A DESIGN OF AUTOMATED SURGICAL ILLUMINATION SYSTEM

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

Nobody gets something for nothing, every challenging work need self-efforts as well as guidance and support from family members. I dedicated this thesis to my parents and brothers who encouraged me to build my motivation towards success. “Keep trying no matter how hard it seems, it will get easier.” This thesis is also dedicated to my supervisor, Dr. Syafeeza binti Ahmad Radzi who has been a constant source of knowledge and inspiration.

ABSTRACT

Surgical lights which consists of a single or multiple-light head assembly attached to a suspension arm are designed to illuminate surgical site. However, it was found out that the need of nurse or surgeon to move the surgical light manually might obstruct the surgical flow and cause contamination of instruments. Thus, the project is aimed to design an illumination system that will automatically track the movement of the hand of surgeon with specific color of. Yet, the project will mainly focus on the automation movement of light with the tracking of hand glove, not related to the specifications of light, operating table, operating room condition, design of suspension arm and others surgical procedure. An algorithm that could track the surgeon's hand movement is be designed using image processing. The best algorithm flow is determined to perform the color tracking process. The project will also include designing a surgical light which consists of a single light head attached with camera to illuminate surgical site that will not cast any shadows and provide high light intensity. Raspberry Pi is used with the Pi Camera to track the movement of the hand of surgeon through the program called OpenCV and the programming language, Python. At the end of the project, the algorithm of color object tracking is executed and the prototype of automation surgical illumination system will be produced.

ABSTRAK

Lampu pembedahan yang mengandungi satu atau berbilang lampu bersepadu telah direka untuk memberi pencahayaan yang mencukupi dan bayangan bebas. Namun, penciptaan ini masih memerlukan jururawat atau doktor bedah untuk mengubah posisi lampu secara manual. Senario ini akan menjejaskan process pembedahan dan mengakibatkan pencemaran instrumen. Oleh itu, projek ini bertujuan untuk mereka sistem lampu pembedahan yang dapat bergerak secara automatik dengan mengesan tangan doctor bedah yang memakai sarung tangan berwarna tertentu. Projek ini hanya focus pada pergerakan lampu pembedahan secara automatik dengan mengesan tangan doktor bedah, tidak melingkupi spesifikasi lampu, meja operasi, keadaan bilik operasi, rekaan penggantungan dan proses operasi. Algoritma yang dapat mengesan pergerakan sarung tangan doktor bedah direka melalui pemprosesan imej. Projek ini akan menghasilkan prototaip yang mempunyai satu lampu bersama kamera untuk memberikan pencahayaan yang mencukupi pada lokasi operasi. Raspberry Pi digunakan bersama Kamera Pi untuk mengesan pergerakan tangan doktor bedah melalui program, OpenCV dan bahasa pengaturcaraan, Python. Akhirnya, algoritma untuk mengesan warna sarung tangan dan prototaip sistem lampu pembedahan telah dihasilkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

CMY	:	Cyan Magenta Yellow
HSV	:	Hue Saturation Value
IMU	:	Inertial Measurement Unit
I/O	:	Input/Output
IR	:	Infrared
LDR	:	Light Dependent Resistors
LED	:	Light Emitting Diode
OR	:	Operating Room
OS	:	Operating System
RGB	:	Red Green Blue
GPIO	:	General Purpose Input/Output
DC	:	Direct Current
PWM	:	Pulse Width Modulation
OpenCV	:	Open Source Computer Vision Library
IC	:	Integrated Circuit

