Colorful World

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Abstract

Have you ever wondered what it’s like to be color blind? Intuitively, color blind people are deprived from the ability to see color. In simple terms, red may not appear to be red or green may not appear to be green. Color blind people have struggled in their everyday lives from mismatching outfits, to misinterpreted color-graphs at jobs, and on top of that, even traffic light coloring. So what has been done to aid the color blind? There exists some technologies out there that indeed help with the problem. For instance, EnChroma is a glasses company that sells glasses that help color blind detect color. However, these glasses are insufficient as they only target one group of consumers, the red-green blindness. What about other forms of color blindness, such as Monochromacy? These people usually see black and white only, which is tough. Alongside glasses, there have been apps out there that help depict colors to the color-blind. Given these facts, it is clear that most solutions help enhance the red-green color-blindness. Therefore, our solution delivers an app that promises great image processing as well as speech recognition, and object detection to enhance detection of various saturations of color for all color blind people while focusing on those who suffer from Monochromacy.

Introduction

Background

Color blind people have difficulties with perceptions of color leading to their main common cause of concern, color confusion. Humans usually are born with three types of color-sensing cone photoreceptors in the retina. These are in charge of detecting color to the brain and aid with visibility as well. However, color blind people have an absence of one or more of these photoreceptors which leads to color confusion and sometimes makes people struggle with their academics when they are younger. [1] Even worse, some color-blind people inherit a disease called Blue Cone Monochromacy (BCM). This is an inherited disease that has an absence of at-least the two main photoreceptors if not all three. Males are more likely to be color blind and have BCM than females because of the X chromosome mutation. [6] The most common form of color-blindness is red-green color-blindness. However, like mentioned above, there have been interesting solutions to help aid those who inherit this most common form. Instead, we want to focus our attention on Blue Cone Monochromacy. These people have struggles identifying any colors as well as objects as well. Given these facts, we will be focusing on aiding those who suffer from BCM.

Unfortunately, there is no direct cure for any kind of color-blindness. It is mainly an inherited disease and color-blind people tend to adapt to their different color perceptions. However, there are assistive technologies out there to help aid the color-blind such as various lenses or mobile apps that help accommodate. One of the most famous current solutions is EnChroma glasses. So as EnChroma enhances the perception of color for mainly red-green color-blindness, it does not help those suffering from BCM. Furthermore, EnChroma glasses reduce the amount of light entering the eye which can lead to other eye irritations or diseases. [3] Once again, glasses are not an ideal solution to help aid those suffering from BCM as they have trouble detecting shades of colors, objects, and are very sensitive to light.

The numbers of color-blind people have been increasing steadily over the past ten years. According to the National Institute of health, color blindness is a condition that affects five to ten percent of the US population. [2] There have been some attempts to improve the life of color-blind people in recent years, but these above-mentioned solutions have yet to have any significant effect on people with BCM. As a result, we plan on creating an application that helps bring change to those suffering from BCM while also welcoming other types of color-blindness potential users.

Problem Statement and Rationale

The effects of color blindness can range from mild to severe depending upon the affected gene. If someone inherited color blindness it will not get better or worse. The environment plays no role in the condition of color blindness. One of the most severe forms of color blindness is monochromacy. People suffering from monochromacy have a color vision deficiency. They perceive everything in the shade of grey.

Color blindness can have a huge impact on someone’s life. it’s important to find a solution to this problem as soon as possible. The goal of our project is to come up with an inexpensive but effective solution to improve color blind people's lives in the US. We will identify the most significant effect of monochromacy through surveys and interviews, and conduct experiments to measure the effectiveness of different strategies.

In the current technological advancements for color blindness, the current direct and absolute solution for color blindness only targets one demographic of color-blind people. Instead of approaching a solution using lenses that block or enhance certain light waves, we opt to utilize a device that is in everyone's pockets nowadays; a smartphone. Using a smartphone's camera. we can utilize its capabilities and help color-blind individuals by identifying colors while cutting costs down to zero for both us and the consumers. This approach is cheaper than most of the available solutions out in the market, and also more encompassing than any other since it will help all color-blind spectrums instead of one or two demographics.

