Full-Color 3D Display System with 360 Degree Horizontal Viewing Angle

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ABSTRACT

The Full-Color Three-Dimensional (3D) Display System using the Direct Light Scanning Method, named “Holo-Table”, was developed and demonstrated. Since the holographic screen as a beam deflector sets horizontally, projected 3D image has a 360 degree full horizontal viewing angle. R-G-B parallax images are time-sequentially projected by only one Spatial Light Modulator (SLM).

Keywords: 360 degree horizontal viewing angle, full-color, 3D display, hologram, holo-table

1. INTRODUCTION

Due to the great demand of Three-Dimensional (3D) display, development of 3D display without special glasses and smooth motion parallax is strongly desired. High density directional images displaying is one of a promising glasses-free 3D display method[1-2]. This method has the following features;

(a) Special glasses are not required.
(b) The eye accommodation function may work.
(c) The smooth motion parallax is obtained.
(d) The observation position is not restricted.

In this method, however, considerably large number of spatial light modulators (SLMs) corresponding to the number of spatial beam directions are needed.

In contrast to the method mentioned above, Direct Light Scanning Method had been proposed by authors and demonstrated that the high-density directional 3D motion

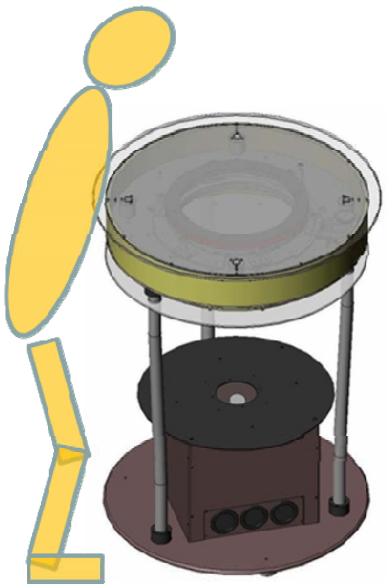


Fig. 1 Brand-new concept of 3D display system, “Holo-Table”.

image can easily be obtained with only one SLM[3-5].

This paper will introduce a brand-new 3D Display System, so called “Holo-Table” as shown in Figure 1. By utilizing newly developed RGB display engine, full-color 3D image with 360 degree full horizontal viewing angle was observed.

2. PRINCIPLE

2-1. High density directional images displaying with high frame rate SLM

In high density directional images displaying for 3D display, directional images are 2D graphics which is orthographic projection of 3D objects. As shown in Figure 2, this method requires projecting these directional images to corresponding directions by parallel rays.

When the ray angle pitch becomes small enough, the rays from display reconstruct the same rays from 3D objects. Therefore, this method allows us to observe reconstructed 3D images without having any special glasses. Thus displayed 3D image has then smooth motion parallax, and the viewing position is not restricted.

In this study, we used only one parallel beam with single SLM to display high density directional images, where the direction of beam was scanned with a horizontally placed holographic screen by synchronously changing the projection image corresponding to the rotation angle of holographic screen.

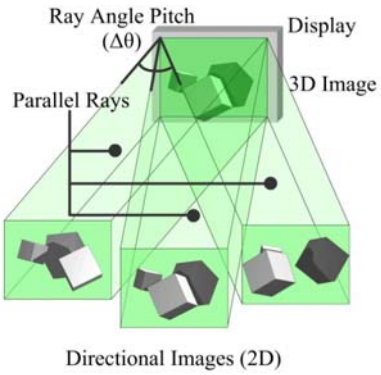


Fig. 2 Depict of high density directional images composed of parallel rays.

2-2. Beam scanning by holographic medium

A simple hologram was set horizontally and rotates on the plane to change the direction of a beam. The incident beam was diffracted and then beam angle was changed due to Bragg-matching of hologram. By rotating the hologram, the incident angle of reference beam is relatively changed the direction (Figure 3). This holographic medium acts as a screen, and hence let us refer to a holographic screen hereafter. The amount of this change of diffraction angle may define by corresponds to vertical viewing direction. According to the holographic screen rotation angle horizontal viewing angle was changed in this 3D display system.

