Analysis of the Integration and Application of Virtual Studio Technology in New-Era Television Program Production: Postprint

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Date: 2023-10-08T00:00:00+00:00

Abstract

Virtual studio represents a relatively novel and distinctive technology for television program production, whose essence lies in the digital compositing of computer-generated virtual three-dimensional scenes with real scenes captured by television cameras. The primary components of virtual studio encompass three aspects: camera tracking, computer-generated virtual scene creation, and video compositing. The application of virtual studio in television program production is primarily manifested in three areas: modeling and infrared detection, virtual character design, and virtual shadow generation. At present, the advantages of virtual studio in television program production primarily include creative freedom, cost reduction, facilitation of upgrades, and resolution of transmission chroma key distortion issues.

Full Text

Analysis of the Integration and Application of Virtual Studio in TV Program Production in the New Era

Abstract: Virtual studio represents a relatively novel and distinctive TV program production technology that essentially involves the digital compositing of computer-generated virtual three-dimensional scenes with real scenes captured by TV cameras. The main components of virtual studio include camera tracking, computer virtual scene generation, and video compositing. The application of virtual studio in TV program production is primarily manifested in three aspects: modeling and infrared detection, designing virtual characters, and creating virtual shadows. Currently, the advantages of virtual studio in TV program production mainly include creative freedom, cost reduction, convenient upgrades, and solving transmission keying distortion problems.

Keywords: virtual studio; TV program production; application; advantages

CLC number: TN948.12
Document code: A
Article ID: 1671-0134(2017)12-119-02
DOI: 10.19483/j.cnki.11-4653/n.2017.01.037

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In the new era, China has gradually increased its emphasis on social informatization construction. With the rapid development of current computer information technology, reforms and innovations in TV program production technology continue to emerge. Virtual studio technology is a new TV program production technology based on virtual computer technology and integrated with TV program production techniques. This technology breaks through the limitations of traditional studios that could only use physical set arrangements and scene design, eliminating the need for physical sets. By relying solely on props and actors, the performance content captured by cameras undergoes computer 3D virtual processing for digital compositing, thereby achieving perfect integration between pre-production and post-production in TV program creation.

1.1 Camera Tracking

The primary task of camera tracking is to accurately calculate the motion parameters and position of the camera within the studio. During real-time filming, various parameters continuously change, including lens zoom, focus, horizontal and vertical angles, and depth of field. These changing parameters are transmitted in real time to the computer responsible for background compositing, which then adjusts the 3D view accordingly [1]. Currently, virtual studio camera tracking and positioning systems mainly employ three methods: infrared emission and reception recognition, mechanical sensor recognition, and pattern recognition.

First, pattern recognition depends primarily on studio size and involves creating grids of different dimensions on the background curtain. The camera's position, orientation, and zoom parameters are then analyzed based on real-time captured images. An important consideration is that camera operation in the studio, whether installation or control, is relatively straightforward. However, particular attention must be paid to the fact that all parameters derive from the camera's real-time footage, which must simultaneously satisfy two conditions: the grid must occupy more than half of the current frame, and there must be four grid intersection points; otherwise, the system cannot correctly identify the parameters.

Second, mechanical sensor recognition obtains various information through mechanical sensors installed on different parts of the camera. This method offers several advantages: it eliminates the need to draw grids on monochromatic (primarily blue) backgrounds and makes background illumination easier; tracking data experiences virtually no delay; adding measurement trackers at certain positions does not restrict camera movement, allowing actors to move freely

within the stage area; and the rate of collecting camera zoom, movement, and pan information can still keep pace with the TV image.

Finally, infrared emission and reception recognition employs the working principle of infrared signal emission and multi-point camera reception for real-time camera positioning. This method uses infrared transceiver devices to detect the positions of actors and cameras in the studio [2]. Receivers are installed above the background, while infrared emitters are mounted on cameras and actors. However, this recognition method has certain drawbacks, primarily its high cost and extremely complicated installation procedures.

1.2 Computer Virtual Scene Generation

Computer graphics for virtual studio scenes differ between 3D and 2D, so virtual scenes are correspondingly divided into three-dimensional and two-dimensional categories. Two-dimensional scenes serve merely as planar backgrounds placed behind real people, though sometimes they may also be placed in front. Additionally, real people can move around these virtual scenes to achieve a realistic illusion. Three-dimensional virtual scene design and production can be accomplished using software such as Alias, Front, Softimage3D, 3ds Max, and Maya. Virtual scenes can also exercise reasonable control over lighting, modeling, and texturing parameters. If virtual lighting effects and video insertion signals are added, the virtual studio will exhibit highly convincing realism.

