

République Algérienne Démocratique et Populaire
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Université Mohamed Khider – BISKRA



Faculté des Sciences Exactes, des Sciences de
la Nature et de la Vie
Département d'informatique
N°d'ordre: IVA18/M2/2023

Mémoire de fin d'études

Présenté pour obtenir le diplôme de master académique en Informatique
Option : Image et Vie Artificielle (IVA)

Réalisation d'une application de réalité virtuelle pour le traitement de la phobie

Phobia treatment with Virtual Reality (Nyctophobia)

Réalisé par : M.MALLOULI Ahmed Rami

Soutenu le 21/06/2023, Devant le jury composé de :

M. Foudil Cherif	Professeur	- Président
Mme. Djihane Babahenini	MCB	- Examineur
Mme. Amina Bouguetitiche	MCB	- Rapporteur

Année universitaire 2022-2023

Acknowledgement

All praises to Allah, the Most Gracious, the Most Merciful.

I would like to thank Almighty Allah for giving me the determination and strength during the whole process of preparation and writing of this thesis.

I am sincerely grateful to my supervisor, Dr.Amina Bouguetitiche, for her support, invaluable insights, vast knowledge, patience, and guidance throughout my research journey. Her dedication to assisting me with my thesis has been instrumental in its completion.

I am thank full to psychologist Souheila Bachir who helped me in Assignment phase where identified the target audience. The virtual environments to be used and the relaxation method to be added.

I would like to extend my sincere gratitude to Intissar Cherif for the valuable assistance and support throughout the completion of this project.I am also grateful to all the members of the LESIA lab for their contributions and support in various ways. My humblest gratitude to all the members of the jury for their willingness to review my work and the individuals who have played a part in this research and have provided their support.

Résumé

La réalité virtuelle (RV) s'est avérée un outil précieux dans le domaine de la santé mentale comme les formes traditionnelles de thérapie d'exposition (VRET), en particulier dans le traitement de la nyctophobie, un trouble anxieux caractérisé par une peur intense de l'obscurité qui coexiste souvent avec d'autres problèmes de santé mentale comme la dépression.

Afin de pallier les limitations rencontrées par les individus dans l'accès aux thérapies psychologiques traditionnelles, une application de jeu de réalité virtuelle appelée **PowerPlay** a été développée. S'appuyant sur des recherches approfondies en thérapie d'exposition, les scénarios de réalité virtuelle ont été méticuleusement conçus pour reproduire les activités quotidiennes des patients, avec des scènes distinctes de relaxation et de confrontation avec la phobie dans un environnement virtuel 3D réaliste qui simule efficacement l'obscurité. Une grande attention a été accordée à l'interaction transparente entre l'utilisateur, l'environnement VR et le matériel associé, comme les casques et les contrôleurs. De plus, l'application de thérapie en réalité virtuelle offre un environnement sûr et contrôlé aux personnes atteintes de Nyctophobie pour qu'elles puissent progressivement affronter et surmonter leur peur, avec une compatibilité avec plusieurs casques.

Mots clés : VR, VRET, Nyctophobia, PowerPlay.

Abstract

Virtual reality (VR) has proved as a valuable tool in the mental health field as the traditional forms of exposure therapy (VRET), particularly in the treatment of Nyctophobia, an anxiety disorder characterized by an intense fear of darkness that often coexists with other mental health conditions such as depression.

To address the limitations faced by individuals in accessing traditional psychological therapies, a VR game application called **PowerPlay** was developed. Drawing on extensive research in exposure therapy, the VR scenarios were meticulously designed to replicate patients daily activities, with distinct scenes for relaxation and confronting the phobia in a realistic 3D virtual environment that effectively simulates darkness. Great attention was given to ensuring seamless interaction between the user, the VR environment, and the associated hardware such as headsets and controllers. Moreover, the VR therapy application provides a safe and controlled environment for individuals with Nyctophobia to gradually confront and overcome their fear, with compatibility across multiple headsets.

Keywords : VR, VRET, Nyctophobia, PowerPlay

ملخص

أثبت الواقع الافتراضي (VR) أنه أداة قيمة في مجال الصحة العقلية مثل الأشكال التقليدية للعلاج بالتعرض (VRET) ، لا سيما في علاج "Nyctophobia" ، وهو اضطراب القلق الذي يتميز بالخوف الشديد من الظلام والذي غالبًا ما ينتج عنه أعراض صحية أخرى مثل الاكتئاب. لتخطي الصعوبات التي يواجهها الأفراد في الوصول إلى العلاجات النفسية التقليدية ، تم تطوير تطبيق ألعاب الواقع الافتراضي يسمى "PowerPlay" . بالاعتماد على بحث مكثف في علاج التعرض ، تم تصميم سيناريوهات الواقع الافتراضي بدقة لتكرار أنشطة المرضى اليومية ، مع مشاهد مميزة للاسترخاء ومواجهة الرهاب في بيئة افتراضية ثلاثية الأبعاد واقعية تحاكي الظلام بشكل فعال. تم إيلاء اهتمام كبير لضمان التفاعل السلس بين المستخدم وبيئة الواقع الافتراضي والأجهزة المرتبطة بها مثل سماعات الرأس وأجهزة التحكم. علاوة على ذلك ، يوفر تطبيق العلاج بالواقع الافتراضي بيئة آمنة وخاضعة للرقابة للأفراد الذين يعانون من رهاب الخوف لمواجهة مخاوفهم والتغلب عليها تدريجياً ، مع التوافق عبر سماعات رأس متعددة.

كلمات مفتاحية : 0 لواقع الافتراضي علاج التعرض، نيكثوفوبيا، باور

Contents

1	Virtual Reality	2
1.1	Introduction	3
1.2	Definition of Virtual Reality	3
1.3	History of Virtual Reality	4
1.3.1	Areas and applications of virtual reality	8
1.4	Tools of VR	10
1.5	Current state of Virtual Reality	11
1.6	How Virtual Reality works	11
1.7	Conclusion	13
2	Phobias	14
2.1	Introduction	15
2.2	Definition of phobia	15
2.3	Classification of phobia	15
2.4	Traditional therapy for phobias:	18
2.4.1	Cognitive Therapy:	18
2.4.2	Exposure Therapy:	18
2.4.3	Assertiveness Therapy:	19
2.5	Virtual Reality Therapy :	19
2.5.1	Advantages of virtual reality therapy	20
2.5.2	Related works	21
2.5.3	Conclusion:	25
3	System Description and Architecture Design	26
3.1	Introduction	27

3.2	What is Nyctophobia:	27
3.3	Virtual Reality Exposure Therapy for Nyctophobia	27
3.4	Proposed System	29
3.4.1	System objectives	29
3.4.2	System Architecture Design	29
3.4.2.1	Virtual World	29
3.4.2.2	Patient	31
3.4.2.3	Patient Interaction	31
3.4.2.4	Controlling factors	31
3.4.2.5	Quality	32
3.4.3	System pipeline	32
3.4.3.1	Research and Assignment	33
3.4.3.2	Treatment Design	33
3.4.3.3	Content Creation	36
3.4.3.4	Implementation and Testing	37
3.5	Conclusion	37
4	Implementation and results	39
4.1	Introduction	40
4.2	Application technical description	40
4.2.1	Development Environment	41
4.2.2	Hardware	41
4.2.2.1	HTC Vive	42
4.2.2.2	Oculus Quest 2	43
4.2.3	Software	44
4.2.3.1	Unity3D	44
4.2.3.2	Steam VR	46
4.2.3.3	Unity OpenXR	46
4.3	Development Process	47
4.4	Application Prototype	48
4.4.1	Graphical User Interface	48
4.4.2	Designed Environment	51
4.4.2.1	Locomotion and Navigation	51

4.4.2.2	Interactions and Behavior	51
4.4.2.3	Animation and Audio	52
4.4.2.4	Application Scenes	54
4.4.3	Application Usability	59
4.5	Conclusion	60

List of Figures

1.1	Sensorama VR machine Turi [2014]	5
1.2	The first augmented reality headset Liu et al. [2018]	5
1.3	The first augmented reality headset Realite-Virtuelle	7
1.4	HTC VIVE Reimer [2017]	7
1.5	Oculus Quest Aleksandrovich and Gomes [2020]	8
2.1	Classification of phobia	16
2.2	Understanding what is the Social Phobia	16
2.3	Understand what specific phobias and fears afflict patients	17
2.4	Understanding what is the Agoraphobia	18
2.5	Virtual Reality Treat Fear of spiders Baus and Bouchard [2014]	20
2.6	Virtual Reality Treat Fear of heights Tsamitros et al. [2022]	20
2.7	virtual reality exposure therapy gamified task Lindner et al. [2020].	22
2.8	The Storyboard of Night Forest Application Paulus et al. [2019].	22
2.9	AcroFree Application Cherif [2020].	23
3.1	Graphic of Motivation to be Braver in Facing Darkness; (b) Graphic of Motivation to Get Used to Darkness Paulus et al. [2019].	29
3.2	System Conception.	30
3.3	System Pipeline of the application.	32
3.4	Activity diagram of the Player/VR System interactions.	34
3.5	Activity diagram of the Player in the Relaxing Session.	35
3.6	Activity diagram of the Player in the Phobia Session.	36
4.1	Description of the application requirements.	41
4.2	Schematic setup of the VR system HTC Vive Tremmel and Krusienski [2019].	42

4.3	Components of Oculus quest 2.	44
4.4	Logo of Unity3D Alex [2020].	45
4.5	Probuilder unity plugin.	46
4.6	Steam VR Application.	46
4.7	Unity OpenXR Support Preview by Late 2020.	47
4.8	Application Data flow.	48
4.9	User Interface of the Main Menu.	49
4.10	Session Menu User Interface.	49
4.11	Pause Menu User Interface.	50
4.12	Player Interaction with Objects.	52
4.13	Hands State Machine with Blend Tree (Grip/Trigger and Both).	53
4.14	Collectable State Machine (Consume).	53
4.15	Fade Screen State Machine (Fade in/Fade out).	54
4.16	Relaxing Scene Context.	55
4.17	Relaxing Scene Menu.	56
4.18	Player view in the security station.	57
4.19	Player view with flashlight in the life station.	58
4.20	Player view inside control room of the crew station.	59
4.21	Patient session results.	60

List of Tables

2.1 Overview of study on nyctophobia Paulus et al. [2019], acrophobia Cherif [2020]
and arachnophobia Lindner et al. [2020]. 24

General Introduction

Virtual reality (VR) is an advanced technology that generates immersive computer-generated environments, capable of replicating real-world experiences. The roots of VR can be traced back to the mid-20th century when scientists and researchers commenced their exploration into creating artificial environments that could be visually and interactively perceived by users. Among the early studies in this field was Sutherland et al. [1965], who introduced the "Sword of Damocles" in 1968. Although it was large and unwieldy, this device served as the first-ever head-mounted display (HMD), setting the stage for subsequent advancements in VR technology. Over the subsequent decades, diligent efforts from researchers and engineers resulted in remarkable improvements to VR hardware and software, thereby leading to the emergence of more accessible and immersive VR systems.

The development of VR has affected several areas, including Virtual reality exposure therapy (VRET) that has become a highly effective application of VR in the assessment, understanding, and treatment of mental health disorders due to technological advancements. In the case of nyctophobia, an intense fear of darkness, VRET involves exposing patients to virtual stimuli that induce anxiety in controlled environments, closely resembling real-life situations. By creating realistic artificial scenarios that can be customized and replicated, VRET triggers phobic responses similar to those experienced in the real world. VRET offers numerous advantages compared to traditional treatments. It provides an engaging and entertaining experience, empowering patients with more control and flexibility during therapy, while also offering a wider range of scenarios. Additionally, VRET eliminates the need for patients to directly confront their fears in real-life settings, reducing the associated anxiety. Therapists can conduct VRET sessions within the familiar confines of their offices, resulting in higher acceptance and facilitating a more effective psychotherapy process.

Due to the persistent characteristics of nyctophobia and its potential to amplify the likelihood of developing other mental disorders when not addressed, along with the challenges of high treatment costs, long waiting lists, reluctance to seek traditional treatment, and limited availability of VR therapy tools, there is a clear need for affordable and scalable VR interventions. Thus, the main objective of this thesis was to develop a VR-based game application called "PowerPlay" as a psychological intervention for treating nyctophobia. This application gradually exposes patients to relaxing environment before they face their phobia than to various dark related scenarios in a motivating manner, enabling them to confront their fear, develop feelings of safety, and learn how to control their phobic responses before facing real-world stimuli.

The thesis is organized into several chapters. Chapter 1 provides a comprehensive definition and historical overview of virtual reality, explains fundamental terminology and aspects of VR systems, discusses the development methods and challenges of VR tools, and explores various application areas. Chapter 2 introduces and categorizes phobias, discusses their severity, presents traditional treatment methods, provides an overview of virtual reality exposure therapy (VRET) and its relevance in treating specific phobias, and discusses previous works. Chapter 3 outlines the proposed research solution and methodology used in this thesis to address nyctophobia. It emphasizes the importance and key concepts of developing a virtual reality exposure therapy application for overcoming the fear of darkness based on statistical data and research from the recent years. Then the chapter describes the system's detailed architecture and design, presenting the prototype's basic idea, and outlines the implementation methodology. Chapter 4 presents the entire setup of the project, including hardware and software details, along with a technical description of the VR application. It describes the prototype, including user interfaces, environment design, game levels, animation and audio , and presents the final results of the system.

Chapter 1

Virtual Reality

1.1 Introduction

Virtual reality (VR) is an innovative technology that transports users into a computer-generated environment, providing a fully immersive experience through a headset that tracks their movements and adjusts their perspective accordingly. The level of immersion created by VR is so convincing that users can feel like they are physically present in the simulated world. This is achieved by the incorporation of various sensory inputs, such as touch and sound, which further enhance the virtual experience. Through VR, users can manipulate objects, explore different environments, and interact with virtual entities in a way that has never been possible before. As technology advances, VR is becoming more accessible and affordable, which has led to its increasing popularity among businesses, developers, and consumers alike. With limitless possibilities, VR has the potential to transform numerous fields, and we have only just begun to scratch the surface of its applications.

1.2 Definition of Virtual Reality

Virtual reality is a simulated 3D environment that introduces users to explore and interact with a virtual world in a way that is approximate to the reality Steuer et al. [1995]. The environment is created with computer hardware such as helmets or goggles to interact with the environment and software to simulate the 3D environment and as link between helmet and the computer.

