Assistive Technology in Gaming for Persons with Multiple Sclerosis

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Report submitted in partial fulfilment of the requirements for the BSc (Hons) in Computing Multimedia Systems/Web Engineering at the Institute of Art, Design and Technology (IADT).

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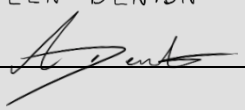
Signed 

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1 Abstract

This project aims to explore Assistive Technology in gaming, focusing specifically on persons diagnosed with and those with symptoms of Multiple Sclerosis. It explores different areas such as gaming hardware, applications and assistive elements in gameplay. This will be examined alongside symptoms that are most common in persons with Multiple Sclerosis. The research will then be put forward into a small video game. This will demonstrate several in which a video game can be made more adaptive.

2 Acknowledgements

Often, I find that words are not enough to express gratitude to people. I am someone who is more accustomed to offering something in return rather than expressing how thankful I am. So, it is with many trials and errors, undo's and redo's that I hope I can express my gratitude thoroughly here.

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1 Introduction

"All of us have a responsibility to adapt our world for the person with a disability rather than demand that that person adapts to us." (About Us | Enable Ireland, n.d.)

The objective of this study is to research the Assistive Technology (AT) in the gaming industry for people living with motor/mobility disabilities.

AT is created to aid people with disabilities partake in everyday tasks and activities that may otherwise be difficult (What is AT? - Assistive Technology Industry Association, 2021).

Game controllers and video games are directed primarily towards non-disabled customers. While there are a multitude of options available for disabled customers, including accessibility options or alternative controllers, this area of development still requires improvement (Mut, 2019).

2 Requirements Analysis

2.1 Existing applications

This section will discuss and examine existing applications that have implemented means that support users relying on AT. In doing so, we will examine in depth game components that may help or hinder assistive gaming.

We will look at a number of different games that have implemented AT solutions in the following areas:

- Customisable Controls
- Assistive in-game abilities
- Caution of bad practices
- Visual assistance
- Auditory assistance

These games were examined in an analytical perspective of assistance for mobility ailments. Since there is the issue of game price, some information will be referenced from DagerSytem (Peeples, 2013), a website engineered towards examination of accessibility and best practices in video games. These may include practices such as assistive gameplay mechanics and general level design. These practices may also correspond with the Game Accessibility Guidelines

2.1.1 Titanfall 2

The developers of Titanfall 2 (TF2), a first-person shooter, had a “core goal of making a game that is for everyone.” (Straub, 2016). The developers have been serious about their aim of inclusivity by enabling assistive gameplay in both an online multiplayer and single player campaign.

This game features a single player and multiplayer mode. The single player mode follows the story of a character named Jack Cooper. This campaign follows the main character and his ‘Titan’, a robot, who must band together to prevent a catastrophic event (Titanfall 2 (Video Game 2016) - IMDb, 2016).

The multiplayer mode features different games for online players. This includes modes such as ‘Capture the Flag’, ‘Skirmish’, ‘Free for All’ and a number of others (Alexandra, 2016).

While the game itself is regarded as “fast-paced”, it is also referred to as “the rare FPS game that purposefully gives all players, regardless of skill level, the opportunity to contribute in multiplayer matches” (Straub, 2016).

This game uses elements of controls and remapping. It introduces certain methods of overcoming challenging game mechanics. For example, instead of holding down a button to sprint while simultaneously pushing forward on an analogue stick, the creators developed an option to remap this to a single one-time button press.

TF2 also uses certain features of gameplay that could aid in multiplayer platforming. One example involves the game's 'Grapple Hook' mechanic. This ability allows for quick, yet simple movements across long distances. The aim of this mechanic is so that less time is spent overcoming obstacles across game levels. This ability is part of the 'Tactical Abilities' in-game. TF2 features other 'Tactical Abilities' that may cater for different playing styles. This includes general gameplay for fully non-disabled users, as well as adaptive gameplay for players with physical or cognitive impairments.

Another interesting adaptive feature in TF2 is the use of enemy outlines. This can allow players with impaired reaction timing to recognise opposing players at a quicker pace (Straub, 2016).

Figure 1 Grapple Hook in TF2

(Titanfall 2, 2016)

2.1.2 Dead by Daylight

Dead by Daylight (DBD) is a third person asymmetrical online multiplayer horror game (Game - Dead by Daylight, 2020). This game takes elements and characters from classic horror films and places them into a match-based horror/thriller game, which includes objectives, tactics and teamwork. One player plays as the 'Killer', which is selected from numerous classic horror movies, while 2-4 other players play as different 'Survivors'. The aim of the game is to escape the map, while completing objectives to open escape routes and sabotage the killer before they kill all survivors.

The game features certain aspects of accessibility that are missing in other popular titles. For example, DBD allows the user to play with either keyboard and mouse, or console controller. It also features remappable keys, which may be vital for users with motor impairments.

A lot of accessibility issues were discovered with gameplay. For context, the killer has the option to 'hook' a survivor. After a certain time of being 'hooked' the survivor must

'struggle' against the hook until another player can rescue them. This is done by continuously pressing a certain button, so-called 'button mashing'.

Figure 2 Struggle mechanic in DBD

This game mechanic is difficult for non-disabled individuals. For users with motor impairments this may be impossible to achieve. Unfortunately, there does not appear to be any option to relieve this feature for easier gameplay.

Another feature of gameplay is called 'skill checks'. This occurs when the survivor is in the process of completing an objective, such as fixing a generator or healing another player. The skill check will randomly initiate and give a short quick time event that, if failed, will result in the enemy knowing the player's position on the map for a brief time. This quick time event cannot be adjusted for accessibility.

Figure 3 Skill checks in DBD

This feature relies heavily on reaction time and button precision. As stated before, as a non-disabled individual, this was a challenge in itself to learn and could not necessarily be refined for someone living with motor or cognitive impairments.

A visual feature included in this game that could be assistive is the killer's 'Red Stain'. This is a bright red light that visualises which way the killer may be facing. This allows players to determine where the opposing player is. Essentially, it allows users to see a visual trigger to indicate danger.

This game also uses sound cues to indicate different events happening. This includes an auditory warning when the killer is close, or a sound triggering at the initiation of a 'skill check'. Auditory warnings are versions of AT that could aid in stimulating reaction timing for users.

2.2 User Profile

The user profile section will be used to discuss feasibility from a potential user's perspective. This will be used to discuss the views of people who have been diagnosed with MS. The user profile section will offer information that can be relayed towards the accompanying project. It will also allow for consideration on best practices for game design.

2.2.1 Interviews

"Multiple Sclerosis (MS) is a condition of the brain and spinal cord (central nervous system)" (About MS | MS Ireland, 2019).

In a brief interview conducted with someone living with MS, a number of issues were discussed. These issues ranged from impaired motor, emotional and cognitive skills that arise from living with this disease.

The interviewee stated that the most common physical symptoms they experience from MS was "heaviness in limbs" and "fatigue". According to the interviewee, fatigue is said to "affect almost everyone diagnosed with MS".

Other physical symptoms mentioned included "numbness", "muscle spasticity" and "tremors". The opinions of this interviewee reflect the documentation of the National Health Service's (NHS) MS symptoms list (NHS Choices, 2021).

When asked, the interviewee defined the ability to play games as "difficult, due to the controllers that are aimed only to be used by able-bodied people".

Regarding the ability to play video games, the interviewee stated that it was "not possible some days". They further explained that there were often issues with "physically holding the controller", and "using all of the buttons". According to the interviewee, this is due to the previously mentioned physical tremors and numbness.

The base issue brought up by the interviewee was that physical tasks, such as playing games, typing or writing are more difficult because the tools and interfaces are aimed primarily at non-disabled persons. Another main issue was that cognition is affected by MS, therefore hindering reaction times.

The interviewee expressed the concern of others being emotionally distraught by not being able to play certain games. According to the interviewee, there is a "level of social exclusion, like loneliness" in not being able to participate in activities with peers. The interviewee also stated that they felt as if "gaming could help with cognitive exercising, but it's hard with the common controllers".

2.2.2 Personas

Personas are fictitious characters created in order to define the needs of different potential users and how these needs may be met. There are three personas, each of which may require a product for different uses.

Astrid Bates, Senior Games Designer:

Astrid Bates is a non-disabled senior designer for a small indie games company in Dublin, Ireland. It is her job to direct the team of designers in the company, as well as participate in designing parts of the games.

In hopes of reaching a wider audience, Astrid was advised to make the game more user-friendly in design. In doing so she needs to research different methods of creating a more assistive atmosphere in-game.

Astrid is hoping to find good examples and demonstrations of user interfaces and design so that she can produce a more globally accessible game.

Mark Bennett, Streamer:

Mark Bennett is a video game streamer who has been recently diagnosed with MS. His symptoms have been making it harder for him to continue his game streaming due to chronic pain and heaviness in limbs.

He has been searching for assistive technologies to help him learn how to make his job easier, but is reluctant to make any purchases due to his limited income from his streams.

Mark is hoping to find a game that can allow him to customise a broader range of settings so that he can stream for longer and make enough money to buy a controller.

Jean Brady:

Jean Brady is a forty-five year old woman who was diagnosed with MS when she was twenty-five. She has been attending rehabilitation after an MS relapse. Her rehabilitation worker is using serious games in their sessions.

Jean is looking for a way to make her rehabilitation something she can practice at home. She has been advised by her rehabilitation worker to try gaming as a common practice, but she is unsure where to start.

Jean needs to find a game that can be adaptive enough for her to change settings, while still offering her enough room to practice her cognitive skills.

2.3 Requirement Modelling

Requirement modelling is used to outline the necessary components to be implemented in the research project. These are divided between functional and non-functional requirements.

2.3.1 Functional Requirements

Functional requirements define the functionality within the research application. This is used so that a user may initiate an event and in turn, obtain an output. For example, a user may press a button, which could make a character jump.

i. Health system
ii. Remappable controls
iii. Ability to pause game
iv. Environmental triggers
v. Scene Management
vi. Animations

2.3.2 Non-Functional Requirements

Non-functional requirements define the performance and aesthetics of the research project. These are functions that do not return an output. This is used to outline the aesthetics and performance of the application.

i. Clear and readable user interface
ii. Straightforward level structure
iii. Understandable storyline
iv. Suitable sound cues and design

2.3.3 Use Cases and Use Case Diagram

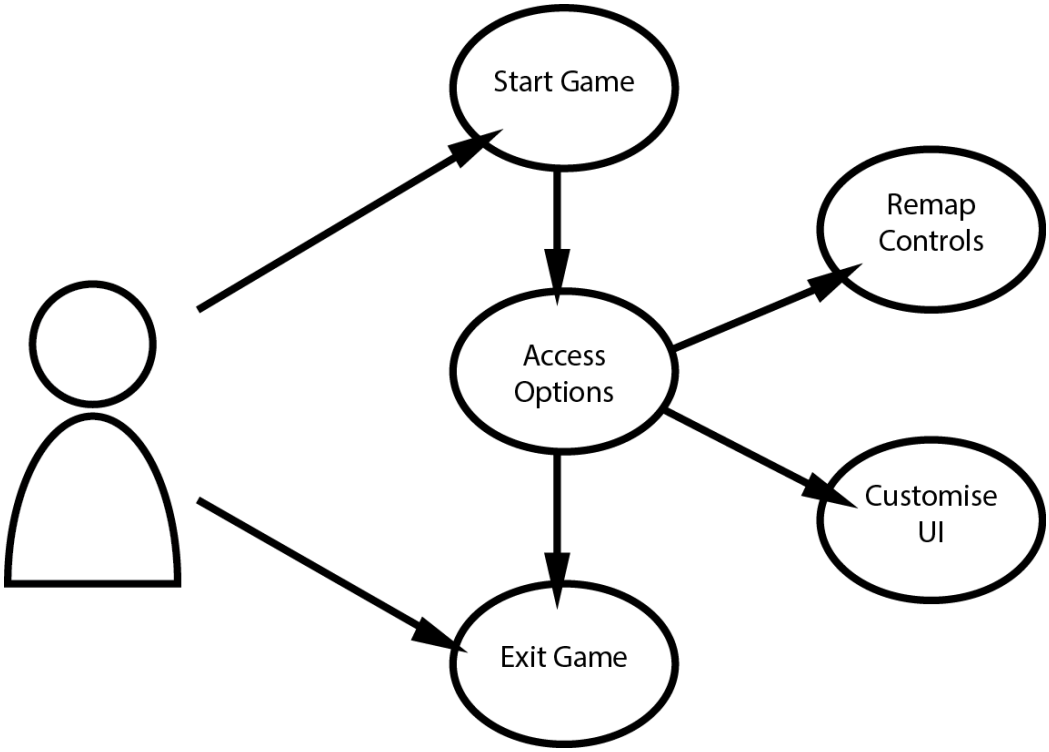

Figure 4 Use case diagram

3 Feasibility Study

3.1 Intro

The feasibility study is used to outline a plan for the project. It will also be used to assess potential risks due to the Covid-19 pandemic, as well as risks of data loss. In doing so, security measures and safety precautions will be taken into consideration.

3.2 Feasibility

There are several risks and obstacles that could potentially hinder progression during this study.

