54.5: Holographic Screens for 3 Dimensional Image Projection

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Abstract
A full color transmission type holographic screen having a size of 40cm X 60cm are developed recently at Korea Institute of Science and Technology. This screen can be operated in reflection mode by adding a mirror at its back. This operation extends viewing angle of the screen to be more than 30degree. This wide viewing angle permits the screen to be operated in viewer tracking regime. By mosaicking the screens, a 120cm X 80cm screen is made. The mosaicked screen shows a good image performance.

Introduction
Holographic screen has been developed to use as an image projection screen for forming viewing zones for the projected images[1]. It is a kind of holographic optical element(HOE)s which has the properties of a spherical mirror or a lens + a diffuser. Since HOE is basically a spectral selective component, full color images can not be projected on the holographic screen[2], unless a specific optical recording set-up is used or a special development process is developed. One good example of the screen is the image combiner in Head Up Display for airplanes[3]. It is tuned to have the maximum diffraction efficiency for the spectral range corresponding to that of the image display device used for the Display, i.e., CRT. This means that the screen has an uniform period fringe structure. To make the screen has a wide spectral response comparable to visible spectral range, it is necessary to make the screen have a variable period fringe structure. Based on this concept, Korea Institute of Science and Technology(KIST) developed a full color transmission type holographic screen with use of a long slit type diffuser as an object[4]. The screen creates a full color viewing zone for images projected from a projector by making the reconstructed diffuser image for each spectral component of the images overlap partially in space. The viewers can perceive the full color images displayed on the screen through the viewing zone.

The advantages of the holographic screen compared with popularly used optical plates to form viewing zones, such as Lenticular, Parallax Barrier and Integral Photography plates and Fresnel lens[5] are such that resolution and depth of the viewing zone of the screen are higher and more, respectively. However, making larger size screen with full color capability is difficult due to problems related with optimizing the recording set-up to minimize aberrations and exposition time, and changing viewing zones following to the viewer's movement. It found that the problems could be solved by mosaicking smaller size screens and by operating the screen in a reflection mode. This reflection mode operation allows the angular selectivity of the screen to be two times of that of transmission mode.

In this paper, some features of the full color transmission type holographic screens developed at KIST are described.

1. Full Color Transmission Type Holographic Screen
Holographic screen is a hologram designed to work as an optical component with a designed property. There are two types of holographic screens, such as reflection and transmission. The reflection type is recorded with a spherical mirror as an object and has a property of (a) spherical mirror(s). The transmission type with a diffuser and has properties of a diffuser + a lens. For the full color image projection, the reflection type needs to go through a chirping process after recording to have a chirp type fringe structure[6]. The transmission type case, the color performance is defined at the recording stage. The relative positions of the diffuser, the reference beam and the screen are the main parameters for determining the full color performance of the transmission type screen[7]. Fig. 1 shows a typical optical recording set-up for the full color transmission type holographic screen. Aligning the point reference source and the long axis of the diffuser to be on a straight line in the recording set-up is required to make the screen have the better color performance. The length of the diffuser's long axis defines the spectral bandwidth of diffraction. The typical projection geometry of the screen is shown in Fig. 2. The size of the holographic screen to be recorded at KIST is currently 40cm X 60cm. It shows a good color reproduction along the whole screen surface.

2. Reflection Mode Operation of the Transmission Type Holographic Screen
The transmission type holographic screen can be transformed into reflection type screen by simply attaching a plane mirror to the backside of the screen. In this case, the diffracted light from the screen is reflected back by the mirror and the viewing zone is formed at the same side of the screen as the projector, as is shown in Fig. 2. The advantage of operating the holographic screen as in Fig. 1 is that the viewing zone position can be controlled easily by rotating the screen together with the mirror and viewing angle becomes two times of that for transmission type case. This viewing zone shifting makes possible to extend the screen capabilities.

