INTERACTIVE OBJECTS FOR AUGMENTED REALITY BY USING OCULUS RIFT AND MOTION SENSOR

YAP JUNE WAI

This Report Is Submitted In Partial Fulfilment of Requirements For The Bachelor Degree in Electronic Engineering With Honors (Computer Engineering)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2017

© Universiti Teknikal Malaysia Melaka

"I hereby declare that the work in this project is my own except for summaries and quotations which have been duly acknowledge."

Signature: .....

Author: Yap June Wai

Date: 1th June 2017

© Universiti Teknikal Malaysia Melaka

"I acknowledge that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of Bachelor of Electronic Engineering (Computer Engineering) with honors."

Signature: .....

Supervisor's Name: PM. Dr. Nurulfajar bin Abd Manap

Date: 1th June 2017

© Universiti Teknikal Malaysia Melaka

Specially dedicated to

My beloved family and friends for the help and encouragement. Thanks for my supervisor, PM. Dr. Nurulfajar bin Abd Manap and all the lecturers who gave me guidance and advice throughout the process of finish my final year project.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

I would like to express my gratitude to the Universiti Teknikal Malaysia Melaka (UTeM) for accepting me as a student of UTeM. I acknowledge with thanks to Faculty of Electronic and Computer Engineering for the support on my final year project. It is a genuine pleasure to express the deep sense of appreciation to my committee PM. Dr. Nurulfajar bin Abd Manap. I am grateful for his guidance and assistance throughout the project.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Augmented Reality is a new technology to blend the digital computer generated information such audio, text, video, animation and 3D models seamlessly to the real world environment. It is believed that this awesome technology is going to change the way how people imagine, see and learn in the future. This project aims to design and develop an interactive object for augmented reality by integrating Oculus Rift, Leap Motion and Webcam. A video-displayed augmented reality is created to work together with an augmented reality interactive book: The Astronomy. A Leap Motion Controller is essential as a peripheral input device for the user to interact with the system. The application of Leap Motion Controller in this project further enhance the interactivity with different well-designed hand gestures such as thumb up, pinching and pointing finger direction. All these gestures give bidirectional way of interaction between the user and the augmented reality system. This project is greatly potential because it is not merely applicable in education, but also works perfectly in business, architecture and medical field.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Realiti Tambahan adalah satu teknologi terkini yang menggabungkan infomasi digital komputer seperti audio, teks, video, animasi dan model 3D secara lancar dengan persekitaran dunia sebenar. Adalah dipercayai bahawa teknologi hebat ini akan mengubah cara bagaimana manusia membayangkan, melihat dan belajar pada masa akan datang. Projek ini bertujuan untuk merekabentuk dan membangunkan objek interaktif untuk realiti tambahan dengan mengintegrasikan *Oculus Rift*, *Leap Motion* dan kamera *web*. Realiti Tambahan ini dicipta untuk bekerja bersama-sama dengan buku interaktif: Astronomi. Malah, pengawal *Leap Motion* adalah penting sebagai peranti input persisian bagi pengguna untuk berinteraksi dengan sistem. Aplikasi pengawal *Leap Motion* di dalam projek ini akan meningkatkan lagi interaktiviti dengan isyarat tangan yang direka dengan baik seperti gerakan ibu jari, mencubit dan jari menunjuk arah. Semua gerak isyarat ini memberi laluan dwiarah interaksi antara pengguna dan sistem realiti. Projek ini adalah amat berpotensi kerana ia bukan semata-mata berkenaan dalam pendidikan, tetapi juga berfungsi dengan sempurna dalam bidang perniagaan, seni bina dan perubatan.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENT

Chapter	Content	Page
	PROJECT TITLE	i
	REPORT STATUS APPROVAL FORM	ii
	DECLARATION	iii
	SUPERVISOR APPROVAL	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENT	ix
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF ABBREVIATIONS	xvi
I	**INTRODUCTION**	
	1.1 Project Background	1
	1.2 Problem Statement	2
	1.3 Objectives of Research	3
	1.4 Scope of Work	3
	1.5 Report Structure	3