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Surgery is an important medical procedure carrying out in operating room (OR) to treat injuries or diseases by incision with equipment and instrument. There are many types of surgery such as elective surgery, cosmetic surgery, reconstructive surgery, transplant surgery and more. The operating room is a specialized environment, where strict adherence to standards and guidelines of practice, and principles of aseptic and technical know-how are paramount [1]. Every equipment, supply and instrument use in the operating room must be accurate and differentiate depend on the level of the complexity of the surgery. OR must be spacious enough to accommodate all the facilities such as the illumination system, operating table, anesthesia machine,

anesthesia supply cart, anesthesia professional chair, intravenous pole or table, case cart/equipment delivery system cart, prep stand, portable documentation station with chair, back instrument table, ring stand, two trash containers, soiled linen container, hazardous waste receptacle, mayo stand, kick bucket, surgical field suction attached to a wall, image viewers, and a sharps disposal receptacle. Beside, some space must be reserved for surgeon, scrub nurse/technician, circulating nurse and anesthesia care provider [2]. Thus, the recommended size of OR is 6.5 m x 6.5m x 3.5 m [3].

As one of the basic requirement of OR, illumination system is used to provide high quality, bright, comfortable and true color illumination of a wound. The light must illuminate the surgical site constantly even though the head or hands of surgeon is in between the surgical site and light source. [4]. The system can be adjusted in different aspects such as color temperature, color rendering index, light spot and illumination. The illumination system can be either ceiling mounted, wall mounted or on floor stand. The mounting configuration of on floor stand is found out to be inconvenient as the space around the operating table is very limited with surgeon, nurse and all the related apparatus.

Figure 1.1.1: Ceiling Mounted Surgical Light

Figure 1.1.2: Wall Mounted Surgical Light

Figure 1.1.3: Floor Stand Surgical Light

Traditionally, the type of lamp used is conventional lamps which containing a certain volume of halogen in an inert gas under a large hemispherical reflector. The light is focused to the specific focal point by reflector to illuminate the surgical site for optimal visualization of small, low contrast objects at different depths in incisions and body cavities. New lighting technology, Light Emitting Diode (LED) is also applied in the illumination system. LED comprises of small semiconductors create light through the phenomenon called electroluminescence when connected with electrical circuit. LED enhances the color performance of the surgical site and solves the problem of heat radiation as the light is cold and in low temperature [5].

Figure 1.1.4: Surgical Light Using Conventional Lamp

Figure 1.1.5: LED Surgical Light

1.2 Objectives

- To design a program of surgical illumination system by tracking the color of surgeon's glove.
- To prototype automated surgical illumination system.
- To analyze and evaluate performance of system in term of light intensity

1.3 Problem Statement

Illumination system did function well by providing sufficient lighting during surgery. However, in the real situation of surgery, the surgeons and nurse encounter inconvenience as they need to reposition the illumination system manually. In the study carried out by Mooijiwer. R (2011) with 98 OR-staff members, it was found out that the need to adjust the illumination system is high and that repositioning is cumbersome [6]. Although electric motors are provided with the light to ease the procedure of adjusting the position of the lamp, the position may sometime not accurate and fail to meet the requirement of surgeon. Thus, the surgeon may sometimes need to operate the light by releasing one hand from the operation area. If the illumination system is controlled by nurse, communication is necessary to locate the light spot. Both methods may distract surgeon and his or her attention might be lost on the operation. Consequently, the period of surgery and anesthesia duration of patient is prolonged which is not encouraged.

The need of nurse to move around in the operating room to reposition the light is not recommended as the risk of contamination of specific sterile instruments and surgical part will step up. Repositioning of light manually may sometime not accurate or fail to meet the requirement of surgeon due to communication error. Besides, the space of OR is very limited with all the apparatus, instruments and surgery team. The need of nurse to reposition the light should be eliminated to decrease the crowdedness around operating table.

1.4 Scope of Work

The project will focus essentially on the automatic movement of light attached with the camera by tracking specific color of surgeon's hand glove, not related to the specifications of light, operating table, operating room condition, design of suspension arm and others surgical procedure. Other aspects such as the production of illumination system and marketing of this system will not be covered in this project.

Table 1.4.1: Scope of Work

Type of hardware	Raspberry Pi 3 Model B, Pi Camera
Type of software	OpenCV
Type of tools	Servo Motor, DC Motors, Sensor Modules
Performance measure	The measurement of light intensity on the color glove after the movement of light
Database	Database develop in house