

HAND GESTURES CONTROLLED IN AUGMENTED REALITY BY USING
OCULUS RIFT AND LEAP MOTION

TAN HUNG CHANG

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

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
University Teknikal Malaysia Melaka

June 2016

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : HAND GESTURES CONTROLLED IN AUGMENTED REALITY BY USING OCULUS RIFT & LEAP MOTION

Sesi Pengajian :

1	5	/	1	6
---	---	---	---	---

Saya TAN HUNG CHANG
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan () :

SULIT*

*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

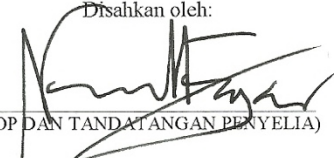
TERHAD**

** (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD


(TANDATANGAN PENULIS)

Tarikh: 10/6/15

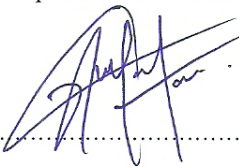
Disahkan oleh:

(COP DAN TANDATANGAN PENYELIA)

Dr. Nurufajar Bin Abd. Manap
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 10/6/15

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

Signature

: 


Author

: TAN HUNG CHANG

Date

: 10 JUNE 2016

“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 (Industrial Electronics/ Computer Engineering/ Electronic Telecommunication/ Wireless Communication)* with Honours.”

Signature : 
Supervisor's Name : DR. MURULFAJAR BIN MANAP
Date : 10 JUNE 2016

ACKNOWLEDGEMENT

This report is the final product to complete my bachelor degree at University of Technical Malaysia Malacca (UTeM). This project was conducted in the period of September 2015 to June 2016, at the Faculty of Electronic and Computer Engineering. I would like to thank my supervisor, Dr. NurulFajar bin Manap, for valuable discussions, support and follow-up throughout the project development and providing me with the necessary equipment. Last but not least, I would like to thank Dr. Lim Kim Chuan for his general support, suggestions and advices on stereoscopic imaging with me.

ABSTRACT

Oculus Rift is a newly introduced technology in this market. It has the features which allow user or player to see virtual reality in it when wearing it. The virtual object or environment build in Oculus Rift can be interacted only if the user or player bought the Leap Motion or specially made controller for it. Leap Motion is a tracking sensor which tracks down both hand in the range of 120°. As long as the virtual object build inside the Oculus Rift is integrated to the Leap Motion function then user or player can interact with the object without a controller. After all, Oculus Rift has not been utilized to the fullest potential for instance, it should be able not only usable in virtual reality but as well as Augmented Reality which brings this technology alive.

In this project, I plan to bring in Augmented Reality into Oculus Rift as current Oculus Rift does not support this feature. It can only be played around with virtual reality which has limited the versatility of this technology. Furthermore, interacting a virtual object with controller is not truly experiencing Augmented Reality. Thus, it should be integrated to Leap Motion in Augmented Reality.

I propose to use two budget webcams as for the purpose to render stereoscopic image into the Oculus Rift and thus user or player can experience a 3D image inside

Oculus Rift. In order to build a virtual object for interaction purpose, Unity 3D will be used to create the graphical interface. Beside creating graphical interface, Unity 3D can also render the output image from both webcams. Stereoscopic image will help human to differentiate or identify the object clearly as well as the distance itself. Due to low budget, the webcam which comes with low specification does affect the result. The major affected results are the colour resolution, sharpness and frame per second.

To enhance user experience, Leap Motion feature will be integrated into this project as well. Seeing a virtual object in real life and user is capable on interacting it can bring lots of benefits toward human activities. The most significant field which will be benefit from this technology is education. During the lesson, students understanding towards the knowledge or message which teacher is trying to deliver will be increased as they can see the virtual object itself and interaction makes the virtual object alive. Beside this, medical field will be benefit with this technology to reduce the risk of an operation and a good practice for fresh doctors.