VR systems must have two main characteristics: immersion and navigation in the environment :

Immersive environment that enables users to engage multiple sensations in a way that approximates reality and there is three categories Sheldon [2021]:

- Non-immersive. Which refers to a 3D simulated environment that is accessed through a computer screen. The environment might also have sound, depending on the program. The user has some control over the virtual environment using a keyboard, mouse or other device, but the environment does not directly interact with the user. A video game is a good example of non-immersive VR.
- Semi-immersive. Which offers partial virtual experience through a computer screen or some type of headsets. It focuses on the visual 3D aspect of virtual reality and does not implement physical movement that full immersion does. As an example of semi-immersive VR is the flight simulator.

- Fully immersive. This type of VR delivers the complete experience immersing the user can have in the simulated 3D world. It incorporates sight, sound and in some cases touch. Users wear special equipment such as helmets, goggles or gloves to fully interact with the environment. The environment might also incorporate such equipment as bicycles to provide users with the experience of moving through the 3D space. Fully immersive VR technology is important field into the gaming industry and the healthcare industry.

Navigation refers to the user ability to move, interact and manipulate objects within the environment. Navigation can be either active or passive. Passive navigation usually involves the presentation of visual information on a path or environment to a static observer, while active navigation requires actual moving around the environment TechTarget [2023].

1.3 History of Virtual Reality

The idea of diving to another world using helmet to escape the real world and interact with virtual worlds is not new. In the past this concept was used for science fiction. Since 2016, VR headsets now become reality thanks to companies like HTC Pico and Oculus we can now dive to virtual reality inside our living room.

This technology took a lot of time and failed attempts to achieve this ease of use through milestones such as:

- **Sensorama:** in 1960-1962, filmmaker Morton Heilig bring his idea in the form of a virtual reality headset with a stereoscopic screen, a field of vision similar to humans vision with stereo sound. In 2017, Tecmo realized this idea with the VR Sense, a booth intended for Japanese VR arcades, offering complete sensory immersion with atmospheric effects like those imagined by Heilig for the Sensorama.



Figure 1.1: Sensorama VR machine Turi [2014]

- **The sword of damocles:** in 1968 by Ivan Sutherland constructs a device presented as "the ultimate screen", this headset has a stereoscopic function to display simple shapes and allows the user to change the perspective according to his head movements. Since the screen is not darkened, these shapes are based on the real world images and it can also be considered as the first augmented reality headset.

However, this helmet remained at the laboratory for long time, because of its very heavy weight and this is the reason Ivan Sutherland referenced "The sword of Damocles" from the famous Roman myth.



Figure 1.2: The first augmented reality headset Liu et al. [2018]

- **Videoplace:** in 1975, videoplace is the first VR platform developed by Krueger that was presented at the Milwaukee Museum. It used video cameras, screens, projectors and local-

position technology. It was based on large video screens that surround the user inside dark room instead of headset or gloves.

The users can watch computer-generated shadows of themselves imitating their own movements and actions since their motions were captured on camera and projected onto the silhouette. Additionally, users could communicate with each other virtual shadows in different rooms. This encouraged the idea that users could communicate virtually even though they were far from each other.

- **Aspen movie map:** a project called 'Aspen movie map' developed in 1977-1978 by MIT with DARPA. This project is based on images captured by cars in Aspen. The application allowed the users to travel inside the city in first person view. A principle that Google Earth VR used in 2017.

The application was depending on a computer and a touch screen. There was no implementation of virtual reality headset, but the interactivity and the first person view was a step towards how traveling in VR .

- **The super cockpit:** in 1986 military engineer Thomas Furness was working on immersive flight simulator project using training cockpit capable of projecting computer-generated 3D maps (infrared and radar images). This project already allowed pilots to train using gestures, words and eye movements.
- **Computer simulated teleoperation:** a VR system was created by NASA scientist Antonio Medina in 1991 to control mars robots from earth in real-time. The term "Computer Simulated Teleoperation" refers to this system and it is the first VR system to introduce mass. These VR arcade games allowed players to interact with a 3D environment by displaying real-time stereoscopic 3D images in virtuality pod together with VR headsets. For multiplayer gaming, some of the devices might be networked together. There were eventually VR adaptations of several of the most well-known arcades like Pac-Man.



Figure 1.3: The first augmented reality headset Realite-Virtuelle

– **Oculus Rift:**

Meta bought the Oculus company for about 2 billion . This was a defining moment in VR's history because VR gained momentum rapidly after this. More people started exploring the possibilities of VR, including adding innovative accessories, for example Cratesmith, an independent developer, recreated a hoverboard scene from Back to the Future by pairing the Oculus Rift with a Wii's balance board.

- **HTC VIVE:** By 2016 many companies were developing VR products and HTC was one of them to release SteamVR headset called HTC VIVE . This headset was the first to use sensor-based tracking that allows users to move easily in a space.



Figure 1.4: HTC VIVE Reimer [2017]

- **Oculus Quest:** Oculus Quest is Meta's standalone headset created a lot of interest and momentum, selling out in different locations and generating 5 million worth of content sales.

This shift from pc VR to standalone VR represented a massive change within the immersive ecosystem, as standalone headsets are much easier to use for the average consumer VirtualSpeech [2021].



Figure 1.5: Oculus Quest Aleksandrovich and Gomes [2020]

1.3.1 Areas and applications of virtual reality

Virtual reality has delivered substantial benefits in numerous fields, resulting in notable progress. The ability of users to manipulate and interact with the virtual environment in a way that closely resembles their actions in the physical world has led to the rapid development of various applications, including:

- **Education and Training:** The utilization of VR technology in education has transformed the learning experience by offering immersive encounters that cannot be replicated easily in regular classrooms. This technology enables students to explore historical events and scientific phenomena, and its interactive and personalized content enhances learning.

Moreover, virtual reality is utilized to create simulations of real-world situations and provide training in various fields. Nevertheless, there are barriers to overcome, such as the implementation cost and ethical concerns that require addressing Kavanagh et al. [2017].

- **Gaming and Entertainment:** The gaming and entertainment sectors have been considerably affected by the increasing use of virtual reality. Virtual reality gaming has made gameplay more immersive and interactive for players, enabling them to explore new and fantastic places while using hand controllers or body tracking sensors to enhance the experience.

Furthermore, virtual reality technology has introduced exclusive entertainment experiences such as virtual reality concerts and theme park rides. Additionally, virtual reality films have empowered filmmakers to create more captivating and unforgettable experiences for their audiences Cruz-Neira et al. [2018].

- **Healthcare:** The healthcare industry has adopted virtual reality technology for medical training, patient education, and therapy due to its immersive simulations. This technology provides a secure environment for healthcare professionals to practice their skills, including emergency scenarios that require quick decision-making. Virtual reality also helps patients understand their medical conditions and manage pain, anxiety, and other illnesses through virtual reality-based therapy.

Additionally, virtual reality can enhance patient outcomes by providing personalized care and reducing medical errors. Creating individual anatomical models enables healthcare providers to plan and rehearse complex surgeries before performing them, reducing the chances of complications. Overall, virtual reality has become an essential tool in healthcare, improving patient education and treatment, as well as healthcare professional skills and expertise Mäkinen et al. [2022].

- **Architecture and Engineering :** The use of virtual reality technology has transformed the way architecture and engineering are carried out, offering an interactive and immersive platform for designing, testing, and visualizing intricate structures and systems. In the past, architects and engineers relied on 2D drawings and physical models to plan and present their designs. However, virtual reality allows them to create 3D digital models that can be explored and experienced in real-time.

Virtual reality has several benefits when applied in architecture and engineering, including the ability to test and evaluate designs in a simulated environment before actual construction commences. This feature minimizes the likelihood of errors and allows early detection and correction of design defects, thus saving time and resources. Furthermore, virtual reality can foster collaboration between design teams and clients, as they can all simultaneously explore and evaluate the same 3D model from any location Delgado et al. [2020].

- **Phobia treatment :** Phobias can cause significant distress and disrupt a person's everyday life, and they are usually treated with conventional methods such as exposure therapy, cognitive-behavioral therapy, and medication. However, these treatments may not be effec-

tive for everyone, and accessibility can be challenging for some individuals due to logistical or financial barriers. Recently, virtual reality (VR) has emerged as a promising alternative for treating phobias.

Virtual reality therapy employs computer-generated environments to replicate the feared object or situation. The patient dons a VR headset that immerses them in the simulation, enabling them to face their fears in a secure and controlled setting. This method is particularly beneficial for treating phobias because it allows patients to confront their fears without exposing them to actual stimuli Horváthová et al. [2015].

1.4 Tools of VR

VR systems typically consist of different components, enabling users to interact with the virtual world. These tools offer a wide range of applications, from entertainment and gaming to therapeutic interventions and training simulations Park and Kim [2022].

- **Head-Mounted Display (HMD):**

The HMD, a crucial component of VR systems, is a goggle-like device worn by the user that displays the virtual world. It contains a screen or screens in front of each eye that shows different images, creating a 3D effect for an immersive experience. The HMD also has sensors to track the user's head movements and adjust the displayed images accordingly.

- **Controllers:**

Devices that users hold in their hands, known as controllers, enable interaction with the virtual world. Hand-held controllers, motion controllers, and gloves are among the various types of controllers available. Haptic feedback is also provided by these devices to enhance the sense of touch in the virtual world.

- **Tracking System:**

The tracking system transfers the user's position and motions in the real world into the virtual environment. Among the sensors used for this are cameras, laser sensors, and magnetic sensors. With tracking technologies, the user may move around and interact with the virtual environment exactly like they would in the actual one, creating a seamless and realistic experience.

- **Computing Hardware:** The computational hardware renders the virtual environment and creates the images displayed on the HMD. The complex graphics and processing required for VR must be supported by the computer hardware. Hardware options include a top-of-the-line gaming machine and a custom VR setup.

- **Software:**

The software forms a crucial part of every VR system, encompassing the different applications and programs utilized for creating and managing the virtual realm. Its primary duties comprise of graphics rendering, monitoring user movements, and guaranteeing a smooth encounter. To achieve these objectives, numerous software options like game engines, 3D modeling software, and VR development platforms are accessible.

1.5 Current state of Virtual Reality

The present status of virtual reality (VR) technology is quickly progressing and becoming more within reach for users. VR has undergone significant improvements in terms of hardware, software, and content creation lately, leading to a more immersive and interactive user experience.

Some of the remarkable advancements in VR technology comprise the creation of more intricate headsets with greater resolution displays, enhanced motion tracking capabilities, and more convenient and user-friendly designs in recent times with corporations like Oculus, HTC, and Sony issuing high-end headsets that offer an immersive VR experience. Furthermore, VR systems are becoming more reasonably priced and reachable, with choices varying from standalone devices to high-end gaming PCs. There is also a growing network of VR software and applications, including games, educational tools, and virtual experiences that enable users to explore new environments and interact with digital objects and characters in a more natural and intuitive way. Although VR is still a relatively new technology, it is rapidly progressing and holds enormous potential for a range of applications, comprising gaming, entertainment, education, and even medical and therapeutic purposes.

1.6 How Virtual Reality works

VR technology uses a combination of techniques that create the illusion of immersion and presence in the virtual environment such as:

Stereoscopy is a primary method employed in VR technology that produces a 3D image by presenting marginally different images to each eye. This results in a perception of depth and viewpoint that enhances the realism of the virtual environment. Additionally, head tracking is another technique utilized in VR technology that modifies the displayed image according to the user's movements. This feature allows users to observe and explore the virtual environment as though they were physically present.

Feedback devices that imitate the sensation of touch during the interactions of user with virtual objects. These devices may incorporate pressure or vibration sensors, thereby enabling users to feel as though they are holding or touching virtual objects.

Sound effects and ambient noise to intensify the user's feeling of engagement and immersion in the virtual environment. This may encompass directional audio that modifies according to the user's location in the environment, along with ambient noise that produces an authentic auditory experience Onyesolu and Eze [2011].

1.7 Conclusion

With the advancement of VR technology, its potential applications have expanded beyond entertainment and gaming to include various industries such as science, engineering, medicine, and more. For example, VR can be used in medical training to provide a realistic simulation of surgeries or procedures, allowing students to gain practical experience without the risks associated with real-life practice. In the field of architecture and engineering, VR can be used to create and visualize complex designs and structures, providing a more immersive and interactive experience for clients and professionals. With the continued development of VR technology and its increasing accessibility, we can expect to see more innovative applications emerge in the near future.

Chapter 2

Phobias

2.1 Introduction

Fear is a natural and necessary response that we all experience when facing potential danger. However, sometimes fear can become excessive and irrational, leading to an intense and debilitating state of anxiety. This state is known as a phobia. Phobias can be triggered by a wide range of stimuli, from specific objects and situations to animals and social interactions. Living with a phobia can be extremely challenging, causing individuals to go to great lengths to avoid their fear. Phobias are the most commonly occurring anxiety disorders, and it can be very exhausting and disabling to live with the intense fear and anxiety that goes with having one. Phobic individuals may even change their whole lifestyle to feel relief. Despite the difficulties, it is important to know that phobias are highly treatable and seeking help can make a significant difference in managing this condition. Understanding phobias is the first step to provide efficacious treatment options for those in need.

2.2 Definition of phobia

A phobia is a type of anxiety disorder characterized by an intense, irrational, and persistent fear of a specific object, situation, or activity. This fear is often excessive and disproportionate to any actual danger posed by the feared stimulus, and can lead to significant distress and impairment in daily life functioning. Individuals with phobias often experience intense physical symptoms, such as rapid heartbeat, sweating, trembling, and difficulty breathing, when confronted with the object or situation that triggers their fear Wolitzky-Taylor et al. [2008].

2.3 Classification of phobia

Phobias are categorized into three main groups based on the stimulus that triggers the anxiety response, owing to the fact that the phobic stimuli can be quite diverse. These categories include agoraphobia, social phobia, and specific phobia. This classification system helps to better understand and categorize the various types of phobias, allowing mental health professionals to tailor their treatment plans to the specific needs of the individual:

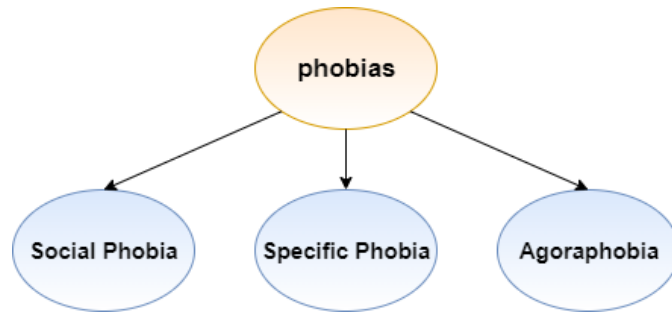


Figure 2.1: Classification of phobia

- **Social Phobia:**

Social phobia, also known as social anxiety disorder, is an anxiety disorder characterized by an intense fear of social situations and scrutiny by others. People with social phobia may fear being embarrassed, judged, or humiliated in social situations, leading to avoidance or extreme distress when faced with these situations. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), social phobia is diagnosed when an individual experiences significant and persistent fear or anxiety about one or more social situations, such as public speaking, meeting new people, eating or drinking in public, or using public restrooms American Psychiatric Association et al. [2013]. The fear must be out of proportion to the actual threat posed by the situation and significantly interfere with the person's daily life. Social phobia often begins in childhood or adolescence and can be influenced by genetic, environmental, and psychological factors.

