
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## DEVELOPMENT OF MOBILE ROBOT FOR SOLVING MAZE USING ARDUINO

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

by

**ANIS ATTHIRRAH BINTI SHAMSUL ARIFFIN**
**B071410756**
**950825-09-5008**

FACULTY OF ENGINEERING TECHNOLOGY
2017

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DEVELOPMENT OF MOBILE ROBOT FOR SOLVING MAZE USING ARDUINO**

SESI PENGAJIAN: **2017/18 Semester 2**

Saya **ANIS ATTHIRRAH BINTI SHAMSUL ARIFFIN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

| | | |
|---|---|---|
| ☐ | SULIT | (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972) |
| ☐ | TERHAD | (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ☐ | TIDAK TERHAD | |

Disahkan oleh:

_____ _____

Alamat Tetap:

No.18 A, Lorong Ampang,

Kampung Batu Bertangkup,Jalan Kilang Gula,02500, Chuping,

Perlis.

Cop Rasmi:

Tarikh: _____ Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

# DECLARATION

I hereby, declared this report entitled “development of mobile robot for solving maze using arduino” is the results of my own research except as cited in references.

| | | |
|---|---|---|
| Signature | : | **…….** |
| Author’s Name | : | **Anis Atthirrah binti Shamsul Ariffin** |
| Date | : | **19TH DECEMBER 2017** |

# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

……

(Mr. Muhammad Salihin Bin Saealal)

# ABSTRAK

Projek ini adalah mengenai mereka bentuk robot mudah alih yang boleh menyelesaikan laluan *maze*. Robot *maze* diprogramkan untuk bermula dan berakhir pada koordinat yang dikehendaki . Algoritma *Left Wall Following* telah dipilih kerana ia mudah untuk difahami dan sesuai dengan objektif projek robot mudah alih ini. Program algoritma dan program robot disusun dan dihantar ke dalam modul Arduino. Modul ini digunakan sebagai pengendali robot. Robot *maze* telah direka daripada beberapa komponen utama iaitu Arduino Uno, sensor digital infrared (IR), Gear DC motor berkelajuan tinggi, Pelindung Arduino Motor (pemacu motor) dan LIPO batteri. Komponen-komponen ini adalah asas untuk penciptaan robot dan mesra digunakan untuk apa-apa aplikasi elektronik. Daripada beberapa eksperimen, robot menyelesaikan *maze* adalah satu kejayaan apabila robot mampu untuk bergerak di dalam trek *maze* dan berjaya menyelesaikan trek *maze*. Beberapa kesukaran turut terlibat dalam melaksanakan projek ini seperti mengendalikan perkakasan robot yang mengambil masa, terutamanya apabila menentu ukur robot untuk mengikut laluan lurus dan membuat pusingan di persimpangan. Masalah-masalah ini telah dianalisis dan diselesaikan dengan kaedah pengujian dan analisis.

# ABSTRACT

This project is about designing and developing a mobile robot that can travel and solve a maze path. The robot was programmed to be started and ended at a fixed coordinate. The Left Hand Wall Following algorithm was selected because it is easy to understand and suite with the objective of this mobile robot project. As for the robot program, it was compiled and burned into the Arduino module. This module used to run the electronic parts in order to operate the robot. The maze robot were constructed from a few main components which are Arduino Uno (microcontroller), digital infrared (IR) sensor, high speed metal gear DC motor, Arduino Motor Shield (motor driver) and compact LIPO batteries. These components were basics and user-friendly to any electronics application. From the experiment, the maze solving robot is a success and made the maze robot travel along the maze path and solve it. Some difficulties were involved in this project such as assembling the robot hardware which takes time and passion, especially on calibrating the robot to follow the path and making turns at the junction. These problems were analyzed and resolved by testing and analysis method.

# DEDICATION

To my beloved parents, I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams.

# ACKNOWLEDGEMENT

First and foremost, I praise to Allah SWT for giving me all His blessing to complete my Bachelor Degree Project successfully in the given time. I would like to express my sincere gratitude and deepest appreciation to Muhammad Salihin Bin Saealal for his supervision, encouragement, suggestions and guidance throughout the duration of this project. I also would like to express my big thanks to all the FTK's lecturers who are direct or indirectly involve with my project. Event such a small contribution means a lot to me. Not to forget my colleagues who are always support me during my hard time while completing this project. Last but not least, I would like to address my deepest gratitude to my beloved parents and family for giving me full support, understanding and patient. Thank you everyone.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| IDE | - | Integrated Development Environment |
| IR | - | Infra-Red |
| LCD | - | Liquid Crystal Display |
| LED | - | Light Emitting Diode |
| SDK | - | Software Development Kit |
| RISC | - | Reduced Instruction Set Computing |

# CHAPTER 1
# INTRODUCTION

## 1.0 Introduction

This chapter provides an introduction to this project. Specifically, it starts with the general information and background about mobile robot of maze solver, project overview, problem statement of this project, description of prototype, objective, scope and it will also cover the thesis outline of the development of the mobile robot for solving the maze using Arduino.

