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Acknowledgements

Project Abstract

<u>**Motivation**</u>

We live in a time where technology is evolving at a massive rate and with that several innovations are here to change the world as we know it forever, including artificial intelligence, machine learning, augmented reality and virtual reality.

Many people believe virtual reality is going to make more of an impact than smartphones. It seems like a big claim until you consider the true potential of virtual reality and the ways in which it can be used.With VR , you don't need to dream, you can become, with its vast array of immersive virtual environments. You can explore entire new worlds, experiences and even careers. All of this is made so immersive by the interactions available in VR. Usually you can pick up anything you could in real life and more and use it like normal or not depending on the application.

VR is making a huge surge in games with headsets becoming cheaper and more available to the public. More people than ever before are becoming exposed to VR but it's not just a medium for games. It can be used in the business world, too. Soldiers and military can get real, life-like training, law enforcement can prepare for emergency situations, the possibilities are endless. Even Walmart announced that it is using 17,000 Oculus Go headsets to train its employees. It is likely we will see industries involving work with expensive tools and equipment, or hazardous conditions using VR more and more.

The use of interactions in VR is essential to feeling truly immersed in the environment. This was the main motivation behind this project, as the interactions you have with your surroundings is what makes virtual reality what it is today.

It was this relevance that influenced my study of *Interactions in VR* as I believe that VR has the potential to become even more than it already is. VR is growing bigger and bigger every day with new uses found all the time, its potential is limitless.

<u>**Purpose**</u>

My aim for this project is a study on *Interactions in VR*, to become more accustomed to developing for VR devices, and expand upon my knowledge of VR. I intend to develop a demo that uses the HTC Vive, and will teach the user about all the different ways in which you can interact with your environment in VR.

Method

I started this study by studying games and gaming in VR. I looked into all the different genres and styles out there. I then focused on specific genres I felt would be feasible to create throughout the year.

I also studied Virtual Reality technology and what it can do, and looked into the different VR headsets and what they are capable of so I could choose the correct one. I inevitably chose the wrong headset (Oculus Quest) and soon swapped to the HTC Vive as I couldn't debug any code using the Quest.

The results of my research gave me some good ideas of games I could develop in VR with the HTC Vive. It didn't take me very long to realise I wanted to change my field of study. The more games I researched the more I saw new and innovative interactions being used. That's when I decided that I wanted to look into just the interactions. But then came the predicament that I still wanted to make something game related. So I came up with the idea of making each interaction into a minigame similar to an arcade.

After this revelation I researched many interactions developers were using in VR and which were most prominent or which could be used to create a game from.

I choose a wide array of different interactions some of which I made minigames surrounding. I felt the decision to explore interactions was the best decision as I can learn about the most important side of feeling immersed in VR environments.

Project Introduction

"Interactions in VR"

My objective is to create fun VR interactions in Unity3D and Visual Studios, using mini games. It is intended to be played using the HTC Vive VR headset. Each mini game is designed as a fun way to experience a single interaction. There are four main interactions I concentrated in turning into mini games. They are pushing buttons, using levers to move objects, picking up objects and clipping them into place and hitting an object with another object. There are two parts to some of the minigames. Both are the same game but the interactions used to play differ. This gives users the option of choosing which style of interaction they preferred. The user can move through the environment using a teleporting system. Each interaction minigame has a teleportation waypoint in front of it the user must simply point at the way point and click the trackpad to teleport to that location.

You start with some basic interactions like opening a door or drawer, or picking up and dropping objects. Then you can move to the first set of minigames involving pressing buttons. This minigame has two parts, one is focused on interactions with UI which means that you point and click to interact with the button, the other is "pure VR", which can also be known as diegetic meaning something that exists in the game world rather than being overlaid onto the game, where you have to actually push the buttons. The objective of these

games is to press the buttons as they light up. The next minigame you come to is a maze-like game, where you use the two levers to maneuver the cube around the maze and find the exit. Next up you will see two more minigames, this is another two part game. Using the picture above them as reference, the user will need to transfer the blocks into the appropriate pattern. On one side the user will move the blocks around using their hands, on the other side the layout of the blocks is there for them, they will have to move the correct block into the correct space and the block will clip itself in place. The final minigame is simple, you have a baseball bat and a ball. All you have to do is try to hit the ball as far as you can with the bat.