A huge risk that would concern of health and safety would come with user testing of the project. Due to the global pandemic of Covid-19 and the current national lockdown actual in-person testing is unlikely to take place. This could be made complicated more so by the risk of users with hindered immune systems being more susceptible to the virus.

Testing may have to take place in either an extremely secure environment in which every component of testing is thoroughly sanitized between tests.

Another method could be to host online testing; however, this may bring complications with internet connections and bandwidth. This could also potentially affect time management, which could reduce the overall tests ran and lead to inaccurate results.

Regarding the project work and research, consistent backing up and saving is extremely important. The work should be backed up each time there is a change to documentation or application work. This can be done using an online cloud storage device, such as Google Drive or OneDrive.

Regarding the application, version control should be considered. This can be overcome using GitHub. Using GitHub will ensure that if there are irreversible errors or mistakes, a previously saved version of the project that is fully functioning can be obtained.

A general sense of risks with this study and, something that should definitely be considered is using the correct terminology. As a non-disabled individual discussing a subject of disability, respect is an extremely important component. There will be study in areas of terminology and etiquette so as to not offend potential users and readers of the completed study. This will also be used towards appreciating the user's circumstances and not simply assuming causes or symptoms.

3.3 Test Plan

The testing of this project will be pending due to the current Covid-19 crisis. There are several options to tackle this, both of which have positive attributes and negative attributes.

One option is to hold testing in a secluded room with accessible entryways and health and safety measures applied. This includes clean stations and hardware. This project could challenge the risk of Covid-19 by testing with potentially susceptible disabled users. With that concerned, other health and safety measures must be taken, such as social distancing, equipping masks and providing sanitizer for each user.

This option, while it could possibly prove the easiest, would also hold a lot of risks that should be assessed and managed, as well as user traveling capabilities under the circumstances. Due to the pandemic, this option is not likely to happen.

The other option is to host online testing. While this would require less travel and safety measures, communication may be hindered due to internet setups, as well as hardware setups. Each test would need to be performed using the same types of controllers and feedback may be difficult to gather. This could also potentially take longer in certain aspects of setup and completion, and could hinder the results of the tests by not being able to test enough individuals.

4 Research

4.1 Introduction

This section will be used to compile information regarding accessibility in video gaming for persons with MS. Emphasis will be placed on discussing assistive technologies, MS, serious games and rehabilitation. This will include specifics on combating symptoms, as well as potential accessibility and good practices for creating games around these issues.

4.2 Assistive Technology

AT is what defines a piece of hardware, software or equipment that helps users in everyday challenges. This technology is used in a wide variety of methods from basic to complex. Primarily, AT can be utilized in order to aid people with physical, cognitive, sensory or psychosocial disabilities. These forms of AT can range from “simple adaptive tools” such as wheelchairs, to “high-tech” tools, such as text-to-speech (TTS) software, assistive controllers and prosthetic limbs (The Understood Team, 2019).

AT is used in order to offer a way for people with disabilities to compensate for bodily impairments. It can also benefit in providing independence for people who may require a lot of aid (*How does rehabilitative technology benefit people with disabilities?*, 2018).

4.2.1 Examples of Assistive Technology

AT is considered an umbrella term that encompasses a wide range of technologies. These technologies are used for a huge variety of physical and cognitive hindrances. As stated previously, AT coincides with anything from simple assistive tools to high-tech assistive tools. These technologies can also be used in forms of hardware, software and everyday devices.

Examples of lesser-technologically complex devices can include wheelchairs, canes, crutches, pen grips, seat cushions and long handled grabbers. Primarily, a lot of these tools are directed towards those with limb/joint disabilities and elderly people.

While not necessarily technologically complex, each of these tools allow for people to build and maintain an independent lifestyle. They can also aid in sensory development and physical rehabilitation (World Health Organization: WHO, 2018).

High-tech ATs offer a more direct way of challenging a disability through software or hardware. These technologies and tools involve a more complex development and outcome than simple AT devices, but ultimately benefit users in similar ways.

Examples of high-tech devices include text-to-speech software, hearing aids, electric wheelchairs, keyboard or controller alternatives, word prediction programs or mouse alternatives (*Assistive Technology: Types of High-Tech Assistive Technology*, 2020).

4.3 Multiple Sclerosis

MS is an illness that compromises the immune and nervous system of a person's body. In MS, the immune system attacks the central nervous system of the host by targeting the protective layer, known as myelin, that covers nerve fibres. This in turn can cause deterioration of nerves or potentially permanent damage which can lead to immobility and hindered cognition.

This illness can be potentially disabling and has a wide variety of possible symptoms. Due to this, symptoms can continue to develop over time and cause progressive deterioration, while for others they can come and go. Symptoms can vary from body parts to cognitive abilities. This illness also has no cure, but can be treated with appropriate medication to hasten recovery after relapses and manage symptoms (*Multiple sclerosis - Symptoms and causes*, 2020).

4.3.1 MS Symptoms

MS has the potential to effect cognition and physical capabilities unpredictably. Due to this, people with MS often need to depend on Assistive Technologies and other people for support and may find difficulties in tackling everyday tasks. Because of these symptoms, people with MS have potential interference with employment, social functioning, emotions and overall quality of life (Can Do Multiple Sclerosis, 2017).

The most common form of MS is called relapse-remitting MS. A relapse in MS occurs when symptoms flare up due to inflammation or when damage occurs in the brain or spinal cord. This in turn can disrupt nerve signals and can vary in length, severity and symptoms (WebMD, 2020).

4.3.2 Cognitive Symptoms

MS effects the central nervous system in the body, which in turn effects the brain and spinal cord. Due to this, MS can disrupt communication between the brain and body, thus leading to cognitive capabilities being compromised. These symptoms are progressive and have the potential to worsen as the person ages. They can affect processing speed, reaction timing, memory, concentration, verbal fluency, visual perception and executive functions (Cognitive Changes, 2015).

According to psychologist Abbey Hughes, as of 2017 the most common form of cognitive difficulty for people with MS is processing speed. This defines reaction timing and capability to process information that effect general senses (Can Do Multiple Sclerosis, 2017).

4.3.3 Physical Symptoms

Physical obstructions in MS can affect people differently. There is a large number of symptoms that effect the body outside of cognitive issues. The most common symptoms include fatigue, muscle spasms and stiffness, motor control, chronic pain, weakness and numbness or tingling (NHS Choices, 2020).

These symptoms have the potential to interrupt an independent lifestyle and can lead to loss of balance, dropping items and unpredictable exhaustion. Due to this, every day activities, such as hobbies and everyday needs.

4.3.4 Psychosocial Symptoms

Psychosocial symptoms define the influences of social and environmental factors on one's mental health (Vizzotto et al., 2013).

In MS, this subject is broad and covers the areas of depression and anxiety. Psychosocial issues can be induced by cognitive and physical symptoms gradually increasing and interrupting everyday life. While it is a complex subject in MS, psychosocial factors may have great potential to influence the development of the disease (Liu et al., 2009).

According to Meghan L. Beier, "depression can occur in up to 50 percent of MS patients and is three times more common than in the general population". As well as this, it is stated that "anxiety disorders are three times more common in MS than in the general population" also (*Multiple Sclerosis and Mental Health: 3 Common Challenges*, 2020).

4.3.5 Serious Gaming applications for MS

According to multiple sources, it is stated that video gaming for people with MS leads to pain relief and improved physical and psychosocial skills. As of 2017, there had been a variety of clinical studies promoting the benefits of gaming for people with central nervous system diseases. This included benefits for depression, balance, weight shifting, cognitive skills and symptom relief (Craven, 2017).

In a study conducted in 2013, it was concluded that video games have great potential to improve health concerns, "particularly in the areas of psychological therapy and physical therapy" (Primack et al., 2012).

Video games have also been reported to have aided people with MS via blogs and forum posts online. One user stated that "even simply as a distraction, gaming has been very beneficial, particularly for pain" (devingarlit, 2018).

4.4 Rehabilitation

Rehabilitation is the practise of improving physical, mental or cognitive abilities required for daily life and functionality. The primary cause of requiring rehabilitation is due to losing capabilities to an injury or illness.

The aims of rehabilitation are to allow people to regain abilities and independence. This procedure has a vast amount of treatment plans depending on the needs of the patient. Treatments can include assistive devices, physio, cognitive, recreational, occupational and pain therapy (*Rehabilitation*, 2020).

4.4.1 Rehabilitation with MS

In MS, due to the primary symptoms being so varied and unpredictable, there is a large amount of potentially required rehabilitation treatments. It is a common practise to use rehabilitation treatments for MS relapses, as well as after diagnosis to understand one's physical limitations (*MS Rehabilitation*, 2019).

Rehabilitation in MS is also focused on symptom management and reducing impact of symptoms on quality of life. This is used in occupational and cognitive rehabilitative treatments (Johns Hopkins Medicine, 2017).

4.4.2 Exergaming Rehabilitation

Exergaming defines the integration of physical exercise and video gaming.

In a study conducted regarding the feasibility of exergaming as a rehabilitative tool, it was concluded that in the opinion of a group of physiotherapists, one of the most valued usages of this treatment could be for people with MS. This was also evident with Parkinson's disease, stroke, traumatic brain injury and chronic obstructive pulmonary disease patients. In this study there was a direct correlation with using exergames to treat patients for balancing and weight shifting issues. This study also used pre-existing controllers for various gaming consoles, such as the Wii-Fit Balance Board and the Xbox Kinect (Tobaigy et al., 2018).

4.5 Serious Gaming

Serious games are games that are designed for an alternative purpose other than entertainment. A variety of video games are developed using elements of educational, healthcare and training purposes (*What are serious games? - Grendel Games*, 2019).

4.5.1 Serious Games in Rehabilitation

Serious games, as stated previously, are designed for specific outcomes. In certain cases, these games are developed for rehabilitation in motor control and cognitive skills. According to a study in 2010, the traditional treatment of serious games in rehabilitation offers a "potential for therapeutic benefit" (P.A. Rego et al., 2010). The use of virtual reality (VR) in rehabilitation has allegedly grown in popularity, the target audience of which has been stroke victims or patients enduring central nervous system diseases. This form of rehabilitation offers an immersive and motivational experience for patients.

This study also examined the main criteria in order to make serious games more effective. Components included application area, interactive technology, user interfaces, number of players, genre, adaptability, performance feedback, portability and progress monitoring. Each of these components reportedly have excellent potential to improve motivation for rehabilitative purposes.

It was concluded within this study that existing video games could be adjusted in order to satisfy the effectiveness of games using the criteria. Thus, these video games could potentially become more functional as tools for rehabilitation (P.A. Rego et al., 2010).

In relation to MS specifically, a study was conducted regarding the use of serious games for arm rehabilitation. The objective of this study was to conclude the feasibility of serious games compared to exergames using the Wii console. This was done in specific relation to arm rehabilitation in persons with MS.

The conclusion of this study showed that VR in a serious gaming approach "was feasible and beneficial to arm function of persons with MS". The results illustrated a significant clinical improvement in arm functionality. Aside from this, it was also determined that motivational aspects of serious gaming may require further attention for rehabilitation (Jonsdottir et al., 2018).

One example of a serious game is "RehaCom". This game was "shaped by neuropsychologists and therapists to lead the way in cognitive therapy" (RehaCom - Cognitive Rehabilitation Software, 2018). The RehaCom game consists of 29 computerized therapy modules, each with the objective of improving cognitive functions. It is used primarily for people enduring cognitive functional disorders, such as stroke, MS, schizophrenia and so forth. This game also adapts to the capabilities of the user's performance. Due to this, the game is designed to improve cognitive functions from a variety of different capabilities.

4.6 Assistive Controller Hardware

As discussed previously, assistive technologies aid in allowing independent lifestyles for those with disabilities. This subject area breaches into the focus of gaming also. Gaming has been studied in a variety of different ways in order to aid in rehabilitative needs and symptom management. This follows the usage of serious games, different gaming genres and motivation. While it appears feasible for gaming to be used for clinical reasons, there are also developments being made to allow persons with disabilities to enjoy gaming for entertainment purposes.

Video gaming has continuously developed to more complex solutions. This involves controllers with more buttons, touch-pads, functions and analogue sticks. As the generations of gaming consoles progress, controllers continue to fit more components of gameplay onto small handheld devices. The same theory applies to the actual game itself. There are more requirements to playing newly released games due to control schemes and lack of adaptability in gameplay (Benj Edwards, 2019).

In order to challenge these obstacles, a variety of companies and projects have developed more accessible means of gaming with disabilities. This was done by designing and developing assistive gaming controllers. These target a large variety of issues, such as sensory problems, immobility, central nervous system diseases and cognitive impairments (Benj Edwards, 2019).

Specific companies and charities that develop and aid in these gaming technologies include Microsoft, The Able Gamers Charity and Evil Controllers.

4.6.1 Microsoft – Xbox Adaptive Controller

Microsoft is a large scaled company that released the globally popular console series, the Xbox. In doing so, Microsoft have released an abundance of video games under its own subsidiary companies.

In an effort to challenge the subject of assistive gaming, Microsoft developed and released the Xbox Adaptive Controller (XbAC). This controller was primarily aimed towards people with limited mobility issues, and also was developed through the feedback of disabled gaming communities (Darryn Bonthuys, 2020).

