

**DEVELOPMENT MODEL OF LUGGAGE FOLLOWER ROBOT FOR  
WHEELCHAIR APPLICATION**

**BY**

**MUHAMAD SANI MUSTAFA**

**A DISSERTATION SUBMITTED TO UNIVERSITI SAINS MALAYSIA  
FOR PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE  
OF MASTER OF SCIENCE**

**DECEMBER 2008**

**SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING  
UNIVERSITI SAINS MALAYSIA**

## ACKNOWLEDGEMENTS

First of all, I would like to show my grateful and prayer to ALLAH S.W.T. for awarded me a good health and wisdom during my dissertation project period. Without HIS blessing, this project wouldn't be a success. I would also like to thank my mentor and supervisor Dr. Syed Sahal Nazli Alhady for guiding me and sharing some of his knowledge. His motivation and dedication towards his work inspired me.

Secondly, I would like to thank all members of staffs and students in the School of Electric and Electronic, Universiti Sains Malaysia for their and morale supports. To my examiners, Dr. Rosmiwati Mohd Mokhtar, and Dr. Dahaman Ishak, thank you for a fruitful viva session. I would also like to thank Associate Prof. Abd. Rahmad Saad from Universiti Malaysia Perlis lecturer. His reference and knowledge on Embedded System Design helps me to my project success. I thanks also to Pusat Kejuruteraan Universiti Malaysia Perlis for their co-operation in terms of supplying engineering tools for my dissertation project.

Finally, I would also like to wish special thanks to my wife Norhafizah Bahrum, my new born baby Nurul 'Awatif Zahraa' and my parents who have been patiently supported in my decisions about life. I am sorry to have sometimes neglected all of you in a way to pursue my dream.

The work reported here would have not been possible without the scholarship from Universiti Malaysia Perlis.

## TABLE OF CONTENTS

Acknowledgements .....	ii
Table of Contents .....	iii
List of Figures .....	viii
List of Tables.....	ix
Abstract .....	x
Abstrak .....	xi
Chapter 1 – Introduction .....	1
1.1 Autonomous Robot Background .....	1
1.2 Autonomous Robot Introduction .....	2
1.3 Problem Statement.....	3
1.4 Overview of Autonomous Luggage Robot.....	4
1.5 Thesis Aims and Objectives.....	5
1.6 Scope of the Study .....	6
1.7 Thesis Outline.....	7
1.8 Summary .....	8
Chapter 2 – Literature Review .....	9
2.1 Introduction .....	9
2.2 Embedded System .....	9
2.3 Microcontroller Concept.....	11
2.4 Microcontroller CPU, Memory, and I/O.....	12
2.5 Atmel 89S52 Microcontroller .....	14
2.6 Sensor Background: Photomicrosensor .....	15

2.6.1 Photomicrosensors Maximum Ratings .....	16
2.6.2 Electrical and Optical Characteristics .....	16
2.7 Line Following Robot Introduction .....	17
2.8 Line Following Robot by Reynolds, C.W.....	17
2.9 Line Following Robot by David, C. and Gordon, W.....	18
2.10 Intelligent Line Follower Mini-Robot System .....	20
2.11 An Autonomous Robot Train by Nathan, N.....	21
<b>Chapter 3 – Methodology .....</b>	<b>23</b>
3.1 Background .....	23
3.2 Basic Architecture of Autonomous Luggage Robot.....	24
3.3 Hardware Components .....	25
3.4 Main Controller Unit (Processing Unit) .....	27
3.4.1 Central Processing Unit.....	27
3.4.2 Input and Output (I/O) Ports .....	29
3.5 Robot Development .....	30
3.5.1 Processor : AT89S52 Microcontroller.....	30
3.5.2 Oscillator.....	31
3.5.3 Voltage Regulator : LM 7805 .....	33
3.5.4 Buffer : DM 74LS244 .....	34
3.5.5 Sensor : Photomicrosensor .....	36
3.5.5.1 Photomicrosensor Characteristics .....	37
3.5.6 Servo Motor .....	39
3.5.7 Motor Driver : H - Bridge.....	42
3.5.8 Autonomous Luggage Robot Connection .....	43
3.6 Software Design: Algorithm .....	44