My goal is to create a pleasant and engaging way of interaction with objects in VR.

Background

If we focus more closely on the nature of virtual reality as a way of creating the illusion that we are present somewhere we are not, then the earliest attempt at virtual reality is surely the 360-degree murals from the nineteenth century. The purpose of these paintings was to fill the whole field of view of the viewer, making them feel present at some historical event.

(Panoramic Painting of Battle of Borodino, 1812)

VR dates back to 1838 when Sir Charles Wheatstone was the first to describe stereopsis, explanation of binocular vision. In 1960 the first HMD was released, there was no motion tracking at this point. Headsight was the first motion tracking headset, it was created in 1961. It had built in video screens for each eye. Used in the military. The first HMD was named The Sword of Damocles. The head mount was connected to a computer rather than a camera. But it was too heavy to wear so users were strapped in while it was suspended from the ceiling [1].
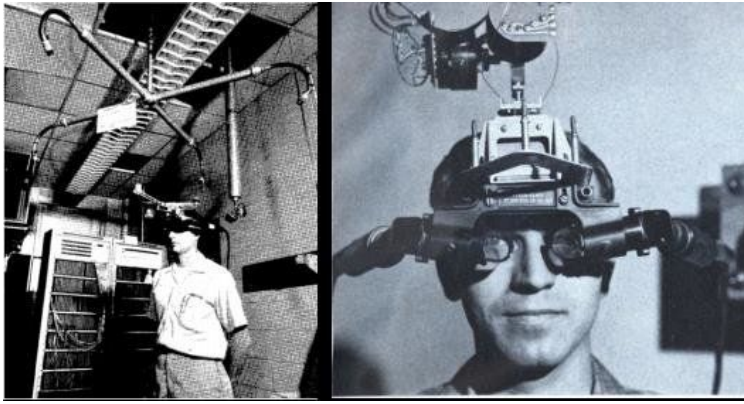
(The Sword of Damocles)

One of the first companies to attempt to launch a VR headset was Sega, which planned Sega VR as an accessory for the Genesis.Unfortunately it was never released, with one explanation being that Sega worried the virtual effect was too realistic, and people would wind up hurting themselves while immersed **[2]**. In 2010, 18-year-old entrepreneur Palmer Luckey created the first prototype of the Oculus Rift. Showing a 90-degree field of view that hadn't been seen previously in a consumer device, it raised $2.4 million on Kickstarter a couple years later, before the company was purchased by Facebook for $2 billion in 2014.

In 2017 hundreds of companies started working on their own VR headsets.These include market leaders such as HTC (makers of the HTC Vive), but also Google (Google Cardboard), Apple, Amazon, Sony, Samsung, and others.

Technology is always advancing at a rate some people just can't keep up with. With virtual reality and augmented reality rising in popularity and decreasing in price, most households have some form of VR headset, if not a €200 - €400 Oculus then a €10 headset for your phone. With this in mind, this project aims to study *Interactions in VR using HTC Vive.* The overall outcome for this project is to create intuitive interactions for beginners that incorporates the technology of the HTC Vive and VR.

Project Description

When the user starts the game they will see a small area with some objects they can interact with. In Front of them is a door which they can open. There is a dial on the wall which if rotated will change the lighting.

To their right is a table with some objects on it and drawers under it. To get to the table the player will use the teleporting waypoint system, they must point at the waypoint and click the trackpad to teleport. Once there they can open and close the drawers by grabbing the knobs. They can also pick up the objects in front of them without touching them, as if they are using the force. The last object on the table is a toy gun that they can shoot at the targets to their right but they must be careful there are only 3 ammo magazines available.

