Path Following Robot using Arduino and IR Sensors

Om Rajkumar Solavat[1]

[1]K.J. Somaiya College of Engineering, Somaiya Vidyavihar University, Mumbai, Maharashtra
[2]Professor Vaibhav Narwane, Dept. of Mechanical Engineering, Somaiya Vidyavihar University, Mumbai, Maharashtra

---***---

Abstract - *This project aims to design and fabricate a mobile robot that can follow the path with the help of IR Sensors. Path following proves to be very useful in today's modern technology and it is still considered an important field of robotics. This type of robot is based on decision-making algorithms. The main aim of this project is to make an Arduino-based efficient self-directed path-following robot. A simple path-following algorithm "LSRB algorithm" is used to make this robot. In this project, Hardware development, software development, and path construction have been done. For capability testing, the robot will implement to follow the black path and complete the maze.*

Key Words: Autonomous Mobile Robot, Arduino, LSRB Algorithm, Decision -making algorithm, Path Follower Robot, IR Sensor.

1. INTRODUCTION

Path planning in Autonomous Mobile Robot Navigation is an important part of the robotics field. Autonomous Mobile Robots (AMRs) can be defined as robotic systems that are able to navigate without disruption and no human intervention in their movement, to avoid obstacles and follow a predefined path (1). The demand for AMRs is rising to its peak across various applications such as logistics transportation (2), robotic cleaning services (7), and surveillance for various purposes. This type of robot can also become a boon in the agriculture field if it is properly designed for unpredictable agricultural climates solving many problems for humans like labor shortages, natural phenomena, and economic issues (3).

AMRs usually navigate through a globally defined geometric path with loose time constraints and can be divided into control theory-based methods and geometric methods (5). Control theory-based methods, such as Proportional–Integral–Derivative (PID) controllers, face challenges in finding optimal parameters (4). Geometric methods, compared to control theory-based methods, have become more popular due to their simplicity, robustness, and suitability for real-time control. The Pure Pursuit (PP) controller, proposed as the earliest geometric approach for path following, fits a circle through the vehicle's current position to a point on the path ahead of the vehicle by a look-ahead distance (5).

Path-follower robots are used in industry to transport materials and objects autonomously by following a particular path, which may be drawn lines or magnetic tapes on the floor that are detected by a sensor array. High performance, high accuracy, lower labor cost, and the ability to work in hazardous places have put robotics in an important position over many other such technologies (6). In this paper path following robot has been presented which will trace a black path on a white surface with the help of IR Sensors, Arduino Board microcontroller, L298N Motor Driver, etc. AMRs follow the LSRB Algorithm, which is usually used in this type of robot. Therefore, this kind of Robot should sense the line with its Infrared Ray (IR) sensors installed under the robot. After that, the data is transmitted to the processor by specific transition buses. Hence, the processor is going to decide the proper commands and then it sends them to the driver and thus the path will be followed by the line follower robot.

Bhargav Srinivasan and S. Siva Sathya propose a genetic algorithm-based approach for maze solving using a mobile robot. Ajith Abraham and Crina Grosan propose a hybrid approach, which combines a genetic algorithm with a fuzzy logic controller to generate an optimal path through the maze. H.N. Krishnan and K.K. Gowtham (2018) built a robot whose movements are controlled by an Arduino microcontroller, which receives input from the image processing algorithm.

1.1 Background of work

In the middle of the 20th century, Path-following problems become an essential field of robotics. In the year of 1972, editors of IEEE Spectrum magazine came up with the concept of a micro-mouse which is a small microprocessor-controlled vehicle with self-intelligence and capability to navigate a critical path. Then in May 1977, the fast US Micro mouse contest, called "Amazing Micro mouse Maze Contest" was announced by IEEE Spectrum. From then, this type of contest became more popular, and many types of maze-solving robots are developed every year. In the late 1970s, the designs of the path-solving robots' designs were used to have huge physical shapes that contained many blocks of logic gates.

1.2 Objectives

The goal of the project is to build a microcontroller-based system that is the brain of the robot, it is used to collect information from various input devices such as sensors to follow the path, by achieving the following objectives:

1- Design a small-scale robot that can follow the path and solve it.