Design

Goal

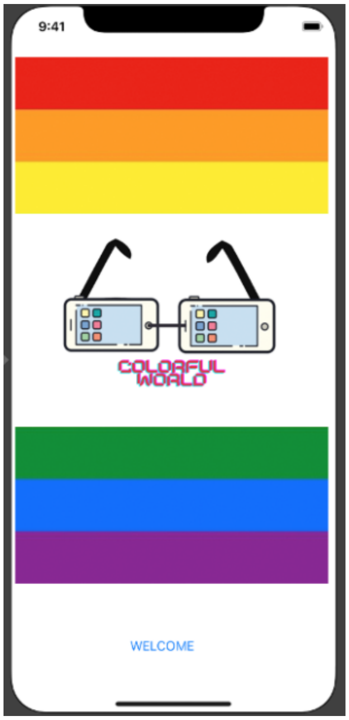
Our main goal is to utilize the camera sensor on the smartphone of the user to detect the color of an object on the display of the phone, as well as the saturation of said color. Our app will have a simplistic design with minimalistic buttons and options to lessen the distractions, and it will originally use a crosshair in the middle of the presented camera vision to help the user identify what color the camera is pointing at. The color of the crosshair will be originally green for maximum saturation for monochromatic people, but there will be an option of changing the color for other color blind demographics. We plan to have this app on both iOS and Android, free to use.

We found out (from asking a first-hand color blind person) that color blind people require assistance in identifying daily things and what do they look like, especially during work, driving, drawing, etc.[5]. Therefore, We also plan to try a more innovative approach to the algorithm of detecting and identifying objects' colors. Through the use of camera tracking, we plan to have the user opt into an algorithm where the application will identify all the colors of every object/area within the camera sensor, and label them accordingly. This design idea will be an automatic one and will lessen the need of human interaction with the algorithm to work as the user intended.

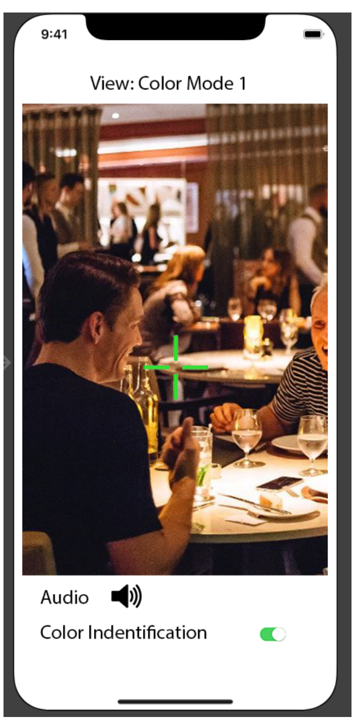
Mockup

Features and UI

We approached our app to have simplistic buttons and user interface. We believed that colorblind people tend to not appreciate applications that have a lot of options and color differences on the screen, and thus we first designed our app interface as shown in the picture below. We had a 60-70% camera frame, and just two buttons to switch between two modes. Mode 1 will be the main color identification and Mode 2 will be the object identification to aid with vision impairment and will also have Text to Speech.

