FAKULTI KEJURUTERAAN ELEKTRIK

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CONTROL OF MOVABLE PLATFORM FOR SURGICAL ILLUMINATION SYSTEM

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Bachelor of Mechatronics Engineering

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SUPERVISOR ENDORSEMENT

" I hereby declare that I have read through this report entitle **"CONTROL OF MOVABLE PLATFORM FOR SURGICAL ILLUMINATION SYSTEM**" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature : .....

Supervisor's Name : .....

Date : .....

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A **report submitted in partial fulfilment of the requirements for the degree**

Of Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

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2018

DECLARATION

"I declare that this report entitle" **CONTROL OF MOVABLE PLATFORM FOR SURGICAL ILLUMINATION SYSTEM** "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 : .....

Date : .....

DEDICATION

To my beloved mother and father

ACKNOWLEDGEMENT

First of all, I am grateful to God for giving me the strength and health all the time, especially during the process of doing my Final Year Project in my final semester.

To progress in this project, I was in contact with many seniors from UTeM, researchers, academicians, and practitioners. They had contributed towards my understanding and thought. I would like to take this chance to express my sincere appreciation to my project supervisor, Pn. Nurdiana Binti Nordin, for encouragement, guidance, and motivation. Without her continued support and interest, this project would not have been same as presented here.

I would also like to thank my friends and housemates and others who have helped on various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. Last but not least, I am grateful to all my family members who trust and support me all the time.

Last but not least, I would like to thank my family members, for supporting me 24 years in mentality or physically. Without them, I cannot perform so well to reach this stage. They always trust me and give me the strength to move forward without any fear.

ABSTRACT

Surgical illumination is an essential element in a surgical room. To illuminate an area of interest, surgeons have to manually orient the surgical light which may interrupt the work flow especially during a delicate surgical operations. Hence, the aim of this project to develop an automated movable surgical light which illuminated area of interest automatically without human intervention. A statistical linear controller was designed at both pan and tilt joints to control the movement of actuator for the automated movable surgical light based on the detection of localized markers. Since the localization algorithm is out of the scope of this project, the goal is directed to ensure the movable platform moves to the desired location. In multiple experiments presented, movable platform was proven to be able to move within the desired angle precisely. The angular position of the actuator is analyzed within 25 to 155 degree in 2 significant figures using Monte-Carlo simulation. It was shown that the mechanism was able to be directed to the desired location at 45 degrees with accuracy of 98.5% and with error 1.5% using the proposed control strategy. These results confirmed that the control strategy for the platform built fulfills the objective of this project.

ABSTRAK

Pencahayaan pembedahan adalah elemen penting dalam bilik pembedahan. Untuk menerangi bidang minat, pakar bedah harus mengarahkan secara manual cahaya pembedahan yang mungkin mengganggu aliran kerja terutama semasa operasi pembedahan yang halus. Oleh itu, matlamat projek ini untuk membangunkan lampu pembedahan bergerak automatik yang diterangi kawasan kepentingan secara automatik tanpa intervensi manusia. Satu pengawal linear statistik telah direka pada kedua-dua kuali dan tilt sendi untuk mengawal pergerakan penggerak untuk cahaya mudah alih yang mudah alih alih berdasarkan pengesanan penanda setempat. Oleh kerana algoritma penyetempatan adalah daripada skop projek ini, matlamat diarahkan untuk memastikan platform alih bergerak ke lokasi yang dikehendaki. Dalam pelbagai eksperimen yang dibentangkan, platform bergerak terbukti mampu bergerak dalam sudut yang dikehendaki dengan tepat. Kedudukan sudut penggerak dianalisis dalam 25 hingga 155 derajat dalam 2 angka penting menggunakan simulasi Monte-Carlo. Telah ditunjukkan bahawa mekanisme tersebut dapat diarahkan ke lokasi yang dikehendaki pada 45 darjah dengan ketepatan 98.5% dan dengan ralat 1.5% menggunakan strategi kawalan yang dicadangkan. Keputusan ini mengesahkan bahawa strategi kawalan untuk platform yang dibina memenuhi objektif projek ini.

