

Mobile-Based Virtual Reality Application for Experiencing and Detecting Claustrophobia

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Abstract — *Phobias may cause anxiety disorder, which imposes the pupils with phobias to overreact compared to the normal situation level. Undergoing therapy is an expensive and time-consuming process. Virtual reality (VR) can help users fully experience and overcome the things they fear without being put in dangerous situations in the real world. However, there is a limited number of VR applications to identify claustrophobic symptoms. In this paper, the Virtual Claustrophobia Room (VCR) is specifically designed for the users to experience Claustrophobia and to detect the symptoms of this kind of phobia while giving information about it. To develop VCR, the framework of VR has been referred which contains VR Application, VR Contents, and VR Evaluation. By developing VCR using the proposed framework, it is ready to test its usability in the real environment. It is believed that this application can early detect the claustrophobic symptoms and at the same time improve the health level of the users with this kind of phobia by exposing them to VR-based applications.*

Keywords — *Claustrophobia, Medicine, Phobia, Virtual reality.*

I. INTRODUCTION

Claustrophobia consists of the Latin term *claustro*, which means locked or closed, and phobia itself [1]. Claustrophobia is a fear of enclosed spaces, which can be unpleasant and distressing [2]. The pupils with this kind of phobia normally find ways to cope with this phobia by avoiding the small and enclosed places such as small or locked rooms, tunnels, cellars, elevators, subway trains, and crowded places. Besides, Claustrophobia is also related to the fears of restriction and of being trapped [2]. Therefore, there are 2 categories of fears related to Claustrophobia, which are fear of suffocation and fear of restriction [2]. Since Claustrophobia is classified as an anxiety disorder, certain claustrophobic symptoms can be detected and appeared especially during childhood or adolescence, such as accelerated heart rate, sweating and chills and high blood pressure, dizziness, fainting, and light-headedness, dry mouth, hyperventilation, or “over-breathing,” hot flashes, shaking or trembling and a sense of “butterflies” in the stomach, nausea, headache, numbness, a choking sensation, tightness in the chest, chest pain, and difficulty breathing, an urge to use the bathroom, confusion

or disorientation, and fear of harm or illness [3]. Even the use of exposure therapy has been proven to be effective in the treatment of phobias [4], undergoing therapy is an expensive and time-consuming process.

Virtual reality (VR) has contributed to helping users to fully experience and overcome the things they fear without being put in dangerous situations in the real world [5]. VR has been defined as a computer-simulated environment that can simulate physical presence in real or imaginary worlds [6]. Through VR, users are able to visualize and interact with the computer and complex data such as graphical objects and virtual agents as well as navigate in the virtual world [7]. Such elements provide the users an immersive feeling [8]. VR has been applied in various fields of medicine and is often used for educational purposes [9]. For Claustrophobia, most VR applications were developed for preventive care, treatment, and learning. There is a limited number of VR applications focusing on identifying claustrophobic symptoms.

This paper explains in detail the method to model VR application for Claustrophobia called Virtual Phobia Room. Through this application, claustrophobic symptoms can be detected. The next sections are about related works in Section 2, materials and methods in Section 3, results and discussion in Section 4, and lastly, the conclusion in Section 5.

II. RELATED WORKS

VR applications for Claustrophobia were developed for its treatment in 1998, as done by Botella et al. [10]. Malbos et al. [1] developed a VR application for the treatments of Claustrophobia using affordable VR apparatus and software. In the application, six claustrophobic patients tested multiple context-graded enclosed game editor virtual environments. Through the implemented questionnaires and behavior tests, the results exhibited a significant reduction in fear towards the enclosed space and quality of life improvement.

Botella et al. [5] studied the effectiveness of VR exposure in treating claustrophobic fear. The developed VR application had utilized a Silicon Graphics Indigo High Impact computer graphics workstation, a high-quality head-mounted display, and an electromagnetic sensor for tracking the participant's head and right hand. The results showed that VR exposure was effective in reducing fear



and avoidance in closed spaces and in increasing self-efficacy in claustrophobic situations.

Bruce and Regenbrecht [4] also developed Virtual Reality Exposure Therapy (VRET) for treating claustrophobia using Microsoft's XNA framework (Game Studio 2.0).