The last object in this area is a ball hanging from a rope. The user can hit this ball like a punching bag. These were all small interactions to get the user settled and comfortable with how some interactions will work.
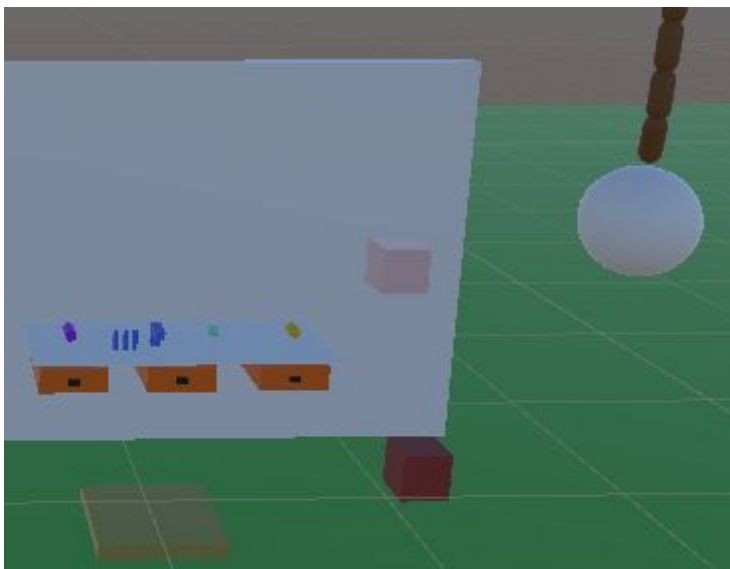
Next they will move onto the first minigame, the button game. They will see a 2D canvas with a start button and orange squares. When the start button is pressed they will notice the orange squares turn blue. If they point at the blue squares and click the trigger button they will increase their score. They will have a limited amount of time to get a high score. After this they will try another version of the same game. This version is 3D and requires the user to push the buttons when they turn blue.
