UNIVERSITI PUTRA MALAYSIA

STEREOSCOPIC AUGMENTED REALITY EXERGAME

BEHNAZ BAGHERIAN

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By

BEHNAZ BAGHERIAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Computer Science

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ABSTRACT

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Computer Science

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JANUARY 2018

Chair: Prof. Dr. Rahmita Wirza O.K. Rahmat
Faculty: Computer Science and Information Technology

Exergaming (also known as active video gaming) is an emerging technology that uses interactive games to increase exercise behavior. Current guidelines for physical activity recommend that children and young people accumulate at least 60 minutes of moderate to vigorous physical activity (MVPA) daily. Unfortunately, many children and adolescents aged 5–18 are not getting their recommended daily dose of MVPA and are thus more prone to obesity and its ill health effects. Furthermore, research shows that children and adolescents are increasingly inactive physically which often associated with poor diet and overweight. This inactively physical has been blamed as one of the leading causes of death. Exergames aim to make exercise more enjoyable, especially for children and young adults who are accustomed to digital technologies. However designing mobile exergames and Augmented Reality interaction has received little scholarly attention. However, most mobile exergames currently either available in the market or in research are focusing on using immersive Virtual Reality The challenge remains that Virtual Reality is only in a virtual environment and AR HMD's are still quite expensive and have their own visual limitations. Also, not much research has been done in the direction of

immersive AR exergames that render the camera feed of the real world to stereoscopic vision like VR and overlay AR, using smart phones that can be mounted on the inexpensive headsets like google cardboard or VR box available today. The focus of this research is to develop an immersive AR smart phone exergame that can be used to mount on a google cardboard or VR box like headset and uses the smartphone's camera feed as the real world frame over which AR overlays virtual interactive avatar to motivate the player. The outcome of this research showed the feasibility of this approach (Immersive AR Exergame) and limitations. A prototype of immersive AR Exergame named *Stereoscopic Exergame* is developed as a proof-of-concept. Evaluation of the prototype application is conducted by testing the application on students and gather the relevant data with questionnaire among them.

The research will provide guide lines to future exergame developers who want to provide immersive AR or Mobile AR exergames.

The limitations will be hardware enhancement in terms of more convenient, smaller and lighter HMD which is suitable during exercise, and replace phone with small microprocessor which can run the application and will place on top the HMD.

ABSTRAK

Exergaming (juga dikenali sebagai permainan video aktif) adalah teknologi baru yang menggunakan permainan interaktif untuk meningkatkan tingkah laku senaman. Garis panduan semasa untuk aktiviti fizikal mengesyorkan agar kanak-kanak dan anak-anak muda terkumpul sekurang-kurangnya 60 minit untuk aktiviti fizikal (MVPA) yang sederhana hingga sederhana. Malangnya, ramai kanak-kanak dan remaja berumur 5-18 tidak mendapat dos harian MVPA yang disyorkan dan oleh itu lebih mudah untuk kegemukan dan kesan kesihatannya yang tidak baik. Tambahan pula, penyelidikan menunjukkan bahawa kanak-kanak dan remaja semakin tidak aktif secara fizikal yang sering dikaitkan dengan diet yang kurang berat dan berat badan berlebihan. Ini fizikal secara tidak aktif telah dipersalahkan sebagai salah satu penyebab utama kematian. Exergames bertujuan untuk membuat senaman lebih menyeronokkan, terutamanya untuk kanak-kanak dan orang dewasa muda yang terbiasa dengan teknologi digital. Walau bagaimanapun mereka bentuk perarakan mudah alih dan interaksi AR telah mendapat sedikit perhatian ilmiah. Walau bagaimanapun, kebanyakan kemahiran mudah alih pada masa ini sama ada tersedia di pasaran atau dalam penyelidikan menumpukan pada menggunakan immersive (VR) Cabarannya tetap bahawa VR hanya dalam persekitaran maya dan AR HMD masih agak mahal dan mempunyai batasan visual sendiri. Selain itu, tidak banyak penyelidikan telah dilakukan ke arah kemewahan AR yang mendalam yang menjadikan suapan kamera dunia sebenar untuk penglihatan stereoskopik seperti VR dan OS overlay, menggunakan telefon pintar yang boleh dipasang pada alat dengar murah seperti kadbod google atau kotak VR boleh didapati hari ini. Tumpuan penyelidikan ini adalah untuk membangunkan arus perdana telefon pintar AR yang boleh digunakan untuk dipasang pada kotak kadbod google atau VR seperti alat dengar dan menggunakan suapan kamera telefon pintar sebagai bingkai dunia sebenar di mana AR mengatasi avatar interaktif maya untuk memotivasi pemain. Hasil kajian ini menunjukkan kemungkinan pendekatan