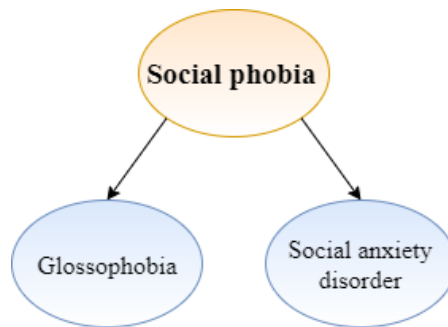


Figure 2.2: Understanding what is the Social Phobia

- **Specific Phobia:** Specific phobia is a type of anxiety disorder characterized by a persistent and excessive fear of a specific object, situation, or activity. This fear is often irrational

and out of proportion to the actual threat posed by the object or situation. Common examples of specific phobias include fear of flying, fear of heights, fear of spiders, and fear of needles. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), specific phobia is diagnosed when the fear or anxiety related to the specific object or situation leads to significant distress or impairment in the individual's daily life American Psychiatric Association et al. [2013]. The fear must also be persistent, lasting for at least six months, and not better explained by another mental health condition. Specific phobia can develop in childhood or adulthood and may be influenced by genetic, environmental, and psychological factors.

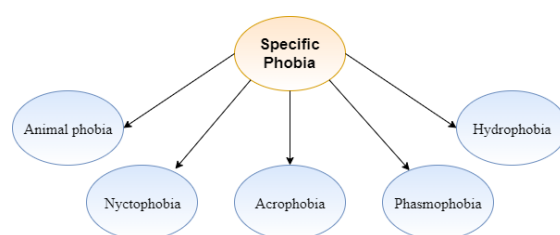


Figure 2.3: Understand what specific phobias and fears afflict patients

- **Agoraphobia:** Agoraphobia is an anxiety disorder characterized by an intense fear and avoidance of situations or places where escape may be difficult or help may not be available in the event of a panic attack or other anxiety symptoms. People with agoraphobia often avoid crowded places, public transportation, open spaces, or unfamiliar environments. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), agoraphobia is diagnosed when an individual experiences significant and persistent fear or anxiety about at least two of the following situations: using public transportation, being in open spaces, being in enclosed spaces, standing in line or being in a crowd, or being outside of the home alone American Psychiatric Association et al. [2013]. The fear must also be out of proportion to the actual danger posed by the situation and significantly interfere with the person's daily life. Agoraphobia can develop as a complication of panic disorder, and it often co-occurs with other anxiety disorders and depression.

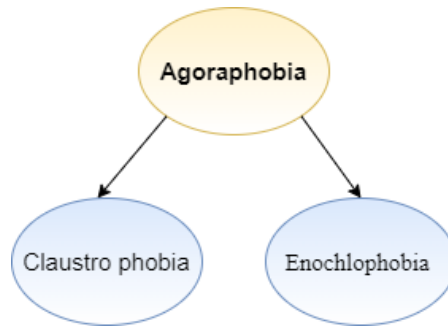


Figure 2.4: Understanding what is the Agoraphobia

2.4 Traditional therapy for phobias:

The conventional treatment for phobias generally employs a cognitive-behavioral therapy (CBT) technique known as exposure therapy. This method involves gradually introducing the person to the feared stimulus or situation within a secure and regulated environment, enabling them to progressively become less sensitive to it. A therapist supervises the process, utilizing a range of techniques such as systematic desensitization where the person is gradually exposed to the feared object or situation through imagination or in vivo exposure where the person is gradually exposed to the feared object or situation in real life Olatunji et al. [2010].

2.4.1 Cognitive Therapy:

Cognitive therapy is a type of psychotherapy that revolves around the notion that negative thinking and behavioral patterns play a major role in the onset of mental health disorders, frequently used for treating depression and anxiety. The primary aim of cognitive therapy is to help patients identify and change negative thought processes and behaviors that contribute to their symptoms. Various techniques, such as cognitive restructuring, exposure therapy, and behavioral activation, can be implemented during the therapy sessions. The ultimate goal of cognitive therapy is to aid patients in developing more positive and adaptive modes of thinking and behaving, leading to enduring enhancements in their mental health Beck [1997].

2.4.2 Exposure Therapy:

Exposure therapy is a form of psychotherapy that aims to systematically expose patients to the objects, situations, or activities that they fear or avoid. The main goal of exposure therapy

is to help patients decrease their fear and anxiety levels associated with the feared stimuli by repeatedly exposing them to it in a controlled and safe environment. This gradual exposure aids patients in learning to tolerate and eventually overcome their fear response. Exposure therapy is a widely used treatment for anxiety disorders such as phobias, OCD, and PTSD, and it is typically administered in a structured and gradual manner with the guidance of a trained therapist Rothbaum and Schwartz [2002].

2.4.3 Assertiveness Therapy:

Assertiveness Therapy is treatment that aims to enhance an individual's assertiveness and communication skills in social situations while still respecting the rights of others. The fundamental tenet of therapy is the belief that individuals can improve simple and straightforward ways of expressing their needs, thoughts, and emotions.

Assertiveness therapy's main objective is to assist patients to develop direct and respectful communication abilities. The purpose of therapy is to assist individuals in recognizing situations in which they are hesitant or unable to affirm themselves, and to stand up for themselves in a non-aggressive manner Franzcp [2007].

2.5 Virtual Reality Therapy :

Virtual reality technology is used in Virtual Reality Therapy (VRT), a form of therapy, to create simulated environments that can aid people in facing and overcoming their fears, phobias, and other psychological conditions Wiederhold and Wiederhold [2005]. It is based on the idea of exposure therapy, which involves progressively exposing the patient to the feared stimulus or situation in a safe environment until they feel at ease and have the ability to handle it in a real-world setting.

VRT (Virtual Reality Therapy) has been shown to be effective in treating various phobias by using exposure therapy in a controlled virtual environment. Here are some of the phobias that have been treated with VRT:

Fear of spiders (arachnophobia): VRT can create a virtual spider environment, allowing patients to confront their fear of spiders in a controlled setting.

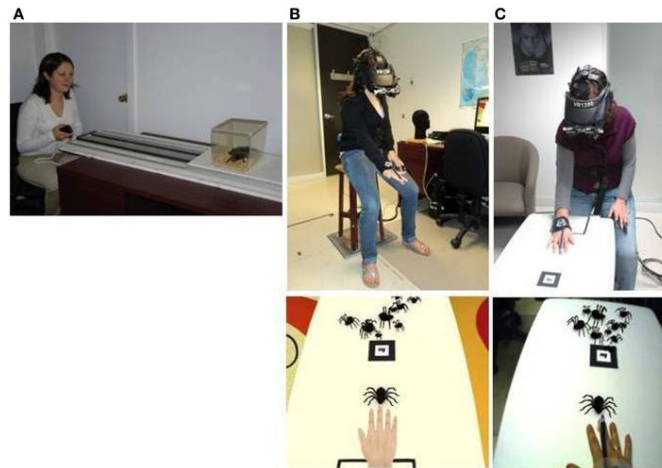


Figure 2.5: Virtual Reality Treat Fear of spiders Baus and Bouchard [2014]

Fear of heights (acrophobia): VRT can create a virtual environment that simulates heights, allowing patients to confront their fear of heights in a safe and controlled way.



Figure 2.6: Virtual Reality Treat Fear of heights Tsamitros et al. [2022]

Treatment for a variety of psychological conditions using virtual reality technology is hopeful and efficient. It provides a secure and controlled environment for people to face and conquer their fears and phobias, improving the results for mental health.

2.5.1 Advantages of virtual reality therapy

Virtual reality therapy (VRT) is a type of treatment that has been shown to be effective for a number of mental health issues. Here are a few of the main benefits:

- **Safe and Controlled Exposure:** VRT offers a safe and controlled setting so that people can face and conquer their phobias and fears without the dangers involved in actual exposure. By offering a secure and monitored environment for exposure therapy, research

has shown that VRT can successfully decrease symptoms of anxiety and phobias Gonçalves et al. [2012].

- **Increased Engagement and Motivation:** By offering a more immersive and interactive experience, VRT can increase engagement and motivation in treatment. According to research, VRT can improve therapy outcomes by boosting patients' motivation and involvement Keshner et al. [2019].
- **Tailored to Individual Needs:** VRT can be tailored to meet the individual needs of each patient, allowing for personalized treatment plans. Research has shown that VRT can be adapted to meet the specific needs of each patient, leading to better treatment outcomes Anderson et al. [2013].
- **Enhanced Learning and Retention:** VRT can enhance learning and retention by providing a more vivid and memorable experience. Research has shown that VRT can improve learning and retention of treatment skills, leading to better treatment outcomes Mishkind et al. [2017].
- **Cost-Effective:** Since VRT can be administered remotely and doesn't call for specialized facilities or equipment, it may be a financially advantageous form of therapy. According to research, VRT can be more affordable than conventional types of therapy Durl et al. [2018].

2.5.2 Related works

Virtual reality therapy is a relatively new and rapidly developing field, and there are several existing solutions available. Here are some examples:

- **Experiences of Gamified for Spider Phobia:** The objective of this research was to investigate the user experiences of automated, gamified virtual reality exposure therapy through qualitative methods. A total of seven participants were selected from a parallel clinical trial that compared automated, gamified virtual reality exposure therapy with an equivalent in vivo exposure. The participants underwent the virtual reality treatment as in the trial and then participated in a semistructured interview. Thematic analysis was conducted on the transcribed data for analysis.



Figure 2.7: virtual reality exposure therapy gamified task Lindner et al. [2020].

- **Night Forest VR Application:** The Night Forest VR Application is an adventure game designed to assist users in becoming more at ease with darkness and natural sounds. In the game, the user takes on the role of a boy scout and navigates the forest while searching for logs in various lighting conditions. A recent study conducted on the game found that female users reported higher levels of fear than male users. However, the repeated use of the game positively influenced all users, increasing their comfort levels in the dark. The article also provides a usability assessment of the VR user interface, using the Sutcliffe approach to evaluate its effectiveness. Overall, the Night Forest VR Application appears to be a promising tool for helping users overcome their fears of the dark, with potential benefits for both male and female users.

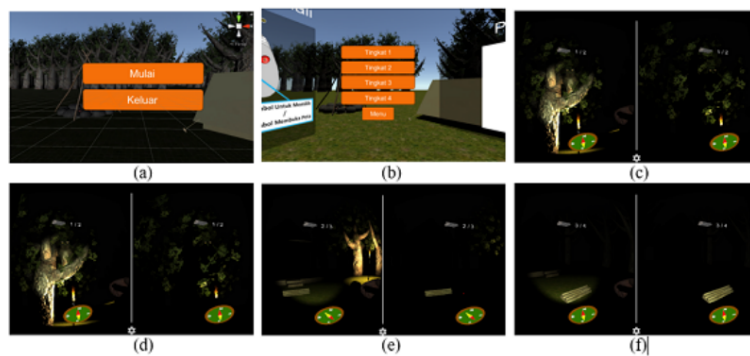


Figure 2.8: The Storyboard of Night Forest Application Paulus et al. [2019].

- **AcroFree:** The VR game for acrophobia treatment offers a promising and innovative approach to the management of this anxiety disorder. By creating a simulated environment

that mimics real-life scenarios, patients can gradually confront and overcome their fear of heights, without exposing themselves to the actual danger associated with high places. This virtual reality game offers three levels, each of which features different challenges and tasks that allow patients to build their confidence in dealing with heights progressively. The game's HTC Vive headset offers high-quality graphics and a fully immersive experience, providing patients with a sense of being in a real-life setting. The primary goal of this game is to provide a safe and controlled environment for acrophobic patients to learn how to manage their phobic responses, which can ultimately help them regain control of their lives and improve their overall quality of life.



Figure 2.9: AcroFree Application Cherif [2020].

Categorizing the features and implementations of different applications in a table can be an effective way to highlight their strengths and limitations. By organizing the information in a table, it becomes easier to compare and contrast different applications, and to identify which features or implementations may be more beneficial for specific use cases. Additionally, a table can provide a clear overview of the features and limitations of each application:

	Night Forest	AcroFree	Gamified for Spider Phobia
Locomotion	The movement done with continuous movement to navigate in the environment.	Teleportation movement with some navigation area restriction.	Teleportation to different locations.
Environment	The place and time of the situation is the forest at night time and there are four levels of simulations that this application is based on: the number of stages of additional light sources and darkness. sound effect for foot steps.	The environment set in tall office building with a lot of floors and a panoramic glass elevator with 3 levels in which the patient complete a series of tasks that gets harder progressively depending on the floors height.	Simulate real-world scenarios related to spider phobia. The environment included realistic visual and auditory cues, such as spiders , webs, and appropriate background sounds.
Interaction	Object grab interaction to hold the object to the start point.	Object drop zones and grab interaction. valid object is released into the zone and snapping it into place.	Picking up virtual objects. interacting with .spiders.
Evaluation	Level of fear of darkness before and while using the application, performing motivational tests, usability testing.	Time that the patient takes to complete each task.fear questionnaires before, during and after the VR sessions to measure the levels of avoidance and distress.	Semistructured interviews were conducted with participants. Thematic analysis to identify patterns, themes, and key findings. Participant feedback and satisfaction.

Table 2.1: Overview of study on nyctophobia Paulus et al. [2019], acrophobia Cherif [2020] and arachnophobia Lindner et al. [2020].

Locomotion method used in the application (continuous movement) is that it may cause motion sickness or discomfort for some users if the navigation area is not reduced or restricted , especially if they are not accustomed to virtual reality environments.

Interacting with objects using controllers instead of hand models can lead to a reduced level of immersion for patients. This is because the use of hand models enables the patient to see a virtual version of their own hands and fingers, leading to a more realistic and immersive experience. On the other hand, the use of controllers may make the patient feel less connected to the virtual environment, leading to a decreased level of presence and immersion.

Using a ray interactor instead of a direct interactor to grab objects or trigger events may result in a less immersive experience for the patient. The direct interactor allows the patient to directly interact with the virtual environment, while the ray interactor creates a barrier between the patient and the environment. This can potentially reduce the patient’s sense of presence and

immersion in the virtual environment.

