360-degree Viewable Cylindrical Integral Imaging System Using Electroluminescent Films

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Abstract

A 360-degree viewable three-dimensional display based on integral imaging is proposed. The cylindrically arranged point light source array which is generated by electroluminescent (EL) pinhole film reconstructs 360-degree viewable virtual 3D image at the center of the cylinder. In this paper, the principle of operation and experimental results are presented.

1. Introduction

In recent years, three-dimensional (3D) display technologies have drawn attention as a next-generation display technology [1]. Among them, integral imaging is one of the most remarkable 3D display methods beyond others; full parallax, quasi-continuous view points, and simple structure are known advantages. However, it also bears depth, resolution, and viewing angle limitation problems. Some techniques for overcoming its weakness have been proposed by many groups [2-6]. The curved structure is one of the viewing angle enhancement methods; it enhances the viewing angle of integral imaging by arranging the lens array or pinhole array in a curve [5].

Among all display technologies, the 360-degree viewable 3D display is the most ideal type. Observing the reconstructed 3D image in 360-degrees, the observer would experience more realistic feeling. Many research groups have proposed various types of the 360-degree viewable 3D displays [7, 8]. However, the previously proposed 360-degree viewable 3D displays are complicated and huge. Therefore, we propose the simplest method for 360-degree viewable 3D display with full-parallax using integral imaging.

Figure 1 is the concept of the 360-degree viewable cylindrical integral imaging system. We extend the curved structure to the cylinder structure method for 360-degree viewing angle. Also, we analyze the characteristic parameters of the proposed method and viewing zone where the reconstructed virtual 3D image can be seen without flipping.

We used two sheets of electroluminescent (EL) film for generating point light source array in a cylindrical shape using their flexibility. Also, the 3D/2D convertibility was obtained by using EL pinhole film backlight switching. In the proposed method, each point light source is arranged cylindrically instead of flatly. The cylindrical arrangement of point light source array enhances the viewing region to 360-degrees, and the reconstructed virtual 3D image is displayed at the center of the cylinder structure. Using this method, 3D display for many viewers or 3D signboard is easily made in a simple structure.

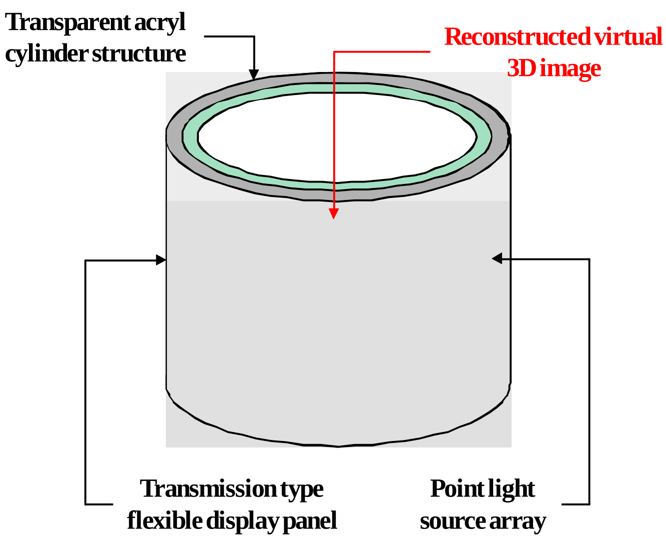

Fig. 1. Concept of the proposed method.

2. Principles

The overall structure of the proposed method in top view is shown in Fig. 2. The proposed method is composed of transmission-type flexible display panel, barrier structures, and cylindrically arranged point light source array. The 3D display principle of the proposed method is based on integral imaging using point light source array. The cylindrically arranged point light source array is generated by EL film and EL pinhole film using their flexibility. Moreover, the EL film backlight can switch between surface light source mode and point light source mode electrically, so the 3D/2D convertibility is possible.

For reconstructing a 360-degree viewable 3D image, the point light source array is arranged cylindrically and emits directional rays to 360-degrees when transmission-type flexible display panel shows the elemental image for cylinder type integral imaging on it. Elemental image for cylinder type integral imaging is generated by the ray tracing method by the supposition so that the 3D object is located at the center position of cylinder structure, with the consequence that the reconstructed 3D image is a virtual image.

