Line Follower Cum Obstacle Avoidance Robot (DIY Project)

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Team F

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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 in the surface consisting of a contrasting color. It is designed to move automatically and follow the line. The robot uses an array of optical sensors to identify the line, thus assisting the robot to stay on the track. The array of two sensors 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 properly tuning the control parameters and thus achieve better performance. In addition, the Ultrasonic Sensor is added to avoid any obstacle present, and divert from its path and come back again to its trajectory. It can be used as industrial automated equipment carriers, small household applications, tour guides in museums and other similar applications, etc.

Acknowledgement

We wish to express our profound and deep sense of gratitude to Professor. Vikranth Racherla and Professor. Sandeep Saha ,the Project Coordinators, for sparring their valuable time to extend help and review in every step of our project work.

We are really thankful to our professors that we did a lot of research work and came to learn a lot of new interesting things while completing this project.

We are mainly indebted to the authors of many references and articles which were used as the reference.

Last but not the least, we would like to thank our friends and family for their help in every way for the success of this project report.

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. Being an engineer one should have sound knowledge of various other disciplines .Most of the Projects have limited scope to only specific discipline.This would limit ones innovation and Creativity. Through this project we aspire to make connections across several disciplines rather than learning topics in isolation as it combines Mechanical, Electronic, Electrical and Programming skills.

- It gives a 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 a way such that it not only tracks the path and follow it, but also changes its path and returns back to the marked trajectory on any obstacle detection by the Ultrasonic Sensors.

Motivation

How do ants always travel in a line, following an invisible route in search of food, or back home?

How are roads divided into lanes to avoid accidents and traffic jams?

Ever thought about a robot which follows a line? A perfect or near perfect mimic of nature? After all, the purpose of robotics is to recreate in terms of machines what one sees around to solve a problem or to fulfill a requirement. These are some of the uses of Robots in a general sense.

- Industrial automated equipment carriers replicating conveyor belts.
- Entertainment and small household applications.
- Tour guides in museums and other similar applications.
- Second wave reconnaissance operations.
- Automated cars running on roads

And infinitely many more applications. It has been an absolute wonder to us, just to realize the fact that Robots can indeed be of great help to Mankind. In this spirit, we decided to make a Line Follower cum Obstacle Avoiding Robot, so as to explore the vast field of Robotics and Automation on a small scale.

Project 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. Needless to say, there are many more uses of our project in the Real World.

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 lightning and noise.
- It must allow calibration of the line's darkness threshold.
- It must be able to detect obstacles, avoid them, and return to its original trajectory.

Building the Line Follower cum Obstacle Avoiding Robot

Building a basic Line Follower cum Obstacle avoiding Robot involves the following steps.

- Designing the Mechanical Part or the body of the robot
- Defining the kinematics of the Robot
- Designing the control of the Robot
- Implementing the Obstacle Avoiding robot on this prebuilt assembly

The Mechanical part or body of the robot can be designed using SolidWorks or any other CAD software. A basic Line Follower robot can consist of a base at the two ends of which the wheels are mounted. A rectangular sheet of hard plastic can be used as the base. Further a rigid body like a cylinder can be added along with other shaped bodies inter connected with each other by joints, and each with its defined motion in particular direction. The Line follower robot can be a wheeled mobile robot with a fixed base, a legged mobile robot with multiple rigid bodies interconnected by joints.

The next step involves defining the Kinematics of the robot. Kinematic analysis of the robot involves the description of its motion with respect to a fixed coordinate system. It is concerned mainly with the movement of the robot and with motion of each body in case of a legged robot. It generally involves the dynamics of the robot motion. The whole trajectory of the robot is set using the Kinematic analysis. This can be done using Workspace software.

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 the 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 another device to control the motor operation through the motor drivers, based on the sensor output.

Finally, once the Line Follower Robot is made, with the help of UltraSensors , we can sense the distance of the objects in front of the robot and change its track if any obstacle is found. (Note: An obstacle in this case is any object that is within a specific predefined distance in front of the Robot)

Limitations

The system is restrained to the following limitations:

- Works only with static obstacles, not the dynamic one.
- The path should be plane. Or else there is a good chance that the Robot will tip off when it comes across a hilly surface.
- The IR sensors might as well detect the external IR signals and cause the robot to move away from its predefined path.

