Development of A Pandemic-Inspired Virtual Reality Exergame to Encourage Exercise During a Lockdown

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Abstract. During the COVID-19 pandemic, physical activity is significantly reduced due to various lockdown requirements and the closures of parks, gyms and fitness centres. The reduced physical activity greatly impacts human heath which may lead to various health issues such as obesity and the people with those conditions are usually associated with a worse outcome once he or she is infected with COVID-19. Exergaming which is defined as technology-driven exercise is expected to make exercise an enjoyable experience by including entertaining game elements into physical activity. To further encourage adoption of exergaming during the pandemic lockdown, this project introduces three additional elements into exergaming. Virtual reality is the first element added for immersive experience to make the participant more engaging with the exergame. The second element is the musical rhythm that is usually associated with physical exercises that is known to provide both physiological and psychological benefits. The last element is the game design that is the metaphor for successfully combating pandemic viruses for inspirational positive thinking. A user testing survey is planned but due to the pandemic lockdown the participation number is very low, but the limited responses still show positive feedbacks.

Keywords: Exergaming · Virtual Reality · Pandemic

1 Introduction

During the COVID-19 pandemic, physical activity of most people is significantly reduced due to various lockdown requirements and the closures of parks, gyms and fitness centres. As an example, movement control order (MCO) was imposed by the Malaysia government on 18 March 2020 and being extended and relaxed repeatedly for more than 2 years [1][2]. The reduced physical activity greatly impacts human heath which may lead to various health issues such as obesity and the people with those conditions are usually associated with a worse outcome once he or she is infected with COVID-19 [3].

Exergaming which is defined as technology-driven exercise is expected to make exercise an enjoyable experience by including entertaining game elements into physical activity. Exergaming has become a trend in virtual reality due to the success of Beat

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Saber, a VR rhythm game [4]. The objective of the current project is to develop an exergaming application that motivate exercising during the pandemic lockdown with interesting elements such as virtual reality and musical rhythm game.

2 Related Work

Exergaming has the potential to improve physical activity and therefore reduce obesity which is clearly demonstrated by dance simulation games [5]. The introduction of motion sensing gaming accessories such as Wii Remote and Microsoft Kinect, enables console games to utilize body motion as the game input mechanism which directly improve the effectiveness of exergaming [6][7].

Astrojumper introduces virtual reality into exergaming with stereoscopic projection display many years before head-mounted VR headsets are available for general consumers. Immersiveness of Astrojumper is achieved with a 3-sided projection display surrounding the player while full upper-body motion tracking is achieved with wearable electromagnetic trackers. This early version of virtual reality exergaming already shown to motivate players of all ages to exercise [6]. The introduction of head-mounted VR headsets for consumers such as HTC Vive and Oculus Rift continue to show encouraging results in virtual reality exergaming that combat sedentary behaviour [4][8]. The concern of motion sickness with the introduction of virtual reality into exergaming is shown to be unnecessary as virtual reality rhythm game such as Beat Saber that does not involve continuous movement is highly tolerated [4].

3 Design and Development

The aim of the project is to design and develop an exergaming application with three additional elements to further encourage the adoption of this mode of exercise during the pandemic lockdown. Virtual reality is the first element added for immersive experience to make the participant more engaging with the exergame. The second element is the musical rhythm that is usually associated with physical exercises that is known to provide both physiological and psychological benefits [9]. The third element is the game design that is the metaphor for successfully combating pandemic viruses for inspirational positive thinking. The target audience of the exergaming application is the residents who is mostly forced to stay at home and lack the motivation to exercise with a wide range of age from 13 until 35.