2.5.3 Conclusion:

Phobias are a type of anxiety disorder that affects millions of people globally, causing significant distress and interference with daily life. While some phobias may appear irrational, they can lead to severe disability and panic attacks if left untreated. It is crucial to seek professional help early on to receive effective treatments such as cognitive-behavioral therapy, exposure therapy, medication, and virtual reality exposure therapy. With the right support and treatment, individuals with phobias can learn to manage their anxiety and overcome their fears, leading to a fulfilling life free from the constraints of their phobias. The potential of virtual reality exposure therapy in providing a safe context for gradual immersion into various phobic situations is a promising advancement in the field of phobia therapy.

Chapter 3

System Description and Architecture Design

3.1 Introduction

Specific phobias, including nyctophobia, are highly common in both adolescents and adults. Nyctophobia is characterized by a chronic fear of darkness and a tendency to avoid situations related to it, which can have negative effects on social and emotional well-being. This fear restricts individuals from engaging in everyday activities such as going outside in the night, stuck in dark room or checking basement.

Seeking psychiatric assistance is crucial for individuals with nyctophobia to overcome their fear and reach their full potential. While traditional methods have proven effective in treating phobias, they often face challenges related to patient engagement and high dropout rates. Virtual Reality (VR) therapy, on the other hand, shows promise as a therapeutic approach for improving outcomes in treating nyctophobia. The affordability and accessibility of the latest VR systems , allowing therapists to incorporate VR therapy into their practice, both in clinics and in patients homes. In this chapter we aims to design our VR therapy application as game that provides a safe and realistic simulated environment to help individuals with nyctophobia overcome their fear.

3.2 What is Nyctophobia:

Nyctophobia is a type of anxiety disorder that makes a person extremely afraid and anxious of the dark. This condition is categorized as a specific phobia, which is an extreme and irrational fear of a specific thing or circumstance. Along with other phobias like social anxiety disorder, panic disorder, and generalized anxiety disorder, nyctophobia is recognized as an anxiety disorder Levos and Zacchilli [2015].

Individuals with this condition may experience extreme panic and anxiety when they are in dark, it is considered that a combination of genetic, environmental, and psychological factors contribute to the development of the condition. Its onset can also be impacted by traumatic experiences, such as being trapped in the dark or seeing a traumatic event occur in the dark .

3.3 Virtual Reality Exposure Therapy for Nyctophobia

Virtual Reality Exposure Therapy (VRET) is a therapeutic approach that utilizes virtual reality technology to create lifelike environments and situations with the aim of helping individuals

confront and overcome specific fears, phobias or traumatic experiences. It falls under the category of exposure therapy, which is founded on the idea that repeated and controlled exposure to anxiety-inducing stimuli can diminish fear and anxiety responses.

During VRET sessions, individuals wear a virtual reality headset that immerses them in a computer-generated virtual environment. Through this simulated setting, they can encounter situations or stimuli that trigger their fears or anxieties. The virtual environment can be customized and regulated by the therapist, enabling gradual exposure where the intensity of the stimuli can be incrementally increased over time. This gradual approach allows individuals to confront their fears in a safe and controlled manner, enabling them to build resilience and tolerance towards anxiety-provoking situations.

VRET offers several advantages compared to traditional exposure therapy. It provides a secure and controlled environment for exposure, eliminating the potential risks associated with real-world exposure. Moreover, therapists can tailor the virtual environment to cater to the individual's specific needs and progression at their own pace Gonçalves et al. [2012].

Recently, VR exposure therapy (VRET) has gained attention as a potential treatment for nyctophobia. In the field of psychology, cognitive behavioral therapy is commonly utilized to help individuals confront their fears by providing positive suggestions and gradually exposing them to the feared stimuli until their anxiety diminishes. A study conducted by Paulus et al. [2019] aimed to explore an alternative approach for treating nyctophobia. The study introduced an adventure game set in a nighttime forest as a novel method to familiarize users with darkness. Within the game, users experienced natural sounds like footsteps, bird chirping, and door sounds, while taking on the role of a boy scout tasked with finding logs in the varying levels of lighting. The game was implemented through Mobile VR Apps utilizing storyboards. The experimental study revealed that fear levels remained higher among female users compared to male users. Nonetheless, repeated use of the game showed positive motivational effects in helping users train themselves to become comfortable in darkness. This study shows that female users tend to have a higher level of fear than male users. The game application can provide motivation to the users to be braver in facing darkness and to get used to being in the dark.

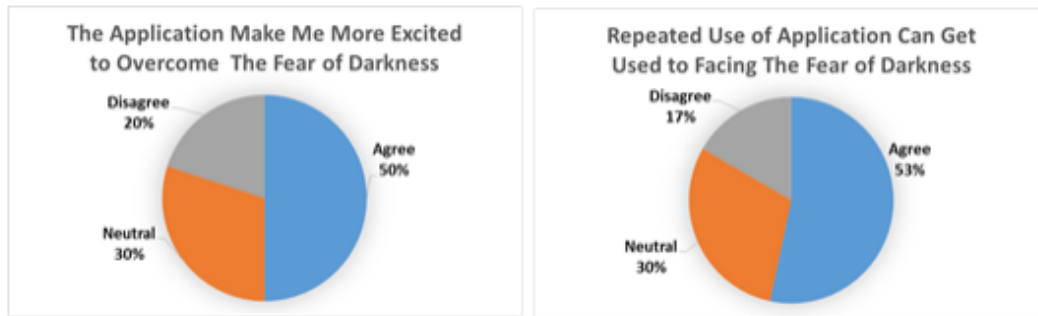


Figure 3.1: Graphic of Motivation to be Braver in Facing Darkness; (b) Graphic of Motivation to Get Used to Darkness Paulus et al. [2019].

3.4 Proposed System

3.4.1 System objectives

The main objective of this project is to develop an immersive Virtual Reality game called **PowerPlay** that aims to help individuals overcome nyctophobia while providing an enjoyable experience. The game exposes patients to anxiety-inducing stimuli resembling real-life situations, allowing them to gradually and repeatedly confront their fear of darkness within a safe and interactive virtual environment. Within this environment, patients have the freedom to move and interact with various objects in order to achieve their goals. To accomplish this, the game needs to fully utilize the capabilities of VR, including immersion, presence, and interactivity. Therefore, significant attention is given to the visual design and game play to enhance patient immersion and trigger fear-related responses. Additionally, **PowerPlay** incorporates fun and motivational tasks, as well as a set of goals to be achieved, in order to increase the effectiveness of phobia treatment and challenge patients to complete their VR therapy sessions.

3.4.2 System Architecture Design

3.4.2.1 Virtual World

Our system relies on immersive virtual reality experience more than reality aspect. To accomplish the project's objectives, we have selected number of features that can be customized to meet the specific needs of individuals state. These features are designed to enhance the sense of immersion

that effectively promotes the desired treatment outcomes.

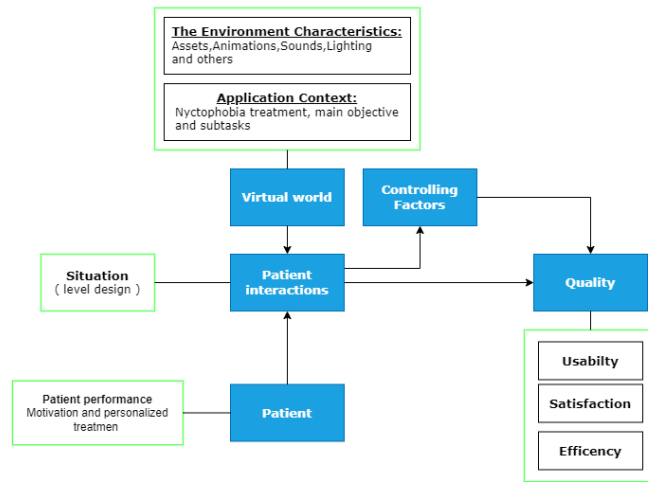


Figure 3.2: System Conception.

- **Application context:** The primary objective of the particular application, in the context of treating the fear of darkness is to minimize or alleviate this specific phobia. To achieve this, the application have two specific tasks ,relaxing session which ensure that the patient is in calm state before the phobia session which must undertake in limited time as part of their therapy(e.g.,restoring the power of the station).Small tasks may encounter the patient based on how well did he do in the current state, offering more challenge to ensure gradual progression and personalized treatment. The selection and design of these tasks take into account the specific context of the fear of darkness, aligning with the goals and objectives of the treatment program.
- **The Environment Characteristics:** it is crucial to develop an appropriate design that convincingly simulates alternative therapy and evokes identical phobic reactions as those experienced in real-world scenarios. The effectiveness of our system and the overall satisfaction of users greatly hinge on this design, as the patient interaction within the virtual reality (VR) environment can have detrimental effects on performance. Conversely, if patients can genuinely engage in a situation, feeling fully immersed and experiencing a profound sense of presence, the treatment becomes feasible. Achieving this requires constructing a consistent environment populated with interactable objects,enhancing the overall stimulation of the

therapeutic simulation.

3.4.2.2 Patient

Virtual reality (VR) offers promising benefits for enhancing patient performance in rehabilitation. Firstly, it creates a motivating and engaging experience by transforming traditional exercises into interactive and game-like activities, combating reduced patient motivation and compliance. By incorporating elements like gamification, rewards, and competition, VR boosts patient engagement and encourages active participation. Additionally, VR facilitates personalized treatment plans by customizing the virtual environment and tasks to suit each patient's abilities and goals. This tailored approach enables therapists to create challenging yet achievable scenarios that optimize patient performance and lead to better outcomes in rehabilitation. Overall, VR holds potential for revolutionizing patient performance by making rehabilitation more enjoyable, stimulating, and personalized Youngblut and Huie [2003].

3.4.2.3 Patient Interaction

The patient interaction aspect is a critical component of our system architecture, as it involves the practical utilization of the system by Patient interaction aspect is a critical component in our system architecture, serving as the practical application of the system by patients. In the virtual environment, individuals actively navigate and participate in a variety of interactions with the purpose of accomplishing the primary objective. As a result, they carry out specific tasks that align with their performance. Maintaining consistency in these interactions within the application's context is crucial, as it guarantees a psychological impact akin to that of real-world experiences.

3.4.2.4 Controlling factors

The factors that govern the outcomes are a direct consequence of the patient's engagement with the virtual world, and they have the potential to impact the effectiveness of our VR application in terms of quality measures. This interaction has the capacity to generate both intended effects, such as a sense of presence, as well as unintended effects like motion sickness. Within our system, one of the anticipated moderating factors is the presence of a fear of darkness, encompassing various symptoms associated with nyctophobia. These factors are expected to be directly activated based on the specific usage scenario.

3.4.2.5 Quality

In our system, the quality of the virtual reality (VR) application is a crucial aspect, as depicted in Figure 3-2. Quality, as defined by the International Organization for Standardization (ISO), refers to the extent to which a set of inherent characteristics meets requirements (International Organization for Standardization, 1998). The degree of quality indicates how well a product or service fulfills its intended purpose, which can be classified as good or poor quality. In the context of VR applications, quality can be further broken down into aspects commonly associated with usability: effectiveness, efficiency, and satisfaction (International Organization for Standardization, 1998). Improvements in these three quality attributes directly impact usability, either enhancing or degrading the user's experience.

Each attribute can be defined as follows:

Effectiveness: The extent to which patients accurately and comprehensively accomplish the designated tasks. Efficiency: The resources expended by patients to successfully and completely achieve the goals of the VR application. Satisfaction: The degree to which patient needs are met through the use of the VR therapy application. A high-quality VR therapy system is characterized by the achievement of its intended purpose which is overcoming the fear of darkness. This entails improved performance with minimal resources and a satisfying user experience.

3.4.3 System pipeline

In order to create the virtual reality therapy application, we needed a systematic approach that focused on designing a virtual environment centered around specific scenario. Our main goal was to develop a methodology that would allow us to create a reliable and engaging virtual world, featuring interactive objects. This methodology was carefully designed, considering both our system architecture and the resources at our disposal. It consists of four steps, which are visually represented in Figure 3-3.

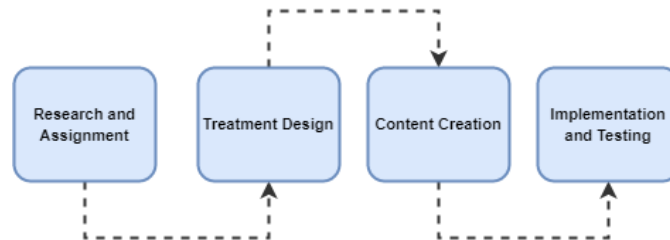


Figure 3.3: System Pipeline of the application.

3.4.3.1 Research and Assignment

This crucial phase was approached with attention to detail, as it serves as the foundation for the rest of the work. We initiated the process by conceptualizing the overall idea for the game, aiming to link the requirements and desired outcomes. The primary and most significant task was to clearly define the goal of the VR application, which, in our case, focused on helping individuals overcome their fear of darkness. Following that, the second step involved identifying the target audience. The virtual environment would be different greatly depending on whether it is designed for children, adults, students, or workers, among others. In this project, the target group consisted of patients with nyctophobia. We then proceeded to describe the specific details of the environment, encompassing elements such as objects, sounds, lighting, and more. Additionally, we outlined the desired user interactions and defined a list of requirements for the development phase. Finally, we made a scenario draft that maintain the context, tasks, virtual world setting, and all the interactions between the patient and the environment.

3.4.3.2 Treatment Design

In this phase, we meticulously analyzed the outcomes of the research phase to establish the fundamental basis of the entire application. The environment description and detailed scenario provided the basis for deriving the lists of objects, actions, and activities. Objects were categorized based on their appearance and functions. The next step involved defining the objects that would be animated within the given situation, including their various states. for example using the flash light as a tool to navigate in the environment , and some doors need to be opened manually if the player is near to them.

All of this is summarized in this diagrams, Figure 3-4 describe the player interaction with the VR System. Once the user is prepared, they select a Session from the main menu and start a new game session or relaxing session depending on the state of the patient (relaxed). Once inside the scenario, In the relaxing session patient will perform '**Schultz training relaxation**' with tips in the scene. When the patient is relaxed he can encounter the phobia in the Game session, the players has the freedom to move in the environment and interact with it. They must successfully complete the main objective, restart the session or exit the game.