Based on the related works done previously, VR applications for Claustrophobia have been contributing to treat the users with Claustrophobia. Therefore, it is recent and very appropriate to apply and develop VR applications for Claustrophobia in detecting its symptoms.

III. METHODS AND MATERIALS

In order to ensure the success of this study, implementation of a case study and framework has been done. This section discusses the case study involved in the project as well as the framework implemented to develop the VR application for the case study.

A. Case study

There were various purposes of the existing VR applications for Claustrophobia. In this study, the main focus of developing the Virtual Claustrophobia Room is to detect the claustrophobic symptoms as an early step to cope with it.

B. Framework

The framework of Virtual Claustrophobia Room (VCR) was designed and implemented to develop the VR application, as shown in Fig. 1. The framework contained three main modules, including VR platform, VR contents, and VR evaluation.

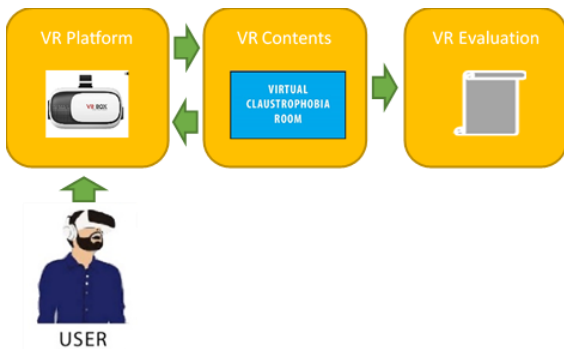


Fig. 1: Framework of VCR

VR platform focuses on the display of this application, which is in Android mobile phone using VR Box. The VR platform allows the users to visualize, walkthrough, and interact with the virtual objects inside the virtual environments.

VR contents emphasize the development the virtual environments for Claustrophobia. There are three types of virtual environments designed based on the levels of difficulties, which are virtual environments of a small room, tunnel, and cave. The obstacles of blocking walls and creeping creatures were created and placed in the virtual environments as the trigger components of claustrophobic symptoms. The virtual environments and

the trigger components were modeled and textured in 3D using Autodesk Maya, as shown in Fig. 2 and Fig. 3. They were exported into FBX file format, including their animations to be gathered in the main platform, Unity3D. In Unity3D, Visual Studio using C# programming language was run to compile and run the scripts of shrinking animation, timer, walkthrough, visualization, and gaze interaction, as shown in Fig. 4.