© Universiti Teknikal Malaysia Melaka

II	**LITERATURE REVIEW**	
	2.1 Augmented Reality History and Definition	5
	2.1.1 Milgram Reality-Virtuality Continuum/Mixed Reality Continuum	5
	2.1.2 Ronald Azuma Augmented Reality Definition	6
	2.1.3 Mann's Reality-Virtuality-Mediality Continuum	7
	2.1.4 Comparison of Augmented Reality and Virtual Reality	8
	2.2 Video-Display Augmented Reality Device Operation	9
	2.3 Oculus Rift	10
	2.4 Augmented Reality Software Development Kit	12
	2.4.1 Metaio SDK	13
	2.4.2 Qualcomm Vuforia SDK	13
	2.4.3 Wikitude SDK	14
	2.4.4 ARToolkit SDK	15
	2.4.5 Comparison of Augmented Reality SDK	16
	2.5 Leap Motion Controller and It's SDK	18
	2.6 Previous Project and Research	19
	2.6.1 Hand Gestures Controller in Augmented Reality by Using Oculus Rift and Leap Motion	19
	2.6.2 An Augmented Reality System for Biology Science Education in Malaysia	20
	2.7 Summary	20
III	**METHODOLOGY**	
	3.1 Overview of the System	22

© Universiti Teknikal Malaysia Melaka

3.2 Description of the Project Implementation 24

3.2.1 Stage 1: Hardware Integration 24

3.2.2 Stage 2: Software Development 26

3.2.3 Stage 3: Prototyping and Improvement of System 28

3.3 Installing and Setting Up of Oculus Rift 29

3.4 Setting Up the Leap Motion Controller 32

3.5 Integration of Leap Motion Sensor and Oculus Rift DK2 36

3.6 Integration of Logitech Camera and Oculus Rift using Vuforia SDK 37

3.7 Image Recognition using Vuforia SDK 38

3.8 Resolving Leap Motion Crash Issue 39

3.9 Development of Hand Gesture Recognition using Leap Motion 42

3.10 Summary 44

IV RESULT AND DISCUSSION

4.1 Prototype Overview 46

4.1.1 Interactive Augmented Reality Book-The Astronomy 47

4.1.2 A Completed Video-Display Augmented Reality Headset 48

4.2 The Simulation of the Augmented Reality Book and Headset 50

4.2.2 The Content Page 50

4.2.3 The Sun 53

4.2.4 The Earth 54

4.2.5 The Moon 55

4.3 The Significant Finding: Hyper-Reality Effect by Augmented Reality 56

4.4 Summary 56

© Universiti Teknikal Malaysia Melaka

V	**CONCLUSION AND RECOMMENDATION**	
	5.1 Conclusion	58
	5.2 Future Development	59
	REFERENCES	60
	APPENDIX	

© Universiti Teknikal Malaysia Melaka

LIST OF TABLE

No	Title	Page
2.1	The comparison of Augmented Reality and Virtual Reality	8
2.2	The specification of Oculus Rift Development Kit	10
2.3	The platform supported of Augmented Reality SDK	16
2.4	The comparison of Augmented Reality SDK advantages and disadvantages.	17

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURE

No	Title	Page
2.1	Milgram Reality Continuum	6
2.2	Mann's Reality-Virtuality-Mediality Continuum	7
2.3	Mann's Reality-Virtuality-Mediality Venn Diagram	8
2.4	Simple Video Display Augmented Reality Device Design	9
2.5	The Structure of Oculus Rift	12
2.6	The Range of Leap Motion Controller	18
3.1	Overview of Project	23
3.2	Block Diagram of the System	24
3.3	Workflow of Project Implementation Stage 1	25
3.4	Workflow of Project Implementation Stage 2	27
3.5	Workflow of Project Implementation Stage 3	28
3.6	Connection of PC, Oculus Rift, Leap Motion and Webcam	29