ini (Immerged AR Exergame) dan batasan. Prototaip AR Exergame yang dinamik bernama Stereoscopic Exergame dibangunkan sebagai bukti-konsep. Penilaian permohonan prototaip dijalankan dengan menguji permohonan kepada pelajar dan mengumpulkan data yang berkaitan dengan soal selidik di kalangan mereka.

Penyelidikan ini akan menyediakan garis panduan kepada pemaju baru yang ingin menyediakan AR atau AR Mobile yang lebih mendalam.

Keterbatasan ini akan meningkatkan perkakasan dari segi HMD yang lebih mudah, lebih kecil dan lebih ringan yang lebih sesuai semasa latihan, dan menggantikan telefon dengan mikropemprosesan dimana ianya lebih kecil yang boleh menjalankan aplikasi, yang akan diletakkan di atas HMD

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APPROVAL SHEET

I certify that a Thesis Examination Committee has met on 19/01/2018 to conduct the final examination of Behnaz Bagherian on her thesis entitled "StereoScopic Augmented Reality Exergame" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Computer Science.

Members of the Thesis Examination Committee were as follows:

Supervisor:
Prof. Dr. Rahmita Wirza O.K. Rahmat
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
Date and Signature: ……

Assessor:
Dr. Noris Binti Mohd Norowi
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia

Date and Signature: ……..

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DEDICATIONS

To my parents, project supervisor, lecturers, friends and internet.

Thank you for making this possible.

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CHAPTER 1 – INTRODUCTION

1.1 Introduction

In postindustrial societies and developed nations, obesity has become one of the major causes for severe health-related problems. Nearly over two billion adults and children are suffering from health-related problems around the world because of obesity according to a team of 2,300 experts led by the Institute for Health Metrics and Evaluation (IMHE), based at the University of Washington in Seattle.

Body mass index is the most common measure of obesity and is a ratio between weight and height. It is imperfect on an individual basis, because it does not allow for muscle as opposed to fat, but it can give an accurate assessment of population risk. BMI of 25 to 29 is considered to be overweight, while over 30 is obese.

Obesity has doubled since 1980 in more than 70 countries and has steadily risen in most of the others. Although the prevalence of obesity among children has been lower than among adults, the rate of increase in childhood obesity in many countries was greater than that of adults.

Among the 20 most populous countries, the highest level of obesity among children and young adults was in the United States, at nearly 13%. Adult obesity was highest in Egypt, at about 35% (N Engl J Med. 2017).

In addition, many challenges affect the quantity and quality of physical activity (PA). Exergames that combines exercise with gaming have been recognized as a

possible method for motivating individuals to become more physically active and to make PA more fun and immersive.

1.1.1 Exergames

It is not hard to guess that the term "ExerGaming" consists of two words merged together – "exercise" and "gaming". In some sense, it is a gamification of an exercising process, and gamification is known for its success in encouraging changes in user behaviour (Deterding et al., 2011). Brauner et al. (2013) assume that the role of exergaming is not only in providing an entertaining way of working out and facilitating PA, but also promoting healthy lifestyle, establishing a pattern for healthy behavior and raising awareness of one's health and physical condition. The potential power of exergaming is based on such psychological principles like performance feedback and rewards/achievement system, self-control and self-efficacy, fun and entertainment (Brauner et al.).

The term "exergaming" emerged presumably in the beginning of 21st century, between 2000-2005, when such video games were popularized, although first video games of this genre existed before. In 1987, Exus released the Foot Craz pad controller for Atari 26001, and a year later Nintendo released similar device for their Nintendo Entertainment System (NES), which they called Power Pad (Bogost, 2007). Both pads, despite the differences in look and components, had

the same purpose – controlling the game play by stepping on the touch-sensitive buttons (circles).