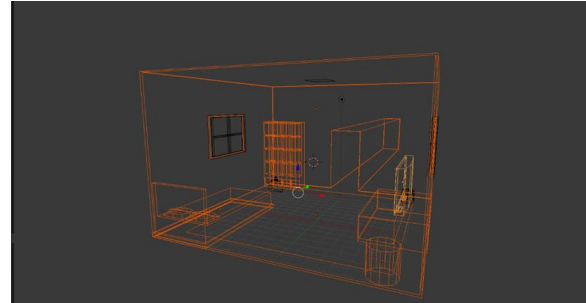


Fig. 2: Modelling 3D virtual environments

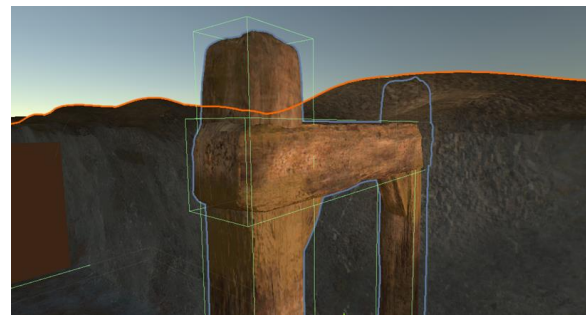


Fig. 3: Texturing 3D models

```

public class Room : MonoBehaviour
{
    public GameObject[] walls;
    public GameObject[] floor;
    public GameObject[] ceiling;
    public GameObject[] furniture;
    public GameObject[] obstacles;
    public GameObject[] creatures;
    public GameObject[] triggers;
    public GameObject[] lights;
    public GameObject[] sounds;
    public GameObject[] textures;
    public GameObject[] materials;
    public GameObject[] shaders;
    public GameObject[] physics;
    public GameObject[] animation;
    public GameObject[] UI;
    public GameObject[] camera;
    public GameObject[] audio;
    public GameObject[] network;
    public GameObject[] security;
    public GameObject[] encryption;
    public GameObject[] decryption;
    public GameObject[] compression;
    public GameObject[] decompression;
    public GameObject[] encryption;
    public GameObject[] decryption;
    public GameObject[] compression;
    public GameObject[] decompression;
}

using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Class : MonoBehaviour
{
    Animator animator;
    bool ClassFX;

    void Start()
    {
        ClassFX = false;
        animator = GetComponent();
    }

    void OnTriggerEnter(Collider kecil)
    {
        if (kecil.gameObject.tag == "Player")
        {
            ClassFX = true;
            KeecilControl("Shrink");
        }
    }

    void KeecilControl(string direction)
    {
        animator.SetTrigger(direction);
    }
}
    
```

Fig. 4: Examples of scripts

VR evaluation focuses on the aspects of collecting data of timer, levels of obeying the given instructions, collision with the obstacles and walls, and frequencies of destroying the obstacles. Collecting the data of these aspects are important to examine their correlations in order to determine or detect the symptom of Claustrophobia.

IV. RESULTS AND DISCUSSION

VCR has been developed and implemented into a real prototype for the end-user. The testings of the VCR application were executed to test the whole functionalities and credibility of the developed application. In this section, the deployment and configuration, the application's interfaces, and the testings have been discussed in detail.

A. Deployment and Configuration

VCR was developed and implemented as an android application using Unity 3D, which has been integrated with Visual Studio in order to develop the designs, codes, tests, debugs, and execute the main process of the application.

In terms of hardware, this application was developed using a Lenovo Legion Y520 i7 with Intel® Core™ i7-7700HQ CPU@2.80Ghz processor, Nvidia Geforce GTX1050 graphic card, 12 GB RAM, SSD 240 GB hard disk, and Windows 10 platform. To test running in the mobile phone through VR Box, Sony Xperia Z5 was utilized as an Android mobile phone.

B. Interfaces

The outputs of the proposed framework can be seen in the forms of interfaces.

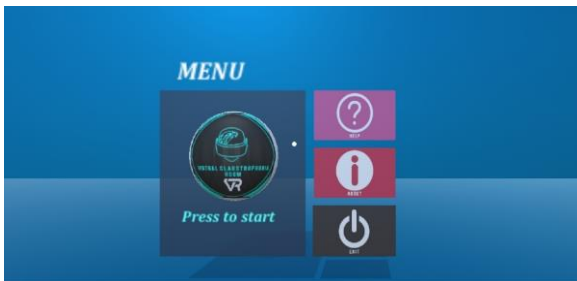


Fig. 5: Main menu containing buttons

The main menu is the first view of this application. Fig. 5 shows the main menu featuring four optional buttons to be selected, including the levels, help for instruction, information about symptoms, and exiting the application.

Fig. 6 and Fig. 7 respectively show the users about the symptoms of claustrophobia information and how to use VCR using the headgear.



Fig. 6: Interface of About

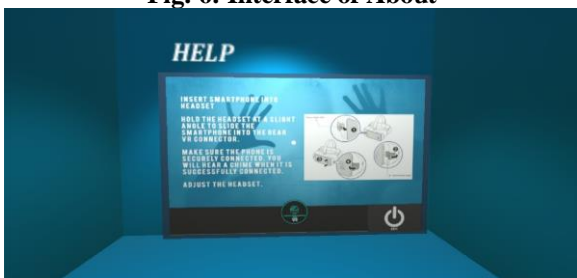


Fig. 7: Interface of Help

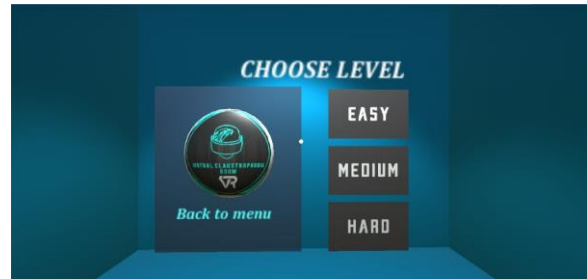


Fig. 8: Interface of Sub-Menu-Levels

When the Start button is pressed by the users, they will be brought in the interface of sub-menu- levels. Fig. 8 shows the options of difficulty levels, including easy, medium, and hard to be selected. Each level of difficulty contains a certain virtual environment of the claustrophobic situation.



