<VR Puzzle Game>

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UXCFXK-30-3

Digital Systems Project



# Abstract

**Your Abstract**

# Acknowledgements

**Just want to give credit to friends and my supervisor who helped me develop ideas.**

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# Introduction

In this paper I will design and build a VR game that involves puzzles. More specifically the 8 queens puzzle, and other such chess related puzzles. The game will be created using a game engine, in this case unity, the language of choice is c#. The chosen platform is the quest 2 which uses a version of the android operating system. Both the headset and its operating system were developed by Meta formally known as Facebook. To add further complexity, I will develop a website a long side the game to display scores submitted by players. This paper will contain the research for said project, design information, testing and research.

# Literature Review

## Chapter introduction

This chapter of the report contains my research on VR technologies, web technologies and other such things that I will require to design and build my VR game

## Introduction to VR

There have been many representations of VR in the media, in the form of books and films.

### VR in past and present media

The first book, William Gibson’s Virtual light, in summary, is about a pair of glasses which allow a person to view information by feeding it into that person’s optic nerve (Gibson et al., 1993). Ready player one is a dystopian future in which people use virtual reality to escape the tough reality of life. The VR world they go to is called the oasis (Cline et al., 2011).

### The metaverse

The metaverse can be described as a 3-dimensional virtual universe (Dionisio, III, Gilbert, 2013). This however differs from the concept of cyberspace that represents all of a shared online and virtual space across all dimensions (Dionisio, III, Gilbert, 2013). There are multiple different versions of the metaverse, the first example is an enlarged virtual world, and another is a large network of virtual world (Dionisio, III, Gilbert, 2013). The second example is wanted can be seen in ready player one. The virtual universe is split into multiple virtual worlds (Cline et al., 2011) that players can explore interact with, they are able to travel to other worlds inside the universe.

All of these examples show how virtual reality has been represented over the years, however in reality, today the technology is much more primitive compared the previous given fictional examples.

To illustrate how VR works in reality, one could look to early examples of VR headsets and VR like devices that have previously been developed in the past.

## Early Virtual reality headsets and headmounted displays

### Sensorama

An early example of a VR headset was the Sensorama( [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true),  [D. Will](https://learning.oreilly.com/search/?query=author%3A%22Jeffrey%20D.%20Will%22&sort=relevance&highlight=true), 2009). This piece of literature describes early VR technology. “The Sensorama was the brainchild of cinematographer and inventor Morton Heilig” ”( [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true),  [D. Will](https://learning.oreilly.com/search/?query=author%3A%22Jeffrey%20D.%20Will%22&sort=relevance&highlight=true), 2009). As described by the writer of this literature the system “was lacking a major component of the modern virtual reality system: response based on user’s actions” ”( [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true),  [D. Will](https://learning.oreilly.com/search/?query=author%3A%22Jeffrey%20D.%20Will%22&sort=relevance&highlight=true), 2009). Early headsets were very basic, this simply means that the system did not allow a user’s actions to have any impact on the virtual world unlike modern day headsets that allow a user to interact with the virtual world using controllers or in some cases the users’ hands.

### Myron Krueger’s Videoplace

“Krueger’s artificial reality provided a second-person view of a virtual world in which participants could watch themselves within the world” ”( [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true),  [D. Will](https://learning.oreilly.com/search/?query=author%3A%22Jeffrey%20D.%20Will%22&sort=relevance&highlight=true), 2009). [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true) literature also talks about another early VR headset such as Myron Krueger’s Video place. This headset gave the user a “second-person point of view” of themselves. No games could be played on this headset and the user did not have any devices or other sensors attached to their body( [Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), [R. Sherman](https://learning.oreilly.com/search/?query=author%3A%22William%20R.%20Sherman%22&sort=relevance&highlight=true),  [D. Will](https://learning.oreilly.com/search/?query=author%3A%22Jeffrey%20D.%20Will%22&sort=relevance&highlight=true), 2009) unlike some modern-day VR headsets that use full body tracking that require sensors to be placed all over the user’s body including head, legs and arms depending on what degree of tracking you want.

## Key elements of VR in 2003

There are a few key elements of VR that have been identified in the past, this information will help with the creation of the puzzle game and help to mitigate any mistakes that could be made during design.

The paper written by Sherman details four key elements of virtual reality.

