16 viewpoints non-mechanical 360-degree holographic display system based on multi directional prism

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Abstract: Three dimensional(3D) holographic display system which are issued on next generation displays. Among many holographic systems, a table-top holographic display system uses a motor and it is observable at 360 degrees in continuous circular viewing zone. In this paper, we propose a prototype holographic display system for 16 viewpoints and circular viewing zone. The difference between the proposed system and the conventional table-top holographic display system is a non-mechanical system by removing a servo-motor. The prototype consists of a panel with color filter, two 4F off-axis optical systems and two types of prisms.

Key Word—*Digital holography, holographic display, Optical system.*

1. Introduction

Although three dimensional(3D) holographic displays are considered the ultimate display, the realization of a 3D holographic display is a practical challenge. The table top holographic display system is one of the next generation 3D holographic display systems. Recently, a prototype of the 360-degree holographic table-top display was introduced. This system consists of three digital micro-mirror device (DMD) for R/G/B colors, 4-f Fourier off axis filtering systems, a parabolic mirror for 3D object and a mechanical motor for time sequentially displaying 360-degree images on the viewing circumference [1]. The prototype needs to replace the mechanical rotation part with the non-mechanical but equivalent part, which is one of challenges.

In this paper, we carried out analysis and design of non-mechanical table-top type display system based on geometric and wave optics. We design and simulate a two type prism [2, 3]. We set up and experiment with prototypes using prisms and optical systems such as 4-f Fourier off axis system. The conventional system generates 1,024 holographic multi-views sequentially, but in this study, we propose the non-mechanical system consist of 16 view point.

2. System principles

In the proposed system, the 1st 4f system part serves as an off-axis system when observing the CGH, and the 2nd 4f system part is the core of the system. A schematic diagram of proposed system is shown in Fig. 1.

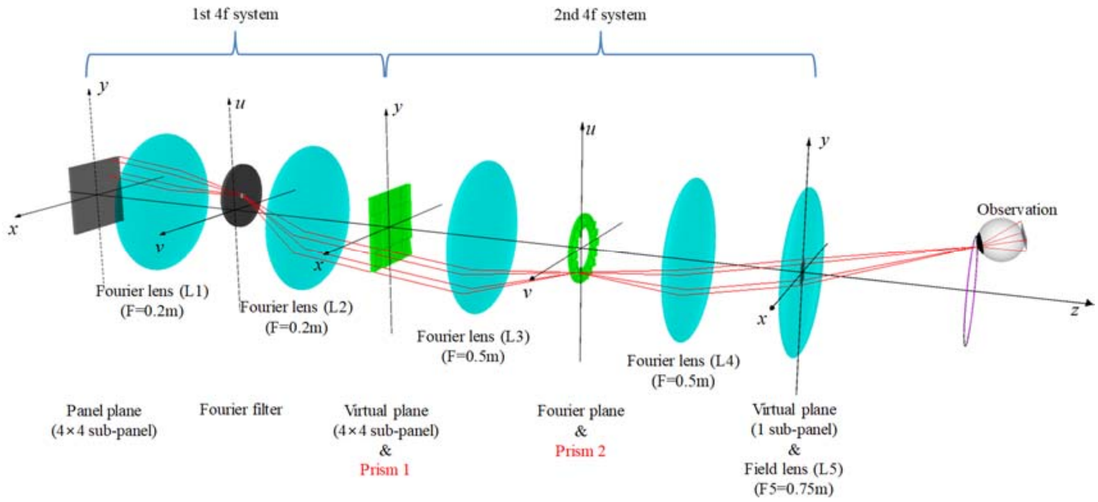

Fig. 1 Schematic diagram of proposal system.

First, the panel is divided into 4 × 4 regions from the total panel to implement the sub-panel. These sub-panels are implemented in a virtual SLM plane through front 4f off-axis optical system with iris filter. Second, the square array prism arranged to virtual SLM plane of 1st 4f system part and refract light propagated from the virtual SLM plane. The light propagated through the square array prism and the Fourier lens (L3) in the 2nd 4f system must be circular position in the Fourier plane. Third, a circular prism is positioned at the location of the signals of circular position to refract in parallel with the optical axis. The parallel light is reconstructed to the virtual plane through the Fourier lens (L4), where all sub-panels converge to one sub-panel on the optical axis. Finally, we can observe the object through the light waves converged by the filed lens (L5). The viewing windows are formed in a circular position because of the square prism that arranges the Fourier signals in a circular position and circular prism that refract the propagated light parallel to the optical axis.

In order to arrange the array of signals as a circle in the Fourier plane, the carrier wave term of the square prism is defined as

$$\text{Square prism} = \exp\left[\frac{j2\pi}{\lambda f}\left(xu_m + yv_n\right)\right]. \tag{1}$$

In the Fourier plane, the Fourier signals are modulated of phase compensation for converging the sub-panel to the optical axis in the virtual plane. The carrier wave term of the circular prism is represented by

$$\text{Circular prism} = \exp\left[\frac{j2\pi}{\lambda f}\left(\left(u - u_m\right)x_m + \left(v - v_n\right)y_n\right)\right]. \tag{2}$$

3. Comparison of simulation and experiments

We simulate based on geometric and wave optics. In the simulation, 2D images propagated through the proposal system and observed in the retina plane as shown in Fig. 2. (a). And, we set-up the test bench based on the simulation, and we observed with the CCD camera as shown in Fig. 2. (b).

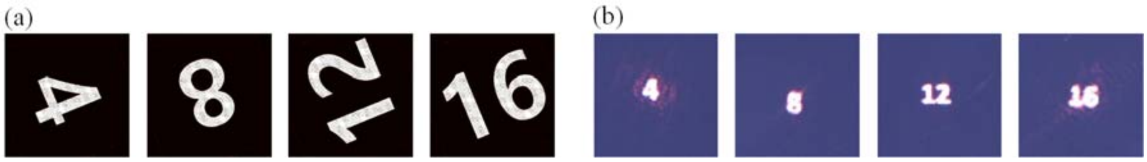

Fig. 2 (a) Simulation results, (b) experimental result

Finally, we experiment an accommodation effect for computer generated holograms(CGHs). Figure 3 shows the experimental results for one of the 16 viewpoints, Fig 3. (a) shows the result of focusing at 300mm from the virtual SLM, and Fig 3. (b) shows the result at 1mm.

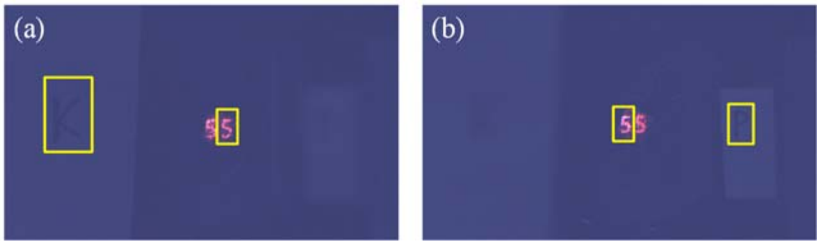

Fig. 3 Experimental results for accommodation effect, (a) focus on "K" & right "5", (b) focus on "P" & left "5"

4. Conclusion

We demonstrate non-mechanical type of 360-degree table-top holographic display system through the simulations and experiments. And, we fabricate two types of prism for core parts and proved the concept. We remain to develop a diffractive optical elements(DOEs)-type system instead of the prism type, and to increase the number of viewpoints. The ultimate goal of this research is the DOEs type and compact 360-degree 1,024 viewpoint holographic display system.

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5. References

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