Department of Electronic and Telecommunication Engineering

University of Moratuwa

EN 1093 – Laboratory Practice I

Project Report

Line Following Robot

Name	**Index No.**
Abeywardena K.G.	160005C
Adheesha K.G.	160009R
Alagiyawanna A.M.A.I.S.	160017N
Aluvihare A.A.J.M.T.C.	160019X

Supervisor: Ms. Hasantha Malavipathirana

This is submitted as a partial fulfillment for the module
EN1093: Laboratory Practice I
Department of Electronic and Telecommunication Engineering
University of Moratuwa

5th February 2018

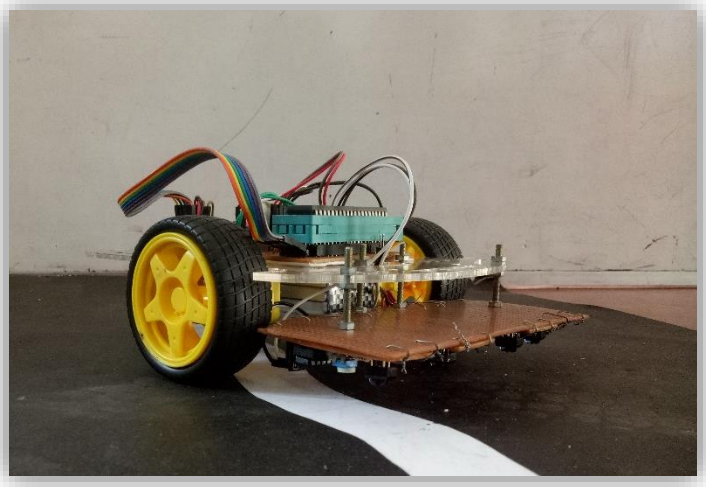
ABSTRACT

The objective of the project is to design and build a robot, which can follow a white path on a black arena, detecting and extinguishing the correct path at a ‘Y’ junction. The given arena consists of a starting point, two destination points including the goal destination, 1 ‘Y’ junction and a ramp with a 15 degree inclination.

The robot is designed using 16F877A microcontroller and Mikro C Pro is used to program the robot. Proteus 8.0 and Orcad Layout software are used to design and simulate the circuits including the main circuit, motor controller circuit, sensor unit and the power supply circuit. It is a sensor based system in which 4 separate sensor units consisting of 4 TCRT 5000 phototransistor sensors are used.

Sensing the white line on the black surface and maneuvering the robot to stay on course amidst constantly amending the wrong moves using feedback mechanism is a simple but effective closed loop system. In addition, it needs to identify the white square near the junction to take the decision as to which path it needs to take. To achieve this, as mentioned earlier, 4 line follower sensors are used in the front of the robot as an array. The same line follower sensors are used to detect the junction.

Table of Contents

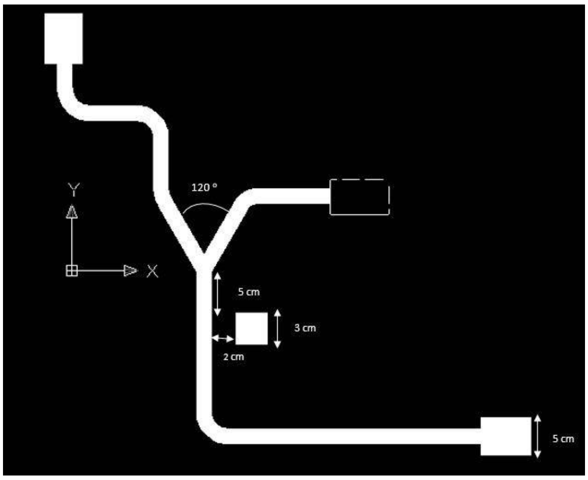


1.0 Introduction

Robotics is a developing and useful field in the present world. Micro controllers which are like small computers with a memory and a processor, play a primary role in robotics. In this project a simple robot is designed using micro controllers to navigate on a specified arena following lines, then detect and extinguish the correct path to be taken at the junction and arrive at the goal destination.

The robot should comply with the following specification

1.1 Arena Specification



- Width of the white track = 30mm
- Inclination of the ramp = 15 degrees
- Square is 30mm x 30mm and has a 20 mm clearance from the path. Mark will be 50mm before the junction

1.2 Robot specifications

- Only one robot is allowed per participating team. The robot cannot separate during the operation.
- Maximum dimensions of the robot are 250mm × 250mm × 250mm.
- There is no weight requirements for the robot
- The robot must be battery powered. (Powered onboard. No external power supply will be allowed.)
- The robot must follow lines in order to navigate on the arena.
- The robot must be completely autonomous
- Need a switch on the robot to start when it is asked

1.3 Scientific Literature

When we started our project, we had not done any robotics or anything on programming microcontrollers. First we started practicing coding using Mikro C and we got familiarized in designing circuits and simulating them using Proteus. Further, we studied about microcontrollers and designed simple circuits and simulated which uses microcontrollers.

Then, we referred some line follower robot projects and got familiar with PID code. We also studied the application of phototransistor sensors and the projects using those sensors.

We sought knowledge of motor controller circuits and different motor controller ICs like L293D and L298D.

In addition we referred the data sheets of 16F877A and L293D to identify its pins and what their tasks.

