Demo Abstract: Through an AR Lens: Augmented Reality Magnification through Feature Detection and Matching

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ABSTRACT

Sensing and Augmented Reality (AR) can benefit a wide range of applications that involve the use of magnifying lenses. Recent developments in AR magnification provide a direct overlay of the magnified scenes in AR. However, instrumentation tasks that require high precision and visual acuity need to selectively magnify a region of interest while maintaining the visual perception of the rest of the environment. In this demo, we present *AR-Magnifier*, an AR magnification system through feature detection and matching. We propose a general framework based on an edge-computing architecture that can be applied to various types of instrumentation tasks. A pipeline is developed for detecting feature points and computing the homography matching to identify the magnified region of an object. We showcase how selective magnification in AR through sensing can assist the user in complex instrumentation tasks by providing visualization-based guidance.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**.

KEYWORDS

Augmented reality, magnification, edge computing, feature detection

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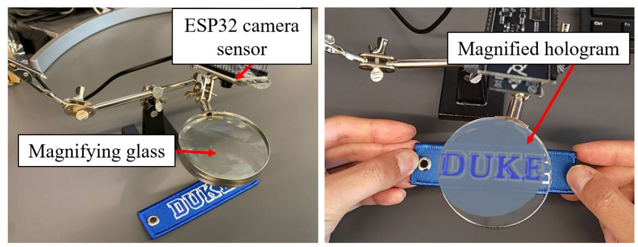

(a) (b)

Figure 1: The system setup of *AR-Magnifier* including a magnifying lens stand and camera sensor (a) and a screenshot of the magnified hologram of the Duke University logo on a magnifying lens (b).

1 INTRODUCTION

Magnifying lenses are optical devices used for inspecting the details of objects. These lenses are used in various instrumentation tasks ranging from simple daily activities (e.g., reading text for people with low vision), to more complex industrial jobs (e.g., assembling parts or inspecting the quality of the product) or medical procedures (e.g., retinal laser therapy which treats the damaged retinal landmarks with a laser [5]). These instrumentation tasks can benefit from Augmented Reality (AR) by visualization-based guidance [3] that overlays the hologram of a magnified object.

Recent developments of AR magnification provide that direct magnification can be achieved through the attachment of the head-mounted loupe to the AR headset [4] or the additional external cameras feeding magnified images in real-time [2, 6]. These approaches directly overlay the visualization of the entire magnified scenes in AR by omitting the use of magnifying lenses. However, instrumentation tasks that demand high precision and visual acuity require the user to maintain the visual perception of the whole environment while selectively magnifying a region of interest. This brings the challenges to embedded sensing in AR magnification to selectively magnify a region of interest in real-time [1].

We propose *AR-Magnifier*, a real-time AR magnification system with a general framework that can be applied to various tasks using magnifying lenses. We developed a pipeline of feature points matching to identify the magnified region of an object. By matching the homography of the feature points, we visualize the hologram of a magnified object by overlaying it on a magnifying lens. To the best of our knowledge, *our work is the first to selectively magnify the hologram and overlay it directly onto a magnifying lens.* Thus, our system allows the user to be guided on the magnified region (i.e., region of interest) by AR, while maintaining the visual perception of the rest of the environment.

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2 SYSTEM DESIGN

The system architecture of *AR-Magnifier* is shown in Figure 2. The architecture contains three hardware components: 1) sensor, 2) edge server, and 3) AR headset.

Sensing: The camera sensor captures the magnified image through the magnifying lens and sends it to the edge server over a wireless local area network. We are using ESP32 as a camera module to capture an image in 240×176 resolution. The sensor is mounted above the magnifying lens to secure a clear view of the magnified image through the lens without obstructing the user's view. The maximum magnification produced by the magnifying lens in Figure 1 is 2×.

Edge processing: The edge server contains three modules for processing magnified images received from the sensor.

Image enhancement: This module takes the magnified images from the camera sensor and enhances image properties such as contrast or edges to produce more "feature-rich" images. The magnified images are first flipped and converted to a grayscale image. We use a contrast-limited adaptive histogram equalization which is a common approach to enhance the contrast of the image to enable more features to be detected.

Feature detection: This module takes the contrast-enhanced images as inputs to compute the feature points on both magnified and reference images (i.e., a pre-taken image that entails the shape and size of the whole object). We use a scale-invariant feature transform from OpenCV to detect the feature points. These detected points are matched using a fast library for approximate nearest neighbor matching and filtered out for good matching points by using a Lowe's ratio test, using 0.9 as a ratio, to eliminate false matches.

Homography matching: This module takes the matched feature points as input to compute a homography matching between the magnified image and the reference image. We calculate the perspective transformation of the magnified image to obtain the correct estimation of a magnified region of the object. The result of homography matching provides the location and scale of the magnified region in relation to the reference image. This result is sent to the AR headset through a wireless local area network.

We evaluated the performance of edge processing using the keychain as an object, shown in Figure 1. Most of the latency came from edge processing, resulting in an average of 190ms per image frame. An average of 83 feature points (5.2% of all feature points) was matched. We will further optimize our system to improve the performance of edge processing.

AR image registration: The AR app receives the homography matching results to reflect the magnification by scaling and positioning the hologram of the magnified object. We define a magnifying lens as a region of interest through contour detection. Upon the detection of the region of interest, the hologram of the magnified region is overlaid on a magnifying lens, providing visualization-based guidance to the user.

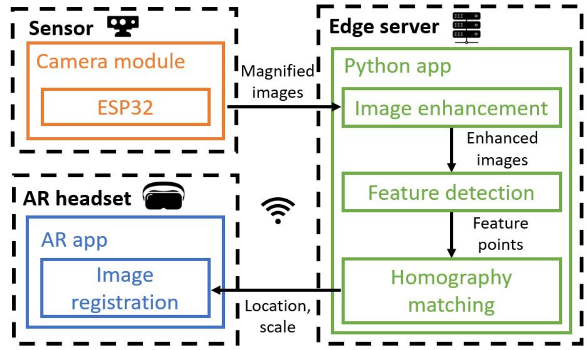

Figure 2: The architecture of *AR-Magnifier*. Magnified images are sent from the camera sensor to the edge server. The result of feature detection and matching is sent to the AR headset for overlaying a hologram of magnified region in correct location and scale.

3 INTERACTIVE DEMONSTRATION

We use the same architecture shown in Figure 2 for our demonstration. It allows the participants to develop an understanding of AR magnification and the advantage of using *AR-Magnifier* in instrumentation tasks that benefit from the visualization-based guidance. We use a keychain with the Duke University logo (shown in Figure 1) in this demo as an example of instrumentation task by allowing users to inspect the four alphabet letters in the keychain. The participants wear the Microsoft HoloLens 2 to initiate the AR app. A video of the demo is available online.[1]

The participants interact with the AR magnification by freely moving the keychain in different directions within the view of magnifying lens. When participants move the keychain up or down, and left or right, the hologram of the magnified keychain updates its location to follow the movement. When participants move the keychain forward and backward, the hologram of the magnified keychain updates its scale to reflect the change in magnification. The participants can observe how effective the feature detection and matching are in the AR magnification, and how sensing integration can enable visualization-based guidance in AR. Furthermore, the participants can envision how selective magnification on the magnifying lens can benefit more complex medical instrumentation tasks such as retinal laser therapy.

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[1]Link to the demo video: https://sites.duke.edu/sangjuneom/arglass