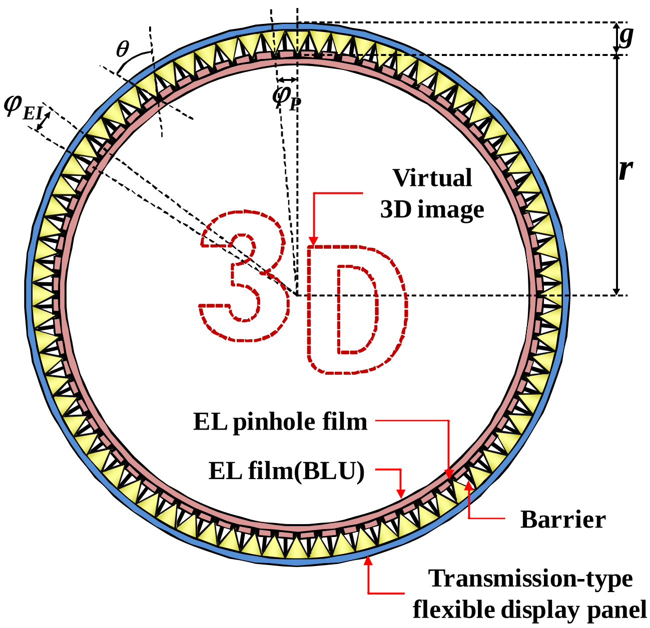

Fig. 2. Structure of the proposed method in top view.

For generating point light source array, we attach EL film for backlight and EL pinhole film which has a set of holes on it. The point light source array which is generated by EL pinhole film can be switched between 3D/2D mode [6]. The emitted light from EL film is limited to specified angle θ by EL pinhole film. Each point light source is arranged cylindrically using the flexibility of EL film. As shown in Fig. 2, point light source array is located on a cylinder with a radius r, and the transmission-type flexible display panel is gap g distant from the point light source array. When the point light source is arranged at a regular interval φ_P, each elemental image region for the point light source φ_{EI} is fixed, and each diverging angle of point light sources θ is derived as follows:

$$\theta = \frac{\varphi_{EI}}{g} = \varphi_P\left(\frac{1}{r}+\frac{1}{g}\right) \tag{1}$$

For preventing flipped image, we build the barrier structure between EL pinhole film and transmission-type flexible display panel within the field of view (FOV) of point light source θ. All cylindrically arranged point light sources have same FOV and display different views. In this situation, each view of point light source is limited by FOV of point light source. For 360-degree viewing angle, we arrange each point light source cylindrically instead of in-plane.

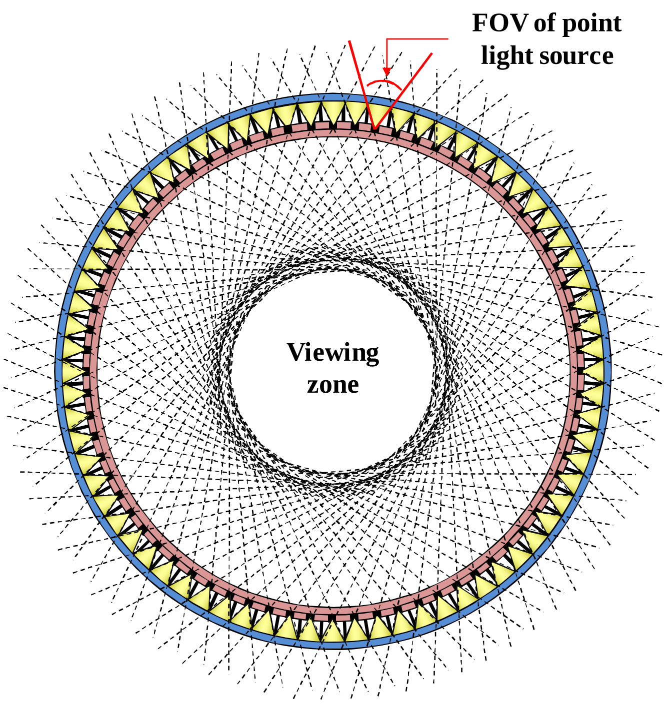

Fig. 3. Viewing zone of the proposed method.

However, the size of reconstructed virtual 3D image is limited by viewing zone which is the superposed region of FOVs of point light sources as shown in Fig. 3. If the size of reconstructed virtual 3D image is larger than viewing zone, the reconstructed 3D image is snapped and flipped. For preventing these problems, the viewing zone has to involve whole reconstructed virtual 3D image.

