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Holographic Pyramid Using Integral Photography

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Abstract **-** The simple aerial display system called holographic pyramid has been eliciting much attention recently. However, the image that appears to be floating in the pyramid has no depth information because it is merely a virtual image of a 2D image displayed on a flat-panel display and reflected at the surface of a transparent board of the pyramid. Therefore, we propose a new holographic pyramid system, in which a floating 3DCG animation with binocular parallax is viewed in a pyramid made of transparent boards. The system is achieved by introducing an integral photography display instead of a normal flat-panel display.

Keywords**:** holographic pyramid, integral photography, fly's eye lens, binocular parallax

1. Introduction

The simple aerial display called holographic pyramid system has been eliciting much attention recently. Its simple hardware and amazing display deserve appreciation. When a quadrangular pyramid made of a clear plastic board is stacked on a flat-panel display, an image of the flat-panel display is reflected on a surface of the quadrangular pyramid and to an observer's eyes. This scenario is possible because transparent synthetic resin generally reflects considerable rays depending on the incidence angle. Therefore, an observer sees an object that is floating in the quadrangular pyramid. The principle of the system is similar to that of Pepper's ghost. However, given that the image of the flat-panel display is 2D, its virtual image caused by the reflection on the surface of the pyramid does not have depth information. It is merely an illusion that appears to be 3D. In this paper, we propose a new holographic pyramid system, in which depth information can be reproduced as a binocular parallax.

2. Method

Instead of a flat-panel 2D display, we used both a flat-panel display and a fly's eye lens because in the integral photography (IP) method, stereo vision is possible even without wearing stereo glasses. Unlike lenticular methods, the IP method produces parallax in all directions, including horizontal and vertical. IP provides a parallax that is near to the actual space; a good sense of reality is thus provided. Therefore, IP is suitable for the display of scientific or artistic contents [1] [2]. Particularly, autostereoscopic vision is possible from any direction of 360° when the lens is placed horizontally. When the stereoscopic image produced by the IP method is reflected on the surface of the quadrangular pyramid, its virtual image is seen in the pyramid near the center and is also autostereoscopic. As a result, a new holographic pyramid in which depth information can be reproduced is realized. Figure 1 shows the principle of the conventional holographic pyramid system. The proposed system can display true 3D images in the pyramid, as shown in Figure 2.

3. Experiment

The laptop computer utilized for our experiment is SONY VAIO Fit15A because its LCD can be made almost flat. The size of the flat-panel display is 15.5 inches, and the number of pixels is 2,880×1,620. We placed a commercial fly's eye lens (Fresnel Technologies 360) on the top of the flat-panel display to achieve autostereoscopic display through the IP method. A quadrangular pyramid was placed on the lens so that the bottom of the pyramid pointed upward. A scene consisting of a 3D object (snowman) and falling grains of snow, both of which were produced with a CG application, was rendered from 32×32 =1024 directions. An IP image for one frame was composed with our software at high speed because the software was developed using the Open Source Computer Vision Library (OpenCV). In this case, the ratio of the pixel pitch of the LCD to the lens pitch of the fly's eye lens is not an integer in general because both components were manufactured independently. The extended fractional view (EFV) method [3] was adopted to synthesize the IP image. The EFV method was proposed as an extension of Ishii's method [4][5] which was applicable only to lenticular systems.

This procedure was repeated until all IP images for 50 frames were synthesized, as shown in Figure 3. A CG animation movie was produced with animation GIF technology. The movie was displayed on the LCD of the laptop computer. For example, an animation of a snowman watching snow and jumping in delight was produced and played back with this system, as shown in Figure 4. When observed from each of the four faces of the pyramid, the snowman appears to be floating in air around the pyramid center and jumping. When the viewpoint of an observer is moved horizontally or vertically, the image changes accordingly, as shown in Figure 5. This observation confirms that both horizontal and vertical parallax exist, which is a characteristic of IP. In addition, the grains of snow in the entire area of the pyramid effectively enhanced the sense of depth.