This controller adopted a broad accessibility in regards to customisation and accessibility. In doing so, the XbAC makes use of external switches, buttons, mounts and joysticks in order to give the player a custom and suitable control scheme. The XbAC acts as a hub for controls, in which each new component (i.e., switch, button, etc.) can simply be plugged in and mounted in a variety of different ways. Each component can then be mapped using the Xbox Accessories App, to specific pre-developed buttons for Xbox (*Xbox Adaptive Controller | Xbox*, 2020).

A key concept of this controller is that it has allowed for more types of buttons, switches and joysticks to be developed from third-party sources. For example, Logitech, a company

that specializes in computer accessories, developed their own Adaptive Gaming Kit as a way to make accessible gaming cheaper. Logitech's gaming kit includes buttons and triggers that are compatible with the XbAC (Porter, 2019).

4.6.2 The Able Gamers Charity

The Able Gamers Charity (AGC) provide aid through preparing gaming setups suitable for a wide range of disabilities. In doing so, this charity works with a multitude of adaptive controllers. The objective of this charity is to "combat social isolation, foster inclusive communities, and improve the quality of life" (*Our Services | The AbleGamers Charity*, 2016).

AGC also works with game developers and designer to bring more accessible qualities to video games. In doing so, they have developed resources in which developers and people with disabilities can share input and resources that will aid in this endeavour (*Accessible.Games - Home of APX*, 2016).

This has also allowed AGC to develop a certified course, known as the Certified APX Practitioner Course, directed towards identifying and applying gaming accessibility to video games (*Certified APX Practitioner Course*, 2019).

4.6.3 Evil Controllers

Evil Controllers (EC) is a company that develops customised controllers for Xbox and PlayStation consoles. In doing so, they offer a wide range of customisation options from appearance to functionality. EC have also began creating customised controllers for individuals with specific disabilities.

EC have worked alongside AGC in order to develop custom controllers for disabled gamers. This includes providing external accessories for controllers that can be manoeuvred to fit the comfort of the player (*Accessible Gaming for Modded Controller and Custom Controller | Evil Controllers*, 2018).

4.7 Assistance in Gameplay

Designing games with disabilities in mind takes a lot of consideration, however it is entirely achievable. According to Mark Brown, the host of the Game Maker's Toolkit YouTube channel; "gaming is for everyone". In stating this, Brown remarks the accessibility in video games and gives a conclusive talk on how games can be designed for users with cognitive and physical impairments. In doing so, guidelines and best practices are demonstrated (Game Maker's Toolkit, 2019).

According to the Game Accessibility Guidelines, as of 2020, 15% of the population are disabled in some way. There are also barriers to be considered for temporary physical, cognitive or situational impairments.

These guidelines illustrate a huge list of best practises towards designing and developing for disabilities. The list is also divided into clear and concise sections, from basic, to advanced, for each type of disability.

In terms of motor disabilities, emphasis is primarily placed on the customisation of gameplay speed and control schemes. This includes changeable controls (key-mapping), adjustable interface elements, support for more than one input device, avoiding repeated inputs (button-mashing/quick time events) and alternative progression essentials. There is a huge amount of other important points to consider in this list.

The Game Accessibility Guidelines also combat cognitive disabilities. These disabilities can include issues with thoughts, memories and information processing. Emphasis is primarily placed on creating a game with tutorials, easy-to-access menus/gameplay, clear and concise language, use of visuals, highlighting important user interface elements, clear narratives and avoiding quick time events. Again, this is simply some of the items on this list (*Game accessibility guidelines | Full list*, 2020).

4.8 Conclusion

From the research conducted, creating games for persons with MS appears entirely possible. Strong evidence suggests that gaming for those with MS could prove beneficial for rehabilitative needs and could be further possible with regards to the Game Accessibility Guidelines. There is also a wide range of resources in regards to assistive controllers, as well as cheaper options in some forms of controller assets.

I believe I have developed a deeper understanding from each chapter of this study that can be put towards my project. This study has given me a far greater insight on how MS effects people, and ideas that may aid in symptom relief. I have learnt a lot on the adaptable possibilities for gaming, and plan to use certain resources, such as the Game Accessibility Guidelines for my own project development. I also plan to consider the rehabilitative aspects of serious games, and how to use the information compiled to create a project to demonstrate how games could be made more accessible.

5 Design

5.1 Introduction

The application for this project is a short video game that will demonstrate adaptive gameplay for persons with MS. This application will be developed using Unity 2019 for scene management and Visual Studio for scripting in C#.

This chapter will show the development in design both technically and aesthetically for the project. It will outline reasons for chosen technologies as well as assets obtained and to be used further into development.

The application is a short video game called “M.A.R.S (Mobile Assistive Robot Server)”. It will be based on a space ship, in which the player must navigate through corridors and vents to reach an escape pod while the ship is in danger. The player will control a small robot called “Mars”. In doing so, the player will be able to interact with objects and slow down time to avoid danger while escaping the ship.

The game will include two identical levels, each with different control schemes and user interfaces. The central objective of this project is to demonstrate the differences between assistive and non-assistive gameplay for users, while obtaining project management and developing skills.

5.2 Technologies

The technologies being used to create this application are:

- Unity 2019.4.16f1
- Visual Studio with C#
- GitHub

5.2.1 Unity 2019.4.16f1

Unity 2019 was chosen as a means of developing personal skills using this application. While this application is somewhat familiar in terms of previous project work, it was chosen as a way to develop skills further for future projects. This application also offers a broad variety of available assets for game development at low or no cost as well as easy-to-access documentation.

5.2.2 Visual Studio with C#

Visual Studio was chosen due to its direct integration with the Unity game engine. It uses integration with Unity in order to offer a fast way for game developers to script. This application will be scripted using C#.

C# is a commonly used programming language for game developers and integrates with Unity's own programming rules. This language was chosen in order to develop personal programming skills further.

5.2.3 GitHub

GitHub will be used for version control. It offers a fast and convenient method of saving versions of application development into a GitHub repository. This allows for developers to maintain a safe structure of work in order to correct critical errors and allow for easier problem solving.

5.2.4 Other Possible Technologies

Other technologies that could have been used include applications such as Unreal Engine or the JavaScript or C++ programming languages.

5.2.5 Alternative Development Engine

Unreal Engine is another game development tool that is popular amongst developers. This game engine offers the same development tools for game developers as Unity Engine. Both engines offer substantial capabilities in terms of development and project management.

Unity was selected over Unreal due to the further variety of available assets. Unreal has a very limited amount of assets available for use at a low cost, which could potentially affect time management and finances in development.

5.2.6 Alternative Programming Languages

Regarding programming languages, there were multiple options to choose from. Aside from the C# language, C++ and JavaScript are alternative programming languages for game development. C++ is the primarily used language for Unreal Engine, while JavaScript can be used with the Unity Engine.

Due to it being the primary language for Unity Engine, C# was chosen over the alternative languages. As well as this, it is an excellent opportunity to develop personal programming skills using this language for further professional use.

5.3 Structure of Unity

The Unity Engine uses a component-driven structure. Each part of the application is implemented through components of Game Objects in Unity. All of Game Objects are stored within a primary Assets folder.

Each Unity Game Object can be placed within a Scene via Unity's "Hierarchy". These Scenes indicate different game states, such as a Start Menu, Options Menu, Playable Level or a Game Over Screen.

The Unity Game Objects hold components which can be manipulated to specific requirements. This includes manipulation of physics, rendering and transformations.

Scripts are also added as components to objects. It allows developers to program instructions or behaviours to specific Game Objects. Once a script is applied to a Game Object as a component, the developer can program behaviours which will be initialised when the game is in "Play Mode".

Scripts for specific Game Objects will only run if the object is present in open game states. For example; the Player will not move unless the user has entered the first level state. From here, the user has full control over the Player's movement.

5.4 Application Architecture

The application architecture will define the framework of the application used to develop a project. In this case, Unity 2019.4.16f1 uses a component driven architecture.

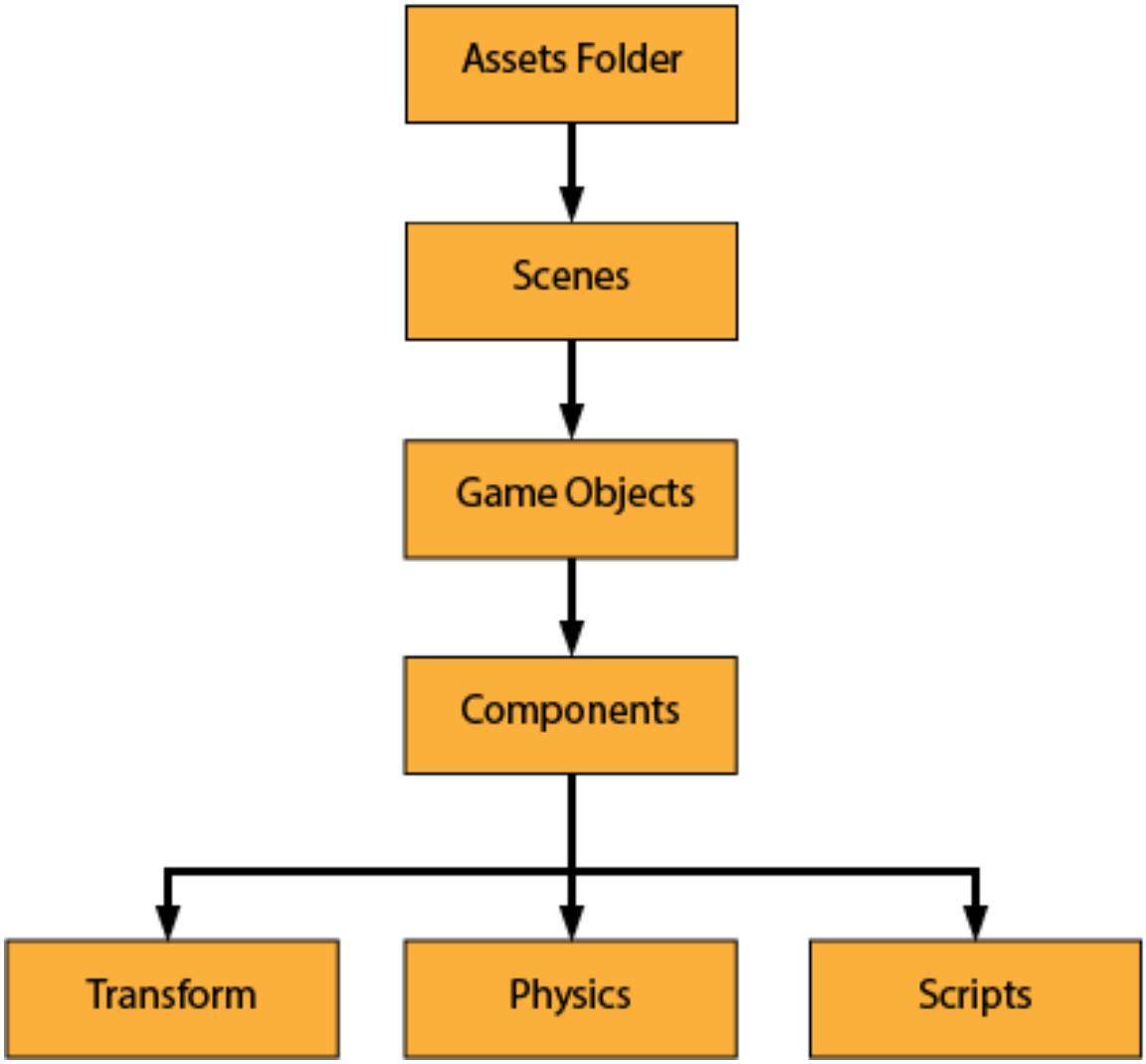

Figure 5 Component driven application architecture of Unity

5.5 User interface design

The user interface design defines user interface elements that may be navigated and managed by the user. In this project, the user may change from scene to scene by meeting certain requirements, for example; if a user presses a button, the scene will change.