3. Experimental result

We performed experiments to verify the feasibility of the proposed system as shown in Fig. 4. In order to generate cylindrically arranged point light source array, we stacked EL film and EL pinhole film which is 150 mm × 50 mm in size and 0.4 mm in thickness and has 200 ㎛ diameter pinhole array at 1 mm interval. EL film and EL pinhole film are curved cylindrically with a radius of 30 mm by using the flexibility of EL film. As transmission-type flexible display panel, we used an over head projector (OHP) film for displaying elemental image of the proposed method. We printed elemental image which is generated by computer using OpenGL in 1200 DPI. We set the gap between the EL film and the OHP film to 2 mm with transparent-acryl-cylinder structure. EL pinhole film is located on the inside and the OHP film is located on the other side of the transparent-acryl-cylinder structure. As barrier structure, we stacked several check-pattern printed OHP films between the EL pinhole film and elemental image.

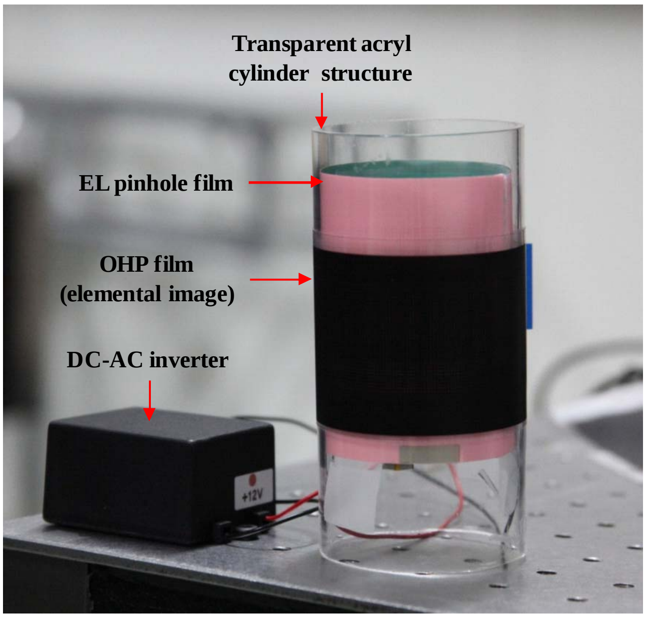

Fig. 4. Experimental setup.

Figure 5 shows the experimental result of the proposed method in 3D mode. The virtual image of 3D volume of modeled letter '3' is formed at the center position of cylinder. We can see the different perspectives in the different viewing positions around the cylinder.

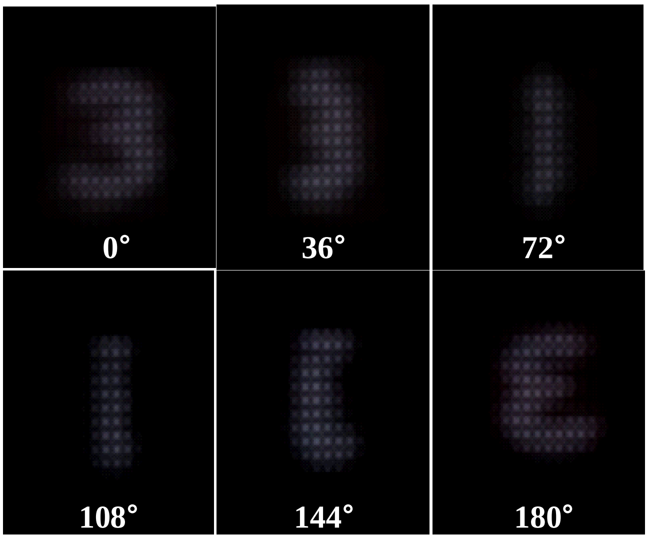

Fig. 5. Experimental results: reconstructed 3D images at different viewing positions.

After switching EL film backlight to surface light source mode, we experiment on 2D mode as shown in Fig. 6. The 2D image on OHP film instead of elemental image is clearly displayed using surface light mode of EL film backlight of cylindrical structure.

Fig. 6. Experimental result of 2D mode.

4. Conclusion

In this paper, we proposed a 360-degree viewable cylindrical integral imaging system using EL films. The proposed method is one of the 360-degree viewable 3D displays. It is based on cylindrically arranged point light source array which is generated by the EL film and the EL pinhole film. Using this method, 360-degree viewable 3D display can be made easily and cheaply with simple structure. Hence, this structure could be competitive for 3D display for many viewers and 3D signboard.

Acknowledgement

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5. References

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