UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF ROPE CLIMBING ROBOT USING ARDUINO

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronic Engineering Technology (Industrial Electronic) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Industrial Electronic) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Projek ini adalah untuk membangunkan satu robot yang mempunyai kemampuan untuk memanjat tali dengan sendirinya atau secara manual. Robot ini terdiri daripada perkakasan dan perisian antara muka. Tujuannya adalah untuk menghasilkan robot yang cekap, berkuasa rendah dan kos yang efektif, yang mampu mencapai bahagian atas tali dalam dalam masa yang singkat. Robot ini menggunakan mikropengawal Arduino sebagai otak. Di samping itu, servomotors digunakan untuk membina pergerakan dan penggenggam robot. Secara amnya, algoritma kawalan robot direka supaya robot yang mampu bergerak kedua-dua arah iaitu mendatar dan menegak. Robot ini boleh bekerja dalam mod automatik atau manual melalui isyarat RF dari pemancar RF. Tambahan pula, robot ini boleh dilekatkan dengan litar luar untuk melaksanakan pelbagai tugas seperti dengan menetapkan kamera video kecil untuk "akses visual" di mana tempat-tempat yang sukar dan bahaya dicapai oleh manusia .

ABSTRACT

This project is to develop a rope climbing robot that has the ability to climb a rope by itself or manually. This robot is built with hardware and software interfaces. The objective here is to produce an efficient, low powered and cost effective self-climbing robot that is able to reach the top of the rope in the least amount of time. The robot is using Arduino microcontroller as the brain. Besides that, the servomotors are used to build the movement and gripper of the robot. Generally, the robot control algorithm is designed so that the robot is able to move both horizontal and vertical direction. The robot can work in automatic mode or manual through RF signals from an RF transmitter. Furthermore, the robot can be attached with external circuits to serve various tasks such as by fixing a small video camera to offer "visual access" in places where access by human presence is difficult and dangerous.

DEDICATION

Specially dedicated to my beloved parents,

Mohamad @ Muda Bin Ismail and Esah Binti Hamzah

To my siblings,

To all my course mates,

4BETE 2014/2015

Thank you for always with my side to complete this journey and I very appreciate with your support and help.

Thank you for all memories.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

RCR	-	Rope Climbing Robot
DC	-	Direct current
CAD	-	Computer Aided Design
GUI	-	Graphical User Interface
CPU	-	Central Processing unit
τ	-	Torque
RF	-	Radio Frequency
PWM	-	Pulse-Width Modulation

CHAPTER 1
INTRODUCTION

This chapter will briefly discuss on the project background, the problem statement, its objective as well as the scope of this project. Last but not least, the project's significance which outlines benefit that can be derived from the outcome of this project.

1.1 Background

High voltage lines should be checked regularly, at least once a year. At present, this work is done by technician, and even by helicopter mission. Examination by the technician requires a lot of time and in some circumstances it is impossible for difficult terrain such as mountains or steep valley. Helicopter mission is quickly but it is very expensive, tedious and difficult, especially for pilots, because he would have to fly at a minimum distance power lines. Possible extra strong side wind turned this task into a hazardous situation. Line maintenance required them to charge their body with power. So that people can move on the cable, that ten meters from the ground. The safety of human operators in hazardous industrial environment have always been the main concern which then resulted in implementation of mobile robots for several inspection purposes.

Conventional mobile robots are normally large in size depending on the task the machine has to endure. With bigger size, comes a substantial amount of weight which then results to a significant rise on the force needed to be mobile or to move. In this case, bigger actuators (motors) consuming more power and the

locomotion or the movement of the robot generally becomes slower. Large mobile robots are normally attached to an external power source whether is pneumatic, hydraulic or electrical power source. The plan here is to surpass all these weakness or element that prevents the full efficiency of a rope climbing robot. To achieve this, few important points have been chosen in this paper to be examined and modified for better performance. Some parts of it have to be implemented with new sources to give it the edge of performance. Through this project a light weight, fast, low power consuming and a cost effective rope climbing robot (RCR) is to be produced.

1.2 Problem statement

For the controlling the rope climbing robot, many method of concept for control the robot such as kind of dynamic modelling and motion control. Controlling a rope climbing robot is a challenging problem due to its nature of kinematics and dynamics on motion control of robot. Necessary to find a simple method to farther enhance the motion stability of the rope climbing robots.

The design and construction of mobile robot, in this case the rope climbing robot must be plotted or planned based on the specification to perform the selected tasks. The rope climbing Robot (RCR) is constructed with few crucial components or parts of the hardware to suit it climbing operation. The elements on the RCR which should be taken into serious Consideration are the grippers, the movement of the body, the microcontroller used for control the power source and the size of the whole body.