1.1.2 Augmented Reality in Exergames

Augmented Reality is a user interface technology that applies machine vision and 3-D graphics to embed virtual content in a real-world view. This augmentation is typically achieved by recording a scene with camera, and then detecting targets such as fiducial markers (e.g., bar codes) or objects from that scene with machine vision algorithms. Upon detecting a target, virtual content, such as 3-D models, graphics, and annotations, can be drawn on it, resulting in a scene where virtual content appears to hover over the target. Milgram and Kishino (1994) define AR as a subset of mixed reality (MR). In their definition, MR comprises AR and augmented virtuality (AV). The difference between AR and AV is that in AR, virtual elements are brought into reality, whereas in AV, real elements are brought into virtual reality.

Usually, Augmented Reality exergames on smart phones are designed to motivate the user to make some physical activity like moving to various locations in the map or various markers placed in locations apart from each other. When the user reaches the locations or markers the user would be rewarded with points or some goodies.

1.1.3 Virtual Reality in Exergame

Virtual reality is a computer-generated world with which user can interact. This interaction can be varying such as looking around or even modifying the world with touch. This virtual world completely disconnects the user to virtual world and immerse into it. This technology has been used in various fields such as creating video games (Exergames). The interaction mostly is conducted using motion sensors such as Microsoft Kinect box. (Ng PY, Ng CK, Al-Haddad SAR, 2015) or specific game motion sensing device (Finkelstein SL, Nickel A, Barnes T, Suma EA, 2010)

1.2 Problem Statement

Existing augmented reality exergames usually motivate the user to perform physical activity by carrying the smart phone and moving to various locations or markers placed in different locations. Upon reaching those locations, they overlay the virtual elements on the real-world video feed. Besides the limitation of user's view to mobile frame, most of existing AR games do not provide a good interface to interact with virtual object inside the game. The existing issue with marker based AR games is that user is limited to see the virtual content just above the defined markers. On the other end, Virtual reality (VR) exergames usually motivate users by completely immersing the

user in a virtual world. Also, VR based exergames limit the mobility of user since the head mounted displays, which are usually connected with a cable since HMDs need extra hardware which is attached to it like PC or GUI. The most existing challenges to VR games is the motion sickness which user feel after playing the game and it is due to sensory disconnect from the real world.

With the advent of head mounted displays (HMD) that provide the facility to mount smart phones, it has become possible to immerse user in to exergame using stereoscopic vision hence enabling them with the mobility also at the same time.

However, not much research is conducted in the direction of immersing the user more into augmented reality exergames (AR) using HMD's described earlier and smart phones.

With the increase in the processing capacity of the generally available smart phones in the market and introduction of inexpensive head mounted displays (HMDs) which use these phones for displaying augmented and virtual reality content to the user, has made it possible to have virtual and augmented reality applications without using expensive HMD's like Occulus Rift etc. However, not much research has been conducted either to use this pair of devices to create and test exergames or to use stereoscopic augmented reality application for exergames.

1.3 Objective

This project involves the extension of previous project that has been developed previous researcher (Laine, Teemu H., and Hae Jung Suk). The previous project only focuses only on using immersive VR in designing Exergame. However, the objective of this project are as follows:

1.3.1. To create a stereoscopic augmented reality (AR) marker less exergame. System can detect the surface and overlay the avatar in desired location and desired size.

1.3.2. To create an exercise routine – two Aerobics mode and boxing mode- which will be guided by a 3D animated avatar in the game.

1.3.3 To calculate metabolic equivalent of task (MET) based on time, weigh and intensity of exercise routine which has been chosen by user at the end of workout.

1.4 PROJECT SCOPE

In this project we focus on creating an augmented reality exergame with stereoscopic vision that will help users to enact an exercise routine based on the 3D avatar in the game. This application can be used indoor or outdoor environment.

In this game marker-less based AR mobile application is developed. The desired plane along with location will be chosen by user. Besides the user can resize the object based on its height or distance.

The vision is stereoscopic to bring the feeling of reality for user.

The 3D avatar is animated with smooth three workout routine mode to guide the user and motivate it be more active.

The dataset used in this work are taken from users with 5-scales questionnaire type. There are five different categories of questions which are:

General statements, Ease of use, Motivation, Expenses and Metabolic equivalent of task.

1.5 Thesis Structure

This thesis includes six chapters which will be started with the Introduction as the first chapter and will be ended with Conclusion as the sixth chapter. Each chapter will discuss as following:

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