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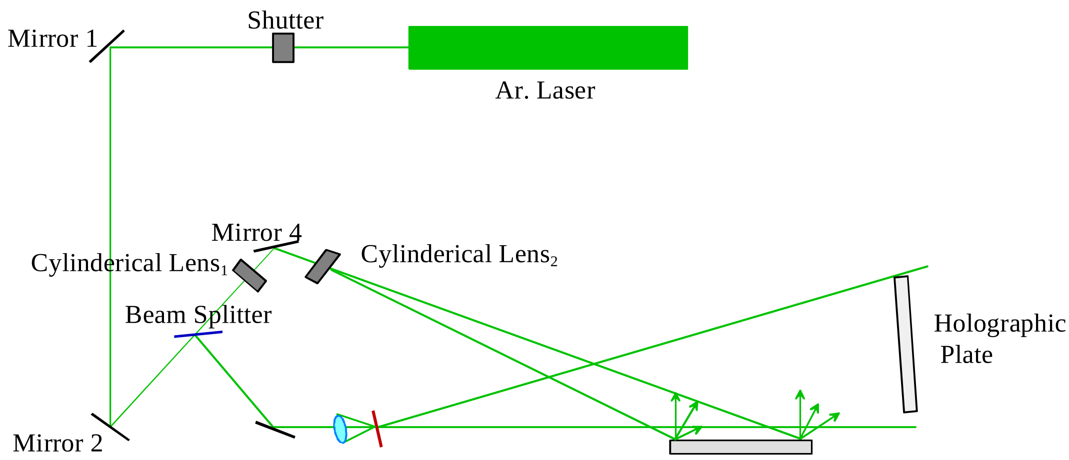

Fig. 1 A typical optical recording set-up for the full color transmission type holographic screen

