Glasses-free 3D Stereo Adapter Using Commercial DIY Goods

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Keywords : 3D imaging, polarized glasses, overlapping stereoscopic images, optical grating film, 3D adapter, stereoscope

Abstract

We developed a glasses-free 3D stereoscopic display using an LCD display panel, a view control film and a grating film for stereoscopic viewing. The observer can watch overlapped stereoscopic images for left and right eyes without special glasses such as polarized glasses.

1. Introduction

We developed a glasses-free 3D stereoscopic display using an LCD display panel, a view control film and a grating film for stereoscopic viewing. The display screen is divided in half in order that left and right regions provide the stereoscopic images for left and right eyes. Because both stereoscopic images are not in the same position, it is difficult for the observer to view the 3D image by the stereoviewing. The grating film can solve this problem because it shifts both left and right images to the same position. Moreover the view control film can give us glasses-free 3D viewing. As the result, the observer can watch overlapped stereoscopic images for left and right eyes without special glasses such as polarized glasses.

Conventional 3D movie systems with the special glasses such as polarized glasses provide us touchable spatial images. However, these 3D imaging systems are very expensive and large scale equipment. Our research group would like to realize the simple 3D imaging system to construct an interactive spatial imaging environment. The authors have researched the 3D displays and applications. We have ever proposed 3D displays using the slit as a parallax barrier, the lenticular screen and the holographic optical elements(HOEs) for displaying active image. In this paper, we describe the 3D adapter using an optical film, which is sold at D.I.Y. stores, for easy 3D image viewing.

2. Motivations

Nippon BS Broadcasting Corporation (BS11 digital) started the BS11 3D television programming in 2007. To watch this program, we need a special TV display which can decode the BS11 3D broadcast signal format. The authors have ever researched information display systems involving 3D imaging[1)2)3)]. In case of a conventional TV monitor, we observe a side-by-side stereoscopic image as shown in Fig. 1. Thus both stereoscopic images are not in the same position because the center of left and right regions has an interval, then it is difficult for the observer to view the 3D image by the stereoviewing. To solve this problem, the authors had developed the 3D adapter using an optical grating film for stereoscopic viewing. However it needs polarized glasses to separate left and right images. So we have developed the 3D viewing system with no glasses. This new 3D adapter, which you can make yourself, enables us to enjoy 3D TV programs using any monitor.

Fig. 1. 3D TV broadcast.

3. Floating View System

A floating display generates a touchable virtual image in the air above the table. This 3D technique, frequently used in exhibitions and magic shows, employs a convex lens or concave mirror to form a realistic image close to the observer. This technology typically uses 2D images for dynamic image-floating systems. A floating lens generates tangible virtual image in the air as shown in Fig. 2. This principle of imaging is based on the optics of a convex lens. Note that each lens has two focal points - one on each side of the lens. The lens converges the ray at the focal point. The generated image by the lens screen can be observed at the restricted regions where an observer watches the floating image and the lens on a straight line.

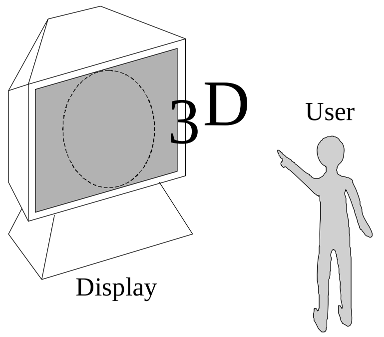


Fig. 2. Floating image display with convex lens.

Fig. 3. Floating image display system(KNX-10).

Fig. 3 shows the appearance of a floating 3D display system. This display consists of a LCD panel and convex lenses. A pair of display and lens generates a floating image in front of a lens. In the prototype display, the interval of the display and the lens is 300 mm. The floating images are generated about 250 mm apart from the lens. Since the 3D image is floating in the air, observers can directly touch virtual 3D objects at front of the display.

Fig. 4. Doubling phenomenon.