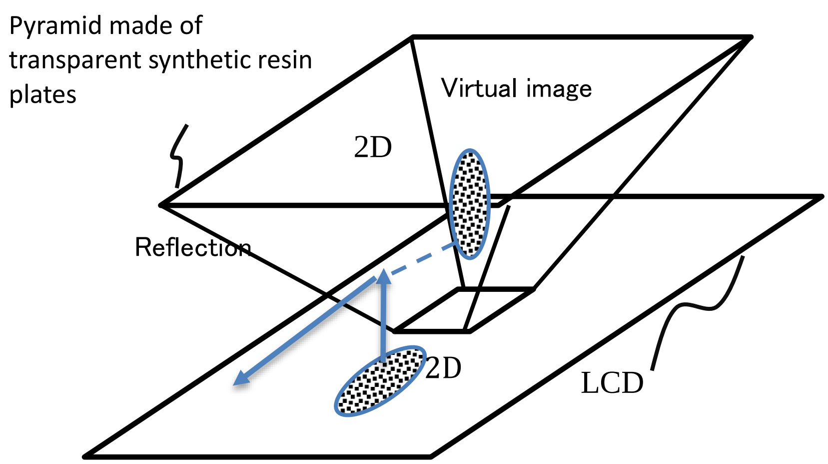

Fig. 1: Conventional holographic pyramid system.

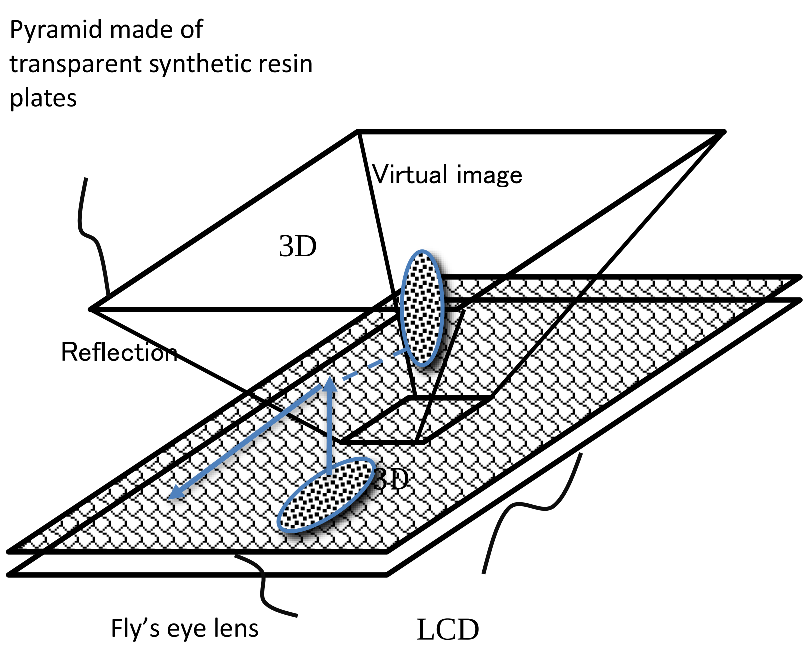

Fig. 2: New holographic pyramid system using IP.