5.6 User Flow Diagram

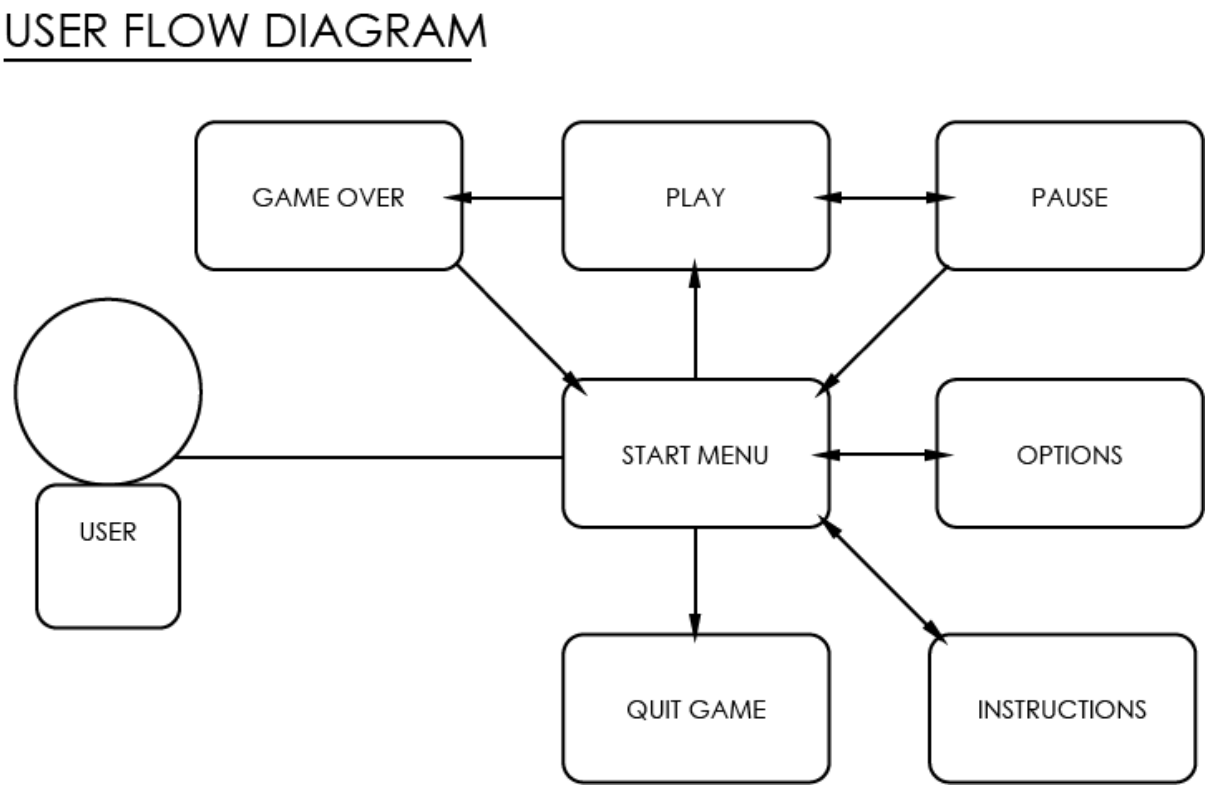

Figure 6 Use Flow Diagram

In the application, there will be only one type of user; the player. The play should be able to navigate from the Start Menu, to Options, Instructions, the game's level, or to quit the game.

Once the player is in the game's playable level, they should have the ability to pause the game and proceed back to the Start Menu. They should also be able to go back to the Start Menu if the player has been defeated.

5.7 Storyboard

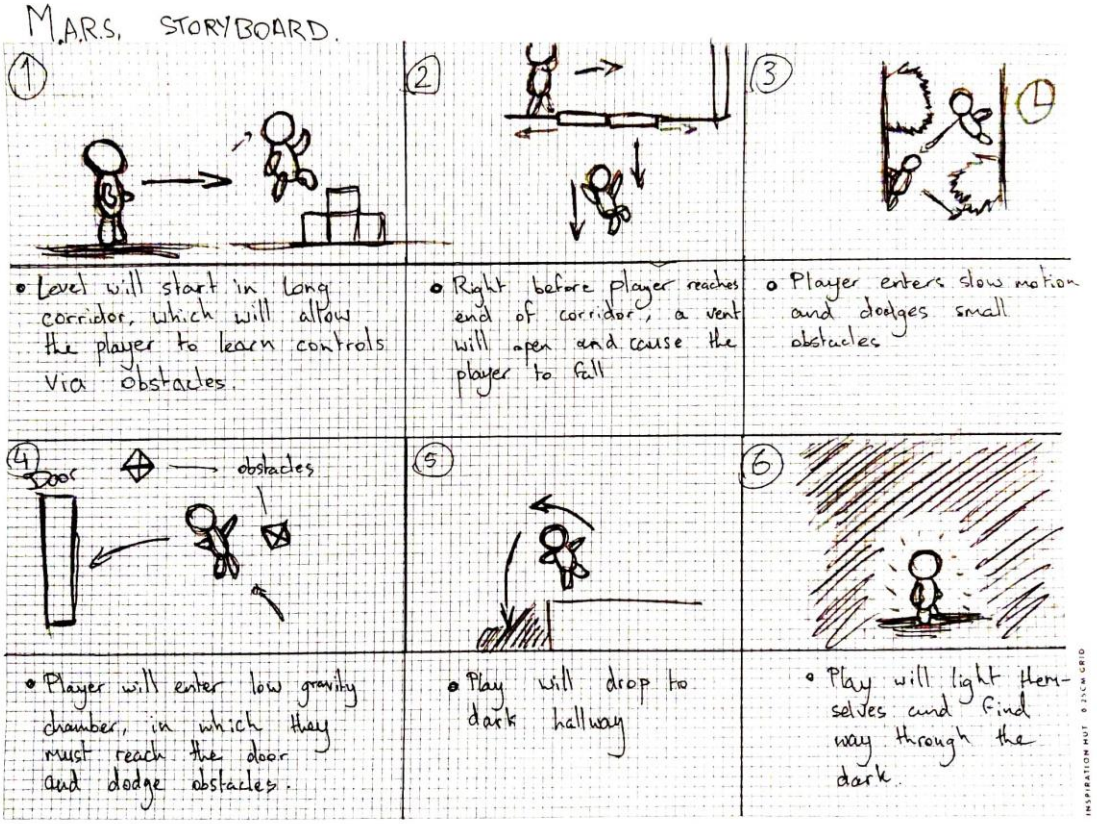

Figure 7 Storyboard Page 1

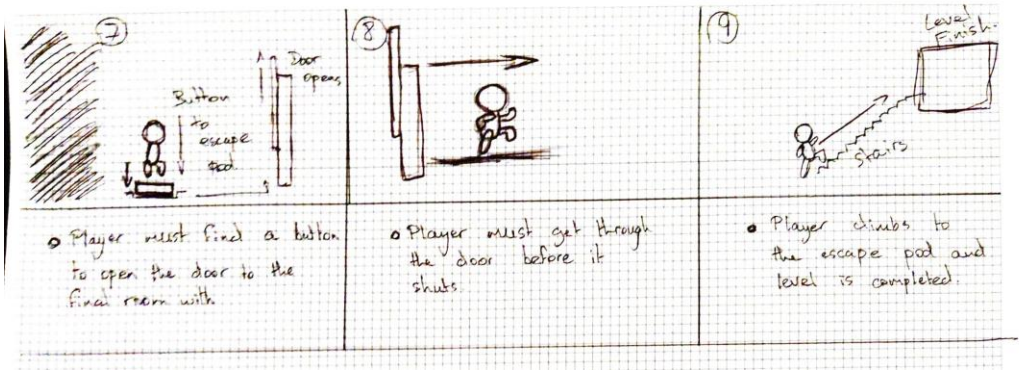

Figure 8 Storyboard Page 2

5.8 Level Design

The level design is a concept the structure of the game environment. This was drawn up manually simply using paper and pencil. The level corresponds with the storyboard directly.

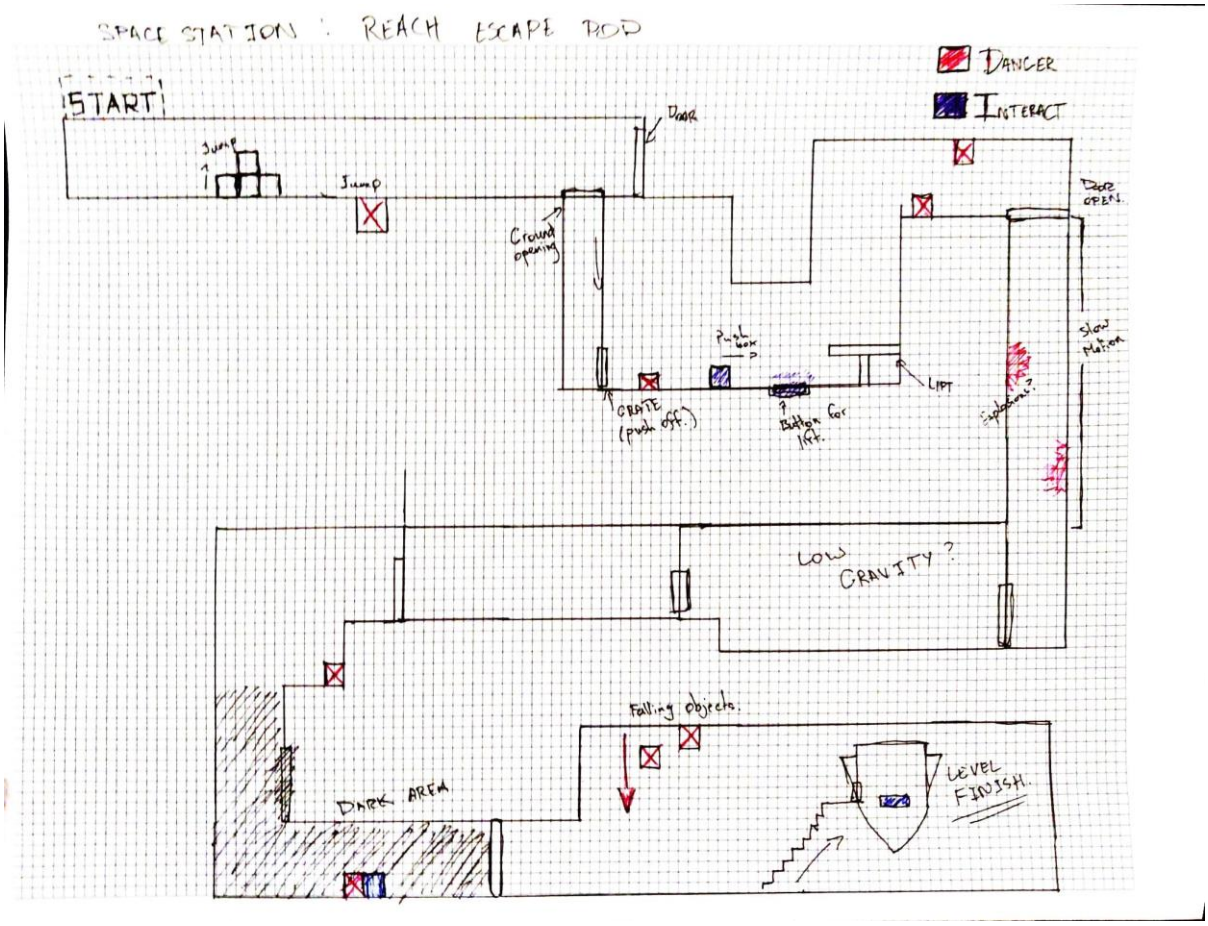

Figure 9 Level design sketch

5.9 Environment

The environment of this project's design was based on research on available resources in Unity's Asset Store. While the asset store is primarily for obtaining assets for game development, it has proved an ideal source of inspiration for the game's story and level environment.

There is an abundance of low costing or free environmental assets available for use in the store. Because of this, the environment design was made easier by narrowing down assets that could be used for the project.

The project was decided to be a 3-Dimensional side-scrolling game, inspired by other titles such as 'Little Big Planet' and 'Little Nightmares'.

Multiple assets from the asset store allowed for the game's theme to be decided, while also adhering to the requirements for a 3D side-scroller. The main environment pack to be used

is the “Sci-Fi Styled Modular Pack”, created by user “karboosx” (*Sci-Fi Styled Modular Pack*, 2018).

This pack offers categorised assets based on the inner environment of a spaceship. It also offers lighting, broken down assets to basic components and animations. The pack is also listed as free on the asset store.

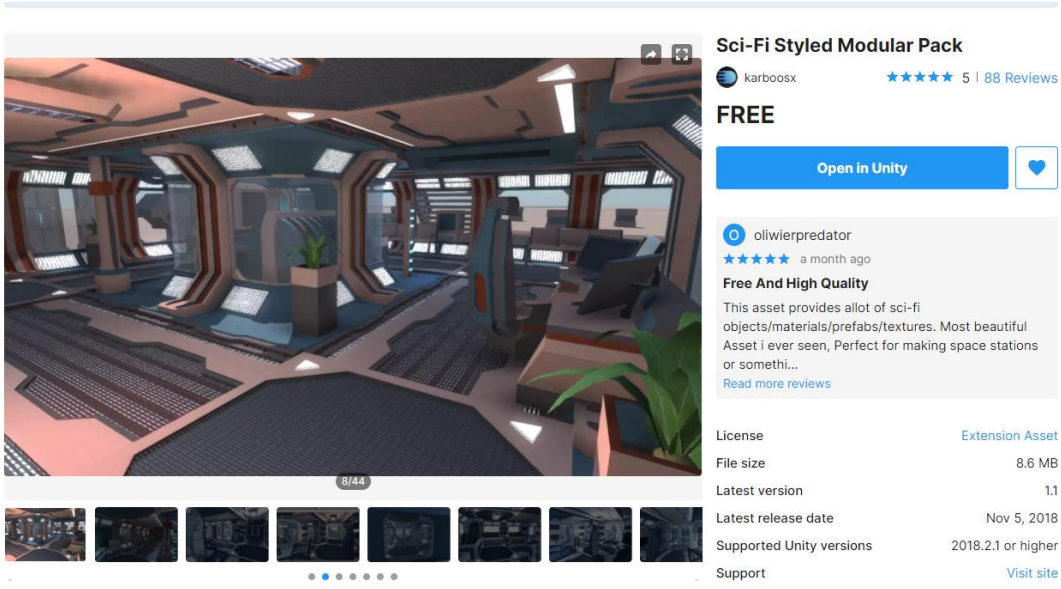

Figure 10 Sci-Fi styled modular pack asset

There is a sizeable variety of 3D objects and props that come with this pack, including walls, corridors, doors, windows and a multitude of environmental sci-fi props.

