ICVGoggles: Wearable Personalised Simulations of Impaired Colour Vision

Babak Momen

AC40001 Honours Project  
BSc (Hons) Applied Computing   
University of Dundee, 2016  
Supervisor: Dr. David Flatla

**ABSTRACT**

Colour is used to tie in closely with a specific meaning, signal or message; however they are mostly used for aesthetics. People with Impaired Colour Vision (ICV) come across challenges every day to distinguish between colours, designers must consider users with ICV since information can be misinterpreted or even missed. Current software and hardware solutions provide real time simulations of various spectrums of impaired colour vision. This project aims to go above and beyond current technologies to provide designers with adjustable simulations viewed with a hands-free Oculus Rift headset.

# INTRODUCTION

## Background

Most cases of Impaired Colour Vision (ICV) are hereditary meaning it is passed on genetically from parent to offspring. They can also occasionally be acquired as a result of certain eye diseases. Failing to discriminate between red and green is the most common form of ICV (Protanopia / Deuteranopia) and the gene is X- linked recessive which explains the prevalence difference between genders (8% in males and 0.5% in females). Blue-yellow ICV or Tritanopia is rare and tritanomalous symptoms are more commonly acquired from environmental factors such as age, where the eye lens becomes increasingly yellow over time, cataracts or trauma to the front or the back of the head. Monochromacy is even rarer and affects two or more types of cone in the eye. Colour vision can be said to be an illusion created by the interactions of billions of neurons in our brain[[1]](#footnote-1), we do not all perceive colours the same way. There is an information gap for designers about ICV, many do not know the problems some users will suffer because of their colour choices. Impaired colour vision varies in severity and because of this, it affects people differently; sometimes it is unnoticeable. Figure 1 was created using an online tool and demonstrates different types of ICV, however just like most other tools available, these images show the maximum severity only.



Figure 1 - Left-to-right, top-to-bottom: Normal colour vision, Protanopia, Deuteranopia, Tritanopia.

Designers do not normally consider ICV in their design practice; they are a small demographic of users. Without doing so, designers run the risk of creating a colour palette which will be confusing to some users. Small measures such as colour checking and ICV simulations can vastly improve the users’ experience.

(ECVD papers)

## Available Products

When designing for users, it can be useful to view content through the eyes of ICV users. This can reveal poor colour choices which can lead to confusion and even missed information. There are a plethora of applications available on many different platforms which can detect and manipulate pixels to simulate ICV. For example, it is possible to obtain a browser add-on for Google Chrome which simulates ICV for the current web page[[2]](#footnote-2). One flaw most software applications present when simulating ICV is the exclusion of environmental factors such as room brightness.

(apps, tablets + phones, explore their weaknesses)

## Social Context

It can be difficult to understand how ICV affects people; emulating the effects on images is useful, however this confines the condition within just the images. ICVGoggles aims to provide a simulation tool which works in real time giving users a peek at ICV 'in the wild'. Once complete, ICVGoggles can be applied to different social contexts in order to raise awareness and to educate users. For example, the tool could be used on trainee teachers to educate them in how ICV affects people. This sort of training could eventually help teachers to recognise comments made by children who have ICV; the earlier ICV is diagnosed, the better. Another application could be the use of the tool on parents who have children with ICV to give them a rich learning experience.

## Scientific Context

By providing an interactive tool which simulates ICV in real time, this project can be used to inform and educate. Young children would enjoy using the headset whilst learning how ICV can affect people.

## Previous Work

# SPECIFICATION

A specification of the problem and an explanation of how the student arrived at this specification. An initial work schedule including an overall project plan with time-scales, deliverables and resources. If using agile development, a prioritised product backlog.

## The Problem

Currently most ICV simulation tools provide a solution to specific problems and have downfalls when applied in other areas. For example, Vischeck[[3]](#footnote-3) provides Photoshop developers with a way to see their work through the eyes of an ICV user, however it does not take external lighting or screen brightness into consideration. Other solutions such as mobile applications[[4]](#footnote-4) are restricted by the hardware they are on; users must always use one hand to move the mobile device around.

## Motivation

## Project Plan

### Work Schedule

The project began on the 5th October 2015 with a meeting with Dr. David Flatla. It was decided that the student should have weekly meetings with their supervisor to ensure all progress was being monitored. The weekly meetings also meant the student could assign smaller deadlines on a weekly basis. Notes were taken at every session and have been compiled into **APPENDIX A – Minute Meetings\***. These minute meetings contain thoughts gathered from the meeting with the supervisor and were used to plan work and to be reflected upon for the following week. A GitHub repository was set up at the start to store all work done whilst the commits and punch card feature proved useful to track progress. For the mid-term progress hand in, the student produced a Gantt chart which would serve as a rough schedule.

### Deliverables

### Resources

# DESIGN

This should include the design method, design process and outcome. Design decisions and trade-offs should be described e.g. when selecting algorithms, data structures and implementation environments or when designing for usability.

