MICROMOUSE
MAZE SOLVING ROBOT

CHANG YUEN CHUNG

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MICROMOUSE
MAZE SOLVING ROBOT

CHANG YUEN CHUNG

This thesis is submitted in fulfillment for the
Requirement for the award of the degree of
Bachelor of Engineering (Electrical - Mechatronics)

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DEDICATION

Specially to my beloved
parents, siblings and friends
for their eternal support, encouragement
and inspiration throughout
my journey of education.

ACKNOWLEDGEMENT

I would like to take this opportunity to express my deepest gratitude to my project supervisor, Assoc. Prof. Dr. Mohamad Noh Ahmad who has given me guidance throughout the entire project. It would be difficult for me to complete this project without his guidance and support.

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ABSTACT

The IEEE micromouse competition has been a popular event among engineering students and engineers. A micromouse is an autonomous vehicle whose objective is to find the centre of an unknown maze. This thesis summarizes the design and implementation of the micromouse for the UTM final year project of semester 2008/2009. The design method of the micromouse project consisted of two stages. The first stage was to design and construct individual system. The second stage of the design process was to interface the systems to form the final prototype. The individual components of micromouse system consist of the motor control system, navigation sensor array, and a mapping system or algorithm for navigating the maze intelligently. A 7x7 cell maze was developed in order to validate the overall performance of the micromouse. As a result of the whole project, the micromouse will eventually move to the centre of the maze without external help and manage to find the shortest path from the mapping system after navigating all the possible path in the maze.

ABSTRAK

Pertandingan IEEE micromouse merupakan satu pertandingan yang popular antara jurutera dan pelajar kejuruteraan. Objektif micromouse adalah mencari laluan ke lokasi tengah dalam sebuah maze yang tidak ditentukan. Tesis ini merangkumi proses ciptaan sebuah micromouse untuk projek saujana muda UTM semester 2008/2009. Secara amnya, projek ini dibahagikan kepada dua proses. Proses pertama adalah membina setiap individu sistem manakala proses kedua adalah menggabungkan semua individu sistem intuk berinteraksi antara satu sama lain. Individu sistem yang dimaksudkan adalah seperti sistem kawalan motor, sistem penderia dan sistem kepintaran. Sebuah maze yangmempunyai 7x7 petak dibina untuk menguji keseluruhan sistem micromouse. Pada akhir projek ini, micromouse yang dibina mampu mencari laluan ke petak tengah maze yang diberikan tanpa bantuan dan akan menghasilkan laluan yang paling pendek dari petak permulaan ke petak tengah maze tersebut.

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LIST OF ABBREVIATIONS

3D	-	3 Dimension
ADC	-	Analogue to Digital Converter
Cm	-	Centimeter
DC	-	Direct Current
IO	-	Input Output
LCD	-	Liquid Crystal Display
PCB	-	Printed Circuit Board
IEEE	-	Institute of Electrical and Electronics Engineering

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The Micromouse is an autonomous robot whose goal is to find the center of a maze. In 1977, the IEEE Spectrum Magazine first introduced the idea of the autonomous Micromouse robot as a maze solving device. Soon after, the first IEEE Amazing Micromouse Maze Contest was held in New York in June 1979. Out of over 6000 entries received, fifteen Micromouse competed, from which the eventual winner was Moonlight Flash, a non-intelligent wall follower mouse.

Popularity of the Micromouse grew from there, and competitions were soon held all around the world. The first European competition took place in London 1980, and the first world Micromouse competition, open to contestants from across Europe and the United States, was held in Tsukuba, Japan in August 1985. From the early 1990s, Micromouse club started to appear in school and universities around the world. The IEEE Micromouse competition now enjoys great popularity among undergraduate and graduate student from various organization around the globe.

Micromouse has undergone an astounding metamorphosis in the last several decades. Early Micromouse was far less technologically and electronically advanced compared to those today. Moonlight Flash, the winner in 1979, was a crude mechanical mouse that simply employed a feeler along the walls to navigate its way to the goal. Moreover, several of the other mouse at the competition did not include microprocessors in their design, instead opting to use simple IC logic. The top motor speed at the competion was 52 centimeters per second from a mouse using then sophiscated stepper motors for its motion.

In contrast, today's Micromouse is extremely evolved, electronically refined robots. Current microprocessor technologies allow the mice to perform computations not conceivable thirty two years ago. As a result, the robots can be programmed to use more sophiscated algorithms to find the center of the maze. Motors, sensors, integrated circuits, and other components have greatly improved features to assist the robot designer. Depending on the maze design, mouse can now run at speeds up to 3 meters per second. Overall, micromouses are now smaller, faster, and smarter than their earlier counterparts.

1.2 Problem Statement

Design and construction of a Micromouse requires a broad range of engineering skills such as electronics design, mechanical design, program design and how the student approach complex engineering problems. This combined with an open design process makes the Micromouse project a very practical and challenging design project.

1.3 Objectives and Project Scope

Basically the Micromouse project is to build the autonomous robot that will perform maze solving algorithm and performs smooth movement while situated in the maze.

The scope of the project will be producing a robot with good interactive between the microcontroller with the mechanical elements, signal controlling and software efficiency. The Micromouse will gain information from the working environment which means it will memorize the maze information from the wall it encounters on each cell it visited. This autonomous robot will perform the maze solving algorithm to the center of the Maze and the size of the Maze will be 49 cells with 18cm x 18cm each. It will also avoid colliding with the maze walls by automatic balancing system and performing all the basic smooth movement which are straight, clockwise or anticlockwise 90 degree turning and also 180 degree turning.

On the wider scope of accomplishment, Micromouse project is hope to play a role in linking the builder with a great aspect in engineering knowledge since it involve in lots of element such as design, control, analysis and others.

1.4 Thesis Layout

This thesis consist of five chapters and after the chapter one about the introduction, chapter two will be the literature review section which was done to gain a clear view and knowledge to this project. So, few existing model of Micromouse will be discussed in this section as a guide for the project.

Chapter three will be the Methodology section which will discuss all the components and methods for building the Micromouse. All the results and achievements for the project will be stated in chapter four and lastly for chapter five will be the discussion and conclusion for the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Preview

Before any development can take place, a research must be carried out on all the possible components that will be used in the Micromouse. Most of the researches were carried out through the web. Beside of the internet resources, the thesis room in FKE also provides some thesis reference from the previous final year project student. Another good source of information is the competitions themselves. Much can be learned by emailing and questioning other teams about issues they experienced while developing their Micromouse. Only then, issues such as microcontroller, chassis design, wheel layout, and sensor placement are to be decided. This is perhaps the most critical design phase, which will affect the rest of the project.

There were four existing Micromouse model which had lead to the design process. Each models' specification were analyzed and being categorized into advantages and disadvantages for reference. The advantages each model provides will be implemented in the project if necessary.

2.2 Dexter [1]

The first literature review is the Micromouse robot named Dexter which is depicted from the internet resources. Dexter was a micromouse created by Steve Benkovic with his senior competing in a micromouse competition. This robot used Motorola 68Hc11 as its controller along with a 32k backed battery memory RAM for replacing the insufficient memory space. The actuator used was two mini stepper motor and was drive by an Allegro stepper motor driver and 8AAA batteries. The robot uses 11 IR sensors and the design was based on wheel chair design while the packaging was mounted by acrylic casing. The other sub components that included into Dexter's' design were plastic wheels and LCD display as information viewer for debugging and testing the performance while exploring in the Maze since in reality cant direct find out the error that shown by the software instruction and just can be view through the assistance of the LCD display. As been informed, this Micromouse managed to solve the maze in the competition using the algorithm but it did not made the fastest time to arrive the center of the maze but the design on the hardware part was a great deal. Figure 2.1 shows the frame for Dexter.

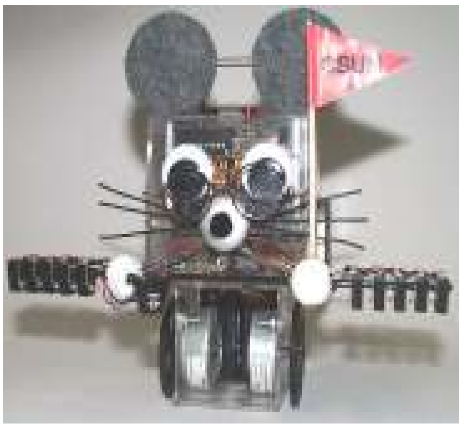


Figure 2.1 Dexter [1]

2.3 Mobot [2]

The second model will is Mobot which was created by an Indian student named Mohit Bhoit. PIC18F452 with large memory was used in the robot as controller. This robot used 4 IR sensors and two unipolar stepper motors along with UCN5804 motor driver. The power supply came from 10AAA Ni-Cd cells and the based was formed by aluminium and mechano base plate. The wheel was created using aluminium steel which mounted by rubber.

