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Path Follower & Obstacle Avoidance Smart Robot Vehicle: Applications of Arduino Programming

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Abstract

This paper is intended on a practical approach to design a prototype Robotic Vehicle by using application of Arduino Programming. The robotic vehicle follows a specified path using an IR sensor. The designed robotic vehicle was smart enough to follow the path and directions in given space. It moves& navigates automatically on specified black lines marked on surface. A customized programme coding was also done to perform customized function. Such programmed robot may be useful in several mechanical, industrial, medical & Army operations and can save cost of human labor, human life at hazardous location & time.

Keywords: Robotic Vehicle, IR sensor, IC l298,Arduino Programming ATmega328. .

Introduction

A path follower robot vehicle is capable of moving on black line on the surface without requiring either a guide or remote control. Robots are smart machines designed to reduce manpower at work. It is often developed to reduce risk factors to human work and increase worker comfort. Younus et al mentioned in their paper that High performance, precision, low labor costs and the ability to work in hazardous locations put the robot at an advantage compared to many other similar technologies (Younus, Gadekar &Walse[1]).

This paper is on actual making of original design and tests the functions of basic robotic vehicle using Arduino application by author. The robot vehicle was smart enough to follow automatically and navigate on black stripped line on the surface while using IR sensor and ATmega 328 microcontroller. The Arduino application is useful in designing of guided robots at low cost.

Such battery backed up robotic vehicle may be used in many applications such as in hazardous mining operation, support to hospital patients, many surface agricultural operations and army operations without using human power, such design not only save labor cost & time but precious human life at low investment. and much time can be save.

Objective

1. To design and make low cost & test the prototype robotic vehicle using Arduino application.
2. To write customized programme coding for a smart machine.
3. To suggest a cost model for robotic vehicle.

Conceptualization of Idea& making of prototype smart Robotic Vehicle by using Arduino Programming

Idea behind making this robotic vehicle came out of interest and curiosity.

Focused study materials were studied to develop the conceptual background for making smart robotic vehicle. Simultaneously, some working models were also observed to work upon the idea and it was tried that a low cost design can be developed to solve the day to day issue in many operations.

Lots of thinking and brain storming was put to start work on the concept. Guidance and assistance from faculty, parents, friends & professionals were also taken to start the ground work and finally design of this machine was made.

However, overall idea was to design such a basic robot which can assist & support in reducing cost of operations in day to day operations at many working place and also to reduce risk to human life at hazardous place.

Design and construction of Line follower Smart Robot Vehicle

Based on the conceptual background and study of predesigned model of machine, an action plan was prepared to develop a low cost and useful model.

The following action plan was followed for the proposed machine:

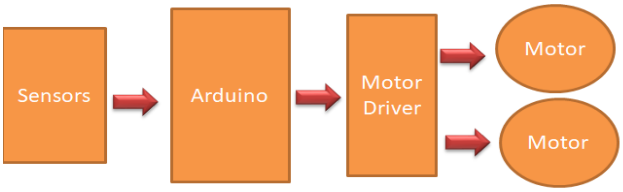
- Block diagram of Robotic Vehicle
- Design of Robotic Vehicle
- Purchase of required components
- Code writing & Programming to run the model
- Test of Model function
- Improvement in model after run, if any
- Finalization of Model

1. Block Diagram of Line Follower

A functional diagram was followed for a line follower using

8IR sensors with Arduino Mega 2560connectedvia a motor driver IC including 6 ultrasonic sensors, Bluetooth module & buzzer. The sensors were connected to the line robot using the following block diagram to detect obstacles on the line tracer.

Block Diagram of Line Follower Robotic Vehicle



2. Design of Robotic Vehicle

Initially a pre- fabricated metallic chassis was used to install the desired equipment, however the metallic chassis was replaced latter with plastic quoted fiber chassis, as metallic chassis was not suitable to make necessary alignment and fixation of equipment over it.

Some necessary design changes were made in chassis so that planned equipment may be fitted without suitably and draft skeleton drawing design of robot vehicle finalized

3. Purchase of Components & Description

Based on action plan the following components were purchased on line and certain circuit material was purchased from local market. Other supporting machine for installation was already available in the laboratory.

