Robocars for Shortest Track Finding and Transmitting

Ismat Ara

ID: 2014–1–60–002

Md Ibrahim Sumon

ID: 2014–1–60–063

Md. Saidur Rahman

ID: 2014–1–60–067

A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

Department of Computer Science and Engineering
East West University
Dhaka-1212, Bangladesh

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the investigation performed by us under the supervision of Dr. Md. Shamim Akhter, Associate Professor, Department of Computer Science and Engineering, East West University. We also declare that no part of this thesis/project has been or is being submitted elsewhere for the award of any degree or diploma.

Signature

. . . .
(Ismat Ara)
(2014-1-60-002)

Signature

. . . .
(Md Ibrahim Sumon)
(2014-1-60-063)

Signature

. . . .
(Md Saidur Rahman)
(2014-1-60-067)

Letter of Acceptation

This Thesis project entitled “Robocars for shortest track finding and transmitting” submitted by Ismat Ara (Id:2014-1-60-002), Md. Ibrahim Sumon (Id:2014-1-60-063) and Md. Saidur Rahman (Id:2014-1-60-067) to the Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh is accepted by the department in partial fulfillment of requirements for the award of the Degree of Bachelor of Science and Engineering on August 2018.

Supervisor

…………………………….

(Dr. Md. Shamim Akhter)

Associate Professor, Department of Computer Science and Engineering

East West University

Chairperson

…………………………….

(Dr. Ahmed Wasif Reza)

Chairperson and Associate Professor

Department of Computer Science and Engineering

East West University, Dhaka, Bangladesh

Abstract

Robocars can reduce human efforts in packet routing management problems in many industries including airport and postal packet services. Large airports and postal departments need many such Robocars to carry their packet properly. Central server-based system can be used to monitor or suggests optimum paths to the Robocars from source to destination. However, central system damage will crash or fail the whole system. The problem even becomes more challenging when the Robocars are autonomously carry information and suggest others the optimum path to choose the destination from their own experience. We built two (2) such Robocars, those are capable to find shortest track and transmit the path to other Robocar. Our Robocars apply optimum and shortest path by applying shortest path algorithm. We fixed seven (7) different paths in a maze of a Robocar. The Robocar traverses all seven (7) paths and then find an optimum path among them (lower cost) to reach from source to destination. After reaching destination, it transmits his experience (the shortest path) to its neighbor Robocars. Other Robocars will follow the given direction to reach the destination. Our Robocars are implemented in a static 4x4 maze environment and communicate themselves using Bluetooth technology, and successfully traverse source to destination using optimum path.

Acknowledgments

First of all, we would like to thank Almighty Allah for giving us strength, patience, and knowledge to complete this thesis work.

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Ismat Ara
September, 2018

Md Ibrahim Sumon
September, 2018

Md Saidur Rahman
September, 2018

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Chapter 1

Introduction

We live in the age of the modern era. In this era, people are busy with their works and they need to travel/visit lots of places due to the communication or recreation purposes. Transportation system plays an important role at this point. Thus, numbers of vehicles are increasing day by day and that proportionally affects the road traffic weights and creates traffic jam recurrently.

When people want to discover an unfamiliar place, they need to find out the shorter, cheaper and comfortable way to reach there. Asking Google maps or familiar people is helpful in this regards. Particularly, Google map user has some limitations as they cannot connect with map without internet. Thus, offline people are to know the situation or status of a roads or transportations. Besides, the accuracy of the Google map is not always good, as it gives information about the optimal way by the direction of the main roads only, sub-main roads are not considered.

In many industries including airport and postal services, usually human labors carry packets physically. Costing of labors is getting higher and higher in days. In addition, it becomes very complex to transport or to route the packets efficiently and timely for the big airports or postal departments. Robotics can help in this regards to build some Robocars as packet transporter.

Robocars can reduce human efforts in packet routing. However, many cars need to choose the optimum paths from source to destination. Central server can be used to monitor their paths and suggests the optimum way to transport or route the packet from source to destination. The problem becomes more challenging when the Robocars are autonomously carry information and suggest others the optimum path to choose the destination from their own experience. We have built Robocars for finding shortest track and transmitting the path to other Robocars. Our Robocars can find optimum or shortest path by applying shortest path algorithm. We fixed seven (7) different paths in a maze to a Robocar. The Robocar traverses all seven (7) paths and then find an optimum among them (lower cost) to reach from source to destination. After reaching destination, it transmits his experience (the shortest path) to its neighbor Robocars. Other Robocars will follow the given direction to reach the destination.

1.1 Motivation

When we knew something about robotics, we became motivated to create Robots. Moreover, in many manufacturer company Robots are used for productivity purpose. For this reason, we are highly interested to implement new Robocars which could be helpful for us.

1.2 Research Objectives

The main objective of this research is the implementation of such kind of Robocar or driverless car which can traverse some random path to reach the destination and by traversing these paths it can calculate the shortest one between source to destination and finally it will send the shortest path's signal to the other Robocar. So that other cars can easily reach the destination by using that shortest path. We divided the purpose of our research into three categories. These are

- Design and implementation Line Follower Robot
- Design and implementation Maze Solver Robot
- Design and implementation an intelligence system to find out shortest path from a 4 by 4 maze and transmit it to the other Robocar.

1.3 Scope and limitation

Our master Robocar is capable to find out the optimal path and can communicate with the other Robocar by using Bluetooth communication. So, the two cars are communicating without the help of the internet. But the limitation is that when they are out of the range of Bluetooth they will not be able to communicate.

1.4 Outline of Thesis

The rest of this thesis is organized as follows: Chapter 2 gives the background study of the work. Chapter 3 is about related work of this thesis. Chapter 4 demonstrates implementations of Robocars for shortest track finding and transmitting model. Finally, chapter 5 concludes the work and shows the outline of our future work.

Chapter 2

Background Study

2.1 What is Robocar?

A robocar (also known as an autonomous car, a driverless car, and a self-driving car) is a vehicle that can sense its environment and navigate without human input [1].
Robocar autos consolidate an assortment of systems to see their environment, including radar, laser light, GPS, odometry, and PC vision. Propelled control frameworks decipher tangible data to distinguish fitting routeways, and as well as obstacles and relevant signage.

2.1.1 A brief introduction to a robot:

A Robot is any machine which is totally programmed, i.e. it begins without anyone else, chooses its own manner of work and stops alone. It is really a reproduction of an individual, which has been intended to facilitate the human weight. It can be controlled pneumatically or utilizing water powered ways or utilizing the basic electronic control ways [2].
Any robot is built on 3 basic laws defined by the Russian Science fiction author Isaac Asimov:

- A robot should not harm the human being directly or indirectly.
- A robot should obey human orders unless and until it violates the first law.
- A robot should protect its own existence provided the 1st two laws are not violated.

Robots can be settled robots or mobile robots Mobile Robots are robots with a mobile base which makes the robot move freely in the environment. One of the advanced mobile robots is the Line Follower Robot. It is fundamentally a robot which takes a specific way or direction and chooses its own strategy which communicates with a deterrent. The way can be a dark line on the white floor (noticeable) or an attractive field (undetectable).

2.2 Line follower robot

A line follower robot is a robot which follows a certain path controlled by a feedback mechanism.

2.2.1 Building a basic line follower robot

Building a basic Line Follower Robot involves the following steps [3].

- Designing the mechanical part or the body of the robot

The mechanical part or body of the robot can be composed utilizing AutoCAD or Workspace. A fundamental Line supporter robot can comprise of a base at the two closures of which the wheels are mounted. A rectangular sheet of hard plastic can be utilized as the base. Further, an unbending body like a chamber can be included alongside other molded bodies interconnected with each other by joints, and each with its characterized movement specifically courses. The Line devotee robot can be a wheeled portable robot with a settled base, a legged versatile robot with various inflexible bodies interconnected by joints

- Defining the kinematics of the robots

The following stage includes characterizing the Kinematics of the robot. Kinematic examination of the robot includes the depiction of its movement regarding a settled arrange framework. It is concerned principally with the development of the robot and with the movement of each body if there should arise an occurrence of a legged robot. It, for the most part, includes the flow of the robot movement. The entire direction of the robot is set utilizing the Kinematic investigation. This should be possible utilizing Workspace programming.

- Designing the control of the robot

The control of the robot is the most important aspect of its working. Here the term control refers to the robot motion control, i.e. controlling the movement of the wheels. A basic line follower robot follows a certain path and the motion of the robot along this path is controlled by controlling the rotation of wheels, which are placed on the shafts of the two motors. So, the basic control is achieved by controlling the motors. The control circuitry involves the use of sensors to sense the path and the microcontroller or any other device to control the motor operation through the motor drivers, based on the sensor output.

