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Invited Paper

Beaming Displays: Towards Displayless Augmented Reality Near-eye Displays

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ABSTRACT

Augmented Reality (AR) near-eye displays promise new human-computer interactions that can positively impact people's lives. However, the current generation of AR near-eye displays fails to provide ergonomic solutions that counter design trade-offs such as form factor, weight, computational requirements, and battery life. Unfortunately, these design trade-offs are significant obstacles on the path towards an all-day usable near-eye display. We argue that a new way of designing AR near-eye displays that remove active components from a near-eye display could be a key to solving trade-off related issues. We propose the beaming display,[1] a new near-eye display system that uses a projector and an all passive wearable headset. In our proposal, we project images from a distance to a passive wearable near-eye display as we track the location of that near-eye display. This presentation will present the latest version of our prototype while we discuss the potential future directions for beaming displays.

Keywords: Near-Eye Displays, Augmented Reality, Virtual Reality, Projection Displays, Computational Displays

1. INTRODUCTION

Augmented reality near-eye displays[2] promise to improve our daily lives with countless applications[3] in communication,[4–6] healthcare,[7–10] and more. In the meantime, in recent years, everyday activities such as work and socialization have steadily shifted to more remote and virtual settings. Thus, augmented reality near-eye displays could play a key role in arriving at new human-computer interactions that could positively impact our societies.[11] However, there are technical challenges and obstacles in achieving compact form factors while equipping an augmented reality display near-eye displays with necessary optical components, sensors, power banks, and computational resources.

2. BEAMING DISPLAYS

We argue that instead of following the common trend in near-eye display design,[12–17] or stereoscopic displays,[18–22] new approaches that avoid solving problems in near-eye display design space is required. Hence, we propose a novel way of designing augmented reality near-eye displays, which we call as the Beaming Display.[1]

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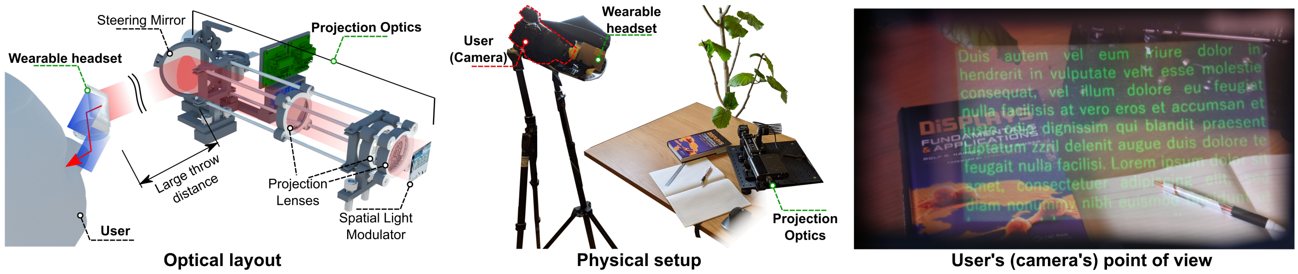

Figure 1. Beaming Displays. Left: Our new optical layout decomposes a near-eye display design into two parts, an all passive light-weight wearable headset, and a remotely located projector, this decomposition effectively avoids trade-offs between ergonomics, computational and power requirements. Middle: We build a physical setup to demonstrate the possibilities with our optical layout. Right: We show experimentally that our design supports resolutions matching a consumer level near-eye display.

We redefine the design framework for see-through near-eye displays by physically separating the image generating parts from the eyepiece as depicted in Fig. 1. In this configuration, an image generating beaming unit beams images from a distance to a light receiving unit equipped with an eyepiece on the user's side. Our final implementation can be described as a remotely controllable all passive wearable AR display with a light-weight body that is free from batteries or electronics that can heat up or any other active components that can pose design trade-offs related challenges in traditional display hardware. We provide the full technical details of our work in our main technical paper.[1]

Figure 2. Photographs from a user's perspective. Left: Steering projector projects an image of a seaside view. Middle: Steering projector projects text, Right: steering projector projects images of a 3D model with some text and colored boxed at the edges, while the real-world view is blocked with an opaque material..

In our experiments, we observe that the resolution is homogeneous across different parts of the FoV, which can be observed from the sample photos in Fig. 2.

3. POTENTIAL FUTURE BENEFITS

In this section, we highlight some potential benefits of beaming displays briefly. We consult curious readers to our main technical paper[1] and stress that benefits highlighted here represents a sub group of potentials in the future.

Privacy. Beyond technical issues, obstacles in a social context such as acceptance or privacy concerns regarding cameras on augmented reality near-eye displays pose a significant challenge for adopting various kinds of AR display technologies. Though we did not conduct a formal subjective test on acceptance of our prototype, we expect that placing cameras and sensors away from a user, as in our case, may have a positive impact from the perspective of a user.

Classical near-eye displays vs beaming displays. Like the current ecosystem, multiple types of displays such as 3D displays and near-eye displays are expected to co-exist in the future. Beaming display as a partial variant of augmented reality near-eye displays will co-exist alongside augmented reality near-eye displays, and we expect augmented reality near-eye display to be miniaturized further. Unlike augmented reality near-eye displays, though, each part of a beaming display, such as the projector, glasses, or tracking unit, can be upgraded in a

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stand-alone way without having to change the hardware as a whole completely. The design approach of beaming displays leaves room for a modular design while enabling considerable computational resources as a steering projector can be connected to such resources without suffering from any miniaturization, heat, or power-related issues.

Applications. Our approach can enable long-duration usage of AR applications. Given the current conditions with the pandemic, virtualization is in increasing demand with remote work and teleconference cases. Enabling improved extended duration usage in hardware can potentially help improve the adoption of AR tools in the long run and support the trend of virtualization. Therefore, we believe that, in this new era, our method is potentially helpful for improving teleconferencing, remote work, education, gaming, and creative design.

Miniaturization of a passive wearable headset. The wearable headset in our prototype is based on a bird-bath optics approach. We have built our headset by harvesting optical components from an existing consumer-level headset from a previous generation. Modern variants of bird-bath optics on the near-eye display market are closely approximating the form of a pair of sunglasses (i.e., Nreal). Switching to smaller optics also requires redesigning steering projector optics because the diffusive screen area in a smaller headset will also be smaller in size. As a more advanced approach, some of the works in literature[12,13] propose a holographic approach relying on patterned diffusers that can be used as an eyepiece without requiring any additional lenses or mirrors. Soon, we plan on expanding on such work by switching to a holographic projection mechanism and a patterned diffuser used as an eyepiece instead of bird-bath optics.

4. CONCLUSION

Augmented reality applications offer a desirable future, where computer-generated visuals improve our daily lives and routines when and where it is needed. Towards that future, AR near-eye displays have to be free from any heating problems, form-factor, and weight-related issues or computational and power issues due to limited onboard resources. Our work proposes a new augmented reality near-eye displays class that can potentially help with ergonomics, computation, and power issues.

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