The making of proposed robot was as per budget available. This project was not sponsored rather out of pocket expenditure.

Accordingly, authentic components were purchased and the details of components are as follows:

i) Chassis and bodywork

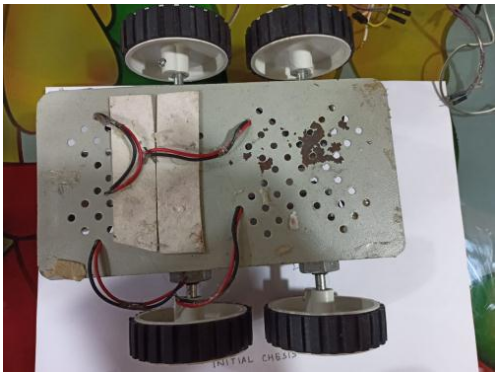


Fig1: Initially selected aluminum chassis (Source: author)

Initially aluminum chassis was bought but it was not suiting for installation of planned components over it, so it was changed with plastic chassis and some minor changes were done to fit the components on it. The final chassis was used is shown in picture below:

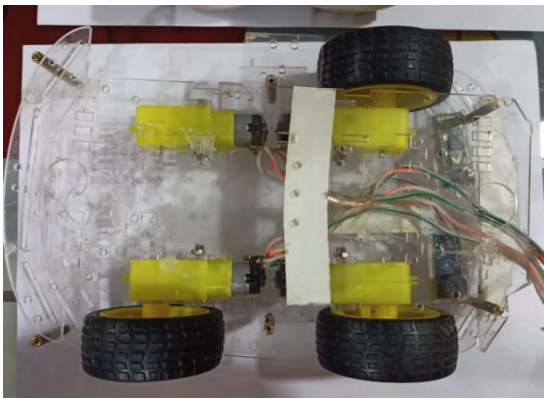


Fig 2: Plastic molded chassis (Source: author)

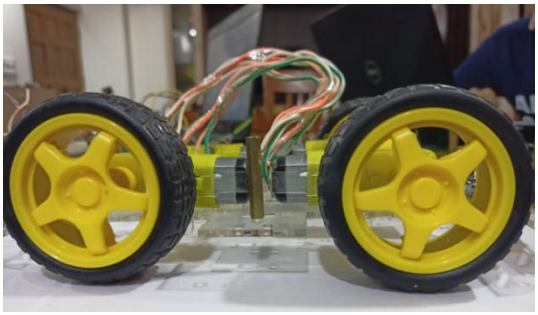


Fig 3: Side view of Chassis (Source: author)

The benefit of plastic body chassis is that it gives flexibility for need based minor modification and adjustment for fitting and fixing the components over it without changing the base design.

ii) Arduino Mega 2560

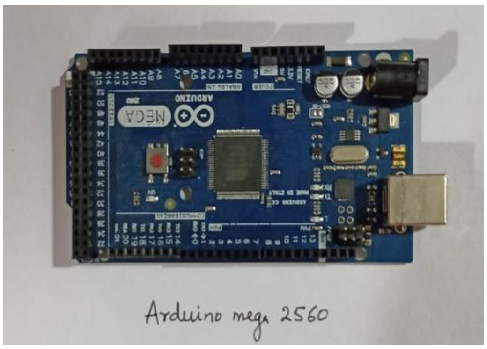


Fig 4: Arduino Mega 2560 (Source: author)

Specification of Arduino

There are several types of Arduinoboards available in the market but the one we are going to be focusing on in this

manual is Arduino Mega 2560. The reason why this board is so balanced:

- 16Mhz processor ATmega328
- It has a flash memory of 256KB
- RAM of 4KB
- Operating Voltage of 5V
- Input Voltage of 6V-20V
- 16 analog inputs
- 54 digital inputs out of which 12 are pwm

Being open sourced, Arduino platform is to build electrical projects. It consists of two important sections, namely, IDE and programmable circuit board. The IDE uses C# or embedded C programming language which is easier and simpler compared to C or C++ programming language. This helps in making it a fun and easy way of learning and understanding Arduino.