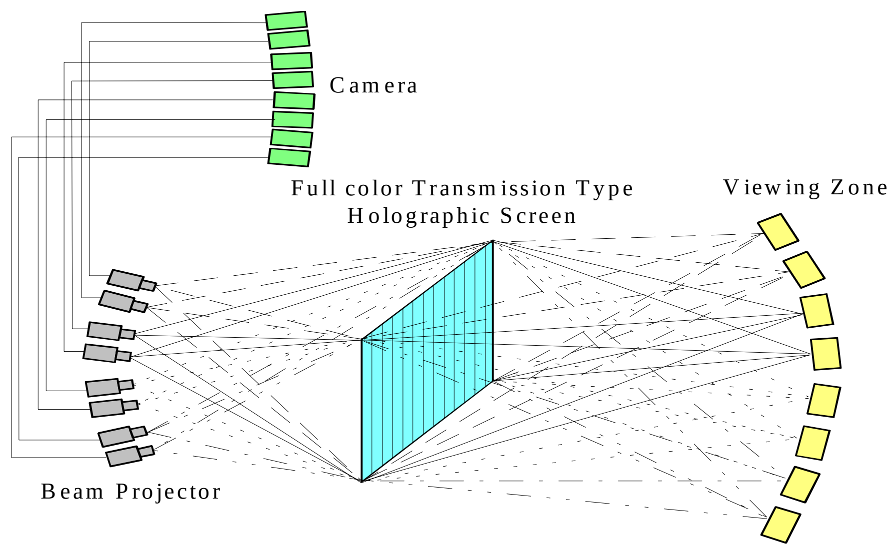

Fig. 2. The typical projection geometry of the screen

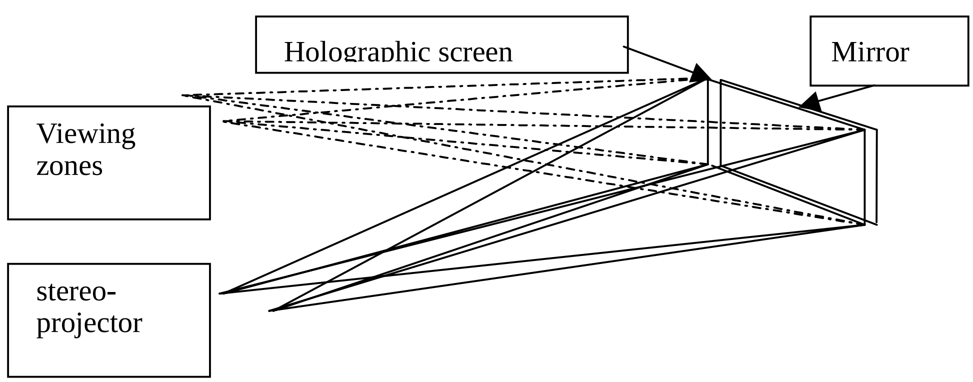

Fig. 3. The transmission type holographic screen working in reflection mode

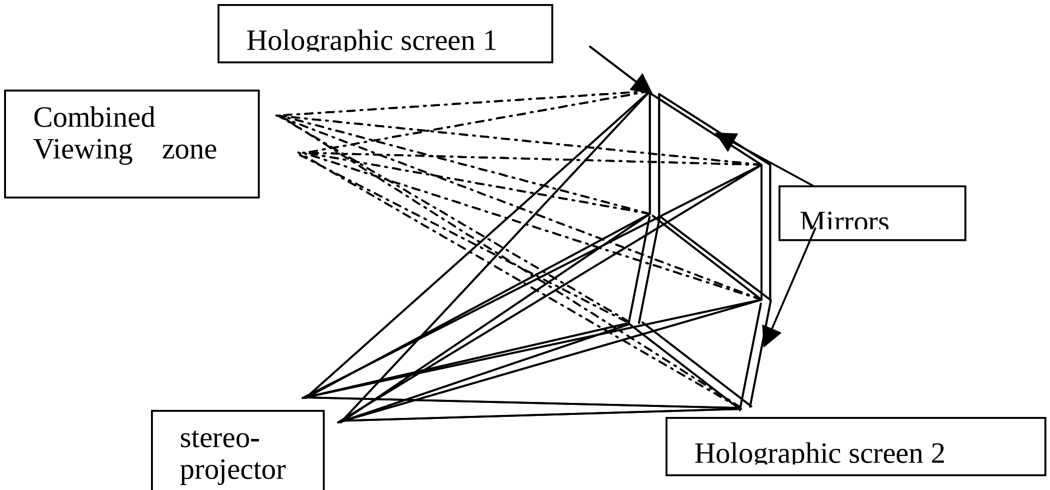

Fig. 4. Viewing Zone Forming in a Mosaicked Screen

2. Making a Larger Size Screen by Mosaicking Smaller Ones

Recording bigger size screens brings extra problems of optimizing the recording set-up due to increasing aberration and exposition time. Making bigger size screens by mosaicking the smaller ones can be a solution for making larger size screen. Each small screen needs to be recorded in the same recording set-up without any additional readjustment for minimizing the complexity of recording. In this case, one required procedure is adjusting each viewing zone from a smaller screen to coincide with others as shown in Fig. 4. Fig. 5 shows the examples of mosaicked screens with sizes 120cm X 80cm and 180cm X 40cm by combining four and three 40cm X 60cm screens, respectively.

The images are projected at 3m distance from the mosaicked screens. It will be possible to combine more smaller size screens in this way to make any desired size screen. One drawback of the mosaicked screens is that the common viewing zone becomes smaller due to angular displacements between different smaller screens.

Viewer Tracking With the Holographic Screen

One serious drawback of most autostereoscopic display systems is that viewers do not have much freedom of moving their bodies to watch the stereoscopic images because viewing zones in these systems are spatially fixed in front of the display. To overcome the drawback, methods of moving the viewing zones according to the viewers movement have been deviced[8-10]. In the stereoscopic display systems based on lenticular or parallax-barrier plates, the viewing zones are shifted by changing the plate position relative to the projected image, according to the viewer's movement. The same method can be applied to the holographic screen operating in the reflection mode. When the screen is rotated as shown in Fig. 4, the viewing zones are moving.

The viewing zone displacement is two times of the value obtained by multiplying the screen's rotation angle and the viewing zone distance from the center of the screen. If the screen in the reflection mode is rotated 10 degree, the reflected image of the viewing zone will be shifted to 20 degrees. The experiment performed with a 40 X 60 size screen showed that the viewing zones can be shifted up to 35 degree with a good image quality. If this angle is converted to the displacement, it corresponds to 120cm at 170cm viewing zone distance. An additional experiment showed that even though, the displacement of the viewing zones in a vertical direction is 70cm, the image quality does not change much. These results indicate that the full color transmission type holographic screen will be a good candidate for the future 3-D display systems.

Conclusions

Holographic screen is only an analogue type among many optical plates for forming (a) viewing zone(s). The full color transmission type holographic screens are developed at Korea Institute of Science and Technology and it shows a good color performance. The screen can work in reflection mode for a wide viewing angle and can be mosaicked for a larger size. The screen will be a promising component for the future 3 dimensional imaging systems.

