MARKER-BASED TRACKING UNDER EXTREME ILLUMINATION:

FEASIBILITY STUDY AND PILOT TESTING

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SUPERVISOR ENDORSEMENT

"I hereby declare that I have read through this report entitled 'Marker-based tracking under extreme illumination: feasibility study and pilot testing' and found that it complies the partial fulfilment for awarding the Degree of Bachelor of Mechatronic Engineering."

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A report submitted in partial fulfilment of the requirements for the Degree of Mechatronics Engineering

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STUDENT DECLARATION

I declare that this report entitles “Marker-based tracking under extreme illumination: feasibility study and pilot testing” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Name : MUHAMAD AFIQ AFIFI BIN FAUZI

Date : 21 MEI 2018

DEDICATION

To my beloved father and mother

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Praise to Allah because give me strength, health, and patience during my Final Year Project. During this semester. I would like to take this opportunity to express my appreciation and thanks to those who are helping and contributed while conducting this project.

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ABSTRACT

The tracking system becomes a necessary need in the modern illumination system in the surgical room. This modern illumination system can replace the shortcomings of manually or old illumination system. This shortcomings including having to adjust surgical lamp manually and the presence of shadow due to obstacle that influence the amount of light reaching to the surgical area. To make this tracking system become efficient, a correct characterization of marker need to be identified. For this project, the characteristic of marker were proposed based on color and shape. This project was proposed to overcome two major problem which were the presence of shadow that inhibits transmission light and the changes of properties on the objects due to high illumination. So this project has focused on a few goal. Firstly was to analyze suitable object for object recognition. Both color and shape characteristic were used to recognize the marker. Black balls of different sizes were chosen due to properties of shape and color which were black and circular. Next was to locate the marker's position and to evaluate the precision of marker's position localization. Three different experiments were conducted by varying the brightness of light, size of object and the position in camera space in order to evaluate the tracking capability. Raspberry Pi with Pi camera were chosen to realize these experiments. Algorithms were written in Python with help from OpenCV libraries. While surgical lights can reach 45000 lux, these experiments were conducted at 5000 lux at maximum due to limited illumination capacity. Therefore the results may only be applicable to lower specification of surgical light such as illumination for dental surgery. It was found that marker with a diameter of 9.3 cm was consistently tracked within all quadrants in the experiment and at distance 100 cm, the error produce in marker detection was the least. The bigger the size was the better for the object to be detected in camera space and object was less susceptible to error when viewed from a longer distance since the apparent circle was smaller and the discrepancy of the approximation of the circle outer edge was minimal.

ABSTRAK

Sistem pengesan menjadi suatu keperluan dalam sistem pencahayaan moden di dalam bilik bedah. Sistem pencahayaan moden akan menambah baik sistem pencahayaan lama dan manual. Kekurangan ini termasuklah perlu menggerakkan lampu pembedahan secara manual dan kehadiran bayang oleh halangan yang mempengaruhi jumlah cahaya yang akan sampai ke kawasan pembedahan. Untuk membuat sistem pengesan ini beroperasi secara efisyen, ciri-ciri objek yang dikesan hendaklah ditentukan. Dalam projek ini, ciri-ciri yang dicadangkan ialah berdasarkan warna dan bentuk. Projek ini dicadangkan untuk mengatasi dua masalah besar iaitu kehadiran bayang yang menghalang cahaya dan perubahan sifat pada objek akibat pencahayaan yang tinggi. Oleh itu, projek ini telah memberi tumpuan kepada beberapa matlamat. Pertama ialah menganalisis objek yang sesuai untuk proses mengesan objek. Ciri yang digunakan ialah warna dan bentuk. Bola hitam dengan saiz yang berbeza telah dipilih kerana sifat bentuk yang bulat dan warna yang hitam. Seterusnya ialah mengesan kedudukan penanda and mengukur ketepatan untuk kedudukan objek. Beberapa kajian berdasarkan kajian kes telah dijalankan. Tiga eksperimen yang berbeza dilakukan dengan mengubah kecerahan cahaya, saiz objek dan kedudukan objek dalam ruang kamera untuk menilai kemampuan pengesanan. Raspberry Pi dan kamera Pi telah dipilih untuk eksperimen ini. Algoritma ditulis dalam Python dengan bantuan pustaka OpenCV. Walaupun lampu pembedahan bileh mencapai 45000 lux, tetapi eksperimen ini hanya dilakukan pada 5000 lux maksimum kerana terhadnya kapasiti pencahayaan. Oleh itu, hasilnya hanya dapat diterapkan pada spesifikasi yang lebih rendah dari cahaya pembedahan sebagai contoh pencahayaan untuk pergigian. Penanda dengan diameter 9.3 cm telah dikesan secara konsisten dalam semua kuadran dan pada jarak 100 cm, kesilapan yang dihasilkan dalam mengesan penanda adalah yang paling sedikit. Semakin besar saiz penanda adalah lebih baik untuk objek dikesan di ruang kamera dan kesilapan akan berkurang apabila objek dilihat dari jarak yang