© Universiti Teknikal Malaysia Melaka

3.7	Pop out Window of Oculus Rift	30
3.8	The “Oculus Manager” icon	31
3.9	Oculus Configuration Utility Window	31
3.10	Calibration of Oculus Rift	32
3.11	Head-Mounted Leap Motion Controller	33
3.12	Warning Message of Leap Motion Controller	33
3.13	Setting Up of Leap Motion Controller	34
3.14	Troubleshooting Tab of Leap Motion Controller	35
3.15	Calibration of Leap Motion Sensor	35
3.16	Integration of Leap Motion in Unity3D	36
3.17	Position of Logitech C310 Webcam Relative to Oculus Rift	37
3.18	Image Detection with Qualcomm Vuforia SDK	39
3.19	The Leap Motion Controller crashing issue	40
3.20	Device Manager	40
3.21	Low Resource Mode	41
3.22	Thumb up Algorithm	44
4.1	Augmented View of Prototype	47
4.2	The Front Cover of The Astronomy	47
4.3	Final Prototype Front View	48

© Universiti Teknikal Malaysia Melaka

4.4	Augmented Reality Mode 1 using Logitech C310 Webcam	49
4.5	Augmented Reality Mode 2 using embedded Camera in Leap Motion	49
4.6	The Design for the Content Page	50
4.7 (i)	About Us Page	51
4.7(ii)	User Guide Page	51
4.7(iii)	Health and Safety Warning Page	51
4.8	Simulation Result of Health and Safety Warning	52
4.9	The Comparison of Augmented View and Real World view	53
4.10	The Leap Motion Augmented Reality Mode	54
4.11	Testing on Earth Rotation Direction	54
4.12	Moon Walking	55
4.13	Stop Moving	55
4.14	The Animation of Photo	56

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

AR	Augmented Reality
3D	Three-dimensional space
SDK	Software Development Kit
C#	C sharp
IDE	Integrated Development Environment
MR	Mixed reality
DOF	Degree of Freedom
VR	Virtual Reality
DK	Development Kit
DVI	Digital Visual Interface
USB	Universal Serial Bus
HDMI	High-Definition Multimedia Interface
IR	Infrared
CMOS	Complementary Metal-oxide-semiconductor

© Universiti Teknikal Malaysia Melaka

OLED	Organic Light-Emitting Diode
API	Application Programming Interface
QR	Quick Response
XML	Extensible Markup Language
HTML	Hyper Text Markup Language
IOS	iPhone Operating System
CSS	Cascading Style Sheets
RGB	Red-Green-Blue
YUV	Luminance(Y)-luminance(U)-luminance(V)
LED	Light-Emitting Diode
RAM	Random Access Memory
AMD	Advanced Micro Devices

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Project Background

Augmented Reality (AR) is a technology which allows the real-world environments seamlessly merged together with computer-generated elements. Through this technology, those computer-generated elements such as text, animation, video, and audio can be incorporated into users' eyes in real world. By bridging the gap between the virtual and real world, new possibility for education is established by using Augmented Reality (AR) technology. Today, various Augmented Reality (AR) applications are emerging in educational environment which may differ regarding to their advantages [1] [2] toward the educational outcomes. The visual augmentation is the main focus of the most Augmented Reality (AR) Books which existed in the market today. However, the "learning" experience can be enrich with added more interactivity between the real world and the virtual contents.

Thus, this project focuses on developing an Augmented Reality (AR) application which comes alive with 3D animated objects by integrating Oculus Rift, Leap Motion sensor and Logitech C310 webcam. Oculus Rift is a virtual Reality Device which originally does not support any Augmented Reality Feature. Hence, a Logitech C310 Camera will be attached together to innovatively convert Oculus Rift to a video-display augmented reality Headset. To enhance further the interactivity, a Leap Motion sensor is also integrated together with Oculus Rift to supplement different features such as users' hand gestures interaction. The 3D [3] animated models, texture animations and enhanced

© Universiti Teknikal Malaysia Melaka

marker design which suitable to education environment will also be included in the project framework. The main idea of the project is provide an interactive, simple but immersive digital book.