2.2.2 Applications of line follower robot:

- Industrial Applications: These robots can be utilized as computerized gear transporters in enterprises supplanting customary transport lines.
- Automobile applications: These robots can also be used as automatic cars running on roads with embedded magnets.
- Domestic applications: These can likewise be utilized at homes for household purposes like floor cleaning and so forth.
- Guidance applications: These can be utilized as a part of open spots like shopping centers, galleries and so forth to give way direction.

2.2.3 Advantages

- Robot movement is automatic
- It is used for long distance applications
- Simplicity of building
- Fit and forget system
- Used in home, industrial automation etc.

2.3 Bluetooth Communications:

Bluetooth wireless technology is a short-range communications technology proposed to supplant the links interfacing convenient unit and keeping up large amounts of security. Bluetooth technology is based on Ad-hoc technology also known as Ad-hoc Piconets, which is a local area network with an extremely restricted scope [4].

The use of Bluetooth has generally expanded for its special features.

- Bluetooth offers a uniform structure for a wide range of devices to connect and communicate with each other.
- Bluetooth innovation has accomplished worldwide acknowledgment to such an extent that any Bluetooth empowered gadget, wherever in the world, can be associated with Bluetooth enabled devices.

- The low power utilization of Bluetooth technology and an offered range of up to ten meters has made ready for a few use models.
- Bluetooth offers intelligent meeting by setting up an ad-hoc network of laptops.
- Bluetooth use display incorporates a cordless computer, radio, cordless telephone and cell phones.

The Bluetooth wireless technology incorporates a few keys focuses that encourage it's across the board selection:

1) Bluetooth underpins both voice and information, making it a perfect technology to empower numerous sorts of devices to communicate.
2) its short-go remote capacity enables fringe gadgets to convey over a solitary air-interface, supplanting the links that utilization connectors with many shapes, sizes, and quantities of pins.
3) it is an open specification that is openly accessible and sovereignty free.
4) Bluetooth utilizes an unregulated recurrence band accessible anyplace on the world.

2.3.1 Spectrum

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, using a spread spectrum hopping, full-duplex signal at a nominal rate of 1600 hops/sec. the 2.4 GHz ISM band is available and unlicensed in most countries.

2.3.2 Range

Bluetooth operating range depends on the device. Class 1 radios are used primarily in industrial use cases have a range of 100 meters or 300 feet. Class 2 radios are most commonly found in mobile devices have a range of 10 meters or 30 feet. Class 3 radios have a range of up to 1 meter or 3 feet.

2.3.3 Data rate

Bluetooth supports 1Mbps data rate for version 1.2, 3Mbps data rate for Version 2.0 combined with Error Data Rate, up to 25 Mbps for version 3.0 and 4.0. Bluetooth 4.0 is an upgrade from Bluetooth 3.0 that includes a power-saving feature called "low-energy technology." Basically, Bluetooth 4.0 is three Bluetooth specs in one.

2.4 Dijkstra's algorithm

Dijkstra's algorithm is an algorithm we can use to find shortest distances or minimum costs depending on what is represented in a graph [5]. You're fundamentally working in reverse from the algorithm to the starting, finding the most limited leg each time. The means to this algorithm are as per the following:

Stage 1: Start at the closure vertex by checking it with a separation of 0, since it's 0 units from the end. Call this vertex your present vertex and put a hover around it showing in that capacity.
Stage 2: #Identify the greater part of the vertices that are associated with the present vertex with an edge. Figure their separation to the end by including the heaviness of the edge to the blemish on the present vertex. Stamp every one of the vertices with their comparing separation, however just change a vertex's check if it's not as much as a past check. Each time you check the beginning vertex with a stamp, monitor the way that brought about that stamp.
Stage 3: Label the present vertex as gone to by putting an X over it. Once a vertex is visited, we won't take a gander at it once more.
Stage 4: Of the vertices you simply stamped, locate the one with the littlest check and make it your present vertex. Presently, you can begin again from stage 2.
Stage 5: Once you've named the starting vertex as went by - stop. The separation of the briefest way is the characteristic of the beginning vertex, and the briefest way is the way that brought about that stamp.

2.5 Components:

It is obvious that the main concern behind building any devices is making it cost-efficient, user-friendly and reliable. So, our main choice was open source Arduino microcontroller board, Bluetooth module, Motor Driver board, Infrared radiation(IR) sensor, Voltage Regulator are used together to build the Robocars.

2.5.1 Arduino Uno R3

The Arduino Uno is a microcontroller board which is based on the ATmega328. It contains 20 digital inputs/output pins, a 16 MHz resonator, a USB connection, a power jack, an In-circuit system programming (ICSP) header and a reset button. To support the microcontroller, it contains every needed thing. The latest and revision of the Arduino UNO is R3 [6].

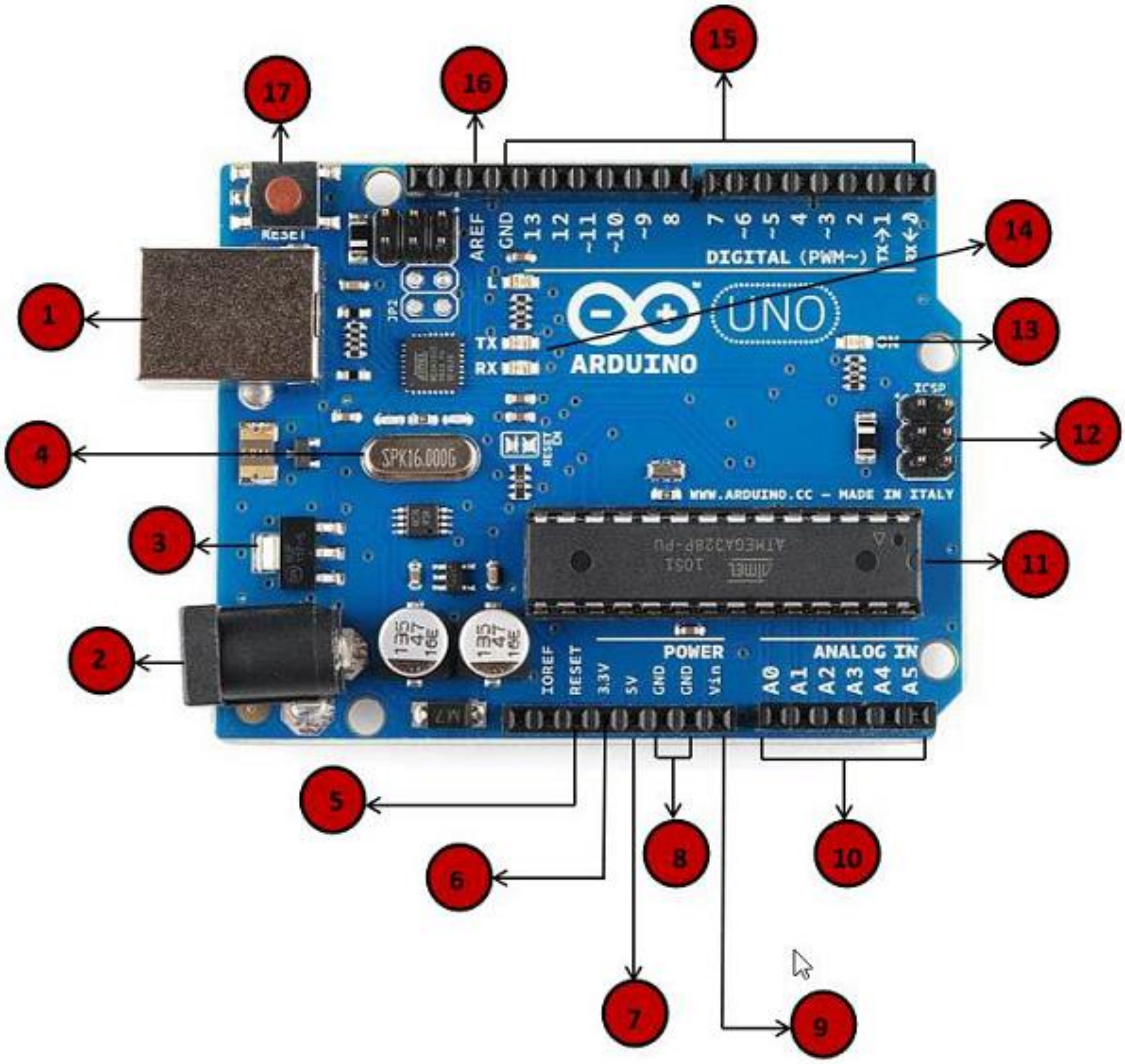

Figure 2.1: Arduino UNO R3

2.5.1.1 Description

1 Power USB: By using the USB cable from computer Arduino UNO board can be powered.

2 Power (Barrel Jack): Arduino board can directly power from the AC main power supply when it connects to the Barrel Jack (2).