Potential Optimizations

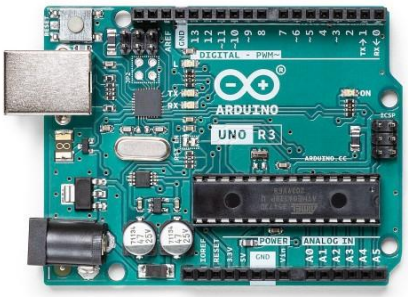
To eliminate/ minimize the above mentioned limitations we have come up with the following ideas. But we haven't been able to implement them, given the strict 3-week time constraint .

1. If the robot were to work in an oblique plane, then the steering system has to be changed into a more advanced system. We might have to implement an Ackerman Steering system, with proper gears and Stepper motors. This hugely decreases the slipping ability of the bot . And thus, the bot can even work in an uneven workspace.

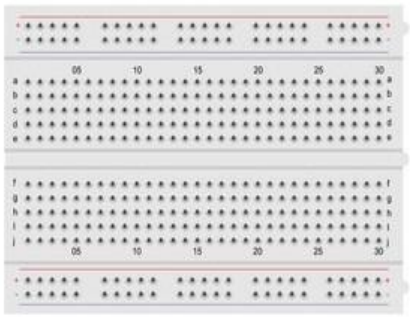
2. To counter the IR sensors issue, we will need to channelize the sensors even more closer to the Line, at the same time keeping in mind the durability of the components.

Hardware Components used

Arduino UNO (Input System)



Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins: 6 are PWM outputs, 6 analog inputs, 16 MHz ceramic resonator, USB connection, power jack, ICSP header and a reset button. Connect it with a computer/laptop using USB connection to get started.

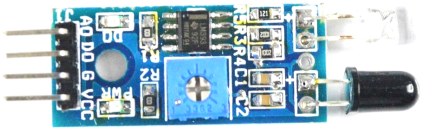


Breadboard

A breadboard, or protoboard, is a construction base for prototyping of electronics. It has 2 power buses, 10 columns, and 30 rows- a total of 400 tie-in points. It is reusable because the solderless breadboard does not require soldering. Modern breadboards have high parasitic capacitance, relatively high resistance, and less reliable connections, when compared to permanent circuit

IR Sensors (Output System)

IR Sensor is an electronic device that emits light in order to sense some objects of the surroundings. It can measure the heat of an object as well as detect the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiation are invisible to our eyes, but infrared sensors can detect these radiations.



Ultrasonic Sensor (Input System)

An ultrasonic sensor is an electric device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electric signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). They have two main components: the transmitter and the receiver.

L293D H-Bridge Motor Driver(Output System)

L293D IC is a typical Motor Driver IC which allows the DC motor to drive in any direction. This consists of 16-pins which are used to control a set of two DC motors instantaneously in any direction. Therefore, we can use two DC motors. Single L293D IC consists of two H-bridge circuits inside which can rotate two DC motors separately.

6V DC Motor (Output System)

A DC motor is any motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. A 6V DC motor is small and inexpensive, yet powerful enough to be used for many applications. It turns electricity into motion by exploiting electromagnetic induction.

Male-Female Jumper Wire

A male connector is commonly referred to as a plug and has a solid pin for a center conductor. A female connector is commonly referred to as a jack and has a center conductor with a hole in it to accept the male pin.

