Design of diffractive filter for 360-degree table top electronic holographic display system

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Abstract: Recently, promising prototypes of 360-degree table-top holographic display systems have been proposed. Digital micro-mirror device (DMD) is employed as necessary fast display panel. A motor is a common key device of those 360-degree table-top systems. Time-multiplexed 360-dgree multi-view projection is driven with synchronized motor and DMD. However, rotational mechanical movement is considered a significant drawback of those system. In this work, we propose a novel design of diffractive filtering system for non-mechanical 360-degree table-top holographic display system.

1. Introduction

Holographic display is considered as the ultimate display system and its application expansibility and flexibility are considerable, but a realization of holographic display is a challenge in practical point of view. A form of table-top display system is a promising candidate for next-generation 3-dimensional (3D) display systems, in which, in particular, holographic display technology can contribute severely. Recently, computer-generated hologram (CGH) content was displayed. One recent prototype of the 360-degree table-top system is composed of the digital micro-mirror device (DMD), 4f optical filtering part, parabolic mirrors and a motor. The viewing windows of 1,024 is formed and multi-view CGHs are displayed to 360-degree viewing window circumference by the sequential operation of the DMD [1]. The drawback is the rotational mechanical movement. Since the bulky optical system is mounted on the motor, sound noise as well as system bulkiness would be problematic. The design of non-mechanical (non-motorized) 360-degree table-top system is required and simultaneously it is a challenging problem.

In this paper, we propose a design of diffractive filter that can remove the motor in the conventional table-top configuration. First, we design multi-focus diffractive optical elements (DOEs) [2] that replicate the incident beam to 360-degree viewing circumference. This multi-focus DOE structures can distribute replicated CGH images along the viewing window circumference. Dynamically, DMD updates CGH contents, then, we need to selectively filter the circularly replicated CGH fields and make the selected direction to observation direction. The filtering aperture structure is fixed and rigid, but the CGH field generation is dynamic and time-multiplex projection of CGH field is realized. Simultaneously, the filtering system can remove twin noise and DC noise of computer generated hologram to be loaded through digital micro-mirror device. As a result, it is possible to construct a smaller and secure non-motorized holographic table-top display system than conventional motorized table-top display system.

2. Multi-focus diffractive optical element

The conventional table top system runs at a speed of at least 300rpm. The observer can see a CGH image of 5fps at 300rpm through one viewing window. Considering human eye recognize a natural moving image at 30fps, we see that the motor for 30 fps should operate at least at 1,800rpm. In order to replace the motor, we designed the multi focus DOE based multi-view filtering system. The multi focus DOE was designed by superimposing prisms that deflect and lenses that direct carrier waves to a desired position on the viewing circumference. Superposition of a number of prisms and lenses produce the multi focus DOE shown in Fig. 1(a) and the imaging pattern of a point source through the multi focus DOE on the viewing circumference is presented in Fig. 1(b). Incident beam is disseminated as much as 38 longitudinal angle through this multi focus DOE.

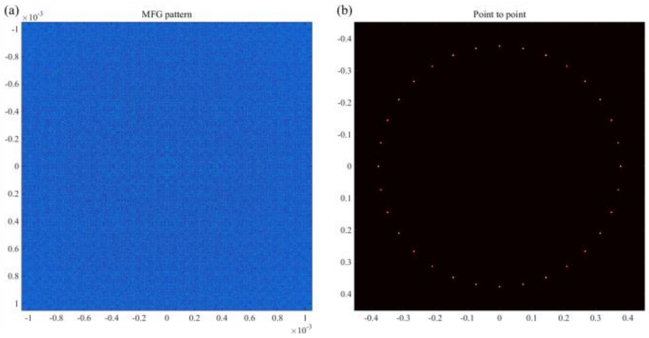

Fig. 1. (a) Multi-focus DOE and (b) Result of simulation that point to point

Fig.1(a) shows the multi-focus DOE which is designed through simulation. It is designed for 32 view point, and the result of superposition of 32 prisms. The points on the filter when beam is incident through the designed multi focus DOE shown in figure 1. (b). The amount of light is divided and weakened, but we can see exactly 32 point. So, we showed that we can replace the motor through multi focus DOE.