Fig. 9: Easy level of VCR

In the easy level, as shown in Fig. 9, the users are located in a virtual environment of a small room, which will shrink from time-to-time. This virtual environment forces the users to follow the instructions given in order to reach the final destination. The timing to reach the final destination is recorded for evaluation purposes.

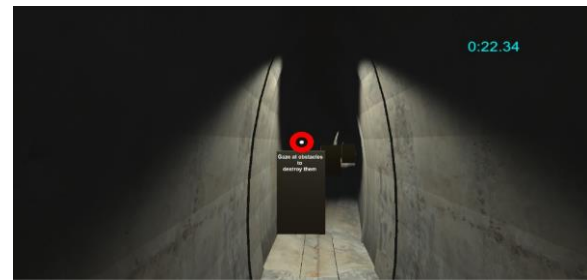


Fig. 10: Medium level of VCR

As shown in Fig. 10, the medium level of VCR brings the users to a virtual environment of the tunnel. The tunnel has blinking lights and several obstacles in the form of blocking walls. To pass or destroy the obstacles, the users need to use gaze interaction for a short period of time at the obstacles. The timing to reach the final destination is also recorded for evaluation purposes.

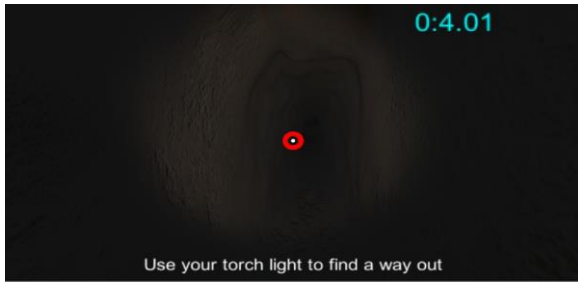


Fig. 11: Hard level of VCR

On the hard level, as shown in Fig. 11, a virtual environment of a cave is designed for the users to be experienced. The cave is very dark, and the users have to use a torchlight to see and walk in the virtual environment. The obstacles of blocking walls and several creeping creatures are also placed in this environment. The users need to use gaze interaction for a short period of time at the obstacles and creeping creatures to pass or destroy them, as shown in Fig. 12. The timing to reach the final destination is also recorded for evaluation purposes.



Fig. 12: The destroyed obstacles using gaze interaction

C. Testing

In order to ensure the developed VR application has fully functioned and free-error, testing is required [11]. The testing can be implemented in several ways in order to check if the users’ requirements are met. In this paper, the testing was implemented to test the functionalities of the modules designed in the proposed framework. The testing called test case could be divided into Test Case 1 for VR platform functionalities, Test Case 2 for VR contents functionalities, and Test Case 3 for VR evaluation functionalities.

Table 1: Test Case 1 for VR Platform Functionalities

Test Case 1			
Test Case Name: VR Platform Functionalities			
Application: Virtual Claustrophobia Room			
Step	Procedures	Expected Result	Result
1	Click on the “VCR” app icon	Display main menu	Success
2	Main Menu Page: -Gaze pointer on the “Press to start” button	Display submenu page	Success
3	Main Menu Page: -Gaze pointer on “Help” button	Display instruction page	Success
4	Main Menu Page:	Display	Success

	-Gaze pointer on “About” button	information page	ss
5	Main Menu Page: -Gaze pointer on “Exit” button	Exit from VCR application	Success
6	Sub-Menu Page: -Gaze pointer on “EASY” button	Display virtual environment of the small room.	Success
7	Sub-Menu Page: -Gaze pointer on “MEDIUM” button	Display virtual environment of the tunnel.	Success
8	Sub-Menu Page: -Gaze pointer on “HARD” button	Display virtual environment of the cave.	Success

As shown in Table 1, there were several buttons placed on certain pages in VCR. The users would be brought into certain pages when the buttons were clicked. The functionalities of each button in this test case were successful.

