AUTONOMOUS LINE FOLLOWING ROBOT USING MICROCONTROLLER

A Project-Il Submitted in Partial
Fulfillment of the Requirement for the Degree of

BACHELOR OF TECHNOLOGY
in
ELECTRICAL ENGINEERING

by

Avinash Kumar Yadav (1811022015)
Rohit Verma (1811022034)
Devesh Kumar (1811020021)
Ravi Kumar Pushpakar (1811020043)

Under the supervision

Mr. AMIT KUMAR YADAV
(Assistant Professor)

Department of Electrical Engineering

INSTITUTE OF ENGINEERING & RURAL TECHNOLOGY

PRAYAGRAJ-211002, INDIA

CERTIFICATE

Certified that Avinash Kumar Yadav (1811022015), Rohit Verma (1811022034), Devesh Kumar (1811020021) and Ravi Kumar Pushpakar (1811020043) have carried out the project work presented in this project entitled "Autonomous Line Following Robot using Microcontroller" for the award of Bachelor of Technology in Electrical Engineering at Institute of Engineering and Rural Technology, Prayagraj under the supervision of Amit Kumar Yadav (Assistant Professor). The project embodies results of original work, and studies are carried out by the students themselves and the contents of the project do not form the basis for the award of any other degree to the candidates or to anybody else from this or any other
University/Institution

Date:

Signature

Place: (Amit Kumar Yadav)

Declaration

I declare that this written submission represents my work and ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Avinash Kumar Yadav (1811022015)

Rohit Verma (1811022034)

Devesh Kumar (1811020021)

Ravi Kumar Pushpakar (1811020043)

Date:

Place: Prayagraj

Dept. of Electrical Engineering

Approval Sheet

This Project entitled "Autonomous Line Following Robot using Microcontroller", by Avinash Kumar Yadav (1811022015), Rohit Verma (1811022034), Devesh Kumar (1811020021) and Ravi Kumar Pushpakar (1811020043) is approved for the degree of Bachelor of Technology in Electrical Engineering. Examiner

____

____

____

Supervisor (s)

____

____

Head of Department

____

____

Date: ___________

ACKNOWLEDGEMENT

We express our great pleasure and gratitude to honorable examiner **Mr. Amit Kumar Yadav** (Assistant Professor) Electrical Engineering for providing the opportunity and platform with facilities in accomplishing the project-based laboratory.

We would also like to express special thanks to **Dr. Vimal Kumar Mishra** (Director, IERT Allahabad) for providing such innovative environment.

We express sincere gratitude to **Mr. Amit Tiwari** (Head of the Department) Electrical Engineering for providing much needed facility and support.

We are sincerely thankful to **Mr. V.K. Gupta (**Assistant Professor), **Mr. Saurabh Kumar** (Assistant Professor) under their guidance and constant motivation provided in successful completion of our academic semester. We record it as our privilege to deeply thank for providing us the efficient faculty and facilities to make our ideas into reality.

We are pleased to acknowledge the indebtedness to our lab technicians who devoted themselves directly or indirectly to make this project success.

Last but not the least we express our deep gratitude and affection to our Friends whose contribution in the completion of the project.

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Line Following is one of the most important aspects of robotics. A Line Following Robot is an autonomous robot which is able to follow either a black line that is drawn on the surface consisting of a contrasting colour. It is designed to move automatically and follow the line. The robot uses arrays of optical sensors to identify the line, thus assisting the robot to stay on the track. The array of four sensor makes its movement precise and flexible. The robot is driven by DC gear motors to control the movement of the wheels. The Arduino Uno interface is used to perform and implement algorithms to control the speed of the motors, steering the robot to travel along the line smoothly. This project aims to implement the algorithm and control the movement of the robot by proper tuning of the control parameters and thus achieve better performance .1n addition the LCD interface is added in order to display the distance travelled by the robot. It can be used industrial automated equipment carriers, small household applications, tour guides in museums and other similar applications, etc.

Line follower is an intelligent robot, which detect a visual line embedded on the floor, and follows it. The path is predefined and can be either visible like a black line on a white surface with a high contrasted color or the path can be a complex such as magnetic markers or laser guide markers. In order to detect these lines various sensors can be employed. Generally, infrared Sensors are used to detect the line which the robot has to follow. The robot movement is automatic and can be used for long distance application. Line follower can be modified by giving obstacle detection capability to it. If any object is placed on the path then a normal line follower will try to push the obstacle and hence it gets damaged. By using ultrasonic sensor, the line follower can detect an obstacle and can stop till the obstacle is removed. This type of robots can perform lot of tasks in industries, like material handling. These robots can be used as automated equipment carriers in industries replacing traditional conveyer belts. They also have domestic application and one of the interesting application of this line follower robot is in health care management. As this smart line follower robot has obstacle detection capability it will not be damaged easily as it stops it motion till the obstacle is removed or till the path is changed. This ability of the robot increases it application especially in industries because obstacles are common in any workplace and if the robot is not able to detect the obstruction it will get damaged so this gives an added advantage wherever this intelligent line follower is used.

The main aim of any robot is to reduce human effort. According to the purpose different types of robots are designed for practical applications. In any work environment proper monitoring is always needed for better results. This smart and intelligent line follower robot can be used in industries for carrying goods from one place to another. The main reason why this robot can be employed for transportation of goods is its fit and forget ability, which means that once the robot is placed on the desired path the working of the robot is totally automatic, there is no need for controlling the robot manually. This is what makes the line follower robot more efficient and useful when compared to other

conventional robots. A traditional obstacle avoiding robot cannot help in transportation of goods because there is no particular path for the robot. It will move randomly by avoiding the obstacles and will not reach the required decision. The movement of obstacle avoiding robot cannot be controlled. Considering this factor line follower robot has more useful applications. This conventional line follower robot can be made smart and intelligent by giving it the ability to detect obstacles. This improves the working of the line follower robot, because in any work environment obstacles are common, so if the line follower is not able to detect any obstacles on its path it will collide with it and will be severely damaged. Adding the features of obstacle avoiding robot to a traditional line follower robot prevents any damage to the robot. This intelligent robot can also be installed for health care management in hospitals, which decreases the human effort in monitoring patients and delivery things or medicines. The workers can be used for other tasks instead of transporting goods from one place to other which can be carried out with this smart and intelligent line follower robot.

The project is design to build an obstacle avoidance robotic vehicle using ultrasonic sensors for its movement. A microcontroller (ATmega328) is used to achieve the desired operation. A robot is a machine that can perform task automatically or with guidance. The project proposes robotic vehicle that has an intelligence built in it such that it directs itself whenever an obstacle comes in its path. This robotic vehicle is built, using a micro-controller of AT mega 328 family. An ultrasonic sensor is used to detect any obstacle ahead of it and sends a command to the micro-controller. Depending on the input signal received, the micro-controller redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver. Some of the project is built with the IR sensors has its own application so in our project those application is not compactable so we are using ultrasonic sensor.

Table of Contents

CHAPTER 1

1. Introduction

Line follower is a machine that can follow a path. The path can be visible like a black line on a white surface. Sensing a line and maneuvering the robot to stay on course, while constantly correcting wrong moves using feedback from the sensor forms a simple yet effective system. It can be used in automobile, industrial automations, guidance, etc [1].

The main aim of any robot is to reduce human effort. According to the purpose different types of robots are designed for practical applications. In any work environment proper monitoring is always needed for better results. This smart and intelligent line follower robot can be used in industries for carrying goods from one place to another.

The main reason why this robot can be employed for transportation of goods is its fit and forget ability, which means that once the robot is placed on the desired path the working of the robot is totally automatic, there is no need for controlling the robot manually. This is what makes the line follower robot more efficient and useful when compared to other conventional robots.

A traditional obstacle avoiding robot cannot help in transportation of goods because there is no particular path for the robot. It will move randomly by avoiding the obstacles and will not reach the required decision. The movement of obstacle avoiding robot cannot be controlled. Considering this factor line follower robot has more useful applications. This conventional line follower robot can be made smart and intelligent by giving it the ability to detect obstacles. This improves the working of the line follower robot, because in any work environment obstacles are common, so if the line follower is not able to detect any obstacles on its path it will collide with it and will be severely damaged. Adding the features of obstacle avoiding robot to a traditional line follower robot prevents any damage to the robot.

This intelligent robot can also be installed for health care management in hospitals, which decreases the human effort in monitoring patients and delivery things or medicines. The workers can be used for other tasks instead of transporting goods from one place to other which can be carried out with this smart and intelligent line follower robot.

1.1. Background

As technology becomes increasingly important in today's world, it is invaluable to not only learn how to use technology, but also to understand how to create it. Since being the engineer one should have sound knowledge of the other discipline. most of the projects have limited scope to only specific discipline. This would limit ones innovation and creativity. This project inspires to make connections across several disciplines rather than learning topics in isolation as it combines mechanical, electronic, electrical and programming skills.