Micro controllers

This is the most popular controlling system due to its low cost, simple power requirements and the ability to be programmed using simple software a simple hardware interface. Once programmed the micro controller acts like a mini-computer. As this project doesn't require high memory capacity, we have used the PIC 16F877A, an 8 bit microcontroller.

Line follower sensor

The line follower sensors are capable of distinguishing black and white according to their reflectance, hence providing the robot the capability to navigate through lines. Here the output node is charged and the time taken for the output voltage due to integrated photo transistor is measured. Shorter decay time indicates greater reflection. For this project, we used TCRT 5000 phototransistors.

Motor Controller

The motor controller controls the motors according to the inputs given from the micro controller. It consists Op-Amps and can be used to vary the speeds of the motors by changing the duty cycle of the motor voltage using the enable pins. For this project we used the L293D motor controller.

2.0 Method

2.1 List of components used

The list of components used is subcategorized into the following categories.

2.1.1 Motor Controller Circuit

The Motor Controller Circuit consist the following components.

- 1- L293D motor controller IC
    - Main Integrated Circuit (IC) used for the purpose of controlling the speed of motors
- Male headers
    - Used to connect the jumpers to the microcontroller and to the motors
- Jumpers

2.1.2 Main Circuit

The Main Circuit consists the following components.

- 1- PIC 16F877A Micro Controller
- Female headers
    - These are used to connect the jumpers coming into the Micro Controller from the four sensors and from the Power Circuit.
- Male headers
    - These are used to connect the jumpers going out from the Micro Controller to the Motor Controller Circuit.
- 1- 8MHz crystal
    - The external clock used by the Micro Controller
- 2- 22pF capacitors

2.1.3 Sensor Panel

The sensor panel consist of 4 individual sensor units which senses the white line on the black arena.

- 4-TCRT 5000 phototransistor sensors
- 4-LM324N comparators
    - These are used to compare the output voltage of the phototransistors against a fixed voltage and output 5V or 0V corresponding to the digital 1 and 0

- 4- 4.7k variable resistors
    - Used to achieve the fix voltage that is needed to compare the analog output of the phototransistors
- 4-150 Ohms resistors
- 4-10k resistors

2.1.4 Power Circuit

The Power Circuit is the circuit which regulates the input voltage into 5V and distribute it to the other circuits. It consists the following components.

- 1-7805 voltage regulator with a heat sink
    - This is used to regulate 11.4V input into 5V output with a maximum current rating of one Ampere. Since it dissipates approximately 6W ((11.4-5)*1 W), we used a heat sink.
- 1-1N4002 diode
- Electrolytic Capacitors

    1 – 10uF

    1 – 1uF
- Barrel Connector
    - Used to connect the Lithium Polymer (LIPO) Battery to the Power Circuit

2.1.5 Other components and equipment used

Apart from the above mentioned components used for individual circuits used for the robot, the following were used as well.

- Proto-Boards
    - Used to test the circuits we designed prior to making the actual Printed Circuit Boards (PCB)
- Multi-meter
- Soldering iron, solder wires, sucker
    - Used for the purpose of soldering the components onto the PCBs printed
- Copper plates
- $FeCl_3$, Thinner
- 11.4V 3-cell LIPO Battery

2.2 Approach

When designing the robot, mainly two aspects needed to be looked at: the hardware and the software. A summary is being illustrated in Figure 2.1

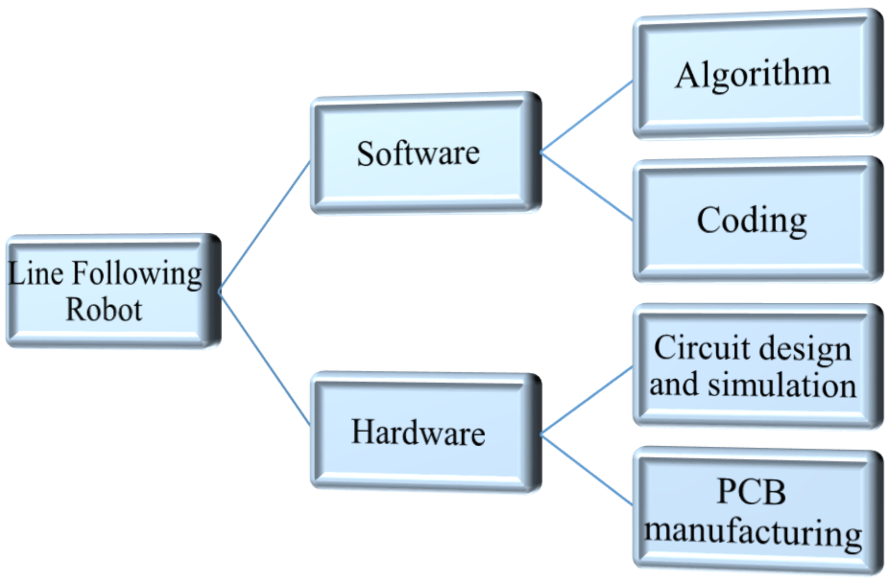


Figure 2.1: Approach

2.3 Steps of the project

Figure 2.2 illustrates the main steps we followed when designing the robot.