A virtual world is the context of a medium(Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003). In this case the case of this project this would refer to the game world. This will also tie into the writers next point regarding immersion. This is because the virtual world, if created correctly helps give a sense of immersion and improves the experience of the player.

It must have immersion, Immersion into a different reality or another point of view(Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003). It must have both Physical and mental immersion, this can be split into two, mental immersion can often be referred to as having a mental presence within the world (Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003) and physical immersion, a body entering into a medium (Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003). Both of these points apply today, If the VR experience will be greatly affected if immersion is broken, so during development I must pay extra attention to this as one of the major causes of braking immersion is frame drops whilst playing a VR game, therefore it is imperative that my code is optimised.

It must have Sensory feedback, “VR allows participants to select their vantage point by positioning their body and to affect events in the virtual world” (Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003). This refers to moving your arm for example in the VR worlds and have it match up with the real world. Technologies to make this more accurate already exist, with the rise of full body tracking for certain headsets. Sensors are placed on the body and tracked by the headset allowing for more accurate tracking of limbs creating the illusion of the player actually being in the virtual world.

The final key element according to the writer is, Interactivity. “For virtual reality to seem authentic, it should respond to user actions, namely, be interactive” (Sherman, [B.Craig](https://learning.oreilly.com/search/?query=author%3A%22Alan%20B.%20Craig%22&sort=relevance&highlight=true), 2003). In the case of current day VR this could be seen to be tied to the act of a user performing an action and getting a reaction. For example, a player pushes a box with there in game hand and the box moves back in response.

## VR Possibilities outside of gaming

### VR in Education

There are many applications for VR outside of gaming for entertainment, there also are applications for VR in the educational sector, for example in the research paper by (Holly, Pirker, Resch, Brettschuh, Gutl, 2021), it goes over how learning environments like Marroon (GameLabGraz), are environments designed to provide an interactive learning environment for students and allows student to perform experiments in a VR environment. The experiment that the researchers performed consisted of testing to test several factors for the game, Immersion, and engagement, learning value from both the teachers and learners’ respective perspectives (Holly, Pirker, Resch, Brettschuh, Gutl, 2021). In summary the response was positive in all areas of study, most students and teachers were happy with the level of immersion and engagement, and on average most students and teachers concluded that is had a high learning value (Holly, Pirker, Resch, Brettschuh, Gutl, 2021).

### VR in medicine

VR also has applications in medicine as out lined in this study by (Pourmand, Davis, Marchak, Whiteside, Sikka, 2018). The study delves into how VR can be used to distract patents from many types of pain, such as acute pain (Pourmand, Davis, Marchak, Whiteside, Sikka, 2018). It concluded that VR have become one important option for helping with pain management and how the evidence in said study shows how VR can be effective at distracting patients from many types of pain including actue and chronic short-term (Pourmand, Davis, Marchak, Whiteside, Sikka, 2018). The study references a paper that goes on to run some experiments on hospitalized patients, it was noted in the study that patents, had a significant drop in pain by around 24% in the VR group of patents compared to the 13% drop in pain in the control group (Tashjian, 2017).

## Game engines

The Wikipedia definition of a game engine is as follows, "A game engine is a software framework primarily designed for the development of video games, and generally includes relevant libraries and support programs. The "engine" terminology is like the term "software engine" used in the software industry."[Game engine 2021].

For further clarification this is what is defined as a game engine in Comparison between Famous Game Engines and Eminent Games journal article. Game engines are sets of tools that allow a programmer to, perform game related tasks like interpretation and physics related tasks and for focusing on the niceties that make the game great([Mishra](https://www.ijimai.org/journal/bibcite/contributor/5998), [Shrawankar](https://www.ijimai.org/journal/bibcite/contributor/5999), 2016).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ASSESSMENT OF ENGINES ON PERFORMANCE ASPECTS** | | | | | | |
| Game Engine | Platforms | Language Support | AI Engine | Physics Engine | Forward Compatibility | Backward Compatibility |
| CryEngine 3 | Win, X360, PS3, Wii U | C++, Visual Script, Lua | Lua-driven AI | Soft body | No | Yes |
| Hero Engine | Win | Hero Script | AIseek | PhysX | Partial | Yes |
| Source 2 Engine | Win, Mac, Xbox 360, Wii, Linux, Android | C++ | AI Director | Ipion | No | Partial |
| Unity 4 | BlackBerry, Win Phone, Win, OS X, Android, iOS, Apple TV, PS3/4, PS Vita, Xbox 360, Xbox One, Wii U, Wii | C#, JavaScript, Boo | RAIN | PhysX | Partial | yes |
| Unreal 4 Engine | Windows, OS X Linux, Xbox 360/ One, PS3/4, Wii U, Android, iOS, WinRT, PS Vita | C++, C#, GLSL, CG, HLSL | Kynapse | PhysX | Partial | Yes |
| Vision Engine 8 | Windows, Xbox 360, PS3, Wii, Wii U, iOS, Android, Win Phone, PS Vita | C++ | Kynapse | Bullet, ODE, PhysX | No | Partial |