## Decisions and trade-offs

(no personalised?)

(ovrvision one cam

## Design method

## Software and hardware used

### C++ in Visual Studio

### OpenFrameworks

### ofxOculusDK2 Addon

### Oculus Rift

The Oculus Rift was chosen as the headset for ICVGoggles to use; specifically the Dev Kit 2 which was released on March 25th 2014.

### OVRVision Cameras

## Design Process

Designing for usability?

UML Diagrams

workflow

# IMPLEMENTATION & TESTING

A description of production, testing and debugging. A demonstration (or even a proof) that the specification has been satisfied.

## Production

(use of davids app and help from that code)

## Testing

- testing during production, methods used

## Debugging

process of debugging during development

- proof it works (images before and after ICV applied)

## Release Package

whats in final folder

instructions manual

# DESCRIPTION OF FINAL PRODUCT

A clear description of what the final product looks like and what it does. This is vital but often neglected.

Full description of final product, well worded and should NOT be neglected

# EVALUATION

Usability should be evaluated with a description of the user-centred design methods employed to produce a usable product, including rapid prototyping, usability methods, results and re-designs as appropriate. Other relevant criteria such as accuracy and computational efficiency should also be employed for evaluation as appropriate.

## Prestudy Interviews

## -prestudy interviews, main testing (plates and exploration), questionairres

## Second Stage Evaluation

## Analysis

## of results, methods used

## Evaluation of Results

## Usability

## Accuracy (important!)

# DISCUSSION

Area where I discuss reasons for the results found and how these results may benefit ICVGoggles.

# APPRAISAL

A critical appraisal of the project indicating the rationale for design/implementation decisions, lessons learnt during the course of the project and an evaluation (with hindsight) of the final product and the process of its production (including a review of the plan and any deviations from it).

## -Rationale for design

## -Rationale for implementation decisions

## -Lessons learnt

## -Evaluation including hindsight

**A description of any research/hypothesis**

# SUMMARY & CONCLUSIONS

## Summary

## Conclusions

# Qualitative evaluation, qualitative (IF DONE) evaluation, personal feelings on project and how it went

# FUTURE WORK

-Mobile ICVGoggles (garreth said a battery back pack, possible?)

A copy of the mid-project progress report should be included.

# REFERENCES

1. Bowman, M., Debray, S. K., and Peterson, L. L. 1993. Reasoning about naming systems. *ACM Trans. Program. Lang. Syst.* 15, 5 (Nov. 1993), 795-825. DOI= <http://doi.acm.org/10.1145/161468.16147>.
2. Ding, W. and Marchionini, G. 1997. *A Study on Video Browsing Strategies*. Technical Report. University of Maryland at College Park.
3. Fröhlich, B. and Plate, J. 2000. The cubic mouse: a new device for three-dimensional input. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (The Hague, The Netherlands, April 01 - 06, 2000). CHI '00. ACM, New York, NY, 526-531. DOI= <http://doi.acm.org/10.1145/332040.332491>.
4. Tavel, P. 2007. *Modeling and Simulation Design*. AK Peters Ltd., Natick, MA.
5. Sannella, M. J. 1994. *Constraint Satisfaction and Debugging for Interactive User Interfaces*. Doctoral Thesis. UMI Order Number: UMI Order No. GAX95-09398., University of Washington.
6. Forman, G. 2003. An extensive empirical study of feature selection metrics for text classification. *J. Mach. Learn. Res.* 3 (Mar. 2003), 1289-1305.
7. Brown, L. D., Hua, H., and Gao, C. 2003. A widget framework for augmented interaction in SCAPE. In *Proceedings of the 16th Annual ACM Symposium on User Interface Software and Technology* (Vancouver, Canada, November 02 - 05, 2003). UIST '03. ACM, New York, NY, 1-10. DOI= <http://doi.acm.org/10.1145/964696.964697>.
8. Yu, Y. T. and Lau, M. F. 2006. A comparison of MC/DC, MUMCUT and several other coverage criteria for logical decisions. *J. Syst. Softw.* 79, 5 (May. 2006), 577-590. DOI= <http://dx.doi.org/10.1016/j.jss.2005.05.030>.
9. Spector, A. Z. 1989. Achieving application requirements. In *Distributed Systems*, S. Mullender, Ed. ACM Press Frontier Series. ACM, New York, NY, 19-33. DOI= <http://doi.acm.org/10.1145/90417.90738>.

1. P.Gouras, 'Colour Vision', in webvision.med.utah.edu, last update 1 July, 2009 [↑](#footnote-ref-1)
2. Spectrum, offered by Yehor Lvivski for Google Chrome [↑](#footnote-ref-2)
3. Vischeck Photoshop Plugin - http://www.vischeck.com/ [↑](#footnote-ref-3)
4. 20 iPhone Apps for the Colour Blind - http://www.color-blindness.com/2010/12/13/20-iphone-apps-for-the-color-blind/ [↑](#footnote-ref-4)