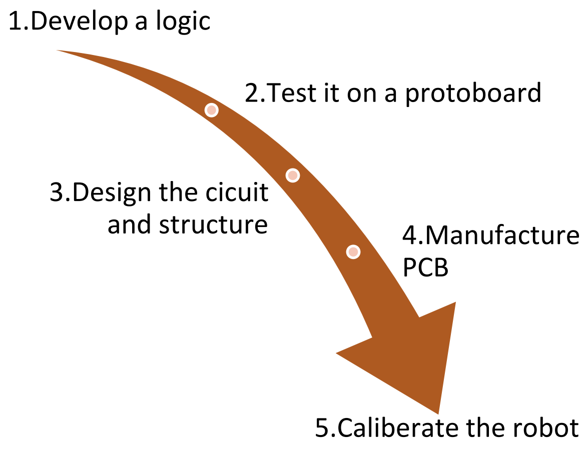


Figure 2.2: Steps of the project

2.4 Logic

The Figure 2.3 illustrates the logic behind the development of code to achieve the given task.

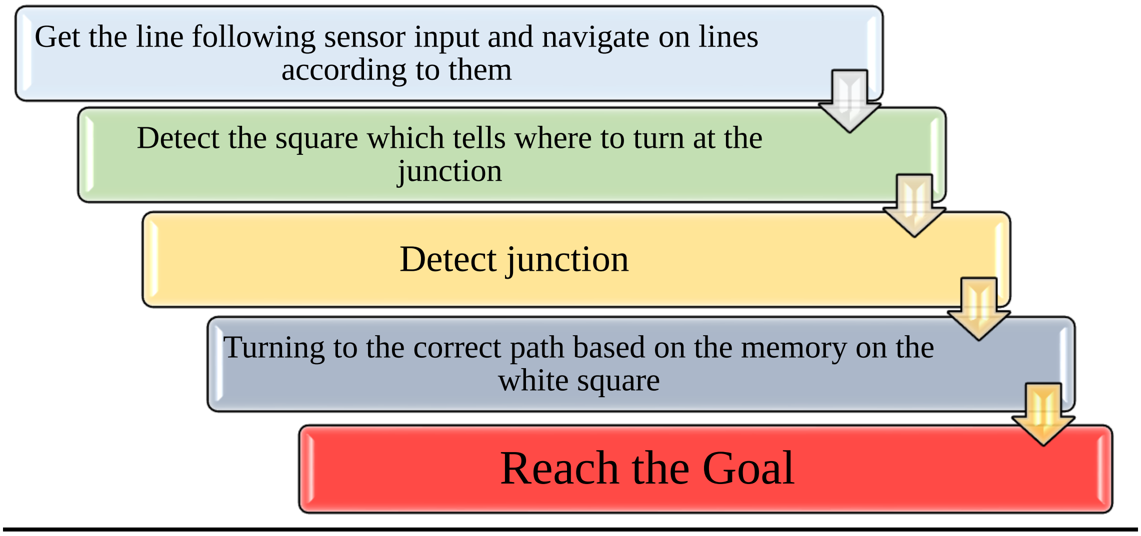


Figure 2.3: Logic

2.5 Main parts of the code

The Figure 2.4 illustrates the main parts in the code we developed for the given task based on the above mentioned logic.