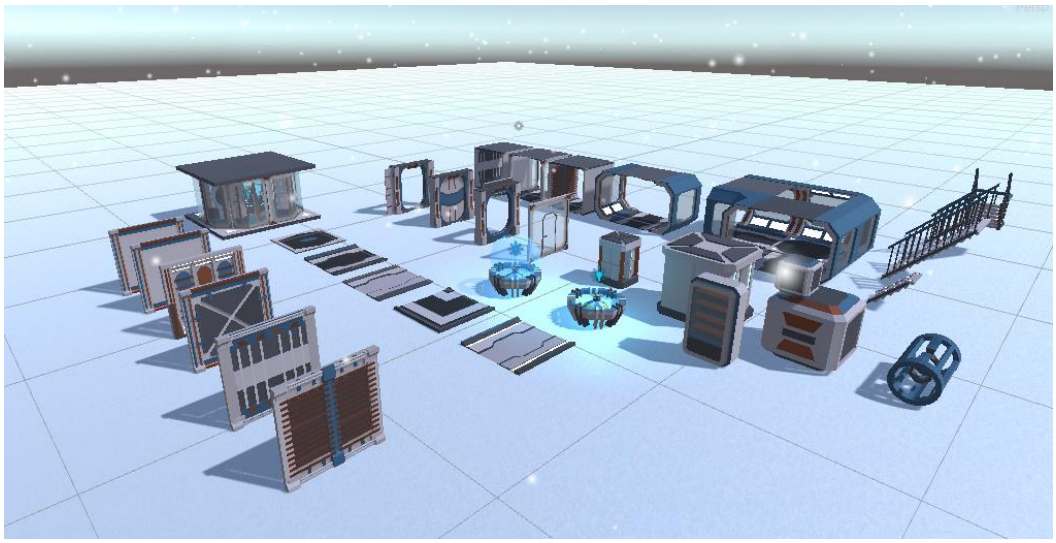

Figure 11 Variety of sci-fi modular pack prefabs

There is also a multitude of pre-defined lighting included in the pack, which will allow for time saving when designing the level. This could prove to be extremely beneficial, given that the game is based indoors and specific lighting could take time to correct.

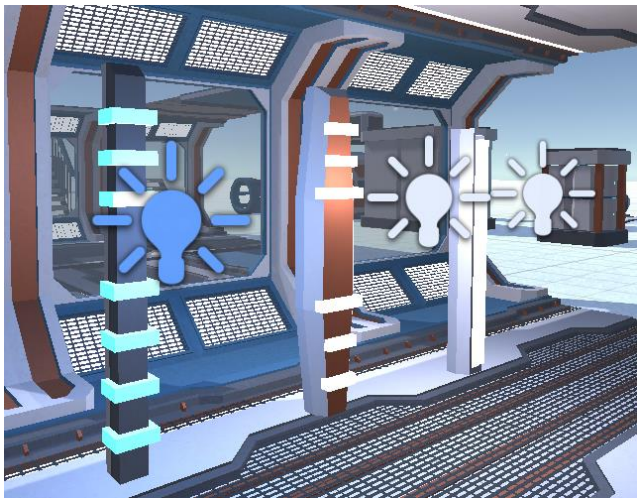

Figure 12 Sci-fi modular pack lighting

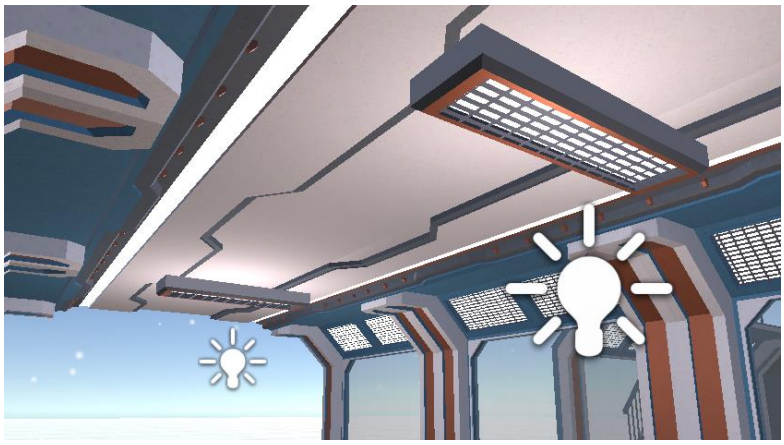

Figure 13 Sci-fi modular pack lighting

5.10 Character

The main character of the game needed to fit the environment appropriately. Due to the nature of the environment, it was decided that the character needed to be sci-fi based. This allowed for specific research into available assets from Unity.

The asset pack that was decided upon is the “Robot Pack 2”, created by user Marcelo Barrio (*Robot Pack 2*, 2021). This pack offers a selection of different robot models to use with a multitude of material options. It also offers pre-rigged characters so that animations can be implemented faster and efficiently.

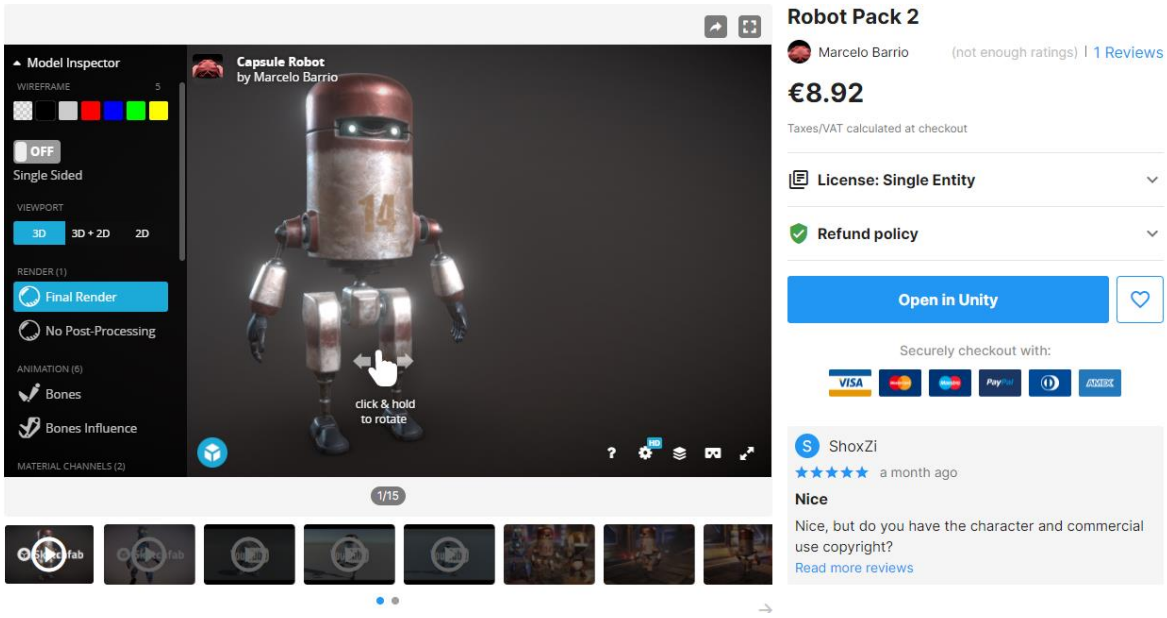

Figure 14 Robot Pack 2 asset

The model decided upon for the main character is the “Marvin” character from the pack. This model appeared to fit most sufficiently with the environment design of the game.

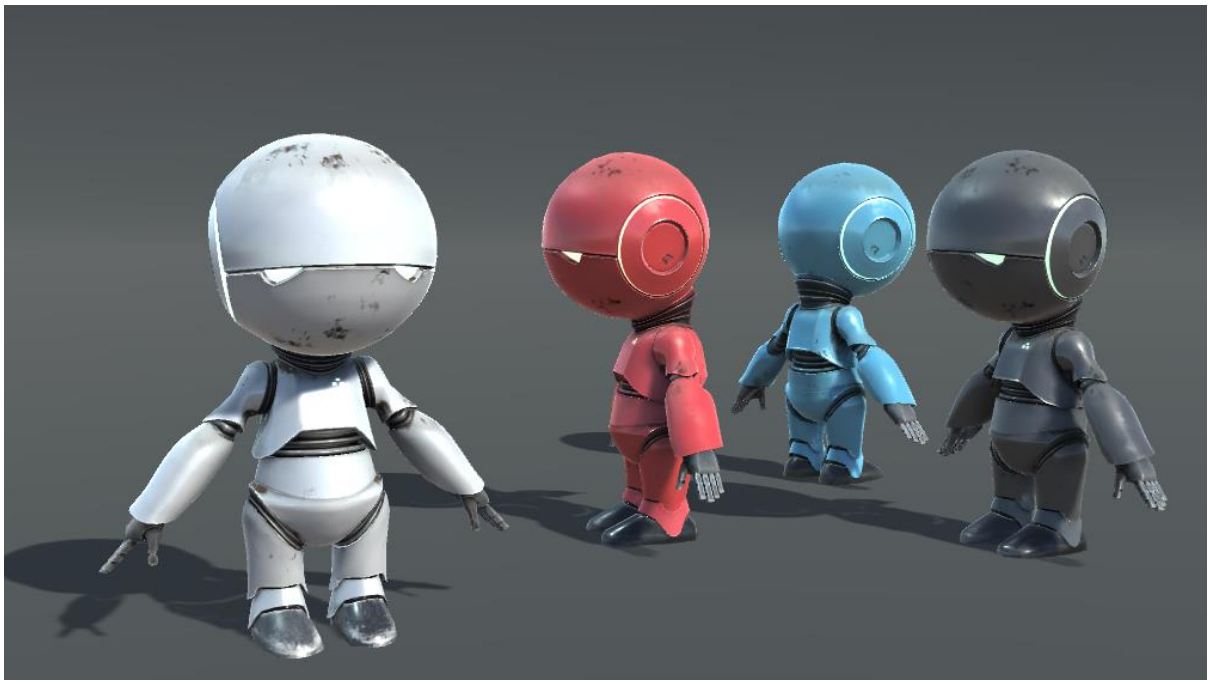

Figure 15 Marvin asset

By using this pre-rigged model, animations can easily be applied using the external animation web application “Mixamo”.

5.11 Conclusion

Through extensive research into Unity's Asset Store, a clear concept of how the application will be designed is set. This should provide easier final steps of design for the game. There are now straightforward design instructions created via the storyboard and level design sketches. This will allow for better time management in completing the game's design. More emphasis should be put forth on the game's user interface components, such as health and instructions during the game.

A deeper understanding of the structure of Unity Engine has been established, thus allowing for more knowledge regarding how the system works.

6 Implementation

6.1 Introduction

This chapter will discuss the process of project application development. The software, programming language and process will all be described in detail, as well as the process in which elements were implemented into the application. These elements will be visualised with code snippets.

6.2 Development Environment

The primary software used to develop this game was Unity 2019.6.14f. This application was used to create basic prototypes of the game before developing further with Visual Studio. This application offered an efficient work structure and file management system.

In order to begin working on this game, functionality needed to be done before design. In doing so, Unity was used to create a primitive environment in order to create scripts for player controls and environmental triggers.

Due to functionality being of utmost importance, Visual Studio was also used majorly as a script editing software. This could allow for manipulation and development of game features, including player health, hazard detection and player movement.

GitHub was used in this project to maintain version control and safety of the project. In doing so, the project could be recovered if there were critical errors that could not be fixed. GitHub also allowed for time management and progress documentation throughout the project. It was also ideal in development due to its online repository accessibility from multiple devices.

6.3 Primitive Development

The first prototype of this game placed functionality before design. A very primitive environment was developed in order to script basic controls and features. The aim was to have a small but playable game as a basic start. This would preceed developing more complex features.

Using this, the first environment created in Unity was simply made up of blocks and a capsule for the player.