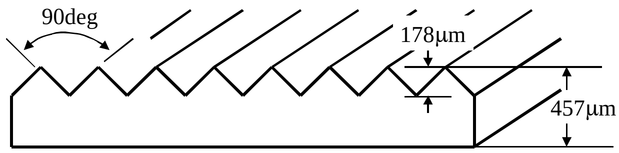
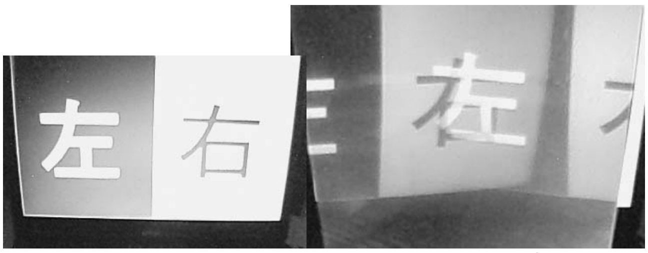


Fig. 5. Structure of optical grating sheet.

4. Superimpose Stereoscopic Images

To overlap left and right images, the authors use an optical film. It is named "SOLF^{TM}" and sold in D.I.Y. materials floor at Tokyu Hands. This SOLF sheet is a product of 3M Company. The SOLF optical sheet is a flexible film with prisms designed to transport and diffuse the light. This sheet has interesting characteristics as follows; the prismatic phenomenon is observed and the doubling can be visible through the sheet like the Calcite. This doubling phenomenon occurs because the prism sheet diffracts two beams. These beams are called as the first order diffracted beam and the second order diffracted beam. Fig. 4 shows the doubling phenomenon. This interesting thing reminds us of method to superimpose left and right stereoscopic images. Fig. 5 shows the structure of the optical grating sheet. A grating diffracts or scatters a light beam with a designed angle. Using the doubling phenomenon, the authors shift the images for superimposing stereoscopic images by adjusting the interval between an optical sheet and image plane as shown in Fig. 6. The optical grating film shifts both left and right images to the same position. The observer watches overlapped stereoscopic images for left and right eyes. This optical grating film is thin and works as a prism. The optical film appropriately locates apart from the display panel so that stereoscopic left and right images are overlapped. As shown in Fig. 6(b), the left and right images are overlapped on the same plane. If this overlapped images can be separated into appropriate eyes, you can perceive the left image only by a left eye and the right image by a right eye. If you are content to wear glasses, this technology enables us to enjoy 3D image viewing using polarized glasses[4]. In order to improve a bother, it is necessary to separate a side-by-side stereoscopic image into left and right eyes.



(a) side-by-side image (b) view thru grating film

Fig. 6. Superimposing stereo images.

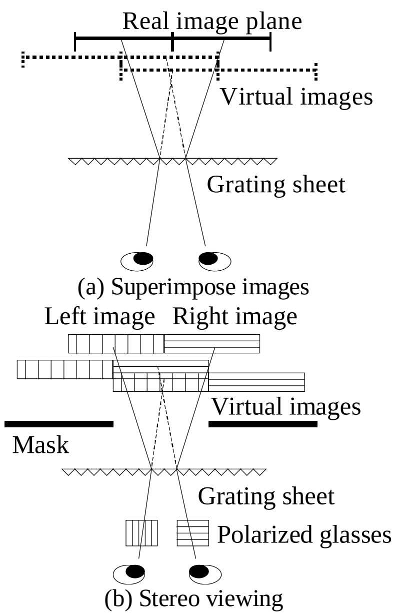


Fig. 7. Stereoviewing using polarized glasses.

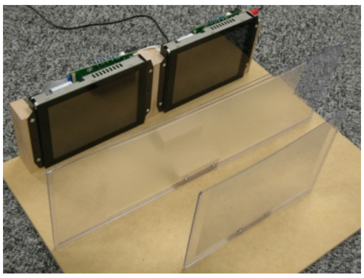
5. Conventional Image Separation Method

We can shift the images for superimposing stereoscopic images by adjusting the interval between an optical sheet and image plane as shown in Fig. 7(a).The optical grating film shifts both left and right images to the same position. The observer watches overlapped stereoscopic images for left and right eyes. But it is possible to separate left and right images when the observer wears polarized glasses. This optical grating film is thin and works as a prism. The optical film appropriately locates apart from the display panel so that stereoscopic left and right images are overlapped. As shown in Fig 7(b), the vertically oriented polarizer is attached on the left half of an image plane. Then an image for the left eye has vertically oriented polarization. Meanwhile, a right eye image has horizontally polarization because the right side of an image plane is covered with a horizontally oriented polarizer. The orthogonal polarized stereoscopic images are overlapped on the same plane. If the observer wears the polarized glasses, he can perceive the left image only by a left eye and the right image by a right eye. Therefore, the observers, who wear the glasses, can view the 3D images by the binocular stereo viewing.

