Colorizer: Smart Glasses Aid for the Colorblind

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ABSTRACT

We present a smart glasses application for helping colorblind people to distinguish problematic colors in daily life. The prototype processes a live video stream from the mobile camera, remaps colors according to the user needs, and displays the augmented result. Color transformation ensures high contrast between colors which are otherwise indistinguishable for the user.

Keywords

Color vision deficiency, accessibility, image processing.

1. INTRODUCTION

Color vision deficiency (CVD), also known as colorblindness, is a widespread phenomenon which affects hundreds of millions of people (about 8% of men and 0.4% of women worldwide [2]). CVD is attributed to the lack or faulty behavior of certain types of retinal cones, which makes recognition of some colors difficult or completely impossible [12]. As a result, colorblindness has serious impact on person's life in multiple areas ranging from daily tasks (such as clothes selection, shopping, cooking, driving) to career choice (difficulties finding a colored ball in grass, recognizing railway and maritime signals, finding wire cables by colors) and health implications (late detection of rashes and sunburns) [3, 8].

Although medical treatment does not exist [11], several sociological and technological methods have been proposed for CVD mitigation. Initially, colorblindness was considered as "color ignorance" rather than a physiological condition, and colorblind people were "taught" to recognize colors; such attempts have failed [12]. Current sociological solutions aim to increase awareness of CVD in order to improve accessibility for the colorblind in daily life scenarios. This is achieved by reducing the color spectrum of images in order to simulate colorblind vision to people with normal color perception (trichromats) [4].

Recoloring images to make problematic colors more distinguishable for the colorblind has proven to be a considerably more challenging task. Early attempts (dating back to J.C. Maxwell [7]) explored the use of wearable color filters, such as tinted glasses and contact lenses [7, 11]. Color filters have been criticized by the users for reducing perception of other, normally unaffected, colors [11, 12, 5]. With further technological advances, a number of computer-based methods were created with the objective to improve color contrast between problematic colors in mobile photos and online images [6, 10]. Unfortunately, existing smartphone-based CVD assistance applications [10, 1] have limited usability due to the high access time (getting the phone, unlocking it, launching the app) and social issues such as unwanted attention from bystanders.

This paper presents a colorblind assistant prototype based on smart glasses. These wearable glasses provide an ideal platform for colorblind assistance since they allow for highly mobile, instantly available and discreet private use. We describe the challenges encountered during the development and present some possible solutions.

2. PROPOSED APPROACH

The general approach to color assistance on smart glasses is similar to that for smartphones i.e.: using a live video stream from device's camera, processing each frame to differentiate hard-to-recognize colors for the colorblind person, and displaying the result. However, in contrast to smartphones, smart glasses provide different display configurations, usually have a smaller battery and require alternative interaction methods.

Our prototype was implemented for Epson Moverio BT200 glasses. The developed application provides two processing modes to accommodate different display types. The full-image recoloring mode is based on Jefferson's color transformation method [6] which increases color contrast between problematic colors (such as red and green) and outputs a complete (recolored) image (see Figure 1); this approach is suitable for side-view displays, either opaque or transparent (as in Google Glass).

In contrast, see-through displays (such as the Epson Moverio) allow for a more subtle approach where high-contrast overlays are displayed only over problematic image areas. For example, a person with red-green CVD would directly see the world through transparent glasses, but any red objects would be superimposed with blue pixels in order to highlight them for the user and help distinguishing them from green objects (see Figure 2); other colors remain unaffected. This approach requires good visual alignment between the displayed area and the camera's field of view.

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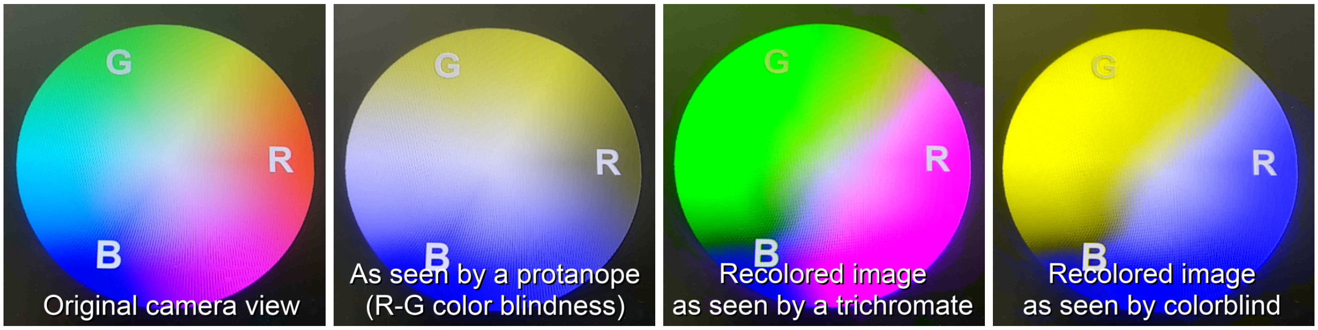

Figure 1: Video frame of a color wheel image as seen by people with protanopia (red-green colorblindness) and with normal color vision (trichromats).

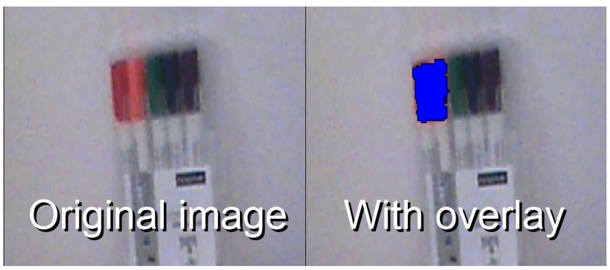

Figure 2: Problematic colors highlighted by a high-contrast overlay.

However, both methods lead to ambiguity, as the user might not know whether any particular highlighting (such as blue) is the original color or a result of color transformation. To address this issue, we display the processed video only for one eye; by comparing the colors seen by his/her eyes, the user can recognize an enhanced spectrum and distinguish otherwise problematic colors.

In order to minimize user distraction and improve battery life, the Colorizer activates only when the user requires it. This is to avoid social awkwardness problems which may arise with more visible/audible forms of interaction such as using a gestures or voice control [9]. For this reason we employed a simple accelerometer-based trigger which activates color assistance whenever the user slightly tilts his or her head toward a shoulder. Conveniently, this gesture sometimes occurs naturally when a person is looking at something that they find of interest.

Finally, real-time video processing requires considerable resources and also adversely impacts the battery life of the smart glasses. However, since all the pixels are processed independently from each other and since CVD assistance does not require high resolution, color transformation can be performed using a small (1 MB) look-up table pre-calculated on a powerful computer.

3. CONCLUSION

We have presented a colorblind assistance prototype for smart glasses and discussed related challenges in visualization, processing and discreet interaction with the system in public spaces. At the time of writing we are focusing on evaluating the system.

4. ACKNOWLEDGMENTS

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