Table 2: Test Case 2 for VR Contents Functionalities

Test Case 2			
Test Case Name: VR Contents Functionalities			
Application: Virtual Claustrophobia Room			
Step	Procedures	Expected Result	Result
1	EASY:		
	i. The users start entering the VE.	-Display the instruction. -Shrinking the wall.	Success
	ii. Gaze pointer on floor.	-Move forward.	Success
	iii. Gaze pointer on left or right.	-Turn left or right.	Success
	iv. Gaze pointer on the door.	-Open the door.	Success
	v. Gaze pointer on obstacles.	-Destroy the obstacles.	Success
1	vi. The users reach the final destination.	-Display the text “You reach the destination. Congratulation!”	Success
			Success
2	MEDIUM:		
	i. The users start entering the VE.	-Display the instruction. -Blink and turn off the lights.	Success
	ii. Gaze pointer on floor.	-Move forward.	Success
	iii. Gaze pointer on left or right.	-Turn left or right.	Success
2	iv. Gaze pointer on the door.	-Open the door.	Success

	v. Gaze pointer on obstacles. vi. The users reach the final destination.	-Destroy the obstacles. -Display the text "You reach the destination. Congratulation!"	ss Succes ss Succes ss
3	HARD: i. The users start entering the VE. ii. Gaze pointer on floor. iii. Gaze pointer on left or right. iv. Gaze pointer on the door. v. Gaze pointer on obstacles. vi. Gaze pointer on creeping creatures. vii. The users reach the final destination.	-Display the instruction. -Turn on the torchlight. -Move forward. -Turn left or right. -Open the door. -Destroy the obstacles. -Destroy the creeping creatures. -Display the text "You reach the destination. Congratulation!"	Succes ss Succes ss Succes ss Succes ss Succes ss

		-Obtain the frequencies of collision with the walls.	
2	MEDIUM: i. The users start entering the VE. ii. The users reach the final destination.	-The timer is started. -Display the instruction. -The timer is stopped. -Obtain the start and stop the timer. -Obtain the frequencies of collision with the walls. -Obtain the frequencies of destroyed obstacles and creeping creatures.	Success Success Success Success Success Success
3	HARD: i. The users start entering the VE. ii. The users reach the final destination.	-The timer is started. -The timer is stopped. -Obtain the start and stop the timer. -Obtain the frequencies of collision with the walls. -Obtain the frequencies of destroyed obstacles and creeping creatures.	Success Success Success Success Success

Table 2 describes the test case of contents functionalities in VCR. The contents functionalities included the capabilities to display instructions, to trigger the claustrophobic symptom components, and to gaze for interactions. For this test case, the results show the functionalities of VR contents for each level had been achieved successfully.

Table 3: Test Case 3 for VR Evaluation Functionalities

Test Case 3			
Test Case Name: VR Evaluation Functionalities			
Application: Virtual Claustrophobia Room			
Step	Procedures	Expected Result	Result
1	EASY: i. The users start entering the VE. ii. The users reach the final destination.	-The timer is started. -Display the instruction. -The timer is stopped. -Obtain the start and stop the timer.	Success Success Success Success

As shown in Table 3, the data of timer, frequencies of collision with the walls, frequencies of destroyed obstacles, and creeping creatures were collected once the users reached the final destination in each level. The data are important to evaluate the correlations between them and the collected users' demographic data in order to determine the claustrophobic symptoms. In this test case, the results show the functionalities of VR evaluation for each level had been achieved successfully.

V. CONCLUSION

The development of VCR using the proposed framework provides new features in placing and experiencing the users with Claustrophobia. This VR application is believed to detect the symptoms of Claustrophobia earlier, which can lead to the affords of treating and improving the users' health. The testing in the

form of test cases was implemented to check whether the users' requirements were met. In the future, this application is ready to be implemented in the real environment in order to test its usability and effectiveness. The target of respondents are the students in primary school as the contents of this project have been designed for detecting earlier the claustrophobic symptoms in VCR.

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