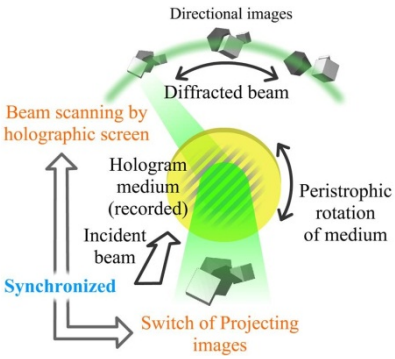


Fig. 3 Beam scanning by rotation of hologram screen.

3. SETTINGS OF 3D DISPLAY SYSTEM

The illuminating beam (horizontal parallax images) was modulated by a Digital Micro-mirror Device (DMD).

The newly developed RGB display engine is shown as Figure 4. In the current system, coherent light source such as laser light was not required as a projecting illuminant, so R/G/B LED were employed as the illuminant light source.

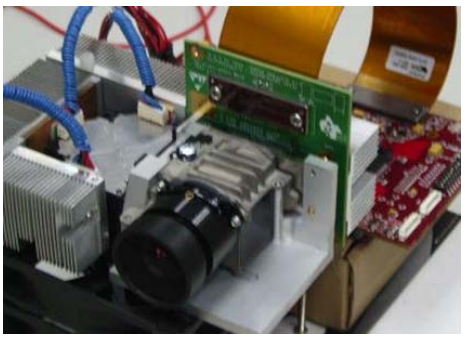


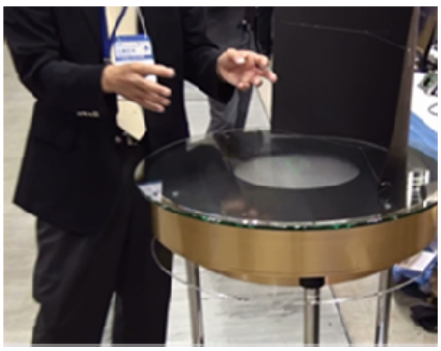
Fig. 4 Developed RGB display engine.

Based upon the principle described in 2, the 3D display system was designed and constructed as Figure 1. The holographic screen is horizontally held at the top of the system by a rotation holder. The parallax images were projected normal to the holographic screen from the bottom side. The optical systems were constructed as a telecentric system.

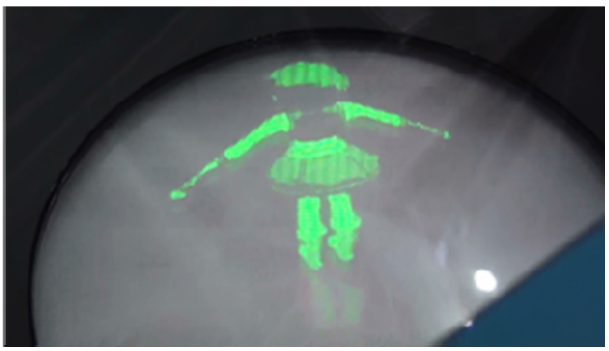
Specification of the 3D display system is summarized as the following: holographic screen size 300[mm].horizontal viewing angle ranges 360 deg., ray angle pitch 1.0 deg., number of directional images 360 per rotation, 3D resolution 1024x768 (XGA), movie frame-rate 30 fps. The holographic screen rotation and the switching of projected images were synchronized by measuring the disc rotating state using a photo interrupter.

4. OBSERVATION OF 3D DISPLAY IMAGES

Figure 5 shows the actual Holo-Table and an example of the observed 3D images which was taken by a digital camera. The displayed image has motion parallax and binocular parallax, satisfying the requirement 3D image seeing. The displayed graphics are usually made from computer graphics, but it can also display graphics made by photographed images.



(a)



(b)

Fig. 5 (a) Holo-Table Demonstration. (b) An example of observed 3D image

5. CONCLUSION

A brand-new 3D display with high-density directional display system composed of the horizontal holographic screen and single SLM was constructed and its performance was demonstrated. The results revealed that this system configuration is able to display the full-color 3D images with 360 degree full horizontal viewing angle in high-resolution. The displayed image is observed by naked-eye, and sufficient motion parallax and binocular parallax was confirmed. R-G-B parallax images are time-sequentially projected by only one Spatial Light Modulator (SLM). Particular feature of this system is the usage of single SLM, ensuring the simple system configurations. Further investigations are now under way by employing super-high-speed SLM, such as magneto-optic SLM, to display the realistic 3D movie images.

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