3 **Voltage Regulator**: It controls the voltage which is given to the Arduino board. The processor and the other elements use the DC voltage which is also stabilized by the voltage regulator.

4 Crystal Oscillator: when Arduino is dealing with the time issues crystal oscillator helps the process. There is a question that, how does Arduino calculate time? And the answer is, With the use of the Crystal Oscillator. Number 16 is printed on the top of the Arduino crystal, 000H9H. It computes that the frequency is 16,000,000 Hertz or 16 MHz

5,17 Arduino Reset: Arduino board can be reset. The UNO board can be reset in two ways. First, we can put the reset button 17 on the board. Second, by connecting an external reset button to the Arduino pin labeled RESET (5).

6,7,8,9 Pins (3.3, 5, GND, Vin)

- 3.3V (6)- Supply 3.3 output volt
- 5V (7)- Supply 5 output volt
- Most of the components used with Arduino board works fine with 3.3 volts and 5 volts
- GND (8) (Ground)- There are several GND pins on the Arduino, any of which can be used to ground our service
- Vin (9)- This pin also can be used to power the Arduino board from an external power source, like Ac main power supply.

10 Analog Pins: The Arduino UNO board contains five analog input pins A0 to A5. These pins can read the signal from any analog sensor. It's like to connect the humidity sensor or temperature sensor into a digital value the microprocessor can read the process.

11 Main Microcontroller: Each Arduino board contains its own microcontroller (11). It can be assumed as the brain of the board. The main IC is slightly different from board to board. The microcontrollers are usually of the ATMEL Company.

12 ICSP Pin: Mostly, ICSP (12) is an AVR, there is a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is usually referred to as an SPI (Serial Peripheral Interface) which spread the output.

13 Power LED indicator: The LED indicates whether it supplies the power correctly or not. If Arduino board power up correctly the LED will light up when we plug the board.

14 TX and RX LEDs: TX (transmit) and RX (receive) is set in two places on the Arduino UNO board. The first one is at the digital pins 0 and 1, it indicates the responsible for serial communication. And the second one is at the TX and RX led (13). When the serial data is sending the speed of TX flashes will different. And the RX led flashes during the receiving process.

15 Digital I/O: The Arduino UNO board contains 14 digital I/O pins (15). From these pins 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays etc.

16 AREF: It is used to set an external reference voltage (between 0 and 5 volts0 for the analog input pins as the upper limit.

2.5.2 Bluetooth Module:

In our project, we have used two different type of Bluetooth module that is the HC-05 Bluetooth module and HC-06 Bluetooth module.

2.5.2.1 HC-05 Bluetooth module

The HC-05bluetooth module is a Bluetooth SPP (Serial Port Protocol) module which is easy to use. It is designed for transparent wireless serial connection setup. It communicates serially which makes an easy way to interface with the controller or PC. It separate master mode and slave mode by providing switching mode, that means it is not used to receive and transmit data [7].

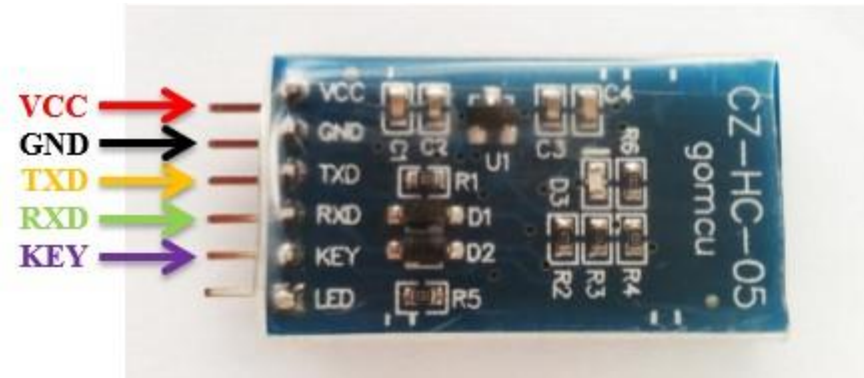

Figure 2.2: HC-05 Bluetooth module

2.5.2.1.1 Specification

- Model: HC-05
- Input Voltage: DC 5V
- Communication Method: Serial Communication
- Master and slave mode can be switched

2.5.2.1.2 Pin Definition

Enable/Key: This pin is used to toggle between Data Mode (set low) and AT command (set high). By default, it is in Data Mode.

RXD-Receiver: It receives Serial Data. Every serial data which is given to this pin will be broadcasted via Bluetooth.

TXD-Transmitter: It transmits Serial Data. Everything received via Bluetooth that will be given out by this pin as serial data.

GND-Ground: Connect to system ground.

VCC: It powers the module. Connect to the +5V supply voltage.

LED: It indicates the status of the Module.

2.5.2.2 HC-06 Bluetooth module

This Bluetooth module can use with any microcontroller. To send and receive data wirelessly it uses the UART protocol which makes the process easy. The HC-06 module is a slave only module. It can only connect to most of the phones and computers with the use of Bluetooth. But it cannot connect to other slave and only connects to such devices like keyboards and other HC-06 modules. A master module will be needed to connect with other slave devices such as the HC-05 version module which can do master and slave [8].

Figure 2.3: HC-05 Bluetooth module

2.5.2.2.1 Specification

- Model: HC-06
- Input Voltage: DC 3.3 to 6V
- Communication Method: Serial communication
- Slave Mode

2.5.2.1.2 Pin Definition

VCC: It indicates the range of 3.6V-6V. The module worked for both 3V and 5V.
GND: Ground.
TXD: Serial output of the module, to be connected to the RX of the microcontroller. This signal is using 3.3V logic levels.
RXD: Serial input of the module, to be connected to the TX of the microcontroller. This signal is using 3.3V logic levels.
STATE: Connected to LED2 (Pin32) of the module.

2.5.3 Green Board L298N Motor Driver Board

This motor driver module uses the popular integrated circuit L298N.

This circuit contains two H-bridges and each of them is capable to observe 2A current. Standard TTL logic can control the module and it works with a wide range of input voltages. For robots and another high power project, it is ideal.

This module is capable to drive 2Dc motors independently or a single 4 phase stepper motor [9].

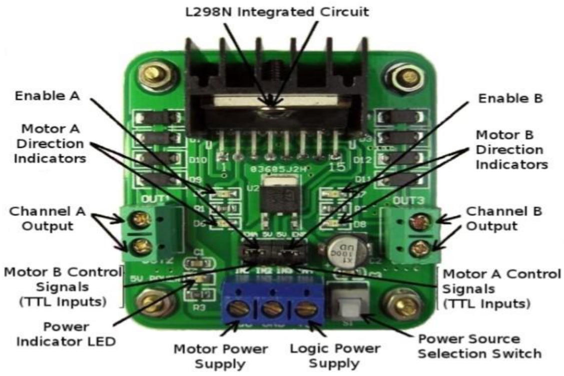

Figure 2.4: Green Board L298N Motor Driver Board

2.5.3.1 Features

- Motor power supply: 6V to 35V DC
- Output current: up to 2 A each channel
- Control logic: standard TTL logic levels
- Logic supply voltage: 5V to 7V

2.5.4 Infrared radiation(IR) Sensor:

IR sensor is consisting of an IR LED ad a photodiode, and this pair is generally called IR pair or photo couple. IR sensor works on the main point where IR LED throw IR radiation and this radiation is sensor by the photodiode. When IR radiation falling on the photodiode resistance it can change according to the amount of IR radiation. It also can change for voltage down. We can sense the change of voltage by using the voltage comparator and then generate the output accordingly [10].

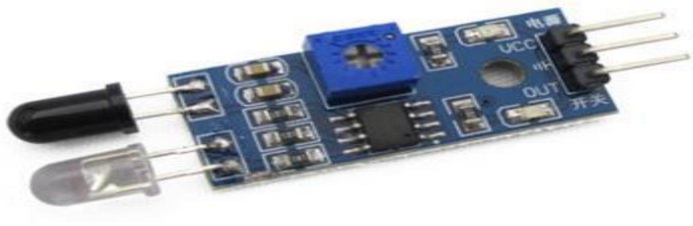

Figure 2.5: IR sensor

IR LED and photodiode are placed in two ways: Direct and Indirect. In Direct incidence, we have to set the IR LED and a photodiode in front of one another, so that IR radiation can directly fall on the photodiode. If we want to stop this process, we have to place any other object between them.