- It gives visual grasp of math and science.
- It builds logical thinking.
- It brings out innovation and creativity.
- It enhances problem solving skills.

The robot designed in such a way that it not only track the path and follow it but also visualize the distance travelled through the LCD displays.

1.2. Motivation

How ants always travel in a line, following an invisible route in search of food, or back home. How on roads the lanes is followed to avoid accidents and traffic jams. Ever thought about a robot which follows line? A perfect or near perfect mimic of nature? After all the purpose of robotics is to recreate in terms of machines what one see around to solve a problem or fulfill a requirement.

The area will be benefitted from the project operations
Industrial automated equipment carriers.
Entertainment and small household applications.
Tour guides in museums and other similar applications.

1.3. Problem Description

In the industry carriers are required to carry products from one manufacturing plant to another which are usually in different buildings or separate blocks. Conventionally, carts or trucks were used with human drivers. Unreliability and inefficiency in this part of the assembly line formed the weakest link. The project is to automate this sector, using carts to follow a line instead of laying railway tracks which are both costly and an inconvenience.

1.4. Objectives

The objectives of the project are:

- The robot must be capable of following a line.
- It should be capable of taking various degrees of turns.
- The robot must be insensitive to environmental factors such as lighting and noise.
- It must allow calibration of the line's darkness threshold. Scalability must be a primary concern in the design.
- It also shows the distance travelled by it through LCD display.

1.5. Methodology

After the detail literature survey through the books, periodical, journal, magazine, websites. The idea of the project is well defined.

The logic is derived for the intelligence of the robot. It is programmed and burn it to the Arduino by using the software Arduino@ 1.65.

The accuracy and viability of the program and electronic components is tested in the simulation software Proteus@.

After the successful simulation result it is implemented in the hardware. After the finishing the programming, electrical and electronics part, the stable, reliable and flexible mechanical design and fabrication is completed. Finally system is tested and encountered error is omitted.

1.6. Limitations

The system has restricted to the following limitation.

- Choice of line is made in the hardware abstraction and cannot be changed by software.
- Calibration is difficult, and it is not easy to set a perfect value.
- Few curves are not made efficiently, and must be avoided.
- The turning radius should be of minimum 100m to take smooth U-turning of robot.
- The width of the path must be of 45mm so that it can cover minimum 3 sensors. • The path should be plane and obstacle free.
- The steering mechanism is not easily implemented in huge vehicles and impossible for non-electric vehicles.

1.7. Organization of Report

This report is a documentary delivering the ideas generated, concepts applied, activities done It contains four chapters. The following is a description of information in this thesis. Chapter I provides a general overview of the project and the use and importance of autonomous robots in the world. The objectives, scope of project, problem statement are also described in this chapter 2describes the hardware development unit in line following robot. This chapter describes about sensor arrays, Arduino, motor driving system, it also describes the project methodology and explains hardware development for the design of the robot.

Chapter 3 contains the process explanation with working algorithm, flowchart and sketch of the Arduino.

Chapter 5 contains all the results obtained from the software experiments that include the algorithm implemented in a program.

Finally, chapter 5 will summarize the final year project. The conclusion, suggestions or recommendations for improvements that can be implemented in future are discussed within this chapter.

1.8. Summary

Line Follower is one of the most important aspects of robotics. A Line Following Robot is an autonomous robot which is able to follow either a black or white line that is drawn on the surface consisting of a contrasting color. It is designed to move automatically and follow the plotted line. It enhances interdisciplinary approach to mechanical, electronic, electrical and programming skills. The application of the project is range from the individual domestic appliance to automation and control aspect of large industry. Human are intelligent natural machine but it has serious limitation of efficiency and reliability. Robots are made to replace dependency of human force partially. The project is somehow designed to perform the similar task. Line follower is an intelligent robot which detect a visual line embedded on the floor and follows it. The path is predefined and can be either visible like a black line on a white surface with a high contrasted color or the path can be a complex such as magnetic markers or laser guide markers. In order to detect these lines various sensors can be employed. Generally, infrared Sensors are used to detect the line which the robot has to follow. The robot movement is automatic and can be used for long distance application. Line follower can be modified by giving obstacle detection capability to it. If any object is placed on the path then a normal line follower will try to push the obstacle and hence it gets damaged. By using ultrasonic sensor, the line follower can detect an obstacle and can stop till the obstacle is removed. This type of robots can perform lot of tasks in industries, like material handling. These robots can be used as automated equipment carriers in industries replacing traditional conveyer belts. They also have domestic application and one of the interesting application of this line follower robot is in health care management. As this smart line follower robot has obstacle detection capability it will not be damaged easily as it stops it motion till the obstacle is removed or till the path is changed. This ability of the robot increases it application especially in industries because obstacles are common in any workplace.

CHAPTER 2

2. Technology and Literature Survey

The line follower is a self-operating robot that detects and follows a line that is drawn on the floor .The line follower robot using Arduino is a self-operating system that detects and follows track drawn on the floor. The track consists of a black path drawn on white surface.

2.1. Basic Operation

The basic operations of line follower are as follows:
Capture line position with optical sensors mounted at front end of the robot. For this a combination of IR-LED and Photodiode called an optical sensor has been used.
This make sensing process of high resolution and high robustness.
Steer robot requires steering mechanism for tracking. Two motors governing wheel motion are used for achieving this task.
This system has LCD display panel to show the distance that it covers.
On the detecting no black surface robot move in a circular motion until line is found.

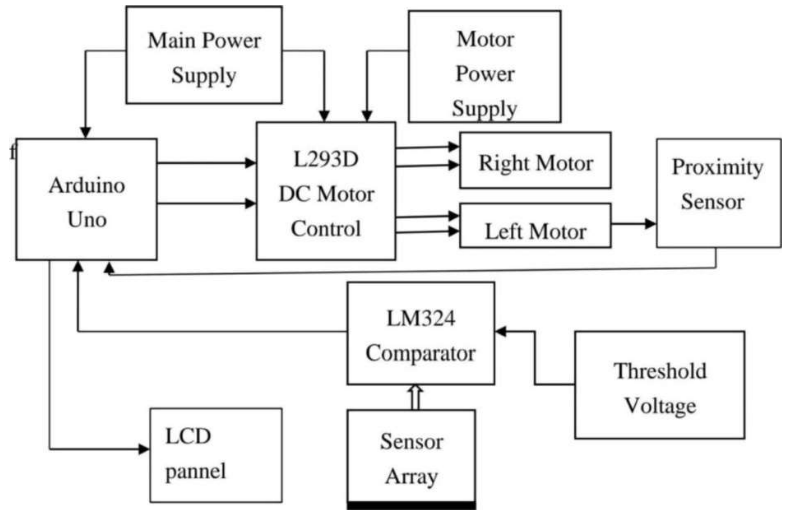


Figure 2-1: Block Digram of the Line following Robot.

2.2. Hardware Required

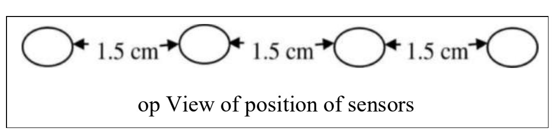
The hardware required is divided in the following category:

2.2.1 Input System

The detail of each components is discussed below.

2.2.1.1. Optical Sensors

The robot uses photodiode sensors to sense the line; an array of four IR- LEDs (TX) and Photodiode sensors (Rx), facing the ground used in this setup. An analog signal is obtained in output, depends on the amount of light reflected back, which is provided to the comparator to produce Os and Is which are then fed to the Arduino.



Left Right

Figure 2-2: Arrangements of the Sensor

The sensors on the left named as Ll, 142 and RI, R2 on the right side. Assumption should be considered that when a sensor is on the line it reads 0 and when it is off the line it reads 1. The Arduino correspondence to the algorithm given below decides the next movement, trying to position the robot such that all sensors read 0.

With sensors, robots can react and respond to changes in their environment in ways that appear intelligent or life-like.

2.2.1.1.1. Arrangement of Sensors.

An array of sensors arranged in a straight row pattern is bolted under the front of the robot. It locates the position of line below the robot. Distance between two adjacent sensors is about 1.5 cm.

We can use any number of sensors. If we have low number, then our robot movement is not smooth and it may face problems during sharp turns. If higher number of sensors were, used robot movement will become smooth and reliable for sharp turns; it requires complex programming for micro-controller and requires more hardware, which is its disadvantage. Thus, optimum number of sensors required.

2.2.2. Comparator.

Comparator is a device, which compares two input voltages and gives output high or low. In circuit diagram it is normally represented by a triangle having-Inverting (negative) Input, Non-Inverting (positive) Input (+), Vcc, Ground, Output.

