

**MOBILE ROBOT FOLLOWING OBSTACLE AVOIDANCE AND
COLLISION**

KHAIRUL FADZLI BIN PATHIL

This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor
Degree of Electronic Engineering (Industrial Electronic) with Honors

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

30 April 2011

**MOBILE ROBOT FOLLOWING OBSTACLE AVOIDANCE AND
COLLISION**

KHAIRUL FADZLI BIN PATHIL

UNIVERSITI TEKNIKAL MALAYSIA MELAKA



UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Mobile Robot Following Obstacle Avoidance And Collison

Sesi Pengajian : 2010 /2011

Saya _____ **KHAIRUL FADZLI BIN PATHIL**
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (\checkmark) :

SULIT*

*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD**

***(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap : No 3 Lorong Mentiga Jaya 7
Taman Mentiga Jaya
26600 Pekan, Pahang DM

Tarikh:

Tarikh:

“I hereby declare that this report is the results of my own work except for quotes as cited
in the reference.”

Signature :

Author : KHAIRUL FADZLI BIN PATHIL

Date : 30TH APRIL 2011

“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honors”

Signature :

Supervisor's name : ENGR. KHAIRUDDIN BIN OSMAN

Date : 30TH APRIL 2011

DEDICATION

Dedicated to my parents, Pathil Bin Hj Abdul Rahman and Lijah Binti Yusoff, my sister Nur Arafah Binti Pathil, my wife Lina Mastura Binti Jasmawi, my sons Muhammad Aliff Nasyriff, Muhammad Amirr Nasymarr and Muhammad Aniqq Nasyhaqq, my supervisor Engr. Khairuddin Bin Osman, and not forgotten to all my friends.

ACKNOWLEDGEMENT

I would like to take this opportunity to express my deepest gratitude to my supervisor Engr. Khairuddin Bin Osman who had been guided me along the project. He has been motivating and inspired me to successfully complete my project. His guidance, advice, encouragement, patient and support given throughout the project are greatly appreciated.

Sincere thanks also to my lecturers who had given me valuable suggestions and helpful discussions to ensure successfulness of the project. My appreciations also extend to my parents , my wife , my sons and friends for their caring and support. Last but not least, I am thankful for those who directly or indirectly lent me a hand in this project.

ABSTRACT

Nowadays, various robots are built to perform multiple tasks. Multiple robots working together to perform a single task becomes important. One of the key elements for multiple robots to work together is the robot need to able to follow another robot. This project is mainly concerned on the design and construction of the robot that can follow another robot. In this project, the follower robot is the robot that follows the robot and the leader robot is the robot being followed. The follower robot can follow leader robot using analog distance sensors. Analog distance sensors are installed in the follower robot to obtain the relative position of the leader robot. Besides, the follower robot also can avoid the collision with the leader robot when perform the task following. Follower robot always maintains a safety distance from the leader robot to avoid the collision with leader robot. Furthermore, the follower robot is also equipped with infrared sensors to detect and avoid obstacles around the environment when perform the task following. The follower robot can perform the following task better with the obstacle avoidance feature.

ABSTRAK

Pada masa kini, pelbagai robot dibuat untuk melakukan pelbagai tugas. Keperluan untuk pelbagai robot bekerjasama untuk melakukan satu tugas menjadi penting. Salah satu elemen yang penting bagi robot-robot untuk bekerja bersama adalah kemampuan untuk mengikut robot lain. Projek ini fokus kepada reka bentuk dan pembinaan sebuah robot yang boleh mengikut robot yang lain. Dalam projek ini, robot pengikut adalah robot yang mengikut robot lain dan robot pemimpin adalah robot yang diikuti. Robot pengikut dapat mengikuti robot pemimpin dengan menggunakan sensor jarak analog. Sensor jarak analog dipasang pada robot pengikut untuk mendapatkan kedudukan relatif robot pemimpin dari robot pengikut. Selain itu, robot pengikut juga boleh mengelakkan pelanggaran dengan robot pemimpin ketika mengikuti robot pemimpin. Robot pengikut selalu akan berada pada jarak selamat daripada robot pemimpin untuk mengelakkan pelanggaran dengan robot pemimpin. Selain itu, robot pengikut juga dilengkapi dengan sensor infra-merah untuk mengesan dan mengelak pelanggaran dengan halangan di sekitar laluan ketika mengikuti robot pemimpin.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	iii
	SUPERVISOR APPROVAL	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTARCT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF APPENDICES	xv
I	INTRODUCTION	1
	1.1 Background	1
	1.2 Robot	2
	1.3 Project Objective	2
	1.4 Problem Statement	3
	1.5 Project Scope	4
	1.6 Outline of Thesis	5