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LIST OF SYMBOL

^{o}	-	Degree
e	-	Error
s	-	second

LIST OF ABBREVIATIONS

PID	-	Proportional-Integral-Derivative
PMDC	-	Permanent Magnet Direct Current
SMC	-	Sliding Mode Controller
SCPT	-	Saturation Constraints and Performance Technique
FFNN	-	Forward Neural Network
DOF	-	Degree of Freedom
TWMR	-	Two-Wheeled Mobile Robot
FLC	-	Fuzzy Logic Controller
ANN	-	Artificial Neural network
PWM	-	Pulse Width Modulation
ANOVA	-	Analysis Of The Variance
SPSS	-	Statistical Package For The Social Sciences
RMSE	-	Root Mean Square Error

CHAPTER 1

INTRODUCTION

1.1 Introduction

The most important element in the surgical room is the illumination of the light. In recent years the surgeon needs to adjust the surgical lighting manually on their own. Therefore, the surgeons move the position of the lamp by holding the lamp body at sterile hand cover and pushed the handle of the lamp to the desired position and orientation. So surgeons required to adjust the surgical light in a proper direction in a continuous during the surgery. During a surgery, it is required the hand of the surgeons is not become unhygienic by placing their hands on this object. This has distracted the focus of surgeons during the operation [1]. In recent years, many surgical illuminations have been developed such automated movement of the surgical bed, surgical robots and so on. At times it is inconvenient to reposition the position of the illumination system whenever the surgeon changes his posture. To overcome this problem an automated movable surgical illumination with the function of several degrees of freedom and precise control of positioning system to be developed.

Generally, the surgical light has two links with a single joint, which one on it able move rotate about the z-axis (yaw) and another one is able to rotate about the x-axis (roll). This mechanism is mounted directly to the ceiling of the operating room. So this project is about to design and developed an automated movement of surgical light based on the movement of the surgical tool. Moreover, each link has an actuator which allows the mechanism to moves in the desired direction. The mechanism moves

based on the torque emitted from the actuators. The movement of the surgical light needs to be precise and accurate in order the system to be more efficient. The movement of the surgical lamp, depends on the positioning of the actuators.

Therefore, for precise positioning and accuracy of the actuators, a controller is very much needed in the system. A linear controller will be developed and be tuned to improve the system performance.

1.2 Motivation

Surgical illumination tools are being invented especially to perform a specific action or carrying out a desired outcome during the surgery. This type of modern tools may assist the doctor and reduce the work on considering the lighting factor during surgery or operation. Over time, many different kinds of surgical instruments and tools have been invented.as the need to do wonders continuous, so does the complexity of the tools.