2- Assemble the hardware components like sensors, motor driver, and Microcontroller.

3- Convert the approved algorithm into a code to control the robot.

4- Make a required path.

5- Capturing the line position with IR sensors mounted at the front end of the robot.

2. Path Follower Robot

2.1 Block Diagram

Initially, I chose a configuration to build a path follower using four Infrared Sensors (Although only 2 IR Sensors are shown in the block diagram) with a connection of an Arduino Uno microcontroller through an L298N Motor Driver. Below is the block diagram which was followed as a reference in the making of the robot. It illustrates the connection for the development of the line follower which follows a black path on a white surface.

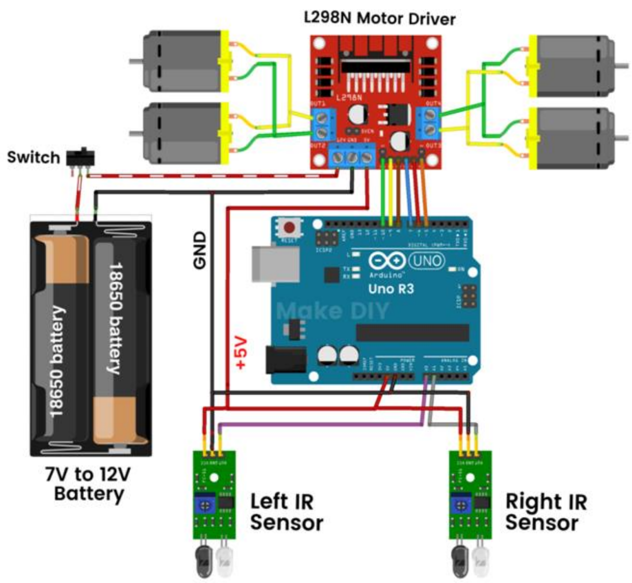

Fig -1: Block diagram of circuit connections used for reference

2.2 Components used

1) 4WD Car kit

Fig -2: 4WD car kit

Kit contains 12 volts DC motors, Wheels, Nuts and Screws, chassis, and jumper wires.

2) L298N Motor Driver

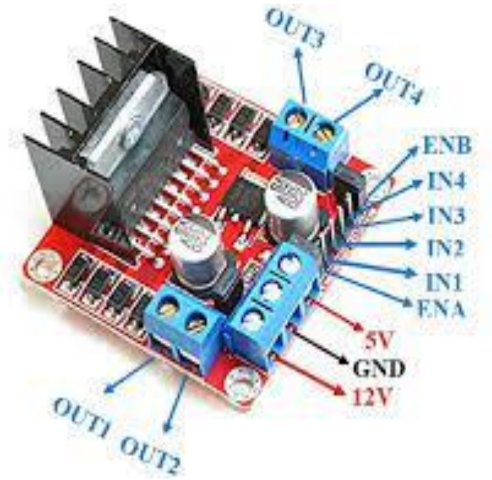

Fig -3: L298N Motor Driver

The L298N is a dual H-Bridge motor driver that controls the speed and direction of DC motors. Four DC motors were connected to L298N, two on the right side and two on the left side. The module can drive DC motors that have voltages between 5 and 35V, with a peak current of up to 2A.

3) Arduino Uno

Fig -4: Arduino Uno Board (Microcontroller)

- Processor-ATMEG328P
- Input Voltage-5V/7-12V
- Speed of USB-16MHz
- Digital I/O pins-14(6 PWN)
- Analog I/O Pins- 8

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board and an IDE that runs on your computer, used to write and upload computer code to the physical board. The Arduino IDE uses a simplified version of C++, making it easier to learn to program.

4) IR Sensors

Fig -5: Infrared Sensor

- Main chip – LM393
- Operating Voltage – 3.6/5 V
- Effective measuring range – 2 cm to 80 cm

Infrared Sensors are utilized to find out the position of the path with respect to the position of the robot. The White surface of the path reflects the light and the black path receives it after the transmission. There are 4 IR Sensors, 1 to the right, 1 to the left, and 2 in the middle. Right and Left IR Sensors will run over the white surface and the middle sensors will run over the black path. This will help the robot to follow the black path in a straight motion.