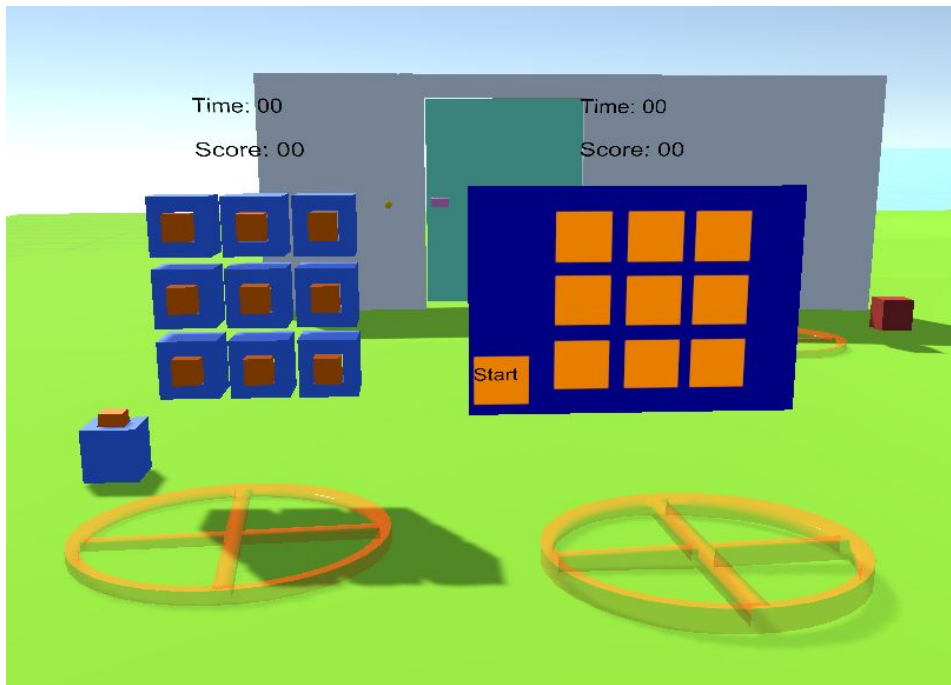
The next game is a maze style game. The user will see a maze, inside it a square, outside it 2 levers. They must use the levers to move the square and traverse through the maze to the finish.
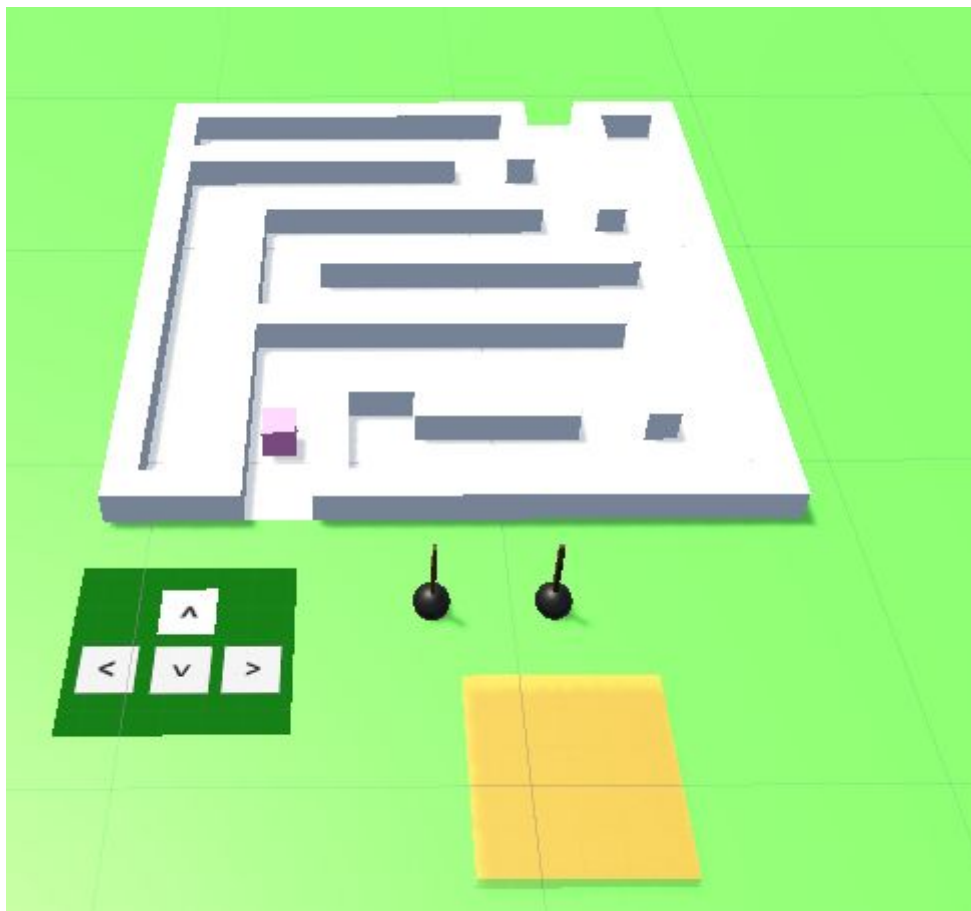
Next we have a building block game. The user can see the picture of what they must build above. They can also see the blocks needed to build it below. Now they can choose to use physics and build themselves on the right or use the outlines and choose the correct block to fit in the correct place on the left. If they put the correct block in the correct place it will clip into place when they release it.