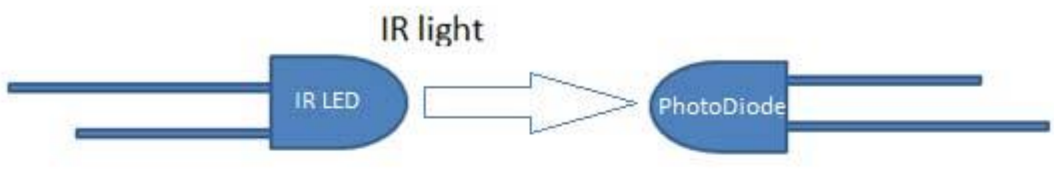

Figure 2.6: IR LED

For Indirect incidence, we must place this IR LED and the photodiode in parallel and facing both in the same direction. In this design, IR light will reflect when an object is kept in front of the IR pair and gets absorbed by the photodiode. At the time of reflecting the object will absorb all the IR lights so that the object should not be black. Generally, IR pair is placed in this fashion in IR sensor module.

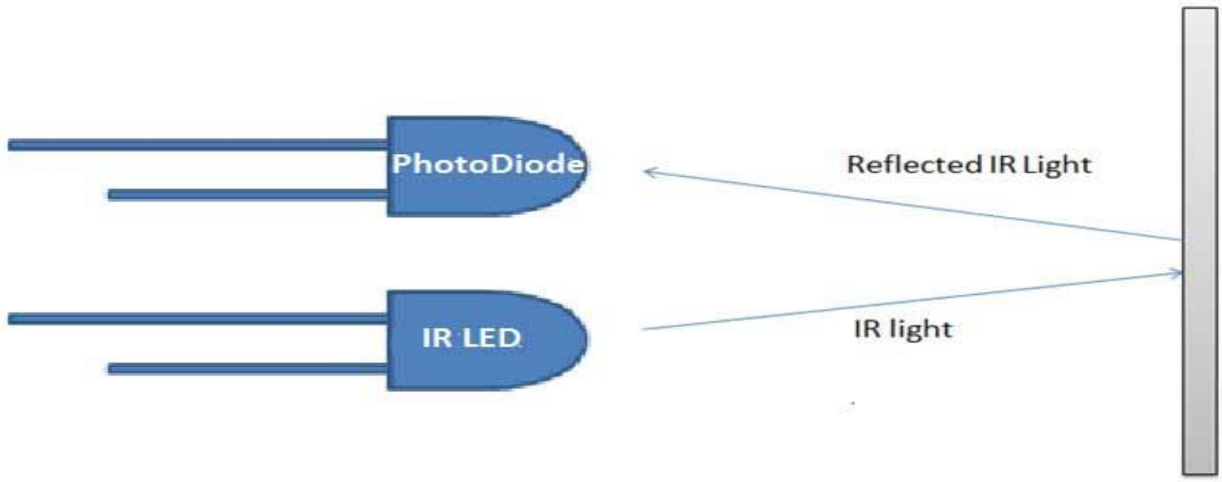

Figure 2.7: IR pair

To build an IR module, we mainly need IR pair and LM358 with some resistors and a LED.

2.5.4.1 Components:

- IR pair (IR LED and Photodiode)
- IC LM258
- Resistor 100, 10k, 330 ohms
- Variable resistor-10k
- LED

2.5.5 Voltage regulator:

A voltage regulator is a power control device intended to naturally change over voltage into a lower, generally coordinate current (DC), steady voltage [11].

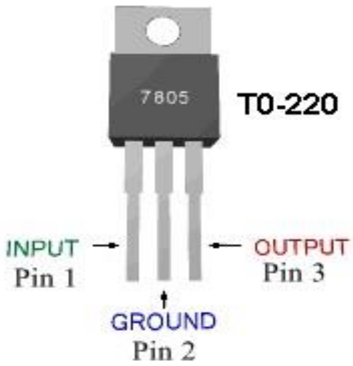

Figure 2.8: Voltage regulator

Chapter 3

Related Works

In many researches, Robocar has been used to solve many useful problems. Xin Zhao, Nan Wu, Yunfeng Lou [12] used Robocar in “Development of automatic driving system by robocar”. D. Tamilselvi, P. Rajalakshmi, S. Mercy Shalinie [13] also used Robocar in their project “Dynamic Programming Agent for mobile robot navigation with moving obstacles”. Kuo-Hsien Hsia, Jr-Hung Guo, Kuo-Lan Su[14] used Robocar in their research “Motion guidance of mobile Robot using laser range finder”. Eun Soo Jang, Seul Jung, T.C. Hsia[15] also worked using Robocar in their thesis “Collision avoidance of a mobile robot for moving obstacles based on impedance force control algorithm”. Abrar M. Alajlan, Marwah M. Almasri, Khaled M. Elleithy [16] also used a mobile Robot that is same as Robocar in their project “Multi-sensor based collision avoidance algorithm for mobile robot”. Most of the works stated above are based on sensor technology. In their works they just made Robocars by using many sensors. By using that, Robocar they made many useful works. The most popular line follower Robot was implemented and by using the line follower Robot, many project or research had done. J.P. Desai, J. Ostrowski, V. Kumar [17] used a line follower Robot in their project “Controlling formations of multiple mobile robots”. The line follower Robot is implemented basically Infrared Radiation (IR) sensor. We are using IR sensor in our Robocar for sensing the line.

IR sensor basically consists of an IR LED and a Photodiode, this pair is generally called IR pair or Photocoupler. IR sensor work on the principal in which IR LED emits IR radiation and Photodiode sense that IR radiation. Photodiode resistance changes according to the amount of IR radiation falling on it, hence the voltage drop across it also changes and by using the voltage comparator we can sense the voltage change and generate the output accordingly.

In the work “Bluetooth communication system for drivers of vehicles” done by Tsuneaki Sakamoto, Masashi Hino, Yasuo Ohishi, Mitsuhiko Yamamoto, Masao Kikuchi and Shinako Watabe [18] they used Bluetooth communication to communicate with driver and vehicle. Instead of driver and vehicle, we used the Bluetooth communication between to robocars.so that they can send and receive signals between them.

Chapter 4

Implementation

4.1 Circuit Connection

There are two circuit diagrams. One is for master Robocar and another is for other Robocar.

