chroma key compositor—these four core components that work in concert to generate virtual scenes and composite them with foreground elements. Typically, the actual footage captured by cameras serves as the foreground, which is then combined with computer-generated 3D virtual scenes. The tracking system continuously collects and captures camera movement data, which the computer graphics workstation processes through complex calculations to generate virtual scenes that match the foreground footage. Depth keying and chroma keying then merge the foreground and virtual scenes into a single output image [2]. This technology fully satisfies the creative demands of production teams and the increasingly stringent requirements of audiences, significantly enhancing program effects and improving viewership ratings.

2. Key Technologies of Virtual Studio

2.1 Camera Tracking Technology

Virtual studio integrates the essence of computer technology as a virtual reality-based television production system. The core focus of this technology is "tracking," which centers on the camera and effectively captures relevant parameters, playing a crucial role in connecting foreground and virtual scenes to achieve seamless integration of performers and virtual environments. This technology employs different methods depending on the environment to accomplish its effects, enabling flexible transitions between reality and illusion. Common camera tracking techniques include pattern recognition, mechanical sensing, infrared sensing, and ultrasonic sensing, each with distinct advantages and disadvantages suited to different environments. In virtual studio production, 2-3 cameras are typically deployed, each equipped with motion detection and recognition systems that monitor various camera movement parameters and transmit this data

to computer graphics workstations for extensive processing. At this moment, both the physical cameras and virtual cameras move in synchronization, with the virtual cameras tracking and locking onto the real cameras in real time.

2.2 Auxiliary Camera Technology

Auxiliary camera technology is a specialized technique based on pattern recognition that uses small cameras to acquire various parameters of studio cameras. The auxiliary camera is highly convenient to install and can be mounted atop any studio camera, while grid patterns can be installed behind the camera operator, on side walls, or on ceilings in any color scheme. Capturing the grid pattern requires coordination between the auxiliary camera and the main camera: the former assists in shooting while capturing the pattern, while the latter performs the actual filming. Once the grid pattern is obtained, the signals it provides are used to acquire all data about the filming camera. This technology allows studio cameras to shoot without any constraints or limitations, participating in production from multiple angles and with various movement patterns [4].

2.3 "Garbage Matte" Technology

The "garbage matte" technology was developed primarily to fill in errors that occur during camera shooting. Production inevitably involves mistakes, some resulting from camera oversights. When cameras capture non-blue areas, revealing shots occur; the garbage matte technology automatically fills these non-blue regions, utilizing its background protection function to achieve perfect shooting. This technology can also expand the studio range beyond the blue background limitations of the studio and enables the creation of virtual ceilings.

2.4 Computer Virtual Scene Generation Technology

Computer virtual scene generation technology is a crucial component of virtual studio systems, implemented through small computer networks that serve as the control center and program production director station. Computers in virtual studios not only create 3D virtual scenes but also transmit relevant image data, coordinating with complete data obtained from trackers to perform intelligent processing and complex calculations, all to ensure seamless integration of virtual and real scenes [5].

In virtual programs, establishing 3D models is a critical task. Although virtual studio backgrounds can be diverse, 3D models are the most frequently used virtual scenes. Unlike traditional television post-production and 3D animation techniques, virtual studio 3D models can be highly imaginative, fully incorporating creative ideas to produce unique and refreshing virtual scenes that satisfy audience visual demands and deliver stunning visual effects. To enhance scene realism, modeling software can also be used to properly control lighting and model parameters, continuously refining and polishing scenes for greater authenticity. In virtual scenes, hosts can move around continuously, and virtual

objects can also move in real time, allowing hosts to interact fully with virtual objects and even hide inside them.

2.5 Lighting Technology

In television program production, lighting technology is indispensable, and similarly represents an important technology in virtual studios. All lighting must serve the blue space floor color to meet the technical requirements of chroma keying. In lighting technology, achieving reasonable fill lighting is an effective way to enhance scene realism. Because virtual studios feature infinite blue screens, lighting processing requirements are elevated, demanding new lighting arrangement methods. On one hand, lighting on floors and walls must be uniform without shadows, requiring reasonable setting of lighting ratios between subjects and blue backgrounds. On the other hand, the relationship between real lighting and virtual system scene lighting effects must be effectively coordinated to make scenes more realistic [6].

2.6 Chroma Key Technology

Chroma key technology primarily ensures effective combination of real foreground and virtual background in virtual studios, requiring depth direction information—that is, the distance from the virtual camera to each pixel. This technology, known as depth keying, offers more realistic matting effects compared to traditional chroma keying. Traditional chroma key technology requires extracting the host from the blue screen, which generates a foreground occlusion signal; the depth key generator then calculates the key's depth value. Depth keying represents a deepening of traditional matting technology, ensuring that hosts or actors maintain correct positional relationships with virtual scenes, achieving realistic effects of being in front of, behind, or even hidden inside virtual objects [7]. This creates excellent visual effects and a sense of realism for audiences.

2.7 Blue Box Technology

Blue box technology application is closely related to chroma key quality. Its principle involves using blue backgrounds to coordinate with host or performer actions, serving as the foundation for generating real and virtual scenes. Blue backgrounds can employ blue curtains or blue spatial structures, and the shape and size of the blue box must be coordinated with virtual studio camera positions. Typically, a small studio with appropriate area is selected as the virtual laboratory to create more reasonable spatial structures. Regarding production techniques, because blue backgrounds must coordinate with performer actions, background production is critical. Blue is generally chosen as the primary color because it protects skin tones and creates a pleasant working environment. To ensure chroma key effects, blue background paint should use pure chroma key blue with flame retardant, matte finish, and certain wear resistance.

In addition to these technologies, virtual shadows and reflections, virtual defocusing, and high-speed digital video processing are also employed. In virtual studios, these technologies are applied in targeted segments, all focusing on enhancing scene realism and delivering excellent visual effects to audiences.

In summary, virtual studios offer numerous advantages, with the perfect combination of real and virtual backgrounds significantly improving program quality. Virtual studio technology is commonly applied in news, entertainment, interviews, weather forecasts, and other programs, where a single scene can be reused multiple times, substantially reducing production costs and effort. Virtual studio technology represents a leap forward in television program production with promising development prospects.

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