Methods for supplying power to the board:

Barrel Jack: DC power jack is a wall adaptor and can supply power from anywhere from 5V to 12V.The recommended power requirement is 7V to 12V.

VIN Pin: This is another way of powering the board but in this case an external power supply is used and connected to VIN pin. The power supply variation is possible.

USB Cable: Lastly, it can also be powered when attached to thecomputer.

Further, certain pins which are necessary for the working for board and external components are as follows:

GROUND-The Arduino Mega 2560 has seven ground pins. The function of this pin is basically to complete the loop.

RESET- resets the board along with the program.

iii) IC l298

2-way DC motors are generally controlled using HBridge. L298 is the most affordable motor in the market as of the moment. HBridge motor can be easily built for high current motor on our own at home, making it cheaper.

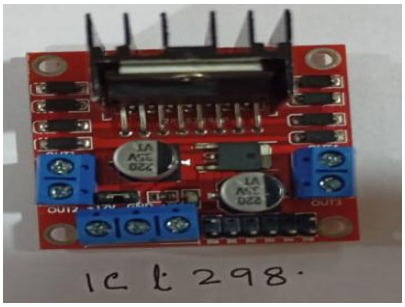


Fig 5: L298 Module (Source: author)

Motor driver amplifies the low current signal and sends a high current signal so that the motor can be driven. This motor control chip can control two small motors in two directions at the same time. Forward and reverse with only 4 pins of the microcontroller.

iv) 8 IR Sensor

The infrared sensor detects the position of the road locator in relation to the position of the robot. In line detection operations, IR sensors are most commonly used in the making of line follower autonomous robot. The fundamental of working of IR sensor are that the black surface reflects less light then white surface, so the amount of light reflected back can be measured. Now using 8 IR sensors in a straight line helps massively in staying on the line always since the black line will always be under at least one of the IR sensors and hence the robot could detect the line faster and turn smoother if going off the path. This won't be possible if we use only 2 IR sensors since we would program the robot to turn only if a black line is detected and hence it could lose the path easily if it doesn't turn on time. So the solution is generally using a 5 or sometimes 8 (like in our case) to always keep track of the black line.

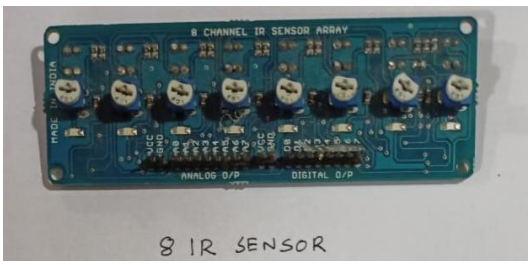


Fig 6: 8 IR Sensor (source: author)

v) Ultrasonic sensor:

Ultrasonic sensor is general used to measure the distance of an object. It send an ultrasonic pulse using a transducer and then receives it back and then the time taken for the pulse to be received can be used to measure the distance of the object. It has some flaws. It might not detect very small or thin objects since the object won't get hit by the ultrasonic pulse and therefore can't be received back. Also it relies on the reflectivity of the object. It the object absorbs it, and then it can't be detected as well. Now, using 6 ultrasonic sensors, we can angle each on differently so that we can have a full 180 degree, to detect all the objects on the field of view of 180 degree.

This in turn also helps in object following, as we can detect any object within 180^0 field of view. And therefore its functionality can change according to our needs.

Fig 7: Ultrasonic sensor (Source: author)

vi). Bluetooth module HC-05:

Bluetooth module works on the principle of serial communication. The module receives the signal from an app installed on the phone or any Bluetooth device, when the button is pressed on the device, the signal is transmitted and the Bluetooth module detects it and receives it and then forwards it to the arduino board. The arduino board then processes the signal and then executes the commands as programmed.