Figure 1 ([Mishra](https://www.ijimai.org/journal/bibcite/contributor/5998), [Shrawankar](https://www.ijimai.org/journal/bibcite/contributor/5999), 2016).

As can be seen from figure one CryEngine, Hero Engine don’t support nearly as many platforms as the other four. Furthermore, Hero engine does not support any of the more popular programming languages like C++ or C#. In addition to this Hero Engine, Unity and unreal only have partial forward compatibility.

Unreal Engine has Blueprint Visual Scripting” (Chu, Zaman, 2021). It was created to support the workflow of designers and artist by giving them access to tools normally only accessible to programmers (Chu, Zaman, 2021). Blueprints is object oriented visual programming system which is used to create gameplay elements (Chu, Zaman, 2021). Other engines also have these capabilities, such as unity. A recent example of plugins that allow unity to obtain this functionality include, FlowCanvas, playmaker, Bolt and Amplify shader editor (Chu, Zaman, 2021).

## Tracking technology

### SLAMs

Slam stands for Simultaneous localization and mapping (MathWorks, no date) There are many applications for SLAM including, using it with autonomous vehicles to produce maps of environments and pinpoint a vehicle in that map all at the same time (MathWorks, no date). They can allow the vehicle to map environments and avoid obstacles and path find in that environment (MathWorks, no date).

There are many methods of slam, the first is Visual slam, this type of slam utilises images obtained from cameras and other sensors and there are two main types of this version of slam, Spare methods that match features of images at then utilise an algorithm like ORB-SLAM and dense methods that use algorithms like LSD-SLAM (MathWorks, no date).

The second method of SLAM is LiDAR SLAM this version of slam usually uses some form of distance sensor, for example a laser sensor (MathWorks, no date).

SLAM tracking technology is a tracking method utilized by the oculus quest and rift s (Hesch, Kozminski, Linde, 2019). On both these headsets it uses three major types of sensors to work out the VR headset’s location, room aspects like where the floor is and track controllers with reference to a 3d map of the space around it that is generated continuously (Hesch, Kozminski, Linde, 2019).). The 3 sensors include, IMUs that track the headsets orientation and position, cameras to generate a 3d map of the room, and infrared emitters mitigating the controller drift cause by having a lot of the IMU sensors (Hesch, Kozminski, Linde, 2019).

## APIS

APIs are powerful tools that can be used in this project, to break down what an API is, we must first learn what it stands for, its stands for application programming interface([Uzayr](https://learning.oreilly.com/search/?query=author%3A%22Sufyan%20bin%20Uzayr%22&sort=relevance&highlight=true), 2016). Is a way in which you can hide the component specification from the actual implementation or the user of said components (Souza, Redmiles, 2009). One reason for doing this is it separates the modules in to public and private modules the public one being the API and the private one being the implementation of said API, there for any changes made to the private module does not impact the public module (Souza, Redmiles, 2009). Using APIs allows a company to give a developer functionality without said developer needing to know how it works (Souza, Redmiles, 2009).

## Rest API

To give context, using rest is one way we could implement a way to transmit data between a virtual reality head set and a webserver, in this case it would be the transmission of score data etc.

To summarize a rest API is a type of application programming interface that conforms to a set of constraints (Kotstein, Justus, 2021). Rest apis have two aspects, the first is that they are a type of architectural style that can dictate how distributed hypermedia systems are built and used like the world wide web (Kotstein, Justus, 2021). Furthermore, this journal article goes into further detail for example the second aspect it gives is that rest is like a guide that formalizes how web components like urls and http for example should be used when creating new applications that utilize them.