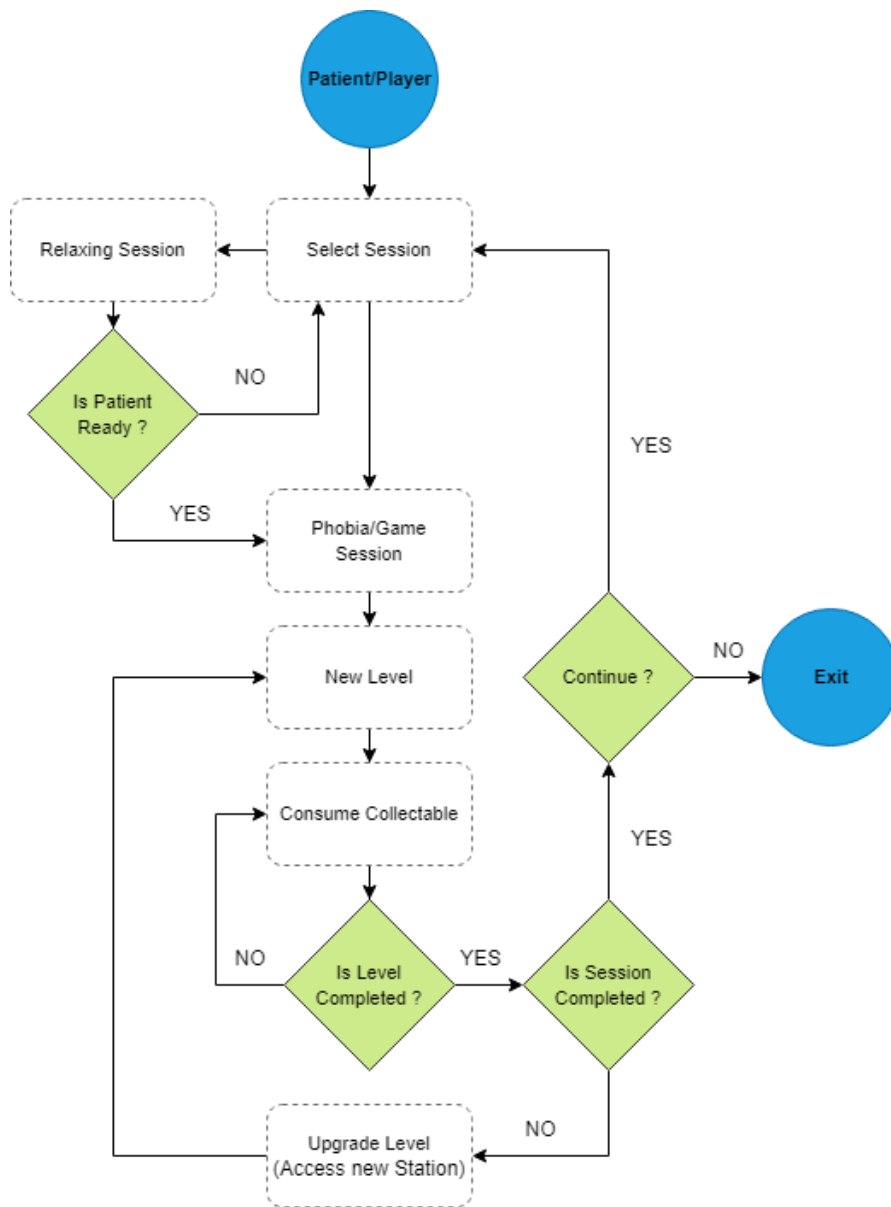


Figure 3.4: Activity diagram of the Player/VR System interactions.

An algorithm flow chart of relaxing session with relaxing and calm environment that contains relaxing steps of Schultz shown in Figure 3-5. The patient will follow and apply the relaxing steps .

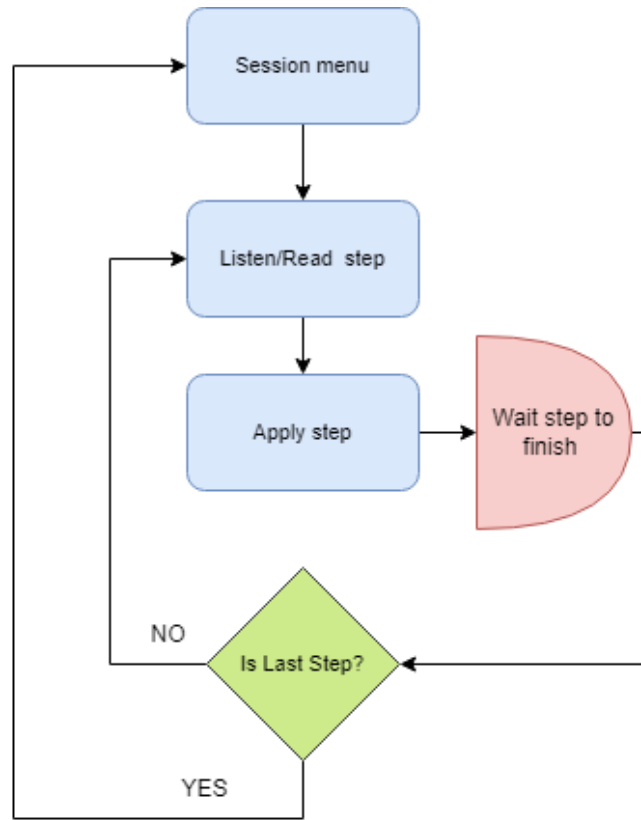


Figure 3.5: Activity diagram of the Player in the Relaxing Session.

An algorithm flow chart of phobia game session with energy collectables distributed randomly in the station and session timer from the scenario draft shown in Figure 3-6. If the patient has consumed all the energy collectables than the station power will be restored and he/she can press the button in the station door to pass to the next station (level) , Completing session could be by session timer or completing last station .

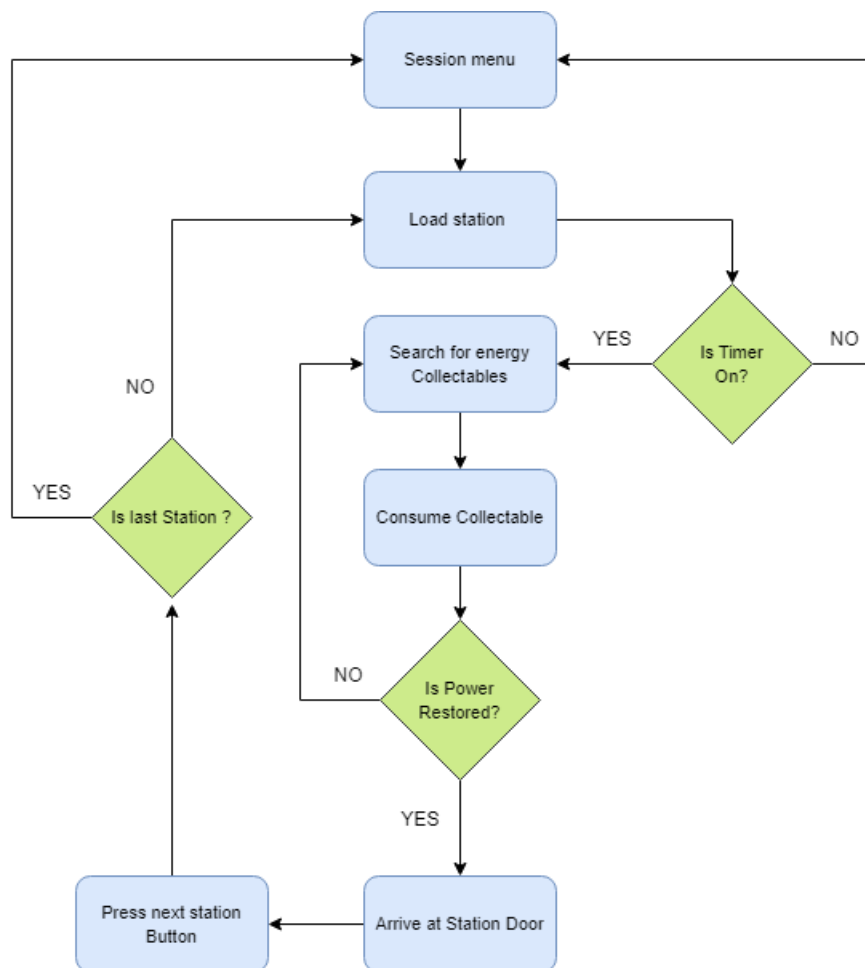


Figure 3.6: Activity diagram of the Player in the Phobia Session.

3.4.3.3 Content Creation

This methodology follows a programming approach in which the assets of the virtual environment are created based on the list of objects and the scenario draft established in previous phases. The objective is to develop the individual components that collectively form the virtual world.

Various assets are required, including scripts, texts, graphics, animations, and sounds, to create a functional environment that addresses the fear of darkness. Graphics encompass both 2D elements like graphical user interfaces (GUI) and 3D models representing different objects within the environment, such as doors, hands, and collectibles. Animations play a crucial role in facilitating interactions between the patient and these graphical elements in the virtual world. Almost every state change is accompanied by a corresponding animation, such as hand animations for inputs or animations for doors and handles. Additionally, the actions and behaviors within the virtual world are supported by various types of scripts. These scripts are responsible for managing object states, initiating state changes, guiding the patient through their experience, and more. The development of these scripts is primarily based on state diagrams that are created in accordance with the detailed scenarios, providing a foundation for their implementation.

3.4.3.4 Implementation and Testing

Once the virtual world was created, we initiated comprehensive testing of all the assets, including scripts, interactions, and the overall atmosphere of the environment. The primary objective was to ensure that our work was aligned with the application requirements and progressing as intended. We placed special emphasis on verifying that the simulated scenario effectively triggered patients with nyctophobia within the intended usage situation. Additionally, we conducted tests to assess the clarity and user-friendliness of the virtual environment and its controls.

Following the testing phase, we proceeded with the deployment of the software application, integrating it with the necessary hardware components. Calibration became a crucial step in this process, particularly for achieving accurate stereoscopic projection and haptic interactions. It was imperative for the patient to perceive touch in its precise position to maintain a sense of presence within the virtual environment. By calibrating for light and acoustic conditions, we aimed to optimize the overall experience. After deployment, a final round of testing was conducted to ensure the system's performance and address any remaining issues or concerns.

3.5 Conclusion

In recent years, virtual reality exposure therapy (VRET) has gained significant prominence as a psychological treatment for Nyctophobia and various anxiety disorders. This therapeutic approach has become widely recognized for its effectiveness. In this chapter, we discussed the benefits of creating overcoming fear experiences specifically to overcome the fear of darkness

within a simulated safe environment. These experiences have demonstrated their efficacy in helping patients confront and control their fears.

Furthermore, we introduced our proposed approach, which aims to provide patients and therapists with an efficient VR therapy application in the form of a game. We outlined the architecture design of the entire system, including its functionality and the detailed phases of system development. Through this approach, we provided a detailed overview of the architecture design for the entire system, elucidating its operational mechanics and outlining the various phases involved in its development.

Chapter 4

Implementation and results

4.1 Introduction

The creation of VR applications, especially in the context of virtual reality therapy for nyctophobia, is a complex process that requires diverse skills and techniques to ensure treatment success. It involves developing a high-performance and low-power architecture through software/hardware design, utilizing prototyping tools, development environments, libraries, and frameworks to create an immersive VR experience with computer-human interactions, and underlying logic. This chapter focuses on the implementation and results of our phobia treatment using a VR system, discussing the implementation details such as the tools and hardware employed in building the application, followed by a description of a series of experiments conducted.

4.2 Application technical description

In preparation for the development of our VR therapy application, we outlined a clear description of the desired game and its objectives. This served as the foundation for identifying the necessary elements, actions, and requirements. The game was designed for collaborative use between the patient and therapist on personal computers. To create an immersive experience, realistic 3D models, graphics, and spatial sounds were developed, providing a high level of fidelity and atmosphere. The patient could interact with the virtual world, including opening doors and manipulating objects, through life like animations and physics-based interactions. The application also offered user control, allowing patients to initiate scenarios, pause game play if needed, or exit the game entirely which is shown in Figure 4-1.

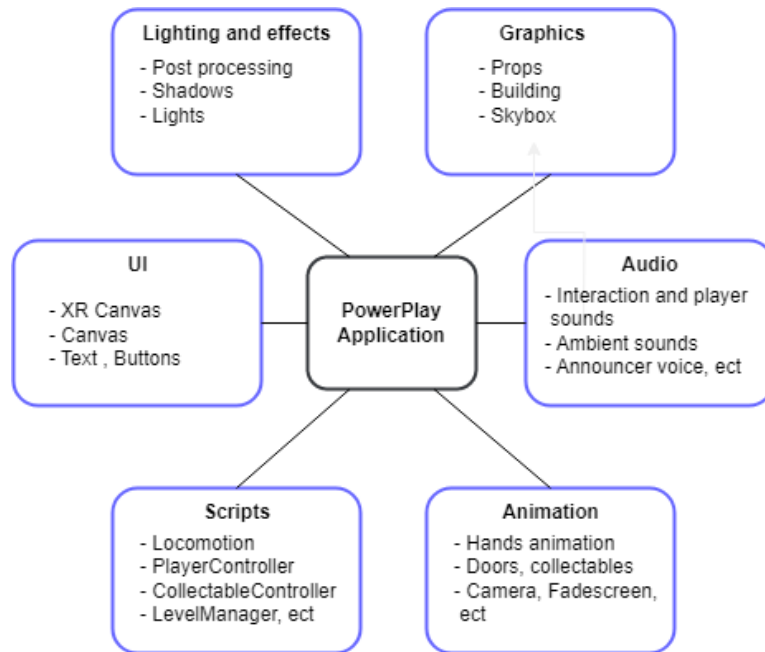


Figure 4.1: Description of the application requirements.

4.2.1 Development Environment

4.2.2 Hardware

To operate our virtual reality system, we have a high-performance PC paired with the HTC Vive headset this hardware configuration for the system includes NVIDIA RTX 3080 GPU, Intel(R) Core(TM) i9-10900F CPU with a processor frequency of 2.8 GHz. It is equipped with 32.0 GB of RAM and runs on the Windows 10 64-bit operating system.

In addition to the hardware configuration mentioned above, two VR headsets were utilized for different purposes. The HTC Vive headsets were employed during the development and testing stages of the application. These headsets offer advanced features and precise tracking, allowing for accurate evaluation and refinement of the VR experience. For the deployment of the application, the Oculus Quest 2 headsets were chosen. These headsets provide a standalone VR experience without the need for a tethered PC, offering portability and ease of use for the end users. The choice of headsets allowed for comprehensive development, rigorous testing, and a seamless deployment of the VR application.

4.2.2.1 HTC Vive

The HTC Vive, a collaboration between HTC and Valve, was introduced in April 2016. The hardware package consists of a headset equipped with a front-facing camera, two handheld motion controllers that provide realistic HD haptic feedback, two base stations for comprehensive 360-degree tracking within the designated play area, a small device to connect the headset to a PC, and all the necessary cables. With its advanced "room scale" tracking technology, the headset enables users to freely navigate and engage with the virtual environment using the controllers in a three-dimensional space. For optimal functionality, the base stations should be strategically positioned at opposite corners of the room, ensuring an unobstructed line of sight between them as they emit laser fields to accurately track motion. Additionally, the room-scale setup, which defines the virtual boundaries of the Vive system.

