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Period 2

Morgan

Simulating Color Blindness Through Virtual Reality

Abstract

At first, we wanted to create a virtual reality app that simulated deuteranopia exclusively, but we ended up creating three apps, each simulating a different color blindness. Using Unity, we created three apps that simulated deuteranopia, protanopia, and tritanopia through virtual reality. This topic is important because I (Kyra) have deuteranopia, and it has severely limited my career options, and is often looked upon with pity. I wanted to create an app that allowed others to empathize and possibly change workplaces to eliminate the stigma against dichromats. We created this project using Unity 5.6.4 by writing a C# script for live camera viewing, overlaying a colorblind shader atop the camera, and enabling Cardboard virtual reality supported in unity. We then USB Debugged the phone, exported the app, and placed the phone in Cardboard goggles for a more immersive experience. Before using the app, my partner took 4 deuteranopia tests, 4 protanopia tests, and 2 tritanopia tests, scoring a 10/10. After using the respective app for each test, she scored a 0/10, the failing of tests indicating a success in our app. Since I came into this app with no coding experience, this project has many mistakes. The version of Unity, the API level, the C# script, and the UI objects were only some of the difficulties encountered. But we also made three different apps in contrast to only one on deuteranopia!

Background and Introduction

______Color blindness is genetic mutation linked in the X chromosome, making it 7.5% more likely to occur in males than females (“Facts About Colorblindness 2015). In the retina of the eye, there are two types of cells that detect light: rods and cones (“What Is Colorblindness?” 2017). While rods detect light and dark levels of light, cone cells detect color, and are concentrated to the center of our vision (“What Is Colorblindness?” 2017). The three types of cones that see color are red, green, and blue; the brain uses these color cells to determine our color perception (“What Is Colorblindness?” 2017). Color blindness occurs when cone cells are missing, non functioning, or detecting different colors, and the extent of cone cell conditions impacts the severity of the color blindness in a person (“What Is Colorblindness?” 2017). There are two axis that determine the type and severity of colorblindness (“Which Type of Red-Green Color Blindness Is It?” 2016). Within the first axis there are long or medium wavelength cones, that are red-weak and green-weak, respectively (“Which Type of Red-Green Color Blindness Is It?” 2016). If the long cones (L-cones) are malfunctioning or absent, they are the source of either red-blind (protanopia) or red-weak (protanomaly) (“Which Type of Red-Green Color Blindness Is It?” 2016). If the medium cones (M-cones) are malfunctioning or absent, they cause green-blindness (deuteranopia) or green-weakness (deuteranomaly) (“Which Type of Red-Green Color Blindness Is It?” 2016). The second axis, the severity, tells if said person is a dichromat (red-blind, protanopia/ green-blind, deuteranopia), or has three different color sensitive cones (called anomalous trichromacy, protanomaly/deuteranomaly) (“Which Type of Red-Green Color Blindness Is It?” 2016). Tritanopia is slightly different than the others, it isn’t X-linked, making it equally common in both males and females (“Tritanopia”). It can also be caused by blunt force trauma to the eye or exposure to ultraviolet light ("Tritanopia"). Although tritanopia is considered a colorblindness where it is difficult to distinguish between blue and yellow colors, it is estimated that 1% of males and females have tritanopia ("Tritanopia").

Engineering Purpose/Problem Statement

We will create a virtual reality app that simulates deuteranopia, protanopia, and tritanopia. The app, coded in Unity, will take live camera footage, overlay a colorblind shader unique to each colorblindness, and will be formatted to fit in Google Cardboard goggles to create an immersive experience. The stigma against colorblindness in careers, in terms of change, is stagnant. Color blind people are excluded from certain jobs without any thought for reform that allows them to possibly pursue a career of their choice. Pilots, surgeons, and even firefighters cannot be colorblind, and most new technology is catered to changing color blind people so they may see normally, however there should be changes in workplaces that allow all jobs to be accessible; with these apps people are able to change jobs to be more color blind friendly. If the change for an entire career is too extensive, at the very least people can empathize and embrace the disadvantages or advantages to each colorblindness. Many dichromats distinguish camouflage more vividly, helping hunters see prey in foliage, or help the military see where people in camouflage are hiding. Colorblindness should not be seen as a disability, people should begin to embrace it and the fact that seeing differently may not always be worse.

Competing Designs

Many people have tried to create technology to help dichromats see what normal people see, but the idea of simulating colorblind vision is rare. In 2016, Purdue University students created simulated VR scenarios you could watch to convey the effect of colorblindness and motion sickness, but their scenarios were pre-made, and you could not view in real time. Our app plans to access the camera to see color blindness rather than creating scenes you can watch. Another group of medical illustrators created an augmented reality scene that allowed you to choose a room and a type of color blindness (deuteranopia, tritanopia, protanopia) to view the room in, but again, our app will view color blindness in real time. Lastly, the website Toptal created a filter you could apply over web pages to see them colorblind, but that's a totally different idea than a VR app. Our app is different and more immersive than all of these because of the easy accessibility and the opportunity to view like a dichromat in real time.