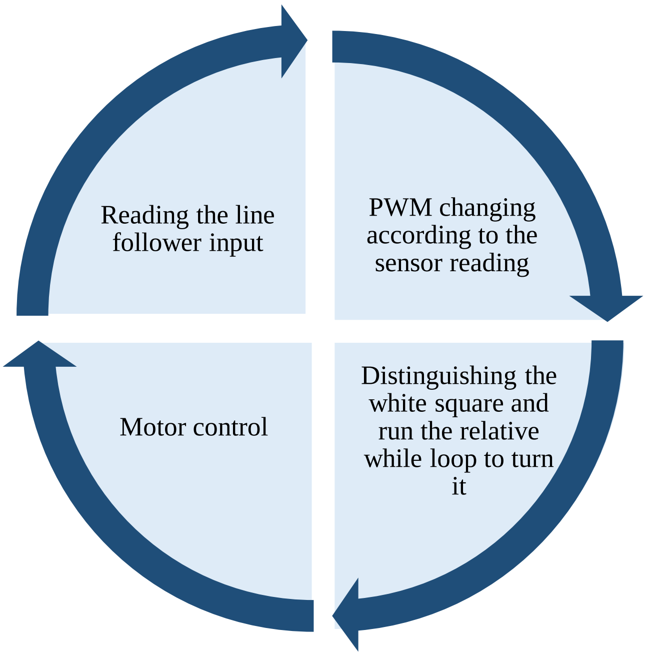
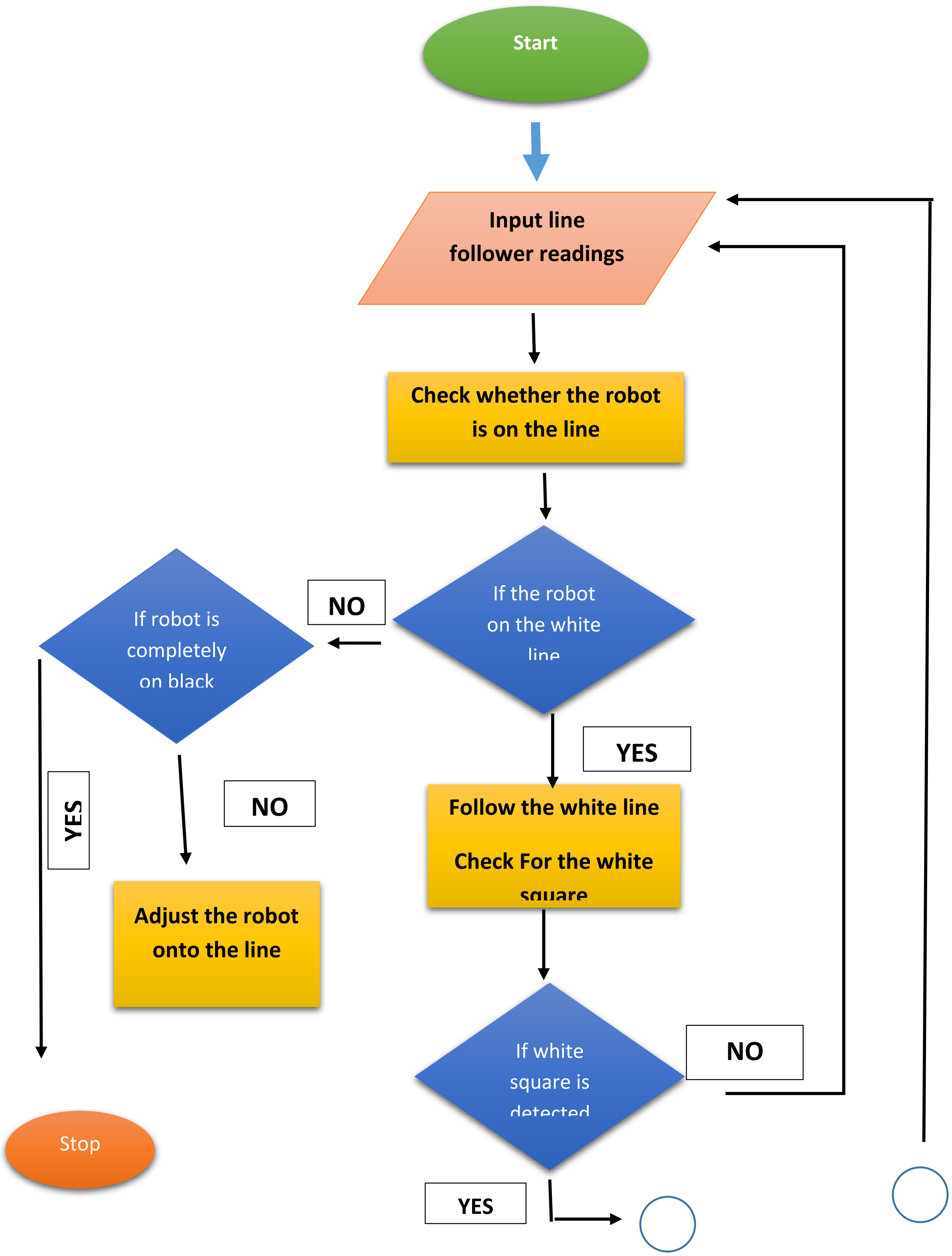


Figure 2.4: Main parts of the code

2.6 Algorithm

The Figure 2.5 illustrates the algorithm developed prior to coding it using MiKro C