6. View Control For Stereo Viewing

Fig. 8 shows newly developed 3D display system. To deliver left and right images into appropriate eyes, we use a view control film "LUMISTY™". The LUMISTY film is produced by Sumitomo Chemical Co., Ltd. Using this film, you can see through the film from the left, but not from the right as shown in Fig. 9. One of the miraculous features of LUMISTY is that it can be either transparent or opaque, so that it looks either like transparent or frosted glass, depending on the angle of sight. It is an adhesive-type transparent plastic film which can be used simply by sticking onto a windowpane, and it does not cut out any of the light coming through the window.

It is useful characteristics for 3D viewing that you can control what can and what cannot be seen depending on which side the viewer is on, or what angle the viewer is looking from. Using the miracle of this LUMISTY visibility control as shown in Fig. 10, it enables us to perceive left images by the only left eye and right images by the only right eye. As shown in Fig. 10, the view control film passes the light within an angle of θ. Let's design the optical layout assuming that 15-inch display panel is used. The width of the 15-inch panel is approximately 280mm. As shown in the Fig. 11, the ray of a left image is emitted with an angle α to vertical and it reaches into the left eye after the ray is diffracted by an optical grating film. Meanwhile the ray with an angle β passes into the right eye through the grating film. If the view control angle θ is α to β ($\alpha < \theta < \beta$), the left image is observerd by the only left eye because the ray with an angle β to vertical is blocked by the optical film. The rays of a right image are the same as the left image. In case of the 15-inch panel, the angle α is 13.37 deg and the angle β is 25.64 deg. The LUMISTY film has many kinds of characteristics; *e.g.*, opaque from front side, one direction, two directions and so on. The grade MFY-2555 is opaque from one direction when the ray is encountering the film with the angle more than 25 deg. Using this MFY-2555 (θ=+25 deg), the observer can perceive the left image only by a left eye and the right image by a right eye with no glasses because the view control film restricts the direction of scattering light after the grating film overlays left and right images at the same position. Therefore, the observers, who wear no glasses, can view the 3D images by the binocular stereo viewing. We have developed the prototype glasses-free stereoscopic 3D display using two commercial LCD panels for playing 3D contents by portable DVD players as shown in Fig. 8. In this display, observers can view the 3D images by the binocular stereo viewing without special glasses.



(a) inner optics

(b) prototye display

Fig. 8. Appearance of 3D display (KNA-20X).

7. Acknowledgements

This research is partially supported by "Grant-in-Aid for Young Scientists(B)" #20700112 and "Scientific Research (C) (General)" #20500481 from Ministry of Education, Culture, Sports, Science and Technology Japan(MEXT) and also by a grant from the Hyogo Science and Technology Association. A part of this work is done while the author is partially supported by the Hirao Taro Foundation of the Konan University Association for Academic Research, Japan.

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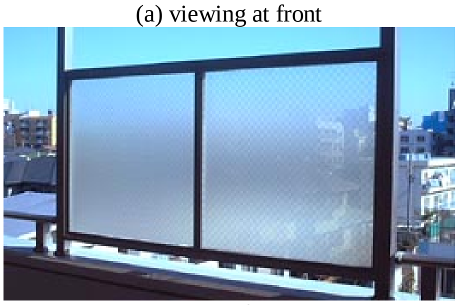
(a) viewing at front



(b) viewing from side

Fig. 9. Effect of view control film.

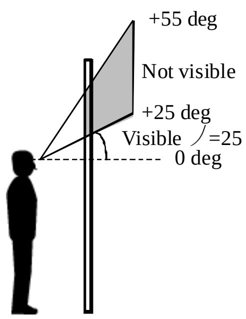


Fig. 10. View control.

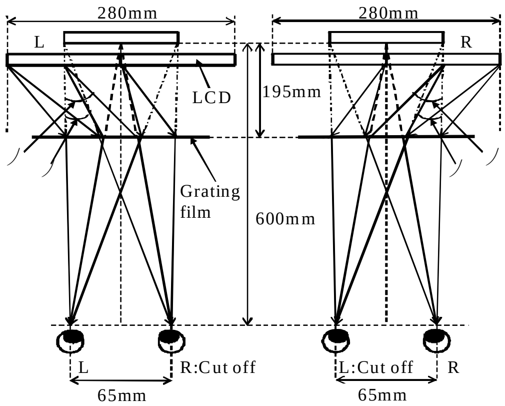


Fig. 11. Optical design for 3D viewing.