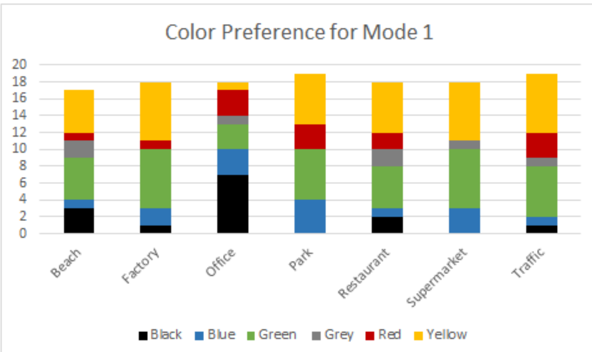


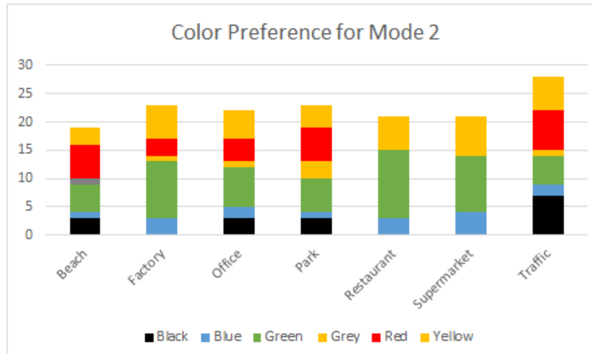
We also wanted to design the app for object identification, where the user could identify the color of an object and the name of the object. The first design was still in alpha but we wanted to give candidates an idea of how the app could look like in the final product. Before we send our preliminary design, we wanted to show and test how the UI will look like in different camera settings (beach, factory, office, park, restaurant, supermarket, and traffic), as well as the options of using different crosshairs or text colors (black, blue, green, grey, red, yellow). Below are a few of those settings and mockups.



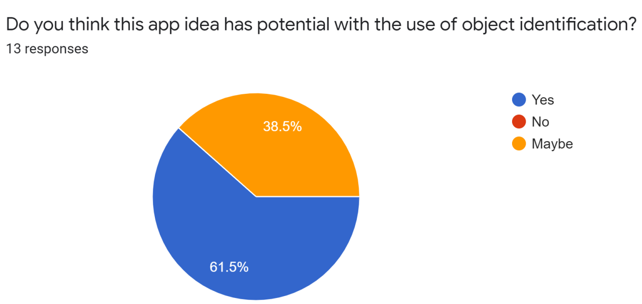
User Survey

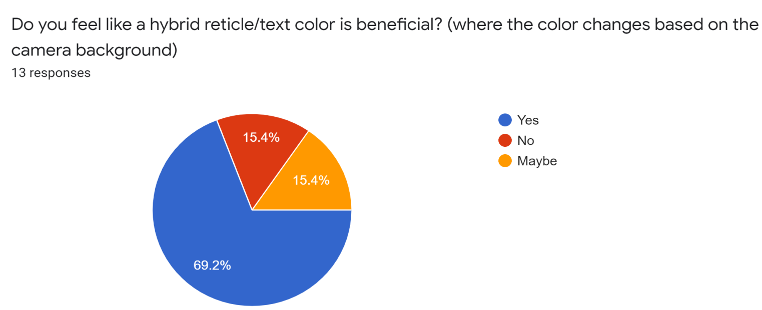
We conducted surveys to our fellow teammates in the capstone class to get some feedback on the initial designs of the application, as well as approaching random colorblind people from online. We showed the color mode 1 and 2 with the settings and colors mentioned above. Below is a chart of the results for each mode. We can see that green was the most consistent color that allowed the user to see the text and reticle.



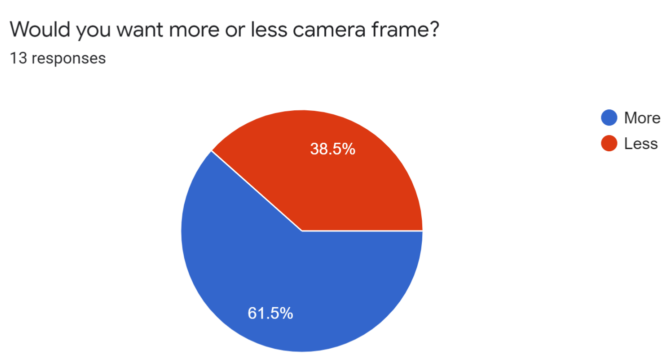


Overall, most of the respondents liked color mode 2, and appreciated the object identification feature. But we also found that most colorblind people did not appreciate the inconsistency of one or more colors and would prefer some sort of a hybrid color change.





We also found that the users liked the light color UI, but after researching on the internet [7], we found that light and color texts are not contrasting enough for users, so we decided to give the user the choice between dark or light UI. We also listened to other feedback on the text information being too small and the camera frame not enough, so we increased both.