The controller provides enough memory to perform with the algorithm. The motor driver being used is quite simple in the connection with the stepper motor in terms of the schematic. Meanwhile, the idea for the wheel covered using rubber is a good idea to prevent the wheel from slipping while performing the task and affect the performance of the robot. Figure 2.2 shows the view of Mobot.

Figure 2.2 Mobot [2]

2.4 Micromouse UTM FYP 2006 [3]

This version of Micromouse was built by Louis Wong Siang San. The controller used was PIC16F627. Louis used PCB circuit for the circuit design, IR sensors, 2 stepper motors drive with darlington array IC and powered by external power supply. The base was formed by wooden plank base and small castor supporting with two wooden wheels.

This model of Micromouse also used a microcontroller that provides sufficient memory for the algorithm. The circuit board is formed by PCB board which in this case the robot circuit will look more neat and the avoidance from circuit failure in terms of connection lose like jumper or else since in reality most of the circuits board not made by PCB board need a lot of jumper to link the connection. Figure 2.3 shows the view for this Micromouse robot.

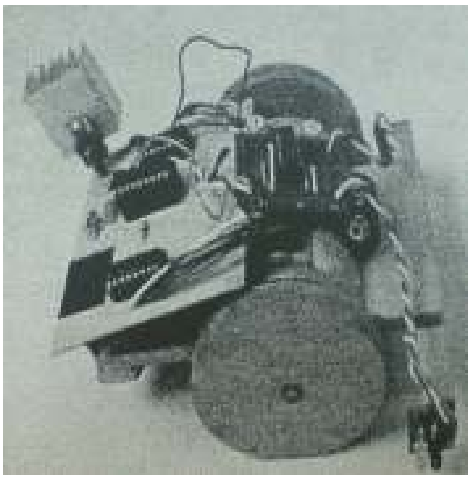


Figure 2.3 Micromouse UTM FYP 2006 [3]

2.5 Micromouse UTM FYP 2006 [4]

Another version of micromouse was builded also by student UTM in FYP 2006. This Micromouse was built by Indran A/L Thandavarian. This robot used Motorola MC68HC11E as controller with two stepper motors, whisker sensor and IR sensors. The base for the robot was formed by aluminium chasis with a big chasis as supporting.

This robot actually is not very good in terms of the design. The overall size is very big in terms of the castor and the body of the robot compared to the other model. The circuit arrangement is very messy in terms of the jumper and it is quite a dangerous design in terms of the circuit layout. The special area for this robot is the sensor it implemented in it, beside of IR sensor it uses also whisker sensor. This brings the idea of another communicating way for the robot with the environment. Figure 2.4 shows the build up for this Micromouse.

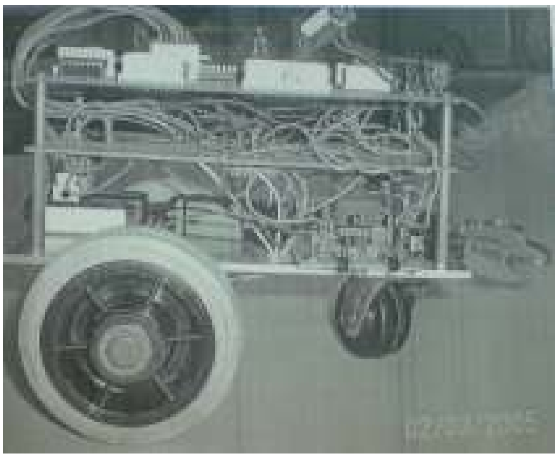


Figure 2.4 Micromouse UTM FYP 2006 [4]

2.6 Overview

From the four model of Micromouse that had been discussed, each model's specification was categorized in terms of advantages and disadvantages. The reason for categorizing was to make as a reference to lead the project design. Each model's advantages and disadvantages were shown in below.

➔Dexter

➔Advantages: Good Arrangement, Good Structure

➔Disadvantages: Large Battery Pack, Complex Circuit, Memory Small, Plastic Wheel

➔Mobot

➔Advantages: Circuit Simple, Good Arrangement and Structure, Easy Programming with Enough Memory, Rubber Mounted Wheel

➔Disadvantages: Large Battery Pack

➔Micromouse (Louis Wong Siang San)

➔Advantages: Small Size, Good Arrangement with Circuit, Simple Circuit, Easy Programming with Enough Memory

➔Disadvantages: Large Battery Pack, Wooden Wheel, Castor Balancing Not Good

➔Micromouse (Indran A/L Thandavarian)

➔Advantages: Rubber Wheel

➔Disadvantages: Bad Circuit Arrangement

2.7 Summary

As a summary from the literature review section, additional knowledge had been gained in the design of the Micromouse and will include components listed below.

1. 2 stepper motor and 3 analog distance sensors will be used
2. PIC as controller with c language
3. Wheel mounted with rubber so not easily slippery
4. Using layer of circuit to minimize circuit size
5. Acrylic casing
6. Battery with small size and last longing
7. Wheel chair design supporting with castor

A simple 3D sketch up shown in Figure 2.5 was done in order to show the basic structure for the Micromouse.

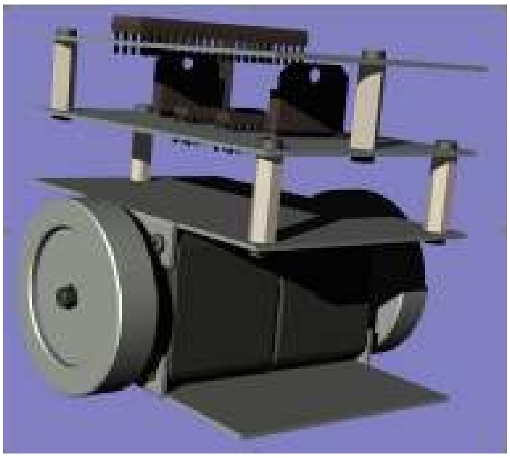


Figure 2.5 First Draft Design

CHAPTER 3

METHODOLOGY

3.1 Overview of Micromouse Function and Theory

There are two fundamental phases to the design process. The first phase was to design individual components of the Micromouse and get them to operate according to individual specifications independent of one another. The second phase was to interface the individual components and have the Micromouse operate as one autonomous unit. The first semester of the project was dedicated to working on the individual components. The goal of the second semester was to integrate the individual components. The individual working components include the navigation sensor array, mapping algorithm, motor control, and chassis design. An effective Micromouse design must be able to meet the following functions in order to find the center of a maze.

a) Recognize walls and openings
b) Stay centered within each cell
c) Know position and bearing within the maze
d) Control the distance needed to travel
e) Make precise 45° and 90° turns
f) Good chassis to keep structure stable
g) Navigate the maze intelligently

As an overview of the Micromouse function, the mouse must recognize walls and openings in order to navigate the maze and prevent crashes. The navigation sensor array provides the mouse with this information. The navigation sensor array consists of a combination of three analog distance sensor situated in the left, right and front of the Micromouse. The mouse must stay centered within the maze to prevent compounding errors in distance and position calculations. The left and right sensors determine if it deviates from its desired bearing. This information is sent to the motor control system to make proper corrections, either speeding up or slowing down one wheel. The motor control portion of the project is responsible for safely moving the Micromouse through the maze.

The mouse must keep track of position and bearing during each run to provide navigation information to the mapping system. The algorithm will calculate the distance the Micromouse travels. The bit 4 and 5 in the information byte determines which direction the Micromouse is facing. The combination of these two systems provides the data needed by the mapping and navigation systems.

To move efficiently through the maze the Micromouse must be able to make precise clockwise or anticlockwise 90° turns and 180° turns. The mechanical soundness of the Micromouse design is an important factor. The chassis needs to keep the systems stable during operation so accurate data is recorded. The chassis also keeps the drive train in line in order to reduce the number of path corrections made. To successfully and efficiently solve the maze the mouse must make intelligent navigation decisions based on its current position. The mapping system utilizes a modified flood-fill algorithm to determine the best solution as the maze is discovered.

3.2 Project Flow Out

As stated in the abstract section, the project consists of two stages. Stage one will be focusing on the development of individual system such as motor control system and the navigation system. Second stage of the project was to interface the individual systems to perform with each other as a whole system. Each stage can be separate into sub stages that will link the whole project development. Figure 3.1 shows the flowchart of the sub stages for the overall project.