Properties of comparator:

If V+ > V- then Vo=Vcc (Digital High output is 1)
If V+ < V- then Vo= 0 (Digital Low Output is 0)

Inverting (-ve)
Input Comparator
Non-inverting OUTPUT
Input

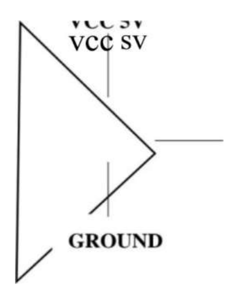


Figure 2-3: Schematic of Comparator Logic

2.2.2.1. Optical sensor.

As shown above that two inputs are required for comparator. One input is from photo receiver (like Photodiode),other is generated by resistor. The second voltage is reference voltage for that sensor.

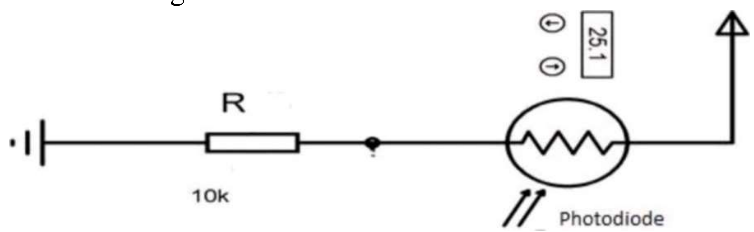


Figure 2-4: Optical Sensor schematic

2.2.2 Processing unit.

Processing system acts as the brain of robot, generating desired output for corresponding inputs, in which microcontrollers are used. There are several companies nowadays that manufacture microcontrollers, for example ATMEL corporation, Microchip, Intel, Motorola etc. We will be using ATmega32L microcontroller in our robot. It is known as AVRI.

2.2.2.1. Arduino

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The heart of Arduino is the microcontroller. For Arduino Uno ATmega328 is used.

It has specification of 8 bit CPU, 16 MHZ clock speed, 2 KB SRAM 32 KB flash Memory, Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. This board uses Atmel microcontroller series.

There are many Arduino hardware models that you can use. Further information about Arduino products, you can visit on website http://arduino.cc/en/.
You must one Arduino hardware to follow practices in this book. I recommend to obtain one of the following Arduino hardware:

Arduino Uno
Arduino Leonardo
Arduino Mega 2560
Arduino Due

Features :-

- 14 digital input output pins (3,5,6,9,10 and 1 1 pins are able to generate PWM).

  6 analog input pins

  Voltage input from the 7 - 12 V

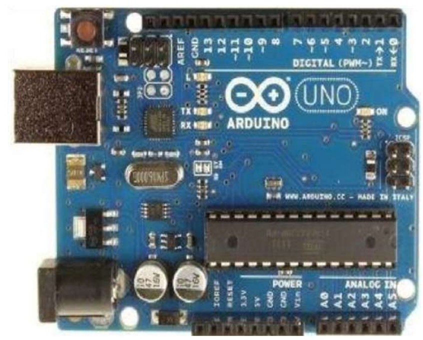


Figure 2-5: Arduino Uno Schematic

Arduino Uno

The Arduino Uno is a microcontroller board based on the datasheet file. There are many varieties of Arduino boards that can be used for different purposes. Some boards look a bit different from the one below, but most Arduino have the majority of these components in common: The pins on your Arduino are the places where you connect wires to construct a circuit (probably in conjuction with a breadboard and some wire. They usually have black plastic ‘headers’ that allow you to just plug a wire right into the board.

The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.

•GND (3): Short for ‘Ground’. There are several GND pins on the Arduino, any of which can be used to ground your circuit.

•5V (4) & 3.3V (5): As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.

•Analog (6): The area of pins under the ‘Analog In’ label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.

•Digital (7): Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).

•PWM (8): You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called PulseWidth Modulation (PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out).

• AREF (9): Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Reset Button

Just like the original Nintendo, the Arduino has a reset button (10). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if your code doesn’t repeat, but you want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn’t usually fix any problems.

Power LED Indicator

Just beneath and to the right of the word “UNO” on your circuit board, there’s a tiny LED next to the word ‘ON’ (11). This LED should light up whenever you plug your

Arduino into a power source. If this light doesn't turn on, there's a good chance something is wrong. Time to re-check your circuit!

TX RX LEDs

TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. In our case, there are two places on the Arduino UNO where TX and RX appear – once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs (12). These LEDs will give us some nice visual indications whenever our Arduino is receiving or transmitting data (like when we're loading a new program onto the board).

Main IC

The black thing with all the metal legs is an IC, or Integrated Circuit (13). Think of it as the brains of our Arduino. The main IC on the Arduino is slightly different from board type to board type, but is usually from the ATmega line of IC's from the ATMEL company. This can be important, as you may need to know the IC type (along with your board type) before loading up a new program from the Arduino software. This information can usually be found in writing on the top side of the IC. If you want to know more about the difference between various IC's, reading the datasheets is often a good idea.

Voltage Regulator

The voltage regulator (14) is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it's for. The voltage regulator does exactly what it says – it controls the amount of voltage that is let into the Arduino board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Of course, it has its limits, so don't hook up your Arduino to anything greater than 20 volts.

2.2.3. Output System

The output system is designed with the function of the following components.

Motor Driver

Motor driver is a current enhancing device; it can also be act as Switching Device. Thus, after inserting motor driver among the motor and microcontroller. Motor driver taking the input signals from microcontroller and generate corresponding output

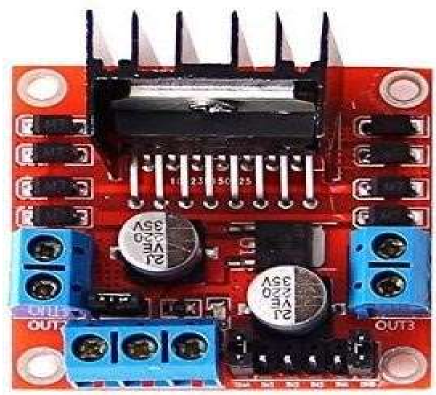


Figure 2 -6 Motor Driver Module.

You can control two DC motor with a single L293D IC. The L293D works on the concept of typical Hbridge, a circuit which allows the high voltage to be flown in either direction. In a single L293D IC there are two H-bridge circuits which can rotate two DC motors independently. You can Buy L293D IC in any electronic shop very easily and it costs around 70 Rupees

The module consists two pairs of pins for connecting the two motors, a Vcc to supply external 5 Volts electricity to drive the motors, a GND for negative terminal. The motor driver consists of 4 pins p1, p2, p3 & p4 (which is input to this module & output from arduino). If pin p1 is HIGH (having 5 Volts and other 3 pins having 0 Volts) motor M1 rotates clockwise, if p2 is HIGH (having 5 Volts and other 3 pins having 0 Volts) then motor M1 rotates anti clockwise, if p3 is HIGH (having 5 Volts and other 3 pins having 0 Volts) then motor M2 rotates clockwise, if p4 is HIGH (having 5 Volts and other 3 pins having 0 Volts) then motor M2 rotates anti clockwise.

IC L293D.

This is a motor driver IC that can drive two motor simultaneously. Supply voltage (Vss) is the voltage at which motor drive. Generally, 6V for dc motor and 6 to 12V for gear motor are used, depending upon the rating of the motor. Logical Supply Voltage deciding what value of input voltage should be considered as high or low .So if the logical supply voltage equals to +5 V, then -0.3 V to 1.5 V will be considered as Input low voltage and 2.3 V to 5 V is taken into consider as Input High Voltage. The Enable 1 and Enable 2 are the input pin for the PWM led speed control for the motor L293D has 2 Channels .()ne channel is used for one motor.

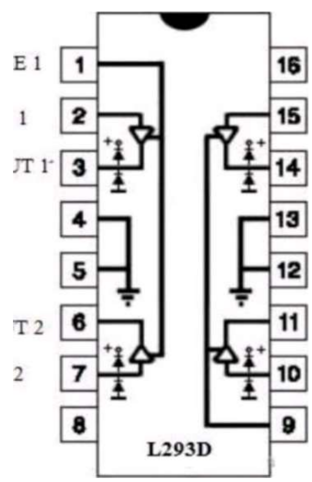


Figure 2-7: Pin Configuration IC L293D

DC MOTOR

Motor is a device that converts any form of energy into mechanical energy or imparts motion. In constructing a robot, motor usually plays an important role by giving movement to the robot. In general, motor operating with the effect of conductor with current and the permanent magnetic field. The conductor with current usually producing magnetic field that will react with the magnetic field produces by the permanent magnet to make the motor rotate. There are generally three basic types of motor, DC motor, even servomotor and stepper motor, which are always being used in building a robot.

DC motor (BO) Battery Operation. Dc motor converts electrical energy into mechanical energy. Why DC gear motor used in robot Motor control circuit. DC MOTOR concept is where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. In DC motor is assembled with multiple gear setup. Speed of motor is counted in terms of rotations of the soft per minute is called RPM. RPM means Revolution Per Minute. The setup assemble helps to increasing the torque and reduce the motor speed. All micro-controller based Robots this type of DC motor can be used.

