Nottingham Trent University

School of Science and Technology

Simulating Visual Impairments in a Virtual Reality Environment

by

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of the requirements for the degree of

Bachelor of Science with Honours

in

Computer Science with Games Technology

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Abstract

Visual Impairments are a hard topic for unaffected people to visualise, and as a result, they are not talked about very often, and the severity and range of visual impairments are not widely understood or known. This led to the investigation of the production of an environment in which Visual Impairments could be Simulated to allow for people to experience the effects of Impairments first-hand, to raise awareness and understanding of the nature of Visual Impairments.

Virtual Reality is a strong medium for building immersion and a sense of being inside of the Virtual World, this makes it the ideal medium to produce a Visual Impairment Simulator as the user will be able to experience the Impairments rather than just see them. This would make the Simulator provide more of an impression and result in a greater understanding of the nature of Visual Impairments.

To produce the environment, Unreal Engine will be utilised as it provides many pre-made utilities for creating projects within a game-style world, especially for Virtual Reality. Unreal Engine also has many built in features to assist with the production of Post-Process Materials, which will be used to simulate the Visual Impairments.

This project concludes that Producing a Visual Impairment Simulator is very viable within a Virtual Reality Environment and that Virtual Reality is a significantly stronger tool for this use than other methods, due to the first-hand immersive experience of the Impairments. The participants who tested the Simulator also reported a greater appreciation for Visual Impairments and those afflicted with them.

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Introduction

Virtual Reality immerses the user inside of a different world outside of our own, in which they can be whatever they want to be or what the designer wants them to be, I can use this to my advantage. I can use this medium to instead of showing them how Visual Impairments can affect you but let them experience and feel how Visual Impairments can affect you. I believe this would be a significantly better method of conducting this project, as it will lead to more successful results of people being more aware of the difficulties of living with a Visual Impairment.

Visual Impairments are a very common yet hard to understand disability. There are many different forms, which tend to be bundled into groups and people do not know the differences between them and how they affect you differently. I will be building a simulator inside of a virtual reality environment which will let me simulate as many symptoms of Visual Impairments as I can so that the effects and complications of each can be demonstrated.

People in the care or design industry without visual impairments may struggle to incorporate consideration for people with visual impairments (Goodman-Deane, et al., 2007) into their job and routine, which can cause issues for their clientele. For example, if a designer does not take into account people with colour-blindness and uses the wrong colour scheme, then their product may be completely unusable to people with that type of colour-blindness, or if text is too small or hard to read, it may cause issues for people with poor eyesight. Also, if people in the care industry do not consider their patients’ eyesight there may be risks of the patients not knowing of a danger or not being able to live their life properly.

Modern Virtual Reality Headsets also contain eye-tracking capabilities, which I will be able to use to more accurately simulate Visual Impairments such as Diabetic Retinopathy, in which, areas of vision may be completely lost or Floaters appear in the vision. Using the eye tracking, I can make these follow the user’s eyesight instead of being stationary, which would allow for the user to simply look around them and not provide a strong simulation of those Visual Impairments. Certain Headsets also contain front-facing cameras, through which I may be able to simulate the Visual Impairments, to allow for the user to experience a situation that they are used to through the eyes of a Visual Impaired Individual.

The goal of this project is to provide a strong tool for people to use to see how Visual Impairments can affect the Quality of Life for individuals afflicted, and to raise awareness and consideration for the Visually Impaired. The simulator could also be used by people in the Design or Care industries for them to be able to more accurately work with people with Visual Impairments as to not exclude them from their services and help them more.



CONTEXT

## Introduction

This chapter will contain a Literature Review, in which similar and adjacent projects will be analysed to discover if there were any shortcomings or gaps which could be touched upon with this project. The methods used within the reviewed projects will also be used to ensure that the methods used by this project provides a different view and to reduce, as much as possible, overlap between projects.

## Literature Review

### Virtual Reality

Virtual Reality is a very powerful Human-Computer Interface (Burdea & Coiffet, 2003), and has been used for a variety of objectives, from Neuroplasticity to Motor Rehabilitation to Virtual Training and Practice (Weiss, et al., 2014). It has also been proved to work very well with Simulations for education, especially for positions that require no mistakes, for example, medicine and surgery (Tsoulfas, 2018).