1.3 Video Composition

Virtual studio system video composition primarily relies on keying technology, which can extract scenes and characters captured by cameras and combine them with computer-generated virtual scenes into complete images. It should be noted that each pixel in a computer-generated virtual scene has a depth value, which provides parameters for controlling the switcher and ultimately accomplishes the transformation of real people's positions within the virtual scene, thereby achieving foreground and background fusion.

2. Application of Virtual Studio in TV Program Production

2.1 Modeling and Infrared Detection When the system models and animations of a virtual studio need to remain in motion, a standardized modeling system should be established. Notably, overly complex models should be avoided. Lighting parameter conversion can be achieved through specific software operations, and mask effects can enhance the realism of the virtual system. In practical applications, a common scenario involves the host walking from behind a virtual foreground object to in front of it, turning the foreground into the background. This requires manual control of mask switching during image processing. Here, coordination between the host and the director's console becomes extremely important. To avoid breaking the illusion, such shots generally require prior rehearsal, with both the host and director's console precisely

timing their actions [3].

However, if infrared detection technology can be skillfully applied, it becomes possible to determine the real-time longitudinal position of detected objects—that is, to capture the positional depth of foreground objects within the background in the studio, thereby avoiding visible errors. The specific operational techniques are as follows: First, fix 2-4 infrared cameras above the studio as receiving devices. Second, use infrared emitting devices to measure the studio space. Third, draw a grid map of the subject's activity area. This allows accurate representation of object positions on the grid map, with data then transmitted to the workstation to calculate the true depth and accurate 3D position of objects in the model. This gives rise to the concept of the depth key. In virtual scene system infrared detection, the depth key concept enables the host in the virtual background to remain in the correct position at all times, preventing visible errors regardless of the camera angle. The depth key creates dynamic occlusion between the host, physical objects, and virtual objects, which is normal. Consequently, when the host walks from behind a virtual scene to in front of it, manual mask switching becomes unnecessary. The system automatically uses the depth key to determine the spatial relationship between virtual objects and the host in the studio, achieving truly realistic occlusion effects with automatically generated occluded images, ensuring the program maintains its illusion.

2.2 Designing Virtual Characters Currently, many TV programs feature virtual characters. When applying this virtual technology, sensors need only be installed on important parts of a real person (primarily joints), with the obtained data transmitted to the workstation to control the virtual animated character, which can then perfectly mimic the performer's various movements. Even when real people and virtual animated characters appear simultaneously in the studio, they can exchange positions and interact—something impossible in traditional studios. Virtual studios can bring a sense of mystery to TV programs through virtual characters, significantly enhancing program effects.

2.3 Virtual Shadows Virtual studios can simulate light and shadow, a unique realism of 3D technology. Therefore, when producing TV programs, virtual studio system modeling should be employed with careful attention to lighting direction, which should remain consistent with reality [4]. However, studio lighting is generally quite bright, which increases the difficulty of chroma keying, making it hard for the host's shadow to maintain consistency with background objects in the composited image. Additionally, when studios use grid recognition methods, keying techniques cannot obtain virtual shadows. Therefore, additional equipment such as virtual shadow machines becomes necessary.

3. Advantages of Virtual Studio in TV Program Production

3.1 Creative Freedom Virtual studios can generate virtually unrestricted 3D images. As long as these images align with the program's theme, creative personnel can fully exercise their imagination to freely determine scene size, materials, layout, animation effects, and more. Such scenes are not constrained by spatial, temporal, or other factors.

3.2 Cost Reduction Every television station produces numerous programs of diverse types. Since different programs have different scene requirements and studio settings must align with program content, establishing separate studios for each program would be extremely wasteful. With virtual studios, only one studio is needed—scenes can be changed at will without any construction or dismantling work.

3.3 Convenient Upgrades Virtual studios are based on computer technology, and both hardware and software in computer technology are constantly upgrading. Therefore, virtual studios can be updated as needed, and whether hardware or software updates, computer upgrades are very convenient.

3.4 Solving Distortion Problems When synchronous tracking technology is adopted, the camera motion parameters of the virtual studio can be converted into electrical signals. Through computer processing, virtual scene parameters can be adjusted at any time to generate background signals linked with the foreground in real time.

5. Conclusion

The virtual studio system provides broad creative space for TV program production in the new era, making significant contributions to enriching TV programs and reducing costs, while also placing higher demands on the creativity of production personnel.

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