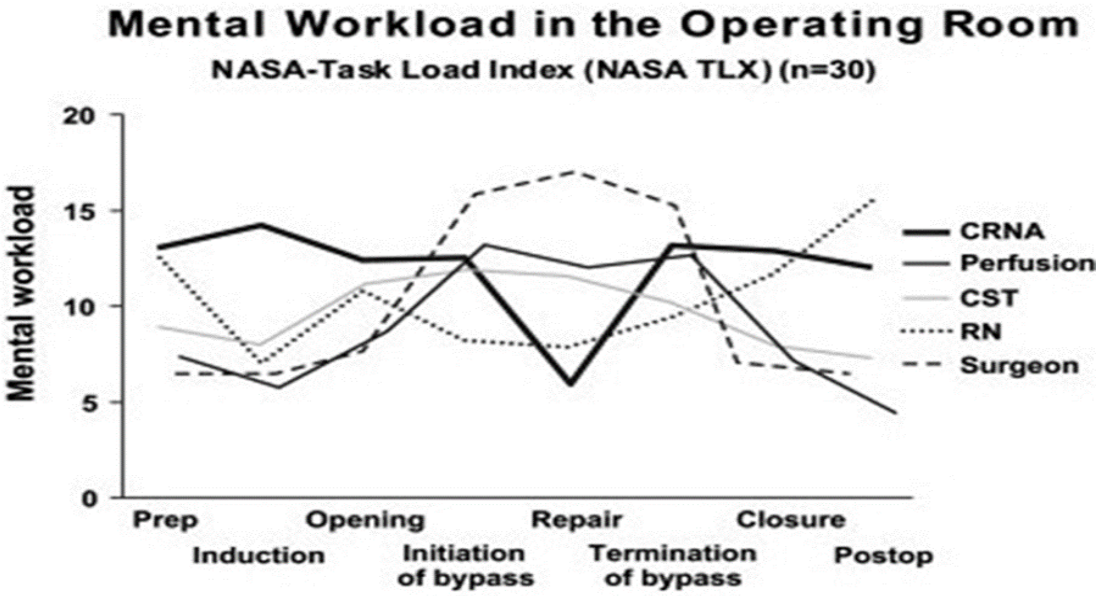

Figure1.1: Percentage Of The Mental Workload In The Operating Room

Figure 1.1 shows the mental workload that has carried by the doctor during the surgery. Doctors have always been needed to perform at their optimum whenever needed. According to the graph, it could be seen that surgeon has the highest mental workload and they do need better equipment to assist them in their daily tasks. A simple thin line is a difference between a successful and failed surgery. A modern equipment may help to reduce their pressure during the surgery and operation, perhaps help them to be more focus in their work.

As they are handling delicate parts of the body, illumination is also a very important so that they could focus on their work. As in the early 18th century, surgeries always takes place in the day due to make full use of natural sunlight. Bad weather conditions may affect the progress of surgery. Moving on, using natural lighting can easily be blocked by tools, nurses or even doctors themselves. This results in higher failure risks to be assessed. Since then the surgical procedure is done in a closed dark room without any light penetration of outside. The necessary light source is provided from the surgical light that is mounted together with the ceiling of the operating room. This mechanism needs to be moved manually by the surgeons or nurses.

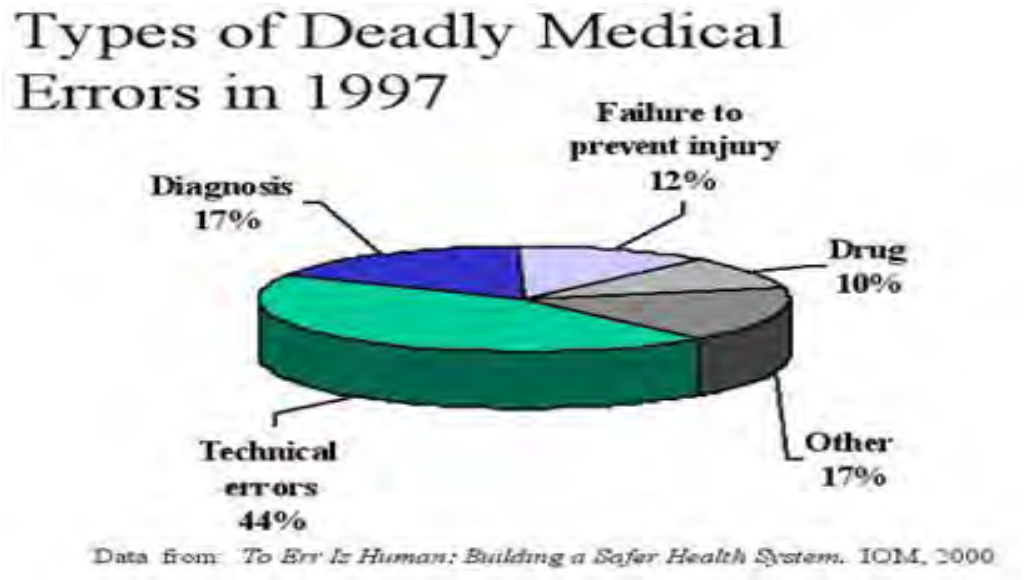

Figure 1.2: Types Of Medical Error In 1997 [2]