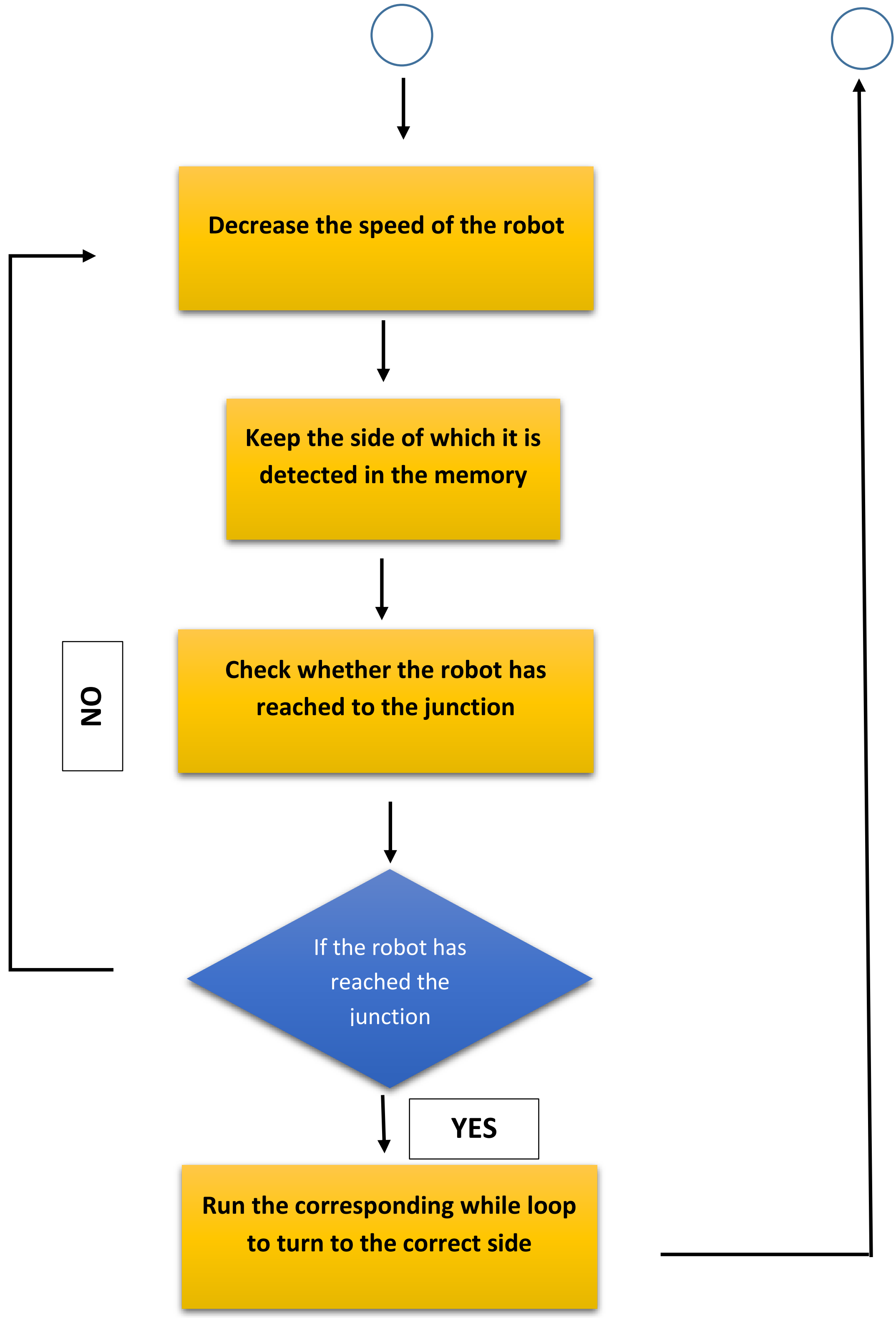


Figure 2.5: Algorithm

3.0 Results

The test runs are done using two arenas;

a.) A black arena with a straight white line
b.) A black arena designed based on the given specifications

The arena (a.) is used to calibrate the robot and its sensors to first follow a white track on a black arena.
The arena (b.) is used to run the tests prior to the competition to calculate the total times taken to complete the task as well as to test whether the logic required to identify the correct path at the junction works.

3.1 Success of following a straight white line

The robot is first calibrated using the arena described in (a.) to follow a white line on the black arena.

Table 3.1: Test Results of Following a straight white line

Trial number	**Successful/ Unsuccessful**
1	Unsuccessful
2	Successful
3	Unsuccessful
4	Unsuccessful
5	Successful
6	Successful
7	Unsuccessful
8	Successful
9	Successful
10	Successful

Average successions of following a straight white line = **60%**

3.2 Success of identifying the correct path at the Junction

The robot is then tested for detecting the square and extinguishing the correct path at the junction.

Table 3.2: Test Results of detecting the correct path at the Junction

Trial number	**Successful/Unsuccessful**
1	Unsuccessful
2	Unsuccessful
3	Unsuccessful
4	Successful
5	Unsuccessful
6	Unsuccessful
7	Successful
8	Successful
9	Successful
10	Successful

Accuracy of identifying the correct path at the junction= **50%**

3.3 Average time taken to complete the task

Time was measured for one round from the starting point to ending pointing disregarding whether the robot didn't follow the line