3.1 Virtual Reality Hardware and Software Development Tools

During the development of the virtual reality exergaming application, a real virtual reality (VR) headset is crucial for testing various interactions in the application using the dedicated VR controllers which is extremely difficult to be reproduced with a computer-based VR simulator using mouse and keyboard or a low-cost phone-based VR headset such as Google Cardboard. HTC Vive is the VR headset being set up in the virtual reality laboratory in authors' university but due to the pandemic lockdown the availability to test

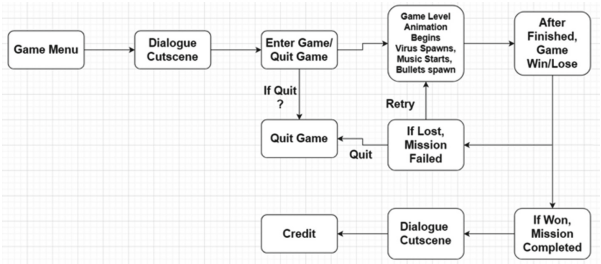

Fig. 1. The game-screen flow diagram.

on the HTC Vive is severely limited. The other option is to ask other students majoring in virtual reality that owns a VR headset to test, and these headsets include Oculus Quest, Oculus Quest 2 and Oculus Rift S. The availability to test on all these VR headsets will greatly influence the selection of VR software development kit.

The development of a virtual reality application requires a 3D game engine together with a virtual reality software development kit. The 3D game engine will be used to generate the 3D game environment including interactable 3D game assets as well as to implement the game logic. Among the choices of 3D game engine that supports virtual reality are Unreal Engine, Unity and Godot. Even with increased popularity, Godot is excluded right away due to the current low number of online tutorials, forum discussions etc. Unity is not selected despite being used as the default game engine for various subjects in the virtual reality major pursued by the co-author, which is responsible for the game logic development. The co-author prefers the visual programming in Unreal Engine using the Blueprint Visual Scripting system as compared to the classic text-based scripting in Unity using C#.

The selection of virtual reality software development kit is however straightforward to ensure the developed exergaming application can run on HTC Vive and various models of Oculus VR headsets. Oculus Integration for Unreal Engine, even though provides the best support for Oculus VR headsets, does not support HTC Vive. The choices left are either OpenXR APIs or SteamVR APIs for Unreal Engine which support all the targeted VR headsets. As OpenXR is relatively new, the more stable SteamVR APIs is chosen, which also, at the time of development, has the advantage of more online tutorials, forum discussions etc.

Figure 1 shows the game-screen flow diagram of one level of the developed exergame. Once the player starts the game, a warning message as shown in Fig. 2 will be displayed. The warning message is important to warn the user that prolonged playing of the game may introduce motion sickness and fatigue of eyes and body which defeat the purpose of a healthy life with exercising. After the acknowledgement of this message, the game will proceed following the game-screen flow shown in Fig. 1.

3.2 Pandemic-Inspired Game Design Element

The backstory of the game is about a trainee agent from a software security company, the player character, being transferred into a simulated virtual world after receiving briefing

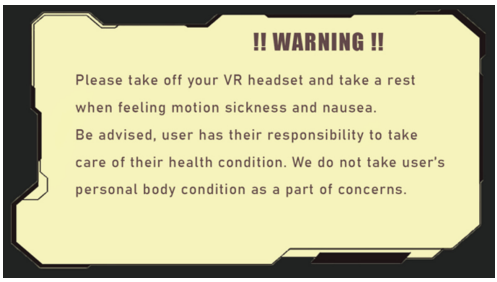

Fig. 2. A warning message displayed at the start of every game session.

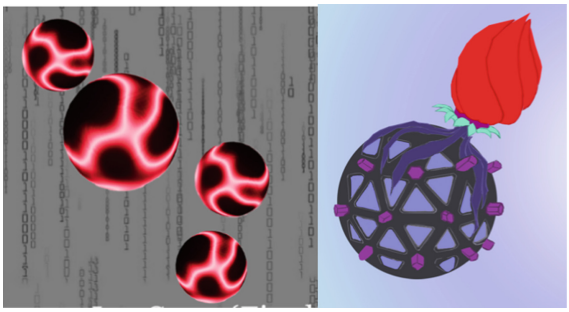

Fig. 3. The design of in-game computer viruses inspired by the Coronavirus.

from the supervisor. The player must defend the supercomputer which serves as the main server by stopping the virus invasion. Once the player entered the virtual world, the floating viruses around will start pulsing while the boss virus start attacking the supercomputer with projectiles. The player must successfully eliminate all the incoming projectiles to be victory for each level. Figure 3 shows the design of the in-game computer viruses which is inspired by the microscopic imagery of the Coronavirus.