Software Used

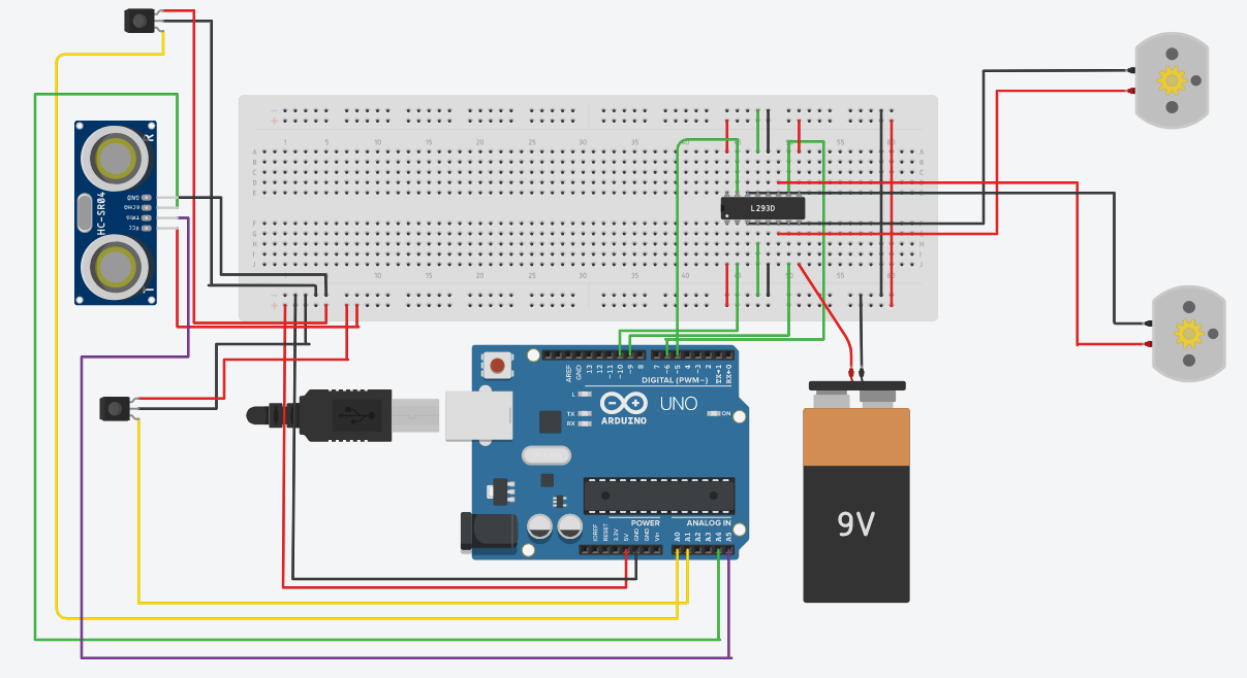
Our project uses TinkerCAD for the stimulation of the circuit. For coding and uploading the sketch, Arduino 1.8.15 is used.

Design And Implementation

Schematic Circuit Diagram

The schematic circuit diagram of the “Line Following Cum Obstacle Avoidance Bot” is given in the figure. We have used the components that were described in the Hardware Components used section. We used the IR sensors to detect the black line, thus making the Robot act like a Line Following Robot. We then used an Ultra Sensor to detect the distance of any object that comes in the locus of the Bot. If this distance turns out to be less than the minimum distance that we set (in the Code), then that object would be identified as a Potential Obstacle. Then the robot will change its course away from the obstacle.

Integrated Circuit Diagram



Integrated Circuit Program Code

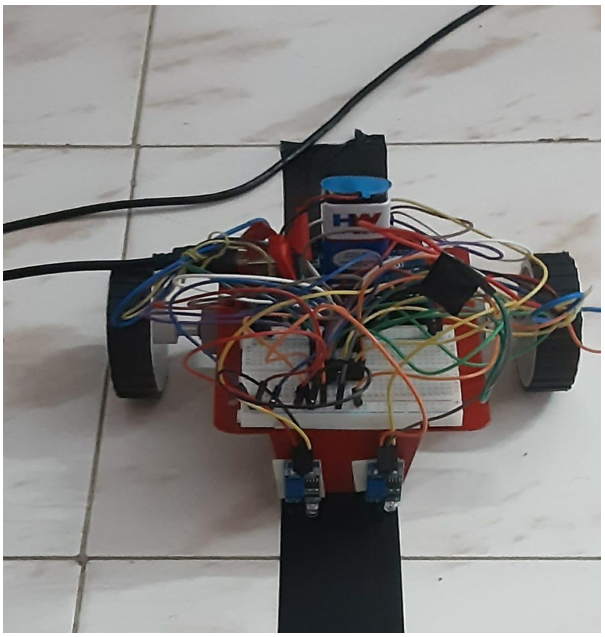
```
#define echopin A4 // echo pin
#define trigpin A5 // Trigger pin
// Ultra Sensor setting
int motor_r2 = 9;  //Initialisations
int motor_r1 = 10;
int motor_l2 = 5;
int motor_l1 = 6;
int speed = 115;
int  frontdist;
long duration;
int setdist= 30; //minimum distance
int L_S = A0; // IR sensor Left
```

```
int R_S = A1; //IR sensor Right
void setup(){
pinMode(motor_l1, OUTPUT); //Setting up pins with their assigned modes
pinMode(motor_l2, OUTPUT);
pinMode(motor_r1, OUTPUT);
pinMode(motor_r2, OUTPUT);
pinMode (trigpin, OUTPUT);
pinMode (echopin, INPUT);
pinMode(11,OUTPUT);
pinMode(3,OUTPUT);
pinMode(L_S, INPUT);
pinMode(R_S, INPUT);
Serial.begin(9600);
delay(1000);
}
void loop(){
frontdist = data();
Serial.println(frontdist);
if(frontdist>setdist){ //Case if obstacle is far from the bot
if ((digitalRead(L_S) == 0)&&(digitalRead(R_S) == 0)){forword();}
if ((digitalRead(L_S) == 0)&&(digitalRead(R_S) == 1)){turnRight();}
if ((digitalRead(L_S) == 1)&&(digitalRead(R_S) == 0)){turnLeft();}
}else{ //If the bot is at a distance less than the specified minimum distance from the
obstacle
turnLeft();
delay(350);
forword();
delay(1000);
turnRight();
delay(200);
```

```
forword();
delay(500);
}
}
long data(){
 digitalWrite(trigpin,LOW);
 delayMicroseconds(2);
 digitalWrite(trigpin,HIGH);
 delayMicroseconds(10);
 duration=pulseIn (echopin,HIGH);
 return duration / 29 / 2;
}
void stop(){ //Defining function for the bot to stop
 analogWrite(motor_l1, 0);
 analogWrite(motor_l2, 0);
 analogWrite(motor_r1, 0);
 analogWrite(motor_r2, 0);
}
void forword(){ //Defining function for the bot to move forward
 analogWrite(motor_l1, speed);
 analogWrite(motor_l2, 0);
 analogWrite(motor_r1, 0);
 analogWrite(motor_r2, speed);
}
void backword(){ //Defining function for the bot to move backward
 analogWrite(motor_l1, 0);
 analogWrite(motor_l2, speed);
 analogWrite(motor_r1, speed);
 analogWrite(motor_r2, 0);
```

```
}
void turnRight(){ //Defining function for the bot to turn right
analogWrite(motor_l1, 0);
analogWrite(motor_l2, speed);
analogWrite(motor_r1, 0);
analogWrite(motor_r2, speed);
}
void turnLeft(){ //Defining function for the bot to turn left
analogWrite(motor_l1, speed);
analogWrite(motor_l2, 0);
analogWrite(motor_r1, speed);
analogWrite(motor_r2, 0);
}
```