Measure of Effectiveness

There are ten photos with numbers in each, and they are each catered to test a different type of colorblindness. There will be photos that test each of the three colorblindness, and if a person cannot see the numbers in the photos, they will 'fail;' meaning they are a dichromat. We have four deuteranopia tests, four protanopia tests, and two tritanopia test, each to be taken first without the app and then with the respective app for each color blindness. My partner will take the ten tests before using the app, and will hopefully receive an 100%, and thus prove the absence of any color blindness that could impact data. Then, when using the right app for each test, my partner will try and distinguish the numbers she just saw, hopefully earn a 0/10, and therefore prove the effectiveness of the color blindness shader.

Risk/Safety Precautions

We must make sure the virtual reality app follows all guidelines, as to not make users nauseous or have headaches. There is the safety precaution of overheating the phone battery with overuse, so we will be sure to use the phone only when necessary, and in short increments of time. The risk of dropping and shattering the phone is also present, and although the Samsung Galaxy S5 is shatter and waterproof, we will be extra careful in handling the phone.

Materials

- Samsung Galaxy S5
- Unity 5.6.4 Program
- Google Cardboard Goggles
- Notebook for data
- Computer containing Windows

Preliminary Timeline/Milestones

1. Download Unity 5.6.4
2. Create a C# script that allows permissions and access to the phone's live back camera.
3. Add a User Interface Raw Image, and make sure it is stretched to 'Envelop Parent'
4. Add the component of AspectRatioFitter to once again make sure the entire screen is the UI Raw Image
5. Add the component of our C# script so the Raw Image is the live camera
6. Add the asset Colorblind Effect®, which is essentially a shader that simulates colorblindnes
7. Choose one color blindness for that specific app
8. Make sure that the Canvas is rendering in Main Camera rather than our C# script
9. Go to Player Settings and make sure Virtual Reality Supported for Cardboard is enabled, with at least the API of 19

10. Make sure we input the correct model Android SDK and JDK
11. Switch platform to Android
12. Make sure the Package name is unique for the app (ex; com.Science.Colorblind
13. Make sure the Android has USB Debugging available
14. Build and Run the app to the phone
15. Allow camera access on the phone
16. Repeat these steps for tritanopia and protanopia
17. Place phone in goggles, and enjoy a fully immersive VR experience!

Results/ Data

When determining the results of our app, we came to the conclusion that it was successful through my test score results. Prior to using the goggles I scored a 100% on 10 color deficiency tests, checking the website post-test to be sure I was viewing the correct numbers. While using the googles I received a 0% on all 10 tests, proving that the goggles simulate color blindness to a somewhat accurate extent.

Conclusion

The effort to create a virtual reality app was successful, and the color blindness shaders worked on the tests that my partner took prior to the project. My partner scored a 0/10 on the deuteranopia/protanopia/tritanopia tests using the app, and failing means that the apps do simulate color blindness to an extent. While they may not be entirely accurate, the failing of the test indicates a close scale. I myself am a deutan, and I scored a 0/4 on the deuteranopia test, the same score as my partner when using the app. The fact that a real dichromat and our app scored the same on a test supports the idea that our app is accurate. The success of the app on the 10 tests is not to say that coding it didn't come with tribulations of its own.

I began this project with zero coding experience, so the amount of research needed for this was extensive and all over the place. I also enlisted for help through multiple Computer Science teachers from different schools, a student pursuing a PHD in Computer Science, and many people in the field that could possibly point me in the correct direction. I began thinking that I'd code through Android Studio, but later ended up in Unity. A week alone was spent researching on a C# code that could possibly change the screen into Virtual Reality mode, before I realized a setting in Unity that automatically programmed the screen to be VR. I then began trying to create an algorithm that ran certain colors of a hexidecimal range and converted them to different shades, before I found a colorblind asset in the Unity Asset Store. I made an error when USB Debugging the phone, and the app wouldn't download. I also used Unity 2017.3 rather than 5.6.4, which didn't contain the tools needed for live viewing and virtual reality. Finding the correct Android SDK (Software Development Kit) and JDK (Java Development Kit) was lots of trial and error, along with the difficulties of downloading incorrect programs and license keys. The project was lots of research, and lots of errors before finding the correct path.

In the future, we may be able to expand this idea by testing how normal people using the colorblind app reacted in different everyday scenarios. We could see if the ability to get dressed was severely affected, or if basic driving was more difficult in light of the absence of red, green, blue, or yellow. We could possibly culture the app for Apple rather than just Android, or even create virtual scenes for people to experience color blind in. The point of the project was to get others to emphasize with dichromats, and the possibilities for what this app may achieve are endless.

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