UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF ROBOTIC ARM SYSTEM FOR A MOBILE ROBOT

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Pada zaman kini, harga robot yang khas untuk penguatkuasa undang-undang di pasaran terlalu mahal kerana banyak sensor dan aksesori dipasang pada robot itu. Project ini adalah untuk mengkaji, merekabentuk dan menganalisis sistem lengan robot untuk robot yang boleh memanjat tangga dan membuka pintu untuk masuk ke dalam bangunan. Lengan robot mesti mengikuti keperluan pelanggan dan spesifikasi yang diperolehi daripada tinjauan. Lengan robot direka dengan menggunakan perisian 'computer-aided design' (CAD) seperti Catia V5. Berdasarkan beban yang telah ditetapkan untuk lengan robot angkat, lengan robot yang direka sama ada strukturnya atau pin-pinnya dianalisis dengan menggunakan perkiraan dan 'computer-aided engineering' (CAE) seperti 'Altair Inspire' dan 'Altair OptiStruct'. Kesimpulannya, rekaan lengan robot yang dipilih telah memenuhi matlamat projek ini.

ABSTRACT

Nowadays, law enforcement mobile robots that available in the market are too expensive because there are many sensors and accessories that installed on them. This project is to study, design and analyse the robotic arm system for law enforcement mobile robot that can climb stairs and open door to enter the building. The robotic arm must follow the customer requirements and specifications that obtained from survey. The robotic arm is designed by using computer-aided design (CAD) software such as Catia V5. Based on the load that has been set for the robotic arm to carry, the designed robotic arm either its structure or pins is analysed by using calculation and computer-aided engineering (CAE) software such as Altair Inspire and Altair OptiStruct. As a results, the designed robotic arm that has been selected fulfilled the aim of this project.

DEDICATION

I dedicated this report to my beloved parents, Kooh Sow Yan and Low Siew Gek.

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First of all, I would take this opportunity to dedicate special thanks to my supervisor, Mr. Herdy Rusnandi for his valuable supervision, continuous support and encouragement along this project period. Without his advice and assistance, it will be difficult task for me to complete this project by my own. Besides that, I would also like to thank to the encouragement and support from my family and fellow friends. Lastly, thank you to others who involve whether directly or indirectly in the completion of this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

θ	-	Angle
F	-	Force
M	-	Moment
τ	-	Torque
V	-	Shear stress
A	-	Area
P	-	Power
v	-	Velocity
W	-	Weight
m	-	Mass
g	-	Gravity = 9.81 m/s
l	-	Length
r	-	Radius

LIST OF ABBREVIATIONS

CAD	Computer-aided design
CAE	Computer-aided engineering
AC	Alternating current
DC	Direct current
CBRNE	Chemical, biological, radiological, nuclear and explosive
EOD	Explosive ordinance disposal
IEDD	Improvised explosive device disposal
HAZMAT	Hazardous materials
IR	Infrared
ROV	Remotely operated vehicle
GPS	Global positioning system
PTZ	Pan, tilt and zoom
LCD	Liquid crystal display
RFID	Radio frequency identification
CAM	Computer-aided manufacturing

CHAPTER 1

INTRODUCTION

1.1 Research Background

This project is a group project that consists 5 person to develop a law enforcement mobile robot. Law enforcement mobile robot has been divided into five parts which are gripper system, robotic arm system, chassis system, power drive system and track system. Each person has chosen one part as the main topic for their final year project (FYP) respectively. This thesis will mainly focus on robotic arm system of law enforcement mobile robot.

Nowadays, many types of robots are widely used in many fields and designed to perform dirty or dangerous tasks because robot can perform jobs more cheaply, high accuracy and reliability than humans. A robot is a machine programmed by a computer and able to execute one or more jobs automatically with precision and speed. A mobile robot is a machine that able for locomotion and can perform one or more jobs automatically or can be controlled by computer or operator.

In the past, some police departments already start to use mobile robot to perform dangerous tasks such as inspection of dangerous area, bomb removal and disposal. Although mobile robot can perform these dangerous tasks but the cost of a law enforcement mobile robot that available in the market are too expensive. So some police

departments cannot afford to buy a law enforcement mobile robot and they have to send police officers to perform these dangerous tasks. This action causes some police officers have been sacrificed when doing these dangerous tasks. Although the cost of a mobile robot that available in the market are too expensive but mobile robot has high potential for commercialization and can easily adapted by industry or society. Mobile robots usually can get high demand from police department, firefighter department and rescuer because of its ease of use and it can perform many dangerous tasks.