Fig. 5a. (180 cmx40 cm) Images on Mosaicked Screen

Fig. 5b. (120 cmx80 cm) Images on Mosaicked Screen

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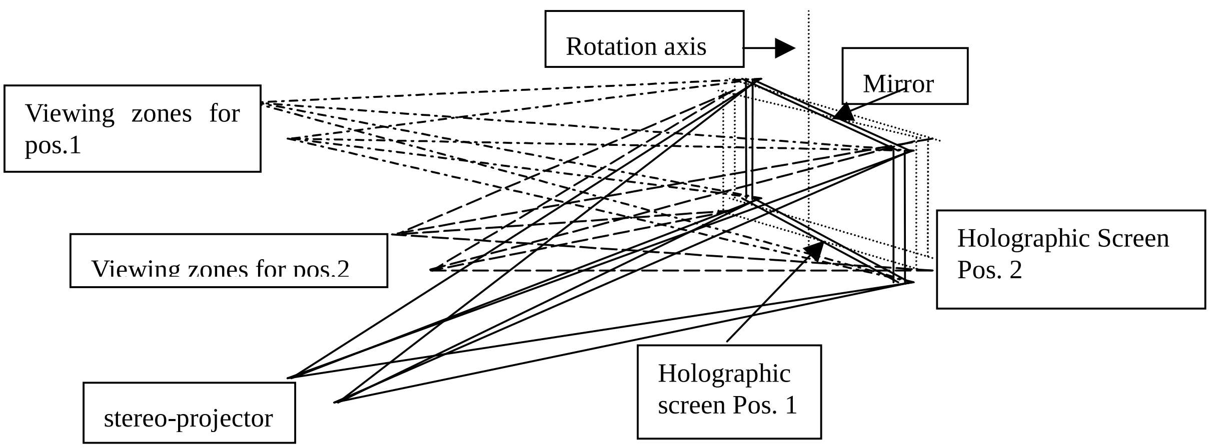

Fig. 6. The viewing zone shifting by rotating the screen in reflection mode.

References

[1] V. G. Komar and O. B. Serov, Image Holography and Holographic Cinematography, M., Iskusstvo, 1987.

[2] R. R. A. SYMS, Practical Volume Holography, CLARENDON PRESS, OXFORD, 1990

[3] C. T. Bartlett, "A second generation holographic Head Up Display", Proc. SPIE 1988, pp. 135-146 (1993).

[4] Jung-Young Son, V. I. Bobrinev, S. A. Shestak and Hyung-Wook Jeon, "The Achromatized Transmission Type Holographic Screen for the Stereo Imaging and the Multiview Projection," SPIE Proc. vol. 2951, *Holographic and Diffractive Techniques*, pp.168-172 (1996).

[5] Adrian Travis, "The Display of Three Dimensional Video Image", Proceedings of the IEEE, V85, pp1817-1832(1997)

[6] Vadim V. Smirnov, Jung-Young Son, Hyung-Wook Jeon, Hyuk-Soo Lee, and Yong-Jin Choi, "A Full Color Reflection Type Holographic Screen," SPIE *Proc. of Practical Holography XI in Electronic Imaging '98*, San Jose, USA. Vol.3293, pp.175-182, (1998).

[7] Seon-Ho Hwang, V. I. Bobrinev, Jung-Young Son, S. A. Shestak, and Hyung-Wook Jeon, "An Achromatized Transmission Type Holographic Screen for a Multiview Stereoscopic Image System," Appl. Opt. 36(26), pp.6605-6610 (1997).

[8] Jai-Soon Kim, V. I. Bobrinev, Jung-Young Son, Yong-Jin Choi, Sang-Hun Shin,"The Optimum Optical Geometry for Recording a Full Color Transmission type Holographic Screen of Large Size", SPIE Photonic West, Electronic Imaging 2000 , Jan 23-29, San Jose, USA (2000).

[9] Graham J. Woodgate, David Ezra, Jonathan Harrold, Nikolas S. Holliman, Graham R. Jones, Richard R. Moseley, "Observer Tracking Autostereoscopic 3D Display Systems", Proceedings of SPIE, vol. 3012, pp187-198, 1997.

[10] H. Imai, M. Imai, Y. Ogura, K. Kubota, "Eye-position tracking stereoscopic display using image shifting optics", Proceedings of SPIE, vol. 2653, pp49-55, 1996.

[11] R. Boerner, Three Autostereoscopic 1.25m Diagonal Rear Projection Systems with Tracking Features, Proceedings of the Fourth International Display Workshops IDW-97, Japan, pp. 835-838, 1997.