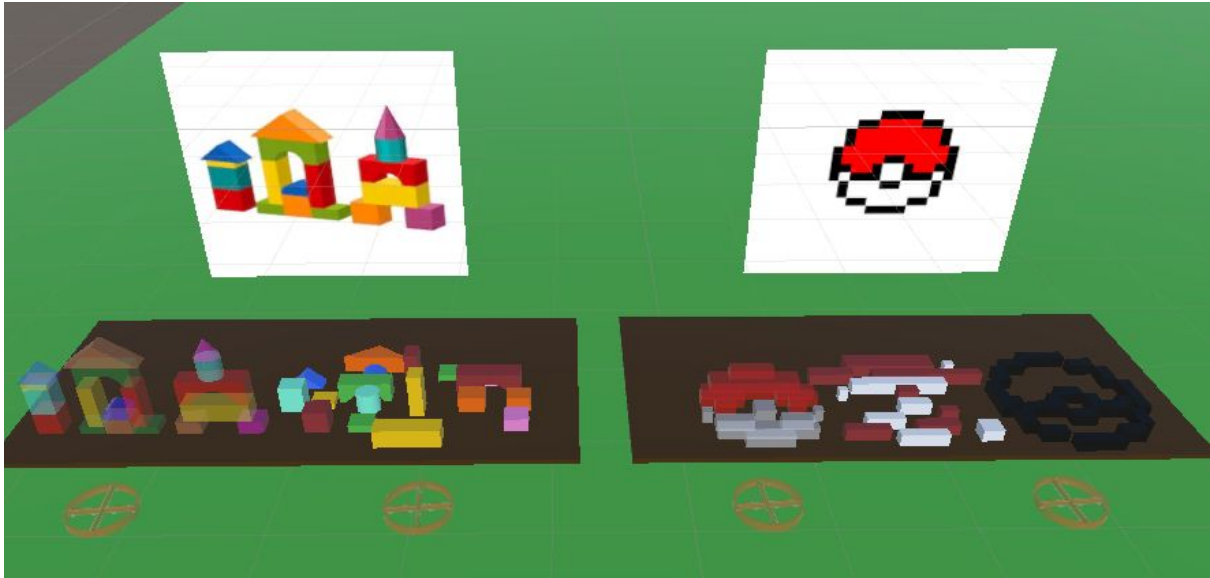
The final minigame baseball. The user can see a baseball bat and a button. The user must pick up the baseball bat and press the button which will release a ball above them. The player is tasked with hitting the ball as far as possible.
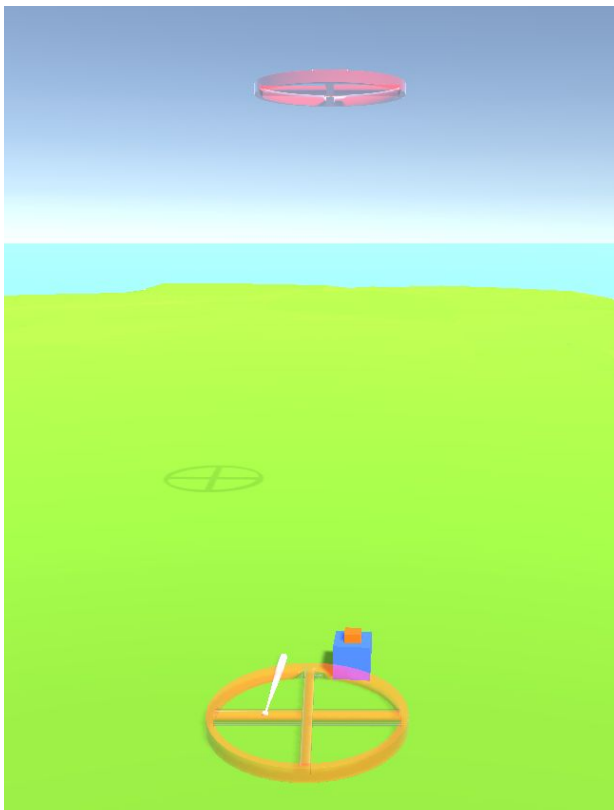
All of these interactions being brought together has really deepened my understanding of interactions in VR and VR in general. It gave me a better understanding of what works and what does not work in VR and why. I now have a greater appreciation for how interactions help make the user feel more immersed in the environment.