## 1.1 Background

A maze is a complex structure with a series of interconnecting pathways designed as puzzles through which one has to find a way. A maze is also viewed as a puzzle that must be solved, eventhough getting through a maze can be a complex process, the solver must work his or her way from the entrance to an exit, or another location. A Maze Solver Robot is an autonomous mobile robot which can find a predetermined destination when placed in an unknown maze. This maze robot was programmed by an algorithm which helps it to have the shortest way and reach the end point of the maze task and also programmed in such a way it will find its path without colliding the walls. The algorithm was made to solve any task of the maze given. In international, this maze solver robot is known as the Micromouse robot. The Micromouse robot was designed as a competition robot which competes for the fastest time it moves to the center of the maze and the shortest path for it to returns to the

starting point of the maze. Figure 1.1 shows the international maze track used as Micromouse robots competition.

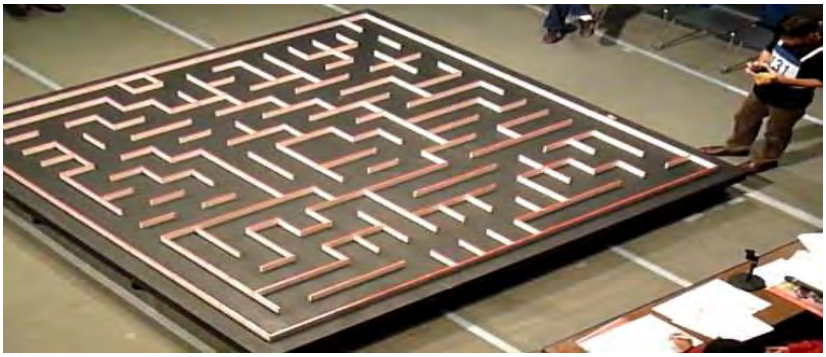

Figure 1.1 International maze track

In 1977, the first maze solving robot competition 'Amazing MicroMouse Maze Contest' is held to challenge the contestants to design and build a maze-solving "micromouse" robot. The robot should have its own logic algorithm and enough memory. The robot needed to be able to map the given maze in order to achieve the objectives of the competition. The maze design would be held secret until the competition day. Each maze solving robot would be given an opportunity to test run the robot in the maze, and calibrating sensor from the errors to improve its time in the final run. But at the first time trials, only two out of five entries ready that able to get the micro mouse travelled through the maze. However, in 1979 National Computer Conference, the number went increased, about 15 mice successfully competed in the Spectrum finals competition. The micromouse competition had become an international event in just a few years later. Micromouse competetion has continued to spread up to now, when it is about more than 100 contests are held annually including countries from Europe, Japan, Korea and Singapore.

The standard micromouse maze is 8 feet square and consists of a 16 by 16 cell matrix but it is in variable size depends on the designed maze. The sides of the maze walls and the floor of the maze are usually white. The maze is made of wood, finished with non-gloss paint. Each micromouse is given a number of trials to test run the maze

first, to determine the shortest path possible to the the center of the maze. As in the competition, the fastest run and the shortest total time consumed for all runs is used as the scoring value.

Nowadays, the micromouse robots are smaller, lighter, and faster, and they can precise 90 degrees turn smoothly. It is because of the maze robot criterion was lightweight and small in size since it has the crucial task to perform such as the square of turning path. The small robot size is preferable because robot needs space to move smoothly. This robot is moving by itself in the maze, autonomously. The movement of the robot is not controlled manually, it basically depends on algorithm programming. The parts of components for a micromouse include a chassis, wheels, motors and motor drivers, distance or wall sensors, microcontrollers, and batteries. As for electronic components, it used the microcontroller, motors, digital compass, and distance or wall sensors to develop the robot. While for the mechanical parts, the wheel and motor encoder units to support the robot movement and speed, which are also the parts of the motor drive system of the robot. Thus, it can be seen that sensors and motors were the main components because both of the components need to work together in the programming of the robot. The micromouse robot can be seen as a compact system involving many interdisciplinary design challenges and requires various engineering skills, that made it as ‘an international phenomenon’ competition among engineering students especially. Figure 1.2 below shows one of the examples of the maze robot used in the competition.

