Design and Prototyping of Wide Field of View Occlusion-capable Optical See-through Augmented Reality Displays by Using Paired Conical Reflectors

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Abstract

Mutual occlusion is essential for augmented reality (AR) displays to display virtual objects with correct perceptual cues and increase the visibility of AR content under an excessive illuminated environment. Although a few works have been developed, rendering mutual occlusion in a wide field of view (FOV) is still challenging to state-of-the-art occlusion-capable optical see-through augmented reality (OC-OST-AR) displays. In this dissertation, we addressed this issue by building OC-OST-AR displays based on paired conical reflectors. With spatial light modulators (SLMs) being utilized, two sub-structures, including transmissive SLM-based paired-ellipsoidal-mirror (T-PEM) structure and reflective SLM-based paired-parabolic-mirror (R-PPM) structure, are proposed. The paired conical reflectors work with a tiny aperture stop to increase the numerical aperture (NA) of AR imaging systems significantly. Then, either typical hard-edge occlusion or enhanced soft-edge occlusion can be conducted in a wide FOV by fixing an SLM before the entrance pupil or at an inner focal plane. Proof-of-concept prototypes are built for both T-PEM and R-PPM structures. Enhanced soft-edge occlusion is demonstrated in a monocular FOV of H122°×V74° with the T-PEM system, and hard-edge occlusion is demonstrated in a monocular FOV of H83.5°×V53.1° with the R-PPM system.