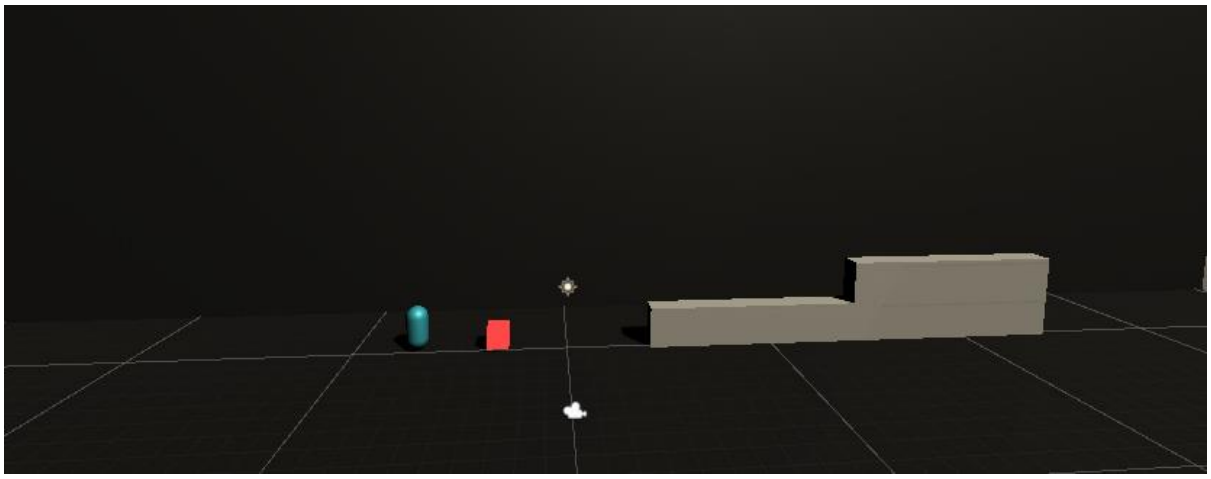

Figure 16 Primitive development

This environment allowed for simple scripting using Visual Studio to develop movement in the character.

The basics required making a simple 'PlayerController' and attaching it to the player object. Then the movement of the player could be created via C# code. At the beginning of this project, the player inputs were created via the Unity Input Manager. This system is a pre-defined general control scheme ready to be programmed into the game for controls in horizontal or vertical axis. This could include other features such as 'Fire1', 'Jump', or 'Submit'.

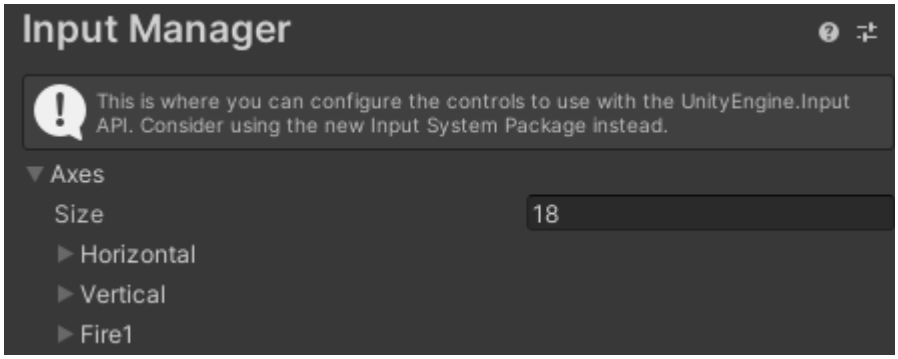

Figure 17 Input manager

Using this, the player was able to move around freely with common inputs of A, D and Space to jump.

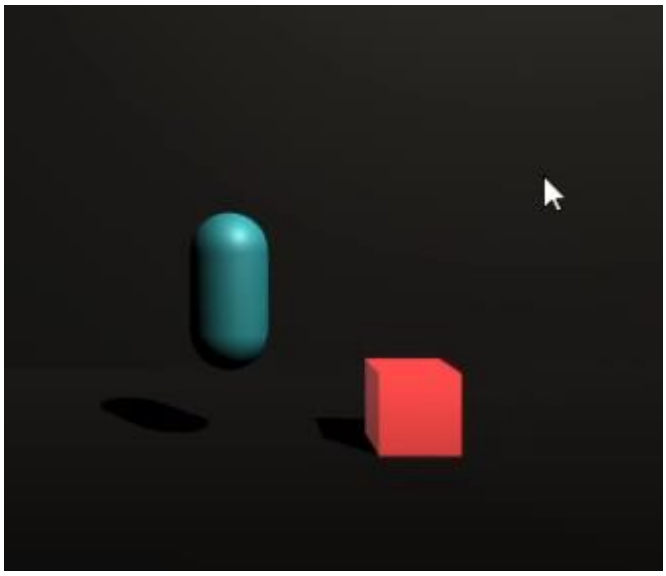

Figure 18 Simple primitives

6.4 Movement and Jumping

While the Input Manager provided by Unity is exceptionally useful, this feature needed to be adjusted greatly in order to create a re-mappable control system for users.

Remapping keys can allow users to adjust controls for personal comfort. Regarding MS symptoms, this option may allow players to use common controllers, such as keyboards and mouse. It can also allow for control adjustment so that users hands can sit comfortably.

This process involved using a Game Manager script along with the Player Controller script in the project. The Game Manager uses get and set key codes to allow the player to assign their own controls for left, right and jump movements.

```
public static GameManager GM;

6 references
public KeyCode jump { get; set; }
6 references
public KeyCode left { get; set; }
6 references
public KeyCode right { get; set; }
```

Figure 19 Key codes for user inputs

This information is used to assign movement controls to the player's preference. This can be established via the Controls menu. The Controls menu holds a series of buttons for the player, in which they can initialise and reassign controls.

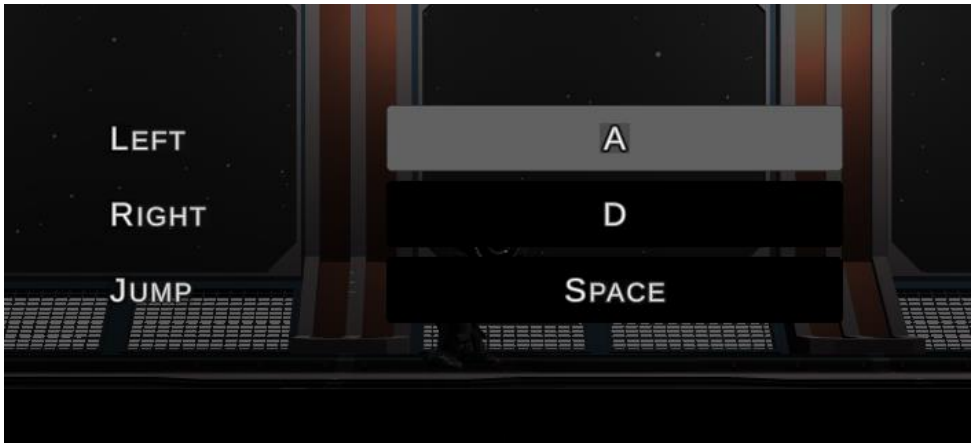

Figure 20 In-game re-mapping inputs

The text objects within these buttons are assigned by the specified input that the user chooses. For example, the left input may change to 'Q', the right may be changed to 'P' and the jump may be changed to 'G'.

```
//Assigns the controls to the previously preferred control scheme based on the last time someone has played
jump = (KeyCode)System.Enum.Parse(typeof(KeyCode), PlayerPrefs.GetString("jumpKey", "Space"));
left = (KeyCode)System.Enum.Parse(typeof(KeyCode), PlayerPrefs.GetString("leftKey", "A"));
right = (KeyCode)System.Enum.Parse(typeof(KeyCode), PlayerPrefs.GetString("rightKey", "D"));
```

Figure 21 Assigning the controls

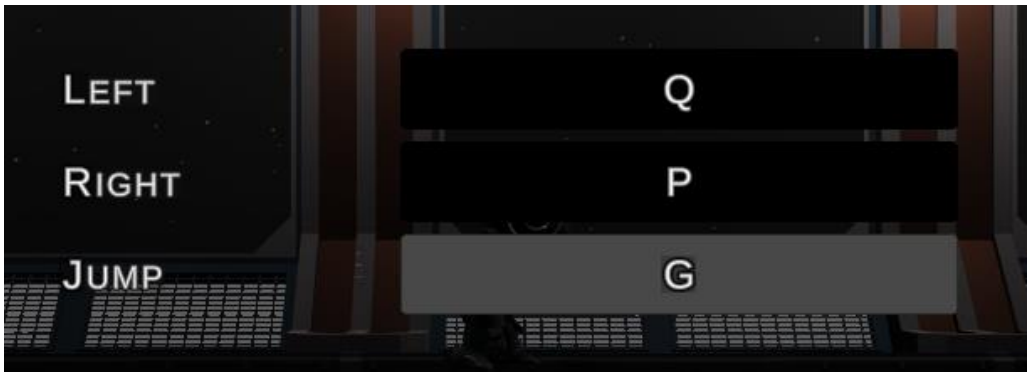

Figure 22 Newly assigned controls

This input system is then taken into the Player Controller script, in which the actual player object movement is defined by the Game Manager's received changes.

```
1 reference
void PlayerMovement()
{
    if (Input.GetKey(GameManager.GM.left))
    {
        transform.position += Vector3.left * speed * Time.deltaTime;
        transform.rotation = Quaternion.Euler(new Vector3(0, 270, 0));
        isMoving = 1f;
        playerAnim.SetFloat("Speed", isMoving);
    }
    else if (Input.GetKey(GameManager.GM.right))
    {
        transform.position += Vector3.right * speed * Time.deltaTime;
        transform.rotation = Quaternion.Euler(new Vector3(0, 90, 0));
        isMoving = 1f;
        playerAnim.SetFloat("Speed", isMoving);
    }
    else
    {
        isMoving = 0f;
        playerAnim.SetFloat("Speed", isMoving);
    }

    if (Input.GetKeyDown(GameManager.GM.jump) && isGrounded == true)
    {
        //Debug.Log("JUMP");
        playerRB.AddForce(Vector3.up * jumpForce, ForceMode.Impulse);
        playerAnim.SetTrigger("jump");
        isGrounded = false;
    }

}
```

Figure 23 Player movement script

6.5 Scene Management

The scene management defines the ability to move between scenes in the game. For example, a user may want to switch from the main menu to the playable level. This is done using Unity's Scene Management.

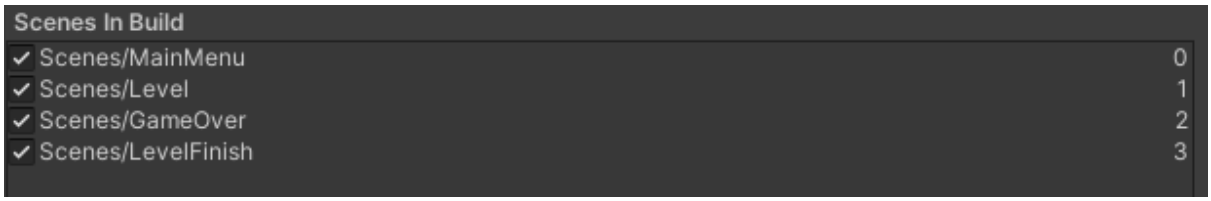

Figure 24 Scene manager in Unity

The scene manager uses index values to define the order in which scenes transition. These values are then used within scripts to make a scene 'Active' when a circumstance is met. In this case, when the 'Play' button is clicked, the active scene will change to the next scene according to the index.

```
0 references
public void PlayGame()
{
    //Loads the level from the build index (this will be set in in a scene manager in build settings
    SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);
}
```

Figure 25 PlayGame function to switch scenes

The button that initiates the 'PlayGame' function holds an 'OnClick' function that triggers when the user clicks it. This will search the script attached to the button and initialize the function to change the scene.

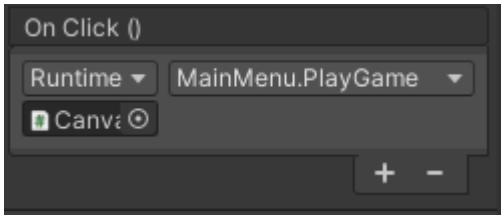

Figure 26 On Click function for the 'Play' button

6.6 Environmental Triggers

The environmental triggers within the game are created to detect when the player has entered a certain area of the map. Once the player has entered the box, the trigger will initiate and something will happen.

In this game, the environmental triggers will make the game's time to slow down. This was done in an effort to allow players more time to think before they act.

The triggers are made up of 3D cubes. The cubes are then set to 'IsTrigger' via the 'Box collider' component. This means that the box will act at a trigger to an event happening.