DC motors are most easy for controlling. One DC motor has two signals for its operation. Reversing the polarity of the power supply across it can change the direction required. Speed can be varied by varying the voltage across motor.

Figure 2-8: Low Volt DC Gear Motor attach with Wheel.

LCD Display

In our project it is used to display the distance travelled by the robot through the output from the tachometer system.

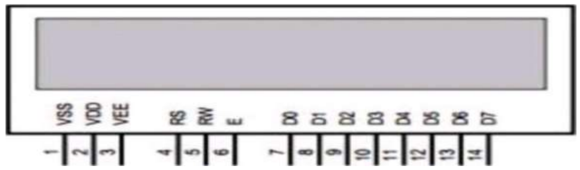


Figure 2-9: Schematic of LCD Panel

Proximity Sensor

The combination of IR- LED and Photodiode is used as the reflective optical sensor. It generate interrupt when the IR-beam is break to the photodiode. To create the IR breakbeam, IR LED is used with a low value resistor so that it shines very bright. The receiver is Photodiode which biases 'on' whenever the IR LED's light is detected. A sensor will be placed adjacent the IR link and turned on so as to generate a pulse to the Arduino. The Arduino LCD interface is used to show the covered distance digitally.

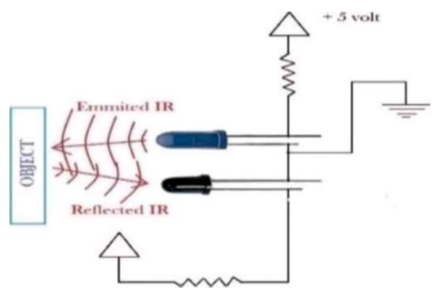


Figure 2-10: Proximity Sensor

The Infrared (IR) sensors consist of Infrared (IR) LED and Infrared (IR) photodiodes. The IR LED is called photoemitter and IR photodiode is called receiver. The IR light emitted by the LED strikes the surface and gets reflected back to the photodiode. Then the photodiode gives an output voltage which is proportional to the reflectance of the surface which will be high for a light surface and low for dark surface. Light colored objects reflect more IR light and dark colored objects reflect less IR light .

One pin on either side of the motor will be HIGH and the other two pins will be LOW. This makes the left and right motor to rotate in clockwise direction and hence the robot moves forward. When only left IR sensor detects black line then the robot has to turn left, for that only right motor has to work. When the left motor stops and the right motor is rotating in clockwise direction the robot will turn left. One pin of the right motor should be HIGH and all the other pins should be LOW.

When only right IR sensor detects the black line then the robot has to turn right, for that only left motor has to work. When the left motor stops and the right motor is rotating in clockwise direction the robot will turn left. One pin of the left motor should be HIGH and all the other pins should be LOW.

When both the sensors are on white surface then the robot moves forward and when both the sensors are on black surface then the robot stops. In this case both the sensors will detect the black line but the position where the sensors are located decides whether the robot will stop or will move forward.[6] When the left sensor detects the black line and right sensor is not able to detect the black line then the robot has to turn left. When the right sensor detects the black line and left sensor is not able to detect the black line then the robot has to turn the right. at any case if there is a black line then rotor has to stop.

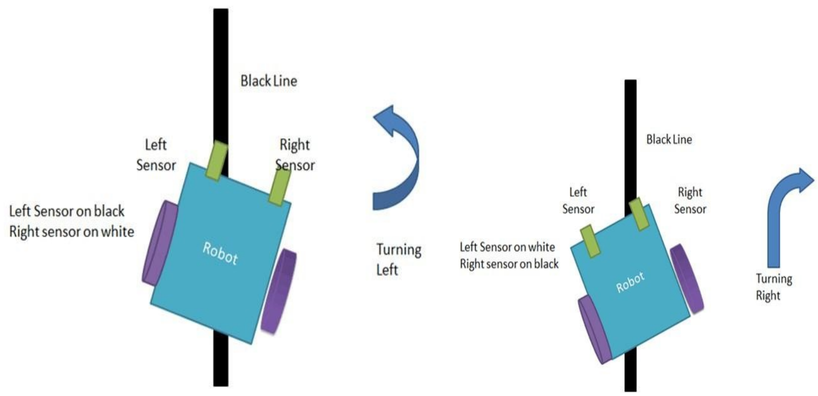


Figure 2-11 : Turning right or left

JUMPER WIRES

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn’t get much more basic than jumper wires.

Figure 2-12 : Jumping Wire

CASTOR WHEEL

A caster (or castor) is an undriven, single, double, or compound wheel that is designed to be mounted to the bottom of a larger object (the "vehicle") so as to enable that object to be easily moved. They are available in various sizes, and are commonly made of rubber, plastic, nylon, aluminum, or stainless steel
\

Figure 2-13 : Castor Wheel

Batteries

A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, mobile phones, and electric cars.[1] When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.[2] The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external

2.3. Software Required

For the simulation of the circuit, Proteus@ software is used. For coding and uploading the sketch, the Arduino 1.65 @ is used .

2.4. Summary

The system is completed in to the three divison i.e is the Input system, Processing System and Output system.

Input system comprises of the optical sensor, is an array of 4 IR-LED and Photodiode pairs arranged in the form straight lines. The output from each sensor is fed into an analog comparator with the threshold voltage (used to calibrate the intensity level difference of the line with respect to the surface). These 4 signals(from each photo-reflective sensor) is given to a priority analog input of the arduino [3].

Processing system is Arduino Uno interface consisting microcontroller Atmega328 which works on the basic of the logic of the program burn to it.

Output system consist combination L293D and gear-motor The control has 6 modes of operation, turn left/right, move left/right, and drift left/right. The actual action is caused by controlling the direction/speed of the two motors (the two back wheels), thus causing a turn.

CHAPTER 3

3. Design and Implementation

3.1. Schematic

The schematic of the "Line Following Robot" is shown in the figure. The main component is the Arduino Uno. Schematic is drawn by using Proteus.

The main features incorporated into the hardware are given below:

Ardunio Uno.

- The IR-LED with IR illuminance, modified to be reflective sensor.
- The LM324 quad comparator IC.
- A potentiometer to calibrate the reference voltage. O The H-bridge motor control IC (L293D) Motors, with coupled reduction gears.
- Connectors to join the different boards to form one functional device.
- A pair of IR-LED and Photodiode is used as proximity sensor for the designing techometer

Each of the hardware is dissected and was designed/implemented separately for their functional and later incorporated as one whole application. This helped in the debugging processes. The schematic of the circuit is given in the next page.

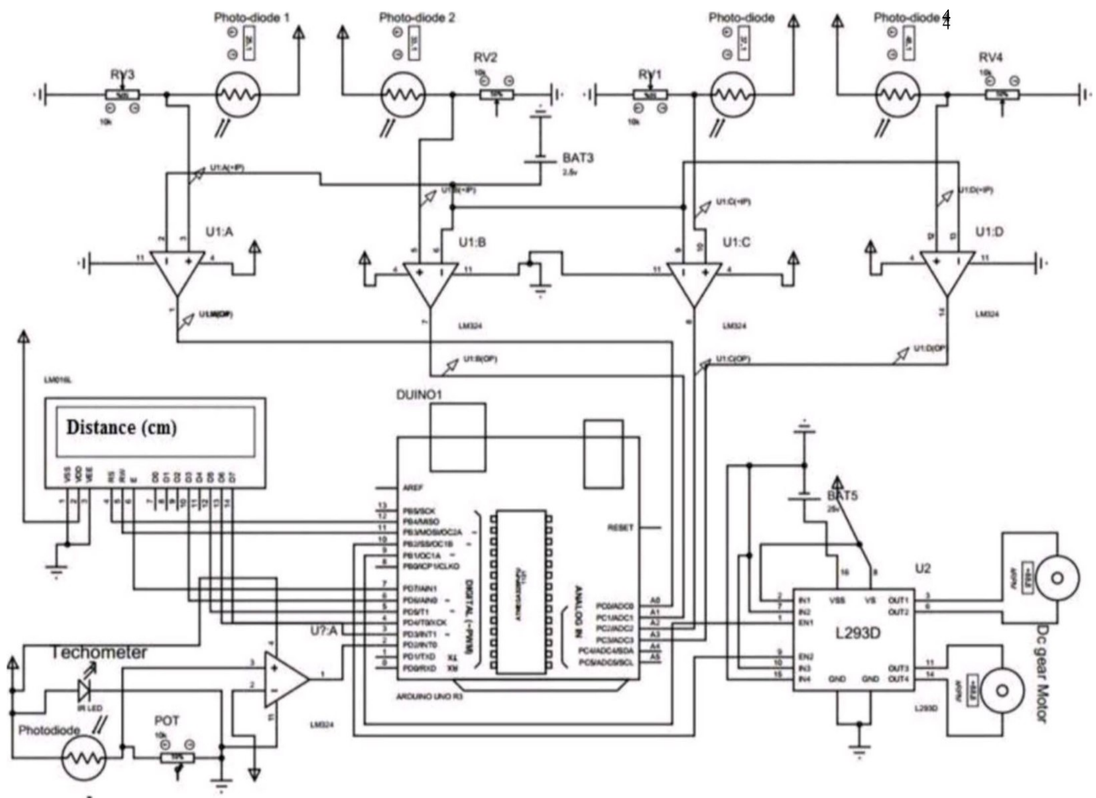


Figure 3-1 Circuit Diagram of Line following Robot

3.2. Arduino Working Logic

Thus totally the microcontroller gets 4 inputs from the sensor circuitry, to the (A3 — AO) of Arduino to decide what to do when on the line. Below is the complete description about what each input mean and what needs to be done.

