IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 14, Issue 8, August 2026

DOI: 10.17148/IJIREEICE.2026.14818

Design and Development of a DIY Line Follower Robot Using Embedded Systems

Kosgi Rishikesh Reddy[1], Palamuru Paramesh[2], Muppana Tarun[3], Dr. B. Ramu[4]

U.G. Student, Geethanjali College of Engineering and Technology,

Department of Electronic and Communication Engineering, Hyderabad, Telangana, India[1,2,3]

Associate Professor, Geethanjali College of Engineering and Technology,

Department of Electronic and Communication Engineering, Hyderabad Telangana, India[4]

Abstract: This paper presents the design and implementation of a D.I.Y line follower robot based on embedded systems and real-time control principles. The proposed system is capable of autonomously navigating a predefined path by utilizing infrared (IR) sensors to detect variations in surface reflectivity between a black line and a white background. The robot is built using an Arduino UNO microcontroller, which acts as the central processing unit, along with an L298N motor driver module and DC motors to achieve controlled movement. The system operates on a closed-loop feedback mechanism, where continuous sensor input is processed to dynamically adjust the robot's trajectory, ensuring accurate path tracking and minimal deviation. The design emphasizes simplicity, low cost, and ease of implementation while maintaining reliable performance. Experimental evaluation of the system demonstrates stable operation, quick response to directional changes, and effective navigation under controlled environmental conditions. However, factors such as ambient lighting, sensor calibration, and surface irregularities influence the overall performance. The developed robot serves as a foundational model for autonomous guided vehicles and can be further enhanced by integrating advanced control algorithms such as PID control, obstacle detection systems, and wireless communication technologies. This work highlights the practical application of embedded systems in robotics and provides a saleable approach for future automation solutions.

Keywords: Line Follower Robot, Embedded Systems, Arduino UNO, Infrared Sensors (IR Sensors), Autonomous Navigation, Closed-Loop Control System, Motor Driver (L298N), Real-Time Processing, Robotics, Automation

1. INTRODUCTION

Automation and robotics have become essential components of modern engineering systems, significantly improving efficiency, accuracy, and productivity across various industrial and commercial applications. In recent years, the demand for autonomous systems has increased rapidly due to their ability to perform repetitive and time-consuming tasks with minimal human intervention. Among the various types of autonomous robotic systems, the line follower robot is one of the most fundamental and widely implemented applications, particularly in the fields of embedded systems and control engineering. A line follower robot is designed to follow a predefined path, typically represented by a contrasting line on a surface, using sensor-based detection and real-time control mechanisms.

The D.I.Y line follower robot developed in this project operates using infrared (IR) sensors that detect variations in surface reflectivity to distinguish between the path and the surrounding area. The system is built around an Arduino UNO microcontroller, which acts as the central processing unit, receiving input signals from the sensors and generating appropriate control outputs to drive the motors through a motor driver module. The robot continuously monitors the path and dynamically adjusts its motion using a closed-loop feedback mechanism, ensuring accurate navigation and minimal deviation from the desired trajectory. This integration of sensing, processing, and actuation demonstrates the practical implementation of embedded systems in autonomous robotics.

The primary objective of this project is to design and develop a low-cost, reliable, and easy-to-implement robotic system that can autonomously follow a path with high efficiency. Unlike complex robotic systems that require advanced algorithms and expensive components, this project focuses on simplicity and functionality while maintaining acceptable performance levels. The proposed system not only serves as a foundational model for understanding robotic control systems but also provides a saleable platform for future enhancements such as advanced control techniques, obstacle detection, and intelligent navigation systems. Through this work, the practical application of electronics, programming, and control theory is effectively demonstrated in a real-world robotic system.

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 14, Issue 8, August 2026

DOI: 10.17148/IJIREEICE.2026.14818

2. PRODUCT DETAILS

2.1 Arduino

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 You can buy this product on your local electronic store. You also can order it by online. Find it on http://arduino.cc/en/Main/Buy. The following is the list of Arduino store you can buy Arduino store, http://store.arduino.cc/ Amazon, http://www.amazon.com Cooking-hacks, http://www.cookin acks.com/index.php/shop/arduino.html RS Components, http://www.rs-components.com Element 14, http://www.element14.com EXP-Tech, http://www.exp-tech.de Because Arduino is an open-source hardware, people can build it. It's called Arduinocompatible. Generally it's sold in low prices.