Colorful World

Functionality and Features

We built the app on iOS xcode architecture in its entirety because most of our work was put into refining the UI for colorblind and monochromatic people. We had to try and test different UI flows and colors and functionalities, and xcode is simple in helping developers at such tasks. For object identification, we used Tensorflow open source API [8] as we did not want to reinvent the wheel and would rather focus on color identification.

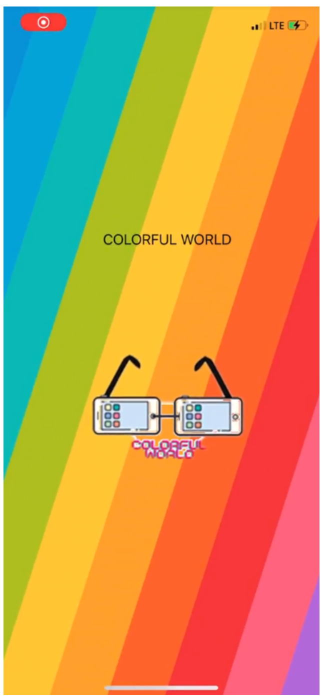
For our main functionality, color identification, it was quite a tough task, and our main developer, Ibrahim, worked hard on writing and testing the code. We ended up approaching the color detection function by approximating colors in a small box (instead of a reticle) in the middle of the camera frame, and then printing the result for the user. Below is a code that is the main function for color detection.

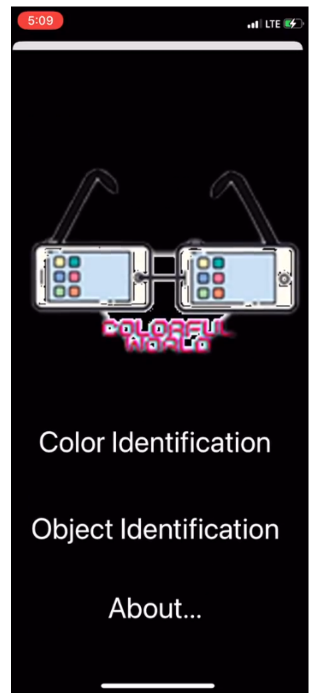
```
 CGContextRef freshContext;
 CGColorSpaceRef colorSpace = CGColorSpaceCreateDeviceRGB();
 size_t w = CGImageGetWidth(croppedImage);
 size_t h = CGImageGetHeight(croppedImage);
 CGRect r = CGRectMake(0, 0, w, h);
 long bitmapBytesPerRow = w * 4;
 long bitmapByteCount = bitmapBytesPerRow * h;
 void *bitmapData;

 bitmapData = malloc(bitmapByteCount);
 if (bitmapData == NULL) {
     NSLog(@"Error allocating memory");
 }

 freshContext = CGBitmapContextCreate(bitmapData, w, h, 8, bitmapBytesPerRow, colorSpace,
(kCGBitmapAlphaInfoMask & kCGImageAlphaPremultipliedFirst));
 CGContextDrawImage(freshContext, r, croppedImage);

 UInt8 *pixels = CGBitmapContextGetData(freshContext);
```

Here, we are generating a UIImage that fits in a small sample square in the center of the video, and then by rendering the sample data into a CGBitmapContext and cropping it down to a rectangle, we can iterate over each pixel in the resulting image averaged all of the red, green and blue values until we have a single RGB value that then get processed for color families. This approach allowed us to gain accurate results almost all the time during testing of different objects.