3.6.1 Programming the Robot .....	46
3.7 Robot Integration .....	48
3.8 Summary .....	49
<b>Chapter 4 – Result and Discussion .....</b>	<b>50</b>
4.1 Introduction .....	50
4.2 AT89S52 Microcontroller Board Testing Phase.....	50
4.3 Motor Driver Board Testing Phase .....	51
4.4 Photomicrosensor Testing Phase .....	53
4.5 Sensor and Motor Operation .....	54
4.6 Autonomous Luggage Robot Model.....	56
4.7 Limitation of Autonomous Luggage Robot.....	59
4.8 The Assessment for Project Reliability .....	60
4.9 Summary .....	60
<b>Chapter 5 – Conclusion and Future Work .....</b>	<b>61</b>
5.1 Conclusion.....	61
5.2 Future Work .....	62
<b>References .....</b>	<b>63</b>
<b>Appendix : AT89S52 Microcontroller Source Code .....</b>	<b>67</b>
<b>Appendix : AT89S52 Microcontroller Data Sheet.....</b>	<b>68</b>

## LIST OF FIGURES

Figure 2.1	Block diagram of a microcontroller.....	10
Figure 2.2	Microcontroller busses.....	13
Figure 2.3	Generic bus timing diagram example.....	13
Figure 2.4	Pin configuration for AT89S52.....	15
Figure 2.5	Craig Reynolds look-ahead guidance .....	18
Figure 2.6	The Line Following Robot by David, C. And Gordon, W.....	19
Figure 2.7	Sensor locations within the prototype.....	21
Figure 2.8	Distance distribution of sensors within layout platform prototype.....	21
Figure 3.1	Common procedures for robot development .....	23
Figure 3.2	Robot block diagram .....	25
Figure 3.3	The architecture of microcontroller .....	26
Figure 3.4	Hardware block diagram .....	27
Figure 3.5	Pin diagram and actual picture for AT89S52 .....	31
Figure 3.6	Corresponding features	
	(a) Oscillator connection.....	33
	(b) External clock drive configuration.....	33
Figure 3.7	Voltage regulator circuit.....	34

Figure 3.8	Voltage regulator pins configuration.....	34
Figure 3.9	Pin diagram of DM74LS244 .....	35
Figure 3.10	Photomicrosensor.....	36
Figure 3.11	Reflective photomicrosensor.....	37
Figure 3.12	Transmissive photomicrosensor.....	37
Figure 3.13	Photomicrosensor pins configuration.....	38
Figure 3.14	Photomicrosensor output circuit .....	38
Figure 3.15	Photomicrosensor connection .....	39
Figure 3.16	Servo Motor .....	40
Figure 3.17	H-bridge motor driver .....	40
Figure 3.18	Autonomous luggage robot circuit connections .....	43
Figure 3.19	Autonomous luggage robot flow chart .....	45
Figure 3.20	Wheelchair and Autonomous Luggage Robot model .....	49
Figure 4.1	Middle sensor detects and robot drives forward .....	55
Figure 4.2	Right sensor detects and robot drives to right.....	55
Figure 4.3	Left sensor detects and robot drives to left .....	55
Figure 4.4	All sensors detect and robot stop .....	55
Figure 4.5	All sensors not detect and robot stop .....	56

Figure 4.6	Wheelchair model and connection path .....	56
Figure 4.7	The robot move forward to follow the wheelchair model .....	57
Figure 4.8	The robot move right to follow the wheelchair model .....	57
Figure 4.9	The robot turns left to follow the wheelchair model .....	58
Figure 4.10	The robot stop when the wheelchair in standby mode .....	58
Figure 4.11	The robot and wheelchair on lose position .....	59

© This item is protected by original copyright



## LIST OF TABLES

Table 2.1 Hierarchy level of transaction on specific instruction.....12

Table 3.1 AT89S52 microcontroller pins connection.....45

© This item is protected by original copyright

## ABSTRACT

Nowadays there is lots of technology based on robotic which has been invented by human intelligence. Therefore, it is not possible for robot to be controlled by sensor technology. This dissertation project objective is to create an autonomous luggage robot model system that can operate with wheelchair model using optical sensor. Autonomous luggage robot is followed a black line tracking path that was designed at the back of the wheelchair model. The product design method has been used to accomplish this project where it focused on hardware devices and assembly language programming. The most important devices used in hardware devices are consist of AT89S52 microcontroller, H-bridge motor driver and Optical Photomicrosensor. This AT89S52 microcontroller is required to control the input from Optical Photomicrosensor and perform the output to H-bridge motor driver for robot movement operation. The robot operation algorithm was designed by the aid of the 8051 microcontroller assembly language programming, in which, the robot machine and the assembly language source codes have been programmed into the AT89S52 microcontroller chips. The objectives result has been archived which the robot can follow the wheelchair model for turn left, turn right and stop operations.