Table 3.3: Average time taken to complete the task

Trial number	Time taken (seconds)
1	36
2	35
3	33
4	32
5	30

Average time taken = **33.2s**

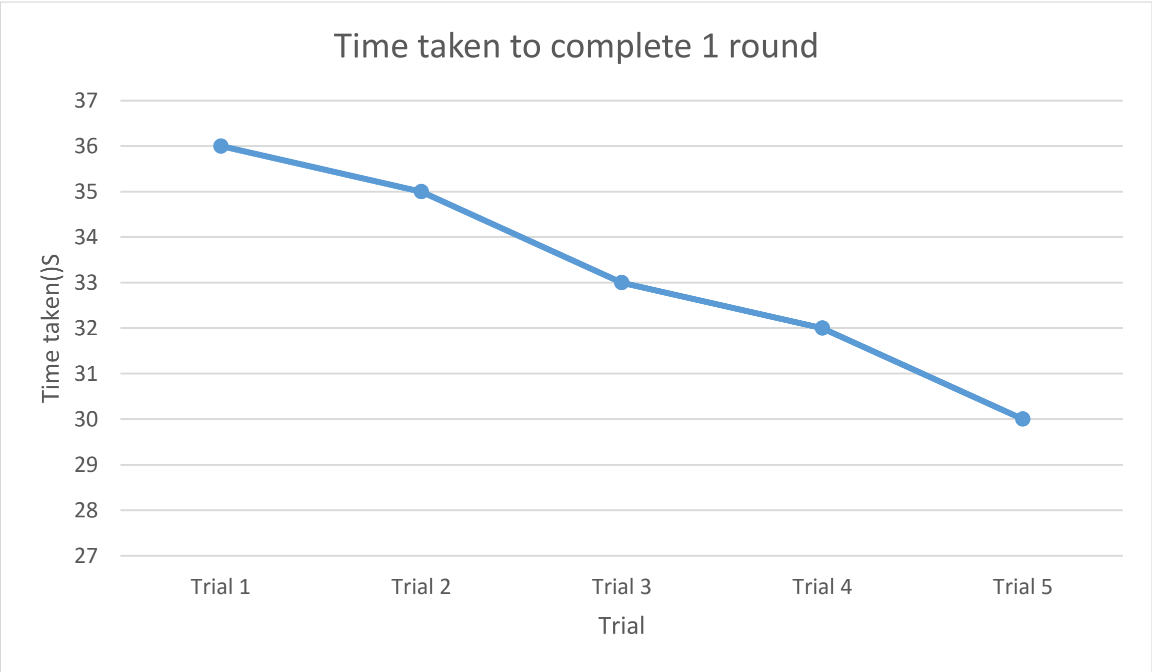


Figure 3.1: Time taken to complete 1 round

4.0 Discussion

As beginners for the robot designing, we had to face many problems while doing this project. We learnt everything from basics: simulating circuits using Proteus, Mikro c and hardware designing.

Sense-Plan-Act architecture (SPA) has been used to design this project and the vision system is sensor based. 3 separate Printed Circuit Boards (PCB) were designed for the motor controller circuit, pic circuit and for the power supply circuit for the easiness.

The problems we faced while carrying on the project are listed below.

- When simulating the code first on Proteus, we had issues with Pulse Width Modulation(PWM) not working properly hence we had to alter the code several times
- When the robot was tested for its functionality using Bread boards, we ran into issues with the batteries as the voltage dropped drastically during the test runs hence the motors didn't move.
- After the manufacturing of PCBs and soldering the components, there were several issues we faced. .
- After the PCBs were assembled, the code did not work as we expected. Hence we had to drop certain plans like using Proportional-Integration-Differential (PID) Control System along with PWM to navigate and control the robot.
- During the test runs, the robot didn't follow even a straight line.

The causes we have identified for these problems are listed below.

- Since the Lithium ion batteries we used were used previously, their life time has expired hence the voltage drops drastically during the run.
- There were some loose connections, bad soldering, paths being disconnected due to some reasons in the PCBs.
- The torque of the DC motors we used was high hence the speed variations cannot be done in a vast range of PWM.
- The distances between the sensors were to be adjusted and the resistance of the variable resistors needed to be varied.

These issues and causes we identified were rectified by having multiple test runs. Some PCBs (sensor unit) had to be remade due to some functional issues we faced of the sensors.

5.0 Acknowledgement

The completion of this line following robot was not an easy task for us. We were novices to all the concepts of robotics and we faced a lot of challenges since this is our first robotics project. There are many personnel behind the accomplishment of this project.

First we would like to pay our gratitude to our supervisor Ms.Hasantha Malavipathirana who always encouraged self-studying and guided us whenever we needed help. The weekly meetings held by our supervisor were very helpful to clear our doubts and discuss issues regarding robot.

In addition, we would like to convey our sincere gratitude to all the lecturers and instructors who were always willing to share their knowledge with us.

We are thankful to all the personal in-charge of laboratories and workshop for allowing us to use the instruments and laboratories and also for helping us in technical problems.

It is our duty to thank our ENTC family, without whom we could not have accomplished this project. Everyone in our batch helped each other and learnt everything together.

We developed team spirit working together in this project for about 2 months and all our group members gave their maximum contribution to succeed the given project.

Further, we would like to thank all the people who are not mentioned here for the great support provided.

6.0 Bibliography

[1] Competition Rules and guidelines- sent by Ms. .Hasantha Malavipathirana on 03/10/2017

[2] www.mikroe.com

[3] http://www.theengineeringprojects.com/2013/03/a-complete-tutorial-on-how-to-use-proteus-isis-ares.html

[4] https://www.newbiehack.com/MicrocontrollerTutorial.aspx

[5] https://electrosome.com/category/tutorials/pic-microcontroller/mikroc/

[6] http://playwithrobots.com/simple-line-follower-robot/

[7] www.micropik.com › PDF › HCSR04

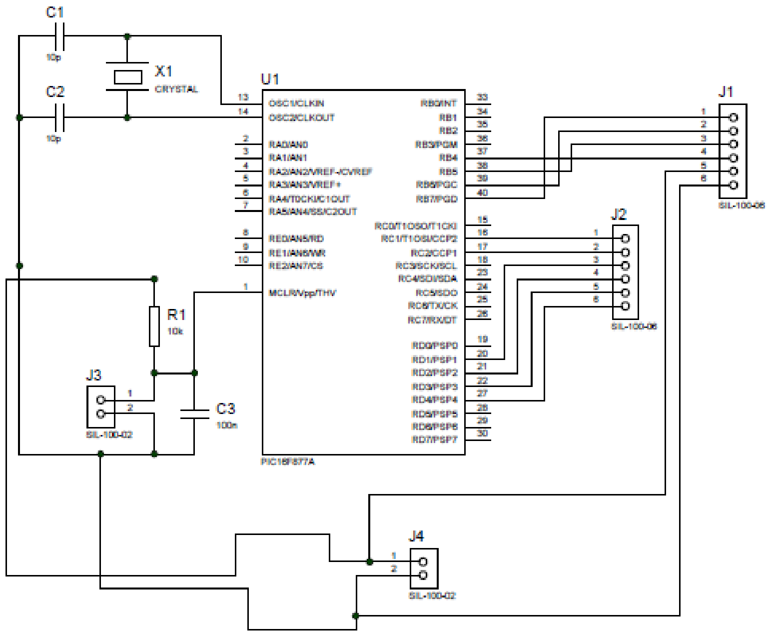
[8] http://diyhacking.com/make-line-follower-10-minutes/