Overview

Philosophy

Philosophical point #1

This project was inspired by demos for an interaction toolkits and so is very similar to them but my project differs slightly by including mini games created from the interactions, showing off examples of how and where to use these interactions.

Philosophical point #2

This demo will only run on devices with 6 degrees of freedom as I saw that this was the best way to experience the demo.

Common Questions

What is the game?

The project is a fun environment full of VR interactions and mini games, made with Unity3D and Visual Studios. It is intended to be played using the HTC Vive VR headset. Each mini game is designed as a fun way to experience a single interaction.

Why create this game?

This project was created for me to understand more about VR and its interactions and for the user to experience interactions in VR and have fun whether it be their first time in VR or not.

What is the main focus?

The main focus is to have fun and play around with the objects and learn about the different interactions that can be had in a VR environment.

What's different?

The difference is I show users where or how these interactions can be used in other games or applications through mini games throughout the environment.

Define the Application

The application is supposed to be a demo of a select few of many interactions that can be had in VR. The user should be able to easily figure out how to interact with all objects and is shown how each interaction can be used, in the form of mini games.

What is the application supposed to do

Tracking controllers and HMD positions- The most important feature for obvious reasons, as the player won't be able to do anything without it.

Tracking controller button presses - Again similar to the first feature the user won't be able to do almost anything without it.

Locomotion - Users won't be able to move around the environment without locomotion.

Grabbing and releasing objects - This is the most important interaction as it is the basis of most other interactions, it is also a basic needed and expected interaction in VR.

Pushing buttons - Is a big interaction in VR and I wanted to implement a button myself.

UI - Some interactions have a UI version to be compared with, which the user can choose their preference.

Who is going to be using this application

Anyone interested in experiencing VR.

New users to VR.

VR gamers.

Developers looking for inspiration for interactions.

Metrics

If there are many interactions implemented and they all work in the way they were intended to work.

Is there a precedent for this application? (Your inspiration):

It is similar to demos of VR toolkits. I took inspiration from the VRTK and Newton VR toolkits demos. Both of these had all the interactions available in the toolkits spread out on tables for the user to play around with.

My project differs from these as it shows how the interactions can be implemented in a game format while also allowing the user to play around with the interactions for themselves.

Project Milestones

<u>**October 2019:**</u>

Started research and development on the Oculus Quest. Researched into physics in Unity and VR and found multiple toolkits called VRTK and Newton VR. Set up a simple scene using VRTK and ported it to my Oculus Quest for testing. I quickly realised that Unity's physics system isn't the best, so making a believable VR golf game would be difficult if not impossible. Project was then changed to an Interactions Demo, showing off some of the many interactions available in VR. I also changed from using the Oculus Quest to the HTC vive as the Quest is an android device meaning debugging code is practically impossible. Using the Vive now I set up a scene with a baseball bat and a ball using VRTK interactions. You can pick up the ball and hit it with the bat.

<u>**November 2019:**</u>

Early November I implemented the HMD and Controllers tracking and the ability to pick up and drop objects by pressing and releasing buttons on the controller. I spent a lot of time trying to implement throwing objects into the demo but by the end of the month decided to take a break and try again later on in the year as it was taking up too much of my time. I then moved on to some simple interactions like a dial that controlled the lighting, a door, a drawer and locomotion (moving around the environment).

<u>**January 2019:**</u>

By January I had the idea of creating an arcade-like demo where some of the interactions I create could be made into minigames for users to test and give feedback on their thoughts of how each interaction felt. I had done some testing and found some bugs with the way I was grabbing objects and decided I would change the way it was implemented to a more effective way. I also developed a rope that had a ball swinging from the end and a lever that moves on one axis. I fixed a lot of major bugs that I had found from previous testing. By the end of the month I was sick of looking at the boring way I had laid out all the objects in the scene so I found an asset pack and decided to make the scene look more pleasing.

<u>**February 2019:**</u>

By February I decided to add some UI into the demo. I created a canvas with a button that could be pressed if you pointed at the button with the controller and pressed the trigger button on the controller. I revisited the throwing mechanic again and felt I was so close to getting it right but it was just taking up too much of my time so I decided to leave it for now and maybe revisit it again in the future when I have time to spare. I decided to change the locomotion to teleporting to different way points throughout the scene instead of just moving around as it can cause motion sickness. I came up with an idea for my first minigame which I called the button game. It took the button I had made and turned it into a whack a mole type

game. I also made the same game but with the UI I made earlier. So I had 2 versions of the same game.

March 2019:

By March I had implemented 2 minigames. The button game and a maze game using the levers to move a block through a maze. I was then onto my third game which was going to be a tangram esque game, you will be given a picture, an outline of the picture and some blocks. The aim is to move the blocks into the outline so they fit and match the picture. I also had the idea of creating a similar game but the blocks would clip into place if they were in the correct slot.

April 2019:

By now the majority of my project was done. All major aspects of the game were implemented. This month was mainly finding and fixing bugs and final polish.

