Computer-Generated Hologram in Holographic Curved Waveguide Display

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Holographic three-dimensional (3D) near-eye displays (NEDs) are attracting attention as immersive 3D displays that can enhance the user's visual experience in augmented reality (AR). To effectively create a more perceptive holographic AR display, user-friendly optical factors such as high resolution, accommodation effect, wide field of view (FOV) and large eyebox should be carefully considered. Importantly, AR-NEDs need thin and lightweight optical component for a comfortable wearing experience with optical see-through. Recently, AR displays with a slim form factor have been introduced using flat waveguide based on exit pupil expansion [1,2]. The flat waveguide-type display can improve the limited space bandwidth product of SLMs that modulate optical wave fields, but when observing high-resolution holographic 3D images, AR-NEDs are unable to achieve a sufficient FOV due to the short eye relief and the limited pixel size of spatial light modulator (SLM).

In this paper, we propose accommodation-capable computer-generated hologram (CGH) synthesis algorithm in curved waveguide. The curved waveguide-type displays can alleviate the FOV limitation compared to flat waveguide-type displays. The proposed algorithm is considered based on angular multiplexing for directional optical fields from pupil-replicated SLM arrays. For generating holographic 3D images with extended FOV, we demonstrate the efficiency of the proposed synthesis algorithm through numerical simulations. As shown in Fig. 1, we present observation results of holographic images in both flat and curved waveguide displays. To observe holographic 3D images with the human eye, we calculate CGH by multiplexing each optical wave field generated from the replicated virtual SLMs, using cascaded Fresnel Transform model. In the flat waveguide display, the user can only observe a partial area of the holographic image due to limited FOV. On the other hand, in curved waveguide display, the reconstructed result on retina plane shows a fully holographic image at near field. The proposed CGH synthesis algorithm can effectively generate holographic 3D images with an extended FOV in a curved waveguide display.

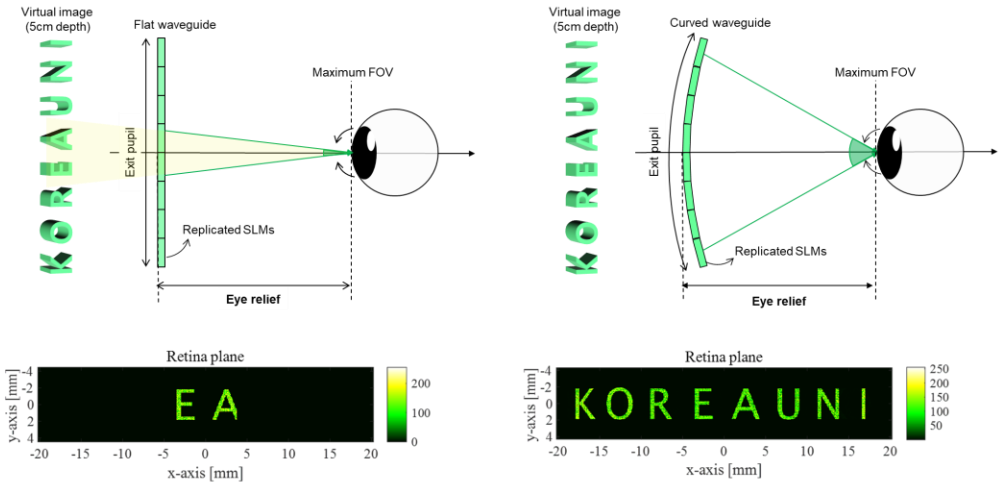

Fig. 1. Numerical eye observation results of holographic waveguide display.

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References

1. C. Jang, K. Band, M. Chae, B. Lee, D. Lanman. Nature Communications., 15.1, 66 (2024).
2. W. Moon, H. Jeon, S. Na, H. Kim, and J. Hahn. Displays., 81, 102617 (2024).