Project Image



Conclusion

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

This project report presents an Ultrasound Sensor based line following robot design which always directs along the black line on white surface. The electromechanical robot is with max rpm 115 at no load, frictionless conditions.

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

Future Modifications

In the process of development of the line follower, most of the useful features were identified and many of them were implemented. But due to time limitations, some of them couldn't be added. A few future development features in this robot can be:

- Use of color sensors.
- Use of a ccd camera for better recognition and precise tracking of the path.

Tasks Done By Each Team Member

Jessica John Britto

Hardware management - assembled the ordered components as per our team's plan, Data curation.

G.V.K. Sai Sarath

Software management, Data curation, Supervision, presentation making, circuit original draft making

Muskan Malik

Software management, circuit draft editing and finalisation, report work, presentation making

Vinay Siwach

Software management, presentation making, circuit draft editing and finalisation, report work

Project Estimate

Sr. No.	Name of the object	Cost
1.	Arduino Uno R3	585/-
2.	DC Motor x 2	260/-
3.	Ultrasonic Sensor HC-SR -04	150/-
4.	IR Sensor x 2	130/-
5.	6V Battery	110/-
6.	Breadboard	65/-
7.	H-Bridge Motor Driver	64/-
Total Cost		1364/-

References

https://create.arduino.cc/projecthub/embeddedlab786/line-follower-and-obstacle-avoiding-robot-baa2bb

https://www.elprocus.com/line-follower-robot-basics-controlling/

https://www.youtube.com/watch?v=QKXEycqRphg

https://www.allaboutcircuits.com/projects/how-to-build-a-robot-line-follower/

Link to TinkerCAD Integrated Line Follower cum Obstacle Avoidance Bot Circuit Design

https://www.tinkercad.com/things/1DNUr5aYzDL-line-follower-cum-obstacle-avoidance-bot-/editel?sharecode=Gw2LdWsllhorcZXuF2S1VT1c-xan5qFqLNr6fM3q5Vk

Link to TinkerCAD Line Follower Bot Circuit Design

https://www.tinkercad.com/things/5mDrYgGNHIp-swanky-jarv/editel?sharecode=cyBxH4Tbv4X34eW_w_DJ7MChZwrXvxsEe_mZX0aRMl8

Link to TinkerCAD Obstacle Avoidance Bot

https://www.tinkercad.com/things/kOzV8VF4q9P-copy-of-obstacle-avoidance/editel?sharecode=fr84VOYvGXS41pL1V1qtuu2fhZMN8CL925llta6xqJs