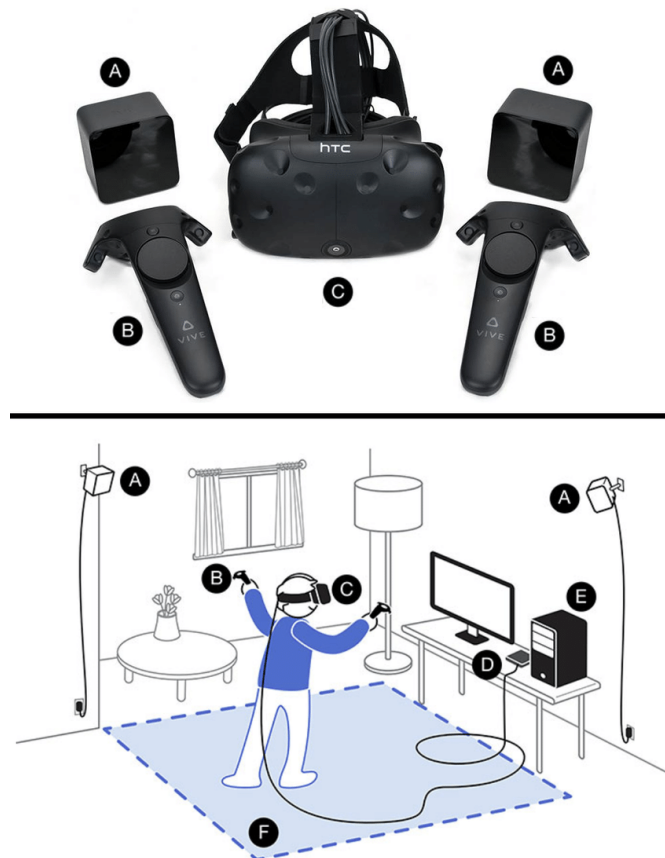


Figure 4.2: Schematic setup of the VR system HTC Vive Tremmel and Krusienski [2019].

HTC Vive system needs to be linked with all the components needed to use the virtual reality shown in Figure 4-2 such as:

- (A) **Base stations:** The base stations are used to track the position of the headset and controllers. They emit lasers that are tracked by the sensors in the headset and controllers.
- (B) **Controllers:** The controllers are used to interact with objects in VR games and experiences. They have sensors that track their movements, and they can be used to grab, throw, or manipulate objects.
- (C) **Headset:** The headset is the main component of the Vive. It has two screens, one for each eye, and it uses sensors to track the user's head movements.
- (D) **Link box:** The link box is a device that connects the headset, controllers, and base stations to the PC. It provides power and data to the headset and controllers, and it sends the video signal from the headset to the PC.
- (E) **high-performance PC:** Computer paired to HTC Vive headset with link box which is capable of generating high quality images.
- (F) **Movement ground:** the ground where players can move in virtual reality beyond this zone Base stations will not catch any movements or rotations from the user.

4.2.2.2 Oculus Quest 2

Released by Oculus in 2020, the Oculus Quest 2 was selected as the VR headset for deploying the application due to its standalone nature, eliminating the need for a PC connection. Equipped with built-in sensors, it enables accurate motion tracking without requiring external base stations or sensors, making it highly portable and adaptable to various environments. The headset boasts a high-resolution display, delivering immersive VR experiences, while the included handheld controllers offer responsive and precise tracking for seamless interaction within the virtual world. A notable advantage of the Oculus Quest 2 is its versatility in accommodating different play areas, allowing users to customize their VR setup based on available space. Utilizing built-in sensors, the headset ensures users can freely navigate their defined boundaries, enhancing the overall VR experience, Figure 4-3.



Figure 4.3: Components of Oculus quest 2.

4.2.3 Software

4.2.3.1 Unity3D

To fulfill the requirements of VR therapy and meet the specified criteria, we have chosen to employ the Unity3D game engine with 2021 long term support version for our application development. Unity3D is powerful 3D engine that supports the creation of both 2D and 3D games and applications across multiple platforms, including mobile, desktop, web, and consoles. As the leading game development platform globally, Unity provides extensive compatibility with various VR devices and file formats commonly used in 3D modeling software such as Blender, 3D Max, and Maya, ensuring seamless integration of rigging, materials, and textures. Moreover, Unity supports widely used image file formats like PNG, JPEG, TIFF, and even layered PSD files from Photoshop. When it comes to audio, Unity supports formats such as WAV and AIF for sound effects, as well as MP3 for music. The primary programming language utilized in Unity is C Sharp, an object-oriented scripting language, which enables the creation of commands for game objects, animations, and the overall logical behavior of the virtual world. Leveraging Unity provided us with an ideal toolkit for implementing imaginative and realistic virtual environments, designing application assets , developing user interfaces, controlling animations, scripting functionality, and maintaining an organized project structure effectively,Figure 4-4.

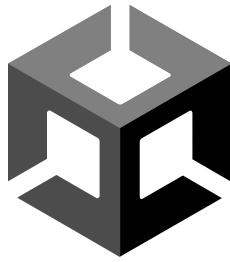


Figure 4.4: Logo of Unity3D Alex [2020].

Unity offers many of plugins in unity assets store that extend the functionality and capabilities of the game engine. These plugins serve various purposes and can enhance different aspects of game development, Such as:

- Unity XR Interaction Toolkit is a plugin that offers a comprehensive framework for implementing interactive elements within VR environments. It simplifies the development process by providing a collection of pre-built components and systems specifically designed for common VR interactions. These interactions include functionalities like object grabbing, teleportation, and user interface interaction. By leveraging the Unity XR Interaction Toolkit, developers can save time and effort in building and fine-tuning these interactions, allowing them to focus more on creating immersive and engaging VR experiences.
- Unity ProBuilder is a powerful plugin for the Unity game engine that allows developers and designers to create, prototype, and refine 3D models directly within their projects. It offers an intuitive interface and editing tools, simplifying the modeling process and eliminating the need for external software. By seamlessly integrating with the Unity Editor, ProBuilder enables rapid prototyping and level design with instant feedback and iteration. The plugin supports UV unwrapping for precise texture mapping and provides advanced features such as subdivision surfaces and procedural geometry generation. With ProBuilder, workflow efficiency and productivity are enhanced, saving time and effort. Its scripting capabilities also offer customization options. Overall, ProBuilder is an invaluable tool that streamlines the 3D modeling workflow and helps create immersive environments in Unity, Figure 4-5.



Figure 4.5: Probuilder unity plugin.

4.2.3.2 Steam VR

SteamVR is a software program designed to improve the overall virtual reality (VR) experience for individuals. It enables them to play VR games and engage in immersive experiences using the HTC Vive headset. The software offers a range of features aimed at increasing user comfort and enjoyment. These include head tracking, which allows users to explore the virtual environment by moving their head. Controller tracking enables natural hand movements to interact with virtual objects, adding a realistic touch. Room-scale tracking allows users to freely move around and fully immerse themselves in the virtual world. The passthrough mode provides a way to see real-world surroundings, making navigation and breaks from VR easier, Figure 4-6.



Figure 4.6: Steam VR Application.

4.2.3.3 Unity OpenXR

Unity OpenXR is a cross-platform API that allows developers to create immersive XR experiences for a variety of devices. It is based on the OpenXR standard, which is an open, royalty-free standard for XR development. Unity OpenXR offers a number of benefits over other XR development platforms, including cross-platform support, performance, and ease of use. It can be used to create a wide variety of immersive experiences, such as virtual reality games, augmented

reality experiences, mixed reality training, and collaborative design experiences, Figure 4-7.

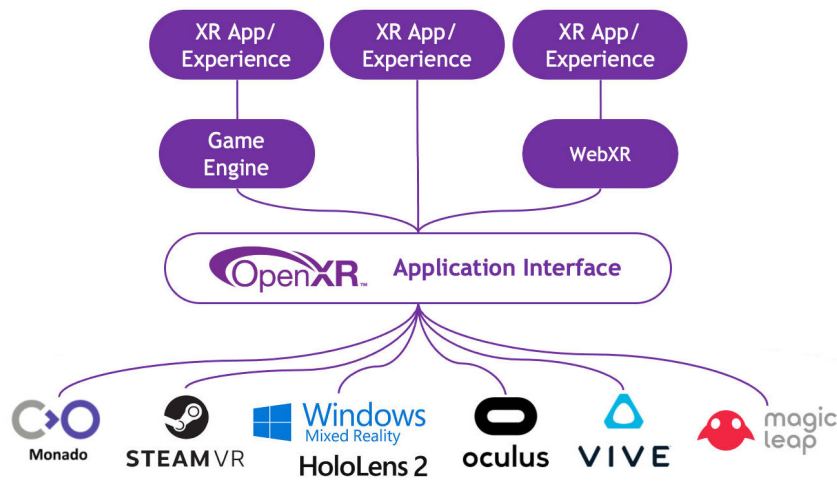


Figure 4.7: Unity OpenXR Support Preview by Late 2020.

4.3 Development Process

In the context of the Application, the HTC Vive device and Controllers captures its own motion using its sensors and transfers this information to the system. These inputs are received by the system's Input Event Listener, which recognizes them and sends the appropriate events to the Event Handler. The Event Handler then sends system functions and GUI system to Level Manager, which contains all the visible elements for the patient. The GUI functions allow the patient to navigate and interact with the interface.

Additionally, the GUI system informs the Level Manager about the visibility status of different parts of the virtual reality (VR) interface. The system functions related to the Level Manager describe animations, audio and behaviors of game objects, such as opening a door, grabbing Objects and playing events sounds.

Once all the information has been processed, any updates are sent to the renderer, which generates the updated visual representation of the scene. This visual result is then sent back to the HTC Vive headset device to be displayed to the patient. A Data Flow diagram in Figure 4-8 illustrates the entire process.

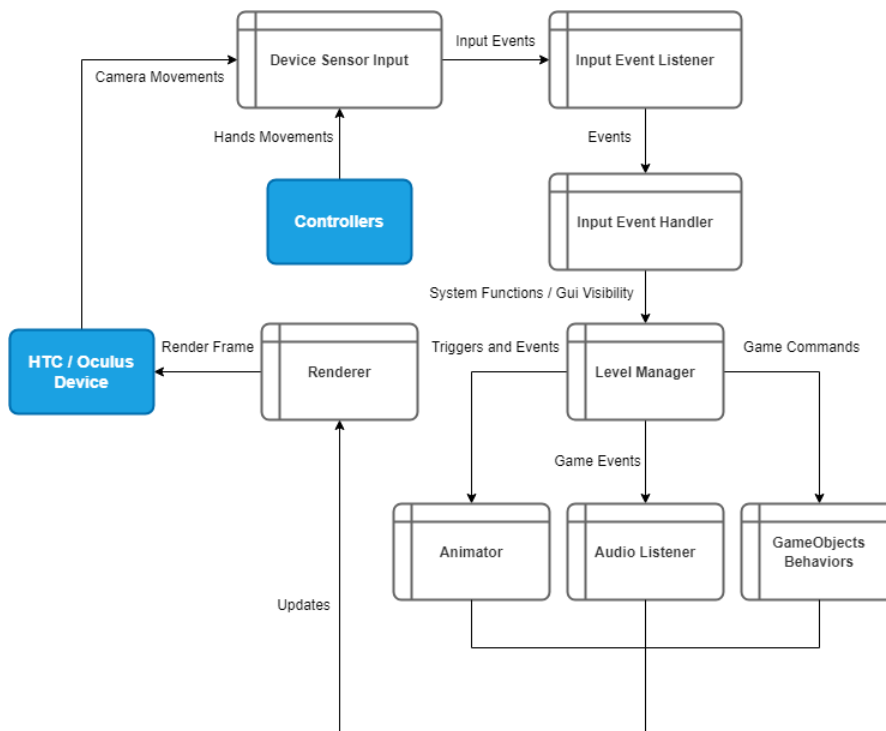


Figure 4.8: Application Data flow.

4.4 Application Prototype

4.4.1 Graphical User Interface

At the beginning of the game, Main Menu is the first scene to start, which is a canvas positioned within the scene. Within the Main Menu, there are several panels that provide various functionalities in Figure 4-9. Additionally, Users can edit some options like relaxing mode, locomotion, main volume settings and more.



Figure 4.9: User Interface of the Main Menu.

Users can create a new session, initiate an available session, or select between relaxing, game or details of the chosen session as shown in Figure 4-10.

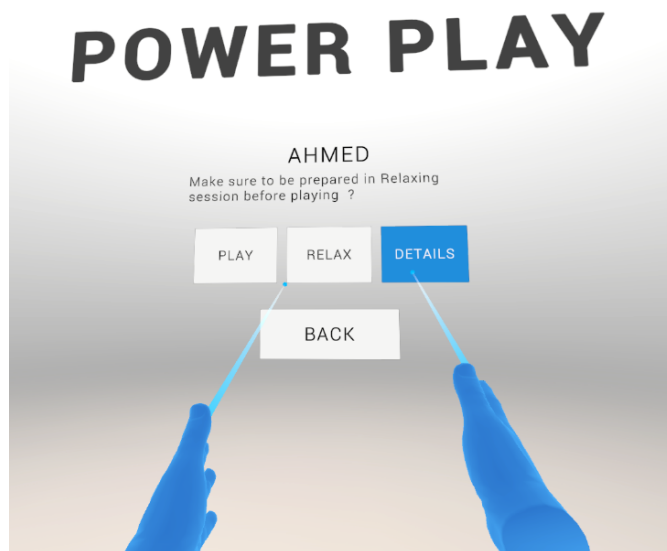
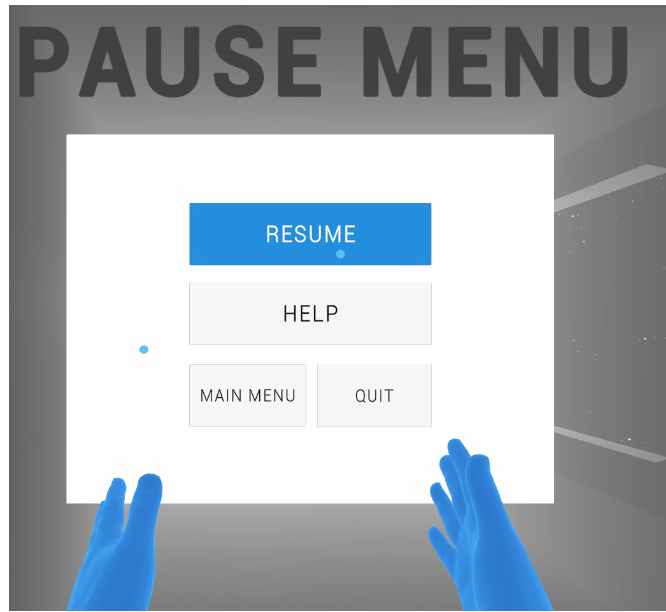
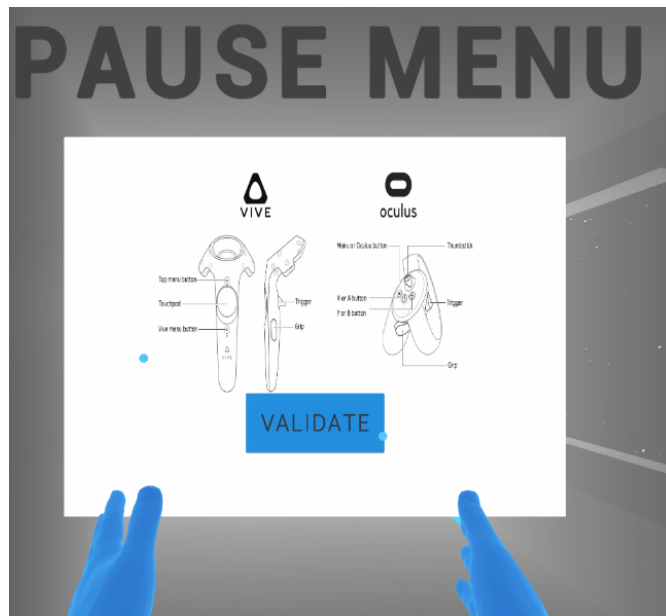


Figure 4.10: Session Menu User Interface.