The implemented control system consists of control station, prototype robot equipped with on-board microcontroller, sensors, and wireless communication. Upon successfully of the project, the robot should be can communicate within controller and movement follow by controller.

1.3 Objectives

The objectives of this project are as follow:

(i) To develop mechanical and mechanism of rope climbing robot
(ii) To develop Graphical User Interface (GUI) to control the rope climbing robot and Arduino for microcontroller and the communication system
(iii) To analyse the performance and the communication system of the climbing robot.

1.4 Scope of work

This project can be divided into two parts which consist of hardware and software development. To achieve the project's objective, the following scopes need to be fulfilled.

(i) The rope climbing robot is develop to move in both horizontal and vertical direction.
(ii) The program is write by using C language in Arduino software for controller (software).
(iii) Software Visual Basic is use as software of Graphical User Interface.
(iv) Radio Frequency is use as wireless device to transmit data from computer to interface input to the output.

CHAPTER 2
LITERATURE REVIEW

In this chapter, reviews of researches which are related to this project will be discussed. It will describe details about literature review on the parts and systems used in the project. In addition, it will include explanations of the component characteristics and the particular component chosen for this project.

2.1 Rope climbing robot

Rope climbing robots are mobile robots that are already in use nowadays. The Robotic industries increased the attention given to problems of safety and health in the Work-place. The environments dangerous for human operators have also been identified which have delineated the characteristics of robots that can operate intelligently in Hostile environments. Many researchers have come out with new type of mobile robots. These robots are used for inspection, surveillance, assistive works, search and rescue and many more.

The first paper found regarding this RCR (Rope Climbing Robot) robot project was a paper explaining about developing and employing special robots for inspections in construction in order to assist the human operator as well as to limit the damage caused to him [1]. For this end, the ROMA robot, a specially developed self-supported robot has 7 been built. The robot is designed to perform 30 complex movements and navigate through metallic structures using the "caterpillar" concept. The control and monitoring of the robot is achieved through an advanced Graphical User Interface, especially built, to allow an effective and user friendly operation of the robot with a

minimum operator training. The GUI has been designed with an open and modular structure allowing future reusability and scalability when necessary. This paper in detail describes the design of the ROMA robot with a special emphasis on its GUI.

This paper also explains that ROMA robot consists of three essential parts: the body of the robot, the locomotion system and the sensorial platform. The body of the robot includes the CPU, the servo multi-axis controller board (PMAC) which comes with its own low level programming language, one servo motor amplifier (driver), the batteries, the radio-based Ethernet communication with the "ground" operation centre, three multiplexing systems and other auxiliary electronics[1].

The difference between this the ROMA robot and the RCR robot that is to be accomplish in this project is, first, the rope climbing robot is much simple and involves less cost. The locomotion of the ROMA robot is formed by two grippers are attached to the robot body and driven by AC brushless servo motors through Harmonic Drive redactors, which permit the 3D movements along complex structures. While the movement of the RCR is based on a servo motor controlling the bottom half body of the robot motion up and down and gripping using two solenoid grippers.

The next paper that has been found regarding this project is the Sky Cleaner 3. In this article, the emphasis for discussion is on the wall cleaning robot for high-rise buildings. Due to a current lack of uniform building structure, wall cleaning and maintenance of high-rise buildings is becoming one of the most appropriate fields for robotization [2]. The Sky Cleaner 3 is a real product designed for cleaning the complicated curve of the 8 Shanghai Science and Technology Museum [2]. The robotic system consists of three parts, a following unit, a supporting vehicle and the cleaning robot. The cleaning robot is supported from above by cables from the following unit mounted on the top of the building. A hose for water, a trachea for pressurized air, and cables for control signals are provided from the supporting vehicle on the ground. The GUI is also installed on this vehicle. On the other hand, the following cables carry some of the weight of the hose and trachea when the robot is in midair. This is some of the information the paper provides. The Sky Cleaner 3 uses a cable to suspend in the air. This is the same concept used in RCR robot, except that

RCR uses a rope to climb and ascend. The main concern of the Sky Cleaner robot is the mobility of the robot. Although the robot is able to move sideways, but it is still limited to the length of the suspending cable and the length of the pneumatic hose for power. Compared to the RCR robot, mobility is not a problem as it is not attached to any auxiliary power. Its power pack (NiCad battery pack) is carried along with the robot.

