Virtual Runner: A Virtual Reality-based Exergaming Application using Accelerometer

Virtual Runner: Sebuah Exergaming berbasis Virtual Reality Menggunakan Accelerometer

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Abstract

Generally speaking, playing video games didn't require a lot of movement or exercise, but with technological advances and the introduction of new features in the game console, you can now design "fitness games" where the movement of the player's body is reflected to the game. This is called exergaming. On the other hand, with the still ongoing pandemic, many opt to work and take their activities back at home including exercising. However, at-home exercise can be monotonous, repetitive, and even discouraging for many, thus an exergaming can be a solution. In this research we created a Virtual Reality-based exergaming that encourage its users to exercise and have fun at the same time. By utilizing a typical Android smartphone's accelerometer, gyroscope, and compass, we created an affordable exergaming device. The app also features estimated calories counter as well as high scoring to entice its users

Keywords—*Accelerometer, Android, Exergaming, Exercise, Virtual Reality*

Abstrak

Secara umum, bermain video game tidak membutuhkan banyak gerakan atau olahraga, tetapi dengan kemajuan teknologi dan pengenalan fitur-fitur baru di konsol game, anda sekarang dapat merancang "permainan kebugaran" di mana gerakan tubuh pemain tercermin dalam permainan. Ini disebut berolahraga. Di sisi lain, dengan adanya pandemi yang masih sedang berlangsung, banyak yang memilih untuk bekerja dan beraktivitas kembali di rumah termasuk berolahraga. Namun, olahraga di rumah bisa menjadi monoton, repetitif, dan bahkan memudarkan semangat bagi banyak orang, sehingga exergaming bisa menjadi solusi. Dalam penelitian ini kami membuat exergaming berbasis Virtual Reality yang mendorong penggunanya untuk berolahraga dan bersenang-senang pada saat yang bersamaan. Dengan memanfaatkan akselerometer, giroskop, dan kompas dalam ponsel Android, kami menciptakan perangkat olahraga yang terjangkau. Aplikasi ini juga menampilkan perkiraan penghitung kalori serta skor tinggi untuk entitas penggunanya.

Kata Kunci—*Akselerometer, Android, Exergaming, Olahraga, Virtual Reality*

1 INTRODUCTION

Public activities have been limited due to the ongoing pandemic. While many have returned to offline activities, still having activities at home still relevant to some. This leads people to seek alternative activities at home such as exercise at home. However, differ from the normal outdoor activities, indoor exercise can be filled with tedious exercise routine with no variation may cause boredom. Cardiovascular exercise such as the treadmill is repetitive in nature, especially when done without proper program and variation, which will lead people to be indolent and prefer other activities which involve less movement to spend on their free time such as watching movies and play video games all day which may cause unhealthy lifestyle and even obesity z [2]. Playing video games traditionally does not involve a lot of movement and exercise, but with advanced technology and the introduction of new features in gaming consoles, video games developer can now design "fitness game" by using technology, which allows the game to "follow" the player's body movement, fitness game itself is categorized as a video game genre called exergaming [2]. Exergaming is a type of game activity which intricate active body movement and body reaction into its gameplay. Therefore, the researcher developed virtual runner: an exergaming application based on virtual reality which encourage gamers to play and exercise at once.

1.1 Literature Review

Virtual Reality (VR) is a technology programmed in a way that users can actively interact with an artificial environment simulated by computer (computer-simulated environment), a copy of reality which only exist in our imagination [1]. VR enables developer to create virtual artificial environment as a simulation. The coordinate system used in VR is the Cartesian coordinate system, which enable user to look at objects from all points of view (up, down, left, right, front, and back) [2].

Exergaming is an amalgamation of two words, exercise and gaming which can be defined as playing a game while moving the body. Exergaming has the potential to help its user to overcome inactive lifestyle. Exergaming combines video game and exercise which will enhance the excitement and fun aspect of physical activities [3] .

Components that support virtual technology can look very real because they are supported by Inertial Measurement Unit (IMU) technology that already exists on smart portable devices in general such as smartphones and tablets that are widely used. All these devices are equipped with common sensor devices such as magnetic field, accelerometer, gyroscope, and sound sensor [4]. The most useful sensors are the accelerometer and digital compass. An accelerometer can provide acceleration information about three axes and a compass can provide direction information. It makes it possible to recognize driving conditions by extracting common features from the readings of the accelerometer and compass. Smartphones can be loaded into the car with the screen facing up [5].