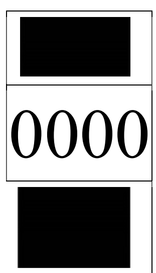
Table 1: Arduino Working Logic

Input				Output (PWM)		State In	Action
				9	10		
O	O	O	O	255	255	All sensor in position	Go straight
1				255	191	Leftmost sensor is out of track.	Move right
1	1			255	127	Two sensor from the left is out of track	Turn right
1	1	1	O	255	64	Three sensor from the left is out of Track	Sharp turn right
	O	O	1	191	255	Rightmost sensor is out of track	Move left
		1		127	255	Two sensor from the right is out of track	Turn left
	1	1	1	64	255	Three sensor from the left is out of Track	Sharp turn left

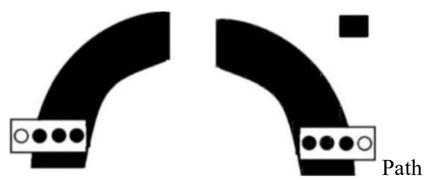
					255	All sensor is out of track	Move circularly Until track is detected

3.3 Process Explanation

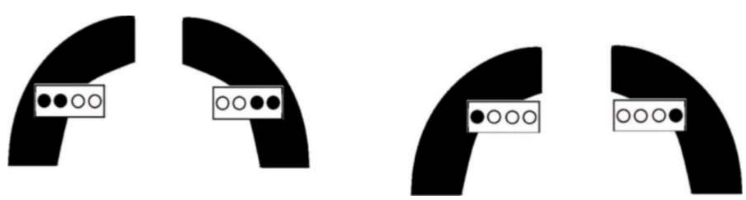
As shown in the data below, is a typical situation involved. At every sampled time the commands executed by the Arduino is also shown. From the below figure, it should be clear about the software requirements.



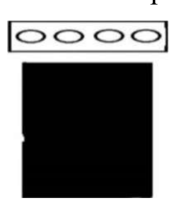
.Go Straight



Move right for the right most condition and move left for left most condition



Turn right for the rightmost condition Sharp turn right for the rightmost condition and turn left for left most condition. and sharp turn left for left most condition.



Move circular until the line is traced down

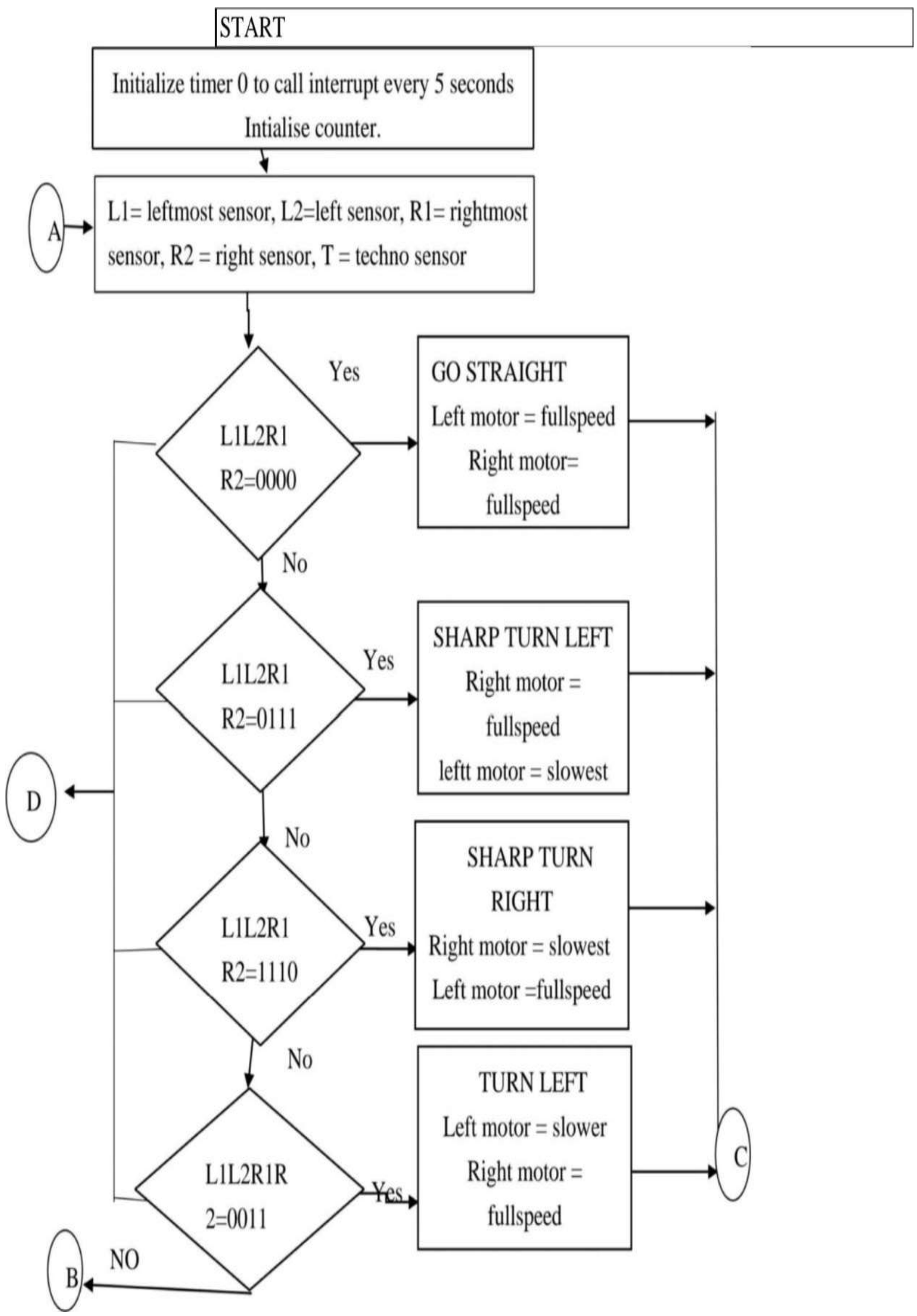
Figure 3-2 : Line Following Process

3.4 Programming and Simulation

The program code acts as the decision-maker embedded in the micro-controller deciding about the outputs for particular set of inputs. The program is coded using Arduino@ 1.65 .and is then compiled to form a " .hex" file which can then be burnt into the Arduino.The output is also checked in simulation using Proteus.

3.4.1. Flowchart.

The following chart shows implemented logic.