## Web frameworks in python

### Django

Django is a collection of python modules designed for building web applications (Yudin et al., 2020). The Django framework can map URLS to methods, it can also render HTML webpages and it can handle cookies, session and also web security (Yudin et al., 2020). Django can also support things like relational databases using object-relational mapping (Yudin et al., 2020). It has a build in database solution, known as SQLite (Yudin et al., 2020). It also contains tools that allow easy authentication and authorization (Yudin et al., 2020). It is also widely used, namely these websites use it, YouTube, Spotify and also many others (Yudin et al., 2020).

### Flask

Flask is a small framework and is small enough to be called a micro framework (Grinberg eta al., 2018). Flash was designed to be extendable, and you can pick and choose what you need to avoid bloat (Grinberg eta al., 2018). Flash has a few dependencies, including the routing, debugging and web server gateway (Grinberg eta al., 2018). However, it does not have support for accessing databases, validating web forms or authenticating users (Grinberg eta al., 2018). This is an issue for this project as we require a database to store score data from the game, also a way to authenticate users.

Comparing Django’s and Flasks features, Django is the most logical option as it allows the use of an SQLite database and has user authentication and authorization features which is lacking in the Flask framework.

## WebSocket scripting

A WebSocket is a transfer control protocol for web applications. It provides connection in both ways meaning data can be sent too and from a server and client. However instead of connecting to a internet host and a port, it facilitates connections using URLS instead. To establish a connection between a server and client the protocol is changed from HTTP to WebSocket protocol. Once a connection is established messages can be sent back and forth between the client and the server (Lubbers, Albers, Salim,2011). This is one way in which information could be sent between the vr headset and a webserver that stores and displays score data in a database. However, in reality, the connection only needs to be in one direction as, no messages are going to be sent to the client from the server.

# Requirements

This section of the report will contain 40 requirements in total. 20 Functional and 20 non-functional. I will be using MosCoW to illustrate the Priority of each of the requirements.

Must – The system must have this, and this is the highest priority

Should – The system should have this, this is mid priority

Could – This system could have this, however it is not necessary

Would – This could be added in the future

## Functional Requirements:

|  |  |  |
| --- | --- | --- |
| Requirement No. | Priority | Requirement |
| FR1 | Must | The game must allow input from both controllers and hand tracking |
| FR2 | Must | Must have an algorithm or algorithms that can detect when a puzzle is solved when a button is pushed |
| FR3 | Must | The game must have two puzzles for the user to play, 8 Queens etc |
| FR4 | Must | The game must save past puzzle solutions onto the headset solved by the user |
| FR5 | Must | Push high scores to a website |
| FR6 | Should | Allow users to login to the website |
| FR7 | Should | Allow users to manage their leader board data, I.E delete, change their name etc |
| FR8 | Could | Store games save data on dedicated server and pull data when game is loaded |
| FR9 | Could | The game will provide a hit if a user does not make a move within a given time frame |
| FR10 | Would | Allow multiplayer – Allow users to join other user to solve the puzzles. |

## Non-functional Requirements:

|  |  |  |
| --- | --- | --- |
| Requirement No. | Priority | Requirement |
| N-FR1 | Must | The game must have a way to select between different puzzles in the form of a UI |
| N-FR2 | Must | Allow for the addition of new puzzles |
| N-FR3 | Must | Must run on the Oculus Quest 2 |
| N-FR4 | Must | Must be simple to maintain both quest 2 app and website |
| N-FR5 | Must | Be able to check a solution within 1 second |
| N-FR6 | Must | Multiple users must be able to use website at the same time |
| N-FR7 | Should | Be able to send data to the website from the headset and update it within 1 second |
| N-FR8 | Could | Use |
| N-FR9 | Could |  |
| N-FR10 | Would | The website would not be down for more than 5 minutes during a fault |

# Methodology

# Design

# Implementation

# Project Evaluation

# Further Work and Conclusions

# Glossary

# Table of Abbreviations

# References / Bibliography

Green = peer reviewed

Purple = books

Blue = trusted websites

Orange = unsure if peer reviewed

Red = Not peer reviewed

Yellow = Video games

**Temp Colour coding**

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# Appendix A: First Appendix