



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN AND DEVELOPMENT OF LINE
TRACKING ROBOT WITH OBSTACLE
AVOIDANCE**

Thesis submitted in accordance with the partial requirements of the Universiti
Teknikal Malaysia Melaka for the
Bachelor of Manufacturing Engineering (Robotic and Automation)

By

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ABSTRACT

Line tracking and obstacle avoidance behaviors are the critical challenge in the creation of autonomous mobile robots. Mobile robots must be able to operate within normal environments to carry out different tasks, such as banks surveillance and transportation of goods without any human intervention. This report describes the design and development of an autonomous mobile robot which exhibits line tracking and obstacles avoidance behaviors. The PIC16F877A microcontroller has been chosen as the brain to control the system. There are 2 types of software that are used in programming development which are MPLAB Integrated Design Environment (IDE) and HI-TECH PICC Lite C Compiler software. MPLAB IDE software is used to program the PIC16F877A microcontroller in C language and the HI-TECH PICC Lite C Compiler is used to convert source code into machine instructions. Tracking system is developed for the mobile robot to have navigation ability. Sensor arrays that are used will be able sense a line and maneuver the robot to stay on course, while constantly correcting its position using feedback mechanism forming a simple yet effective closed loop system. Contact detection approach is used in this project in order to avoid the mobile robot from colliding with obstacles. The testing phase results had shown that successful programming algorithm had been implemented. Several suggestions of improvements to the robot have been recommended from the observation at the end of the report.

ABSTRAK

Pembangunan robot bergerak yang memiliki kemampuan untuk menuruti satu laluan dan mengelak sebarang halangan merupakan satu cabaran yang agak kritikal. Robot bergerak ini perlu ada sifat-sifat tersebut bagi menghadapi manusia di sekelilingnya semasa beroperasi, sekiranya ia ditugaskan untuk menjalankan kerja seperti mengawasi keselamatan bank dan mengangkat barang-barangan. Laporan ini membentangkan sebuah rekabentuk dan pembangunan sebuah robot bergerak yang boleh mempamerkan kebolehan untuk menuruti satu garis laluan dan mengelak sebarang halangan yang telah dikesan. Microcontroller PIC16F877A telah dipilih untuk mengawal sistem yang telah digunakan. Dua jenis perisian telah digunakan dalam pembangunan pengaturcaraan iaitu MPLAB Integrated Design Environment (IDE) dan HI-TECH PICC Lite C Compiler. Sistem penjejakan dibangunkan untuk membolehkan pelayaran robot. Dengan susunan penderia yang digunakan, ia akan mengesan dan memandu robot tersebut sentiasa di dalam kedudukannya sementara ianya berterusan dengan bantuan sistem maklum balas atau gelung tertutup yang mudah dan berkesan. Pengesan sentuhan digunakan di dalam projek ini adalah untuk tujuan mengelak pelanggaran. Hasil daripada fasa ujian yang telah ditunjukkan adalah algoritma pengaturcaraan telah dilaksanakan. Beberapa cadangan untuk penambahbaikan robot akan diusulkan setelah membuat pemerhatian akan dinyatakan di akhir laporan ini.

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TABLE OF CONTENTS

Abstract	i
Abstrak	ii
Acknowledgement	iii
Table of Contents	iv
List of Figures	viii
List of Table	xii
List of Abbreviations	xiii
1. INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Project Objectives	3
1.4 Scope	3
1.5 Project Overview	4
2. LITERATURE REVIEWS	5
2.1 Introduction to Robot	5
2.2 Robot Categories	6
2.2.1 Industrial Robot	6
2.2.1.1 Classification of Industrial Robots	7
2.2.2 Mobile Robot	9
2.2.2.1 Classification of Mobile Robots	11
2.2.2.2 Type of Mobile Robot Navigation	13
2.3 Major Component of Mobile Robot	14
2.3.1 Electric Motor	14
2.3.1.1 DC Motor	15
2.3.1.2 Brushless Dc Motor	19