[9] http://www.rakeshmondal.info/L293D-Motor-Driver

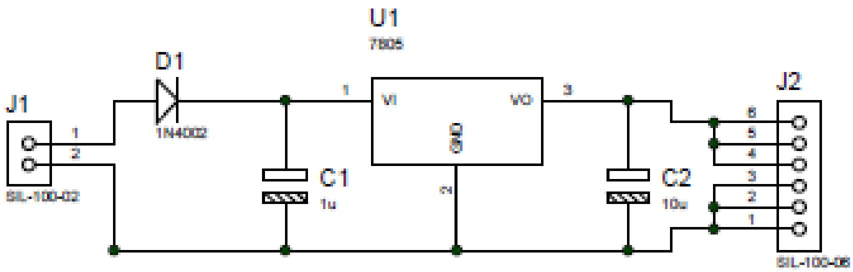
[10] http://forum.allaboutcircuits.com/threads/detecting-a-candle-flame.117300/

7. 0 Appendix

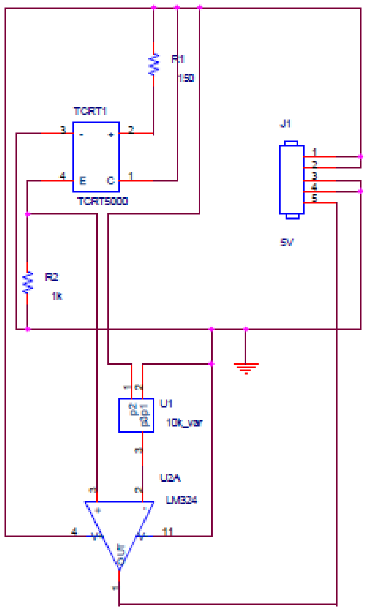
7.1 Appendix 01 – The main circuit diagram



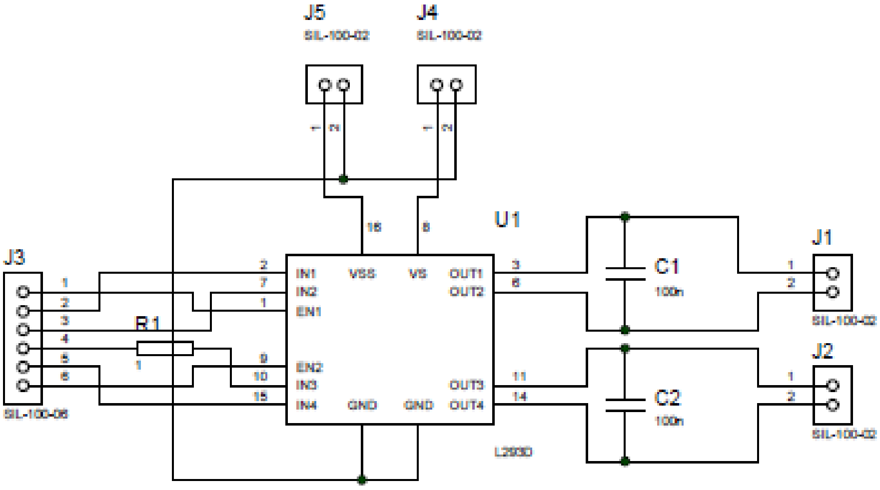
7.2 Appendix 02 – The power supply circuit diagram



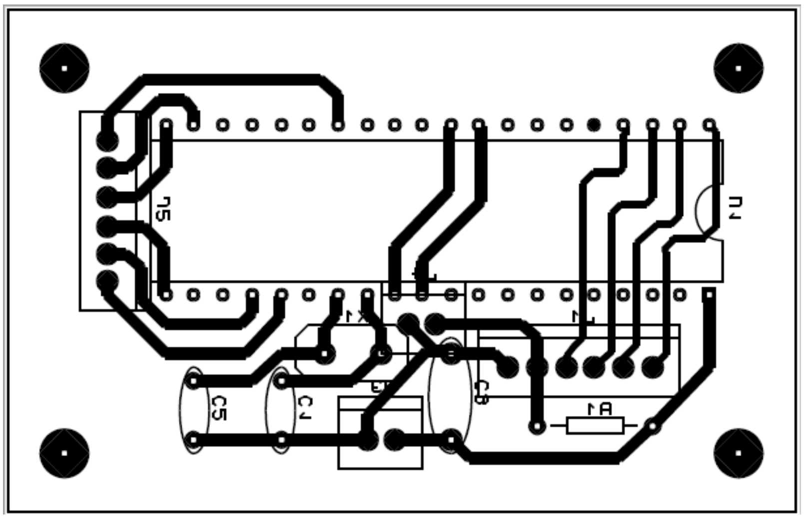
7.3 Appendix 03 – The sensor unit



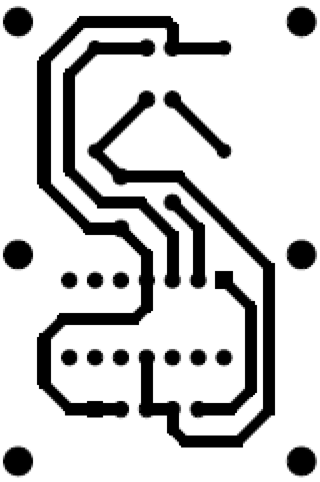
7.4 Appendix 04 – Motor Controller circuit