## ABSTRAK

Dewasa ini terdapat pelbagai jenis teknologi berdasarkan robotik yang mana telah wujud hasil kebijaksanaan manusia. Oleh itu, maka tidak mustahillah jika sebuah robot dapat dibina dan dikawal dengan menggunakan teknologi sensor. Objektif projek disertasi ini adalah untuk membina sebuah model bagasi robot yang boleh beroperasi bersama-sama dengan kerusi roda melalui jaringan optikal sensor. Bagasi robot ini akan sentiasa mengikuti garisan hitam yang diletakkan di belakang model kerusi roda sebagai medium perantaraan. Cara produk ini dibentuk untuk menyempurnkannya ialah dengan memberi focus kepada barangan perkakasan dan bahasa pengaturcaraan. Barangan perkakasan yang sangat penting digunakan ialah mikropengawal AT89S52. Ia diperlukan untuk mengawal motor Jambatan-H dan Optikal Fotomikrosensor. Mikropengawal AT89S52 juga diperlukan untuk mengawal masukkan data daripada Optikal Fotomikrosensor dan mengawal operasi keluaran data melalui pergerakan Jambatan-H motor robot. Operasi algoritma robot ini dicipta dan dikawal oleh bahasa pengaturcaraan mikropengawal 8051, yang mana mesin robot dan sumber kod bahasa pengaturcaraan ini telah diprogramkan ke dalam cip mikropengawal AT89S52. Objektif projek disertasi ini tercapai di mana robot akan mengikuti segala pergerakan model kerusi roda melalui operasi kiri, kanan dan berhenti.

## **CHAPTER 1 – INTRODUCTION**

---

### **1.1 Autonomous Robot Background**

Over the last few decades, remote autonomous vehicles had been researched well and some commercial versions were produced. Autonomous mobile robotic is an intelligent machines capable of performing task in instructed environment by themselves, without explicit human control or guidance. (Parker, 2002). Autonomous mobile robotic are design to sense some physical properties of the environment, besides other tasks, based on hypothesis of intelligent behaviours, artificial intelligence, cognitive science, psychology and philosophy. (Nehmzow, 2003). Autonomous or semi-autonomous device which performs its tasks either according to direct human control, partial control with human supervision, or complete autonomously. A robot may include a feedback-driven connection between sense and action, not under direct human control, although it may has a human override function. (Howard et al, 2002). The action may take the form of electro-magnetic motors or actuators (also called effectors) that move an arm, open and close grips, or propel the robot. The step by step control and feedback is provided by a computer program run on either an external or embedded computer or a microcontroller. By this definition, a robot may include nearly all automated devices.

### **1.2 Autonomous Robot Introduction**

Autonomous robots are robot which can perform desired tasks in unstructured environments without continuous human guidance. Many kinds of robots have some degrees of autonomy. Different robots can be autonomous in different ways. A high degree of autonomy is

particularly desirable in fields such as space exploration, cleaning floors, mowing lawns, and waste water treatment. (Emken et al, 2005).

Some modern factory robots are "autonomous" within the strict confines of their direct environment. It may not be that every degree of freedom exists in their surrounding environment but the factory robot's workplace is challenging and can often contain chaotic, unpredicted variables. The exact orientation and position of the next object of work and (in the more advanced factories) even the type of object and the required task must be determined. This can vary unpredictably (at least from the robot's point of view).

One important area of robotics research is to enable the robot to cope with its environment whether this is on land, underwater, in the air, underground, or in space.