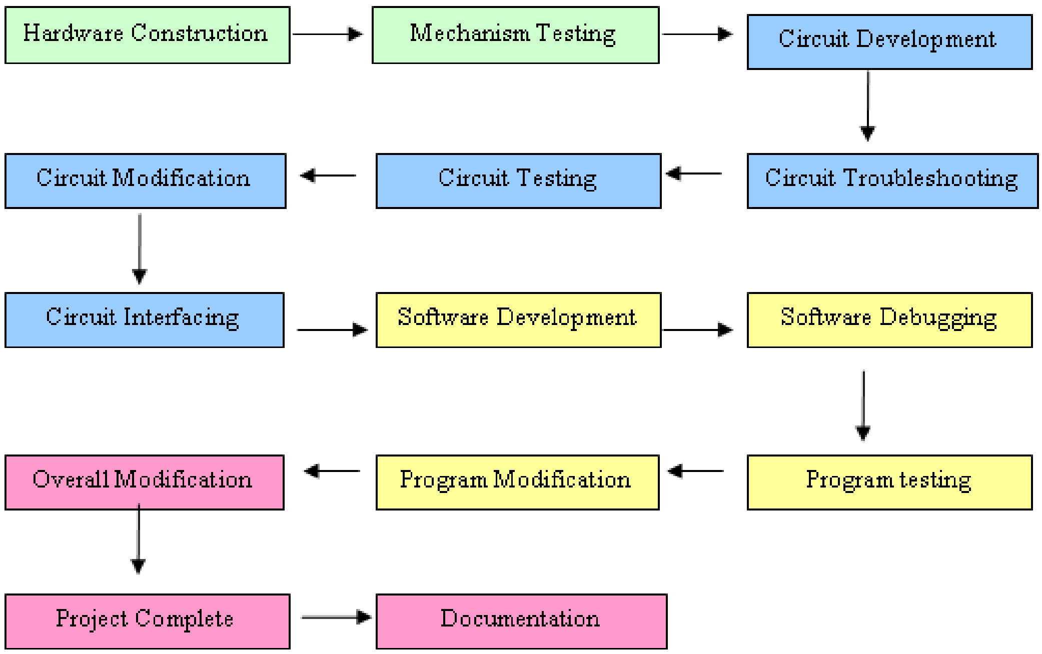


Figure 3.1 Flowchart of the Sub Stages for the Project

3.3 Structure and Mechanism

In order to build the structure and the base for the Micromouse, a 3D sketch up had been performed by using the Solidwork software. Figure 3.2 shows the front, back and side view for the Micromouse.

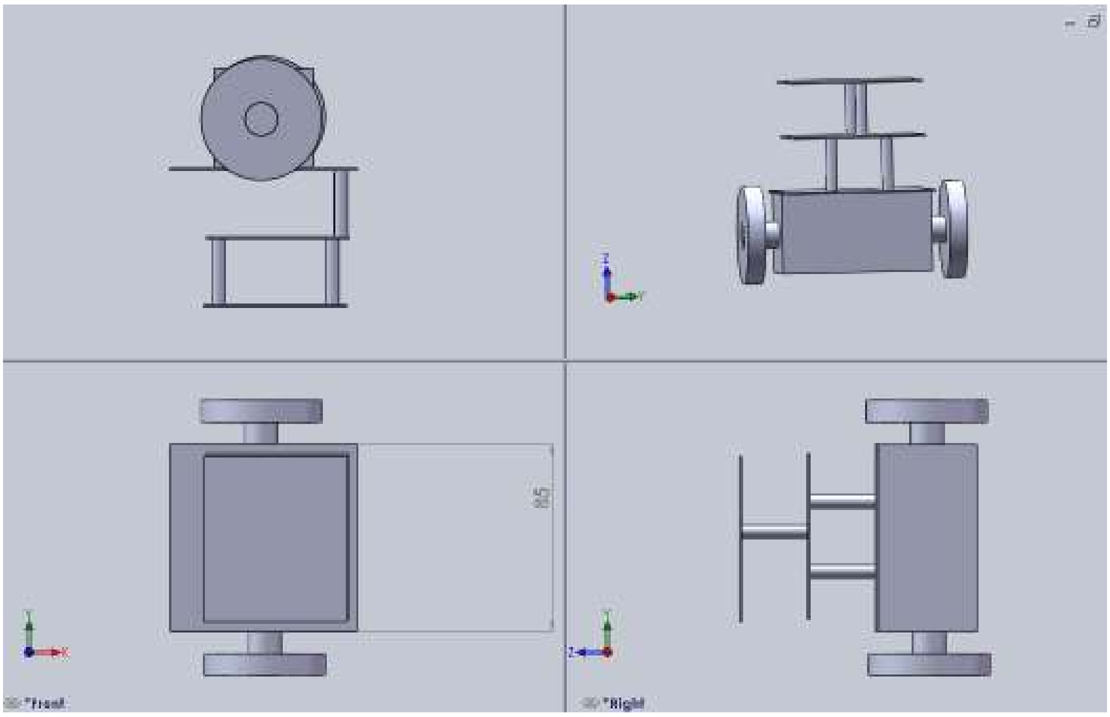


Figure 3.2 3D Lookup for the Micromouse

3.4 Hardware and Components

In this section, the individual working components on the hardware part will be briefly described. The individual working components that will be described are stepper motors, analog distance sensor, castor, batteries and LCD display. Each component plays a role in assisting the system to perform the task.

3.4.1 Stepper Motors

Figure 3.3 Stepper Motors

Stepper motors have been chosen as the actuators for the robot because of the stepping effect of the motor. This can easily for counting the movement for the robot in terms of distance inside the maze. Two units of LINIX 42BYGHD439 stepper motors will be used with hold torque of 2.5kg.cm and step angle of 1.8 degree/step. Figure 3.3 shows a pair of stepper motors being used in the project.

3.4.2 Sensors

Figure 3.4 Analog Distance Sensor

Sensor was like the eye for the robot and it is important when exploring for the maze. Research found that using normal IR sensor might cause problem while exploring the maze due to the environment infrared intensity. So in order to avoid this problem, analog distance sensor had been chosen. This sensor had been choose because it can only receive the signal with frequency emit by it own self without alter by the environment. Figure 3.4 shows the analog distance sensor being used in the project.

3.4.3 Battery

Figure 3.5 Lithium Polymer Battery

While choosing the battery, the weight and the lifetime of the robot had been considered. Normally battery with long lifetime will had a big size and weight while small size will had low lifetime. So after consideration, lithium polymer battery will be chosen since its size is small and long lifetime. The rating for the battery will be 11.1v with 1300mAh. The disadvantage for this kind of battery was only the price quite high. Figure 3.5 shows a view of the lithium polymer battery.

3.4.4 Castor

Figure 3.6 Castor

Figure 3.6 shows a castor that was used as the balancing point or supporting for the robot base. The base basically consists of the two stepper motor mounted by acrylic but will not balance so the castor was implement to provide the balancing.

3.4.5 LCD Display

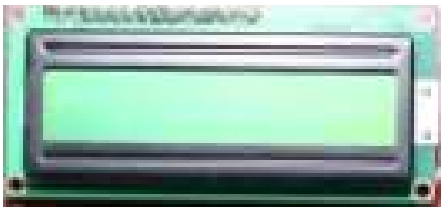


Figure 3.7 LCD Display

LCD Display was used as an error debugging tools for displaying the information we wished to see from the system. Figure 3.7 show a 16x2 LCD display that was used in the project.

3.5 Circuit Design

The circuit development for Micromouse will be consists of the main board and motor board. Both of the boards will combine with the other hardware components to work as a system.

3.5.1 Main Board

The main board can be considered as the brain for the robot since it consist the PIC18F452 microcontroller. Figure 3.8 shows the characteristic tables and pin diagram for PIC18F452. Beside of the microcontroller, the board consist all the other components such as the voltage regulator, pin connection to the power supply, connection to the motor board, sensors connection, and other basic electronic components. The main board can considered as the main control unit for the robot since all the signals processing will be done on this board.

Flash Memory	32k
RAM	1.5k
EEPROM	256bytes
Max clock frequency	40Mhz (10x4)
PWM channels	2
10 bit ADC channels	8
Timers	4
I2C,SPI,USART,PSP	yes
In Circuit Serial Programming (ICSP)	yes

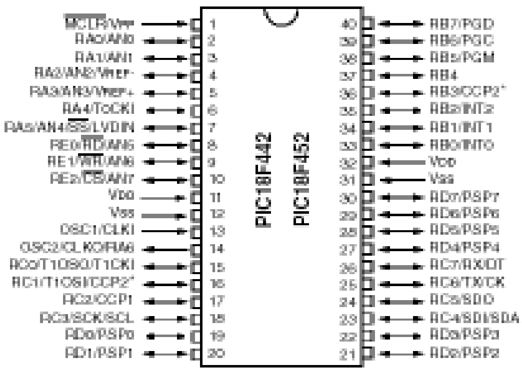


Figure 3.8 Characteristic Table and Pin Diagram for PIC18F452

3.5.2 Motor Board

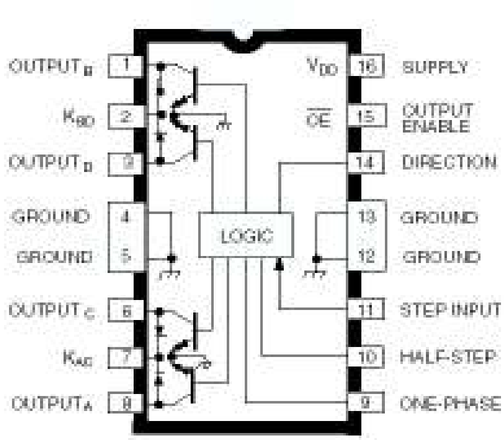


Figure 3.9 UCN5804

Motor board was used to control the high voltage and current to the stepper motor since the microcontroller not affordable to supply high voltage and current to the motor. Motor board was mainly consisting of the UCN5804 unipolar stepper motor driver which shown in Figure 3.9. The driver will receive signal from the PIC and operate the motor to move or either stop. The basic connection idea for the motor board is shown in Figure 3.10.