2.3.1.3 Stepper Motor	20
2.3.1.4 Servo Motor	21
2.3.2 Sensor	22
2.3.2.1 Sonar Sensor	22
2.3.2.2 Infrared Sensor	24
2.3.2.3 Touch Sensor	25
2.3.3 Microcontroller	26
2.3.3.1 ROM	27
2.3.3.2 RAM	27
2.3.3.3 CPU	28
2.3.3.4 Input/Output Port	28
2.4 Programming	29
2.5 Previous Research	30
3. METHODOLOGY	37
3.1 Introduction	37
3.1.1 Research of Project Phase	37
3.1.2 Design of Project Phase	38
3.1.3 Implementation Phase	38
3.2 Project Planning	38
3.2.1 Identifying the Problem Statement, Objectives and Scope of Project	40
3.2.2 Literature Review	40
3.2.3 Methodology	40
3.2.4 Project Implementation	41
3.2.4.1 Body Structure	41
3.2.4.2 Electronic Circuit	44
3.2.4.3 Behavior Planning	45
3.2.5 Integration	45
3.2.6 Testing	46
3.2.7 Analysis of Result	46

3.3 Selection of Component	46
3.3.1 Brushless DC Motor	46
3.3.2 Microcontroller	47
3.3.3 Photoelectric Sensor	48
4. DESIGN AND DEVELOPEMENT	50
4.1 Electronic Circuit	50
4.1.1 Printed Circuit Board Development	51
4.1.2 Circuit Board Description	56
4.1.2.1 PIC Microcontroller Board (SK40B)	56
4.1.2.2 Motor Driver Board (MD10A)	60
4.1.2.3 Motor Driver Circuit Board	63
4.1.2.4 Sensor Circuit Board	65
4.1.2.5 Power Supply Circuit Board	68
4.2 Development of Mechanical Structure.	70
4.2.1 Base of Robot.	71
4.2.2 Lifting Mechanism.	75
4.2.3 Gripping Mechanism.	77
4.3 Electrical Wiring	78
4.4 Programming	82
5. TESTING, RESULT AND DISCUSSION	86
5.1 Introduction	86
5.2 Testing	86
5.3 Result	88
5.4 Discussion	90
6. CONCLUSION AND RECOMMENDATION	92
6.1 Conclusion	92
6.2 Recommendation	92

REFERENCE	94
APPENDICES	98
A: Using the MPLAB Integrated Development Environment (IDE)	98
B: Programming (Source Code)	110

LIST OF FIGURES

1.1	Block Diagram of Similarity Between Human and Robot	2
2.1	Assembly Line Robot	7
2.2	Cartesian Robot and it's Work-Space	8
2.3	Cylindrical Robot and it's Work-Space	8
2.4	Polar Robot and it's Work-Space	9
2.5	Articulated Robot and it's Work-Space	9
2.6	Mobile Robot	10
2.7	Legged robot	11
2.8	Autonomous Underwater Vehicle	12
2.9	DC Motor	15
2.10	Motor Construction and Terminology	16
2.11	Electric Motor Field-Current Interaction	16
2.12	Electric Motor Six-Winding Commutator	17
2.13	Electric Motor Theory Operation	18
2.14	Brushless DC Motor	19
2.15	Stepper Motor	20
2.16	Servo Motor	21
2.17	Sonar Transducer	23
2.18	Three Problems With Sonar Range Reading	23
2.19	Infrared Sensor	24
2.20	Touch Sensor	25
2.21	Elements on a Single Chip	26
2.22	Program Language Hierarchy	29
2.23	Top View of Sensor Layout in The SMART Car	31
2.24	Integrated System	32
2.25	The Automatic Tobacco Transport and Feeding System Based on The Mobile Robot	33

