Augmented Reality Magnifying loupe for Surgery

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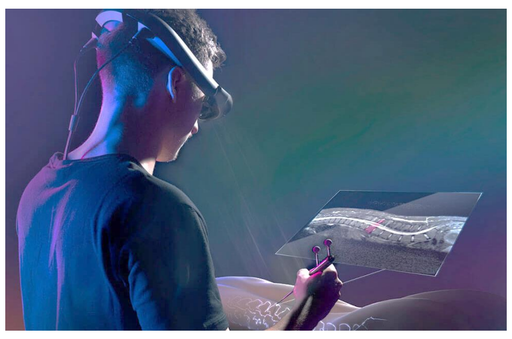
Introduction

- Head-mounted display (HMD) based augmented reality (AR) has been used in the medical domain for treatment, education, and surgery.
- A magnifying loupe is often used in surgical procedures such as dentistry to enhance visualization of fine detail, to compensate for the loss of near vision, and to ensure maintenance of correct posture [1].



AR used in medical procedures

Magnifying loupe used in surgery

- In this work, we have adapted an optical see-through head-mounted display (OST-HMD), to provide AR guidance in the optical magnified view

The Problem

- Previous work was done on a video see-through HMD [2]. Latency between the real world and the rendered graphics and potential to cause motion sickness are problematic for surgery.
- The surgical loupe has an obvious barrel distortion. The same distortion and zoom effect needs to be provided in the magnified AR view.
- The registration of the AR content and the real world has to be maintained within the accuracy requirements.

The Solution

- OST-HMD Modification:

Magic Leap One

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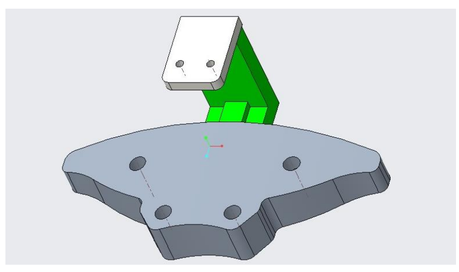


Mount

+

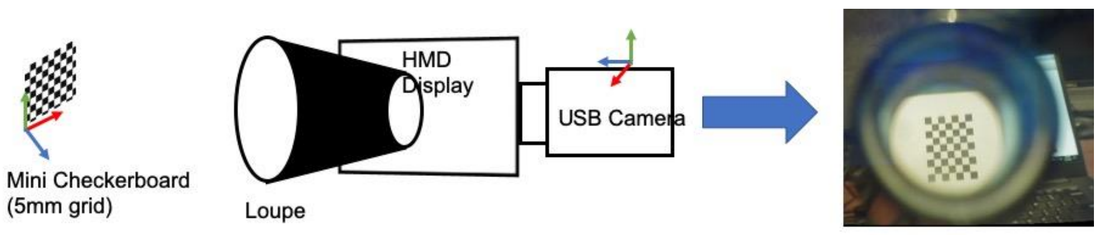
Surgical Loupe

=

AR Magnifying Loupe

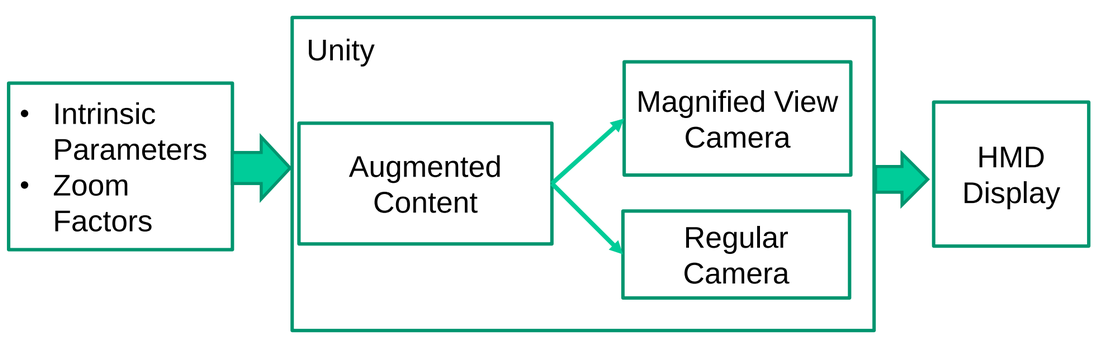
- System Calibration:

A calibrated USB camera module was attached to the HMD display to capture images of a 5mm checkerboard to get the intrinsic parameters of the system with Zhang's algorithm [3]



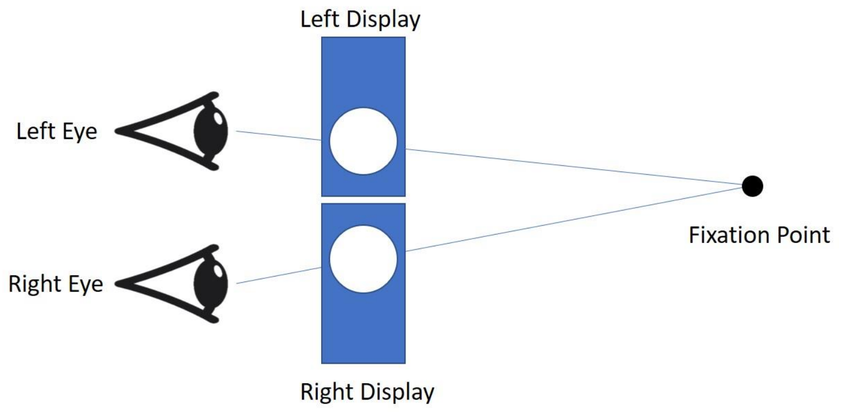
The system calibration setup

- AR Rendering Pipeline:



- User-Dependent Calibration:

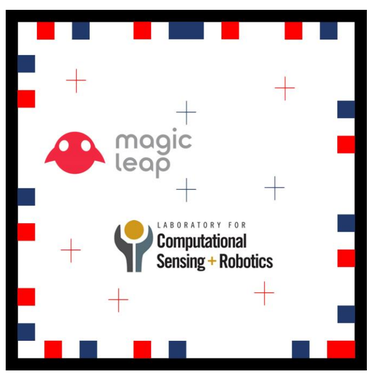
3D to 2D Eye-tracking based method to associate the field-of-magnified-vision and the HMD screen space.



3D to 3D Real-to-Virtual Alignment Calibration method [4] to register the rendered graphics with tracked objects in the real world

Outcomes and Results

- Target Augmentation Error (TAE):



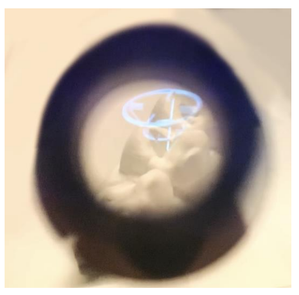
Marker for TAE measurements.

Experiment setup for TAE measurements.

TAE in Regular View	Mean	RMS	Median	Standard Deviation
	2.59 mm	1.21 mm	2.63 mm	1.29 mm
TAE in Magnified View	**Mean**	**RMS**	**Median**	**Standard Deviation**
	3.47 mm	0.96 mm	3.22 mm	1.03 mm

- Surgical Use Case:

An AR target indicator is shown in the magnified view to assist the dentists to prepare access cavity



Future Work

- The tracking accuracy of the system can be possibly improved by attaching a zoom lens to the tracking camera.
- Preclinical and clinical evaluation at various surgical tasks as well as a multi-user study are needed.

Lessons Learned

- Magic Leap One has a minimum clipping plane of 0.371 m. Luckily, the working distance of the loupe is around 0.38 m.

Credits

- Tianyu Song – Mount design, calibration and evaluation of the system

Publications

[1] T. James and A. S. Gilmour. Magnifying loupes in modern dental practice: an update. Dental update, 37(9):633–636, 2010.

[2] A. Martin-Gonzalez, S.-M. Heining, and N. Navab. Head-mounted virtual loupe with sight-based activation for surgical applications. In 2009 8th IEEE international symposium on mixed and augmented reality, pages 207–208. IEEE, 2009.

[3] Z. Zhang. A flexible new technique for camera calibration. IEEE Transactions on pattern analysis and machine intelligence, 22, 2000.

[4] E. Azimi, L. Qian, N. Navab, and P. Kazanzides. Alignment of the virtual scene to the 3d display space of a mixed reality head-mounted display. arXiv preprint arXiv:1703.05834, 2017.