1.2 Related Research

This research is a continuation of [2] and [3] which were a prototype of accelerometer-driven apps. Those two app basically utilize accelerometer as means to interact with the exergame. One of them is VR-based and the other one utilizes mirroring feature of a smartphone. Another three previous research are shown on Table 1 below.

Table 1 Related Research

Title	Tools		Purpose
	Hardware	Software	
1. Astrojumper: Designing a Virtual Reality	-Virtual Reality -Large Display (Dekstop)	-3D Studio Max -OpenScene Graph	To help autistic children to exercise using VR device

Title	Tools		Purpose
	Hardware	Software	
Exergame to Motivate Children with Autism to Exercise [6]	-Barco stereoscopic projectors -Polhemus Fastrak electromagnetic trackers	-OpenAL	
2. Challenges in Virtual Reality Exergame Design [7]	Oculus Rift, Arduino micro-controller, LifeFitness 95, CI Upright, Computer, Kinect	-Unity 3D -Seeing Machines -Gaze Tracking	Identify 5 designs of virtual reality .
3. Virtual Reality For Persons With Dementia: An Exergaming Experience [8]	-Camera(sensor) -TV	None	To improve the performance of the brain of someone who has dementia.
4. *Skiing in a Blended Virtuality – An In-The-Wild Experiment* [9]	-Oculus Rift DK1 HMD -Laptop PC -Bluetooth Mouse	-Unity 3D - GPS positioning -Speed Overground Sensor -Direct Optical Motion Sensing Solution	Evaluating the potential of the Mixed Virtuality approach to deliver Implementation in a virtual world, to ski users
5. Low Cost VR System Based on Wireless Accelerometer Sensor [10]	- MMA7260QT as accelerometer sensor, it is a triple-axis accelerometer - CC2430 as a transceiver, is a true System-on-Chip(Soc) solution specifically tailored for IEEE 820.15.4 and ZigBee applications	The build-in programs in the motion capture node and the motion receiver (Data receiving and A / D conversion algorithm)	The system is relatively simple, low cost VR games and improved by adding a lot of elements such as three-axis gyroscope.

Research number 1 requires the use of a large screen, projector, electromagnetic tracker, and a VR which are quite costly while research number 2 only identifies the design of VR without using compass, accelerometer, and gyroscope. In research number 3, the aim is to improve the brain capacity of a dementia patient, where it only requires TV and a camera with sensor. Research number 4, in this study can only be done at the ski area, and can not be anywhere. Then the researcher will create a virtual runner: an exergaming application based on virtual reality, where this research is more efficient. The last research number 5 presents a system that uses an accelerometer to capture body movements to achieve a gaming style.

First, the accelerometer sensor captures your movement, and then the signal collected by the sensor can be processed and sent to a computer. Finally, the motion data of the virtual character is synthesized into the VR game by a common interface that processes this data. This

motion mimicking system is versatile by integrating a variety of different equipment, and has a lower price and lower development difficulty compared to the current mainstream VR game development method. Based on the five previous studies, this study tries to combine existing research methods, especially in the fifth research by utilizing the accelerometer sensor. where in this research tried to use the accelerometer sensor that already exists on smartphone devices. as previously explained that nowadays all smartphone devices already have an accelerometer sensor so they no longer use additional devices as used in the fourth research. All these research are somewhat lack of certain things that is fulfilled in this research.

2   RESEARCH METHOD

In this research, the researcher uses software engineered based on model prototyping. In this model, there are several phases such as; communication, quick plan, modeling quick design, construction of prototype, deployment delivery & feedback [11].