The gameplay mechanic is the metaphor for combating Coronavirus with vaccination, represented by the player character to protect our human body, represented by the supercomputer. Playing the game whether to achieve victory or defeat hopefully will inspire positive thinking of the players.

3.3 Musical Rhythm Element

The design of each level will be based on a particular song. The duration of the level is corresponding to the length of the song while the difficulty of the level is based on the tempo of the song. The faster the tempo, the higher the frequency of the virus attack which directly contribute to the difficulty of the level. To maintain exciting gameplay, all the songs in the song selection list will at least have a moderately fast tempo around 100 beats per minute.

The rhythm of the song will also be visualized in the game by the pulsing viruses surrounding the player character as shown in Fig. 4. This music visualizer acts similarly

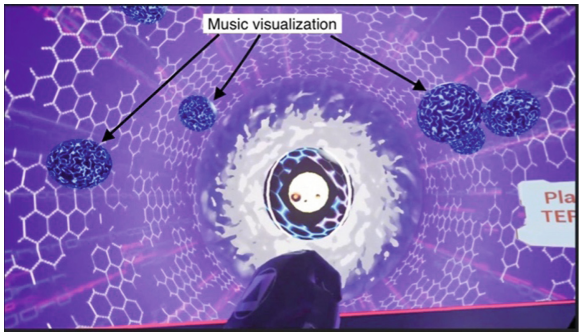

Fig. 4. The music visualization elements in the game.

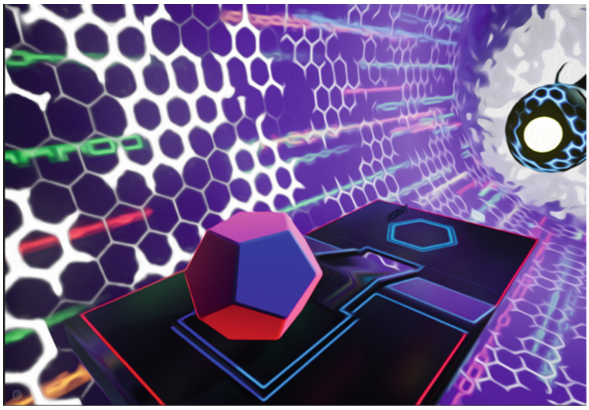

Fig. 5. The screenshots of the exergaming application.

to the classic 2D visualization in MP3 player which the synchronization of the visual display and the background song is enjoyable to watch and listen. The visualization of the rhythm which dictates the state of the game should help player to be more engaging in the exergame.

4 Implementations

The exergaming application is successfully tested on HTC Vive in the lab and on various Oculus VR headsets in the hand of lecturers and students. Figure 5 shows the screenshots of the application captured on the computer in the lab connected to HTC Vive.

Figure 6 is the photo of some users testing the exergaming application with their own Oculus Quest 2 at home which clearly shows high degree of physical body movements as compared to sitting in front of a computer screen playing a regular computer game or watching other mode of entertainments.

A user testing survey is planned but due to the pandemic lockdown the participation number is very low, but the limited responses still show positive feedbacks. Figure 7

Fig. 6. Users testing the exergaming application with their own Oculus Quest 2 at home.

6. If yes, which following platform have you played in this game?

Check all that apply.

- [ ] Valve Index
- [ ] HTC Vive
- [ ] Oculus Quest
- [ ] Oculus Rift

7. Do you feel motion sickness or any while playing? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

8. While playing do you feel energized?

Mark only one oval.

- ◯ Yes
- ◯ No

Fig. 7. Part of the user testing survey.

shows the printout of a portion of the user testing survey form which is prepared in Google Form. Some noticeable comments are “sweating a lot just by finish one song”, “felt tired after several songs”, “the surrounding viruses in the game does remind me of Covid-19”.

5 Conclusions

To encourage a physical healthy lifestyle through active exercise, a pandemic-inspired virtual reality exergaming application with a focus on musical rhythm has been developed. Using a system usability test and a technology acceptance model, a comprehensive

user evaluation will be conducted in the near future to determine the effectiveness of the proposed exergame in promoting physical activity.

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