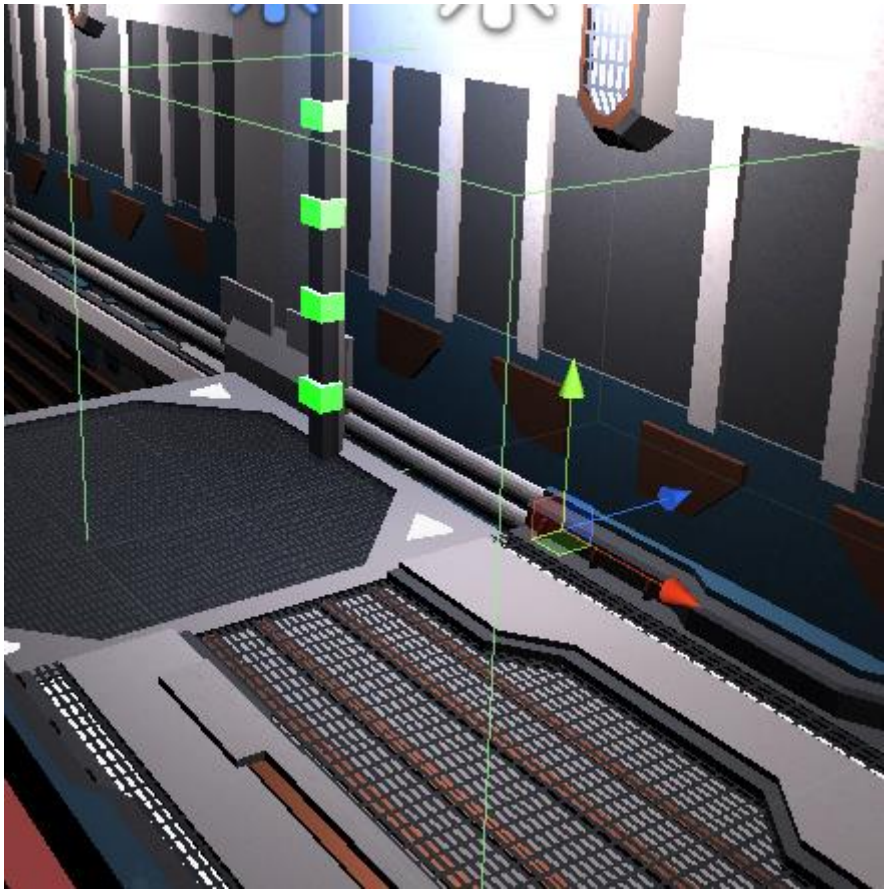

Figure 27Box collider highlighted

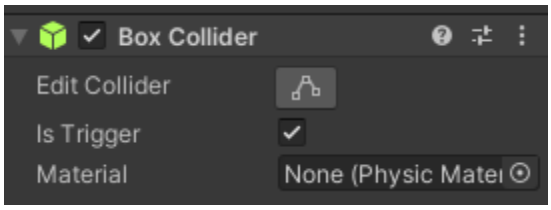

Figure 28 IsTrigger set to Active

The script attacked to the box, in this case the 'SlowDownTime' script, will use an 'OnTriggerEnter' function. This will detect a collision between the trigger and the established collider. The collider it is looking for is the player.

```
private void OnTriggerEnter(Collider other)
{
    if(other.tag == "Player") {
    slowMotion();
    }
}
```

Figure 29 OnTriggerEnter function detecting player object

Once the player enters this trigger, time will slow down using a function called 'slowMotion'. This was set to change the time scale at which the game is running, thus changing the time to slow motion.

```
1 reference
void slowMotion()
{
        Time.timeScale = slowDownSpeed;
}
```

Figure 30 slowMotion function

The trigger will change the time back to normal if the player has stopping colliding with it. This uses a function called 'OnTriggerExit'. This will detect when the player object has left the collider. It will also run the function 'regularSpeed' which re-establishes the time scale to normal.

```
Unity Message | 0 references
private void OnTriggerExit(Collider other)
{
    if(other.tag == "Player") {
    regularSpeed();
    }
}
```

Figure 31OnTriggerExit function detecting player object leaving

```
1 reference
void regularSpeed()
{
    Time.timeScale = normalSpeed;
}
```

Figure 32 regularSpeed function

6.7 Health and Hazards

The health bar is a user interface element that displays the amount of health that the player has. This needed to correspond with how much damage the player has taken, as well as how much health they may pick up.

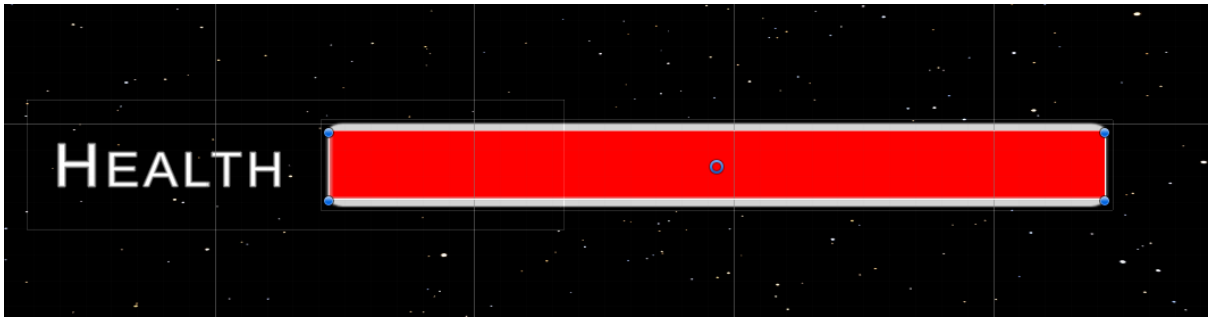

Figure 33 Health bar

The initial health is set to 100 and is established at the beginning of the 'PlayerController' script. The health will update if anything initiates a change in the number. For example; if the player collides with a hazard, the health will decrease slightly.

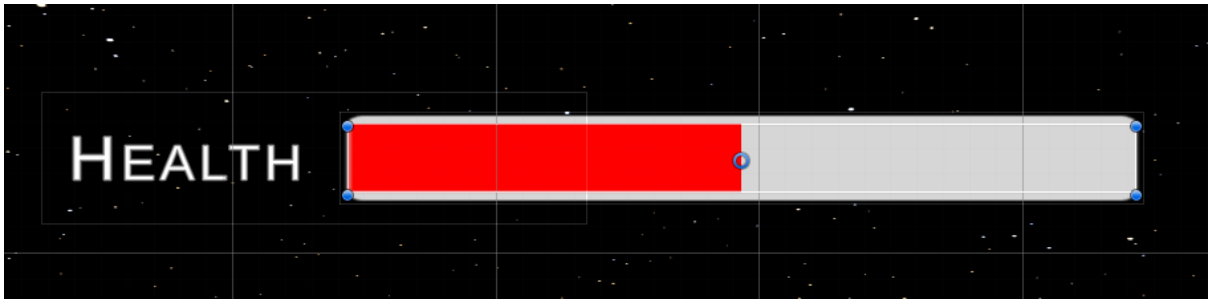

Figure 34 Health bar decreased

This happens by detecting when the player object has collided with a hazard. The hazards hold a set amount of damage they can apply to the player. Once the collision happens, the player's health will take away the amount of damage that the hazard offers. This is established using a Boolean called 'isDamaged'.

```
//Checking if the player is colliding with a gameObject with the Tag "Hazard"
if (other.gameObject.CompareTag("Hazard"))
{
    //Setting a knockback vector3 value so that the player's position is taken away from the hazard position
    Vector3 knockBack = playerRB.gameObject.transform.position - other.transform.position;
    //Add force to the player rigidbody when it comes into contact with the hazardous object
    playerRB.AddForce(knockBack * knockBackForce, ForceMode.Impulse);

    //Is the player is NOT damaged, set it to true
    if(isDamaged == false) {
        isDamaged = true;
        //Take the pre-defined damage (in the danger script) away from the health value
        health -= dangerScript.damage;
        //Start the routine timer for the player so that damage is not conitnuously happening.
        StartCoroutine(DamageRoutine());
    }
}
```

Figure 35 Using an if statement to check if the player has collided with a hazard

```
Unity Script | 2 references
public class Danger : MonoBehaviour
{
    public int damage = 5;

}
```

Figure 36 Hazard damage

The damage process uses a short coroutine to allow the player a small amount of time to not be damaged again. This coroutine is call the 'DamageRoutine'. It will be initiated when the 'isDamaged' Boolean is set to true. The duration of time that the players have runs, and then the 'isDamaged' is reset to false.

```
//CoRoutine for when damage is taken, this will allow half a second to not lose health
1 reference
IEnumerator DamageRoutine()
{
    //Setting the seconds to the damageDuration value
    yield return new WaitForSeconds(damageDuration);
    isDamaged = false;
}
```

Figure 37 Damage Routine

Once the 'isDamaged' is reset to false, the player can be damaged again.

This game uses health pickups to re-establish the health. These work similarly to the damage. They will hold a certain amount of health points that are added to the player's current health.

```
//Health Pick UP system
Unity Message | 0 references
public void OnTriggerEnter(Collider other)
{
    if (other.GetComponent<HealthPickUp>()!= null)
    {
        HealthPickUp healthPickUp = other.GetComponent<HealthPickUp>();
        health += healthPickUp.healthBonus;
        Destroy(healthPickUp.gameObject);        }
}
```

Figure 38 Health pickup

Like the environmental triggers, the health uses a collider that has 'IsTrigger' active. It will detect the player when collided and immediately add a number to the player's health. The health pickup object will then be destroyed.

```
public int healthBonus = 5;
```

Figure 39 Health bonus to be added to current health

If the health reaches 0 a function called ‘gameOver’ will initiate. This function will stop the game and switch the scene to the ‘Game Over’ scene using the scene index. This uses the same logic as changing from the main menu to the playable level.

```
//If gameOver is true, change the scene to the game over scene.
1 reference
void GameOver()
{
    if(health <= 0)
    {
        gameOver = true;
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);
        Debug.Log("Game Over!");
    }
}
```

Figure 40 Game Over scene change once health reaches 0

6.8 Level Design

The level design had a clear concept which was followed throughout the implementation. This is seen in the Figure 9 Level design sketch. This sketch was followed when creating the overall structure of the game’s level.

Figure 41 Level structure design

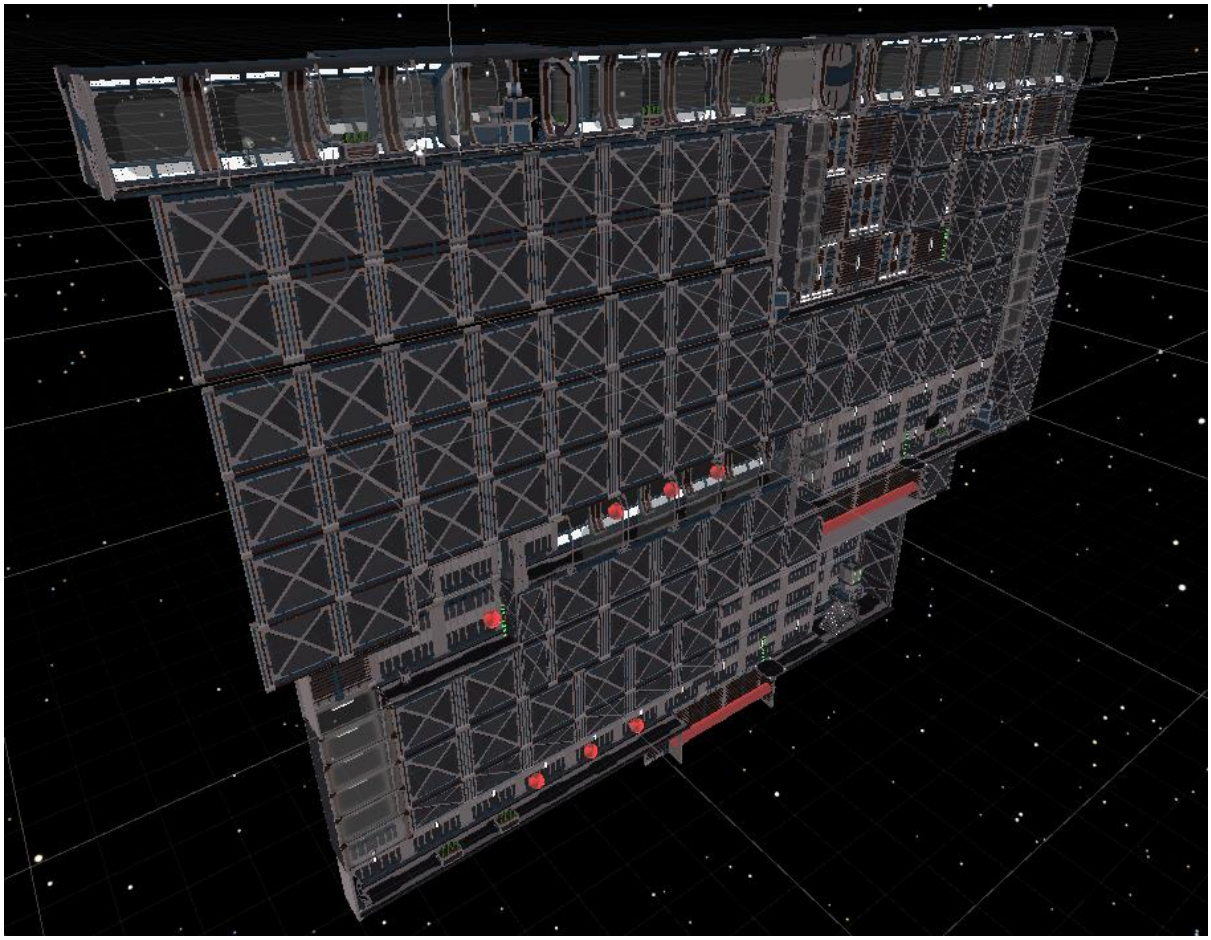

Figure 42 Level structure design 3D

This level was created as a one direction level. The concept was to create a clear line from start to finish that allowed the player to navigate seamlessly.

6.9 Accessibility Features Discussion

The accessibility features were of utmost importance when creating this game. These features include visuals, environmental triggers and primarily the option to re-map controls.

Regarding visuals, the game uses emission materials to indicate danger. This is used as a way to quickly trigger reactions when a user plays the game.

A common symptom of MS, as discussed previously, is information processing. This means that reaction times may be hindered. The red emission material is used to aid in these reaction times, so that players may quickly realise where a hazard is.