4.1.1 Circuit Connection of Master Robocar

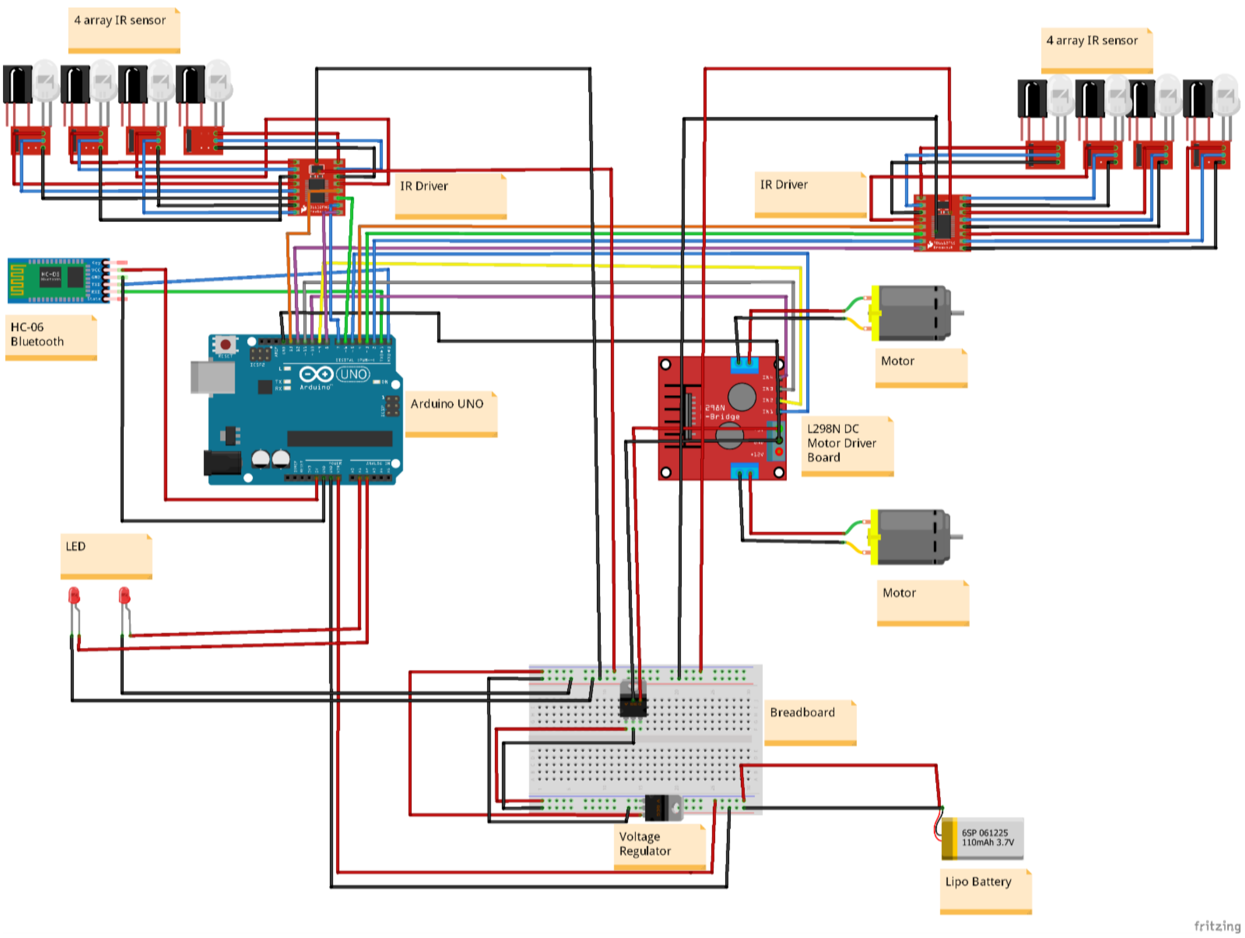

Figure 4.1: Circuit Diagram of Master Robocar

We use L298N motor driver which has 4 input pins, 4 output pins, VCC and GND pin. 4 output pins are connected with two motors and 4 input pins are connected with Arduino 5, 9, 10 and 11(PWM) pins. We connect VCC to a 6-volt voltage regulator so that we can control the speed of the motor and this voltage regulator is placed in the breadboard. GND pin is connected to both common GND and Arduino’s GND.

There are two sets of 4 array IR sensor. Each set has 4 pieces of IR sensor and an IR driver. 4 piece of IR sensor is connected with the IR driver. The right-sided IR driver is connected with Arduino 12, 2, 3, 4 pins and the left-sided IR driver is connected with Arduino 13, 6, 7, 8 pins. We use a 5-volt voltage regulator to get the voltage for both IR drivers and this voltage regulator is placed in the breadboard. VCC pins are connected with that voltage regulator. GND pins are connected in common GND.

HC-06 Bluetooth module is used to transmitting the optimal path. There are 4 pins which are VCC, GND, RX, and TX. VCC is connected with Arduino’s 5-volt. GND is in Arduino’s GND. RX is in Arduino’s TX and TX is in Arduino’s RX pin.

We use a lipo battery as a power source. Arduino and two voltage regulators are directly connected with the battery. The positive wire of the battery is connected to the common positive side in a breadboard and the negative wire of the battery is connected to the negative side in the breadboard.

The input pin of two voltage regulator are connected with a common positive side and the GND pin of both are connected with the common negative side.

There is two LED light. One is red, and another is blue. The positive side of the red light is connected with Arduino’s A1 analog pin and the negative side is connected with common GND. The positive side of the blue light is connected with Arduino’s A2 analog pin and the negative side is connected with common GND.

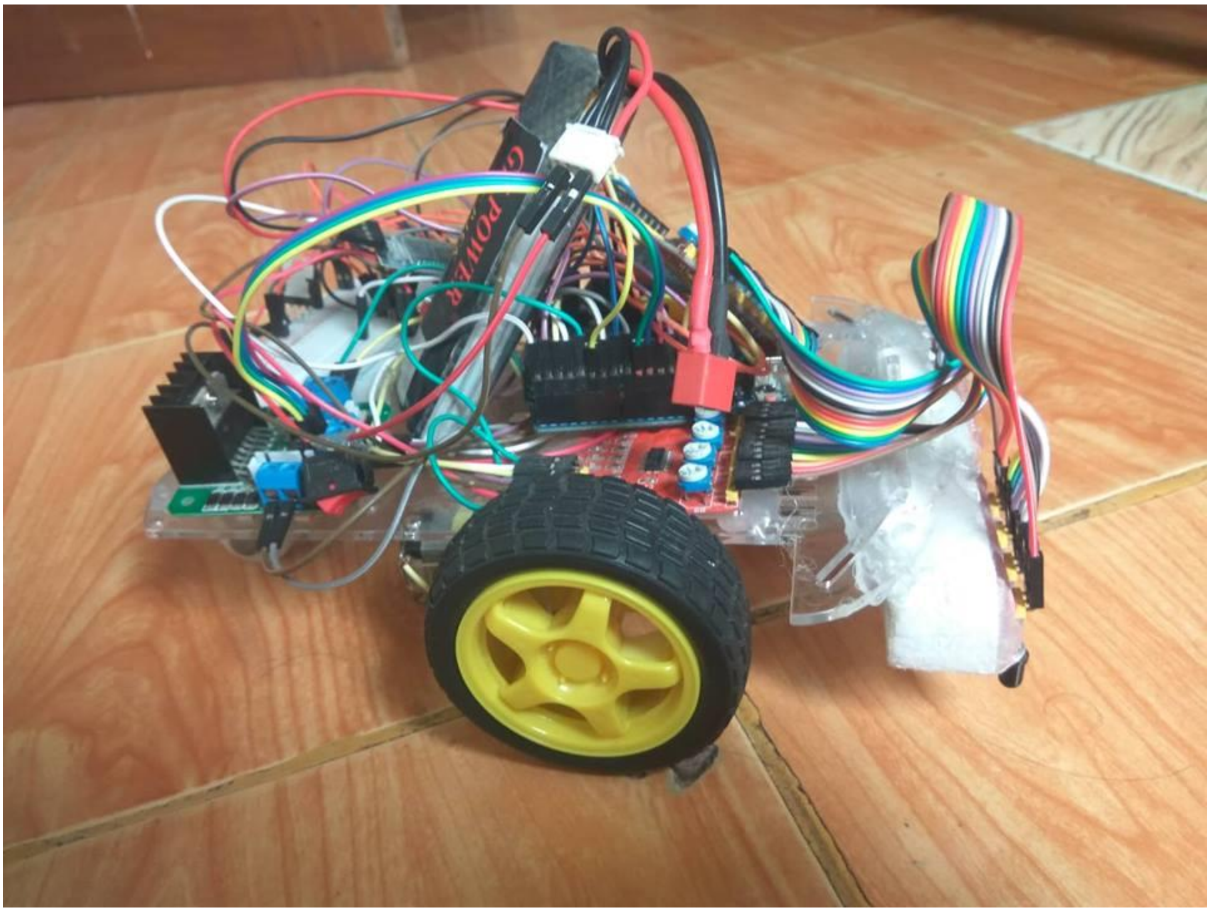

Figure 4.2: Picture of hardware (Master Robocar)

