School of Computing
FACULTY OF ENGINEERING

UNIVERSITY OF LEEDS

Vive Virtual Reality Technology Demonstration

Khen Cruzat and Philip Nilsson

Submitted in accordance with the requirements for the degree of Computer Science

2016/2017

The candidate confirms that the following have been submitted.
<As an example>

Items	Format	Recipient(s) and Date
Final Report (2 copies)	Report	SSO (DD/MM/YY)
Final Report (digital)	Report	VLE (DD/MM/YY)
Project Code	GitHub Repository	Supervisor, Assessor (DD/MM/YY)
User Manual	Report Appendix	Client, Supervisor (DD/MM/YY)

Type of project: Software Product

The candidate confirms that the work submitted is their own and the appropriate credit has been given where reference has been made to the work of others.

I understand that failure to attribute material which is obtained from another source may be considered as plagiarism.

Khen Cruzat

Philip Nilsson

Summary

<Concise statement of the problem you intended to solve and main achievements (no more than one A4 page)>

Acknowledgements

<The page should contain any acknowledgements to those who have assisted with your work. Where you have worked as part of a team, you should, where appropriate, reference to any contribution made by other to the project.>
Note that it is not acceptable to solicit assistance on 'proof reading' which is defined as the "the systematic checking and identification of errors in spelling, punctuation, grammar and sentence construction, formatting and layout in the test";
see http://www.leeds.ac.uk/gat/documents/policy/Proof-reading-policy.pdf.

Contents

Chapter 1

Introduction

1.1 Problem Statement

The goal of the project is to produce a technical demo for the HTC Vive to be used by the university to showcase development skills for virtual reality. This demo would be used in the School of Computing open days.

1.2 Client Background

The client for this project is the School of Computing in the University of Leeds.

1.3 Problem Background

The School of Computing wanted this project to be done as currently they own virtual reality hardware, however they do not have any software made by University of Leeds students to show to potential students. They are currently using software bought online in order to show the capabilities of the virtual reality hardware. They would prefer it if the software that they used is made by students from the School of Computing.

1.4 Project Aim

The aim of this project is to create a technical demo for the School of Computing, using the HTC Vive. This demo should appeal to prospective students, as well as appealing to people in the industry. This means that the project has to be both technical, for the industry, and interesting, for the prospective students.
To make it technical enough for the people in the industry features have been added that are not trivial to implement in Unreal Engine 4.
To make it interesting for the prospective students, the demo has to have good gameplay and an interesting concept behind it.

1.5 Possible Demo Idea

One possible idea for the demo would be to combine the Towers of Hanoi with graph flow. These could be combined by having a generated landscape with a randomly generated graph on it, matching the flow of the terrain. This graph's edges would be rivers, or ditches with water running through them, and the nodes would be either river intersections or pools of water. This would be merged with the Towers of Hanoi by using the Towers of Hanoi system as a dam, to block off flow to a certain river, or by moving the disks you could control the amount of flow. This would work by having the disks stack upside down, with the smallest disk at the bottom. This is done in order to accommodate the shape of the ditch. The less disks that are blocking the river, then the more flow it would have.
The goal of this demo would be to keep all the plants at each node alive. The plants would be considered alive if they got the right amount of water. Too much water they would die and too little water they would die too.

This would be a possible demo idea as it implements several features that are non-trivial in Unreal Engine. Tasks are classified as non-trivial if they cannot be done in engine. It also demonstrates two aspects that are covered in the computer science course, which are the Towers of Hanoi, and Graph Flow.
These features are:

- Running water
- Water Collision
- Having the plants be affected by the amount of water
- Randomly generated river "graphs"
- Towers of Hanoi logic for flow control

The trivial tasks, that are done in-engine, would be:

- Generating terrain and landscapes
- Simple Gesture Controls
- Simple virtual reality gameplay (including teleport mechanic)
- Physics
- Flowers on the terrain

1.6 Deliverables

1. A link to the full code repository on GitHub
2. An instruction manual, detailing how to compile the code, the objectives of the technical demo, and how to control the technical demo
3. Project Report

The reasoning behind these deliverables are:
The code is needed so that the assessors can see what has been for the project, and this will show all the progress that has been made on the software over the course of the project, and how each feature was implemented. This will be on the version control site that is being used for the project, which is GitHub. The Version Control page will be delivered so that the software engineering project management side of the project can be assessed.
An instruction manual was decided on so that the assessors know how to compile the code properly, so that they can test the software, and it will also detail the controls and the objective behind the game.
The project report should be delivered as it provides insight into the inner workings of the project. It also shows the knowledge that the authors gained from doing the project.
These will be the only deliverables as they fully encompass all the work done during the project.