1.2 Problem Statement

Imagine there are a lot of things that we have in the world that are physical which does not actually necessary to be physical. With the introduction of Augmented Reality (AR) technology, all these things could be exist in digital virtual form such as text, audio, video and 3d object [4]. This technology can go beyond the entertainment field and apply in education sector. The knowledge which supposedly does not need to be in physical form can be pass on to younger generation in augmented reality environment which is more effective, engaging and more interactive compared to conventional physical education tool. However, the current Augmented Reality (AR) device such as Microsoft HoloLens is too expensive and unaffordable for community. Hence, the integration of virtual reality Device such as Oculus Rift with C310 webcam can really bring a solution for this issue.

Initially, Oculus Rift is just limited to immersive learning in Virtual Reality environment. Learning in the virtual environment is more engaging, but users are restricted to interact with their teachers and friends who might be in the real world or another virtual environment. With the attached webcam, the Oculus Rift is well-equipped with a new Augmented Reality function. Therefore, immersive learning process [5] can also be carry out in the augmented real world. The performance of Oculus Rift can be further improved with added Leap Motion Sensor. User is allowed to interact with virtual object in real world by using both of their hands.

© Universiti Teknikal Malaysia Melaka

1.3 Objectives of the Research

The purpose of this study is to develop the interactive objects for Augmented Reality that can be used in education purpose. The following objectives of project had been determined as following:

i. To design and develop interactive objects for Augmented Reality by using Oculus Rift and Motion Sensor.
ii. To implement interactive Augmented Reality Book suitable for teaching and learning.
iii. To design and develop hand gestures for virtual object interaction in Augmented Reality.

1.4 Scope of Work

This project is separated into three stages and most of the time will be conducted in the Research Lab 3 in Faculty of Electronic and Computer of Universiti Teknikal Malaysia Melaka. In the first phase, the integration of Leap Motion Sensor, Oculus Rift and C310 Logitech Webcam as a video-display augmented reality device will be the main focus of this project. After that, the design of the Marker Based Augmented Reality by importing the Augmented Reality Qualcomm Vuforia SDK package will be emphasized in this project. In last phase, the development of hand gesture such as "Thumb Up" and "Okay" will be developed in the project using C# programming language in Microsoft Visual Studio 2015 and Unity IDE version 5.3.4f. In this process, the leap motion sensor is needed to detect the hand motion of people.

1.5 Report Structure

The thesis is organized and arranged into 5 major chapters. In Chapter 1, the overview of Augmented Reality is discussed in the project background. In addition, the problem statement, objective and scope of project will be outlined clearly in this section. In Chapter 2, the past studies related to Augmented Reality are reviewed and criticized. The background theory of Augmented Reality will be included in this chapter. In

© Universiti Teknikal Malaysia Melaka

Chapter 3, all relevant experiments and techniques used in the project will be discussed in detail. The flowchart for the Augmented Reality system design will be explained in this chapter. In Chapter 4, the performance of the completed project and prototype will be recorded and interpreted in this section. The obtained and collected data from the experiment will be analyzed carefully to verify if the objectives have been achieved. In the last chapter, a conclusion will be drawn from the project. In addition, the recommendation for the future plan which related to the project will be made in this section.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

This chapter presents the literature survey from the related journals and papers on the theoretical background of Augmented Reality. The differences and similarity of Augmented Reality and Virtual Reality (VR) is also analyzed in this chapter. The background and introduction of Oculus Rift and Leap Motion Controller will also be included in this section.

2.1 Augmented Reality History and Definition

In this section, the history and the definition of the development augmented reality is reviewed carefully. This is to ensure the characteristic of an augmented reality system is clearly matched to whatever has been well-defined by the expertise.

