Vision Enhancer

Mixed Reality Project Proposal
Supervised by: Dr. Zuria Bauer, Bessie Dominguez Dager
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GROUP MEMBERS

Susanna Di Vita

Reto Gerber

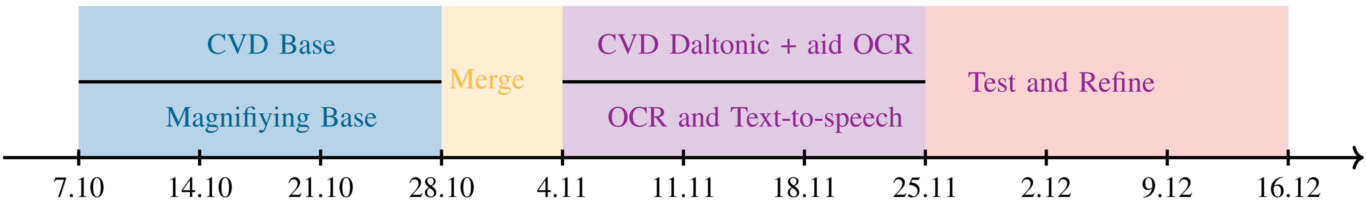
Carlo Hartmann

Jeremy Chew

I. DESCRIPTION OF THE PROJECT

In the Vision Enhancer project, we aim to develop a comprehensive mixed reality application for the Microsoft HoloLens 2 that addresses various forms of color vision deficiency (CVD) and different degrees of visual impairment, specifically focusing on individuals with blindness or low vision (BLV), including those affected by myopia (nearsightedness). The app will include a selection of customizable filters for the users specific color blindness. This will aid a person with CVD to better distinguish colors in their visual spectrum as highlighted by prior research in vision augmentation [1]. Additionally we plan to include a magnifying feature allowing the user to enlarge a chosen region in his visual field and display it close up [2]. Our vision is to create a tool for visually impaired people that is easy to use and effectively aids to remove any challenges differentiating colors or difficulties reading distant text. As students, we are personally motivated by these challenges, having experienced these difficulties in lecture halls ourselves to some extent.

II. WORK PACKAGES AND TIMELINE



As shown in the above graphic, we divided the next 10 weeks into 3 main sections. In the first phase, we intend to get the setup working on the members' computers and implement a basic working prototype of our app. We aim to divide the project into two main features: the CVD (Color Vision Deficiency) part and the BLV (Blindness or Low Vision) part, and work in pairs. Base versions will include buttons and sliders for different filters, along with a mechanism to smoothly capture images and display them with enhancements. The two features will be developed in parallel, with the intention of merging them after the base functionality is complete.

In the first work package, the CVD module will implement customizable color filters tailored to individuals with color vision deficiency (e.g., deuteranomaly, protanomaly, tritanomaly). The filters will be based on the Daltonization method developed by Jefferson and Harvey [3], [4] and further applied in studies like [5], allowing users to better distinguish colors in real-time. The GUI will include sliders for adjusting filter intensity, providing personalized control for different needs. This will ensure a more responsive and accessible experience for a wide range of CVD users. Given the computational intensity of the Daltonization method, as noted in [6], real-time performance may be challenging. As a fallback, we may consider applying filters on a translucent structure in front of the user to reduce the need for continuous video processing. The CVD module will be developed as a Unity application using C# for the Microsoft HoloLens 2 platform. The expected outcome is a set of functioning, customizable filters, selectable through a dashboard, that can be applied in real-time or near-real-time to enhance color distinction. This work package will be completed within 4.5 weeks, with Susanna and Carlo leading the effort.

In the second work package, the focus will shift to developing a magnification feature for individuals with low vision or myopia. This feature will allow users to zoom in on specific areas of their visual field, making distant objects or text easier to see. A customizable zoom slider will let users control the level of magnification. The magnification tool will also include Optical Character Recognition (OCR) and text-to-speech (TTS) functionality, enabling users with difficulty reading distant text to hear it read aloud. This will be implemented by capturing screenshots of the user's current view and sending them to the Google Vision API for text extraction, as referenced in [7]. Several optimizations will likely be necessary to ensure near-real-time performance, such as reducing the resolution of images sent to the API, applying image compression, or focusing on the region of interest (ROI) to minimize data transmission. Asynchronous API requests will ensure the application remains responsive while processing. Batching requests and parallelizing API calls will improve processing efficiency, and caching mechanisms will be used to avoid redundant requests when the user's view remains unchanged. An alternative approach could involve projecting live-feed data as a texture on a translucent object in front of the user, applying magnification similarly to the color filter mechanism. The magnification feature will be developed as a Unity application using C# for the Microsoft HoloLens 2 platform, with integrated OCR and TTS functionalities through Google Vision API. The expected outcome will be a fully functioning magnification tool enabling users with low vision or myopia to read distant text more easily. This work package is estimated to take 6 weeks, with Reto and Jeremy leading the implementation. Once the first work package is complete, Susanna and Carlo will join to help finalize the second phase. In the final phase, we will integrate the CVD and BLV features into a cohesive user interface. We will collect user feedback to refine the design and ensure a user-centered approach. A buffer period will be allocated for testing, optimization, and a user study to evaluate usability and effectiveness, addressing performance and accessibility issues as discussed in [8], [9], and [10]. Following best design practices and utilizing frameworks like those in [11] and [12], we will involve users throughout the development process to ensure the final product meets the specific needs of visually impaired individuals.

III. Outcomes and Demonstration

Our Vision Enhancer project aims to develop a mixed reality application for Microsoft HoloLens 2 that assists individuals with color vision deficiency (CVD) and low vision (BLV). The app will provide customizable CVD filters, allowing real-time adjustments to enhance color differentiation based on the user's condition (e.g., deuteranomaly, protanomaly) through a simple GUI. For low vision, the app will feature real-time magnification with a zoom slider, enabling users to see distant objects and text more clearly. It will also integrate Optical Character Recognition (OCR) and text-to-speech (TTS) to capture and read aloud distant text.

To ensure the successful implementation and usability of these features, we will test the performance of both the CVD filters and magnification tool to ensure that they operate in real time or near-real-time. This will involve measuring latency for filter application and magnification adjustments, assessing the efficiency of image compression, and evaluating the asynchronous API calls for OCR. We will also test the CVD filters with individuals who have different types of color vision deficiency to evaluate the usability and accuracy of the filters, collecting feedback on how effectively users can differentiate colors by asking them to retake the Ishihara test [13] (widely used test for diagnosing color vision deficiency) and the Color Contrast Sensitivity (CCS) test [14] to determine if their ability to distinguish colors improves. For the magnification tool, the accuracy of text recognition through the OCR functionality will be assessed by comparing extracted text against ground truth data, factoring in different resolutions, distances, and lighting conditions. Furthermore, we will examine how effectively the caching mechanisms and parallelized API requests contribute to smoother performance. User studies will focus on interface usability, evaluating how intuitive the controls are for adjusting filters and magnification. Participants will complete tasks such as reading distant text and differentiating colors, with their feedback used to refine the application's design. At the end of the semester, we plan to present a live online demo showcasing the real-time functionality of both the CVD filters and the magnification tool with integrated OCR and TTS. This demo will highlight real-world use cases and summarize how user feedback has been incorporated into the final design. A recorded version will be available for offline viewing, providing a comprehensive walkthrough of the app's features.

References

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