A fully autonomous robot has the ability to

- i. Gain information about the environment.
- ii. Work for an extended period without human intervention.
- iii. Move either all or part of itself throughout its operating environment without human assistance.
- iv. Avoid situations that are harmful to people, property, or itself unless those are part of its design specifications.

Autonomous robots have the capability to move around in their environment and are not fixed to one physical location. In contrast, industrial robots usually consist of a jointed arm (multi-linked manipulator) and gripper assembly (or end effector) that is attached to a fixed surface. Autonomous robots may be classified:

1. The environment in which they travel:
  - i. Land or home robots. They are most commonly wheeled, but also include legged robots with two or more legs (humanoid, or resembling animals or insects).
  - ii. Aerial robots are usually referred to as “Unmanned Aerial Vehicles” (UAVs)
  - iii. Underwater robots are usually called “Autonomous Underwater Vehicles” (AUVs)
  
2. The device they use to move, mainly:
  - i. Legged robot: human-like legs (i.e. an android) or animal-like legs.
  - ii. Wheeled robot.
  - iii. Tracks robot.

### **1.3 Problem Statement**

A wheelchair is a wheeled mobility device in which the user sits. The device is propelled either manually (by turning the wheels by the hand) or via various automated systems. Wheelchairs are used by the people who have difficulties to walk or impossible due to illness (physiological or physical), injury, or disability. (Yanco, 1998). For example, if they want to travel to a place, they need to bring a lot of luggage, perhaps. Thus, they are going to face some problems in order to bring their luggage because they need to control their wheelchair and luggage or trolley at the same time. So controlling both of them at the same time will be an uphill task.

The following research question provides motivation to explore and research on the design and development of arachnids:

- i. How to construct an artificial luggage robot that follows the wheelchair?
- ii. How to develop the robot with more effective and efficient tracking movement and good stability?
- iii. How to program the microcontroller when it tracks the black line color?

#### **1.4 Overview of Autonomous Luggage Robot**

An intelligent autonomous luggage robot that navigates safely through the environment without requiring constant control from its human driver can reduce driving-stress and increase mobility of a disabled person. The ability of the autonomous luggage robot to gracefully perform common navigation tasks such as going through a door, going up and down ramps, and turning sharp corners is an important factor in ensuring the comfort of the human driver. (Murarka et al, 2006).

The one of the method can be used for the autonomous luggage robot is line tracking. Line tracking is a very important notion in the world of robotics as it give to the robot a precise, error-less and easy to implement navigation scheme. As you may have seen, many robotics competitions promote this concept, by adding lines on the playground for the robot to follow, or sometimes, the sole purpose of the competition is to race with other robots following a line along a track. (Lindstrom, 1993). Autonomous luggage robot has use a line tracking path to follow where ever wheelchair model go. The path can be visible like a black line on a white surface (or vice-versa) or it can be invisible like a magnetic field. Sensing a line and maneuvering the robot

to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system. (Gerkey et al, 2003).As a programmer you get an opportunity to ‘teach’ the robot how to follow the line thus giving it a human-like property of responding to stimuli.

## 1.5 Thesis Aims and Objectives

The main aim of this research is to produce and construct the application luggage robot model that follow every where wheelchair model go. The main objectives of the research are outlined:

- i. To create an “Autonomous Luggage Robot Model” and “Wheelchair Model” system and it can operate effectively.
- ii. To detect a distance between line and wheelchair using optical sensor.

Besides, my personal objectives by doing this project are to learn more about Photomicrosensor and how it works. Then to gain more knowledge about sensor, motor driver and microcontroller that have learn in Embedded System Design subject to make a real world. Finally is to help wheelchair user by giving this idea and solution overcome their problem.



## 1.6 Scope of the Study

The scope of this system consist of both software and hardware components. The software component is used to control the motor and the hardware components is basically consists of input/output (I/O) unit and processing unit. The limitation of I/O unit is handled by sensor and motor devices. The Processing unit is handled by 8-bits microcontroller as the processor. An appropriate program must be written to integrate between microcontroller and the I/O devices connected to it.

Those are project scope in this study:

- i. This robot only smooth curves line follower from wheelchair model movement and necessarily fail at line follower sharp turns and 90deg turns.
- ii. This robot cannot go through when the path is high and low.
- iii. This robot also fails through when the path is black color.
- iv. This robot cannot follow the line if the wheelchair model moving too fast.
- v. This robot model cannot operate for heavy luggage because that only has a small servo motor.
- vi. This robot cannot reverse direction because the sensor just was put in front of robot.