TABLE OF CONTENTS

TITLE	i
CONFORMATION REPORT STATUS	ii
DECLARATION	iii
SUPERVISORS COMFORMATION	iv
ACKNOWLEDGEMENT	v
ABSTRACT.....	vi
TABLE OF CONTENTS.....	viii
LIST OF EQUATION	xi
LIST OF TABLE	xii
LIST OF FIGURES	xiii
LIST OF ATTACHMENTS	xvii
INTRODUCTION	1
1.1 Background.....	1
1.2 Problem Statement.....	2
1.3 Objectives	3
1.4 Scope of Project.....	3
1.5 Thesis Organization	4
LITERATURE REVIEW	5
2.1 Introduction.....	5
2.2 System Specification and Details.....	6
2.2.1 Stereoscopic Vision	6
2.2.2 Augmented Reality	9
2.2.3 Oculus Rift.....	10
2.2.4 Leap Motion.....	14
2.2.5 3D Printing.....	17

2.3	Related Work	18
2.3.1	3D Environment Augmented with Virtual Objects	18
2.3.2	Augmented Reality in Education	20
2.3.3	Augmented Reality Tracking for Enhancing the User Interaction during Virtual Rehabilitation	22
2.4	Summary of Related Works	26
2.4.1	Table of Limitation on Related Works	26
2.5	Summary	27
METHODOLOGY		28
3.1	Introduction.....	28
3.2	Installing and setting up Oculus Rift and Leap Motion.....	30
3.3	Setting up webcams	33
3.4	Webcams and Leap Motion Sensor 3D Printing Mount.....	35
3.5	Stereo Image Capturing	37
3.6	3D Stereo Imaging	40
3.7	Integrating Leap Motion to Unity for Augmenting Purpose	42
3.8	Summary	47
RESULT AND DISCUSSION		48
4.1	Introduction.....	48
4.2	Stereoscopic Imaging Rendered to Unity 3D	49
4.3	Integration of Virtual Object in Augmented Reality with Leap Motion ...	57
4.4	Summary	64
CONCLUSION AND FUTURE WORK		65
5.1	Introduction.....	65
5.2	Conclusion	65
5.3	Future Work.....	66
REFERENCES		67

APPENDIX A.....	72
APPENDIX B.....	74
APPENDIX C.....	76
APPENDIX D.....	80
APPENDIX E.....	98
APPENDIX F.....	101
APPENDIX G.....	104
APPENDIX H.....	106

LIST OF EQUATION

NO	Equation	PAGE
4.1	Focal length formula	52

LIST OF TABLE

NO	TITLE	PAGE
2.1	Limitation on Related Works	26

LIST OF FIGURES

NUMBER	FIGURE	PAGE
2.1	Stereo Pair Before Rectified	8
2.2	Stereo Pair After Rectified	8
2.3	Reality-Virtuality Continuum	10
2.4	Oculus Rift FOV	11
2.5	Oculus Rift Development Kit 2	11
2.6	Infrared LEDs and Tracking System	12
2.7	Interaction Area of Leap Motion	14
2.8	Leap Motion Sensor Teardown	14
2.9	Pipeline Approach	16
2.10	3D Printer Ultimaker 2	18
2.11	Correct Occlude Virtual Object	19
2.12	Augmented Reality in Education	21
2.13	Augmented Reality Rehabilitation Setup	24

2.14	Virtual 3D Arm during Shoulder Exercise	25
3.1	Complete Methodology	29
3.2	Oculus Runtime	30
3.3	Oculus Runtime “Show Demo Scene”	31
3.4	Nvidia 0.7 driver for Oculus Rift	32
3.5	Leap Motion Configuration Setup Result	32
3.6	Details of Logitech C310	33
3.7	Logitech Webcam Configuration Software	34
3.8	Webcam De-mounted	34
3.9	Design Spark Sketch for Customised Mount	35
3.10	Thingiverse Leap Motion Holder	36
3.11	Printed Customised Mount	36
3.12	Front View of Customised Mount attached to Oculus Rift	37
3.13	Side View of Customised Mount attached to Oculus Rift	37
3.14	Package from Github	38
3.15	“OculusWebcams.unity”	38
3.16	Webcam1/Webcam2 plane location	39
3.17	Coding for Webcam Rendering	40
3.18	Duplicated “OVRWebcams”	41
3.19	Setting Target Eye	42
3.20	Leap Motion Core Assets Orion 4.0.1 Beta	43
3.21	“LMHeadMountedRig” and “HandModelIsNonhuman” in Prefabs	43