jauh kerana bulatan lebih kecil dan pencanggahan penghampiran lingkaran luar bulatan adalah minimum

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LIST ABBREVIATIONS

RGB	-	Red, Green, Blue
UV plane	-	Aperture Plane
HSV	-	Hue, Saturation, Value
HSI	-	Hue, Saturation, Intensity
ACD	-	Automatic Color Detection
GP	-	Ground Plane
ODM	-	Object Detection Mechanism
SBC	-	Single Board Computer
LAN	-	Local Area Network
RAM	-	Random Access Memory
VGA	-	Video Graphics Array
LCD	-	Liquid Crystal Display
DSP	-	Digital Signal Processor
CSI	-	Camera Serial Interface
FOV	-	Field of View
SD	-	Standard Deviation
RMSE	-	Root-Mean-Square Error
HDMI	-	High-Definition Multimedia Interface
OS	-	Operating System

CV	-	Computer Vision
CMYK	-	Cyan, Magenta, Yellow, Key
I/O	-	Input Output
JPEG	-	Joint Photographic Experts Group
PNG	-	Portable Network Graphics
GUI	-	Graphical User Interface
GTK	-	Gimp Tool Kit

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

One of the main components in the operating room is surgical light. Surgical light is a medical device intended to assist medical personnel during a surgical procedure by illuminating a local area or cavity of the patient. A combination of several surgical lights is often referred to as a "surgical light system".

There are several problems come from the surgical light systems. Even the surgical light was designed to eliminate shadow problem, but it still cannot remove the shadow completely. The surgeons have to adjust this surgical light manually in order to get the maximum amount of light intensity during a surgical operation. This will disturb the surgeon's concentration during operation process and the mistake will occur.

Recently, in order to counter this problem, a new illuminating system that has several functions such as many degrees of freedom, controlling the intensity and with auto tracking function is developed. Many auto tracking systems such as vision systems with the stereo camera are developed. These tracking systems are used to adapt automatically to the given light condition.

In order to improve existing technology, this study will discover and analyze suitable markers for localization. This project has been supplemented with other technology to make sure the outcome of this project are quality and usability in the

medical field. The project was developed and discovered in this report by taking consideration of several methods, hardware, and software after meticulous research

1.2 MOTIVATION

The good illuminating system is very important to make sure there is no shadow which inhibits the transmission of light that can affect the amount of light reach at the surgical area and to make sure surgical operation run smoothly. A new illuminating system that has several functions such as many degrees of freedom, controlling the intensity and with auto tracking function is developed. The markers used in the surgical room must be taken into a count. The suitable object needs to be used for the tracking system due to limitedness of things in the surgical room. The high illumination in the surgical room will cause changes to the properties of an object that have been designated as markers and to counter it, the object selected can be used without any changes occur to the characteristics that cause by light condition. Therefore, this project was designed to improvise the existing illuminating system with auto tracking system by considering the shape and color as the markers characteristics. This technology will be great to be implemented in the surgical room because it does not require manpower to manually adjust the direction of the surgical illumination system and the surgeon can give their full concentration to their surgical operation. Based on the issue stated, the motivation has been found to create this project in order to counter the problem.