Figure 1.2 indicates that in the year 1997, 44% of the death in a hospital are caused by technical error. Technical error falls due to the failure of the surgical instrument, tools and etc. so one of the important elements in an operation room is the surgical light. The focus of the light towards the patient surgical part plays a key role in the surgery or operation. So during a surgery or operation, doctors or nurse have to relocate the surgical light to the required position until they get a good focus of light [3]. This will distract the focus of the doctor on their work if they did not receive a good light source to the surgery part at the right time and may cause an error. So an automated control of a surgical lamp may east the doctor job. Moreover, to reduce the number surgeons and nurses required during the surgical procedure is done, which there are no needs of a person for handling the orientation of the surgical light. Perhaps the person can be utilized in other ways during the surgery. Besides that to limit the disturbance produce from surgical lighting mechanism. So a control system with surgical lighting mechanism can limit the disturbance produce from the mechanism. Therefore, a control movable platform for surgical illumination is beneficial, so it can assist the doctor in achieving greater heights in a successful surgery.

1.3 Problem Statement

A movable platform for the surgical lamp is very useful in surgical work environment instead of shifting it manually. So in this project, an automated movable platform for surgical illumination prototype was designed where the surgical lamp was mounted with a pan-tilt mechanism model. However, mounting the pan-tilt mechanism with surgical lamp might produce some problem in the system.one of the main concerns in this prototype is suffer from external disturbance [4]. The external disturbance occurs due to the connection of the parts between the link joints and surgical lamp. For example, a loose part of mechanism could weaken the stability and performance of the system. Generally, the noise produced by a mechanical vibration could differ the performance of the system. External disturbance also happens at the joints of the mechanism. The friction produce between one link joint with another link joint will cause the delay in movement of the surgical illumination mechanism.

Furthermore, it also suffers from high-frequency vibration. High-frequency vibration happens when the joint of the mechanism coupled together with a heavy load. Thus, if the mechanism moves with a heavy load, it may cause inertia to be initiated on the mechanism. So inertia from the load can cause the mechanism to jerk and vibrate. The load in our mechanism is from the weight of the surgical light [5]. Moreover, sudden shock also influences the mechanical movement. Sudden shock occurs when frequency tracking where the position and the speed of certain target differ in unpredictably so it can't sense the actual input signal. Then the transition from stationary to any moving at a rapidly cause sudden shock [6].

Therefore a good controller like linear controller can compensate this type of problem and allows the mechanism to move smoothly.

1.4 Objective

The objective of this project are;

1. To analyze the open loop performance of movable platform for surgical illumination
2. To design a controller to improve closed-loop performance for movable platform of surgical illumination
3. To compare and analyze the controller performance of the movable platform.

1.5 Scope

The scope of this project are;

I. Using two degrees of freedom pan-tilt mechanism model as linkage bound between the surgical lamp and motor for mechanical modelling.

II. Angular position will be analyzed within (25 -155) in 2 significant figures using Monte-Carlo simulation

1.6 Report Outline

This report consists of 5 main chapters. Firstly, the title of the project was confirmed at the initial stage. This report starts with the first chapter that is the introduction. The first chapter discussed the overview of the project background, problem statement, objective, scope, and the expected outcome of the project. It is explained in detail about the motive of this project. Then this report is continued with the second chapter literature review. Chapter 2 discussed literature review that is related to this project based articles, journal, books, and internet.in this particular chapter it is discussed briefly about the fact, technique and results about from the previous studies. Next is the methodology chapter where it described the planning, methods going to use, procedures of experiment going to be done throughout the project and tools such as Matlab Simulink. Chapter 4 discussed the results and analysis. The results obtained from the project will be analyzed well in this chapter. Finally, the last chapter is conclusion where discussed the project achievement and future recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this particular section, several studies have been done regarding "control of movable platform for surgical illumination system". This part covers the previous study that is related to this project. The existing surgical light head is able to move in pitch and yaw direction which is already mounted with the ceiling of the operation room. So an automated development in this system needs to move in that particular direction. So based research done the existing pan-tilt mechanism which mostly used in surveillance camera able to move in pitch and yaw direction. Thus, the concept pan-tilt mechanism is inherent in this automated surgical illumination system. Moreover, the type automated system used to move the surgical light also discuss.