EyeAR: Physically-Based Depth of Field through Eye Measurements

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Figure 1: The goal of our demo is to embed computer graphics (CG) objects into the real world, which are indistinguishable from real objects. Up to now, this has been impossible in Optical See-Through Augmented Reality, because of the mismatch between the properties of the user’s eyes and the virtual camera used to generate CG. Using an Auto Refractometer (a), we measure the user’s pupil size and accommodative state and feed these values into a realtime raytracer. (b, c) The resulting Depth of Field of the CG dragons (left) matches 3D-printed dragons (right) - as the user focuses on dragon in front (b) and back (c).

ABSTRACT

Augmented Reality (AR) is a technology which superimposes computer graphics (CG) images onto a user’s view of the real world. A commonly used AR display device is an Optical See-Through Head-Mounted Display (OST-HMD), which is a transparent HMD, enabling users to observe the real-world directly, with CG added to it. A common problem in such systems is the mismatch between the properties of the user’s eyes and the virtual camera used to generate CG. The goal of our system, is to accurately reflect the state of the user's eyes in our renderings.

Using an Auto Refractometer, we measure the user’s pupil size and accommodative state and feed these values into a realtime raytracer. The resulting renderings accurately reflect the Depth-of-Field (DoF) blur effect the user perceives in their view of the real world. In our demo, users can verify the accuracy of our system by simultaneously observing 3D-printed objects next to their CG counterparts.

We believe that our technique is the most promising way for achieving augmentations that are indistinguishable from real objects. Integrating it into consumer OST-HMDs will be a crucial step for bringing photo realistic AR to the masses.

Keywords: Raytracing, Physically Based AR, Augmented Reality, Depth of Field, Optical Defocus

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; I.3.7 [Three-Dimensional Graphics and Realism]: Computer Graphics—Raytracing; I.3.3 [Computing Methodologies]: Picture/Image Generation—Display Methods;

1 BACKGROUND

Augmented Reality (AR) is a technology which superimposes a CG image on a user’s view of the real world. Ideally we aim to do so in a way which directly reflects the user’s view of the surrounding environment. There are two main archetypes of Augmented Reality: Video See-through where CG is composed onto a video background of the environment observed by a camera, and Optical See-through, where CG is rendered on a transparent background allowing the user to observe the real world directly with CG added to it. Due to this key difference between the two archetypes above, it has been, up til now, impossible to create coherent CG. This is because of the significant difficulty to model the eye compared to a camera lens, which was previously done in [2].

What makes this demo unique and special? AR is becoming an increasingly popular technology, especially with the mass production of commodity OST-HMD devices. Since the Microsoft Hololens and Google Glass are attracting attention, we believe this will be an engaging demo.

Additionally, users will become aware of the need to measure the eye since it is a major requirement in coherent CG for AR. Through this demo, users can experience a perfect DoF AR rendering during this demonstration, further enforcing the need for EyeAR.

2 RELATED WORK

Previously[2] shows physically correct DoF in AR using Distributed Raytracing methods based on [1], however a major restriction is that the camera properties are pre-calculated for Video see-through AR (Such as the aperture size and focus length) for rendering Depth of Field effects.

Contribution: We extend this research to relieve this limitation, allowing use with Optical See-Through AR. We do this by measur-
The user is then able to observe through peripheral vision two 3D Stanford Dragons with the physically correct DoF applied on a screen in the left box enclosure and a pair of 3D printed Stanford dragons in the right box enclosure. The user is free to change their focus between the two placed physical targets.

5 Demo Requirements

- The amount of floor or desktop space needed:
  - Floor space: 5m x 5m
  - Desktop space: one table (1m x 2m) and two chairs
- The list of equipment you will bring (as detailed as possible):
  - Grand Seiko W AM-5500 Auto Refractometer
  - Desktop computer, Cables, Monitor
  - Netgear R7500 Wireless router
  - Flat-screen display
  - 2x Box-Enclosures
  - 2x 3D Printed Models
- Any power, socket and outlet needs:
  - 3x power outlet
  - Total power consumption 1-1.5 kw
- Environment requirements:
  - Please provide one table (1m x 2m) and one chair.
  - We require constant illumination because pupil size depends on light environment.

References