2.26	GS-I type Mobile Robot	35
3.1	Project Planning	39
3.2	Base Conceptual Design 1	42
3.3	Base Conceptual Design 2	42
3.4	Base conceptual design 3	43
3.5	Example of Circuit Layout	44
3.6	Brushless DC Motor	46
3.7	PIC Microcontroller	47
3.8	Photoelectric Sensor	48
4.1	Circuit diagram	51
4.2	Circuit layout in Express PCB	52
4.3	Printed circuit layout	52
4.4	Ironing Process	53
4.5	The Circuit Layout on a PC board	53
4.6	Etching Process	54
4.7	Finished Circuit Layout	54
4.8	Drilling Process.	55
4.9	Soldering Process.	55
4.10	Final Result.	56
4.11	PIC Microcontroller Board (SK40B)	57
4.12	Pin Diagram of PIC16F877A	60
4.13	Motor Driver (MD10A)	61
4.14	Connection of Motor Driver	62
4.15	Motor Driver Circuit Board.	63
4.16	Sensor Circuit Board.	66
4.17	Comparator Circuit Board	67
4.18	Power Supply Circuit Board	69
4.19	Acrylic is being cut by using Laser Cut	71
4.20	Shaped of Robot Base	72

4.21	Attaching a Second Shaft to a Wheel	72
4.22	Attachment of Wheel and Motor	73
4.23	Mounting Motors on Base Structure	74
4.24	Mounting Castors	74
4.25	Base Structure	75
4.26	Rail Guide Attachment	76
4.27	Attaching the Lifting Mechanism on Base Structure	77
4.28	Gripping Attachment	78
4.29	Integrating Circuit Boards on The Circuit Platform	79
4.30	Installing The Integrated Circuit Boards to Body Structure	80
4.31	Installing Limit Switch on The Front Side of Robot	81
4.32	Mobile Robot.	81
4.33	USB ICSP PIC Programmers	82
4.34	Line Tracking Module Code	83
4.35	Line Tracking Functions	84
4.36	Obstacle Avoidance Module Code	85
5.1	Straight Line	86
5.2	Starting Point	87
5.3	Detecting the Obstacle	88
5.4	Result after Turn Back at the Junction	89
5.5	Result after Senses an Obstacle	90

LIST OF TABLE

3.1	Specification of Photoelectric Sensor	49
4.1	Descriptions of board layout	58
4.2	PIC circuit board components	59
4.3	Descriptions of board layout	61
4.4	Descriptions of Board Layout	64
4.5	Motor Driver Circuit Board Components	65
4.6	Descriptions of Board Layout	67
4.7	Sensor Circuit Board Components	68
4.8	Descriptions of board layout	69
4.9	Power Supply Circuit Board Components	70

LIST OF ABBREVIATIONS

PCB	-	Printed Circuit Board
PIC	-	Programmable Interrupt Controller
OHP	-	Overhead Projector
DC	-	Direct Current
I/O	-	Input Output
AC	-	Alternate Current
ALU	-	Arithmetic logic Unit
ROM	-	Read Only Memory
RAM	-	Random Access Memory
EPROM	-	Erasable and Programmable Read Only Memory
CPU	-	Central Processing Unit
PWM	-	Pulse Width Modulation
IC	-	Integrated Circuit

CHAPTER 1

INTRODUCTION

1.1 Background

Robot is the one of technology that is growing rapidly in our modern world. We can see that, the utilization of robot today had being widely used in various fields. The robot can be used either to aid in human duty or replace the use of human to do a certain works. For example, robot has already widespread used in the industry especially in manufacturing sector where it used to replace the use of manpower in lifting heavy material or assembling part in production line. It may be caused by several factors such as may increase productivity, enhance quality and also can perform a dangerous task.

Robot can defined as a mechanism which moves automatically and be able to deal with the changing information received from its environment. Generally, robots have three main parts known as actuators, sensors and controllers. Sensors are devices that used to detect information from it's environment. These detected information or input information are transformed into electrical signals and its will send to the controller. The controller processes the inputs by executing the functions of operation that have been programmed such as start, stop, reverse and speed change. The output signals that have produced by controller are conveyed to the actuators to perform a desired operation. Within all these part we can conclude that the robot have similar characteristics to human. Figure 1.1 shows the similarity of feature between human and robot.