3. Optical filtering mechanism

The off-axis systems are widely used to avoid DC noise and twin noise in optical observation experimental system [3]. The phase shifting method by multiplying the carrier wave term to the CGH pattern allows us to change the signal spot position in the Fourier domain. Using the phase shifting, we can adjust the signal to desired position (Fig. 2). Then, we put an aperture band-pass filter where a selected signal converges to point through the multi focus DOE and the other signals are blocked by the aperture filter. Then, DC noise and twin noise can be removed through the filter and also the directional selection is carried out. This filtering mechanism is descriptively summarized by filtering a desired part of the CGH signal delivered by the directional carrier wave for observance at each selected view point

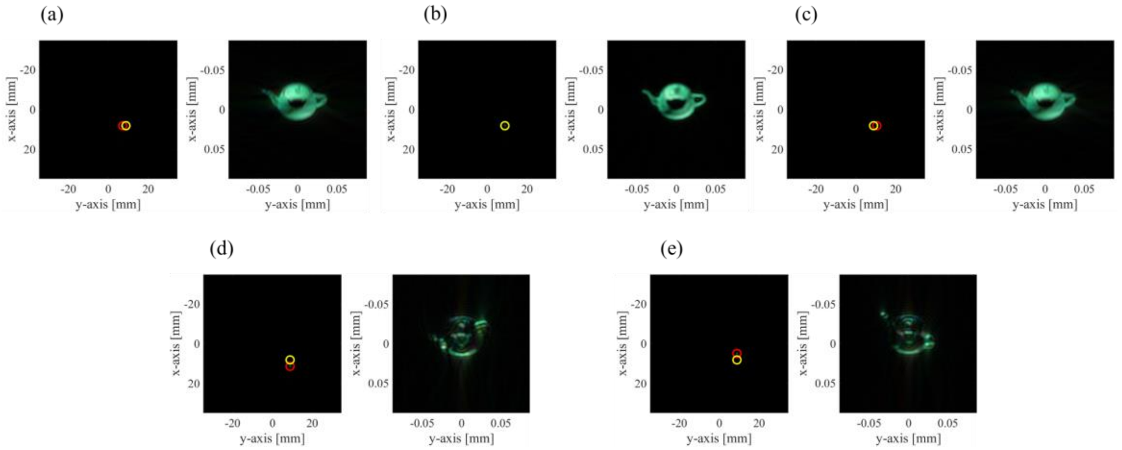

Fig. 2. Red circle is signal and yellow circle is filter. (a) Left signal, (b) center signal, (c) right signal, (d) under signal, (e) upper signal.

We simulated 1,024 CGHs by multiplying them by different carrier waves sequentially and 32 × 32 matrix filter. Figure 2 shows the filter and signal in the filtering domain and observation result. It is the simulation result of the filtering effect that removes the noise except the signal and the surrounding signals. Fig. 2(b) shows the filtered signal and its result. Figure 2. (a), (c) show results when the signals for similar images on the left and right sides are invaded. The signals on the left and right sides are similar images. However, we need to increase the vertical directional gap size between filtering apertures since the observation results of the above and below CGH signals are quite different as shown in Fig. 2(d) and (e). We have proven the 32 × 32 filter for 360-dgree 1024 multi-view generation.

4. Conclusion

Conclusively, we have proposed a novel diffractive filtering method to remove the motor in the conventional table-top holographic display system and compensate the need of 360-degree multi-view generation. Some optical systems in the conventional table-top holographic display system. In the presentation, we will prove theoretically the possibility of the proposed diffractive filtering technique and present simulation results to support the dynamic mechanism of the 360-dgree holographic table top display system.

Acknowledgement

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6. References

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