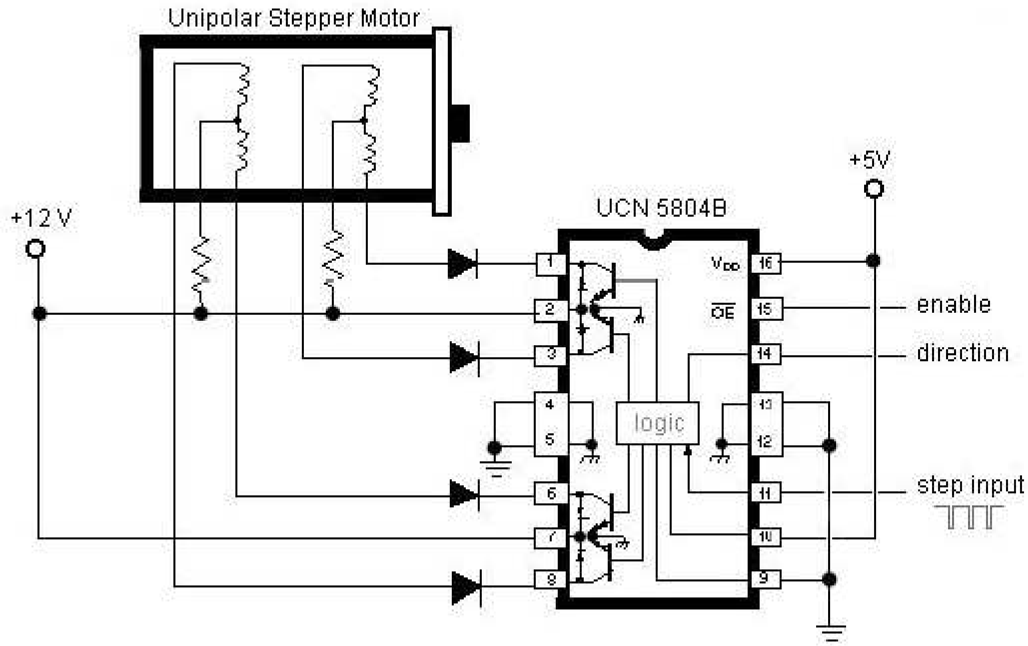


Figure 3.10 Connection of the Motor Board with Stepper Motor

3.6 Algorithm

The principle goal of the Micromouse is to solve the maze and find its center as quickly as possible. To accomplish this task, the Micromouse uses a particular maze searching algorithm.

A vast amount of research on searching techniques already exists and is currently being undertaken. Mathematicians in the fields of topology and graph theory have been studying maze creation and maze solving algorithms for several centuries. However, the algorithms they have developed area not feasible for Micromouse applications due to the memory and speed limitations of most Micromouse microcontrollers. Moreover, since searching through data is a fundamental function of computers, computer scientists have also devised a number of different searching techniques throughout the last few decades. Again, while these algorithms are highly effective and efficient for computers built with sophisticated microprocessing unit, they cannot practically implement in the less advanced microcontrollers utilized for Micromouse. As a result, Micromouse robot generally uses some variation of the following search algorithms: Wall Following, Depth First Search, and Flood Fill.

Wall Following is a trivial algorithm in which the mouse chooses a wall, either left or right, and then always keep the chosen wall on its side as it moves through the maze. This algorithm is very simple to implement in code, but unfortunately it is inefficient and does not work for IEEE mazes because they are specially designed to prevent Wall Following mice from succeeding.

Depth First Search is an intuitive algorithm for searching a maze in which the mouse first starts moving forward and randomly chooses a path when it comes to an intersection. If that path leads to a dead end, the mouse returns to the intersection and choose another path. This algorithm forces the mouse to explore each possible path within the maze, and by exploring every cell, the mouse eventually finds the center.

It is called “depth first” because, if the maze is considered a spanning tree, the full depth of one branch is searched before moving onto the next branch. The relative advantage of this method is that the Micromouse always find the route. Unfortunately, the major drawback is that the mouse does not necessarily find the shortest or quickest route, and it wastes too much time exploring the entire maze.

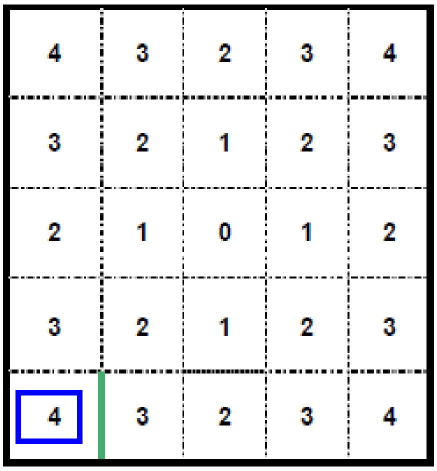
Flood Fill is better suited to the Micromouse than the two algorithms discussed above. This algorithm, also known as Bellman’s algorithm, uses a sophisticated system of distance and wall information to refine a short path to the center of the maze. Since the maze has a fixed size already known to the Micromouse, it must first assign a value to each cell in the maze representing the distance from that cell to the center and store these values in an array. The Micromouse must also store a wall map which will be continually updated with information as the sensors detect new walls in the maze. At each cell, the Micromouse performs the following steps:

1. Check for new walls and update the wall map.
2. “Re-flood” the maze with new distance values and update the distance array.
3. Move to the neighbouring cell with the lowest distance value.

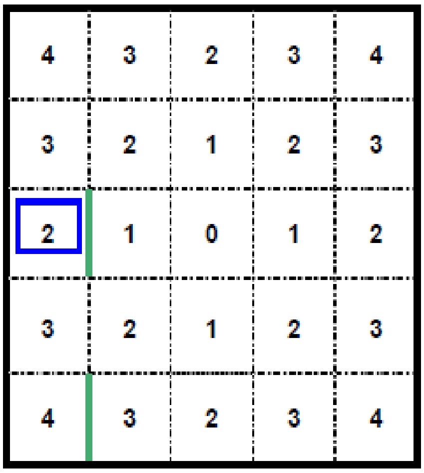
Flood Fill is called a “breadth first” algorithm because, if the maze is considered to be a spanning tree, an entire level is searched before exploring the whole depth of a particular branch. The major advantage of the Flood Fill algorithm is that it always finds the shortest path to the center of the maze. It is important to note that the shortest path is not necessarily the quickest path since a path filled with turns will take a longer time to traverse than one primarily composed of forward going moves. The relative disadvantage of this algorithm is that more memory required for execution.

Several modifications of the flood filled algorithm may be implemented to increase efficiency. For example, Modified Flood Fill is a derived version of regular Flood Fill in which only those valued which need to be changed are actually updated when searching the maze rather than re-flooding the entire maze as in regular Flood Fill. This method is considerably faster than regular Flood Fill because entire maze does not need to update each time the Micromouse moves to a new cell.

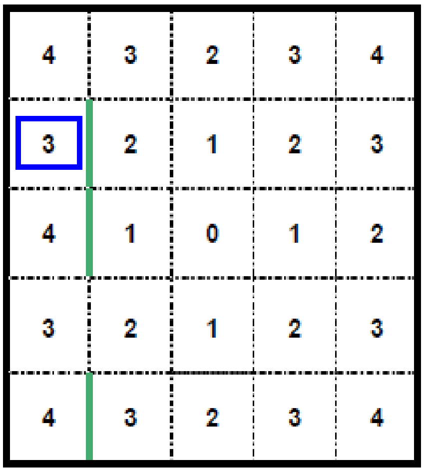
Flood Fill algorithm will be developed in this project since it is the most effective algorithm among the algorithms been explained. The Modified Flood Fill algorithm will also be carried out from the modification of Flood Fill algorithm. Figure 3.11a and 3.11b shows the pictorial illustrations for Modified Flood Fill Algorithm:



1. Here we have a smaller version of the maze for illustration purposes. No prior wall information is known to the Micromouse. The mouse begins at the bottom left corner and sees a wall to the right and goes forward to the cell of lower distance.