In this condition, a sufficient amount of light gets reflected back to the LDRs. So, their resistance will be low. So, the voltage dropped across the LDR will be low. When the robot drifts to one side, the sensor on the opposite side falls over the black line and the intensity of light reflected back to the corresponding LDR will be low. As a result, the resistance of the LDR shoots up and the voltage dropped across it will be high. The voltages dropped across the right and left LDRs (nodes marked R and L in the above circuit) are given as input to the analog input pins A3 and A4 of the Arduino board. These sensors are connected to the Chassis and then used for our system.

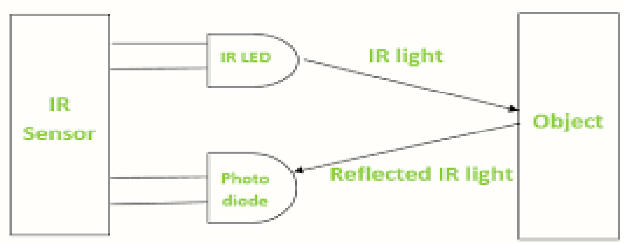

Fig-6: Working of IR Sensor

3. Procedure of sensing the Path

Path Following robot is very similar to the Line Follower Robot. In this project, sensors are used to detect the path rather than sensing the light. Hence any kind of light-sensitive sensor could be used for the robot to follow the path. So Infrared ray sensor will first send a wavelength for detecting a black path and then other infrared ray sensors will be receiving the information and make the decision to follow a black path on a white surface.

In this way, Sensors attached in the front of the chassis give signals to the microcontroller. The microcontroller receives this input from the IR Sensors, processes it according to the programming done in the Arduino, and gives the signals to the Motor driver. Motor driver L298N, according to the input received from the Arduino, controls the DC motors. This entire mechanism results in the robot following the path and reaching its end. “LSRB Algorithm” is used for the programming of the robot.

The robot body (chassis) is three-layered. It is made of laser-cut fiberglass. Arduino nano and L298N motor drivers are placed on the chassis. 4 DC motors with the 4 wheels are attached to the chassis. Connections from L298N to Arduino and Arduino to IR Sensors are made using breadboard. The 12V Battery is connected to the L298N motor driver

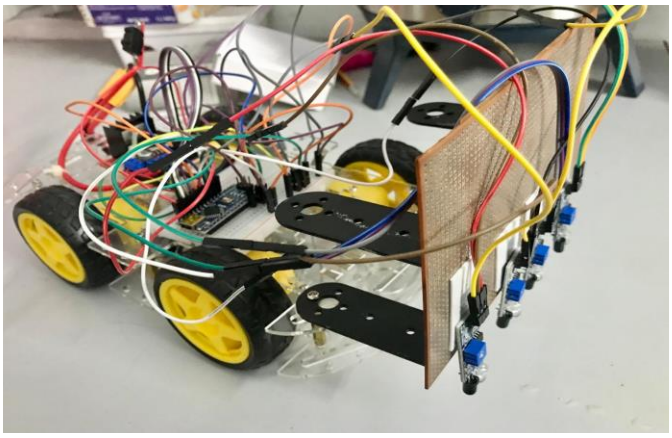

Fig-7: Actual Path Follower Robot Image

4. LSRB Algorithm

This is the algorithm by which the robot follows the path. In "LSRB", L stands for 'LEFT', S for 'STRAIGHT', R for 'RIGHT', and B for 'BACK' or BACKWARD. These LEFT, RIGHT, STRAIGHT, and BACK are the directions that the robot follows. In this algorithm, the LEFT direction has the highest priority and the BACK (U-Turn) direction has the least priority. Let's see what this algorithm looks like:

- Step 1: Always follow LEFT whenever there is a turn possible7.
- Step 2: If LEFT is not possible, go STRAIGHT.
- Step 3: If LEFT and STRAIGHT both are not possible, take RIGHT.
- Step 4: if LEFT, STRAIGHT, and RIGHT are not possible, go BACK (or it means, take a U-Turn)