For example, on February 2013, Jamalul Kiram III, the self-proclaimed Sultan of Sulu brought about 200 of 'Royal Sulu Army' to intrude into Lahad Datu, Sabah, Malaysia because they wanted Sabah to be returned to Philippines and claimed that Sabah was seized by British from their government. Duration for this Lahad Datu standoff was about 2 months which started from February until March 2013 and this standoff caused total 71 deaths which were 56 people from Sulu sultanate, 9 people from Malaysian security forces and 6 civilians. (Najiah Najib, 2013)

1.2 Problem Statement

The problem statement for this project is to design and analyse a law enforcement mobile robot that can climb stairs and open door to enter the building at minimum cost. Law enforcement mobile robots that available in the market are too expensive because there are many sensors and accessories that installed on them. If the law enforcement mobile robots that available in the market become cheaper, there will be high demands from police departments to buy law enforcement mobile robots because law enforcement

mobile robots can perform dangerous tasks such as inspection of dangerous area, bomb removal and disposal. This can helps to reduce the scarification of police officers and crime rate. Therefore, some modifications on law enforcement mobile robots are required to neutralize the problems that stated above.

1.3 Objectives

The objective of this study is to:

1. Study robotic arm systems for a mobile robot that can climb stairs and open door to enter the building.
2. Design and analyse a robotic arm that apply loading to pull or push the door.

1.4 Scope of Research

Scope of the project:

1. Design robotic arm by using computer-aided design (CAD) software such as Catia V5.
2. Use house of quality to evaluate the designs of robotic arm.
3. Analyse robotic arm by using computer-aided engineering (CAE) software such as Altair Inspire and Altair OptiStruct.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Czech novelist, Karel Capek was the first person that applied the term robot in a 1920 play titled Rassum's Universal Robots (RUR). Meaning of the term robot in Czech is worker or servant. For design and operation of robot, there are some knowledgebase that are important such as dynamic system modelling with analysis, feedback control, sensors with signal conditioning, actuators with power electronics, hardware or computer interfacing and computer programming. (Shankar & Harmon, 1986)

Key components of robot is power conversion unit, sensors, actuators, controller, user interface, manipulator linkage and base. The important information that received from human senses such as sight, smell, taste, sound and touch make human function and survive. Thus, robot also equipped with sensors to determine the robot configuration, condition and environment. After that, robot will send the information that determined by sensors to robot controller as electronic signals. Robot actuators are combined of various type of electro-mechanical devices such as synchronous motor, stepper motor, AC servo motor and brushless or brushed DC servo motor. (Shankar & Harmon, 1986)

Robot controller controls the robot intelligently, processes the information that collected from sensors and compute control commands for actuators to perform specified missions. Storage hardware stores control program and state of robot system that received from sensors. Computation hardware computes the control commands from the user.

Interface hardware allows the user to interact with digital controller by using sensors and actuators. Fixed base robot are mainly used in manufacturing industry and cannot remove their base away from the work being done. On the other hand, mobile base robot are equipped with wheels, tracks or legs to move around. (Shankar & Harmon, 1986)

2.2 Mobile Robot

Mobile robot is designed specially for mobility needs like travel with high speed, transverse rough terrain or maneuverer in compact spaces. Mobile robot can prevent itself from step over obstacles like bomb or protect the objects from being destroyed. (Shakhatreh, 2011) Features of mobile robot are performing tasks as a teleoperated robot, equipped with operator feedback that can control it from a distance, mobility and remote-object manipulation.

2.2.1 Vanguard MK2

Vanguard MK2 as shown in Figure 2.2.1 is designed by Allen-Vanguard and a high-risk use robots according to Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) and EOD/IEDD threats, HAZMAT operations, tactical and surveillance needs. Vanguard MK2 is lightweight, portable and tactical EOD robot with additional features and improved functionality to maintain excellence of quality. Vanguard MK2 can support mission across all dangerous duty situations. (Allen Vanguard, 2004)