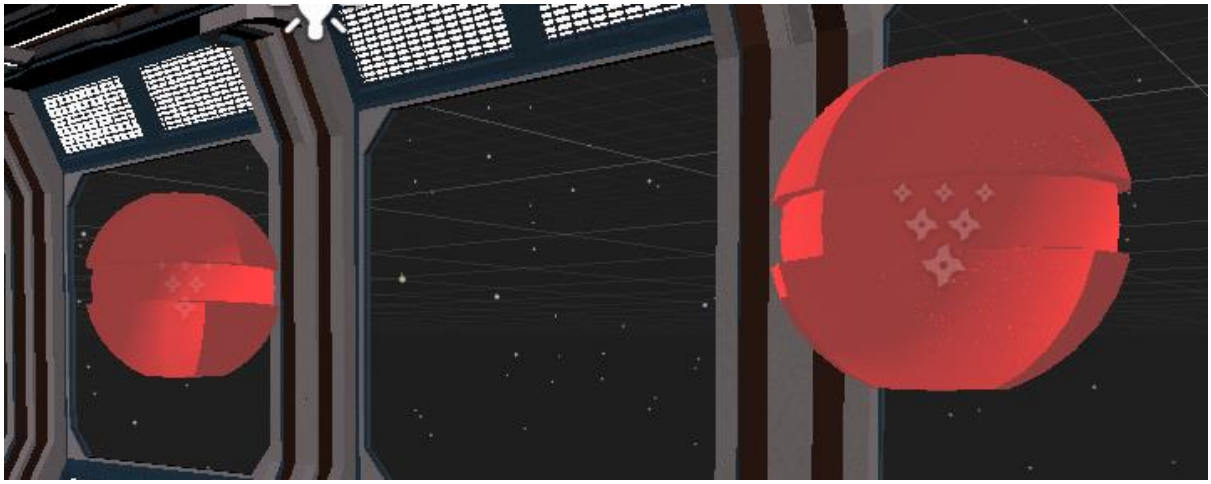

Figure 43 Danger recognised with emissive materials

The environmental triggers for slow motion were also aimed to be assistive. In this case, the slow-motion trigger was used to aid in information processing also. As stated previously, a common symptom in MS is hindered reaction times. This was added as a way to help players make decisions with more time available.

The primarily focused assistive feature in this game was the remappable controls. This was implemented so that players may use common keyboard to play.

Other common symptoms of MS as discussed previously are hindered mobility, tremors and muscle spasticity. This feature aims to challenge that symptom by providing a way in which users can adjust controls and physically be more comfortable with gaming. The player may also pause the game at any given time and change controls via the 'Controls' menu. This allows users to have full control over their controls throughout the game.

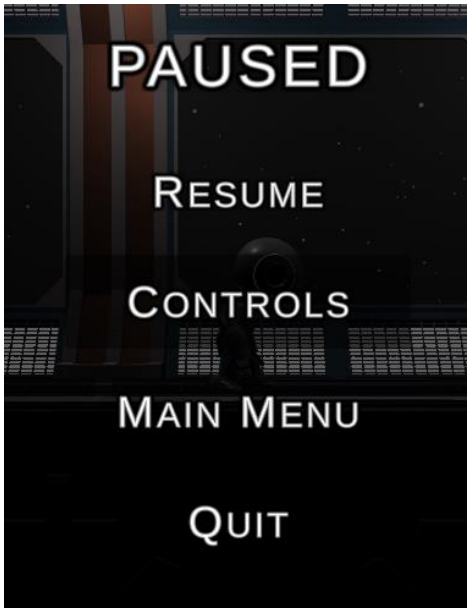

Figure 44 Pause menu

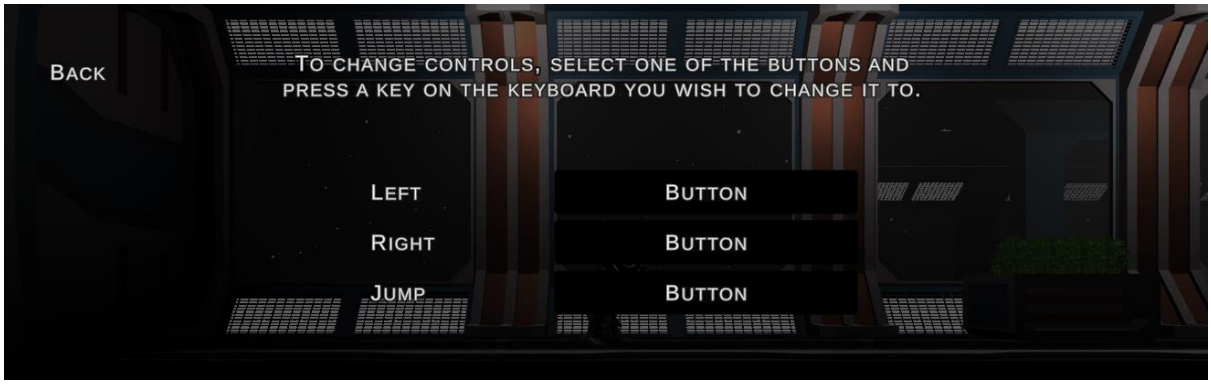

Figure 45 Controls menu

6.10 Conclusion

This project has implemented necessary assistive features that are aimed towards challenging several common symptoms of MS. It also uses basic gameplay practices by providing changeable scenes, a health and damage system, general movement and gameplay and simple but effective menu navigation.

While all of the necessary components were implemented, time management effected certain areas that could be improved.

7 Testing

This chapter will outline the process of testing the project application, 'M.A.R.S'. This testing should be undertaken by potential players of the game and documented thoroughly. The testing will consist of two sections;

- Functional Testing
- User Testing

7.1 Functional Testing

Functional testing is a type of software testing whereby the system is tested against the functional requirements. The game is tested by looking to see if the actual output for a given input corresponds with the expected output. The tests should be based on the requirements for the game. The results of functional testing can indicate if game is functional, but not if the software is easy to use.

The functional testing will be carried out in two main categories;

- Navigation
- Response

Navigation will determine the ease of use in navigating through the game's user interface. This may reflect on overall aesthetics, as well as gameplay user interface readability.

Response will determine the ability to play the game and retrieve expected outputs from specific inputs. For example, pressing a button to make the character jump, or changing the controls via the controls menu.

The functional testing will allow for extremely vital feedback from users. This could be used to gain important criticism and recommendations, as well as more personal information about MS symptoms.

7.1.1 Navigation

Test Number	Description of Test	Input	Expected Output	Actual Output
1	Navigate to the “Instructions” Menu	Click the “Instructions” button in the main menu	The Instruction page will appear and the Main Menu will disappear.	The Instructions menu appeared and the Main Menu disappeared.
2	Start the level	Click the “Play” button from the Main Menu	The next scene will load, which is the playable level.	The next scene loaded and the player was placed into the game.
3	Pause the game	Press the “ESC” key on the keyboard.	An overlayed menu will appear and time will be paused in the game.	The overlayed menu appeared and time paused in the level.
4	Navigate to the Controls menu	Click the “Controls” button from within the Pause menu.	The Pause menu will disappear and the “Controls” menu will open.	The Controls menu appeared and the main pause menu disappeared.
5	Resume the game	Click the “Resume” button from the Pause menu.	The game will resume at normal time and the Pause menu will become inactive.	The game resumes and the Pause menu became inactive.
6	Navigate to the Main Menu	Click the “Main Menu” button from the Pause menu.	The Main Menu scene will become the active scene and the Level scene will become inactive.	The Main Menu scene opened and the Level scene closed.

7	Quit the game	Click the "Quit" button from the Main Menu.	The player will exit the application.	The player exited the game.

7.1.2 Response

Test Number	Description of Test	Input	Expected Output	Output
1	Jump	Using pre-determined controls (Space button), make the player jump.	The player will jump in the air and the jump animation will player.	The player jumped and the jump animation played.
2	Move left	Using pre-determined controls (A button), make the player move left.	The player will rotate to look and move left and the running animation will play.	The player rotated and moved left and the running animation played.
3	Move right	Using pre-determined controls (D button), make the player move left.	The player will rotate to look and move right and the running animation will play.	The player rotated and moved right and the running animation played.
4	Re-map the player movement controls from the Controls menu	Using the Controls menu, re-map the Jump, Left and Right buttons to any new keyboard keys.	The new controls should appear the Controls input boxes.	The player can see the new controls within the input boxes.
5	Using the new controls, Jump	After re-mapping the key, press the newly assigned jump button and make the player jump.	Using the newly re-mapped controls, the player should be able to jump.	The player successfully jumped using the newly re-mapped key.

6	Using the new controls, move left	After re-mapping the key, press the newly assigned left movement button and make the player move left.	Using the newly re-mapped controls, the player should be able to move left.	The player successfully moved left using the newly re-mapped key.
7	Using the new controls, move right	After re-mapping the key, press the newly assigned right button and make the player jump.	Using the newly re-mapped controls, the player should be able to move right.	The player successfully moved right using the newly re-mapped key.

7.2 User Testing

User testing is used to document the general usability and experience within the game. This will be accomplished by assigning testers small tasks to undertake before they complete the game. This will also allow for vital feedback and criticism which may be used in future research.

7.2.1 Ease of Use Testing

Ease of use is a general review from testing, which will offer an overall impression of how easy the finished game is to play and navigate. This can take into account the speed at which users navigate and play the game as well as any hesitations or issues that may occur.

7.2.2 Test Participants

The most ideal participant for testing would be a person diagnosed and living with MS. Ideal participants would also be between the ages of 18 and 60. Strict safety guidelines must be taken into consideration for testing. Due to the current Covid-19 global pandemic as well as the immunodeficiency of MS, testing will take place online.

7.2.3 Test Results

There was difficulty in finding many participants to test with due to the current global pandemic. The participants that tested the game were all diagnosed with MS. Each tester provided excellent feedback and criticism that may be used for further research. Each testing session, with the participants permission, was recorded and used to accumulate the feedback. The participants requested to remain anonymous in the testing results.

There was a total of three participants diagnosed with MS that tested the game. Each participant provided critical feedback that allowed for more consideration regarding the project.

All of the participants agreed that the menu and scene navigation was straightforward and clear. Two participants added that they found the ‘Instructions’ extremely useful to understand the story of the game and what to expect before they began.

Regarding visuals, two of the participants noted that the user interface in game, i.e., the health bar, was clear for them to read. One user found it difficult to read.

All of the participants found that the emission materials applied to hazards in the game enabled them to immediately know where danger was.

Two users chose to remap the controls of the game. Once doing so, they noted that the game easier to play and complete. One of these users switched their controls to the

keyboard arrow keys, while the other chose to play with two hands. This user set the controls to the ‘A’ key for left, the ‘L’ key for right and kept the ‘Space’ key for jump. The last user chose to keep the default controls and found it easy to play.

All of the users agreed that the slow-motion environmental trigger was somewhat distracting. One user suggested that there should be a timer or a visual indication included in the user interface to allow users to see what is happening.

7.3 Conclusion

The testing offered vital feedback that could be used in further research. While there was good feedback provided, the criticism was notably important to further understand the issues with MS. Some areas, such as the environmental triggers and the user interface could be further improved to allow for more adaptive gameplay. Overall, the testing was extremely helpful in understanding how this subject area could be researched further.

8 Conclusion

The aim of this project was to research assistive technologies in gaming for persons diagnosed with MS. This objective was achieved. This project was primarily research based with the aim of producing a proof of concept in a gaming application. By doing this, the game needed to contain assistive features that could aid in gameplay, directly correlating with common MS symptoms.

The research was thorough and allowed for a lot of learning in developing this project. It allowed for a deeper understanding of MS and how symptoms can affect those diagnosed with it. This in turn was used towards the final gaming application. There was also a lot of consideration to be taken when using terminology.

This project was aimed to be respectful of those diagnosed with MS and in doing so required extensive research through reading and word of mouth. An excellent resource for correct terminology was used in order to be respectful.

The design of the project was affected slightly by time management. This weas because the design was the last part to be implemented. The project was aimed to place functionality before design, so that all the necessary components of the game were implemented before the design was completed.

The testing proved difficult, but did provide extremely good feedback in the form of positivity and criticism. The criticism itself allowed for even more consideration in terms of design and function. This in particular proved to be extremely useful for personal learning and reflection on the project.

9 Reflection

While this project posed many challenges, I believe it was a success. My primary aim was to research and learn about MS and push that information into a game as a proof of concept. I believe I completed this objective.

I aimed to be respectful and mindful of MS and those diagnosed with it by using terminology approved by Gov.uk (Office for Disability Issues, 2016).

While I believe I completed my objective of creating an assistive game, I believe there is still room to learn. I believe time management became an issue which hindered some progress in the application development. I also believe some areas could be improved in the project application for more adaptability.

I believe my research during this project is in-depth and expansive to include many different subjects within this subject area. That aided me a lot in creating the application and writing about MS.

Overall, I am content with the outcome of this project and would be willing to use my knowledge in this subject area for further use.

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11 Appendix

https://github.com/AJDenton/4thYearProject - Github Repository

https://play.unity.com/mg/other/4th-year-project - WEBGL Game Application