Ubiquitous Computing - Final Project
Colour Blindness Detection and Aid System

Robin White (50 %) - 100175876 & Eddie Allen (50 %) - 100165686

1 Aims Motivation and Background

We chose to build a colour detection and recognition device to help people who are colour blind or may not be aware that they have the condition. Colour blindness can have a huge impact on a student's ability to learn, and actively testing for colour blindness with physical objects and in-perfect lighting conditions normally requires visiting an optician, performing a range of tests and can be expensive and time consuming if the patient finds they don't have the condition. Our device can be used to perform quick initial tests to determine whether a person is colour blind and what type of colour blindness they may have. The device can also be used by working professionals such as designers and artists etc, to help them accurately determine what a colour is and its hex code.

The system itself was designed to be discrete as possible, no beeps or flashing lights to confirm a scan, just the confirmed colour, hex code and colour blindness type sent to the mobile app. Existing solutions for colour detection all made audible bleeps and none gave the colours hex code or what type of colour blindness the user may have. The motivation to build this device came from my own colour blindness (Robin White), I wasn't confirmed to have colour blindness until I was 13 and during my placement year I worked as a UX developer which involves some level of UI design. I found myself often having to ask co-workers or friends to confirm colours for me and was frustrated that their weren't any discreet solutions for this problem which were especially crucial when in design meetings or working in a groups.

2 Sensing

The system uses an Adafruit Flora, Adafruit colour sensor and Adafruit Bluefruit module to sense colour data and send it to an iPhone app. The Adafruit colour sensor gets the RGB values of the current colour which is sent back to the Flora to be decoded into a 255 format RGB value, colour and hex value. If the user has scanned enough colours to build a colour blindness profile,colour and hex data will be sent to the phone along with a colour blindness type to be displayed in the app.

We originally had hoped to include a proximity sensor to determine when the user was holding the device up to an object so that it could automatically scan the object without any user input. However, the COVID19 pandemic prevented us from getting this from the university so we chose to use the app to activate the scanner instead. The iPhone app itself now records and scans each colour when the user presses the 'scan colour' button.

3 Data Collection

If the user has the iPhone app connected to the Adafruit Flora Bluetooth module the user can press the scan button and the colour sensor will read the current colour in the form of an RGB value. From this data the program will calculate and store the RGB value in 255 format, the colour name, occurrence of specific colours and its current prediction for the users colour blindness type. In a typical use of the system, the user would connect their iPhone to the Adafruit Flora using the app, and hold up a colour to the sensor then press the scan button. Currently the device is wired together using crocodile clips but in an ideal scenario the system could be wired onto a watch band or sleeve to discretely check colours and easily hold the sensor up to an item.

One aim of this project was to solve a relatively simple problem with a well structured but equally simple solution, by only using one sensor, the system is more compact and has more potential to be implemented as a wearable. The strength of this system being it's mobility and discrete function, the aim was to design the system so it could be used in a work place or educational environment without drawing too much attention and being easy to use. A Weakness of the current build is that it isn't stored in a box or wired to a physical object so the system is loose making it difficult to scan objects without it being static on a flat surface. The app however does make collecting data much simpler and means the device can use a battery pack and provide the user feedback without needing to be connected to a physical device.

4 Data Processing/Interpretation

The system uses a simple model to interpret the colour data and build a profile of scanned colours. When the user scans in a colour it is converted to a colour name, hex value and increases an integer value that represents the number of times that specific colour has been scanned. Each time the user scans a colour these integers for each colours are reviewed and if there is a higher percentage of scans that correlate to a specific type of colour blindness the program returns a string containing the predicted colour blindness type. So for example, if red and green appear in scans more often than blue and yellow, the user likely has one of two types of red-green colour blindness.

This approach was deemed appropriate, as the three colour sensing 'cones' in the human eye each react to R, G and B light. The three main types of colour blindness are a deficiency in one of these three cones respectively - hence limited reactivity to R, G or B light. This heavily restricts the range of colours the individual would be able to perceive. Hence, the most commonly misinterpreted value between the R, G or B values between scans can indicate a limited range of perception for that colour cone, and therefore the type of colour blindness can be reasonably predicted.

The accuracy of this calculation was tested using a range of coloured cards, testing the output when scanning in different colours and creating scenarios where the user may be blue-yellow or red-green colour blind. After testing throughout building the program and after the iPhone application had been implemented the model produced consistently accurate results.

5 System Output & Feedback

All output and feedback to the user is done through the app, displayed as simple labels that change dynamically when the user scans a new colour. The system was app was designed to be very simple and just a method of viewing the output of the Adafruit without the ability to send any commands back to the Adafruit or alter preferences. Having the output displayed in an app again contributes to the mobility of the system but also the app allows the user to easily view the output in a format that's much easier to read than a console or small LCD screen. When designing the system we also considered using a speaker to confirm a successful scan but by purely using the app the system itself is more discrete and the user can view the scan instantly after pressing the scan button. Potentially a future addition to the UI could be an image of the colour on the screen so that user can more accurately confirm that they scanned the correct colour.

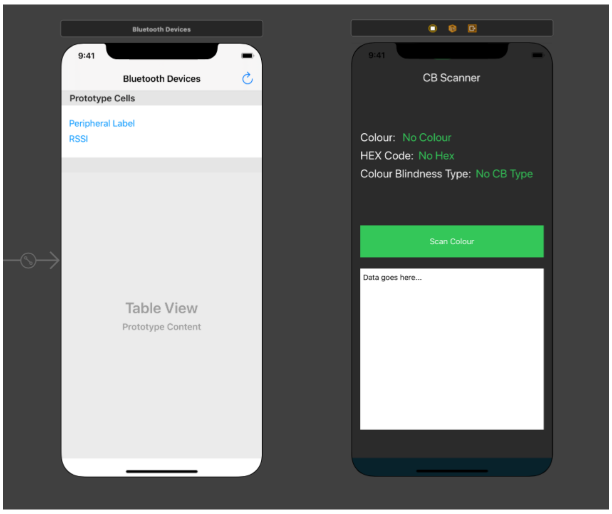

Figure 1: UI/UX

6 Conclusion

Overall, the aims of our project were successfully met. We developed a discreet, functional device capable of providing useful information for colour-blind users, or users with suspected colour-blindness who can determine their suspected type over time. In summary, the functionality we implemented, in particular the Bluetooth transmission to the iOS application, was an appropriate and sufficient way to allow the user interact with the device, and to present the data quickly and efficiently to the end user. There are considerations to be made in terms of further development of the system, for example a 'confidence rating' for each type of colour blindness could be displayed in the case of the user suffering with multiple types of colour blindness, and an Android platform application for Android users to expand the potential user base. In terms of hardware, a proximity sensor could replace the manual scan function in the app UI, so holding the device close to a surface for a short amount of time may prompt an automatic scan.

If this project was developed further, designing a case or container for the sensors and system, it could be used in educational environments to cheaply and quickly recognise colour blindness in students. Once refined this system could give students accurate representations of their colour blindness type, let them know what colours they might find hard to see and help them pick colours and take part in art or design classes without the need for support from other students or teachers. Its applications are also apparent in business, allowing designers, artists and photographers etc. to have confidence they are producing content that contains the correct colours and can help them recognise spectrum's of light they might have difficulty with. In conclusion our implementation while not perfect, represents the core technology behind a simple device that could solve a real world issue that 1 in 13 people suffer with and could especially impact the lives of young students, recognising colour blindness at an early age and getting them support.

References