Since the initial release of the Oculus Rift DK1 in 2013, the amount of companies investing and upgrading consumer-grade Virtual Reality Systems has dramatically increased (Mealy, 2018). As more companies have started producing Virtual Reality Devices, their general availability and power increased, in 2018, the release of the Oculus Quest (Zuckerberg, 2018), marked the first full-strength, completely self-sufficient Virtual Reality Headset, increasing the availability of Virtual Reality to even more people than before.

A close up of a device

Description automatically generated

Figure : Oculus Rift DK1

However, immersion in Virtual Reality is done by simulating as many human senses as possible (Altobelli, 2019), and this was increased recently with the release of the HTC VIVE PRO EYE, which is a Virtual Reality Headset with Eye Tracking Capabilities (HTC, 2019). Eye tracking allows for the Virtual Environment to be interacted with more, allowing for more immersion.

A picture containing table, sitting, cake, black

Description automatically generated

Figure : HTC VIVE PRO EYE

### Visual Impairments

#### Visual Impairments

There are a vastly large amount of types of Visual Impairment and there is an even greater number of causes (FightForSight, 2019). The population of people with Visual Impairments is diverse; anybody can be affected, and most will be during their lifetime (Huebner, 2000). Although all people who have Visual Impairments are grouped together, the nature and severity of their individual impairments are very different and can affect them in different ways (Huebner, 2000).

#### Simulating Visual Impairments

There have been many projects where Visual Impairments have been simulated for various reasons and in various ways. In an 1983 study by [Dr. Christof C. Krischer](https://journals.sagepub.com/action/doSearch?target=default&ContribAuthorStored=Krischer%2C+Christof+C), in which he simulated visual impairments and asked people to follow a reading speed test, and concluded that Simulated Visual Impairments resulted in similar reading speed results as People afflicted by the Impairments (Krischer, 1983).

Visual Impairments can be simulated using different methods, a basic method is to simulate a static image, this works for the purpose of simulating that single image however, for education, it does not provide much benefit. They can also be simulated using tinted lenses on goggles as done by J. Wood et. al.’s “Effect of Simulated Visual Impairment on Night-time Driving Performance”, where the researchers gave able sighted testers goggles that provided a cataract-style impairment and a pair that simulated a general blur effect and tested to see how the testers’ abilities to drive were affected (Wood, et al., 2010)

### Similar Projects Review

<https://pdfs.semanticscholar.org/4009/b68ac12a67b4b06858ebc7a6c12fd84dd42b.pdf>

<https://ieeexplore.ieee.org/abstract/document/7009734>

<https://ieeexplore.ieee.org/abstract/document/6165430>

## Conclusion

In Conclusion, I found that Virtual Reality is a Powerful and Available Medium in which to Simulate a Visual Impairment. I also found that Simulating Visual Impairments is proven to be a possible goal and that Visual Impairments can be simulated to a high degree of similarity and relative strength.

Utilising Eye-Tracking inside of a Virtual Reality Visual Impairment Simulator is something that has not been done before, and therefore I shall be trying to include it within my project and recording if doing so increased the perceived level of immersion and if it resulted in the participants appreciating the nature of visual impairments more.



New Ideas

## Introduction

* What was learnt last chapter, what is the specific area of research
* What I will be doing different to the papers I looked at
* What I shall be doing in the project, specific as heck
* How is it different to what has been done before?

## Software Development

* Requirements for Software Dev (Hard and Soft)
* How these Requirements were decided
* How they relate to background research

## Time Management and Development Process

* supposed to take 400 hours of your time.
* evidence of project planning
* estimates of workload for the various phases, setting these in context with other estimated workloads (e.g. course work and revision) and other deadlines.
* Reference Gantt Chart in Appendices
* your planning you should include contingency planning to allow for the unexpected disaster.



IMPLEMENTATION

## Introduction

* details of the development of the new material proposed in 'New Ideas'
* business-like manner, formal.
* must follow a suitable analysis and design methodology (CASE tools)

**THE COMPLETE REQUIREMENTS ANALYSIS, PROBLEM ANALYSIS & DESIGN OF SOFTWARE MUST BE DONE RIGOROUSLY AND INCLUDED IN FULL IN AN APPENDIX. AVOID CROSS-REFERENCING IT TOO OFTEN, THUS CAUSING THE READER TO KEEP FLICKING PAGES BACK AND FORTH, RATHER REPRODUCE SECTIONS THAT YOU WISH TO DRAW THE READER'S ATTENTION TO. ( FOR EXAMPLE, PARTS THAT WERE PARTICULARLY HARD, OR PARTS YOU ARE PROUD OF). REFERENCE TECHNIQUES USED, SHOW SHORTCOMINGS THAT YOU CAME ACROSS**

## Software Development

* Explain Project Management Method

### Analysis

* Analysis

### Design

* Design
* Consideration of Human Computer Interaction, aka user-friendliness

### Production

* Production

### Testing

* Testing, including table.