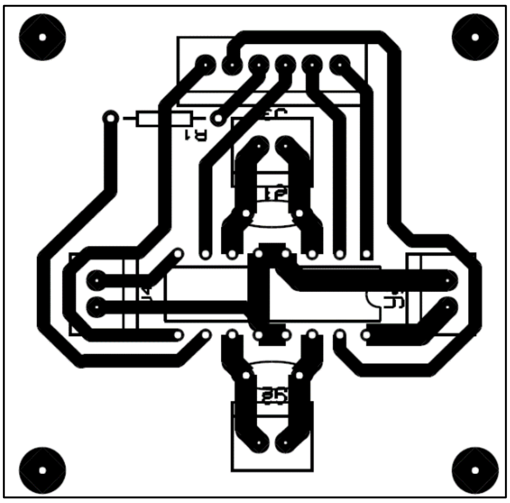
7.5 Appendix 05 – Main circuit PCB layout



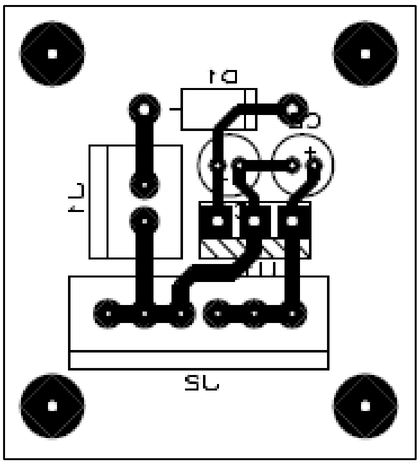
7.6 Appendix 06 – Sensor unit PCB Layout



7.7 Appendix 07 – Motor Controller PCB layout



7.8 Appendix 08 – Power supply PCB Layout



7.9 Appendix 09 – 16F877A PIC code

```
#define sensors TRISB
 #define s1 PORTB.F7
 #define s2 PORTB.F6
 #define s3 PORTB.F5
 #define s4 PORTB.F4

#define motors TRISD
 #define M_R_F PORTD.F1
 #define M_R_B PORTD.F2
 #define M_L_F PORTD.F3
 #define M_L_B PORTD.F4


void forward () {
PWM1_Set_Duty (220);
PWM2_Set_Duty (220) ;}


void forwardd (){
PWM1_Set_Duty (200);
PWM2_Set_Duty (200) ;}

void right(){
PWM1_Set_Duty (50);
PWM2_Set_Duty (220) ;}

void rightt(){
PWM1_Set_Duty (100);
PWM2_Set_Duty(220) ;}

void left(){
PWM1_Set_Duty(220);
PWM2_Set_Duty(50) ;}

void leftt(){
PWM1_Set_Duty(220);
PWM2_Set_Duty(100) ;}

void stop(){
PWM1_Set_Duty(0);
PWM2_Set_Duty(0) ;}

void main() {
TRISD=0x00;
TRISC=0x00;
TRISB=0xFF;
PORTD=0; PORTB=0; PORTC=0;
PWM1_Init (5000);
PWM2_Init (5000);
```

```
PWM1_Start ();
PWM2_Start ();
PWM1_Set_Duty (0);
PWM2_Set_Duty (0);
M_R_F=1;
M_R_B=0;
M_L_F=1;
M_L_B=0;

while (1) {

if ((s3==1) &&(s2==1)){
stop () ;}

else {

if ((s4==1)&&(s3==0)&&(s2==0)){

while (1){

if ((s3==0) &&(s2==0)){
forwardd () ;}

else if ((s3==0)&&(s2==1)){
left () ;}

else if ((s3==1)&&(s2==0)){
right() ;}

else if ((s3==1)&&(s2==1)) {

while (1){
if ((s3==0)&&(s2==0)){
break ;}

else{
leftt() ;}
}

break ;}
}
}

else if ((s1==1)&&(s3==0)&&(s2==0)){

while (1){

if ((s3==0)&&(s2==0)){
forward () ;}
```

```
else if ((s3==0)&&(s2==1)){
left() ;}

else if ((s3==1)&&(s2==0)){
right() ;}

else if ((s3==1)&&(s2==1)){

while (1){

if ((s3==0)&&(s2==0)){
break ;}

else{
rightt() ;}
}
break ;}
}
}

else {
if ((PORTB.F5==0)&&(PORTB.F6==0)){
forward() ;}

else if ((s3==0)&&(s2==1)){
left () ;}

else if ((s3==1)&&(s2==0)){
right () ;}

else {
stop () ;}
}
}
}
}
```