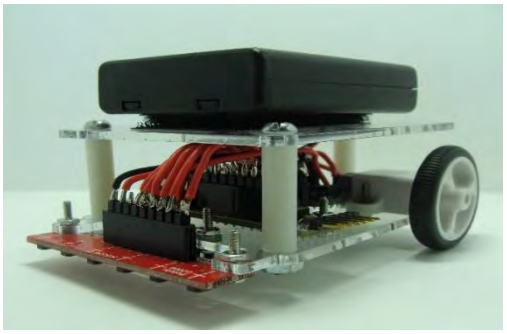

Figure 1.2 Micromouse robot

## 1.2 Problem Statement

For a few decades until today, the micromouse robot challenges can be seen as ‘an international phenomenon’ competition especially among engineering students. Micromouse robot that is a maze solving robot plays a very vital role in solving the maze and offers a variety of engineering skills. Basically, the robot should be able to find the center of the maze with the shortest possible path. However, most of the micromouse robots are still having the problem in solving the maze.

This project comes with several problems which are on electronic parts requirement, mechanical design and development, and programming of the robot. The challenges of electronic parts are the importance of component output pin and input pin declaration whether it is positive or negative, analog or digital pin along with the choosing component itself. Besides, both distance sensors of infrared and ultrasonic sensors have their own advantages and disadvantages as the distance and obstacle detection sensor. Both type of the sensors, complement each other that it is difficult to choose only one of them as the distance sensor. In mechanical design development, all of the components which are batteries, sensors, motors, wheels and microcontroller need to be arranged wisely, especially for the distance sensors. Since the distance sensor is the most sensitive input, the design position need to always in check. Furthermore, the robot structure must be light because the high speed of motor was used since the light structure will cause less torque used in order to move the robot. Figure 1.3 below shows the maze solving robot in a maze.

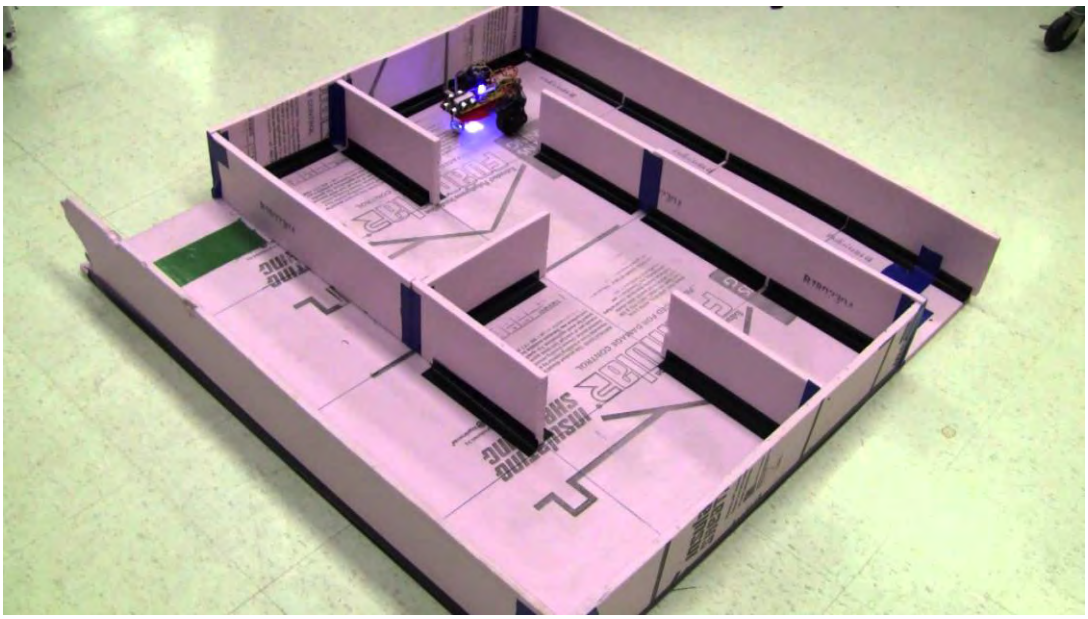

Figure 1.3 Maze solving robot in a maze

The robot also has a problem in the programming of the robot movement and path planning (algorithm). Since the robot movement is the most crucial part, so the problem in the robot movement has to be solved first. Then the program of the robot to making a turning within 90 degrees and 180 degrees should be right in order to accomplish the task. If the program used is not right, then the robot will easily crash the wall. Furthermore, if the battery is in low voltage, the robot also will have a difficulty in making a turning. For the robot path planning method, the most efficient algorithm will be chosen. The paths will have a starting and ending points. The problem is, the point of starting position and its end needs to be clarified according to the design or maze task, along with a lot of trials using different algorithm also need to be implemented which consumes a lot of time in order to have the best path planning. The most likely issue is that so far there has also been only a few research on the shortest path maze solving robot.

In order to overcome those problems, the datasheet of every component was referred, strictly manage the sensor position without doubtful, scheduling the usage of battery, and lastly, strictly decide the starting and ending position of the maze design along with always refer to previous related research articles.