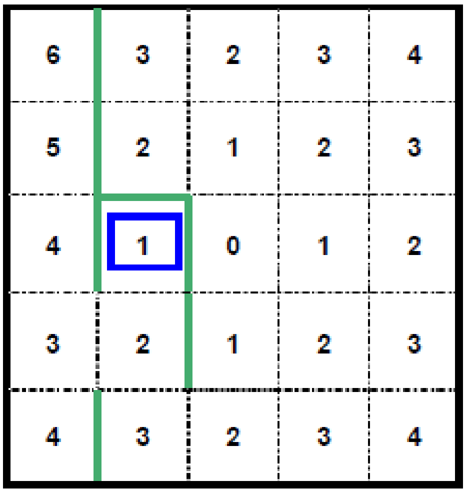


2. The Micromouse continues to follow the lowest distance number path and finds a wall to east. The neighboring cells all have a higher number, so it must adjust its current distance number to 1 higher than lowest neighbor.



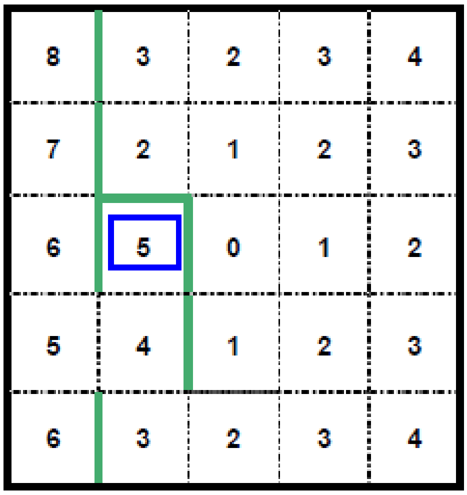
3. The Micromouse finds another wall to the east and updates the wall map. It also re-floods the distance array with the new values.

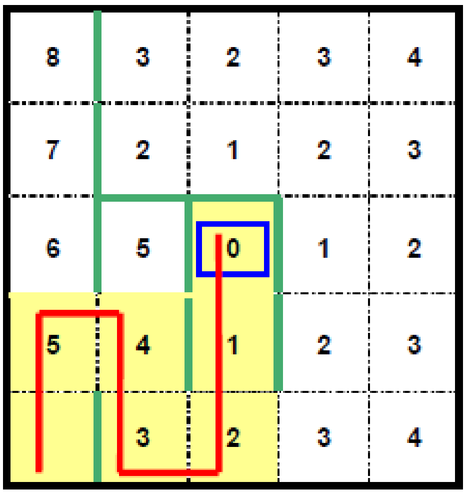
Figure 3.11a Pictorial Illustrations for Modified Flood Fill Algorithm



4. The Micromouse continues exploring up to the top left corner, updates wall and distance information as required, and then follows the lowest distance path towards the center of the maze. At its current position, cells to south have incorrect distance information, so they must be updated.

5. In order to update the values, the distance array is changed as shown to the right.





6. The shortest path has now been discovered. The Micromouse must simply follow number sequence in descending order from the start to the center of the maze.

Figure 3.11b Pictorial Illustrations for Modified Flood Fill Algorithm

3.7 Summary

As a summary for chapter 3, the whole Micromouse architecture had been plan out. The hardware design, circuits design and algorithm had been predefined so the progress will just follow as shown in the flow chart in Figure 3.1. Good time management should also be alert since this project involves a lot of work such as system built up, testing, modification and documentation. So, time management can also be considered as an element of methodology.

CHAPTER 4

RESULT AND ARCHIEVEMENT

4.1 Hardware and Structure

Figure 4.1 shows the mechanism and structure for the Micromouse being built. The base of the robot was formed by acrylic casing that holds the stepper motor. The base was supported by the two wheels made by PE rode and a castor. The wheels were covered with rubber stripe to prevent against slippery while navigating in the maze.

Meanwhile, the upper part of the Micromouse was formed by the two layer of circuit arrangement which is the main and motor boards. The sensors were attached on the front, left and right of the robot. The battery was located at the middle of the robot to form the center of the mass and supported by the castor and the base of the robot. Circuit connectors were made to link the board and other components together to work as w system. Overall, the robot weight was around 0.7 kg, height of 13 cm, length of 13 cm and the width of 8.7 cm.

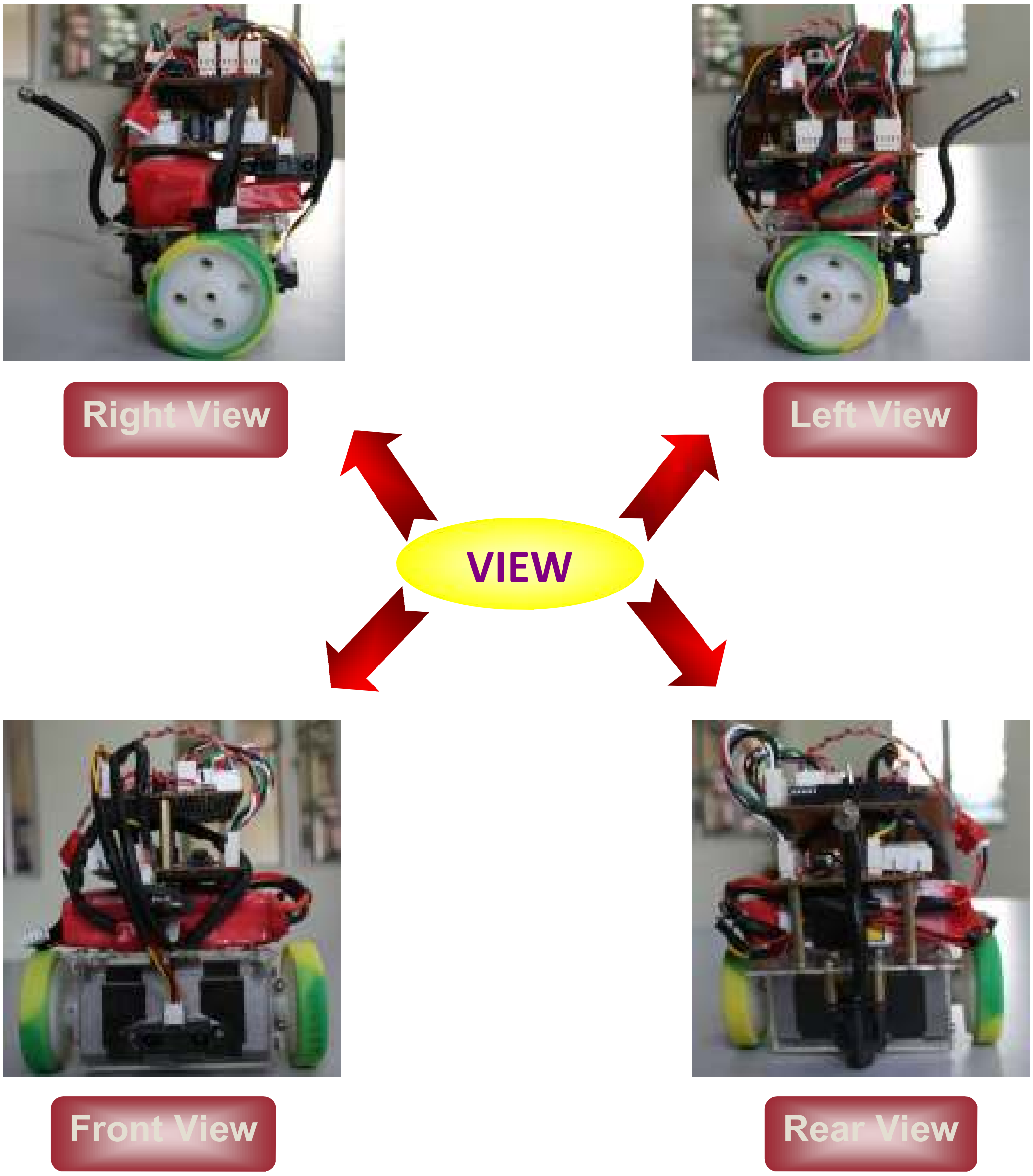


Figure 4.1: Views of the Micromouse

4.2 Electronics

As stated in the methodology part, the electronics circuit consists of two parts which is the main board and motor board for the purpose of neat arrangement. The circuit will link to each other and also other components using connector to perform as multi stages system.

4.2.1 Main Board

As mentioned before, the main board is the processing unit for the whole robot. The board consists mainly of the microcontroller PIC18F452, voltage regulator, switches, connectors to motor boards, sensors connectors, connection from the power supply and others. The main task of the main board is to receive information from the sensors and passed to the algorithm for decision making. The outcome signals will be send to the motor board as reaction of movement. Beside that, main board is also the center of power supply to the other components and motor board. Figure 4.2 shows the view of the main board and Figure 4.3 shows the schematic for the main board connection.