While inside the virtual environment, patients can pause the game by pressing the menu button on their controller. This action activates the In-Game User Interface as shown in Figure 4-11, which offers the patient the ability to rest restart the entire scenario, consult the help panel, exit the game completely or go back to the main menu.



(a) Pause Menu



(b) Pause Menu Controllers Helper

Figure 4.11: Pause Menu User Interface.

4.4.2 Designed Environment

The primary objective of our game 'PowerPlay' is to assist individuals that have fear of darkness to overcoming their fear. Therefore, the main focus of the project was on creating various situations that realistically portrayed low key lighting scenes, allowing patients to learn how to control their phobic responses in a secure environment before facing similar situations in the real world.

To achieve this, a 3D environment was designed, incorporating diverse assets such as hallways and props with textures to create an engaging and interactive setting. Sound elements were also utilized to enhance the sense of realism and immersion, including relaxing music during graphical user interfaces and relaxing session, doors sounds, ambient sounds like wind, birds and river in the relaxing session rustling and station sounds for the game session. Within these environments, patients are guided by a therapist's tips as notifications in the scene. The first virtual environment in the game is a control station with high light fidelity , featuring numerous hallways with automatic doors. To challenge and motivate individuals with nyctophobia, the game incorporates three progressively difficult levels with different light fidelity and global timer that will decrease the light in the station with time to restore the power of the spaceship, each station requiring to collect all the energy collectables to access the next station.

4.4.2.1 Locomotion and Navigation

When the scene of the first environment is loaded, the patient will be asked to move inside the station and observe what is around to get used to the station environment. Therefore, we added continues turn because most of the patient is used to it and continues movement locomotion due to our environment design that need it. We implemented the locomotion in the right controller which use touch pad for the navigation inside the scene.

4.4.2.2 Interactions and Behavior

To not only replicate the feeling of darkness but also expose patients to realistic situations that teach them how to adapt in environment and make actions, our focus was on the movements of patients so involved searching specific collectable objects designed to increase the station power.

We placed random positions in each station to spawn the collectables and utilized the grab interaction to catch the objects and trigger to consume it for other interactions such as hand

panel and buttons we only use grab. Additionally, we implemented hand poses to show the interaction with the objects which is shown in Figure 4-12.

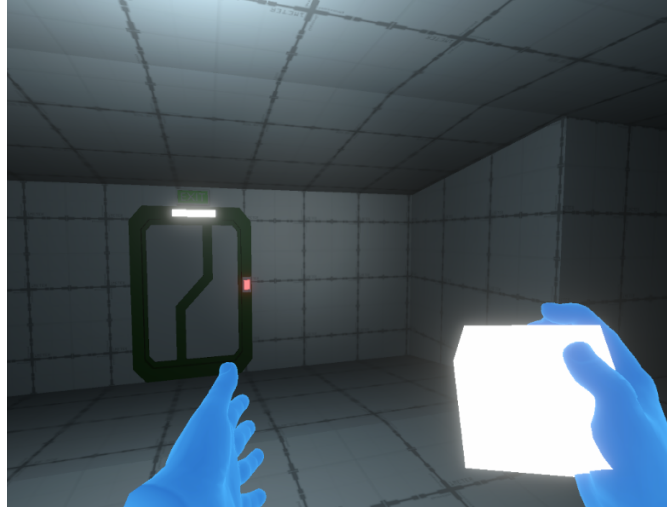


Figure 4.12: Player Interaction with Objects.

4.4.2.3 Animation and Audio

We used multiple animations in the scene such as doors opening and closing, hands trigger/grip/both and collectable animation consume. To effectively control the animation sequences, Unity Animator controller and scripting were employed. The management of animation clips relied on the flow of the Animation State which is determined by external variables such as Triggers, Floats and Booleans, The exit time for all transitions in the animations is set to zero.

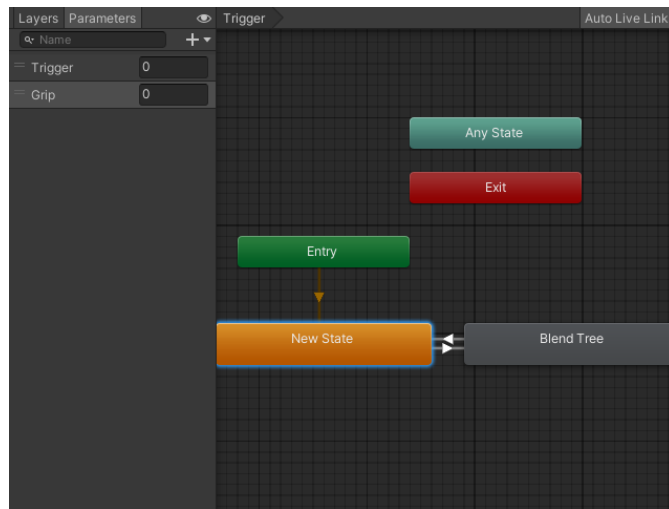


Figure 4.13: Hands State Machine with Blend Tree (Grip/Trigger and Both).

Hands State Machine contains blend tree with animation fingers masks to achieve three goals: trigger that close the thumb and index fingers, grip that close the rest of the fingers and both of the masks will return closed fist animation, as shown in Figure 4-13.

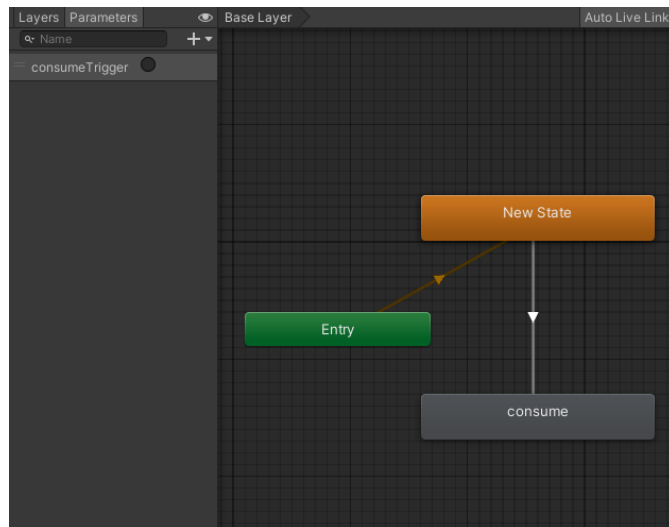


Figure 4.14: Collectable State Machine (Consume).

When player interact with collectables (Trigger) this collectables will be consumed by scale transition animation from default size to zero scale as consume animation , Figure 4-14.

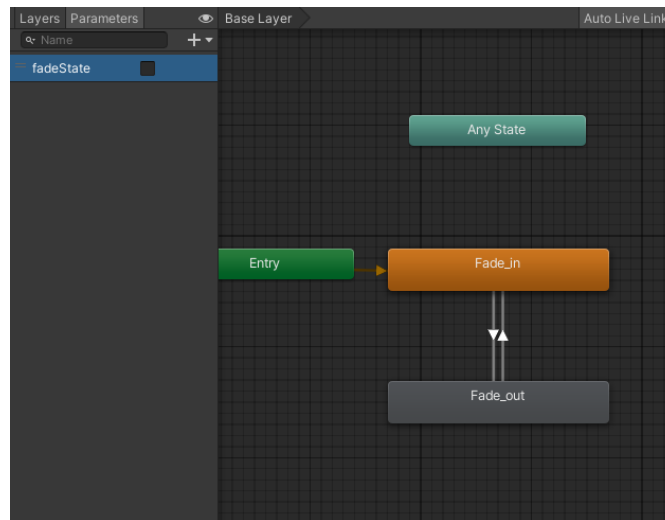


Figure 4.15: Fade Screen State Machine (Fade in/Fade out).

Fade Screen animation is in every scene to mimic the transition between scenes and actions so we created UI Canvas that fill the screen and we change the alpha channel with time to produce the fade in and fade out effect, in Figure 4-15.

Audio and sound play a vital role in enhancing the immersive experience of the application. By incorporating ambient sound loops and realistic player breathing sounds, the scenes come to life, creating a more dynamic atmosphere. Additionally, various objects within the scenes are accompanied by grab and use sounds, such as doors opening and closing, collectables being grabbed and consumed, and the satisfying click of toggling the flashlight on and off. However, one of the standout features is the presence of an announcer station voice, which not only adds depth but also provides essential information about the state and progress of the session, further engaging the users and keeping them informed throughout their play session.

4.4.2.4 Application Scenes

- **Relaxing Scene:** The Relaxing Scene is an important phase of the treatment, designed to create therapeutic environment for the patient. Set against a vibrant green landscape with trees, bushes, and blooming flowers, it aims to evoke a sense of tranquility and peace. The scene is further enhanced by the calm sounds of nature, such as the rustling of wind through leaves, the melodic chirping of birds, and the water flow of a nearby river. These

ambient sounds work harmoniously to guide the patient into a deep state of calmness and relaxation, Figure 4-16.



Figure 4.16: Relaxing Scene Context.

Additionally, within this scene, a user-friendly menu is conveniently placed, allowing the patient to initiate a personalized relaxation session or easily navigate back to the main menu. This scene serves as a pivotal aspect of the treatment, providing a therapeutic escape and fostering a peaceful state of mind for the patient before the phobia phase treatment, Figure 4-17.

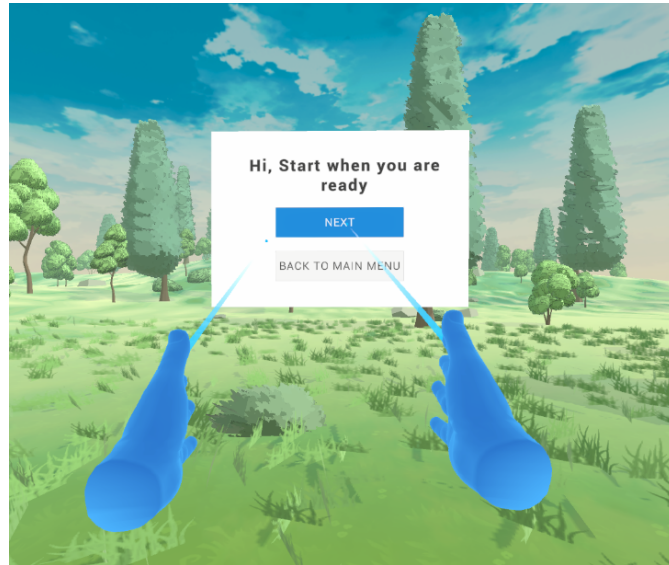


Figure 4.17: Relaxing Scene Menu.

- **Game Scene**

The Game Scene is a carefully designed interactive environment set in a spaceship station, intended to captivate and challenge the patient. It offers a visually stunning experience, paying attention to small details. It consists of three levels of increasing difficulty, aiming to test the patient's decisions and problem-solving skills. Each level presents the patient with a range of engaging challenges and pressures to enhance mental agility and concentration.

To create an additional sense of excitement and urgency, a timer is incorporated, requiring the patient to restore power to each station within a specific time limit. This dynamic element enhances the feeling of accomplishment when successfully completing each level, boosting the patient's confidence and ensuring a positive therapeutic experience. The Game Scene not only provides entertainment but also plays a crucial role in the treatment by promoting resilience, and decisions flexibility.

- **First level**

As the patient enters the first level, they find themselves in security station where an announcer initiates communication, providing essential information about the state of the station. In front of the player, an energy cube becomes visible, acting as a collectable item that can be consumed to demonstrate its functionality. This interactive

element allows the patient to grasp the mechanics of the game while actively engaging with the environment. To effectively trigger the phobia of darkness, the level employs a deliberate approach by gradually decreasing the light fidelity with each progression, Figure 4-18.

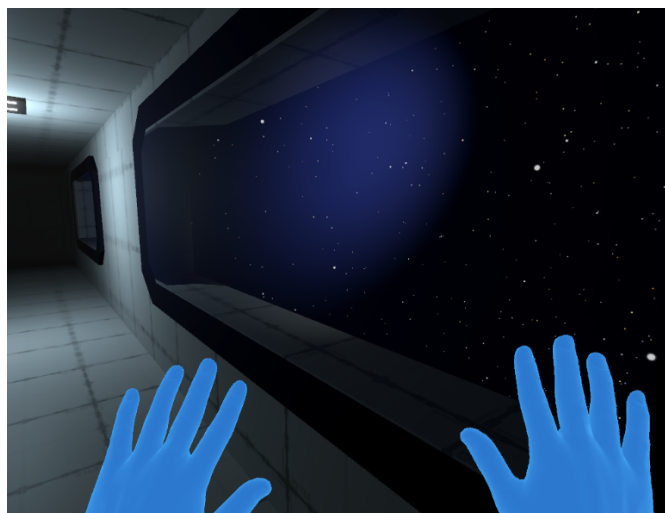


Figure 4.18: Player view in the security station.