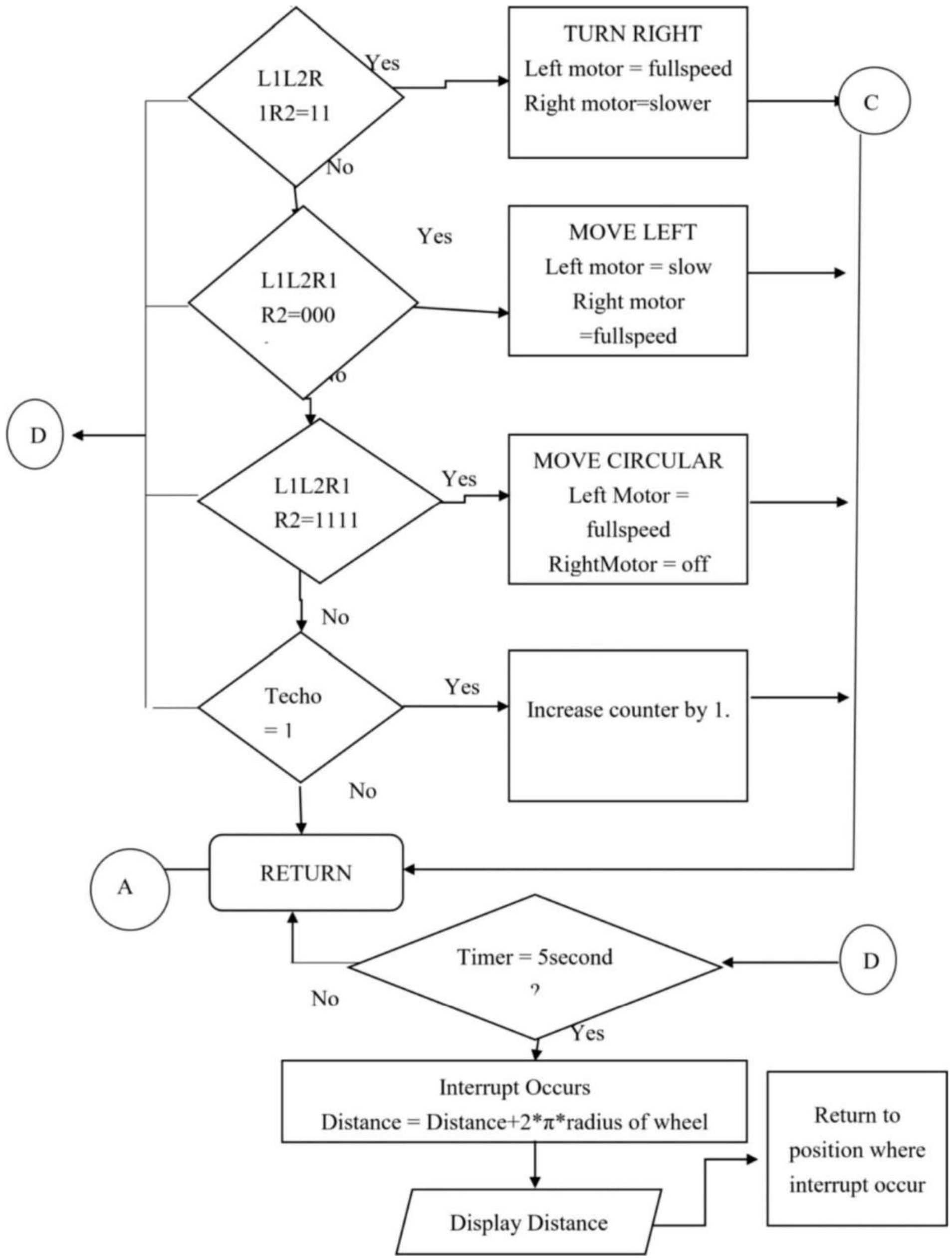


Figure 3-3: Flowchat of the line following Process and Distance Calculation

3.5. Summary

The logic behind the working of Arduino is to analyze the input from the sensor according to program fed to it and provide corresponding output to the the motor driver which finally drive the motor in such way that, it produce required motion.

These robots are pretty cheap and easy to design. Infrared Sensor is used to detect the black line on the path and Ultrasonic Sensor is used to detect obstructions on the path. The robot then responds to the sensor's reading and does something.

This robot can follow a thick line of at least of 1 inch width perfectly and even follow the most complex path consisting of obtuse/acute angled turns and intersection of those black lines.

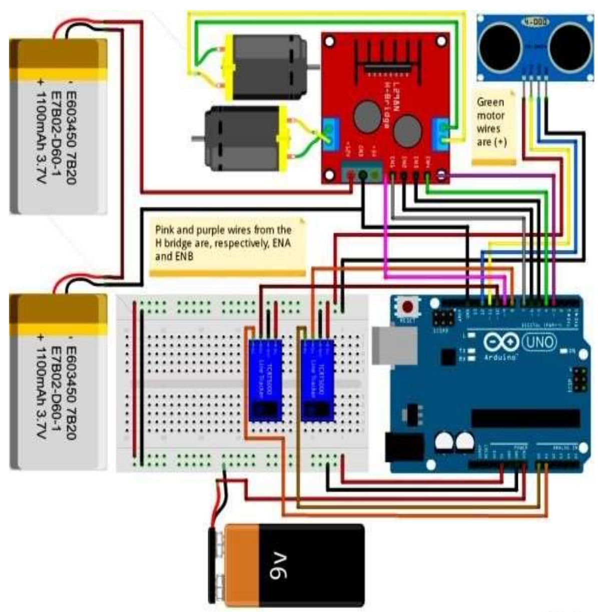


Figure 3-3 : Assembly

When the two Infrared sensors connected at both sides of robot senses white path then the two motors rotate clockwise and the robot moves forward. Similarly, when both the Infrared sensors senses black path (signifying intersection of black lines) then also the two motors rotate clockwise and the robot moves forward.

When one of the Infrared sensors (say the one located at the right side) senses a black path while the other one (left one) senses a white path, then the path is turning towards right, hence the robot turns right. To make the robot move right, the right motor stays stationary and left motor rotates clockwise, hence robot takes a right turn. When one of the Infrared sensors (say the one located at the left side) senses a black path while the other one (right one) senses a white path, then the path is turning towards left, hence the robot moves left. To make the robot move left, the left motor stays stationary and right motor rotates clockwise, hence robot takes a left turn. To take a sharp right turn, make the left motor rotate clockwise while making the right motor rotate anticlockwise. To take a sharp left turn, make the right motor rotate clockwise while making the left motor rotate anticlockwise. When the ultrasonic sensor in front of the robot senses any obstruction (in programmed range) while moving forward then the motors stops rotating and the robot stops. The robot starts moving as soon as the obstruction is removed. The differential steering system is implemented to turn the robot. In this system, each back wheel has a dedicated motor while the front wheels are free to rotate. To move in a straight line,both the motors are given the same voltage . To manage a turn of different sharpness, the motor on the side of the turn required is given lesser voltage as level of steering required.

CHAPTER 4

Result and Analysis

The practical analysis of the components and the mathematical calculation is performed at different stage.

Dc motor are most easy for controlling. One dc motor has two signals for its operation. Reversing the polarity of the power supply across it can be change the direction required. Speed can be varied by varying the voltage across the motor. The Dc motor don't have enough torque to drive the robot directly. So in order to solve the problem the dc gear motor is which increase the torque of the dc motor in the expense of the speed.

Mathematical Interpretation:
Rotational power (Pr) is given by:

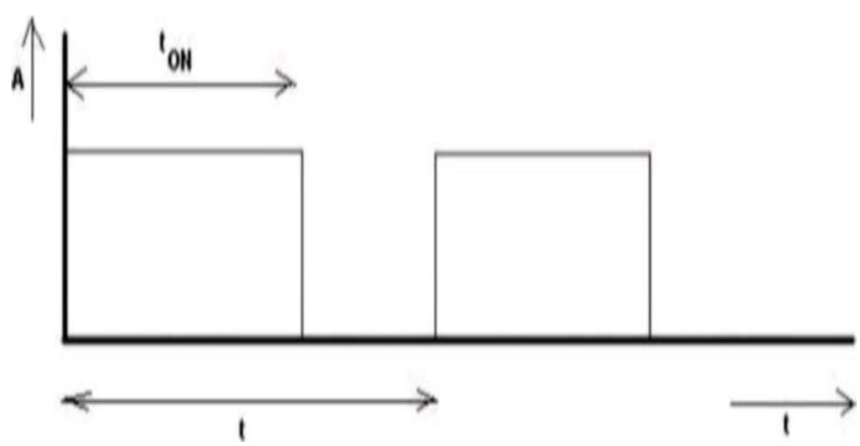
Pr= Torque (T) X Rotational Speed (o)

Pr is constant for DC motor for a constant input electrical power. Thus torque (T) is inversely proportional speed (o)

4.1. Speed Control

The speed of the dc motor is control by feeding PWM from Arduino to the enable pin of the L293D which change the voltage across the motor. Due to which speed is also decreased. On the command over the speed and the direction is also controlled.

4.1.1. PWM speed Control



Calculation :

Where p is the duty cycle of the PWM control signal; this shows that by varying the duty cycle of the PWM control, we effectively vary the DC voltage supplied to the motors, thus controlling their speed. This is generated by the Arduino built-in hardware.

4.1.2. Practical Result Analysis :

Here the motor is tested under all condition in the lab. The reading of the motor RPM and the voltage across it is illustrated below. Inertia is neglected.

Table 2: Analysis of effect of PWM on RPM of Motor

Duty cycle (p)	Voltage Across Motor	RPM
0%		
	3	16
50%	6	29
	9	45
100%	12	58

4.2. Digital Revolution Counter

A Digital RPM counter is a measuring instrument which can measure the number of a rotation machine digitally. The similar concept is used in instrument called "Tachometer". It is an important measuring device in the field of electrical engineering & widely used in industries and laboratorial work. IR- Pair is the heart of the system which found the number of revolution. It works by detecting the black spot in the wheel and transfer digital high to the arduino.

4.2.1. Calculation

The system is designed in such way that it updates the distance value in every 5 seconds. i.e. 12 times per minute.

4.2.2. Practical Result Analysis

Here the build revulution counter is used as Tachometer tested under all condion in the lab with reference of standard Tachometer. The reading of the motor RPM is illustrated below.

Table 3: Comparison between standard Tachometer and Build Tachometer

Voltage Across Motor	RPM (Standard Tachometer)	RPM (Build Tachometer)	Percentage Error
3	70	75	6.25%
6	120	132	9.3%
9	184	173	6.67%
12	258	235	
15	330	284	12.4%

4.3. Summary

Pulse Width Modulation, or PWM, is a technique for getting analog results with digital means. Digital control is used to create a square wave, a signal switched between on and off. This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off. The duration of "on time" is called the pulse width. To get varying analog values, change or modulate that pulse width.

