Examining The Eye: Stereoscopic Eye Image Viewing in Virtual Reality

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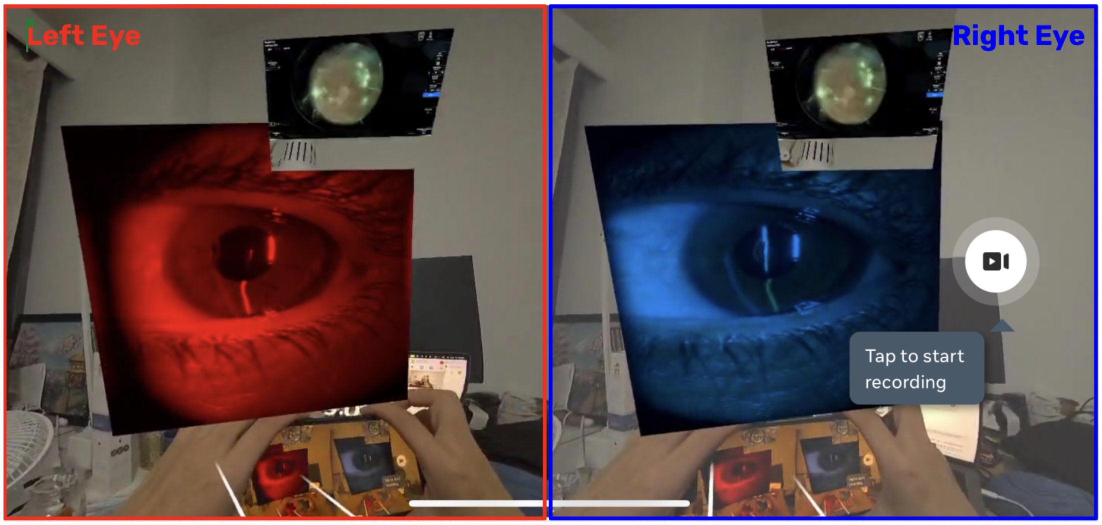

Figure 1: System UI showing left-eye versus right-eye view using an L-R stereo pair of a patient's eye.

ABSTRACT

The Slit Lamp Microscope (SLM) enables 3D visualization of eye structures through stereoscopic image pairs. However, current stereoscope-based methods are limited: only examiners see the 3D view, while observers and students view 2D images, hindering collaboration, remote education, and telemedicine. To overcome these challenges, we developed an XR-based application on the Quest 3 headset that renders stereoscopic SLM images in immersive 3D, enabling multi-user viewing, interaction, and analysis. Our system introduces intuitive features such as image scaling and movement. Using distinct left/right camera layers and custom shaders, we achieve accurate stereoscopic rendering for both images and video. Future extensions include real-time stereo video streaming, zoom functionality for focused examinations, and a searchable, centralized library of ocular image data. This XR solution enhances the accessibility and usability of stereoscopic eye imaging, revolutionizing educational and diagnostic workflows by enabling remote, synchronized, and interactive visualization of eye conditions.

Index Terms: VR, XR, Stereoscopic Visualization, Telemedicine, Medical Imaging.

1 INTRODUCTION

Currently, eye-care practitioners use the Slit Lamp Microscope (SLM) to evaluate the eye. This instrument examines the anterior structures of the eye using magnification and variable illumination. The images taken by SLM are pairs of 2D images of the same eye, each half from a different eye's point of view. Doctors use these images as diagnostic tools for ocular conditions such as retinoscopy, cataract illness, and more.

Doctors use a stereoscope to view the stereo image pair taken by an SLM in three dimensions. Stereoscopes render 3D images through binocular vision. Binocular vision is the way our brain links two separate images when each is viewed with a different eye to produce 3D effects.

1.1 Problem statement

Using traditional stereoscopes are inconvenient for medical professionals to use and are inaccessible in terms of setup and having a shared-view when medical doctors show students. These have limitations for both medical and educational scenerios. First, stereoscopes don't allow remote cooperation. Although the examiner sees 3D stereo images through binocular vision, observers and students can only see the 2D images through a single ocular. Thus the current adoption of stereoscopes isn't optimal for remote education and telemedicine. Second, stereoscopes don't allow flexible interaction with the images such as scaling, which would allow the doctors to observe and discuss the details in the images closely. Doctors have expressed the need to compare and contrast different stereo images at the same time.

Therefore, we explored visualizing the 2D stereo image pairs on VR using Quest 3 to facilitate remote cooperation, education and analysis. This is achieved by rendering the left-skewed image in the left eye and the right-skewed image in the right one. This generates a streamlined stereoscopic effect, improving user experience for medical doctors and students.