## 1.3 Description of prototype

a) Autonomous mobile robot

Controlling the robot path movement is depends on the algorithm so it does not need to be controlled manually. The other mobile robots usually require a controller to handle the robot movement. Autonomous robots usually capable of performing tasks in the real life situation by themselves, without the need of human control.

b) Maze solving robot

The maze solving robot is not a line follower robot. Instead of following the line to move, it detects the distance from the wall of the maze as the input data to keep their movement to solve the maze.

## 1.4 Objectives of Research

Maze solving robot is actually an autonomous mobile robot that employs most technical and coding skills in the engineering point of view. As the way of the maze solver robot are not manually controlled and only depends on algorithm path planning, it serves as a better learning platform as it could help in enhance skills and knowledge, especially in the engineering field. In this project, the project aims to meet the following objectives:

a) To design and develop an autonomous maze solver mobile robot.

b) To verify the algorithm of the autonomous maze solver mobile robot.

c) To analyze the movement of the maze solver mobile robot.

## 1.5 Scope of Research

A few guidelines are proposed to ensure that the project will achieve the objectives by narrowing the needs for this project. These are the scopes covered in this project to solve the maze:

a) Using a 4x6 maze track; each cell is 18cm square.

b) Using Left Walll Following algorithm as the path finding method to achieve the objective of this project, to find the shortest path possible to solve the maze.

c) Maze solving robot size is estimated about 12 centimetre width.

d) Using Arduino Uno board for interfacing between all of the components and the chosen path planning algorithm method.

e) Comparing between ultrasonic and infrared sensor as the input devices for robot movement.

f) It is for indoor activity with normal room temperature and light intensity.

## 1.6 Thesis Outline

The structure and layout of the thesis are as follow:

Chapter 1 – Introduction: This chapter briefly explains about the introduction which cover the objectives, scopes of the project and the problem statements.

Chapter 2 – Literature Review: This chapter describes what is Maze Solver Mobile Robot by using Arduino and the existing project with different path planning algorithm which have been developed by the previous researchers. It also consists of the information which will be the parameter for the developing this project.

Chapter 3 – Methodology: This chapter explains about the methodology of this project, which describe details about the method used for developing this project and also approach taken in order to complete the project.

Chapter 4 – Expectation Result: This chapter will consider about the expectation result of the robot to solve the designed maze task.

Chapter 5 – Conclusion and Recommendations: This chapter will conclude about the entire project and future expectations that can be done for the future project improvement.

# CHAPTER2
# LITERATURE REVIEW

This chapter is a review about the journal and article of the related information to the robot for solving maze project. Besides, it contains the description of product that has been developed by certain party, especially students, as a guide and reference of creating the robot. It is focused on design, algorithm, components and sensor of the robot.

## 2.1 Mobile Robot for Solving Maze Design

The micromouse is an autonomous vehicle whose goal is to find the center of a maze. Basically, the robot has to search from the start cell to the destination cell as the goal in an unknown maze, using the shortest path. The goal is fixed in the center for classic contests (16×16), and can be at any area in the maze for the new larger maze (32×32). The maze solving maze task is becoming more complex since an arbitrary goal area and smaller maze cell dimensions is introduced when the larger maze size is adopted. The original Micromouse contest, in which autonomous robots compete in terms of speed and intelligence, were started more than 30 years ago. The official IEEE Micromouse Competitions began in 1987 at the World Micromouse Competition, where David Otten of MIT captured first and second place with his MITEE Mouse. This competition used a new scoring system design to reward intelligence, efficiency, and self reliance. Micromouse competitions have become a popular event among engineering students and engineers. Because the robots' performance is still improving, these contests are still very popular with engineering students in the U.K., US, Singapore, Japan,and Taiwan.

Reviews of research on Mightymouse, An Autonomous Maze Solving Robot have discovered the maze solver robot and describe knowledgeable information of the robot (Ridge, Sanjeev, Peter, & Jason, 2005). The primary objective of the project is to build an autonomous mobile robot, a micromouse, that able to navigate to the center of a maze. A 16 by 16 cell maze, is to be explored for some time and the robot will make its attempt. The design method of the MightyMouse project consisted of two stages. The first stage was to design and construct individual components. The second stage of the design process was to interface the components to form the final prototype. Secondly, the robot is designed based on IEEE Micromouse Competition criterions and specifications and also the maze itself is built in accordance with IEEE specifications. Both of the objectives are assigned to solve the maze in less than ten minutes, and implementing both a mapping mode and speed run mode. Figure 2.1 below shows the MightyMouse robot project.

Figure 2.1 MightyMouse robot

Arkib, Ahmad, and Sathya (2016) identified an achievement made a shortest distance maze solving robot. The goal is to build an autonomous mobile robot, as shown in Figure 2.2, which is able to solve any given maze in multi direction and accordingly traversed by all the way it finds the shortest possible distant path. Then,