Multi-channel viewing-zone scanning holographic display

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Abstract: A multi-channel viewing-zone scanning holographic display that enables an increase in the screen size using multiple projection systems is proposed. A screen size of 7.4 in and viewing-zone width of 630 mm are demonstrated.

OCIS codes: (090.2870) Holographic display; (090.1760) Computer holography; (120.2040) Displays

1. Introduction

The electronic implementation of holography has a drawback of limited screen size and viewing zone. We previously proposed a viewing-zone scanning holographic display [1], which uses a MEMS spatial light modulator (SLM) and a galvano scanner, to enlarge both the screen size and viewing zone. However, the enlargement of the screen size by this system is limited by the mirror size of the galvano scanner. In this study, we propose a multi-channel viewing-zone scanning holographic display that enables further enlargement of the screen size.

2. Proposed system

Figure 1 illustrates the proposed multi-channel viewing-zone scanning holographic display. It consists of plural holographic projection systems and a flat-type horizontal scanner.

Each holographic projection system consists of an MEMS-SLM, a magnification lens, a single-side band (SSB) filter, and a screen lens. The magnification lens produces an enlarged image of the MEMS-SLM screen onto the screen lens, and the screen lens converts light into parallel light. The SSB filter eliminates the zero-order diffraction light and the conjugate image component. Multiple holographic projection systems are aligned so that their screen lenses are tiled seamlessly to enlarge the screen size. The tiled screen lenses also emit parallel light, which is converged by a common lens to generate a viewing zone. Because the pixel pitch is increased, the width of the viewing zone is reduced.

The reduced viewing zone is scanned horizontally by the flat-type horizontal scanner to enlarge the viewing zone. The flat-type horizontal scanner comprises a rotating off-axis lens and vertical diffuser, as shown in Fig. 2. The common lens used to generate the reduced viewing zone is used as the rotating lens; however, its lens axis is shifted from the rotating axis. When this off-axis lens rotates, the reduced viewing zone also rotates around the rotation axis. Because the vertical diffuser enlarges the reduced viewing zone in the vertical direction, the rotary movement of the viewing zone becomes the horizontal movement, as shown in Fig. 2. Thus, a horizontal scanner with a large screen is achieved.

Fig. 1. Multi-channel viewing-zone holographic display.
3. Experiments

A two-channel display system was constructed to demonstrate the effectiveness of the proposed technique.

Figure 3(a) shows the holographic projection system. A digital micromirror device (DMD) was used as the MEMS-SLM. The maximum frame rate, resolution, and pixel pitch were 22,727 Hz, 1,024 × 768, and 13.68 μm, respectively. A laser diode with a wavelength of 641 nm was used as the light source. The magnification of the imaging system was 7.43, and the pixel pitch was increased to 102 μm. The viewing zone was reduced to 5.05 × 2.52 mm². The DMD was placed in the portrait direction, and the screen size was increased to 78.0 × 104 mm². The screen size of the two-channel system was 156 × 104 mm² (7.4 in).

Figure 3(b) shows the flat-type horizontal scanner. A Fresnel lens was used as the rotating off-axis lens. The effective diameter of the Fresnel lens was 200 mm. A lenticular lens was used as the vertical diffuser. The rotation speed of the off-axis lens was 1,800 rpm, and the frame rate of 3D image generation was 60 Hz. The number of reduced viewing zones generated during a single scan was 189. The width of the enlarged viewing zone was 630 mm at a distance of 800 mm from the flat-type horizontal scanner.

The reconstructed images generated by the experimental system are shown in Fig. 4. The images were captured from five different positions in the enlarged viewing zone. The reconstructed images could be observed in a wide area. The two screens of the two channels could be seamlessly tiled, except that a black vertical line was observed from the center position in the enlarged viewing zone.
4. Summary

We proposed a multi-channel viewing-zone horizontally scanning holographic display. The screen size was enlarged using plural holographic projection systems and a flat-type horizontal scanner. The two-channel experimental system with a screen size of 7.4 in. and viewing zone width of 630 mm was demonstrated.

This study was supported by JSPS KAKENHI Grant Number 15H03987.

5. Reference