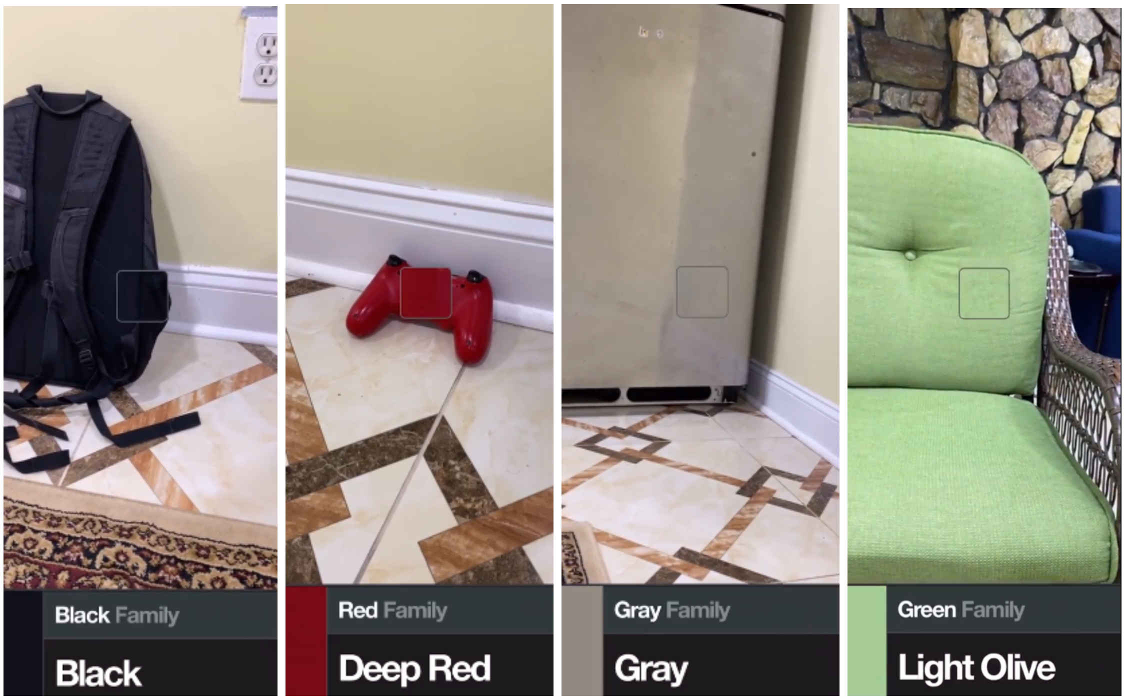
User Interface

As mentioned before while surveying our users, we focused on getting our UI more refined and contrasting to colorblind people. In the first screen of the app, we however wanted to use a rainbow background to let users know that this is our goal; to show you the colors of the world. Then, we show the menu where the user will choose either dark mode or light mode. Once they choose, the user has the option of choosing color mode 1 or 2, or go to the about page where we explain our application and its use.





For our main app functionality (color detection), we scrapped the crosshair since it is not ideal and it is not suitable for colorblind design rules. We used a small box that is sort of blurry to denote the location of the main area of detection. We then identify the color for the user in a black background area with white text (contrasting colors) at the bottom of the screen. We identify colors by families (Green, Yellow, Red, Violet, Blue, Orange) and then denote the shade of the color, for example light olive or dark red. This design eliminates distracting colors, focuses the user's attention to the camera frame, and gives concise information.

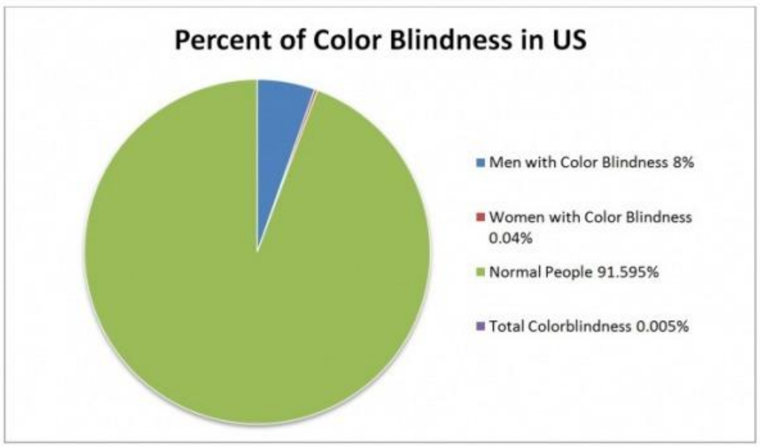


For color mode 2, which focuses on object identification, we used the Tensorflow API open source code to help the colorblind user to point the camera at a view, and the code will automatically notice the objects in front of the user and identify them using bounded boxes. The name of said object will be written on the box around the object, and as of now, we are working on also detecting the color of the object and writing it next to the name of said object.