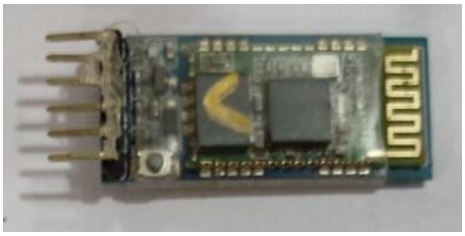


Fig 8: HC Bluetooth Module (Source: author)

vii). Buzzer:

Buzzer is a simple arduino component that produces a sharp sound when given the command. It is just an output device.

Fig 9: Buzzer (Source: author)

4. Code writing & Programming to run the model

i) Process of detecting a line and avoiding the obstacle:

Sensors are used to detect straight lines. An array of 8 infrared sensors is mounted under the robot and the ultrasonic sensor on top facing 6 directions making it 180^0. The 8 IR sensors keep the robot on line and the ultrasonic sensor keeps it from colliding an obstacle. The power supply from the 9V DC power adapter powers all sensors and motor control, as well as motors, the ultrasonic sensor, the Bluetooth module, the buzzer and the arduino. Useful for power outage-free setup the sensor circuit outputs are connected like analog inputs on an arduino board.

Fig 10 : Basic design of Robotic vehicle (source: author)

ii) Algorithm:

Firstly, the Bluetooth module receives the mode it is going to run in, then:

If the mode is Ultrasonic + IR sensor, then:

If the ultrasonic sensor doesn't detect any obstacle in front of it:

- If the 3rd, 4th, 5th or 6th sensor detects the black line, or the combination of sensors detecting black line is 4th and 5th, then the robot will move forward.
- If combination of sensor is 3rd and 4th, the robot will slowly turn to the right.
- If combination of sensor is 5th and 6th, the robot will slowly turn to the left.
- If the black line is detected by 1st, 2nd or the combination of sensor detecting the black line is, 1st and 2nd, 2nd and 3rd then the robot would turn right
- If the black line is under 7th or 8th sensor or the combination of sensor is 6th and 7th, and 7th and 8th then the robot would turn left.
- If the black line is under all the sensors, then the robot would stop and sound the buzzer.
- In any other case, it would keep moving.

❖ If the command received by the robot from the Bluetooth module is only ir sensors, then the robot won't take values from any ultrasonic sensor and hence it won't matter if there is an obstacle in front of it or not.

❖ If the command received is only ultrasonic sensor, then the robot wont be following any black or white lines. It would simply follow the object or human in front of it.

iii) Code for line follower robot:

Code was written to run the application; the sample code is given below:

```
Int Speed=100;
Int turn=200;
Int td=10;
const int motor1=8;
const int motor2=10;
const int motor1speed=9;
const int motor1=12;
const int motor2=13;
const int motor2speed=11;
const int left=A0;
const int right=A1;
int left;
```

```
int right;
voidsetup(){
pinMode(motor1,OUTPUT);
pinMode(motor2,OUTPUT);
pinMode(motor1,OUTPUT);
pinMode(motor2,OUTPUT);
Serial.begin(9600);
delay(3000);
}
voidloop(){
l= analogRead(left);
r=analogRead(right);
if(r>500&&l<500)
{
Serial.println("right");
digitalWrite(motor1,LOW);
digitalWrite(motor2,HIGH);
digitalWrite(motor1,LOW);
digitalWrite(motor2,HIGH);
analogWrite(motor1speed,Speed);
analogWrite(motor2speed,turn);
}
if(r<500&&l>500)
{
Serial.println("left");
digitalWrite(motor1,HIGH);
digitalWrite(motor2,LOW);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,LOW);
analogWrite(motor1speed,turn);
analogWrite(motor1speed,Speed);
delay(td);
}
if(r>500&&l>500)
{
Serial.println("forward");
digitalWrite(motor2,LOW);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,HIGH);
digitalWrite(motor1,LOW);
analogWrite(motor1speed,Speed);
analogWrite(motor2speed,Speed);
delay(td);
}
if(r<500&&l<500)
{
Serial.println("stop");
analogWrite(motor1speed,0);
analogWrite(motor2speed,0);
}
}
```

Fig 11: Sample coding (Source: author)

5. Test of Model Function

After coding & Programming the model was put on run. The model robotic vehicle was able to follow the computer command and was following the path and able to detect obstructions but due to initial balancing issues like setting up 6 sensors, buzzers on chassis there was movement problem. However, these small challenges were fixed by adjusting the fitted components. And finally robotic vehicle was able to run smoothly.