2.1.1 Milgram Reality-Virtuality Continuum/ Mixed Reality Continuum

In 1994, the Reality-Virtuality Continuum [6] [7], also known as the mixed reality continuum is first introduced by Paul Milgram to describe the concept of Augmented Reality (AR). In Figure 2.1, Milgram's Virtuality Continuum illustrates all possible variations and compositions of real and virtual environment. According to Milgram, virtual environment is represented at one end of the continuum, and the real world environment is represented at the other end. The environment in between both extreme ends is known as mixed reality (MR).

© Universiti Teknikal Malaysia Melaka

However, Milgram did not make a clear definition on the term of "Augmented Reality", which the definition of "Augmented Reality" could be reasonably differs from people to people. The characteristic or of an "Augmented Reality System" can be imprecisely interpreted and hard to identified by other people. Hence, more research is made to understand the term "Augmented Reality" better.

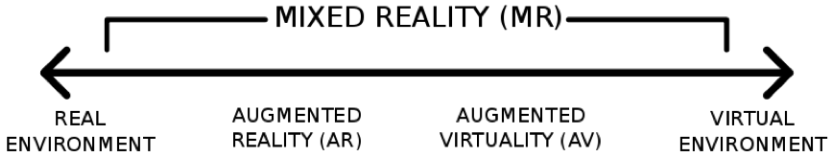

Figure 2.1: Milgram Reality Continuum

2.1.2 Ronald Azuma Augmented Reality Definition

Later in 1997, a survey on Augmented Reality (AR) is published by Ronald Azuma to define the taxonomy for virtuality and reality. According Azuma's definition [8], Augmented Reality (AR) is a variation of Virtual Environment or Virtual Reality. It is noted that the definition of Ronald Azuma on Virtual Reality is matching the Milgram Reality Continuum in 1994. Azuma stressed on the differences between the virtual reality and augmented reality. According to Azuma, the main difference between the virtual reality and augmented reality stated that user is completely immersed inside a synthetic world by using VR technologies.

In contrast, Augmented Reality (AR) allows user to see the real world, with virtual objects overlay or superimposed upon the real world. Besides adding objects to a real environment, Augmented Reality has the potential of removing them from the real world. Augmented Reality System can be identified by the three following characteristics:

- It combines the Reality and Virtual
- It is in 3D
- It is interactive in real time

© Universiti Teknikal Malaysia Melaka

This is very important information to clearly clarify the characteristics of an Augmented Reality System. This will be the reference for us to make an Augmented Reality application to avoid any unnecessary mistakes in project. The developed augmented reality application must match the above three characteristics stated by Azuma.

2.1.3 Mann's Reality-Virtuality-Mediality Continuum

In 2002, a second axis is added to Milgram's Virtuality-Reality Continuum to cover other forms of alteration as well. Mediated Reality and Mediated Virtuality [8] is defined clearly by the two-dimensional Mann's Reality-Virtuality-Mediality Continuum (Figure 2.2).

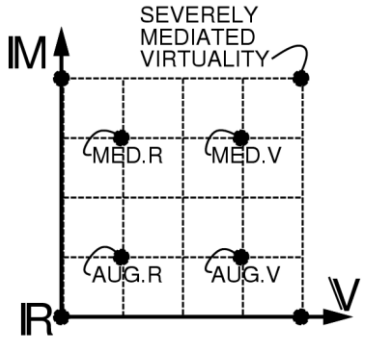

Figure 2.2: Mann's Reality-Virtuality-Mediality Continuum

According to Mann, in mediated reality, a person's perception of reality is manipulated in one way or another. The reality can be altered by a system in multiple ways. For example, something can be added (Augmented Reality), removed (Diminished Reality) or even changed in some other way (Modulated Reality). The relationships between these areas are further presented by Mann in the Venn diagram as shown in Figure 2.3m.

© Universiti Teknikal Malaysia Melaka