Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses using Defocused Point Light Sources

Andrew Maimone⋆ Douglas Lanman† Kishore Rathinavel⋆ Kurtis Keller⋆ David Luebke† Henry Fuchs⋆
⋆The University of North Carolina at Chapel Hill †NVIDIA Research

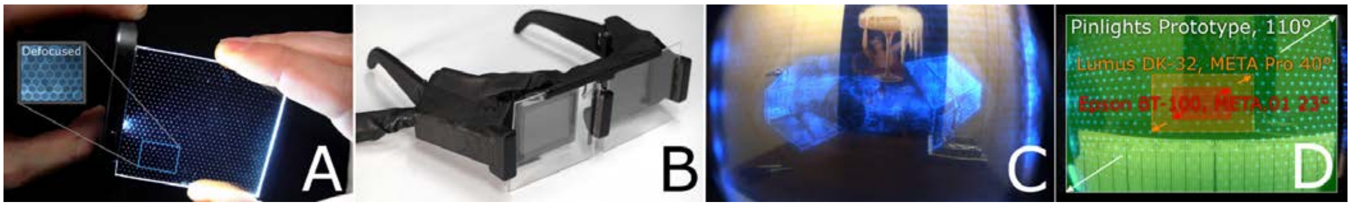

Figure 1: *A) An array of point light sources, called* pinlights*, fill the eye's image plane when* defocused *near the eye. B) Prototype optical see-through display consisting of pinlight arrays and spatial light modulators (SLM). The SLMs code the defocused pinlights to form an image on the retina. C) A photograph taken through our prototype display using a camera that approximates the human eye. D) A comparison of the field of view of our prototype display (*110°*) to state-of-the art commercial optical see-through glasses. Ship model by Staffan Norling.*

Abstract

We present a novel design for an optical see-through augmented reality display that offers a wide field of view and supports a compact form factor approaching ordinary eyeglasses. Instead of conventional optics, our design uses only two simple hardware components: an LCD panel and an array of point light sources (implemented as an edge-lit, etched acrylic sheet) placed directly in front of the eye, out of focus. We code the point light sources through the LCD to form miniature see-through projectors. A virtual aperture encoded on the LCD allows the projectors to be tiled, creating an arbitrarily wide field of view. Software rearranges the target augmented image into tiled sub-images sent to the display, which appear as the correct image when observed out of the viewer's accommodation range. We evaluate the design space of tiled point light projectors with an emphasis on increasing spatial resolution through the use of eye tracking, and demonstrate a preliminary human viewable display.

1 Overview

The field of Augmented Reality (AR) shows promise of advancing to an integration of graphics and human vision; we imagine using an AR system to *casually* interact with *spatially registered* overlays instantly and at many moments throughout the day. Perhaps the most fundamental challenge to realize this goal is obtaining an AR display with a sufficiently *wide field of view* (FOV) and *non-encumbering form factor* to allow spatially registered applications and extended everyday use. Today's *optical see through glasses* target these primary requirements in isolation, offering a wide FOV *or* a compact form factor. However, conflicting hardware constraints have prevented creation of a device with the wide FOV and comfort expected of ordinary eyeglasses. We propose a new approach that avoids the need for traditional bulky and FOV limiting optics (e.g. beamsplitters and waveguides) and instead relies on two simple components: an LCD panel and an array of bright point light sources. Our core innovation is the use of *defocused* point sources, called *pinlights*, coded through an LCD panel to form miniature and see-through projectors. These projectors direct light into the eye through a *virtual aperture*, allowing their small image areas to be tiled to create an arbitrarily wide FOV. Software decomposes the target image into tiled sub-images, each corresponding to a miniature projector.

2 Related Work

Optical see-through displays are available from Google, Lumus, Vuzix, and others. The most prevalent approaches are freeform optics and waveguides. Instead, we use a direct view display, a technique shared by only a handful of near-eye displays, e.g. the Innovega iOptik display, which requires a custom contact lens. Our development of coded pinlight projectors is related to work in defocused projection systems, e.g. Mohan et al. [2009], which presented a compact alternative for traditional barcodes. However, existing approaches do not directly facilitate near-eye see-through applications. Other related work includes 3D displays using *parallax illumination*, e.g. Son et al. [2007]; however, existing work is designed for opaque desktop displays within the viewer's focus range.

3 Implementation

To test our approach, we constructed a prototype display consisting of LCD panels and point light arrays (edge illuminated etched acrylic sheets, see Figure 1A) installed in a 3D printed frame resembling eyeglasses (Figure 1B). Software decomposed the target image into tiled sub-images displayed on the LCD in real-time. A camera placed behind the display simulated a viewer wearing eyeglasses (2.3 mm aperture with a center of projection to display distance of 16 mm); see Figure 1C for an example. The display FOV was measured as $\approx 110^\circ$ diagonally (Figure 1D), far exceeding existing displays with similar form factors. In a human wearable display, eye tracking is employed to maximize spatial resolution.

References

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