Project Review and Conclusions

I aim to review my project and discuss the development process, what went right and what went wrong, along with what I would have done differently, in this section.

One of the first road blocks I came upon was doing research for my initial project proposition in October. While researching I realised that Unity's physics system is not great so creating a realistic feeling mini golf game would be quite difficult. Because of this I decided to completely change my project to a study of interactions in VR.

During the first month of development I was using the Oculus Quest to develop on. I realised quickly that this was not the best option. The Oculus Quest is an android device and to test work on an android device with unity you have to build and port the project every time which took quite a long time. Another drawback of using an android device is its very hard to debug code so my project supervisor kindly offered me the HTC Vive which is a computer controlled device. This was a much better suit for me as i could now easily debug and test code without having to wait 10 minutes to build and port the project.

My project is based on interactions in VR so I found some VR toolkits that I could run in Unity and used these as inspiration for what interactions I could implement. These toolkits included VRTK and NewtonVR.

During Development in February, I had to abandon my plan to include a throwing mechanic as one of the interactions. This was not an easy decision as throwing is such an important if not one of the most important interactions in VR. However, I had already spent many hours trying different methods with zero result and there were other tasks that needed prioritisation. Although I didn't implement throwing into my project, it was a learning experience as I now have an understanding of how this is achieved and why I was unable to implement it.

Unity is the most accessible and easy to understand programs out there for developing in VR. Although it is easy to understand it is not easy to use or to find information on especially in

VR. Unity has a massive community with so many useful forums online and it is constantly being updated with new patches and versions. The problem with this is if you need to make sure that the information you find online is referring to the correct version of unity which can be difficult. VR however is a whole nother can of worms. If you search anything to do with VR in Unity you will either come across Steam VR or Oculus Integration. Both of these are very useful libraries for developing in VR. Both have a wide array of resources so that you don't have to code almost anything to do with the VR side of games, all you have to do is find the script and drag it onto your gameobject. But for me, I wanted to really understand what was going on behind the scenes so I decided I wanted to code most of the VR side from scratch which led me to Unity XR a plugin for VR/AR development. It's quite hard to find much of what I needed while using this as most people opt for the toolkits mentioned previously.

If I could have done things differently at the beginning, I would have decided what interactions I was going to implement sooner. It took me quite some time to decide on what interactions I would use. I would also spend more time trying out different implementations of the basic grabbing and releasing mechanic as I feel that was my downfall. I stuck to the first implementation I got working and it gave me some trouble later on. I had to fix the way I had implemented this mechanic and it took me some time to figure this out. Even still I see this as useful knowledge for me as I now know that the original implementation was inefficient.

Once the quarantine for Covid-19 set in, everything became much more difficult for development. It was quite hard to find the motivation to do work at home but once you get stuck in you don't feel the time pass. The biggest problem for me with working at home was the space. You need quite a lot of space for VR, which is something I lack in my bedroom. I had a very small area to move around in, maybe a metre wide and two and a half long. This became a huge problem as testing almost anything in my game ended up in me hitting the wall or bumping into my bed. I managed to get by but not without difficulty.

In conclusion, I have an overall sense of satisfaction looking back on the work I did for this project. I believe I achieved everything I set out to do. I created many different interactions and even created minigames centred around some of them Interactions. All of which are fun to play around with. This project also taught me the importance of interactions in vr for combating motion sickness and for the user to feel immersed.

However, I can't look back and not be disappointed with the exclusion of the throwing mechanic. It is definitely a much needed interaction as most people's first reaction to picking anything up in VR is to throw it. I spent a lot of time on this mechanic but in the end it wasn't worth spending more time on one feature when I had many more to do.

These decisions had the best interests of this project in mind, meaning sacrifices had to be made. I am very proud of the end product and all the decisions I have made in the process lead me to create a successful project.

References

[1] Virtual Reality Society (2017) History of Virtual Reality.
https://www.vrs.org.uk/virtual-reality/history.html

[2] Luke Dormehl (November 13, 2017) 8 Virtual Reality Milestones that took it from Sci-fi to Your Living Room. https://www.digitaltrends.com/cool-tech/history-of-virtual-reality/