2 ITERATION I: CURRENT SYSTEM

We propose an XR system that renders SLM images in either eye, allowing for streamlined stereoscopic image viewing using the Meta Quest 3. SLM images are imported to Unity and projected on game object quads (Figure 1). These quads are then rendered in their respective eye. In our current system, we have 3 main UI sections:

- **Viewer panel:** Three panels together, and the pane consists

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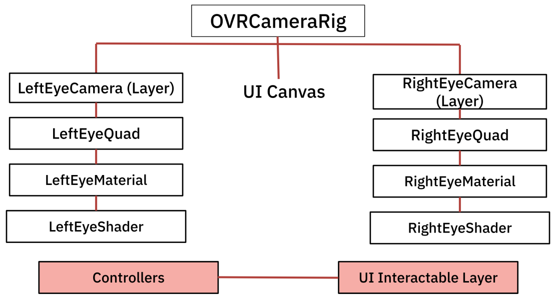

Figure 2: Technical flow of rendering for stereoscopic vision using Unity v6000.2.26f1.

of three side-by-side image displays for simultaneous image comparison. This is above the large image display.

- **Main image display:** The central focus of the app, displaying a large rendering of the "default" eye image.
- **Image selection panel:** Located at the bottom of the UI, and allows users to view a patient's eye images. Provides a gallery of thumbnails for quick image selection.

The main controller actions include 1. selecting, 2. scaling, and 3. moving images. To use each, users must point the controller at the interactable element and use the index trigger or joystick to modify the objects. **Selecting images:** Press the index trigger button to select the thumbnail. This is displayed on the main image display. **Scaling images:** When the controller is pointed at the image, use the thumbstick (up/down) to scale the image size (up to large, down to shrink). **Moving images:** Hold the index trigger while pointed using the controller rays, hold down while dragging to move images. This translates and rotates images across all three axes (x, y, z).

3 Technical Implementation

Our current system uses an OVRig to configure different graphics in either eye (Figure 2). The system uses two different layers with separate cameras: LeftEyeCamera and RightEyeCamera. Each layer includes game objects which have their own respective materials and shaders. The shaders process left and right textures independently to ensure accurate 3D rendering by assigning each eye its respective image. We attach a texture associated with the split images given. When projected on the quads, the shaders configure the quads to separate eyes. In order to render videos, we follow a similar process; however, we use a VideoPlayer to the associated Texture Renderer (Figure 2). Interactions with controllers utilize OVR anchoring to allow the left and right controllers to interact with the objects separately (Figure 2). Scripts were attached to each controller to allow movement and scaling capabilities for the UI interactable layer. The UI interactable layer is rendered for both eyes, containing items such as the panel library.

4 Iteration II: Refined System UI

We plan to modify our system to optimize app usage for ophthalmology education. In collaboration with Dr. Stanley Chang, we defined the central use case for the app as intended for students to view eye images synchronously for educational purposes. In addition to viewing static images and videos, this will also require live-streaming images to multiple students and process a live-video feed in stereo. Feedback from Dr. Chang also highlighted the need for "simple, chronological access" to a patient's eye images over time. Thus, we propose the following additions to the UI:

Figure 3: Visualization of the intended user interface with a 3-image viewer pane and a library for accessing an entire eye data database.

1. "Focus-on-eye" feature: Focus and zoom in on parts of the eye (solo view of the iris, for example).
2. Centralized library: Library where examiners can toggle between all patients and view all corresponding image data in a centralized location (Figure 3).
3. Name/MRN based-search: A search field allowing examiners to find all user data based on paitent name, MRN, or date search (Figure 3).
4. Timeline/patient-based scrolling: Use controller buttons to quickly scroll through a patient's timeline.
5. 3-image viewer pane: Feature allowing a maximum of three images to be selected and compared side-by-side.
6. Thumbnail labeling: Images on each date might be color-coded indicating the type of image corresponding to their "type". (Ex: Green- Slit lamp cornea (anterior), Red- Retina, Yellow- Optic nerve).

All of these features would allow examiners a streamlined process of accessing and viewing images.

5 Conclusion

Conclusion:

The XR SLM eye image viewer provides effortless stereoscopic viewing of an entire library of patient data. This seamless process is much more efficient than manually aligning a stereoscope to view images in three dimensions, giving users an intuitive experience. This ability bridges the gap between collaborative and observational analysis in opthamology. We are confident t hat the system's centralized UI will revolutionalize diagnostics, making traditionally inacceisble views of optimial conditions easily eaccessfily for both learning and analysis.

Stereoscopic image viewing in XR not only allows examiners a streamlined view of optical conditions with higher accuracy, but it also allows a shared view that can be used for tele-medicine or education. This ability bridges the gap between collaboration and observation in ophthalmology. We are optimistic that providing a centralized UI for stereoscopic image viewing will revolutionize collaborative diagnostics, making traditionally inaccessible views of optical conditions easily accessible for both learning and professional analysis.

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