A paper on the modular climbing robots was also found. This paper discussed about the task of traversing terrain by climbing, and presents various methods of climbing with modular robots. In particular, the paper also focuses on the tasks of climbing across a horizontal rope, climbing up a vertical rope, and climbing up stairs using the Superbot modular robot [3]. Locomotion is an interesting challenge in modular robotics as it involves the interconnection of several modules to overcome limitations of a single module such as power, size, torque and actuation precision. Wheels, tracks, paddles, legs and arms can be formed with modular robots enabling a large number of gaits for traversing diverse terrain. This paper presents a robot for rope climbing demonstrated on the Superbot modular reconfigurable robot. The robot has an inchworm type movement. The primary considerations in a rope-climbing action are the gripping attachments used to traverse the rope and how to deal with changes in rope tension. The inchworm robot essentially works by alternating gripping between each connector and sliding the other end along the rope in the desired direction. Much of the attention in developing the rope climbing action was on getting the attachments to grip and release at the appropriate times and consistently.

There was also a website on a modular climbing robot called SLOTH. SLOTH is a robot that is used for rope climbing. Studying the anatomy and movement of a real biological sloth animal has inspired SLOTH's mechanical design and it's climbing gaits [4]. SLOTH robot is constructed by three small servos and is controlled through an SSC II serial servo controller. SLOTH robot can be used as a telepresence robotic system by carrying a small video camera to offer "visual access" in places where access by human presence is difficult and dangerous. The robot's brain is based on the SSC II serial servo controller. The controller is connected through an RS-232 connection with a personal computer that runs the robot's Control Panel software. The robot uses only

three servos. The first two servos used for the up and down grippers and the third for the body.

2.2 DC motor with built in gearing

DC motors provide excellent speed control for acceleration and deceleration with effective and simple torque control. The fact that the power supply of a DC motor connects directly to the field of the motor allows for precise voltage control, which is necessary with speed and torque control applications. A simple motor has six parts, Armature or rotor, Commutator, Brushes, Axle, Field magnet, and DC power supply of some sort [5]. The brushes act as contacts between an external power source and the commutator. The design of these carbon brushes allows them to move up and down on a brush holder, to compensate for the irregularities of the commutator surface. Thus they are said to ride the commutator. The commutator regulates current flow in the armature coils, allowing it to flow in one direction only. Each segment of the commutator is directly connected to an armature coil, so the commutator rotates with the armature. In this project the DC motors used is a 5 Volt built in gearing model. This enables the motor to drive a large load. Figure 2.1 show the standard DC motor with gearing.

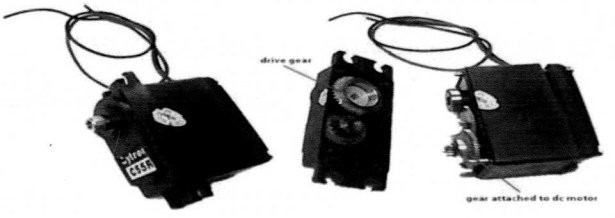

Figure 2.1: The standard DC motor with gearing

2.3 Controller system 18f4620 Microcontroller

The host computer function as a user interface for human operates the robot and the system. This is where normally the human create the programming and execute or compiles the program. If there is any modification on the programming needed, all the work required is done here. All programs then will be sent to the controller. The controller is most important part in this project. The function of this controller is as a brain of the system. It processes all the input from the host computer and from the feedback error, and provide an appropriate output based on the sequence and programming made by the user. In the existing system, the controller part for these system are control by microcontroller PIC18f4620.

A microcontroller is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory. Microcontrollers are designed for small or dedicated applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used with an embedded

The compiler that used in this project is HI Tech Picc. This compiler supports the lot of microcontroller 18F, 12F and 16F devices, this compiler is chosen because it is a low cost tool for student. It is ideal as a teaching tool for an introduction into C language and embedded programming.

2.4 Obstacle Detection Ability

An element of intelligence is applied to the robot so that it can detect an obstacle and do the decision making process. To do this, an IR sensor or ultrasonic sensors is located at the head of the robot. Once it hit an obstacle, it will move a step down next it will try to determine whether the obstacle is still blocking its way up or not. Next movement will either be moving upward or downward depending on the existence of the obstacle. Autonomous robot for a power transmission line inspection [7] and Development of an inspection robot control system for 500KV extra-high voltage power transmission lines [8]. This two paper using IR sensors to detect obstacle on the rope because the IR sensors has high directionality and accuracy. The IR sensor also can detect the distance more accurate. Other than that, Line scout Power Line Robot: Characterization of UTM-30LX LIDAR System for obstacle detection [9] and using coded signals to benefit from ultrasonic sensor crosstalk in mobile robot obstacle avoidance [10] is presented. The advantages of using this sensor are cheaper and simple to operate and has high object detection reliability.

CHAPTER 3
METHODOLOGY

The methodology section provides detailed and precise procedural information, material or equipment's that will be used. Then, Methodology section also describes how to conduct the investigation. Each step of the information gathering process is described in order. A proper methodology will leads as guidance for researchers to achieve the goals of the research. In general, the process is divided into three main parts, namely the development of hardware, circuit development, and software development.

The methodology and explanation about flow chart that used by this project is summarized in the next page.