2.1 Research Conceptual Framework

The conceptual framework of this research discusses on how the research process is executed:
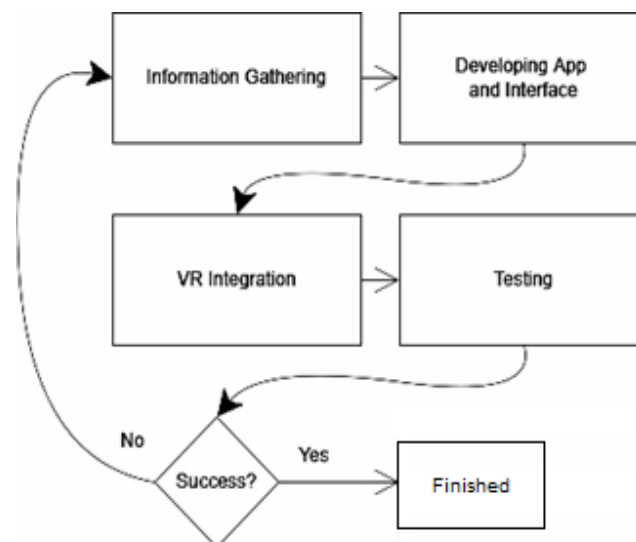

Figure 1 Research Conceptual Framework

1. Gathering Information: This is the first phase where the researcher gathers related information in the form of data that will be used in the development of the application.
2. Constructing the App and Interface Design: This is the second phase of the research; the researcher will design an app based on the interface design as a baseline of the app. The app creation and coding process use Unity 3D to create 3D model of the running track and every score object that can be gathered.
3. Virtual Reality Integration: This is the third phase where the researcher integrates the app that has been built with the VR headset.
4. Testing: This is the last phase of the research process where the researcher conducts trial process towards the application that has been built, if the outcome is not yet satisfying, the researcher will restart the whole process, on the contrary, if the outcome is satisfying, further trial will be conducted.

2.2 *Conceptual Framework of the Application*

Figure 2 describes the conceptual framework of the app, which are:

1. The user will open the apps through their smartphone and place it on to the VR headset
2. The user wears the VR headset
3. The app will start, and 3D images, sound, and text integration will appear
4. The app will utilize the accelerometer sensor, gyroscope, and compass
5. The app will execute each logic. Eg. If the user jumps, then accelerometer Y-axis will change thus character in the game will jump as well.
6. The app will render frame per frame so it will be displayed on the screen.
7. Transmitting rendering outcome to smartphone screen
8. The smartphone display shown on the VR screen
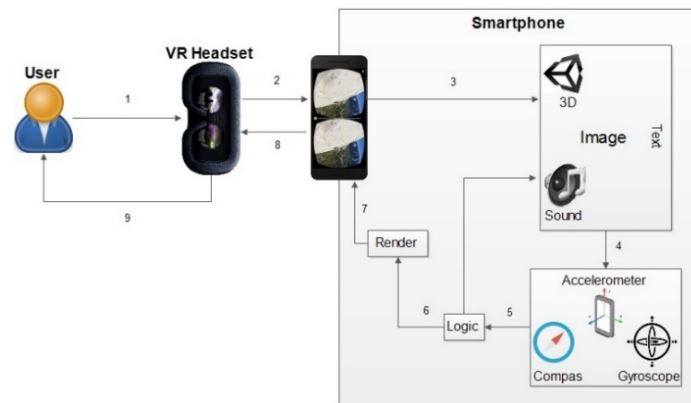9. User will see the rendered visual on their screen

Figure 2 Research Conceptual Framework

2.3 *Tools for app development*

We develop the app using the one of the leading 3D app development that is Unity 3D [12]. Unity is a game engine that is easy to use, where users only create objects and are given functions to run those objects. Every object created has a variable. The variables that are owned must be understood so that the making of an application can be of high quality. The use of Unity 3D in this research is to create applications and integrate with VR.

3   RESULT AND ANALYSIS

3.1 *How to Play*

First, put the smartphone into VR Headset and wear it. It enables the user to have 360 degree view. User can walk forward accordingly to the view. User can also run or jump on the spot to move as shown in Figure 3. When walking the character in game will move forward and when user jumps character will jump as well.
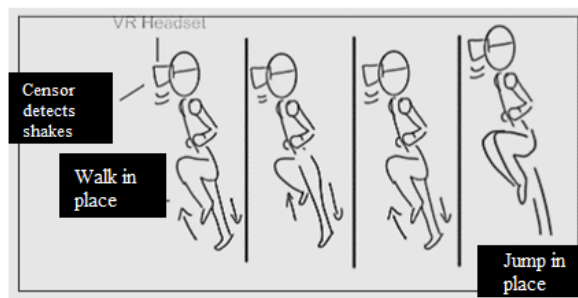
Figure 1 Illustration how to Play