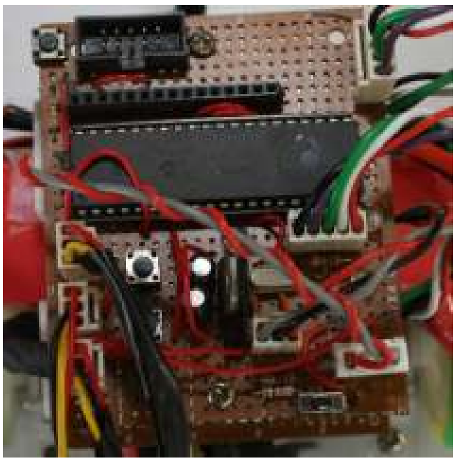


Figure 4.2 Top View of Main Board

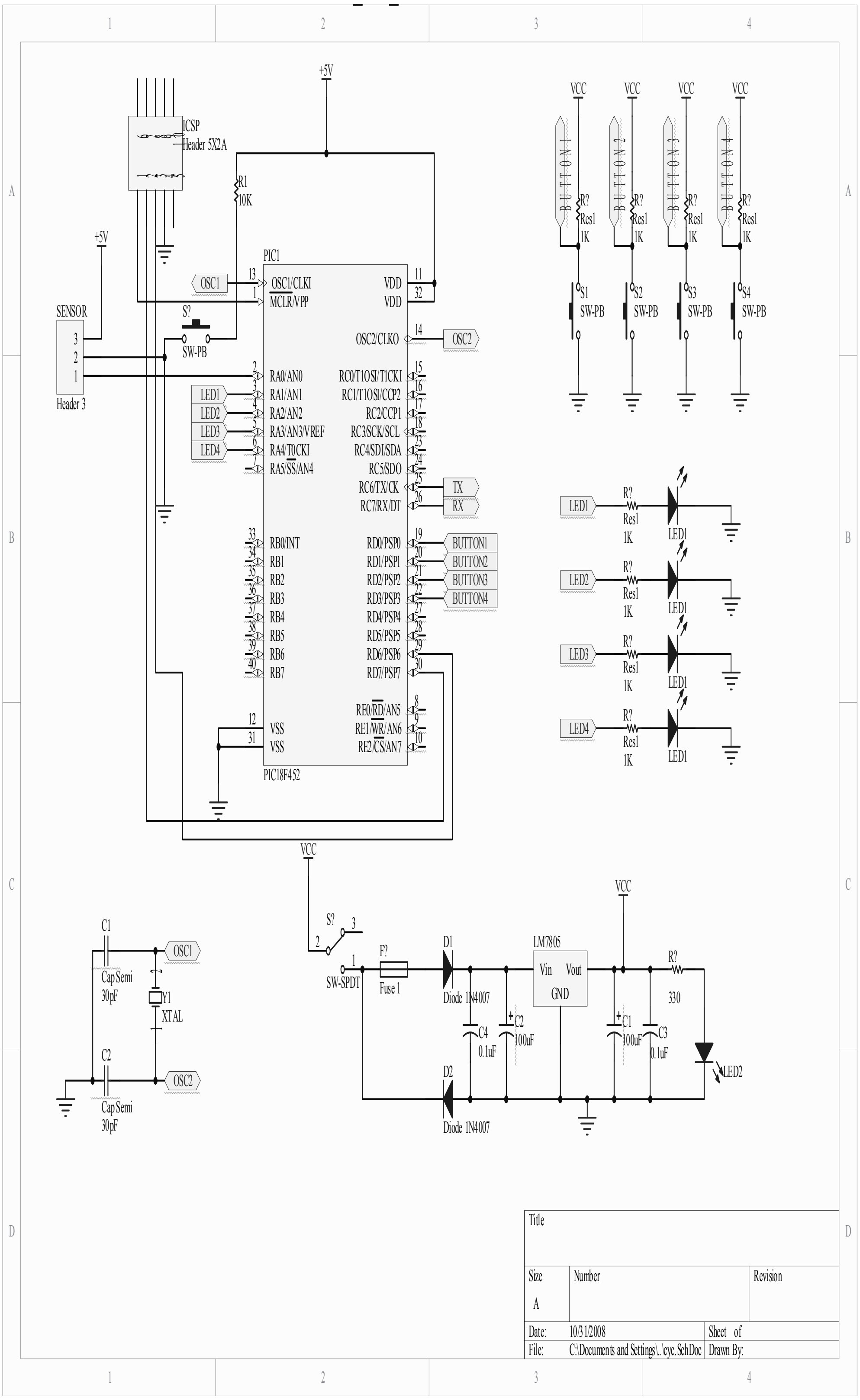


Figure 4.3 Schematic for the Main Board

4.2.2 Motor Board

For the motor board, the circuit consists of the UCN5804 unipolar stepper motor driver, connectors to the main board and stepper motor, power resistor, diodes and capacitors. The main task for the motor board is to receive signals from the main board and send to the motor to control the movement of the robot. The view of the motor board is shown in Figure 4.4 while the schematic diagram for the motor board is shown in Figure 4.5.

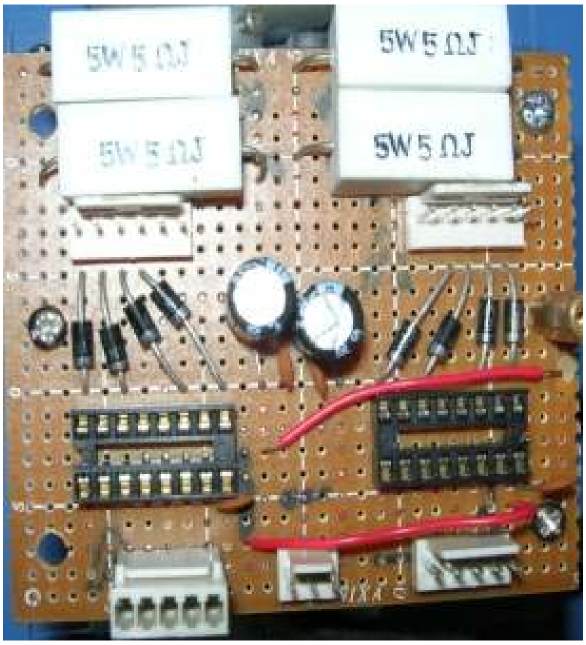


Figure 4.4 Top View of Motor Board

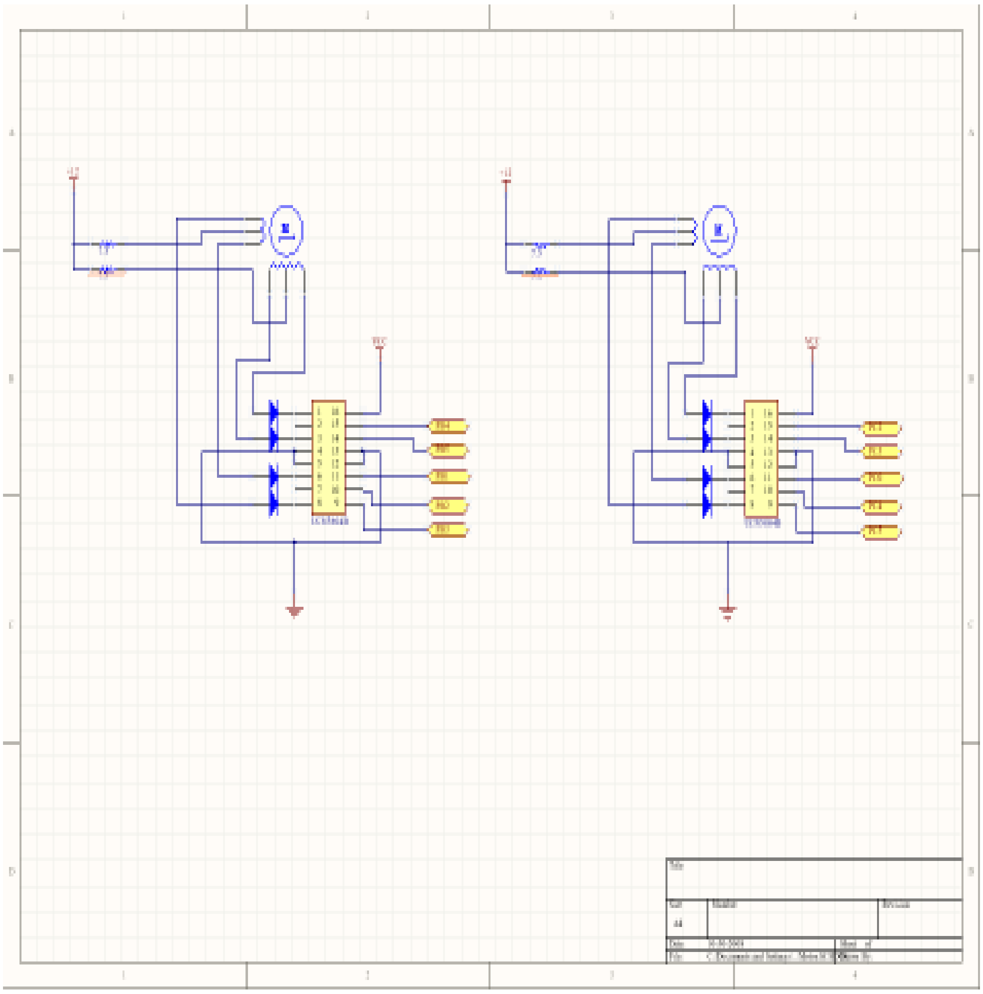


Figure 4.5 Schematic for the Motor Board

4.3 Maze Field

The maze field constructed for the Micromouse to operate is a maze with 49 cells and each cell has dimension of 18cm x 18cm. The height of the maze is 18cm. The maze is a randomize maze which means the wall inside the maze can be randomly organized to any pattern as wished.