Chapter 2

Background Research

2.1 Problem Overview

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2.2 Virtual Reality

Virtual Reality is a technology that has been around since the early 19th century, although in a primitive form through the use of stereoscopic photos [3]. Stereoscopic photos work by using two photos that are taken of the same place but are slightly offset from each other, as can be seen in 2.1. This creates an illusion of depth for the person viewing the images, when viewed through a stereoscope. A stereoscope is a viewing device that only allows one eye to see one of the two images, so each eye sees a similar, yet different image, and this gives the illusion of depth. Stereoscopic vision is the same technology used in current Virtual Reality headsets although now the images are moving.

Figure 2.1: Example of a stereoscopic image.

In the past couple of years the amount of consumer Virtual Reality products has increased significantly, and now there are several consumer products on the market. Examples of some are the HTC Vive, Oculus Rift, Samsung Gear VR and the Google Cardboard.

2.2.1 Mobile VR

On the market right now there are two different Mobile Virtual Reality hardware. There is the Samsung Gear VR and the Google Cardboard.

Google Cardboard

The Google Cardboard is the cheapest Virtual Reality headset out on the market right now, but it does come with the least features out of them. The cardboard viewer is a stereoscope made out of cardboard. It contains two 40mm focal lenses that are designed to give a distortion when looking through them, which is counter-acted by the distortion from the application[1].
To use the Google cardboard you would need to install the cardboard application on your compatible phone and then place your phone inside of the Google Cardboard. Once the phone is inside the Cardboard it uses the phone's inertial measurement unit to track head movement. This does have limitations however as the Google Cardboard does not track displacement if the user was to walk in any direction.
The Google Cardboard still uses the technology of stereoscopic images, as can be seen in 2.2. Although it now does it with moving images, which creates a more immersive experience.

Figure 2.2: Image showing the Cardboard demo application

The Google Cardboard was not chosen to the virtual reality device for this project as there are many drawbacks to it, and as such it does fully demonstrate all the features present in modern technology for virtual reality. The drawbacks to the Google Cardboard are:

- No displacement tracking, making it less immersive than the other options
- Only one input method, a button on the cardboard which acts as a screen press.

Samsung Gear VR

The other mobile Virtual Reality headset on the market is the Samsung Gear VR. The Samsung Gear VR is slightly more expensive than the Google Cardboard, and as expected with the price increase, it comes with more features compared to the Google Cardboard.
The Samsung Gear VR uses the same technology as the Google Cardboard in the sense that it uses stereoscopic imaging to create the illusion of depth. This is done in the same way for both VR devices, by inserting a compatible phone into the phone holder in the headset, and then showing the stereoscopic images on the phone screen. As seen in 2.3 the Samsung gear VR uses the same stereoscopic technology as the Cardboard uses, as seen in 2.2.
The Samsung Gear VR also uses an inertial measurement unit to detect head movement, similar to the Google Cardboard. The Samsung Gear VR uses an inertial measurement unit contained in the headset, rather than using the attached phone's inertial measurement unit. The inertial measurement unit contained in the headset is more accurate, has lower latency, and is better calibrated than standard phone inertial measurement units, as it uses the same I.M.U. as the Oculus Rift. This I.M.U. is more accurate as it has a higher sample rate than internal phone I.M.U.s and therefore gives it more values to use, so that it can more accurately detect erroneous values.

Figure 2.3: Image showing the Samsung Gear VR menu

The Samsung Gear VR has a few extra features compared to the Google Cardboard, for example when a phone is placed inside the Galaxy Gear VR it needs to be connected by a micro-usb connection, which allows the headset to have more input methods to the phone, as well as giving access to the headset's I.M.U. The extra input methods that the Gear VR has access to are:
test test test

- A home button, which works the same as the home button on Android phones.

- A back button, which works the same as the back button on Android phones.