3.2   Interface Implementation

Figure 4 is the interface design implementation of the app's main menu. There are six main options provided in the main menu which are, PLAY button for the user to start the game, VIEW CALORIES display the amount of calories that have been burnt, VIEW HIGHSCORE to display the high score in play history, HELP to guide the user on how to use the app which also includes a TUTORIAL, and EXIT to leave the game. In Figure 4, we can also find two types of game, LINING AND SPINNING. LINING is a game mode with singular direction while SPINNING allows the user to walk freely and explore the surrounding area.
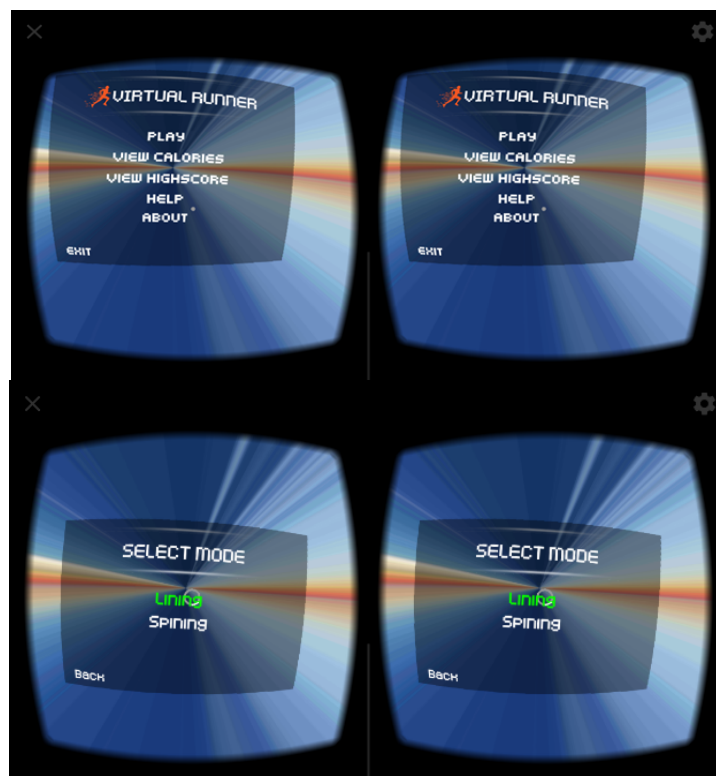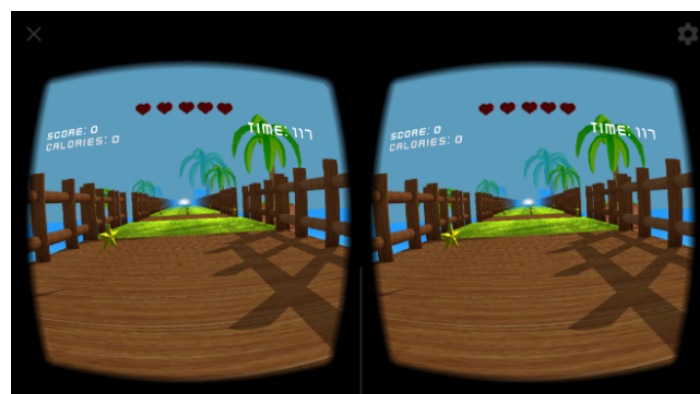

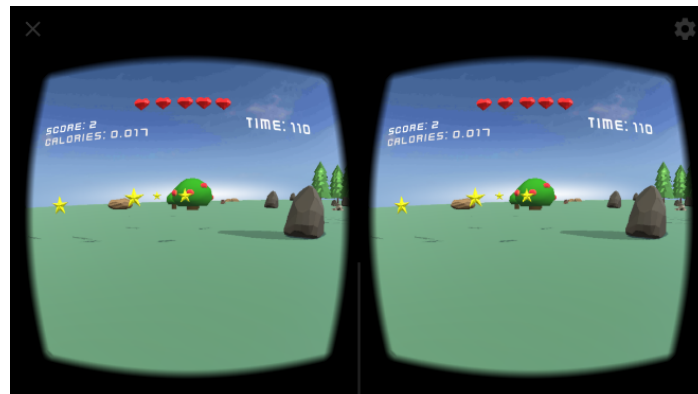Figure 4 Main Menu Interface

3.3   Game Interface

Figure 2 Virtual Runner's world interface

After choosing the game mode, users will be able to enter the virtual world and start interacting with it. The interface of LINING and SPINNING mode can be seen in Figure 5. The goal of the game is to collect all the stars while avoiding monsters.