The maze field was constructing mainly using "manila" cards and polystyrene. Figure 4.6 shows the maze that been constructed.

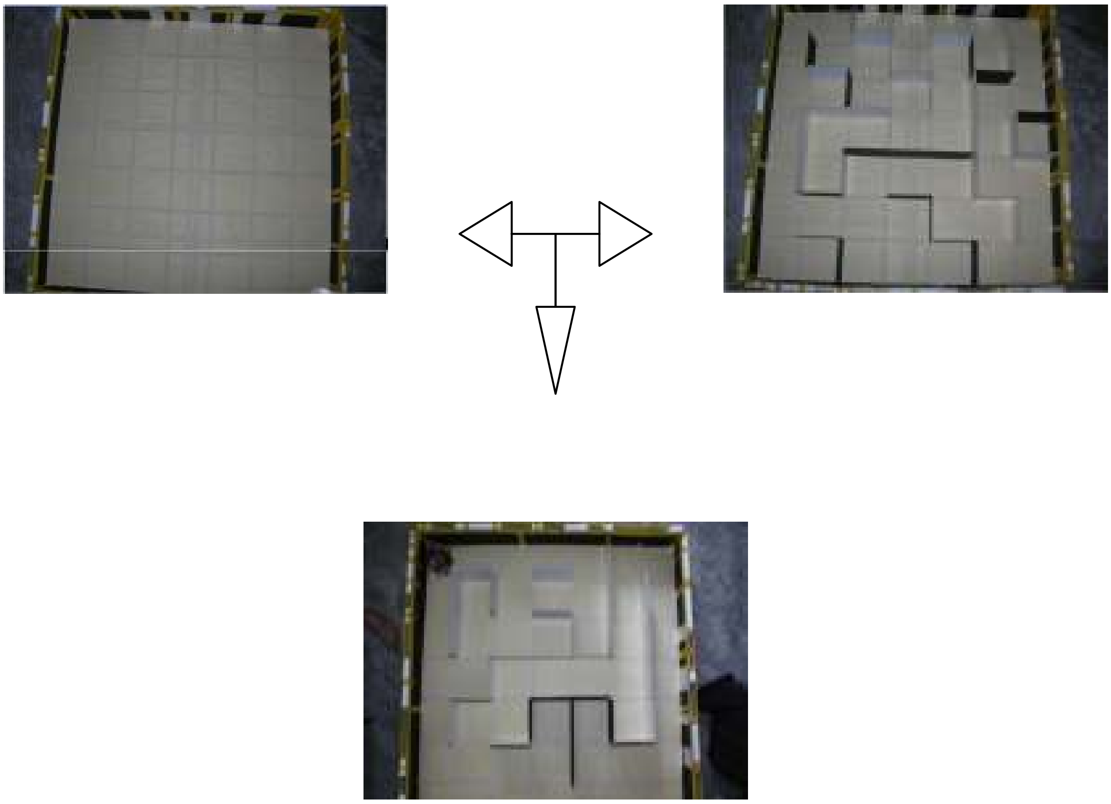


Figure 4.6 The Different Type of Maze Made By the Randomize Maze

4.4 Algorithm

The Flood fill and Modified Flood Fill algorithms have been successfully tested perfectly in the constructed randomized maze field. Both of the algorithm will always find an alternative path to the center of the maze and after few rounds of traveling, it will determine the shortest path to the center of the maze. Modified Flood Fill algorithm will be use as main solving algorithm since it takes less process.

EEPROM had been used to memorize the maze map when exploring and assisting the effectiveness of the algorithm. Since there are 49 cells, so 49 byte will be use to memorize the maze map. Each of the byte is called the information byte since it stores the information for the map. Basically, each information byte consist of 8 bits where bit 0 to bit 3 will used to store the existence of wall in the North, West, East, South direction. Bit 4 and bit 5 will be used to keep the facing direction of the Micromouse in the current cell. The other left bit will not be used. Figure 4.7

shows the content of the information byte while Figure 4.9 shows the view of the EEPROM using MPLAB. Beside of storing the map information, another 49 byte was used to store the weight of each cell since also a part for the algorithm.

Beside of the EEPROM, stack pointer is also used to assist the algorithm. The stack pointer is used to store the cells which need to be checked by the algorithm. Figure 4.8 shows the memory structure of a stack pointer.

7	6	5	4	3	2	1	0
No Used		Direction		West	South	East	North

00-Facing North
01-Facing South
10-Facing East
11-Facing West

Figure 4.7 Information Byte

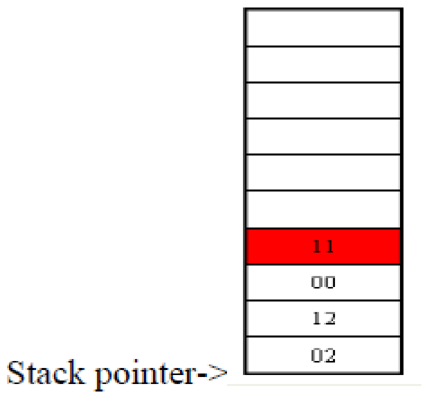
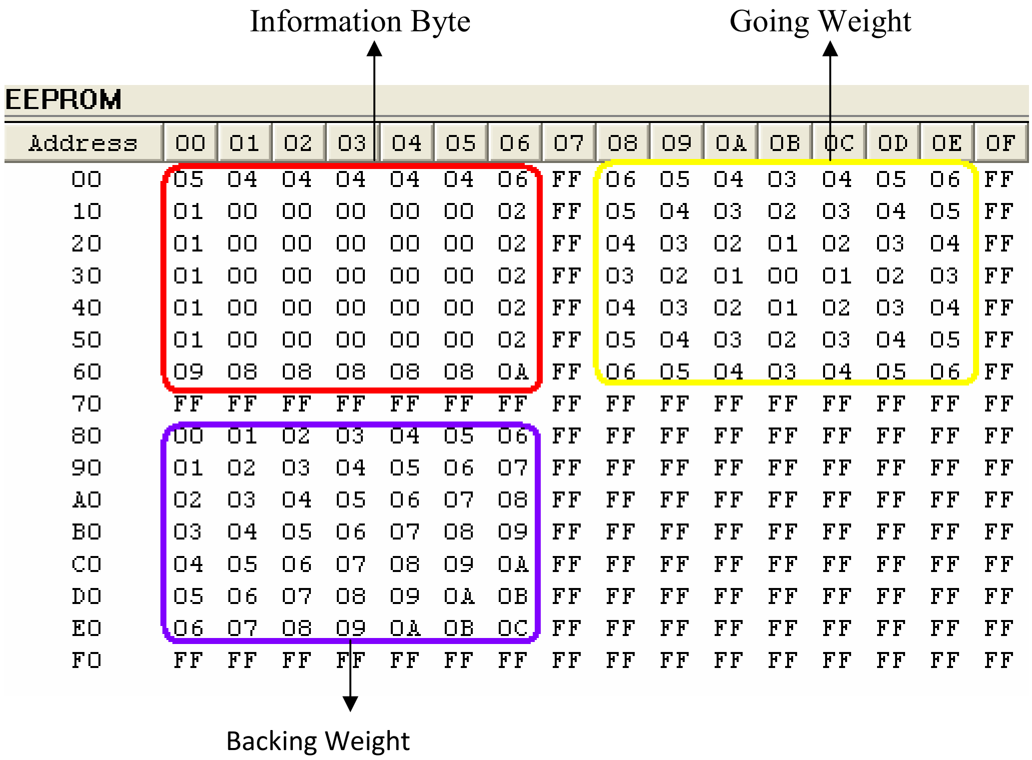


Figure 4.8: Memory Structure of A Stack Pointer



Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
00	05	04	04	04	04	04	06	FF	06	05	04	03	04	05	06	FF
10	01	00	00	00	00	00	02	FF	05	04	03	02	03	04	05	FF
20	01	00	00	00	00	00	02	FF	04	03	02	01	02	03	04	FF
30	01	00	00	00	00	00	02	FF	03	02	01	00	01	02	03	FF
40	01	00	00	00	00	00	02	FF	04	03	02	01	02	03	04	FF
50	01	00	00	00	00	00	02	FF	05	04	03	02	03	04	05	FF
60	09	08	08	08	08	08	0A	FF	06	05	04	03	04	05	06	FF
70	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
80	00	01	02	03	04	05	06	FF	FF	FF	FF	FF	FF	FF	FF	FF
90	01	02	03	04	05	06	07	FF	FF	FF	FF	FF	FF	FF	FF	FF
A0	02	03	04	05	06	07	08	FF	FF	FF	FF	FF	FF	FF	FF	FF
B0	03	04	05	06	07	08	09	FF	FF	FF	FF	FF	FF	FF	FF	FF
C0	04	05	06	07	08	09	0A	FF	FF	FF	FF	FF	FF	FF	FF	FF
D0	05	06	07	08	09	0A	0B	FF	FF	FF	FF	FF	FF	FF	FF	FF
E0	06	07	08	09	0A	0B	0C	FF	FF	FF	FF	FF	FF	FF	FF	FF
F0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Figure 4.9: A View of the EEPROM Memory Using MPLAB

4.5 Summary

The overall achievements for the Micromouse project had been achieved based on the objective and project scope listed in chapter 1 and 2. The mouse can perform the maze solving techniques using the algorithm. The mouse can make smooth movements in straight, 90 degree turns and 180 degree turns.