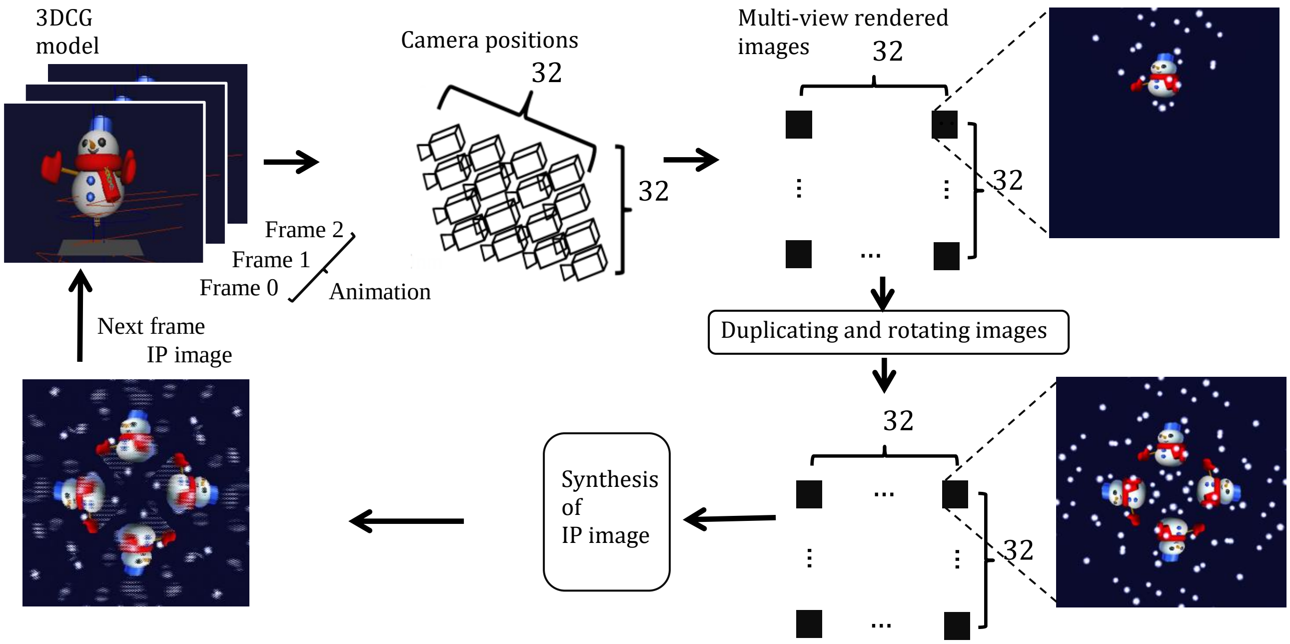

Fig. 3: Synthesis of an IP image sequence for animation.

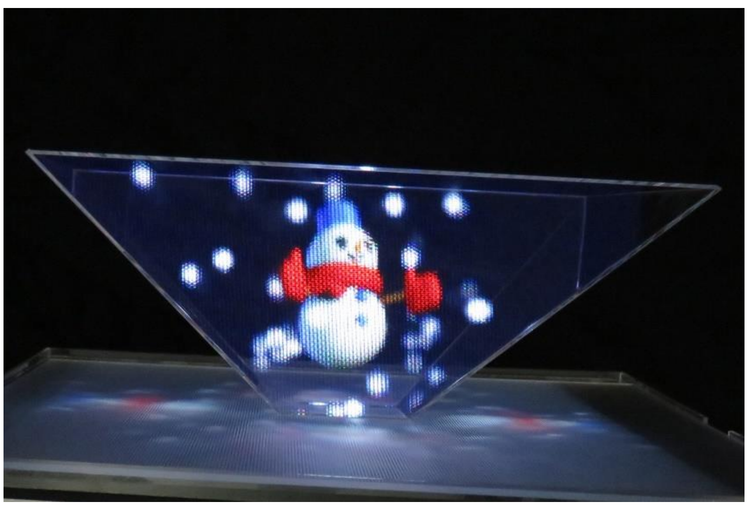

Fig. 4: Typical frame of an animation movie displayed by the proposed system.

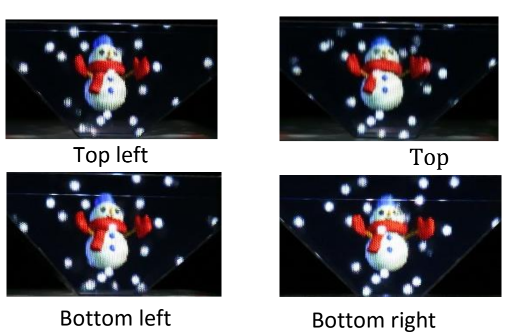

Fig. 5: Change in the image caused by moving the viewpoint.

4. Conclusion

Although an image appears to be floating around the center of the pyramid in the conventional holographic pyramid, the image itself is not 3D but 2D. In the proposed system, a 3D image with binocular parallax is displayed. Hence, a good sense of reality is obtained. The proposed system can be extensively applied in various fields, such as media artwork, museum exhibition, store exhibition, and theme park attractions.

References

[1] N. Maki and K. Yanaka, “Display of diamond dispersion using wavelength-division rendering and integral photography,” in *Proceedings of the ACM SIGGRAPH 2015 Posters*, 2015.

[2] N. Maki and K. Yanaka, “Natural user interface for integral photography of dispersion-rendered diamond,” in *Proceedings of the 20th ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, 2016, pp. 197-198.

[3] K. Yanaka, “Integral photography using heagonal fly’s eye lens and fractional view,” in *Proceedings of SPIE 6803,* Stereoscopic Displays and Applications XIX, 68031K, 2008, pp. 1-8.

[4] Motonaga Ishii, “Fractional View 3D Display,” in *Proceedings of the 3D Image Conference*, 2004, pp. 65-68, 2004 (in Japanese).

[5] Motonaga Ishii, “Spacial Image by Fractional View Display,” *ITE Technical Report,* IDY-2006-100, AIT2006-136, vol. 30, no. 58, pp. 33-38, 2006 (in Japanese).