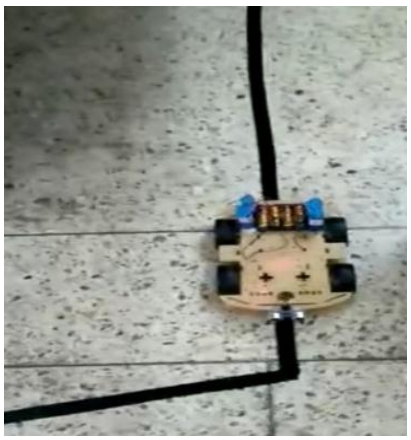


Fig 12: Line follower robotic vehicle (source: author)

6. Design Improvements after Trail Run in Model & Finalization of Line Follower Smart Robotic Vehicle

As development of machine was progressing several requirements were also arising, however, keeping costing in view, it was tried that a robust model should come on ground without escalating the cost and without compromising the engineering functionality of robotic vehicle.

Some major and minor challenges were faced during making of this prototype model. Among them major challenges were

as under:

1. How to make vehicle to sense 180^0 movement
2. Consumption of power
3. Balancing of vehicle with components load
4. Circular movement of vehicle on four wheels
5. Arrangement of electrical wiring
6. Short circuit of components & power load

The robot built doesn't give enough power to all the components. The amount of current is restricted and hence the bot doesn't function as intended. The correction needed to be done is to connect all the sensors parallel to one 24v supply of battery. And then connect the arduino and motor driver to another battery supply of 12V. In this way, all the components can get enough voltage and current and work as intended. A high capacity rechargeable battery is advised for long run of the robot.

However, some of challenges were resolved but still there is need to improve this model in future.

7. Final Robotic Vehicle model for use:

After overcoming technical challenges a final prototype model was ready to function on its own. The machine was functioning well on its own on given command.

This smart line follower robotic vehicle was show cased in some of the robotic competition events in Kolkata by the author and was appreciated for effort but could not win award due to lack of functioning documents.

However, further work is going on to improve its function & design.

Cost Model

The whole process has consumed time and incurred cost. The details of man days and costing in US $ is given below in table 1:

Table 1: Costing sheet of project

S.No.	Name of Component	Quantity	Price per unit (US$)	Total Price (US$)
1	8 IR Sensors	1	6.36	6.36
2	Ultrasonic Sensors	6	1.07	6.43
3	Bluetooth	1	3.57	3.57
4	Buzzer	1	0.57	0.57
5	Arduino Mega 2650	1	13.00	13.00
6	I 298	1	1.79	1.79
7	Chassis	2	14.64	29.29
8	Battery (up to Trial)		0.29	7.14
9	Electric Plastic Black Strip	2	2.86	5.71
10	Soldering & adhesive tape		1.00	1.00
11	Wires & Miscellaneous		2.86	2.86
12	Number of working Hours	61	0.00	0.00
	Total		**43.86**	**77.71**

Currency Conversion rate: 1 US$= INR 70

So, there was total costing of US$ 77.71 up to final trial of model. However, man days cost has not been considered for this project.

CONCLUSION:

By application of Arudino programming line follower robotic vehicle and other robotic machines can be designed and run. This application is very good and easy to use for robotic learners. Such machines may be useful in many operations like mining operations where space is constraints, reaching narrow and dark place by human, agricultural operations and can be sent to hazardous location to carry out operations. Such machine also saves time and labor cost by which cost of production can be brought down for many operations without affecting the quality of operations.

The short video of line follower robotic vehicle was also made and available with designer cum author of this paper.

Way Forward:

The option for further improvement in design and make may be on the following lines:

- Use of GPS to detect the location of machine
- Installation of Pay loader to increase use of robot
- Option of Speed controller
- Use of 360^0 sensors
- Addition of other robotic applications & integration

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