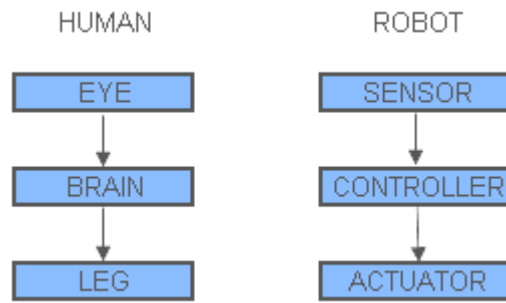


Figure 1.1: Block Diagram of Similarity between Human and Robot.

1.2 Problem Statement

Sensor is one of the important components in line tracking robots. It is because the skills of line tracking robots are highly dependant on the effectiveness of the sensor. Surrounding light could make the sensor produce a signal whereas it shouldn't. This will cause the controller to make a wrong decision. As a result the robots will make unnecessary movement and can't achieve it's objective. The contrast between the background and the line can also cause a problem to the sensor. The sensor may detect the background as its line thus making a wrong decision.

This project will also consider of noise which is produced by electric dc motor. The motor that will be used may be able to contribute imbalance to the PIC microcontroller. Noise or interference consists of unwanted electrical signals which imposes on and masks the desired signal. Noise is always present in a system that involves high power and small signal circuitry. The source of the noise could be from the switching of the driver circuits or the motor itself. Internally, the relatively high current motor drivers are the source. Electrical unbalance occurs when the magnetic attraction between stator and rotor is uneven around the periphery of the motor. This causes the shaft to deflect as it rotates creating a mechanical unbalance. Electrical unbalance usually indicates an electrical failure such as an open stator or rotor winding, an open bar or ring in squirrel

cage motors or shorted field coils in synchronous motors. An uneven air gap, usually from badly worn sleeve bearings, also produces electrical unbalance.

1.3 Project Objectives

The main aim of this project is to design an autonomous line tracking robot with the ability to avoid obstacle. This aim is achieved through these objectives:

1. To design and build the structure of an autonomous robot.
2. To construct suitable electronic circuits and integrate them with the robot structure.
3. To program the PIC to achieve line tracking and obstacle avoidance behavior.

1.4 Scope

In order to design a successful autonomous robot, scopes are required to assist and guide the development of the project. The scope should be identified and planned to achieve the objective of the project successfully on the time. The first scope for this project is literature study on journals or books that related with the project. The purpose of literature study is to find all information which can help in completing this project. The next scope in this project is design and fabricates of body structure for the mobile robot. This project will be more focused on the construction of electronic circuit which uses a PIC microcontroller to control the motion of the robot. In order to make the robot performs the desired task; a programming development will be executed.

1.5 Project Overview

The goal of this project is to design an autonomous robot that can follow the defined path and detect obstacles. The concept of this robot is a wheeled robot that can move in two directions: forward and backward. The movement of the robot will be driven by two motors. As a path guideline, white line is created on the dark floor in order to make the contrast between of them should be large enough. In this project, the photoelectric sensors will be used to detect the white line and then convert into the electrical signal. There are four sensors will be used where three of them are placed close together at the front side of the robot and one sensor at the backside of the robot.

If the middle sensor at the front side and the sensor at the backside sense a presence of reflection, the robot will be properly positioned on the line. If the left or the right sensor sense a presence of reflection, the robot is not proper position on the line. In order to control these statements, the PIC controller is used to make a decision whether the motors should be move forward or backward depending on the instruction that have been programmed. Other feature of this robot is detecting the obstacle on the path. This feature is developed in order to avoid the robot from collusion with an obstacle and protect the motor from stalling.

This chapter describes the problem statement, objectives, project scope and overview of the project. Chapter 2 will describes more detail the fundamentals of mobile robots and its involved component. This chapter also explained about types of mobile robot navigation and previous studies on the performance of the mobile robots published in books and journals. While in the chapter 3 will presents the planning process from the beginning till the project completed. This report also includes the discussion and conclusion in the chapter 4 and 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Robot

Nowadays, majority of public have known what is robot. This is because, we can see that the robot already much used around our environment especially in industry, house, office and also military. However, the word of robot was introduced to several decades ago. The word robot is originated from the word Chez robota which means menial labor. We also found that there were many difference definitions if we refer to difference dictionaries. Therefore, the following definition from the Robot Institute of American can reflect main features of modern robot systems [1].