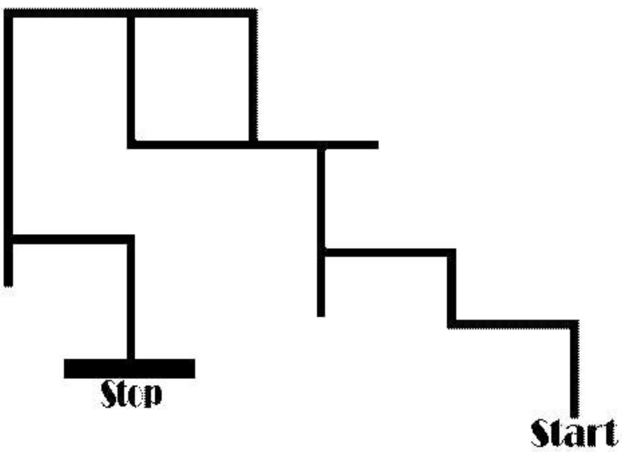

Fig-8: Path layout for the robot

5. Results and Discussions

The robot solves the Path. Because of the front sensor robot moves forward and because of the left and right sensors it takes the required turns. The robot follows the LSRB Algorithm to travel till the Path ends. This type of robot can also be made by using ultrasonic sensors that detect obstacles and solve the path. The Time Required by the car to cover a distance of 60cm path is approx. 4 sec. The speed of the car is approx. 15 cm/s or 220 RPM. IR Sensors detect the path in the range of 2cm-80cm by increasing or decreasing its sensitivity. The Robot runs on the Black path of the maze using IR Sensors. IR sensors give output as 0 when it detects a black path/no object and 1 when it detects a white path/object. Arduino UNO Board (which acts as a micro-controller) takes input from Infrared Sensors and transfers output into the L298 Motor driver, which controls all the DC motors according to the program. This whole system connected Altogether works as a Path Solving Robot.

6. Conclusion

Nowadays, robots are widely used in various critical and dangerous finds. This project is based on decision-making algorithms. So, it can be used in various intelligence fields. It can be used for rescue operations, navigation problems, search operations, medical attention, military search and rescue, etc. There are many caves, that are like mazes where humans could get lost. This robot can find its way out again. It can also be used in too small or dangerous caves where humans can't enter. High-performance sensors can be used by us for the better-performance robot. Instead of using a path, we may add an ultrasonic sensor to let the robot move in the natural environment by avoiding any obstacle it may face while moving. We can add PID control to make our function well by managing the speed of our motor which is done by calculating the error value.

7. References

1. A review on challenges of autonomous mobile robot and sensor fusion methods. **Alatise, M.B. and Hancke, G.P.** Akure, Nigeria : IEEE, 2020, Vol. 8.

2. A master-slave separate parallel intelligent mobile robot used for autonomous pallet transportation. . **Li, G., et al.** 3, s.l. : Applied sciences, 2019, Vol. 9.

3. A review of autonomous agricultural vehicles. **Roshanianfard, A., et al.** Hokkaido : J. Terramech, 2020, Vol. 91, pp. 155-183.

4. Design of a control system for an autonomous vehicle based on adaptive-pid. **Zhao, P., et al.** s.l. : Int. J. Adv. Robot. Syst., 2012, Vol. 9, p. 44.

5. CF-pursuit: A pursuit method with a clothoid fitting and a fuzzy controller for autonomous vehicles. **Shan, Y., et al.** s.l. : Int. J. Adv. Robot. Syst., 2015, Vol. 12, p. 134.

6. Line Follower Using Arduino And Its Applications. **Md Younus, Pooja Gadekar, Adhiraj Walse.** s.l. : International Journal of Applied Engineering Research, 2019, Vol. 14. 0973-4562.

7. Navigation of autonomous vehicles for oil spill cleaning in dynamic and uncertain environments. **Jin, X. and Ray, A.** 4, s.l. : Int. J. Control, 2014, Vol. 87.

8. Experimental analysis of maze solving robot using LSRB algorithm. **Selvakumar. R 2R.V.S. Abhiram, 3K. Pranay Reddy.** Coimbatore : International Conference on Computer Communication and Informatics (ICCCI), 2022, Vol. 22.

9. www.instructables.com/Line-Follower-Robot-Using-Arduino-Uno-and-L298N/