– **Second level**

As the patient progresses to the second level in the life station, the announcer provides crucial information regarding the station's status, like the first level player must collect the energy items and because the effectiveness of low fidelity light in this level player will be forced to use the flashlight, providing them with a controlled opportunity to confront and overcome their phobia within the game's supportive setting. This meticulous design ensures a challenging yet manageable experience, making the second level a significant and impactful phase of the overall treatment process, Figure 4-19.

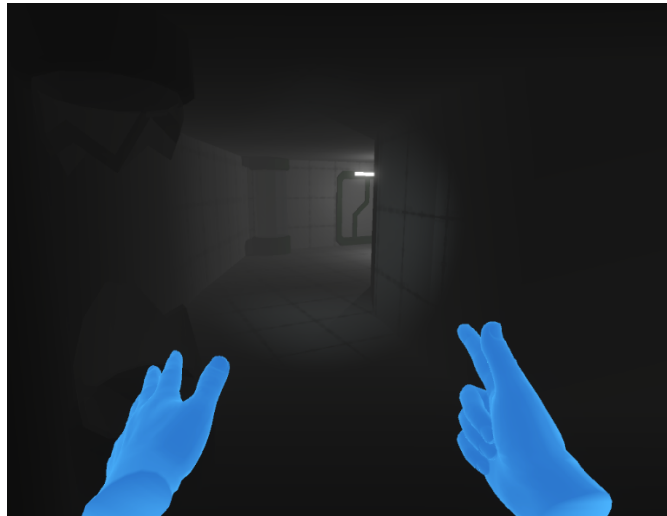


Figure 4.19: Player view with flashlight in the life station.

– **Third level**

In the last level at the crew station, the player relies only on the flashlight to navigate and confront their fear of darkness phobia. In order to fully immerse the patient in this challenging environment, the scene is intentionally rendered as dark as possible, creating an atmosphere that progressively intensifies as they advance through the treatment sessions. As the player consume all the collectables and successfully restores power to the station, they will be able to return to the main menu by pressing the button in the control room. This allows them to save their session states, but if the player fails to restore the power within the designated time frame, they will still be able to return to the main menu with their session states saved accordingly, ensuring continuity and the ability to resume their treatment at a later time, Figure 4-20.

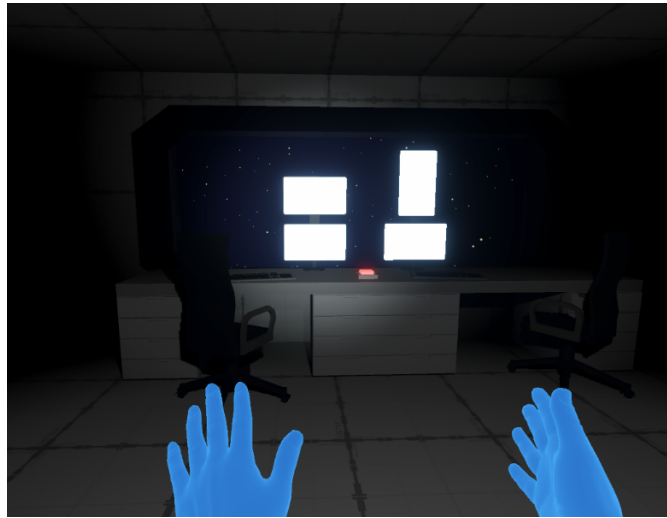


Figure 4.20: Player view inside control room of the crew station.

4.4.3 Application Usability

Using PowerPlay, virtual reality technology is employed to assist individuals in overcoming their fear of darkness. Throughout the therapy, patients are exposed to dark environments in the virtual world, while therapists observe their experiences and fear responses. The therapists then offer cognitive feedback based on these observations, aiming to understand the situations that trigger the highest levels of anxiety for each patient. This understanding is achieved through various methods, such as :

- Measuring the time taken to complete tasks, number of levels completed, session date, conducting fear questionnaires prior to, during and after the virtual reality sessions to evaluate behavioral avoidance and distress levels, Figure 4-21.
- Monitoring the patient's physiological responses and interactions using heart rate sensors. The therapy sessions can be repeated as many times as needed until the patient feels at ease with their responses and witnesses a decrease in anxiety levels.



Figure 4.21: Patient session results.

4.5 Conclusion

The main objective of this chapter was to introduce and discuss the implementation process and outcomes of our virtual reality therapy application. We started by providing a detailed technical description of our system, covering the integration of both hardware and software components. Following that, we proceeded to the development process and data flow involved in creating the application. Lastly, we presented the prototype design and content, which encompassed the virtual environments, graphical user interfaces, locomotion system, interactive elements, Animation and audio within the therapy scenes. Through this comprehensive explanation, we aimed to provide a thorough understanding of the mechanics and features of our VR therapy application.

General Conclusion

Virtual reality (VR) has gained recognition in the mental health field as an effective form of exposure therapy in treating different conditions, including nyctophobia an anxiety disorder prevalent among many individuals, involves an overwhelming fear of darkness that can greatly impact other mental health disorders like major depression. In response to this challenge, PowerPlay a VR game application was created, aiming to offer accessible treatment alternatives to those who face barriers in accessing conventional psychological therapies.

Extensive research on traditional exposure therapy guided the development process, ensuring that the scenarios within the VR application closely resemble the daily activities of patients. A crucial element of the design was the creation of two separated scenes, the first one for relaxation and the other for phobia encounter with realistic 3D virtual environment that effectively conveys the sensation of darkness to the patient. Attention to detail was given during the Virtual World-User Interaction phase to establish a seamless and coherent experience by seamlessly connecting the VR environment, headset, and controllers. Furthermore, the inclusion of a therapist's voice and immersive sound effects contributed to enhancing the patients' sense of presence. The development also encompassed the implementation of an interactive Graphical User Interface, empowering users to control various functionalities of the application.

PowerPlay VR Application immerses individuals with nyctophobia into virtual environments that are both safe and designed to evoke fear gradually. These environments are carefully designed to challenge patients and encourage them to confront their fear repeatedly, all within a controlled and secure setting. The application prototype was developed using the Unity Game Engine, with specific customization to ensure compatibility with multiple headsets like the HTC Vive and Oculus headset and integration with various libraries and plugins.

The advancement of virtual reality (VR) technologies and their potential to transition from specialized laboratories to clinical settings, making top-tier psychological interventions more accessible for individuals with mental health disorders. We believe that our application can provide comprehensive and effective clinical assessments in the future. To achieve this goal, we plan to conduct and validate our system in collaboration with a therapist. we specifically aim to evaluate the impact of "PowerPlay" on a group of individuals with nyctophobia. After that, we intend to assess the effects of VR sessions before and after treatment. After the feedback we will make changes in the environment based on the majority of the patients feedback and add more immersive elements and technology like hand tracking and hand physics and more immersive functions to augment the effectiveness of the application in the treatment.

Bibliography

- A. Aleksandrovich and L. Gomes. Shared multisensory sexual arousal in virtual reality (vr) environments. *Paladyn, Journal of Behavioral Robotics*, 11:379–389, 08 2020. doi: 10.1515/pjbr-2020-0018.
- Alex. Oculus rift s review – how it holds after 1 year of usage. 2020. URL <https://riftinfo.com/oculus-rift-s-review-how-it-holds-after-1-year-of-usage>.
- D. American Psychiatric Association, A. P. Association, et al. *Diagnostic and statistical manual of mental disorders: DSM-5*, volume 5. American psychiatric association Washington, DC, 2013.
- P. L. Anderson, M. Price, S. M. Edwards, M. A. Obasaju, S. K. Schmertz, E. Zimand, and M. R. Calamaras. Virtual reality exposure therapy for social anxiety disorder: a randomized controlled trial. *Journal of consulting and clinical psychology*, 81(5):751, 2013.
- O. Baus and S. Bouchard. Moving from virtual reality exposure-based therapy to augmented reality exposure-based therapy: A review. *Frontiers in human neuroscience*, 8:112, 03 2014. doi: 10.3389/fnhum.2014.00112.
- A. T. Beck. The past and future of cognitive therapy. *The Journal of psychotherapy practice and research*, 6(4):276, 1997.
- I. Cherif. Acrofree: A virtual reality serious game application for overcoming acrophobia. 2020. URL http://archives.univ-biskra.dz/bitstream/123456789/15790/1/Intissar_Cherif.pdf.
- C. Cruz-Neira, M. Fernández, and C. Portalés. Virtual reality and games, 2018.

- J. M. D. Delgado, L. Oyedele, P. Demian, and T. Beach. A research agenda for augmented and virtual reality in architecture, engineering and construction. *Advanced Engineering Informatics*, 45:101122, 2020.
- J. Durl, T. Dietrich, B. Pang, L.-E. Potter, and L. Carter. Utilising virtual reality in alcohol studies: A systematic review. *Health Education Journal*, 77(2):212–225, 2018.
- A. R. Franzcp. Assertive community treatment-issues from scientific and clinical literature with implications for practice. *Journal of Rehabilitation Research and Development*, 44(6):813, 2007.
- R. Gonçalves, A. L. Pedrozo, E. S. F. Coutinho, I. Figueira, and P. Ventura. Efficacy of virtual reality exposure therapy in the treatment of ptsd: a systematic review. *PloS one*, 7(12):e48469, 2012.
- D. Horváthová, V. Siládi, and E. Lacková. Phobia treatment with the help of virtual reality. In *2015 IEEE 13th International Scientific Conference on Informatics*, pages 114–119. IEEE, 2015.
- S. Kavanagh, A. Luxton-Reilly, B. Wuensche, and B. Plimmer. A systematic review of virtual reality in education. *Themes in Science and Technology Education*, 10(2):85–119, 2017.
- E. A. Keshner, P. T. Weiss, D. Geifman, and D. Raban. Tracking the evolution of virtual reality applications to rehabilitation as a field of study. *Journal of neuroengineering and rehabilitation*, 16(1):1–15, 2019.
- J. Levos and T. L. Zacchilli. Nyctophobia: from imagined to realistic fears of the dark. *Psi Chi Journal of Psychological Research*, 20(2):102–110, 2015.
- P. Lindner, A. Rozental, A. Jurell, L. Reuterskiöld, G. Andersson, W. Hamilton, A. Miloff, P. Carlbring, et al. Experiences of gamified and automated virtual reality exposure therapy for spider phobia: qualitative study. *JMIR serious games*, 8(2):e17807, 2020.
- X. Liu, J. Zhang, G. Hou, and Z. Wang. Virtual reality and its application in military. *IOP Conference Series: Earth and Environmental Science*, 170:032155, 07 2018. doi: 10.1088/1755-1315/170/3/032155.

- H. Mäkinen, E. Haavisto, S. Havola, and J.-M. Koivisto. User experiences of virtual reality technologies for healthcare in learning: An integrative review. *Behaviour & Information Technology*, 41(1):1–17, 2022.
- M. C. Mishkind, A. M. Norr, A. C. Katz, and G. M. Reger. Review of virtual reality treatment in psychiatry: evidence versus current diffusion and use. *Current psychiatry reports*, 19:1–8, 2017.
- B. O. Olatunji, J. M. Cisler, and B. J. Deacon. Efficacy of cognitive behavioral therapy for anxiety disorders: A review of meta-analytic findings. *Psychiatric Clinics of North America*, 33(3):557–577, 2010. ISSN 0193-953X. doi: <https://doi.org/10.1016/j.psc.2010.04.002>. URL <https://www.sciencedirect.com/science/article/pii/S0193953X10000444>. Cognitive Behavioral Therapy.
- M. O. Onyesolu and F. U. Eze. Understanding virtual reality technology: advances and applications. *Adv. Comput. Sci. Eng*, pages 53–70, 2011.
- S.-M. Park and Y.-G. Kim. A metaverse: Taxonomy, components, applications, and open challenges. *IEEE Access*, 10:4209–4251, 2022. doi: 10.1109/ACCESS.2021.3140175.
- E. Paulus, F. Yusuf, M. Suryani, and I. Suryana. Development and evaluation on night forest virtual reality as innovative nyctophobia treatment. *Journal of Physics: Conference Series*, 1235(1):012003, jun 2019. doi: 10.1088/1742-6596/1235/1/012003. URL <https://dx.doi.org/10.1088/1742-6596/1235/1/012003>.
- Realite-Virtuelle. Failed vr headsets: top of the worst virtual reality failures. URL <https://www.realite-virtuelle.com/casques-vr-rates-top-echecs/%7D>.
- D. Reimer. *The Illusion of Infinite Space Inside a Positional Tracked Virtual Environment*. PhD thesis, 08 2017.
- B. O. Rothbaum and A. C. Schwartz. Exposure therapy for posttraumatic stress disorder. *American journal of psychotherapy*, 56(1):59–75, 2002.
- R. Sheldon. Virtual reality, 2021. URL <https://www.techtarget.com/whatis/definition/virtual-reality>.
- J. Steuer, F. Biocca, M. R. Levy, et al. Defining virtual reality: Dimensions determining telepresence. *Communication in the age of virtual reality*, 33:37–39, 1995.

- I. E. Sutherland et al. The ultimate display. In *Proceedings of the IFIP Congress*, volume 2, pages 506–508. New York, 1965.
- TechTarget. What is virtual reality?, 2023. URL <https://www.techtarget.com/whatis/definition/virtual-reality>.
- C. Tremmel and D. Krusienski. Eeg spectral conditioning for cognitive-state classification in interactive virtual reality. pages 2806–2811, 10 2019. doi: 10.1109/SMC.2019.8914264.
- N. Tsamitros, A. Beck, M. Sebold, M. Schouler-Ocak, F. Bempohl, and S. Gutwinski. The application of virtual reality in the treatment of mental disorders. *Der Nervenarzt*, 94, 09 2022. doi: 10.1007/s00115-022-01378-z.
- J. Turi. The sights and scents of the sensorama simulator, 2014. URL <https://www.engadget.com/2014-02-16-morton-heiligs-sensorama-simulator.html>.
- VirtualSpeech. History of vr, 2021. URL <https://virtualspeech.com/blog/history-of-vr>.
- B. K. Wiederhold and M. D. Wiederhold. *Virtual reality therapy for anxiety disorders: Advances in evaluation and treatment*. American Psychological Association, 2005.
- K. B. Wolitzky-Taylor, J. D. Horowitz, M. B. Powers, and M. J. Telch. Psychological approaches in the treatment of specific phobias: A meta-analysis. *Clinical Psychology Review*, 28(6):1021–1037, 2008. ISSN 0272-7358. doi: <https://doi.org/10.1016/j.cpr.2008.02.007>. URL <https://www.sciencedirect.com/science/article/pii/S0272735808000639>.
- C. Youngblut and O. Huie. The relationship between presence and performance in virtual environments: Results of a vertx study. In *IEEE Virtual Reality, 2003. Proceedings.*, pages 277–278. IEEE, 2003.