3.22	Virtual Hand Configuration	44
3.23	Cube Properties	45
3.24	Coding for “Hide_unhide”	46
3.25	Integrating Leap Motion to Unity	46
4.1	Rendered Image from Both Webcams	49
4.2	5mm away from Eyes	50
4.3	15mm away from Eyes	51
4.4	25mm away from Eyes	51
4.5	Maximum length of focus, 100cm	52
4.6	Calibration with 100cm	53
4.7	Focus Object at length, 50cm	53
4.8	Calibration for 50cm	54
4.9	Led Tracker on Oculus Rift	55
4.10	Front View	55
4.11	Left View	56
4.12	Right View	56
4.13	Grabbing a Cube	57
4.14	Cube without Collider function	58
4.15	Cube with Collider function	58
4.16	Rigidbody Properties Setting	59
4.17	Flowchart for Hand Grabbing	60
4.18	“Down” arrow is pressed	61
4.19	“Up” arrow is pressed	61

4.20	Hide Unhide Cube	62
4.21	Flowchart of Hide Unhide Cube	63
4.22	Fixed Area for Cube	64

LIST OF ATTACHMENTS

NUMBER	TITLE	PAGE
A	Project Proposal	72
B	Project Milestone	74
C	System Requirement	76
D	Hand Grabbing Coding	80
E	Webcam Rendering Coding	98
F	Cube Hide Unhide Coding	101
G	INNOTEK Poster	104
H	Project Achievement	106

CHAPTER 1

INTRODUCTION

1.1 Background

Augmented reality is perceived as the future of the technology. It transforms the way people see and learn from their surrounding. It is an experience that supplements the real world with a virtual layer of information. It will greatly help in user experience. For instance, it increases the students understanding on science and to related subjects. Even though augmented reality is anticipated by the community, but the existing device such as Microsoft Hololens is way too expensive to be owned one. This is due the device is build with advanced technologies and the involvement of large number of engineers who made this device works. Hence, the community can only afford Oculus Rift which is a device that allows user experience only in

the virtual world with virtual objects. Thus, this project focuses on creating an augmented reality environment in a cheaper way by using Oculus Rift. The user experience in the augmented reality environment can be improved by integrating the Leap Motion to the Oculus Rift to allow user interaction with virtual object in augmented reality environment. Leap motion acts as the hand gestures recognition device. For example, leap motion detects the hand and perform grabbing action if we are trying to grab the virtual object.

1.2 Problem Statement

Since the introduction of Oculus Rift, this technology has offered a new kind of technology experience to the user. A new kind of interaction and experience based on Virtual Reality. It utilizes the virtual environment which consists of virtual object. User tends to picture themselves into the virtual world and at the same time interacting with the virtual object. This technology has brought human one step further in the development of augmented world. Augmented reality is needed due to some limitation that is virtual reality offering. Augmented reality is whereby virtual object exists or appears in the real world and on the same time user can interact with the virtual object. Imagine if the user can perform a phone call with the virtual feature in the real world, it will tremendously improve and ease the human life. Hence, it can be said that Oculus Rift and its features are limited only to the Virtual Reality and not fully implemented in Augmented Reality. Users are restricted to interact only with virtual object in virtual world. Users are constrained beneath the cover of Oculus Rift and cannot see the outside world. Thus, augmented reality with hand gesture recognition will be the real solution for this.

1.3 Objectives

The main objective of this work is to create an Augmented Reality by using Oculus Rift, Leap Motion sensor and a pair of webcams. The following objectives will be achieved throughout the implementation of the system:

1. To integrate Oculus Rift & Leap Motion for Augmented Reality by using a pair of cameras (Logitech HD310 Webcam).
2. To implement hand gestures control in Augmented Reality by using Oculus Rift and Leap Motion.
3. To develop a friendly usable Oculus Rift which attached with Leap Motion by using hand gestures control.