‘A Robot is a re- programmable multifunction manipulator designed to move materials, parts, tool, or specialized devices through variable programmed motions for performance of a variety of tasks.’[1]

According to the above definition, we can say that the robot is the machine that used to carry out a variety of task such as transfer the material from one location to another. The robot that performs their tasks is depending on the motions that have been programmed. The re- programmable multifunction is the most important feature in order to make the robot more adaptable to the task change.

2.2 Robot Categories

When looking different kind and design robot which have been produced by various companies today, we could classify these robots into 2 main categories which are industrial robots and mobile robots.

2.2.1 Industrial Robot

The first category of robot is the fixed robot or more popularly known as industrial robot. Most of the industrial robots today are developed similar to the human arm. These robots are usually equipped with end-effector to perform a variety of task such as gripper used in material loading or part assembling and welded head used in welding process. Besides that, most of the industrial robots are also furnished with humanlike characteristics in order to make them more intelligent. Industrial robots are become most important in industry because it can be more competitive and can do some things more efficiently than people. The main advantages the use of industrial robot may be to increase the speed of production rate and additionally to reduce the mass production cost. Robots never get sick or need to rest, so they can work for a long period. Furthermore, they can also be carrying out the task which would be dangerous for a person. In the earliest, the most applications of the robot are used for material transferring, part sorting, part inspection and part cleaning. However the performances of the industrial robot are often enhanced in order to perform tasks that need accuracy such as part assembly and continuous arc welding [2].



Figure 2.1: Assembly Line Robot [9].

2.2.1.1 Classification of Industrial Robots

Industrial robots are only able to carry out their tasks in their work-space. Work-space means the maximum point of reach for the end-effector of an industrial robot. Usually, the work-space of industrial robots exists in 3 dimensional spaces. They also have a different work-space according to the 2 type of motion which are linear and rotate. The first 3 joint at the robot or called 3 major axes combination contribute the various shape of work-space and its can determine the position of wrist. Therefore, statements below will describe the 4 basic types of movement of industrial robot [3].

Cartesian Co-ordinate Robot: The first 3 major axes combination of this robot are linear. This robot is mounted in 2 ways either gantry mounted usually for a large Cartesian robot or mounted on track on the floor. It's sometimes called an x-y-z robot, indicating the axes of motion. The x-axis is lateral motion, the y-axis is longitudinal motion, and the z-axis is vertical motion. Thus, the arm can move up and down on the z-axis; the arm can slide along its base on the x-axis; and then it can telescope to move to and from the

work area on the y-axis. The Cartesian co-ordinate robot was developed mainly for arc welding, but it is also suited for many other assembly operations [1].

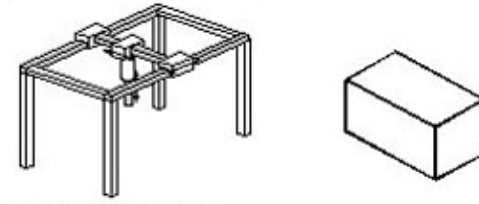


Figure 2.2: Cartesian Robot and it's Work-Space [10]

Cylindrical Co-Ordinate Robot: The cylindrical co-ordinate robot is a variation of the Cartesian robot. This robot consists of a base and a column, but the column is able to rotate. It also carries an extending arm that can move up and down on the column to provide more freedom of movement. The cylindrical co-ordinate robot is designed for handling machine tools and assembly [1].

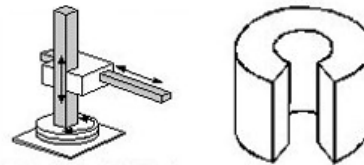


Figure 2.3: Cylindrical Robot and it's Work-Space [10].

Polar Co-Ordinate Robot: The polar co-ordinate robot or spherical co-ordinate robot consists of a rotary base, an elevation pivot, and a telescoping extend-and-retract boom axis. These robots operate according to spherical co-ordinates and offer greater flexibility. They are used particularly in spot welding [1].