## Project Progress Diary

**CAN BE DONE INSTEAD OF 4.2 BUT IS NOT AS GOOD, NO REASON TO REMOVE AFTER DOING 4.2 THOUGH.**

* Simple Chronological Retelling of production of the System



RESULTS / DISCUSSION

## Introduction

* Your Method was meant to develop and improve upon others, evaluate whether this was true
* Construct and Complete quantitative test for results and to prove conclusion
* Explain the success and limitations of your work and show how this relates to the aims and objectives set out in the introduction.



CONCLUSIONS / FUTURE WORK

## Conclusions

* Summary of Results and Meaning of Results
* Did you achieve what you set out to do
* Success?
* How would you have done things differently in retrospect

## Future work

* If you were to continue this project, what would get done
* Expand on successful outcomes
* Produce solutions to issues raised within project
* Further implications of what you have achieved (??????)

## Legal, Social, Ethical and Professional Issues

Any issues that may arise during my project should be monitored, as I should follow the British Computer Society (BCS) Code of Conduct (British Computer Society, 2015). However, BCS is not the only institute in the field of computing, so it would be advisable to also follow the Association for Computing Machinery Code of Ethics and Professional Conduct (Association for Computing Machinery, 2018)as well as the Institute of Electrical and Electronics Engineers’ Code of Conduct (Institute of Electrical and Electronic Engineers, 2014). The reason I should follow all of these, is due to the fact that if one society may have missed a certain topic, it is still an issue and should be addressed to as such.

“Have due regard for the legitimate rights of Third Parties” (British Computer Society, 2015), also “Ensure that you have the knowledge and understanding of the Legislation and you comply with such” (British Computer Society, 2015). The biggest issue would be the gathering and storing of user’s information, and specifically to follow the regulations of the Data Protection Act, 2018. Under the Data Protection Act, any person whose data I possess, has the right to know what it is being used for, the right to know what I hold, have incorrect data updated and to have data erased if wanted. I will follow this by explaining what the project is about and what conclusions I will be drawing, and what information shall be getting used in that. I will also provide any user with ways of contacting me if they require information updated or erased.

“Avoid harm … examples of harm include unjustified physical or mental injury” (Association for Computing Machinery, 2018). Since I am working in Virtual Reality there is a slight inherent risk for the user of the Simulation. Not being able to see and having greatly reduced other senses and awareness of the surroundings can result in risk to the user. I will ensure, with the user, that they are aware of the risk and that the area is as safe and with the lowest risk of harm possible. The risk cannot be removed; however, the user will be aware of it and is fully within their rights to not take part if they are not happy with the precautions.

An ethical issue would revolve around whether or not I should use stock assets or make my own, since if I were to use the assets that are for educational use, I would not be able to continue work on the system, unless I paid for the licenses, or took them out and made my own. Making my own would mean there would be none of those issues, however, it would take more time. I consider this project a proof of concept and would be willing to use premade assets as they would allow for more time to be spent on more time-consuming components.

## Synoptic Reflections

* reflection on the project in relation to employment aspirations
* skills that you have developed with the project.

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Appendix A

The content of these will differ with the different types of project. Any design and analysis charts/diagrams will be included here in full. In projects where software has been developed there will be an appendix for this. Our departmental requirement is that a CD, DVD or USB memory stick of all source code is submitted to your project supervisor. The appendix contained in the report will refer to this CD, DVD, or USB memory stick, provide a directory style listing of the files submitted and instructions for rebuilding and running the software. This might be source code of programs written in high level languages (C, C++, etc) together with any pertinent files ('make' files, non-standard libraries, etc). Alternatively, or in addition, you can place some or all of the source code in the appendix. In any case the source code needed to reconstruct any software you have developed must be submitted in its entirety in the CD, DVD, or USB memory stick. (Any code that has been used from a third party should reference the original developer).

Hardware designs will require schematics/circuit diagrams, PCB layouts, simulation tests and pin outs.

Most projects will require some form of user documentation to explain how to use the software/hardware produced. A researcher following up the work may wish to utilise the work of the original author and an appendix laying out the format of input files and how to interpret the output is required.