4.1.2 Circuit Connection of 2nd Robocar

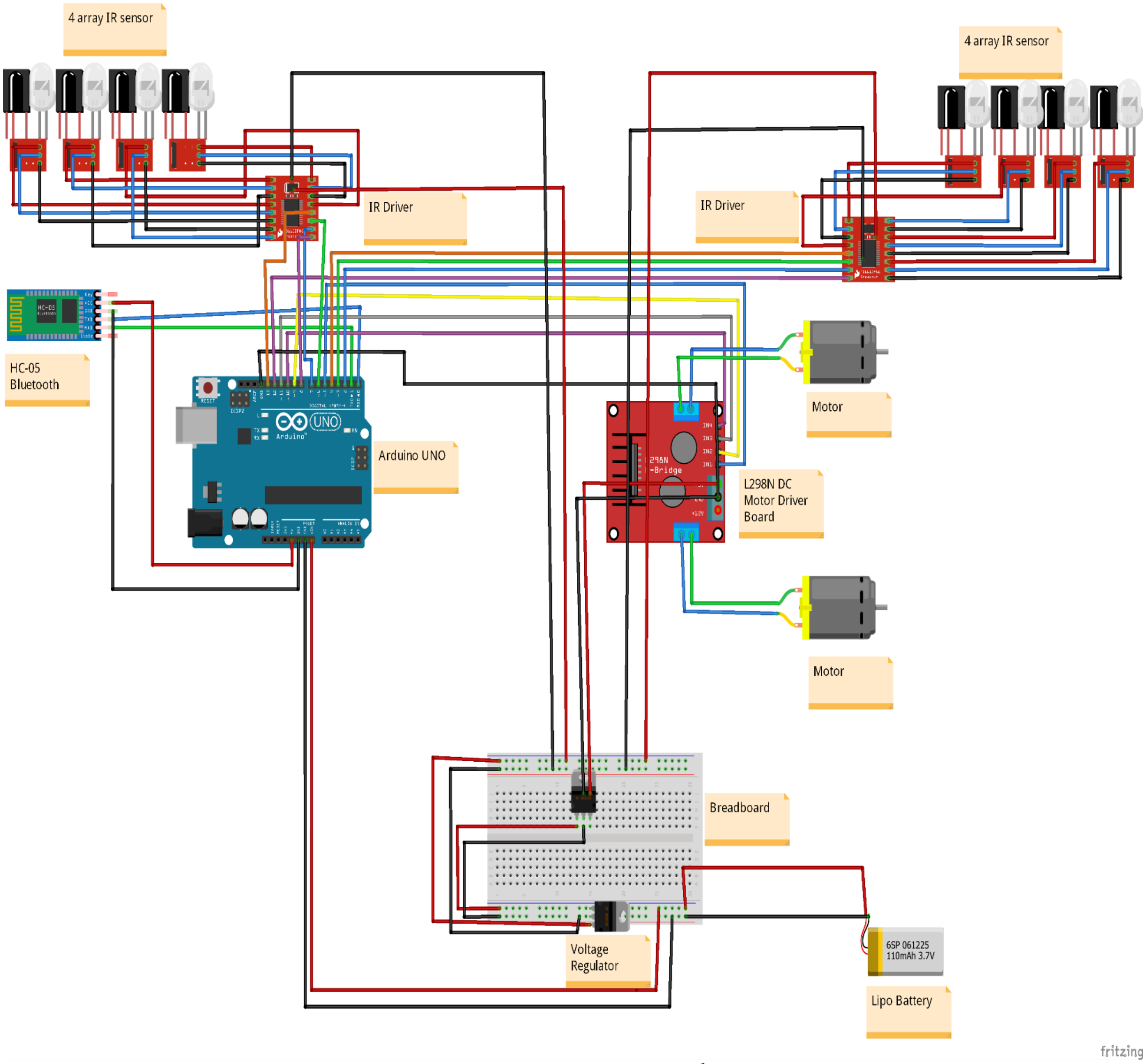

Figure 4.3: Circuit Diagram of 2nd Robocar

We use L298N motor driver which has 4 input pins, 4 output pins, VCC and GND pin. 4 output pins are connected with two motors and 4 input pins are connected with Arduino 5, 9, 10 and 11(PWM) pins. We connect VCC to a 6-volt voltage regulator so that we can control the speed of the motor and this voltage regulator is placed in the breadboard. GND pin is connected to both common GND and Arduino's GND.

There are two sets of 4 array IR sensor. Each set has 4 pieces of IR sensor and an IR driver. 4 piece of IR sensor is connected with the IR driver. The right-sided IR driver is connected with Arduino 12, 2, 3, 4 pins and the left-sided IR driver is connected with Arduino 13, 6, 7, 8 pins. We use a 5-volt voltage regulator to get the voltage for both IR drivers and this voltage regulator is placed in the breadboard. VCC pins are connected with that voltage regulator. GND pins are connected in common GND.

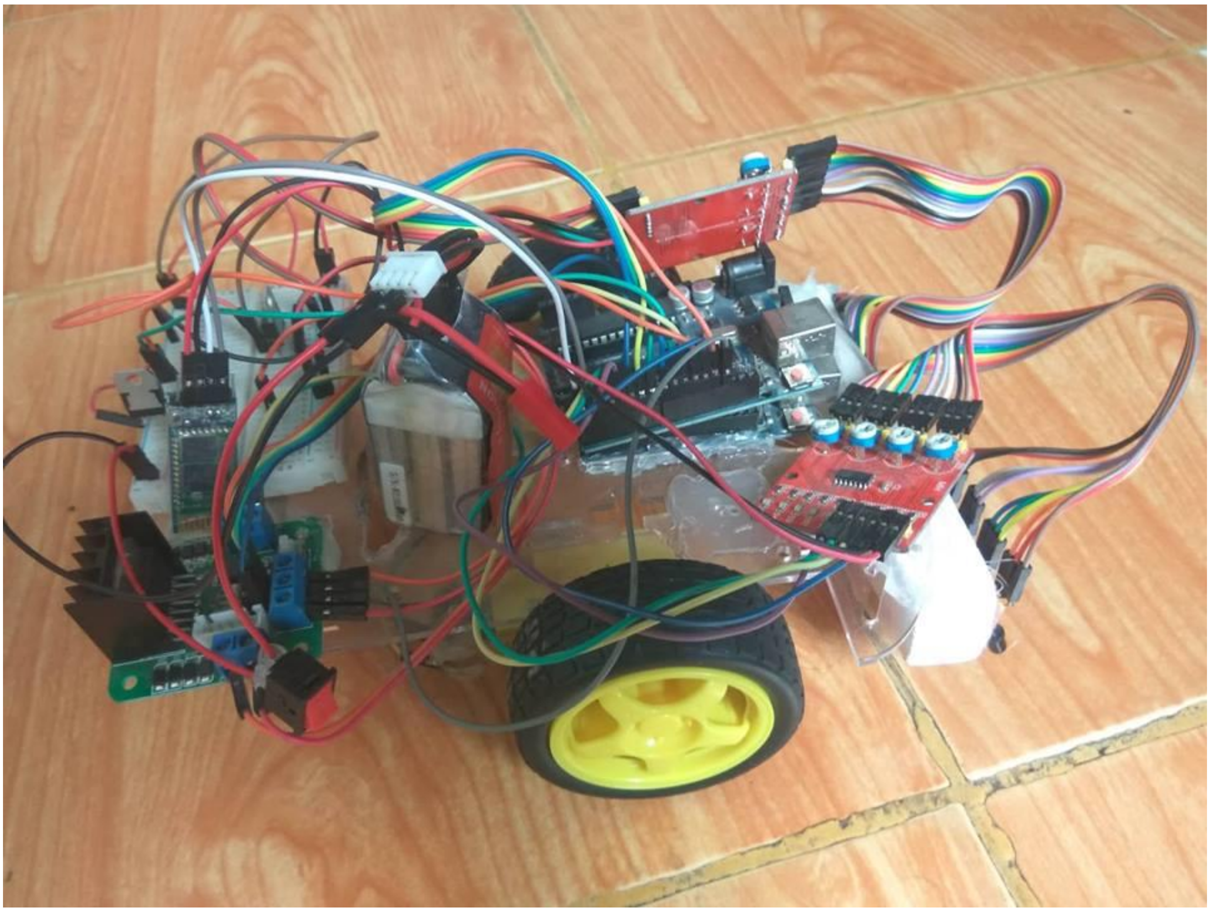

Figure 4.4: Picture of hardware (2nd Robocar)

HC-05 Bluetooth module is used to transmitting the optimal path. There are 6 pins which are VCC, GND, RX, TX, STATE and ENABLE. VCC is connected with Arduino’s 5-volt. GND is in Arduino’s GND. RX is in Arduino’s TX and TX is in Arduino’s RX pin. STATE and ENABLE pins are not connected.

We use a lipo battery as a power source. Arduino and two voltage regulators are directly connected with the battery. The positive wire of the battery is connected to the common positive side in a breadboard and the negative wire of the battery is connected to the negative side in the breadboard.

The input pin of two voltage regulator are connected with a common positive side and the GND pin of both are connected with the common negative side.

4.2 Line Follower

For line follower Robocar, it has 8 IR sensor. In white surface, it read 0. In black surface, it read 1 [19].