## 1.7 Thesis Outline

This thesis is divided by 5 chapters.

**Chapter 1** demonstrates brief explanation about the research. It covers the background of the research and provides guideline of every chapter in this thesis.

**Chapter 2** presents the literature review of the research. It first gives an overview of the mechanical and aspects of autonomous robot and line tracking control system. Next this chapter provides discussion on Microcontroller and sensor concept. This includes the history of the microcontroller and application for line tracking robot for wheelchair model or for the other application that is similar. A number of previous autonomous robot projects are discussed as a guideline.

**Chapter 3** describes the methodology of the research. This methodology is split into two parts that are hardware component and software component. In hardware component, the explanations are focused on approach taken to design and integrate the input capturing part, main controller part and the output displaying part. A brief theory about the devices that involve also provided. For software components, the microcontroller assembly languages are explained in details. Then the design for both of parts is discussed by presenting the flow chart of the program.

**Chapter 4** provides the results, discussions and findings of the experimental design and problem that have arised during the process.

**Chapter 5** is the final chapter in this thesis. This chapter conclude every work done and also highlights the recommendations pertaining to the improvement of the autonomous luggage mobile robot and its ability to emulate the environment in a more biological like behaviour. Future works and developments are also proposed as future improvement of the research work especially for the real robot model that be used for wheelchair user or others.

## **1.8 Summary**

This project has done successfully with the Autonomous luggage robot and wheelchair model were integrated to overcome the problem. The Photomicrosensor was used as an input unit to detect a black line color and AT89S52 microcontroller as a processing unit to control the output for robot operation.

## CHAPTER 2 – LITERATURE REVIEW

---

### 2.1 Introduction

This chapter provides an extensive review of literature that is relevant to the topics that addressed in this project. The important field relevant to this thesis is the chosen of microcontroller that will be used and the suitable sensor and how to construct an output circuit. Besides, the introduction of line following robot and a number of previous autonomous robot projects was being taken as a guideline.

### 2.2 Embedded System

An embedded system is a system (or controller) that is embedded in a greater system. An embedded controller is a controller (or computer) that is embedded into some device for some purpose other than to provide general purpose computing. When all hardware required to run the application is provided on one chip, it is referred to as an embedded microcontroller or in short microcontroller. A microcontroller is a single chip microprocessor system which contains:

- i. Data and program memory.
- ii. Serial and parallel I/O.
- iii. Timers.
- iv. External and internal interrupts.

It is the additional circuitry compared to the microprocessor that makes the microcontroller such a unique device. The microcontroller operates on data that is fed through its

serial or parallel input ports controlled by software stored in the ROM. (Yanbing & Wayne, 1999). Microprocessors are generally utilized for relatively high performance applications where the cost and the size are not critical selection criteria. Because microprocessor chips have their entire functions dedicated to the CPU and thus have room for more circuitry to increase execution speed, they can achieve very high-levels of processing power. (Hua & Wayne, 2000) However, microprocessor requires external memory and I/O hardware. Microprocessor chips are used in desktop PCs and workstations where software compatibility, performance, generality, and flexibility are important. Figure 2.1 show the block diagram of a microcontroller. (James & Kai, 1999).