II	LITERATURE REVIEW	6
2.0	Introduction	6
2.1	Low Cost Sensing for Autonomous Car Driving on Road	6
2.2	Raccoon	8
2.3	Scale Invariant Feature Transform (SIFT) algorithm	9
2.4	The X80 Robot	11
2.5	Leader/Follower Behavior using ultrasonic transmitter and receiver	12
2.6	Conclusion	13
III	RESEARCH METHODOLOGY	14
3.1	Project Methodology	15
3.2	Hardware Selection	16
	3.2.1 Microcontroller	16
	3.2.2 PIC16F877A	17
	3.2.3 Actuators	18
	3.2.4 Geared DC Motor	18
	3.2.5 Servo Motor	21
	3.2.6 Sensors	23
	3.2.7 Analog Distance Sensor	23
	3.2.8 Infrared Sensor	26
	3.2.9 Motor Driver (L293D)	27
3.3	Circuit And Software Implementation	28
	3.3.1 Microcontroller unit	29

3.3.2	Voltage Regulator circuit	31
3.3.3	Comparator circuit	33
3.3.4	Motor Driver circuit	34
3.3.5	Software Implementation	36
3.3.5.1	MPLAB IDE	37
3.3.5.2	Programmer	38
3.3.5.3	Proteus 7 Professional	39
IV	RESULT AND DISCUSSION	40
4.1	Result	40
4.2	Ability of the Follower Robot	42
4.3	Summary	43
V	CONCLUSION AND FUTURE WORK	44
5.1	Conclusion	44
5.2	Limitation	45
5.3	Suggestion and future development	46
	REFERENCES	48
	APPENDICES A – B	50-57

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	PIC16F77A key features	17
4.1	Data collected corresponding with the actual voltage and measured voltage	41

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	HANS Vehicle	7
2.2	Occupancy Grid	8
2.3	Robot follower using SIFT algorithm	10
2.4	X80 ROBOT	11
2.5	IR Sensor on X80 robot	11
2.6	Maxelbot	12
3.1	Flow chart for project methodology	15
3.2	PIC16F877A pin diagram	18
3.3	DC motor components	20
3.4	Geared DC motor	21
3.5	Hextronik Servo Motor	22
3.6	Analog Distance Sensor	23
3.7	Triangulation	24
3.8	Analog Output Voltage vs Distance	25
3.9	3mm and 5mm IR pairs	27
3.10	Motor Driver (L293D)	28
3.11	Electronic parts and interfacing procedures	29

3.12	The connection of oscillator and reset button to the PIC16F877A	30
3.13	Actual picture of the circuit with highlighted box refers to the main controller unit	30
3.14	Schematic of 5 volt voltage regulator circuit	31
3.15	Schematic of 6 volt voltage regulator circuit	32
3.16	Placement of voltage regulator on the completed circuit	32
3.17	Schematic of comparator circuit	33
3.18	Placement of comparator circuit on the completed circuit	34
3.19	Pin diagram of L293D	34
3.20	Example connection of L293D with motor	35
3.21	Schematic of motor driver circuit	35
3.22	Placement of motor driver circuit on the completed circuit	36
3.23	MPLAB IDE Editor	37
3.24	ICSP Programmer and PICKit software	38
4.1	Graph analogue voltage output (V) versus distance object (cm)	41
4.2	Move Forward	42
4.3	Turn Right	43
4.4	Turn Left	43

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Program in PIC16F877A Microcontroller for The Follower Robot	50
B	Program in PIC16F877A Microcontroller for The Leader Robot	52

CHAPTER I

INTRODUCTION

1.1 Background

Nowadays, robots are built to perform multiple tasks with different level of complexity. There are some situations that require multiple robots to perform a single task. When these situations are required, the robots are required to cooperate with each other. One of the key elements for the multiple robots to work together is that the robot need to able to follow other robot or human. This element leads to the study of the leader and follower behavior.

Basically, the leader in leader/follower behavior is the target that is followed by the other robot (follower). The leader (target) can be either human or robot. The follower, which is a robot, need to follow the leader autonomously. The task of this behavior is called task following.

When a robot (follower) performs a task following, the most important thing for the follower is to be able to obtain the position of the target (Leader). The follower must be able to obtain its current position relative to the target

before it makes decision on how to follow the target. “Localization” or knowledge of its current location is calculated by one or more means, using sensors such as motor encoder, vision, laser or sonar sensors. There are many vision systems being built to track and follow the target effectively. The method can be seen in [1], [2], and [3].

The visual tracking system installed on the follower enables the follower to follow the leader robustly in a variety of environment. Despite this advantage, there are quite a number of disadvantages for using vision system. One of the main disadvantages of the vision system is that it is costly to build. This is due to the high computational power required to process the raw data obtained from vision sensor. This reason makes the vision tracking system less preferable to be used.

1.2 Robot

A robot [6] is a mechanical or virtual artificial agent. In practice, it is usually an electro-mechanical system which, by its appearance or movements, conveys a sense that it has intent or agency of its own. The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots. There is no consensus on which machines qualify as robots, but there is general agreement among experts and the public that robots tend to do some or all of the following: move around, operate a mechanical arm, sense and manipulate their environment, and exhibit intelligent behavior, especially behavior which mimics humans or animals.

1.3 Project Objective

The main objective of this study is to design and construct an autonomous robot. It is two identical mobile robots. It means that the robots are communicating to each other and will collaborate to accomplish specific task given. Each robot is equipped with infrared sensors to detect and avoid obstacles around the environment when perform the task following.