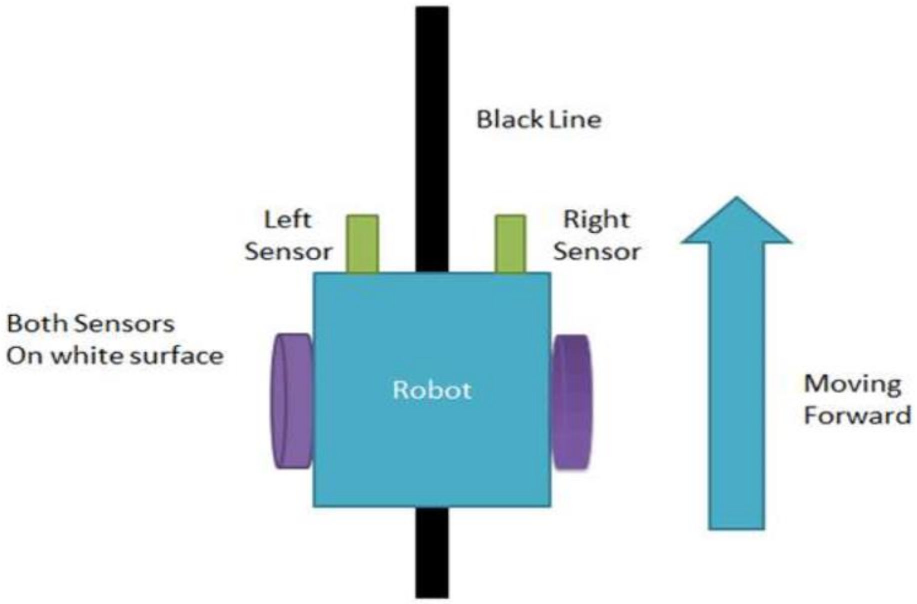

Figure 4.5: Line Follower Robocar Moving Forward

When all left and right sensors are on the white surface, it reads zero. If it happens, then Robocar will go forward.

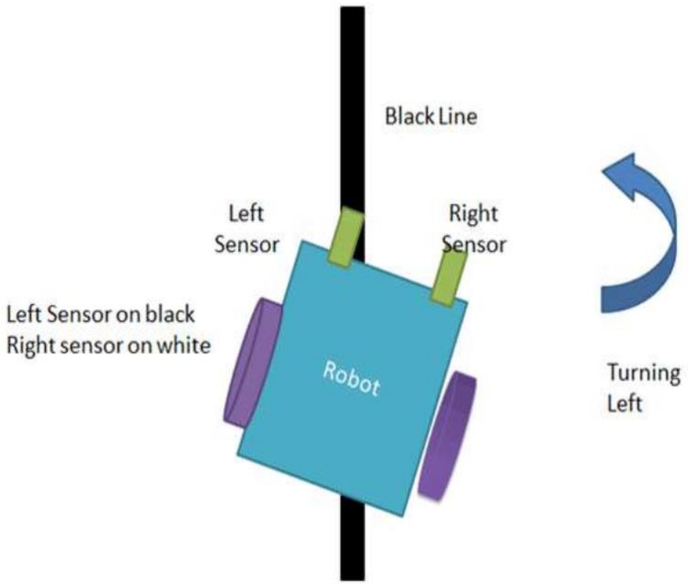

Figure 4.6: Line Follower Robocar Turning Left

When any left-sided sensors are on the black surface, it reads one and then Robocar will turn left.

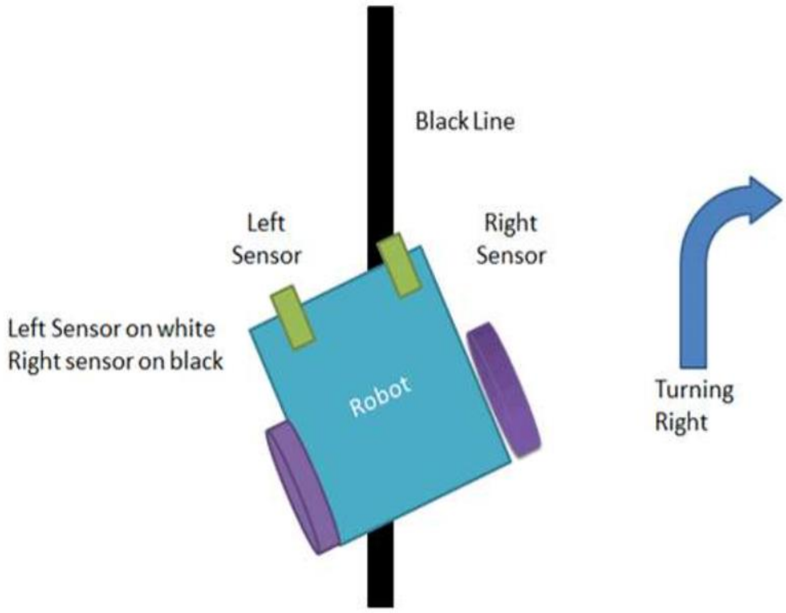

Figure 4.7: Line Follower Robocar Turning Right

When any right sided sensors are on the black surface, it reads one and then Robocar will turn right.

4.3 Path Declaration

A Robocar can't see anything. Initially, we declared 7 paths in it. From this path, the master Robocar can randomly choose that path and traverse it.

In path declaration, we use junction to calculate a total number of turns and the total number of crossing junction. When master Robocar gets a junction, it will increase the counter of crossing junction. For every crossing like forwarding, left or right, this counter will increase. For a total number of turns, we consider only right or left turn. If Robocar takes a right turn, then the turn number will increase for that path.

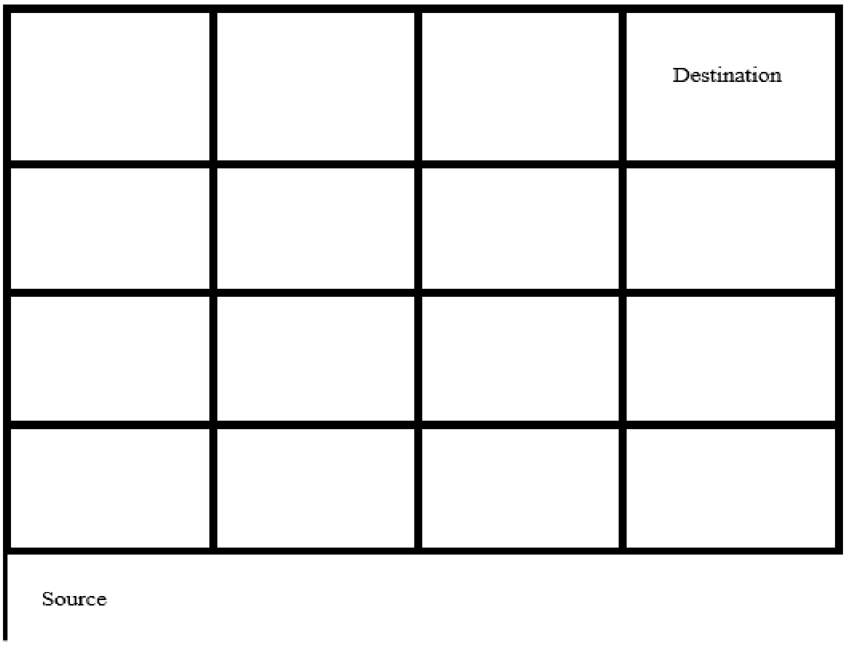

Figure 4.8: Maze for Robocars

The following paths are declared for our system:

1. Right-Left-Left-Right-Right-Left-Right-Forward-Left
2. Forward-Forward-Forward-Forward-Right-Forward-Forward-Right
3. Right-Forward-Forward-Forward-Left-Forward-Forward-Left
4. Right-Left-Right-Left-Right-Left-Right
5. Forward-Right-Left-Forward-Right-Forward-Left
6. Forward-Forward-Forward-Right-Forward-Right-Forward-Left-Left-Forward-Right
7. Right-Forward-Forward-Left-Left-Right-Forward-Right-Left

Master Robocar will randomly choose this path. After choosing, there are two lights which will blink to indicate the shortest path number. And Serial monitor will show that path number.

4.4 Cost Calculation of a Path

There are many algorithms to find the shortest path. In our maze, every edge has the same distance. That's why the cost is also the same. We calculate the shortest path considering the turn number. The path that has the lowest turn number is the shortest path.

Suppose, the master Robocar choose 6 number paths randomly.