Since, the build tachometer can be used, as from the analysis the error percentage within limit, for the maximum rpm is to be measured i.e 250 rpm.

CHAPTER 5

5.Kinematics of the Robot

The backbone of our design is the differential steering system which is familiar from ordinary life because it is the arrangement used in a wheelchair. Two wheels mounted on a single axis are independently powered and controlled, thus providing both drive and steering. Additional passive wheels (usually casters) are provided for support. Most of us have an intuitive grasp of the basic behavior of a differential steering system. If both drive wheels turn in tandem, the robot moves in a straight line. If one wheel turns faster than the other, the robot follows a curved path. If the wheels turn at equal speed, but in opposite directions, the robot pivots.

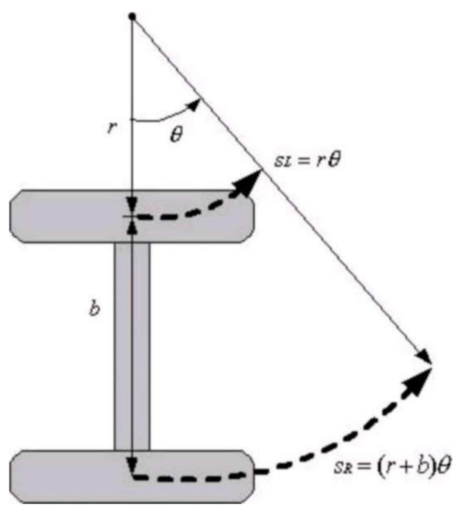


Figure 5-1: The Differential steering model

SL = r.ϴ
SR = (r + b)ϴ
SM = (r + b/2)ϴ

Where SL and SR give the displacement for the left and right wheels respectively, r is the turning radius. b is the distance between wheel, and 0 is the angle of turn. SM is the speed at the center point as the main axle.

5.1. Mechanical Design

The chassis of the robot is made up of the acrylic glass since it can carry more load and have lighter in weight. The detail orthographic projection of the robot is drawn at the appendix.

Design of Path

The path consists of three U-turns of different radii. Among three, the system swiftly turn two U-turn and it goes out of track in one initial U-turn and retrace it's path.

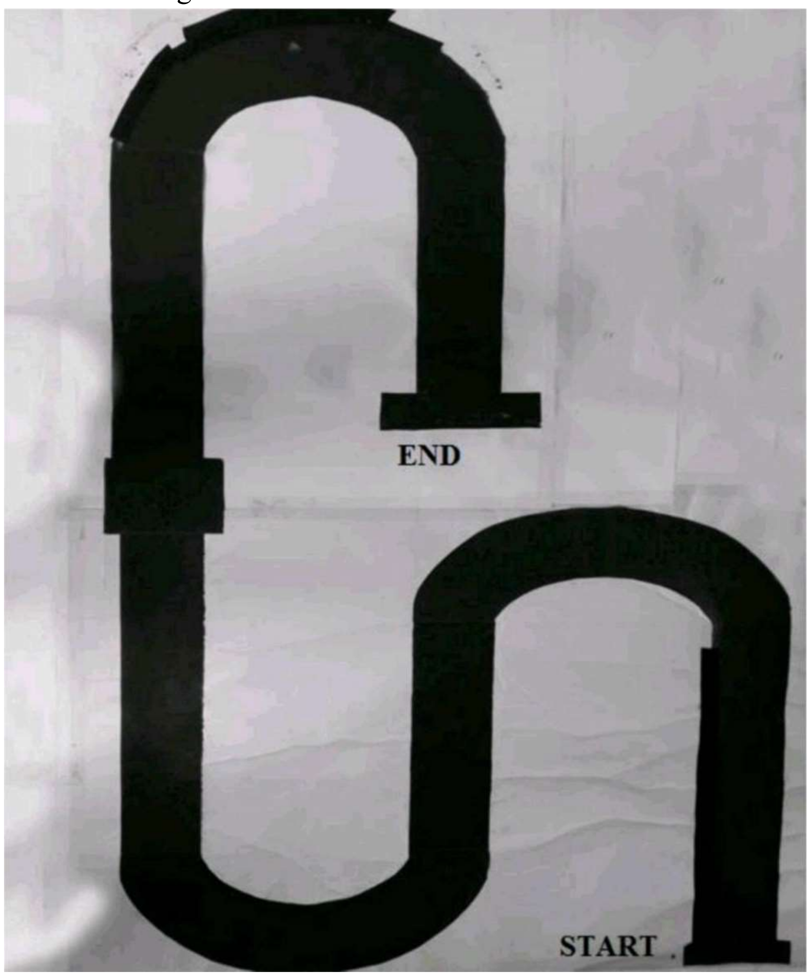


Figure 5-2: Path of the Line Following Robot

Picture of Line Following Robot

The picture of the line following robot is captured by the still camera at some angle and shown below.

Figure 5-3: Top View of the Line following Robot

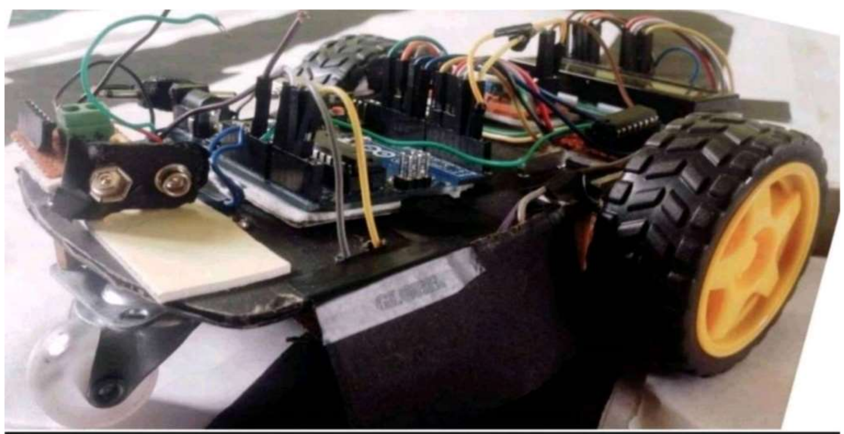


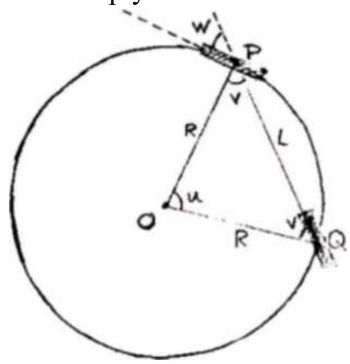
Figure 5-4: Side View of the Line Followinng Robot

5.2. Turning Radius :

The turning radius of a vehicle is the radius of the smallest circular turn (i.e. U-turn) that the vehicle is capable of making. The term 'turning radius' is a technical term that is commonly used to mean the full diameter of the smallest circle, but in technical usage the turning radius still is used to denote the radius.

Calculation :

The total length of the robot car is 172mm (approx 17.2mm.) the minimum turning radius that it can turn sharply.



The diagram in which robot car is making a turn. The situation is show in the figure above. The wheels are shown shaded in the figure. The front wheel's center is P and the rear wheel's center is Q. Let O be the center of the circle, along whose circumference the car moves. Let L=PQ be the length of the car and let R be the radius of the circle. Sharpest turn corresponds to smallest possible value of R. Note that PQ is a chord of the circle. Let us say that the front wheel can rotate at most by an angle w relative to the 'straight' position. For triangle OPQ.

$$u + 2v = 180^0 \qquad (1)$$

also , $$w + v = 90 \qquad (2)$$

From, cosine rule for OPQ:

$$L^2 = R^2 + R^2 - 2R^2 \cos(u) \qquad (3)$$

From eq^n (1), (2) and (3)

$$R = L/2\sin w$$

At the maximum value of sinw i.e 1 .

The turning radius is found to be L/2 = 87.2mm.

Now, the velocity of the automobile is the prime factor to determine the ability to take turn smoothly or not. So we have to derive the relation between the turning radius and. The velocity of the robot car.

Turning Radius(r) = 100mm.

Acceleration due to gravity(g) = 9.81m/s^2 = 9.81xIOOmm/s^2

Velocity(v) = ?

Coefficient of friction between rubber and cardboard (μ) = 0.07

$$V = \sqrt{\mu r g}$$
$$= \sqrt{0.07 \times 8.75 \times 9810}$$
$$= 245.20 \text{ mm/s} = 24.52 \text{ cm/s}$$

Which is attained at the speed of 1.4 rps (or, 84 rpm).

5.2. Cost Estimation

The details of price of components used in project is given below.