Discussion

Market and Value

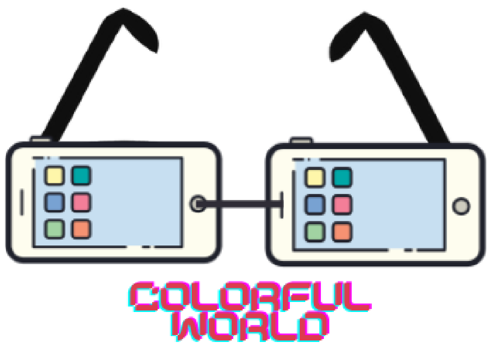
Colorful World was built around the idea that we need to find a simple yet accessible solution to monochromacy, and with the nature of our approach, we found ourselves also tackling all kinds of colorblindness. Therefore, our market has expanded from 200 thousand monochromatic customers to almost 316 million colorblind people in the US [9]. Nevertheless, every development we do mainly focuses on catering monochromacy.

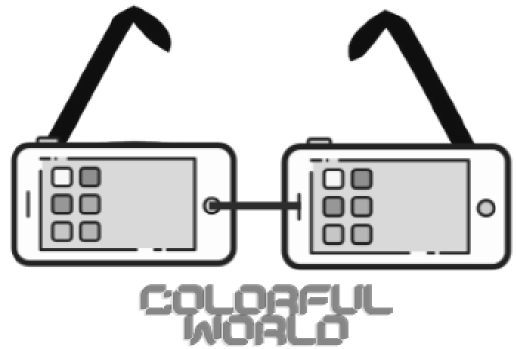


Usually, app developers utilize servers and clouds to save and maintain an app's efficiency regarding the user's data and the algorithm behind the app, but we decided to opt to locally update our app and omit collecting customer's data. This has cut costs of maintaining monthly/annual fees. We intend to keep the future development of our app using charitable donations from nonprofit companies and our users. Once our app is fully functional without any bugs and polished, we will put our app in the App Store with a small cost of $1.

Branding

We started the main branding of the app with a rainbow intro background to imply that our app will be able to detect all color spectrums. Our logo is very simple yet effective. The logo has the name of our project, Colorful World, in a very high contrast color (pink) under a white background to help monochromatic people to quickly identify the message of our app's name. The logo is also in the shape of glasses with phones as lenses, noting that while currently our phone app is a window for the eye to see colors, we could in the future apply our solution to better hardware solutions like smart glasses. Finally, the color boxes on the phones reiterate that our app can detect all color spectrums for the colorblind.





Conclusion

Future Development

In our original proposal, we wanted to implement our idea onto Google Glass so that our colorblind user does not have to rely on moving his phone around, and rather utilize their eyesight and their heads to apply the color detection automatically. Lenovo Smart Glasses is also another option for us to implement the software on, and we hope that in the future we could design our own simple solution that will not be expensive and accessible to all users.

During our code development, we also were intending to integrate a third color mode where the user could tap on the screen where they want to detect the color. This future was going to be called Tap Feature and as of now the results are not accurate, but we also hope to gain some better results during future developments.

Acknowledgements

The work in this project is our own. Any outside sources have been properly cited. The project is supported by the CCNY CEN Course Innovation Grant. Our team members consisted of Mena Matta who assisted with the first pitch of the project, researching for some open source codes, the first 3 presentations of the second semester, the first 6 wiki logs, uploaded links of the slides/video, and the writing of the final report; Ibrahim Hassanain who was responsible for the majority of the logs after the first few weeks, developing the UI on xcode and also developing code and integrating swift/obj-C open source codes to create the application, responsible for testing the application consistently, also reached out to a few developers for some insight with color detection, created all demos/ the final video, and helped refine presentations made by other team members; and Eric Ngansop who was responsible for the last 3 wiki logs, created 3 power point presentation including the final presentation. I also conducted research about the project and I was able to build the object identification using nod.js, build an user interface using Reat-Native and lastly built a color identification using ionic and angular. My object identification app was not accurate and my team member suggested that we xcode since my team members have made significant progress.

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