The player will have five "hearts" which will decrease every time they run into monsters. After completing each game session, the player can view an estimate of calories burnt as well as the high score as shown in Figure 6.
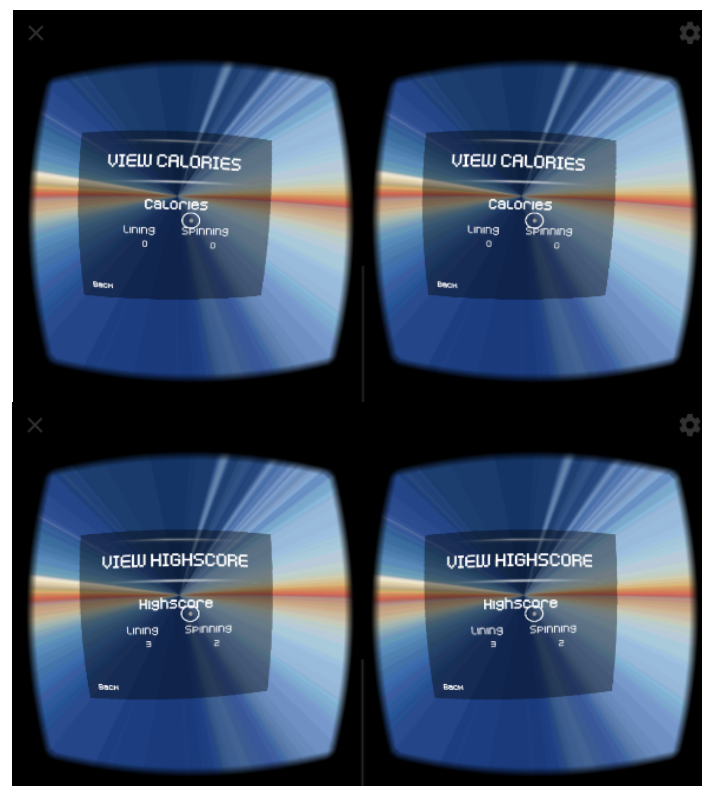

Figure 3 View Calories and High score interface

Before start playing, user may look at the help screen which show some useful information as well as instructions how to play the game. This view is shown on Figure 7.

Figure 7 Help Screen

3.4 Testing

We also conducted a black box [13] testing on the app, which tests its functionality without having knowledge of its internal structure, implementation as well as its internal paths [14]. Basically it focus on the software output [15]. Every menu and game feature are tested and each of them performs accordingly without any issue or bug.

Table 2 Menu and Features Testing

Input	Output	Result
Choose *Play*	Show the play *mode*	Successful
Choose *View Calories*	Show estimated Calories burnt	Successful
Choose *View High score*	Show highest scores	Successful
Choose *Exit*	Close the app	Successful
Choose *Lining*	Show *mode lining*	Successful
Choose *Spinning*	Show mode *spinning*	Successful
View High score	Show highs core while playing	Successful
View Calories	Show burned calories while playing	Successful
Hit Damage	If hit by object, then *health point decreased 1 heart*	Successful
Collect point	*Users* collect *point*	Successful
Run	*User* run	Successful
Jump	*User* jump	Successful

4 CONCLUSION

Virtual Reality apps are a great way to get some exercise at home. There are a variety of exergaming apps available that can provide a workout while also being fun. One of the best things about virtual reality is that it can make working out feel like less of a chore. Some VR headsets are quite expensive, but with utilizing the accelerometer, gyroscope, and compass on a typical

Android smartphone exergaming with VR becomes more affordable and this application proves it.

On this research we have created an app where user can have fun while exercising. Aside of being a bit healthier, this will also allow the user to exercise at home, which reduces their chance of contacting COVID-19 if they prefer to. With the built-in proximate calories counter and high score feature, this apps may be sufficient to entice and encourage users to exercise while having fun at the same time.

5　RECOMMENDATION

A suggestion for further study would be feature where user can post their results online especially on social media as well as a link that allow user to play and compete with their friends.

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