Table 4: Details of Price of components

.N.	articulars	Quantity	ate per item(NRs.)	Total(NRs.)
1	Arduino	1	2000	2000
2	Chassis	1	500	500
3	Motor	2	500	1000
4	Rear Wheel	2	200	200
5	Front Wheel	1	250	250
6	LCD	1	500	500
7	Motor Driver	1	500	500
8	Jumper Wire	20	10	200
9	Photodiode	5	50	250
10	IR Sensor	5	50	250
11	LM 358	1	100	100
12	LM 7805	1	100	100
13	AAA Battery	4	50	200
14	9V Battery	1	100	100
15	Battery Holder	1	50	50

16	Switches	1	20	20
17	Miscellaneous			2000
			Total	8220

Hence, the product is finalised in INRs. 8220 excluding the labor cost.

5.3. Summary

The main criteria of the mechnical design is mainly depends upon the differential steering mechanism, turning radius. The caculation of turning radius is necessary because it finds out the mechanical limitation for the types of the curve which is avoded. The turning radius for the design is found to be 100mm

So, in case of designing path the maximum turning radius mustn't be less than 100mm

.

CHAPTER 6

6.1. Conclusion

The line following robot is automobile system that has ability to recognize it's path , move and change the robot's position toward the line in the best way to remain in track.

The applications of the line follower are limited because it cannot be controlled. The only way to control the line follower is to change the path. Using WIFI module to control the line follower robot will not be helpful because more power will be consumed, so the battery will drain out quickly. Apart from these limitations smart and intelligent line follower robot can be used for long distance applications with a predefined path.

This smart and intelligent robot has more benefits because it doesn’t consume much power. This robotic system can provide an alternative to the existing system by replacing skilled labor, which in turn can perform better tasks with accuracy and lower per capita cost. This project report presents a photodiode sensor based line follower robot design of 200gm weigh which always directs along the black line on white surface. The electromechanical robot dimension is $192\times100\times70$ mm^3 with max rpm 180 at no load and frictionless condition.

The minimum turning radius for the system is 100mm at velocity of 24.2 cm/s. The robot is able to detect it's path in case it is out of path.

The line following robot project challenged the group to cooperate, communicate, and expand understanding of electronics, mechanical systems, and their integration with programming. The successful completion of every task demonstrated the potential of mechatronic systems and a positive group dynamic.

6.2. Future Work

In the process of development of the line follower, most of the useful feature is identified and many of them was implemented. But due to the time limitations and other factor some of these cannot be added.

So the development features in brief:

- Use of color sensor.
- Use of ccd camera for better reconigsation and precise tracking the path..

BIBILOGRAPHY

[1] B. Klaus and P. Horn, Robot Vision. Cambridge, MA: MIT Press, 1986.

[2] J. Warren, J. Adams and H. Molle, "Arduino for Robotics," in Arduino Robotics, New York, Apress publication, 2014, pp. 51-83.

[3] Jim, "PWM/PID/Servo Motor Control," 2005. [Online]. Available: http://www.uoxray uoregon.edu. [Accessed 15 December 2015].

[4] Komonya, S. Tachi, K. Tanie, "A Method for Autonomous Locomotion of Mobile Robots, "in Journal of Robotics Society of Japan, vol. 2, pp.222-231, 1984.

[5] S. Monk, Programming Arduino Getting Started with Sketches, New Delhi, India: Tata McGraw-Hill, 2012.

[6] Open Source community, " Open Source Sketch," January 2015. [Online]. Available: https://www.arduino.cc/en/Guide/Introduction. [Accessed 25 November 2015].

[7] A. Prasad, "Line Following Robot, "Dept. Elex. & Comm. Eng., Visvesvaraya Technological University, Bangalore, India, 2005

[8] S. Bhatia, "Engineering garage, " 23 May 2011. [Online]. Available: http://www.engineersgarag.com//tachometer-microcontroller-circuit

[9] S. Debopath and Md. Jinnah, "Digital RPM meter using Arduino,"Dept. Elect.Eng., Ahsanullah Univ. of Sci. & Tech., Dhaka, Bangladesh, 2012.

[10] Zin, "Alldatasheet," March 2003. [Online]. Available: http://www.alldatasheet.com [Accessed 06 December 2015].

[11] Word press "Turning radius of the Car," July 2013 [Online]. Available: https ://goodmaths.wordpress.com/2013/07/19/turning-radius-of-a-car/.

[12] Intelligent Line Follower Mini-Robot System Roman Osorio C., José A. Romero, Mario Pena C., Ismail Lopez-Juarez, International Journal of Computers, Communications & Control Vol. I

APPENDICES

PROGRAM CODE

Here code is developed in the same view represented by the flowchart. Code accompany with algorithm side of it.

LINE FOLLOWING ROBOT

```
int revleft4 = 10; // Motor Pins

int fwdleft5 = 11;

int revright6 = 12;

int fwdright7 = 13;

int ls=2;

int rs=3;



void setup() {

  // put your setup code here, to run once:

  pinMode(revleft4, OUTPUT); // Set Motor Pins As O/P

  pinMode(fwdleft5, OUTPUT);

  pinMode(revright6, OUTPUT);

  pinMode(fwdright7, OUTPUT);

  pinMode(2,INPUT); //left ir sensor
```

```
  pinMode(3,INPUT);  //right ir sensor

}

void loop() {



int ls=digitalRead(2);

int rs=digitalRead(3);



// line follwer

if(ls==LOW && rs==HIGH)

  {

    digitalWrite(fwdright7, LOW);  //Stop

    digitalWrite(revright6, LOW);

    digitalWrite(fwdleft5, LOW);

    digitalWrite(revleft4, LOW);



  }



  if(ls==LOW && rs==LOW)

  {
```

```
  digitalWrite(fwdright7, HIGH); // Move Left

  digitalWrite(revright6, LOW);

  digitalWrite(fwdleft5, LOW);

  digitalWrite(revleft4, LOW);




 }

 if(ls==HIGH && rs==HIGH)

 {

  digitalWrite(fwdright7, LOW); // Move right

  digitalWrite(revright6, LOW);

   digitalWrite(fwdleft5, HIGH);

  digitalWrite(revleft4, LOW);



 }



if(ls==HIGH && rs==LOW)

{

  digitalWrite(fwdright7, HIGH); // Move Forward
```

```
    digitalWrite(revright6, LOW);

    digitalWrite(fwdleft5, HIGH);

    digitalWrite(revleft4, LOW);

  }

}

 // put your main code here, to run repeatedly:
```

Obstacle Robot Avoiding Code

```
// Obstacle avoiding



int trigPin = 9;      // Trig Pin Of HC-SR04

int echoPin = 8;     // Echo Pin Of HC-SR04

int revleft4 = 10; // Motor Pins

int fwdleft5 = 11;

int revright6 = 12;

int fwdright7 = 13;

 int ls=digitalRead(2);

 int rs=digitalRead(3);



long duration, distance;



void setup() {

  Serial.begin(9600);

  pinMode(revleft4, OUTPUT); // Set Motor Pins As O/P

  pinMode(fwdleft5, OUTPUT);

  pinMode(revright6, OUTPUT);
```

```
  pinMode(fwdright7, OUTPUT);

  pinMode(trigPin, OUTPUT); // Set Trig Pin As O/P To Transmit Waves

  pinMode(echoPin, INPUT); //Set Echo Pin As I/P To Recieve Reflected Waves

  pinMode(2,INPUT); //left ir sensor

  pinMode(3,INPUT);  //right ir sensor



  }




// loop for obstacle avoiding

void loop()

 {



  digitalWrite(trigPin, LOW);

  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH); // Transmit Waves For 10us

  delayMicroseconds(10);

  duration = pulseIn(echoPin, HIGH); // Recieve Reflected Waves

  distance = duration / 58.2; // Get Distance
```

```
  delay(10);

// condistion for obastacle avoide

  if (distance > 20) // Condition For Absence Of Obstacle
  {
    digitalWrite(fwdright7, HIGH); // Move Forward
    digitalWrite(revright6, LOW);
    digitalWrite(fwdleft5, HIGH);
    digitalWrite(revleft4, LOW);
  }

  if (distance < 20) // Condition For Presence Of Obstacle
  {
    digitalWrite(fwdright7, LOW); //Stop
    digitalWrite(revright6, LOW);
    digitalWrite(fwdleft5, LOW);
    digitalWrite(revleft4, LOW);
    delay(500);
```

```
    digitalWrite(fwdright7, LOW); // Move Backward

    digitalWrite(revright6, HIGH);

    digitalWrite(fwdleft5, LOW);

    digitalWrite(revleft4, HIGH);

    delay(500);

    digitalWrite(fwdright7, LOW);  //Stop

    digitalWrite(revright6, LOW);

    digitalWrite(fwdleft5, LOW);

    digitalWrite(revleft4, LOW);

    delay(100);

    digitalWrite(fwdright7, HIGH); // Move Left

    digitalWrite(revright6, LOW);

    digitalWrite(revleft4, LOW);

    digitalWrite(fwdleft5, LOW);

    delay(500);

  }


}
```