The randomly organized maze field had proved the efficiency of the algorithm implement on the robot. All the other individual components such as the sensors, battery, stepper motors, LCD display and castor had also successfully played their role as part of the system. The mechanism and structure for the robot work well in terms of the stability of the robot.

The objective for the electronic parts had been achieved since the main board and the motor board link to each other to produce good interactive controlling process. Not much circuit debugging error had been encounter in the whole circuit development process. Figure 4.10 shows some of the view for the Micromouse moving in the maze.

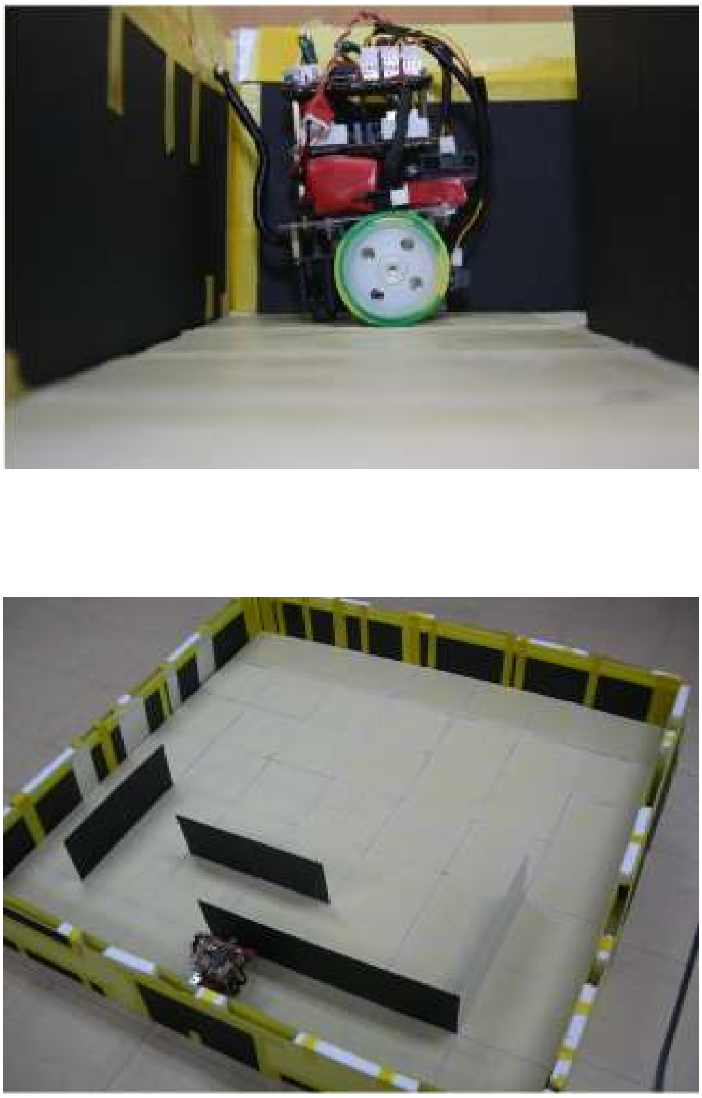


Figure 4.10 View of Micromouse Moving in the Maze

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Discussion

Based on the achievement and respond from the lecturer and student, the Micromouse project is seen successfully achieve its project scope and objectives as discussed in chapter one. There is not much constraint occurs on the first stage of the design for developing the individual system. However, there is some constraints occurs in the second stage of the project when combining all the individual system to perform the Micromouse function.

The sensor system and the motor control system face some difficulties to interact with each other. The sensor system response time is too much faster than the motor response time. So there are cases that the motor will not react as wishes and hence affect the performance of the robot. This problem has been solved by applying timer application to the sensors and motors.

The project limitation also involve by the characteristics of the sensors being used. The balancing method for the Micromouse can only be done between walls separate by a cell. If there is wall between two cells or more than two cells, the balancing method cannot be applied. Higher performance sensors can be used in order to improve the performance of the Micromouse.

5.2 Conclusion

As a conclusion, this project had been an incredible learning experience. It is a daunting task to undertake a project of such huge magnitude and wide breath, but is able to meet the challenge by diligently working on the whole design in the entire two semesters.

The Micromouse project is of great value to our future academic or working goals due to its broad engineering nature. By completing the project, great deal experience gain in several areas of computer and electrical engineering which had been studied and now definitely know the internal link of all the elements such as mechanical, signal, control, software, and electronics knowledge. All of the elements form the soul related to the studying field of Mechatronics Engineering.

In addition, the development of searching algorithm will allow the incorporate aspects of mathematics backgrounds such as the Modified Flood Fill algorithm can be consider as a game of playing with numbers to ending of the maze. Furthermore, the project has a research aspect which is strongly in accordance with my future career aspirations which the project can dedicate to the more talented engineering field or find out the field that more interested in.

5.3 Suggestion and Future Developement

There is still a lot of space for improvement and enhancement for this Micromouse project. Micromouse project involved a lot of creativity in the hardware and software side since this is the fundamental soul for the Micromouse to operate. In addition, Micromouse was a project involved knowledge from elements of mechanical, control, signal, electronics and computer engineering. So there is a wide spec of improvement since it involved many kinds of elements inside the whole project.

From the aspect of the Micromouse project, there are some enhancement can be made to make the robot more intelligence and whole system more perfect. Since the driving system was a bit not perfect due to the limitations of the sensors, so higher performance sensors can be implement into the robot in order to improve this specification. The Micromouse can be upgraded in terms of the movement speed by changing the actuators since nowadays technologies, there are more high speed and accurate motor in the market can be found such as a kind of motors called “mini motor” and this kind of motor had been widely used to build Micromouse which contribute in international competition of its efficiency in terms of speed and accuracy.

The mouse can also apply diagonal movement when moving inside the maze. Another method to increase the intelligent of the Micromouse is applying image processing technique inside the robot to perform better navigation and observing skill.

REFERENCES

[1] Web Reference:
http:// www.micromouseinfo.com (Retrieved on 06.09.2008)

[2] Web Reference:
http:// www.mobots.com (Retrieved on 20.09.2008)

[3] Louis Wong Siang San. 2006. *Micromouse The Maze Solving Robot*. University Technology Malaysia. Degree Thesis.

[4] Indran A/L Thandavarian. 2006. *Micromouse The Maze Solving Robot*. University Technology Malaysia. Degree Thesis.

[5] Web Reference:
http:// www.wikipedia.com (Retrieved on 19.08.2008)

[6] Web Reference:
http:// www.cytron.com.my (Retrieved on 19.08.2008)

[7] Web Reference:
http:// www.Linix.com (Retrieved on 17.08.2008)

APPENDIX

APPENDIX-A: Project Flow Chart

First Semester 2007/2008

	JULY				AUGUST				SEPTEMBER				OCTOBER				
Weeks	1	2	3	4	5	6	H	7	8	9	10	11	12	13	H	14	SW
Project Proposal		■															
Background Study & Literature Review			■	■													
Design & Planning				■	■												
Part Perchasing (Hardware)						■											
First Prototype							■	■									
Research on variety of Microcontroller									■	■							
PIC18F452 microcontroller learning											■						
Microcontroller & Actuator Interfacing												■	■	■	■	■	■
Presentation PSM1												■					
Report Writing															■	■	■

Second Semester 2007/2008

	JANUARY					FEBRUARY				MARCH				APRIL			
Weeks	1	2	3	4	5	H	6	7	8	9	10	11	12	13	14	15	SW
Enhancing Prototype (Prototype-2)	■	■	■														
Study on Obstacle & Avoidance					■	■											
Voice Ability & LED Interfacing						■											
Further research on PIC18F452 Microcontroller							■	■									
Microcontroller Programing and interfacing		■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Microcontroller & Actuator Interfacing			■	■			■	■	■	■	■	■	■	■	■		
Microcontroller & Physical System Interfacing										■	■	■	■	■	■		
Presentation PSM2																■	
Thesis Writing												■	■	■	■	■	■