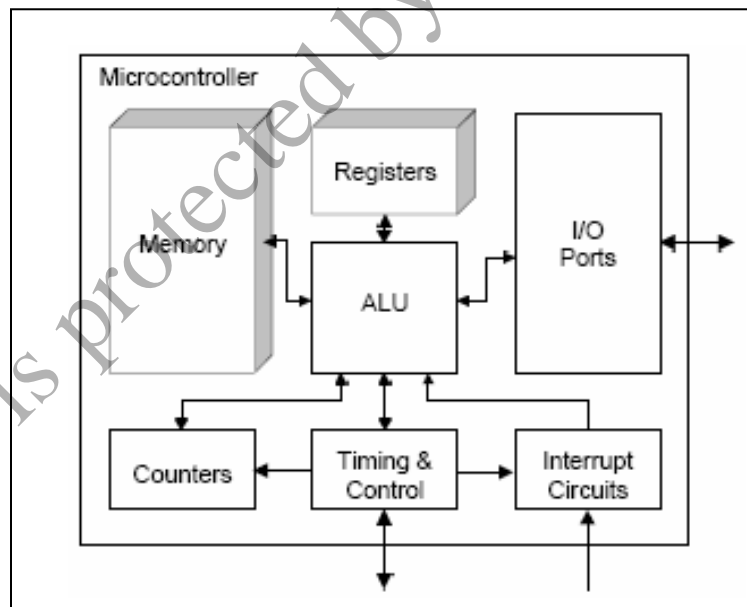


Figure 2.1 Block diagram of microcontroller.

By contrast, microcontroller chips are usually designed to minimize the total chip count and cost by incorporating memory and I/O on the chip. They are often “application specialized” at the expense of flexibility. In some cases, the microcontroller has enough resources on-chip that it is the only IC required for a product. Examples of a single-chip application include the key fob used to arm a security system, a toaster, or hand-held games. The hardware interfaces of both devices have much in common, and those of the microcontrollers are generally a simplified subset of the microprocessor. (James & Kai, 1999). The primary design goals for each type of chip can be summarized this way:

- i. Microprocessors are most flexible.
- ii. Microcontrollers are most compact.



There are also differences in the basic CPU architectures used, and these tend to reflect the application. Microprocessor based machines usually have a von Neumann architecture with a single memory for both programs and data to allow maximum flexibility in allocation of memory. Microcontroller chips, on the other hand, frequently embody the Harvard architecture, which has separate memories for programs and data.

### **2.3 Microcontroller Concept**

One way of looking at a computer system is to consider the successive “translations” that occur from the high level code (a programming language such as C++) to the electrical signals that “communicate” with the hardware. A computer system can be broken down into multiple levels or layers to show the translation of a specific instruction into a form that can be directly

processed by the computer hardware and hierarchical levels. The hierarchy level is shown in table 2.1. (Hua & Wayne, 2000),

Table 2.1 Hierarchy level of translation on specific instruction.

Hierarchy	Example
High Level	Sum := Sum + 1
Assembly	MOV BX,SUM INC (BX)
Machine	1101010100001100 00100011011101011111100011001101
Register Transfer	Fetch Instruction, Increment PC, Load ALU with SUM ...
Gate	
Circuit	

## 2.4 Microcontroller CPU, Memory, and I/O

The interconnection between the CPU, memory, and I/O of the address and data buses is generally a one-to-one connection. The hard part is designing the appropriate circuitry to adapt the control signals present on each device to be compatible with that of the other devices. The most basic control signals are generated by the CPU to control the data transfers between the CPU and memory, and between the CPU and I/O devices. (Kleitz, 1997).

The four most common types of CPU controlled data transfers are:

- i. CPU reads data/instructions from memory (memory read).
- ii. CPU writes data to memory (memory write).
- iii. CPU reads data from an input device (I/O read).
- iv. CPU writes data to an output device (I/O write).

The address decode and control logic shown in Figure 2.2 is the key part of the design which requires attention to timing analysis to guarantee signal logic and timing compatibility between the other blocks. Figure 2.3 is a generic bus timing diagram and represents a typical example of a bus cycle for a typical CPU.

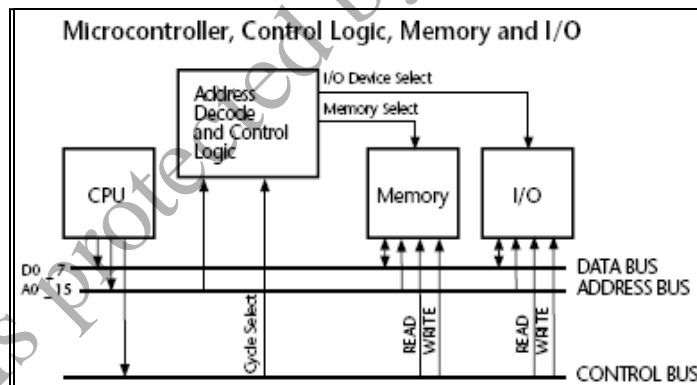


Figure 2.2 Microcontroller busses.