1.4 Scope of Project

Since the main concern of the Augmented Reality device is mainly on Oculus Rift, Leap Motion sensor and a pair of webcams, this experiment will be conducted in Faculty of Electronic and Computer Engineering, University Technical Malaysia Malacca Laboratory only. This work is going to focus on integrating the Oculus Rift with Leap Motion in Augmented Reality with the recognition of hand gestures feature included. A pair of webcams will be needed in order to capture the stereoscopic images for the implementation of Augmented Reality whereby the stereoscopic images will be projected or rendered onto the Oculus Rift. Since one of the objective is recognition of hand gestures, hand gestures recognition will be implemented into the Augmented Reality environment with the function of grabbing, interacting and colliding with virtual object inside the augmented reality. The hand gestures is detectable with the use of Leap Motion sensor.

1.5 Thesis Organization

The first part of this chapter is background which includes fundamental, history, and existing Augmented Reality applications. These criteria are outlined in order to better define specific aspects of Augmented Reality in terms of function and feature addressed in this thesis. The second part of in this thesis explains an overview of related work. The third part which is methodology provides the tutorial or the steps which make up this project. The fourth part outlines the result and performance based on the new method of this new model in order to verify if the objectives are achieved. Discussion of the result and validity also included in this part. Lastly, fifth part of this thesis concludes the whole project and offers future work recommendation for improvements of this project. Program codes and gantt chart are contained within the Appendices.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the related works have been studied for a better understanding and improve the weaknesses of these works. Information and techniques are gathered and recorded throughout this work to avoid unnecessary mistakes or decision making.

As the world has been emerging toward virtual reality, people realize it is the time to bring the virtual reality to another level which is augmented reality. An environment which the user can experience the virtual object in the real world. By using Oculus Rift, we are able to modify it into a device which is not just limited to virtual reality but also augmented reality. With the combination of Leap Motion controller, the hand gestures can be detected and recognized to perform different tasks.

This technology will greatly help in any learning field for instance hands on experience and education. The real time experience and interaction with virtual object can increase and enhance the understanding and knowledge of the user. It may also implement into other purposes such as a virtual layout which comes with the features on making call, checking email, weather forecast and internet browsing.

2.2 System Specification and Details

2.2.1 Stereoscopic Vision

Monocular vision using a single image source provides only 2D view, where the third dimension which is depth is missing [1]. Generally, a stereoscopic system makes use of pair of views and disparity between these two views provides depth information. Stereoscopic systems are functionally very close to our human vision system and depth information can considerably improve an experience of user. It affects the impression formation when human watch 3-Dimensional things and prevent false identification [2].

Stereoscopic vision is a technique determining the 3-Dimensional position of an object by two (or more) simultaneous views of the scene. Compared to the monocular vision, it is the enhancement of depth perception, hence, the additional information such as disparity and issues related to binocular vision induced difficulties and problems on both resizing image and saliency map detection step [3].

Even though it has complex setting and calibration, yet by implementing the standard setting we are able to have a cheap and simple calibration for 3-Dimensional reconstruction of an environment [4]. It does not produce any interferences with other sensor devices because it is using passive sensor. With this implementation, it can be

applied and integrated with other vision routines for instance object recognition, tracking, distance measurement and object differentiation [5][6].

Standard setting of setting and calibrating a stereoscopic vision is by measuring the parallel optical axes and coplanar image planes. It is important to undergo the procedure of calibrating the Stereoscopic vision in proper way as the wrong way may induce headache to the user. For this setting, the two images has to be aligned which mean by the epipolar lines has to be corresponded to the horizontal rows of both images and the point correspondences are searched over these rows. This setting cannot be applied to real cameras as the real cameras do not have these configuration but on the mean time, if the camera calibration parameters are known then this standard operation procedure is applicable. For example, the focal distance of the two cameras has to be paralleled, the entity of lens distortion must not be over distorted as it has to be corrected in to the correct position and lastly the relative orientation and position of the cameras [7][8][9].

By using the technique, Epipolar Rectification, it can overcome these limitation and problems. It transformed each image plane to become collinear and parallel to one of the image axes which is usually in horizontal to conjugate epipolar lines. Figures 2.1 and 2.2 show that the Epipolar Rectification technique where one is the before epipolar lines and the other is after the rectifying process. The rectification task of preceding the 3-Dimensional reconstruction can be divided into three different categories or stages which are: perspective correction (by considering the relative position and orientation of the cameras), lens distortion compensation and bilinear interpolation (needed to map the two final images with respect to the original ones, whose indexes of the texture map are stored in a Look-Up-Table) [10].