Volumetric 3D Display System using Rotating Screen -Confirmation of image distortion and its compensation-

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ABSTRACT

We have suggested a novel method of volumetric 3D display, in which multi layers of screen images are projected on a rotating spiral screen. In this study, we focused on possible distortion of 3D image in our volumetric 3D display system and its compensation.

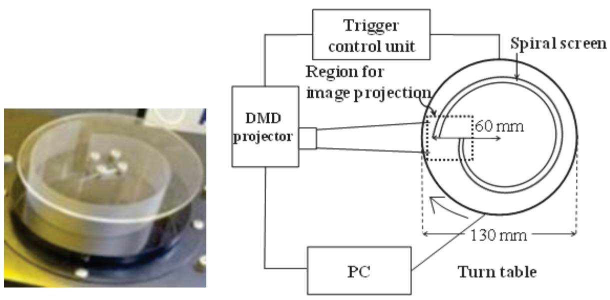
1. CONSTRUCTION OF OUR NOVEL 3D DISPLAY SYSTEM

Popular 3D displays which use binocular parallax can bring us 3D images which were observed usually from only a single view point. We have focused on a volumetric 3D displays which can produce more realistic 3D images for universal view point. Our 3D display system can form an infinite number of sliced images by using a spiral screen. On the other hand, 3D image distortion is supposed when considering the curved shape of the spiral screen. In this study, we confirmed basic characteristics of 3D image formation by our 3D system. We also tried to compensate one of distortions.

2. EXPERIMENTS

2-1. Construction of our 3D display

Figure 1: shows the construction of our novel 3D display system[1]. Volumetric 3D images can be formed with accumulated multi layers of section images projected on a rotating spiral screen. We can form volumetric 3D images by utilizing afterimage effect by high speed rotation of screen (Fig. 2). High speed switching of projected image for synchronizing high speed screen rotation up to 2000 rpm, was realized by using DMD (Digital Micromirror Device) projector. Green LED was used as a light source of the DMD projector in our experiments.



(a) Spiral screen (b) System construction

Fig. 1 Our 3D system using rotating spiral screen

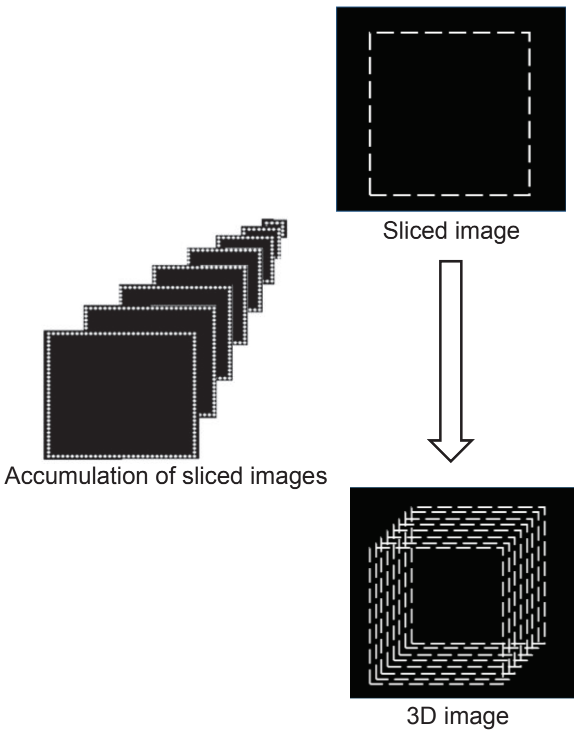


Fig. 2 Principle of volumetric 3D image formation

Table 1 Experimental conditions

Room illuminance	0 [lx]
Illuminance on screen by the projected light	1130~1250 [lx]
Distance from projector to screen surface	200 [mm]
Rotation speed	2000 [rpm]
Number of sliced images	64 [sheets]

2-2. Evaluation of Basic Characteristics of 3D Image Formations

[Experimental methods]

Straight lines and flat planes were formed at the center and peripheral region of the display area. We also formed cubic images (side length: 24 mm). Figure 3 shows coordinate axis set for the display region. Axis Y was set parallel to the optic axis of the projector. Axis X and Z were set vertical to the optic axis of the projector. Axis X was parallel to the direction of the screen rotation.