Forward-Forward-Forward-Right-Forward-Right-Forward-Left-Left-Forward-Right

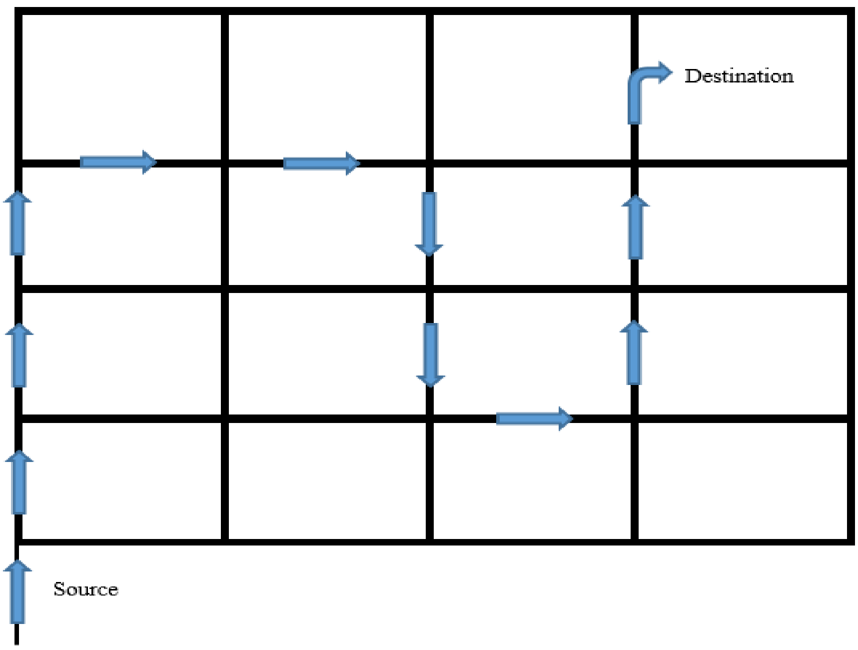

Figure 4.9: Path Number 6 in Maze

In this path, Robocar will go forward when it senses the first junction. But it will not increase turn number because this is not a left or right turn. This is how it will cross 3rd junction and the turn number will be 0. When it gets 4th junction, it will turn to the right and increase turn number by 1. In the 5th junction, it will go forward and the turn number will remain 1. When 6th junction comes, it will turn right and turn number will become 2. In 7th junction, it will go forward and the turn number will remain the same. When 8th junction comes, Robocar will turn left and the turn number will be 3. For 9th junction, it will turn left and also increase turn number. And the number of turns will become 4. In 10th junction, it will go forward and a number of turns will remain the same. When 11th junction comes, it will understand that is the destination. Then it will go forward for some distance and will turn right. Lastly, for the right turn, it will increase the number of turns and the final cost or turn number will be 5. So the cost of a 6th path is 5. In this way, the cost of all the path can be calculated.

4.5 Find the shortest path

After traversing, master Robocar has the cost of every path. Now it will perform minimum sorting algorithm. If minimum sorting is done, then it will find which path has this minimum cost. This is how the shortest path can be calculated by the master Robocar.

4.6 Transmit the Shortest Path

When master Robocar finds the shortest path, it will indicate the number of the path using that 2 LED lights. Then it will transmit that path number to other Robocars through Bluetooth. If Bluetooth between master Robocars and other Robocars are paired, then they will get the shortest path number.

4.7 Following the Master Robocars command

After getting the shortest path number, other Robocars will follow the command of master Robocars and they will go to the destination using that path.

In our 7 paths, the 2nd path has the lowest cost. When other Robocars receive path number 2, then they will follow that path.

Forward-Forward-Forward-Forward-Right-Forward-Forward-Right

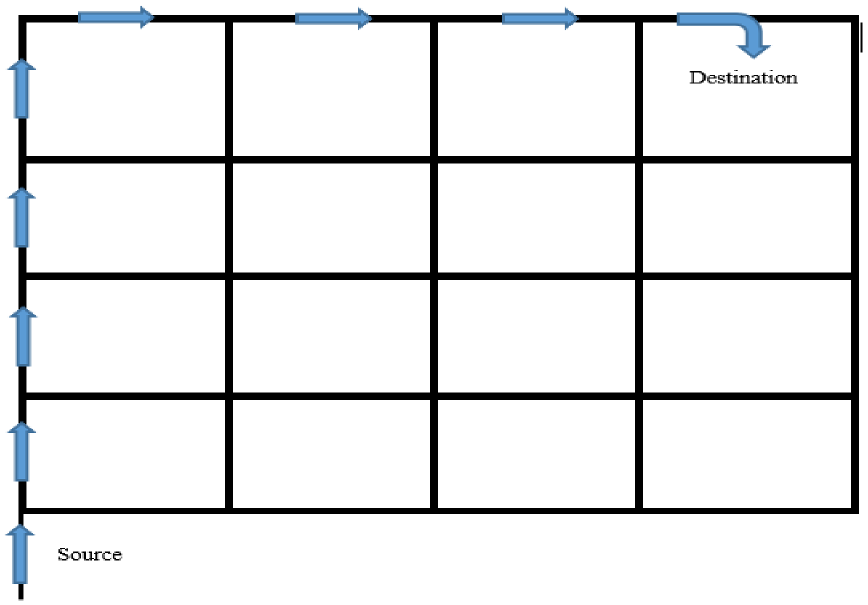

Figure 4.10: Shortest Path Following by Other Robocars

In this process, master Robocar can find the shortest path from source to destination and it can command other Robocars. The rest of them can follow that selected path.

4.8 Result and Analysis

4.8.1 Generating Random Path

```
COM4 (Arduino/Genuino Uno)

...........Serial Communication Opened............

=================Process start=================

Generating Random Path
Auto Generated Path : 6
Auto Generated Path : 3
Auto Generated Path : 1
Auto Generated Path : 7
Auto Generated Path : 3
Auto Generated Path : 5
Auto Generated Path : 5
```

Figure 4.11: Random Path Generated

This is the output of randomly generated path.

4.8.2 Visiting Three (3) Generated Path

```
==================================================
IR Sensors are taking the reading

==================================================
Robocar start to explore the generated path

Auto Generated Path 6 visited

Auto Generated Path 3 visited

Auto Generated Path 1 visited
```

Figure 4.12: After Visiting Chosen Path

We set our master Robocar to traverse first 3 generated paths just for the experiment. If we want to set it as 7 then it will also work.

4.8.3 Shortest path calculation and transmit

```
====================Shortest Path is Generating======================

Shortest Path is 3

Cost is 3
=============Sending the Shortest Path to other Robocars================

Bluetooth is sending path number 3
□
========================================================================
Now the Master Robocar stops

2nd Robocar will start within 1000 mili sec
```

Figure 4.13: Calculate Shortest Path and Transmit

After traversing selected paths, it calculates the shortest one and sends it to other Robocar. Then 2nd one will start to follow that path.

4.8.4 Second Robocar receives the shortest path and traverses it:

```
COM3 (Arduino/Genuino Uno)
|

..........Serial Communication Opened............

=================Bluetooth is receiving the shortest path=====================

The shortest path number is 3

Now Robocar starts to follow the shortest path

***************************************************************************
***********2nd Robocar reached the destination successfully!!***************
***************************************************************************
```

Figure 4.14: Receiving Signal and Following that Path

Second Robocar received the shortest path number and starts to follow it.

Chapter 5

Conclusion and Future Work

The Robocars for shortest track finding and transmitting is successfully implemented. Our sensor-based device is capable to find the optimal path from source to destination and can follow the path by IR sensor. We have Implemented basically two Robocars. The first Robocar will try to find out the optimal path or shortest path by traversing some random path between source and destination. Then it will send a signal to the second Robocar by using Bluetooth communication. The second car will receive the signal and it will go for the destination by following the signal.

So far, we have successfully implemented the communication between Robocars and they can move from source to destination by using optimal path. In near future, we will integrate Swarm intelligence (Ant Colony Algorithm) into the Robocar. The popular Ant Colony algorithm can be used for this intelligence. It will help to reduce traffic jam and save the time. The biggest advantage will be that the Robocars can make communication with each other and make decision to take the optimal path based on time and distance. Thus, our system does not need to use database and internet. So, the enhanced traffic routing will be introduced in near future.

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Appendix A

List of Acronyms

GPS	Global Positioning System
PC	Personal Computer.
ISM	Industrial, Scientific and Medical
GHz	Gigahertz
Mbps	Megabits Per Second
IR	Infrared Radiation
MHz	Megahertz
USB	Universal Serial Bus
ICSP	In-Circuit System Programming
AC	Alternating Current
DC	Direct Current
GND	Ground
Vin	Voltage In
IC	Integrated Circuit
AVR	Automatic Voltage Regulator
MOSI	Master Out Slave In
MISO	Master in Slave Out
SCK	Clock signal from Master to Slave
VCC	Voltage Collector to Collector
SPI	Serial Peripheral Interface
LED	light-Emitting Diode
TX	Transmitter

RX	Receiver
I/O	Input /Output
SPP	Serial Port Protocol
UART	Universal asynchronous Receiver-Transmitter
TTL	Transistor-Transistor Logic
PWM	Pulse Width Modulation