- A touch pad, which works by swiping to move across menus, and tapping clicks the highlighted item in a menu.

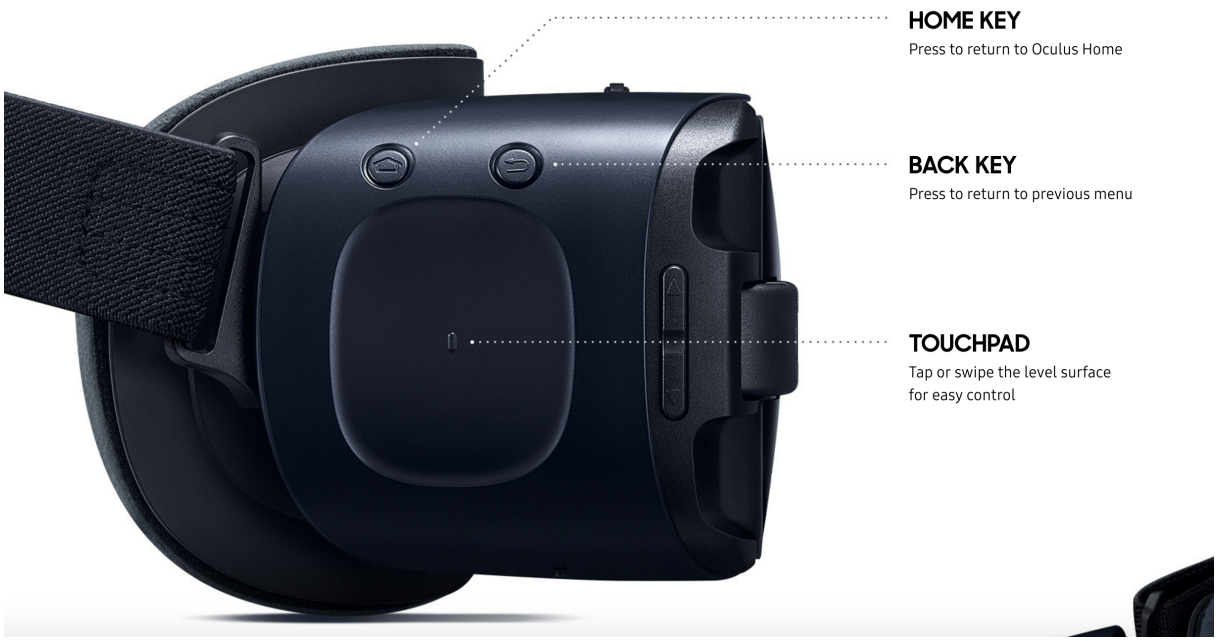

Figure 2.4: Image showing the hardware controls on the Samsung Gear VR

The Samsung Gear VR will not be used for this project as again it has several drawbacks, which are:

- It only tracks rotational movement, not displacement, which makes it less immersive than the other options
- The Samsung Gear VR has very primitive control, which are only the buttons and touchpad on the side of the headset

2.2.2 Oculus Rift

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2.2.3 HTC Vive

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2.4 Development Environments

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2.4.1 HTC Vive

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2.4.2 Oculus Rift

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Chapter 3

Requirements

3.1 Client Requirements

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3.2 Feasibility Assessment

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Chapter 4

Project Management

4.1 Methodology

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4.2 Schedule

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4.3 Version Control

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4.4 Risk Assessment

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Chapter 5

Planning and Design

5.1 Game Design Process

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5.2 Virtual Reality Features

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5.3 Random Generation of River Graphs

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5.4 Towers of Hanoi

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5.5 Plant Survival

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Chapter 6

Implementation

6.1 Development Environment

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6.1.1 Vive Hardware

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6.1.2 Game Engine

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6.1.3 Out of Engine Development

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6.2 Random Generation of Rivers and Terrain

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6.3 User Interactive Reverse Towers Of Hanoi

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6.4 Flow Dependant Flora

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Chapter 7

Testing and Evaluation

7.1 Testing Against Requirements

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7.2 Client Evaluation

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7.3 Result Evalutaion

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7.4 Project Evalutaion

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Chapter 8

Conclusion

8.1 Conclusion

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8.2 Future Work

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8.3 Personal Reflection

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Appendices

Appendix A

External Material

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Appendix B

Ethical Issues Addressed