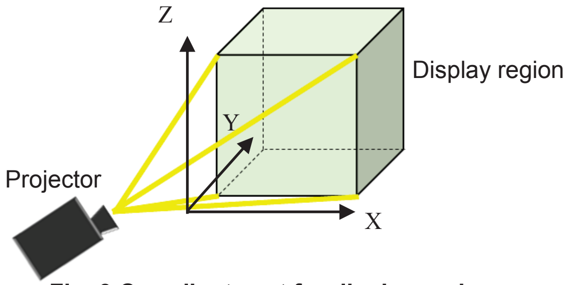
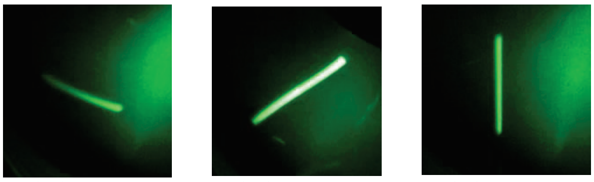


Fig. 3 Coordinate set for display region

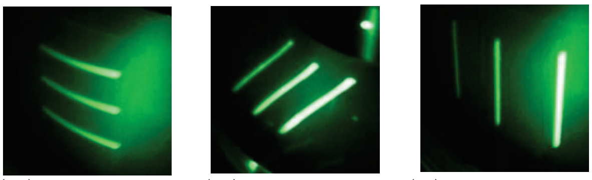
[Results]

Figure 4 ~ 8 show results of various 3D formations. Bending distortion was observed along the X axis. Funnel shape image distortion was also observed along the Y axis in Figure 8.



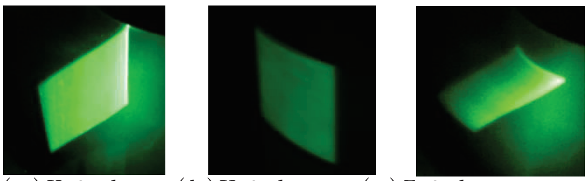
(a) X axis (b) Y axis (c) Z axis

Fig. 4 Projection results of straight lines (center)



(a) X axis parallel (b) Y axis parallel (c)Z axis parallel

Fig. 5 Projection results of straight lines (peripheral)

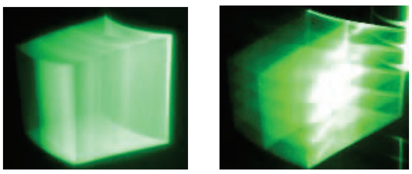


(a) X=0 plane (b) Y=0 plane (c) Z=0 plane

Fig. 6 Projection results of flat planes (center)

(a) X=0 parallel (b)Y=0 parallel (c)Z=0 parallel

Fig. 7 Projection results of flat planes (peripheral)



(a) Cube (b) Multilayer cube

Fig. 8 Cubic images

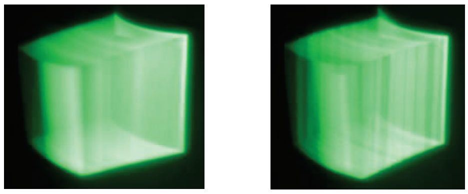
2-3. Trial of correction for image distortion

[Experimental methods]

We tried the funnel shape image distortion along the Y axis. We reduced size of each sliced image in proportion to the distance of each sliced image from the projector.

[Results]

Figure 9 shows the results before and after reduction processing of the sliced images along the Y axis. In the corrected 3D image, distortion along the Y axis is suppressed.



(a) Before (b) After

Fig. 9 Cubic images before and after correction.

2-4. Confirmation of 3D Image Correction Effects

[Methods]

Various 3D image before and after reduction processing along the Y axis direction of sliced images were formed and compared to confirm the correction effect.

[Results]

Figure 10 shows various 3D image before and after correction of the funnel type image distortion. Correction effect for funnel type distortion was clearly observed especially in Fig. 10 (d): dice image.

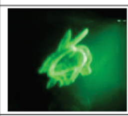
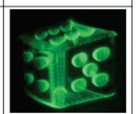
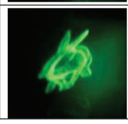
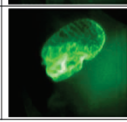
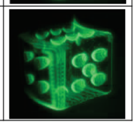
	(a) Rabbit	(b) Spider	(c) Skull	(d) Dice
Before				
After				

Fig. 10 Various 3D images before and after correction

3. CONCLUSION

In this study, we confirmed distortions of various 3D images projected on the spiral screen. And, distortion correction processing for the funnel shape distortion was performed. Our results are summarized as follows.

1) Bending distortion was observed along the X axis. Funnel shape image distortion was observed along the Y axis.
2) Funnel shape image distortion was successfully compensated by section image reductions in proportion to the distance of each section image from the projector.
3) The correction effect for funnel shape distortion was confirmed at various 3D images.

REFERENCES

[1] S. Suzuki et al., “Volumetric 3D Display System -Evaluation of Flicker when using a Rotating Spiral Screen-”, Proceedings of 1st ICAI, PB2-02 (2015).