Numerical modeling and diffraction efficiency analysis of diffractive augmented reality system

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1. Introduction

Augmented reality (AR) technology is one of the next-generation displays, head-mounted-display (HMD) technology, and has received great attention in recent years [1]. Accordingly, Microsoft's Hololens is at the forefront of augmented reality technologies that are commonly used with diffractive optical elements. It is necessary to study the holographic lens because the high performance is achieved through the thin combiner even though the lens is not used. In this paper, we show the numerical model based on the accurate structural design through the electromagnetic analysis of the combiner of the diffractive optical element implemented in the diffractive AR system.

2. Results

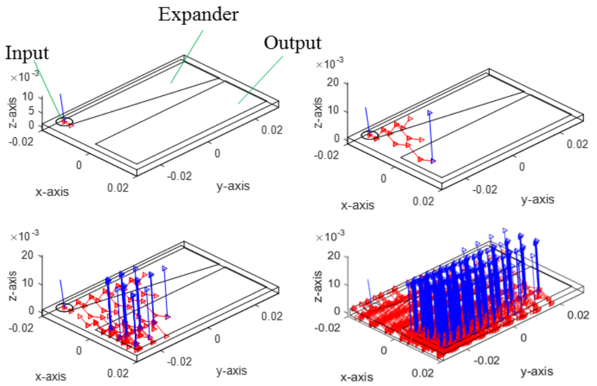

Fig 1. Geometrical optical modeling of diffractive AR combiner system

Figure 1 shows the geometric optics modeling simulation of a beam combiner of the diffractive AR system. When light passes through the input grating structure, the light is diffracted in the direction of the extended grating structure. The diffracted light is diffracted in the direction of the output lattice structure by the extended diffractive structure and replicated on the surface through repetitive total internal reflection (TIS). The duplicated light is again diffracted and duplicated by the expansion grating structure, and the light incident on the output grating structure is output in a direction parallel to the input light. This allows one light to be cloned and output in a multitude of lights, forming a field of view (FOV).

Geometric optical modeling can analyze the direction of reflection or diffraction of light, but the efficiency of light cannot be interpreted. However, in this study, the efficiency of light diffracted by the grating structure can be analyzed by electromagnetic field analysis using FMM (Fourier modal method) technique. The FMM is one of the most popular numerical electromagnetic analysis methods for periodic optical structures [2].

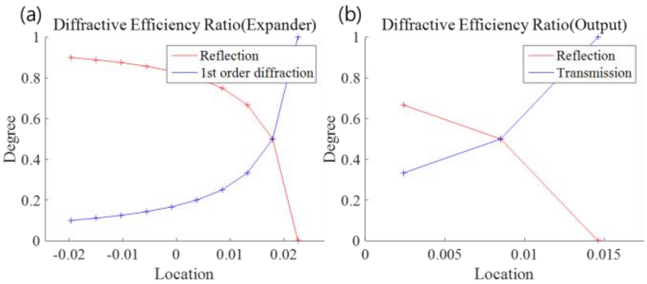

Fig 2. Expander and output coupling parts

Figure 2 shows the diffraction efficiency distributions of the expander and output gratings obtained by simple calculation theory. Figure 2 (a) shows the ratio of the reflected light and diffracted light from the expander grating. Figure 2 (b) shows the ratio of the reflected light and the transmitted light from the output grating. The gratings with these efficiencies can be designed by the Fourier modal method (FMM) and applied to expander gratings and output gratings to finally obtain a uniform light efficiency. If the light efficiency is uniform, a clear image is formed on the retina when entering the eye through the light beam from the output grating.

3. Conclusions

In this paper, we will analyze the optical structure of the diffractive AR system using the hybrid modeling of geometric optics and electromagnetic field analysis as described above, and ultimately propose a new optical structure to improve yield of the grating process, FOV and light emitting efficiency.

References

[1] Levola, Tapani, and Viljakaisa Aaltonen. "Near-to-eye display with diffractive exit pupil expander having chevron design." *Journal of the Society for Information Display* 16.8 (2008): 857-862.

[2] H. Kim and B. Lee, "Rigorous Fourier modal analysis on slab structures with finite thickness and one-dimensional arbitrary permittivity and permeability profiles," The 11th Microoptics Conference Tokyo, Japan, pp. 222-223, Oct.-Nov. 2005.