The second objective is to integrate the concept of collision avoidance into the leader/follower behavior. The follower can follow the leader effectively. Besides, the follower can follow the leader when the distance between them is too close.

The last objective of this project is to improve the capability of the robot in performing the following task smoothly by using different approaches compare to the previous projects.

1.4 Problem Statement

It is an increased in research interest in systems composed of multiple autonomous mobile robots exhibiting cooperative behaviour. Groups of mobile robots are constructed, with the aim to studying such issues as group architecture, resource conflict, origin of cooperation, learning, and geometric problems.

As yet, few applications of cooperative robotics have been reported, and supporting theory is still in its formative stages. One of the main tasks for cooperative wheeled mobile robots is the object (target) following task, which

usually represents to follow another robot. Also, the following task is important for the wheeled mobile robots in and the target can be static or a dynamic object.

There are many problems arise when designing a robot to perform a following task. These problems include robot may loses or hits the target being followed. Besides, the robot may also choose not to follow the desired object and goes after another detected object from the environment in a dynamic environment.

1.5 Project Scope

The scopes of this project are:

- i. The design and construct an autonomous robot.
- ii. Study the concept of collision avoidance into the leader/follower behavior.
- iii. Study the capability of the robot in performing the following task smoothly.
- iv. Learn about Basic Compiler Programming for interaction between the Leader Robot and the Follower Robot using PIC.
- v. Learn more about MPLAB IDE, Proteus 7 Professional and OrCAD.
- vi. Simulate and investigate the circuit for the leader robot and the follower robot.

1.6 Outline of Thesis

This thesis consists Five chapters. In chapter 1, it discuss about the objective and scope of this project. While Chapter 2 will discuss literature reviews that have been done. It well discuss about various type of robot, advantages and limitation for each of the robots.

In Chapter 3, the discussion will be on the methodology hardware and software implementation of this project. The result and discussion will be presented in Chapter 4. Last but not least, Chapter 5 discusses the conclusion of this project and future work that can be done.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

This chapter review some of the robots that were built to perform the task following. The advantages and disadvantages for each of the robot are also included in the review.

2.1 Low Cost Sensing for Autonomous Car Driving on Road

According to [1], a car-like robot equipped with a system called HANS shown in figure 2.1, is able to navigate in an autonomous and safe manner, performing trajectories similar to the ones carried out by human drivers. The system was successfully tested in both simulations and in a laboratory environment using a mobile robot to emulate the car like vehicle. As a result, this autonomous car can follow the front vehicle in curve road. Besides, this mobile robot also can follow the road, keeping the car in the right lane, maintaining safe distances between vehicles, and avoiding collision. For this mobile robot, it is assumed that there are no cars driving faster than the HANS vehicle which means that no cars will appear from behind.



Figure 2.1 HANS Vehicle [1]

HANS in [1] uses a low resolution web camera located in the centre of the vehicle behind the rear-view mirror and a set of sixteen sonar sensor. The key role of the camera is to act as a vision system. It is used to detect the side lines that bound 7 the traffic lanes, the position and orientation of the robot relative to these lines, and the vehicles driving ahead and determining their lane and distance to the robot.

The sixteen sonar sensor was arranged to build up a occupancy grid as shown in figure 2.2. This strategy is to reduce the influence of sonar reflections. Each sonar sensor will form up one cone and each cone is divided into zones. The distance of each zone is defined from the robot. Obstacles lying over a region of the occupancy grid contribute to the voting of the cells. The zone with the highest number of measurements (votes in a sense) is considered as being occupied by obstacle. Sonar sensors are also used to detect emergency stopping conditions. With combinational of camera and sonar sensor, the perception of environment also can be mapped for the robot making autonomous decision.

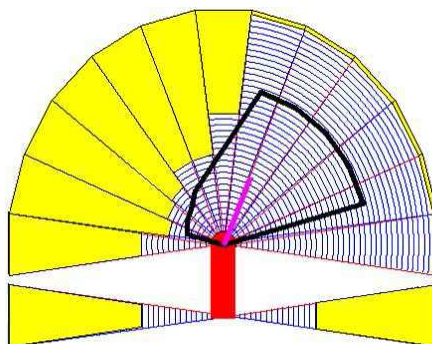


Figure 2.2 Occupancy Grid [2]

2.2 Raccoon

RACCOON is a vision-based system that tracks car taillights at night as described in [2]. The RACCOON system was developed at Carnegie Mellon University. The prototype was built and integrated with RACCOON system. This system enables the autonomous vehicle to chase the leading car effectively under low light condition. According to [2], this project was inspired by following reason:

- a) The road cannot be seen clearly at night.
- b) Unlit landmarks cannot be detected so corners and intersections have to be negotiated based solely on the observed actions of the lead vehicle at night.

Problems above make the following vehicle cannot detect the leading vehicle clearly at night using normal vision system and algorithm. In normal algorithm, the taillights can be easily extracted from a dark background. After the extraction, the autonomous car steers toward the taillight of lead vehicle. According to [1], the autonomous vehicle may follow the lead vehicle successfully with this algorithm.