2.2 Arduino Uno

The Arduino Uno is a microcontroller board based on the datasheet file, http://www.atmel.com/dyn/resources/prod_do cuments/do c8161.pdf Further information about Arduino Uno, you can read it on http://arduino.cc/en/Main/ArduinoBoardUno

Fig -2.2.1: Arduino Uno

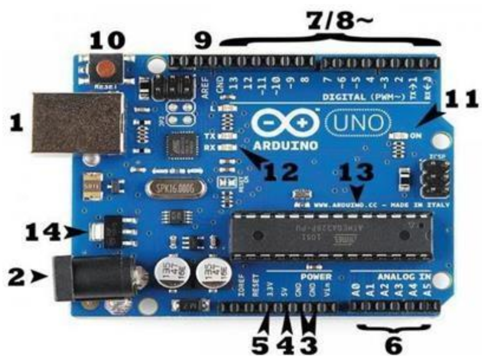

Fig -2.2.2: Quaduino Uno R3

What's on the board?

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:

Power

(USB / Barrel Jack)

Every Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply that is terminated in a barrel jack. In the picture above the USB connection is labeled (1) and the barrel jack is labeled (2).

NOTE: Do NOT use a power supply greater than 20 Volts as you will overpower (and thereby destroy) your Arduino. The recommended voltage for most Arduino models is between 6 and 12 Volts.

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

DOI: 10.17148/IJIREEICE.2026.14818

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 Pulse-Width 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. Motor Driver Module: You can control two DC motor with a single L293D IC. The L293D works on the concept of typical H-bridge, 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)

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 8, August 2026
DOI: 10.17148/IJIREEICE.2026.14818

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.

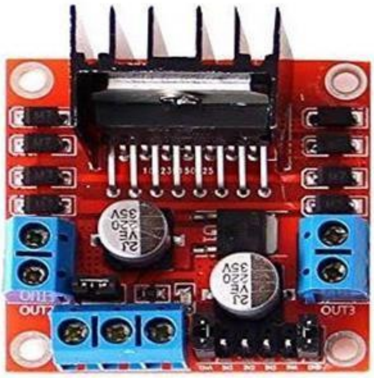

Fig -2.3.1: Motor Driver Module

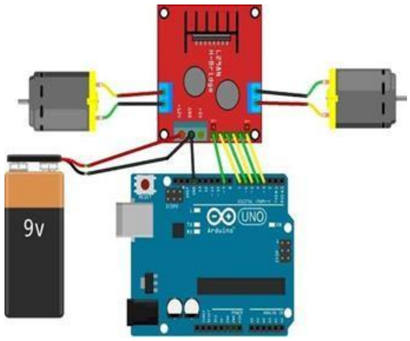

Fig-2.3.2:L298N Motor Driver Design

IR 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

Fig -2.4.1: IR Sensor

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.

DOI: 10.17148/IJIREEICE.2026.14818

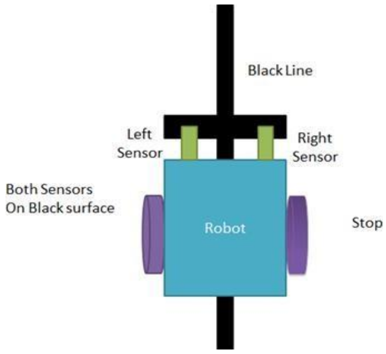

Fig -2.4.2: Stop the robot

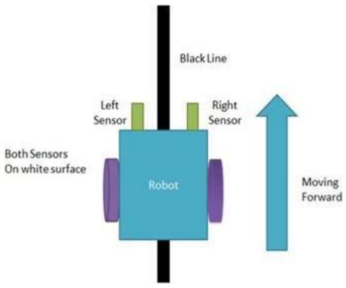

Fig -2.4.3: Forward movement

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 right. At any case if there is a black line then rotor has to stop.

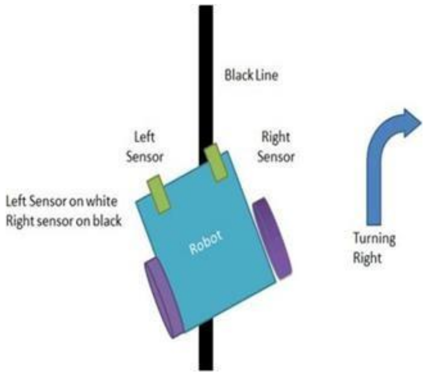

Fig -2.4.4: Turning right

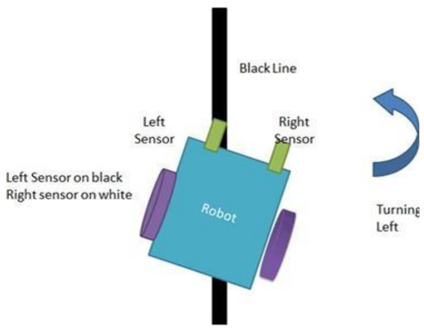

Fig -2.4.5: Turning right

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 14, Issue 8, August 2026

DOI: 10.17148/IJIREEICE.2026.14818

2.3 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 wire

Fig -2.5: JUMPER WIRES

2.4 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.

Fig -2.6: Castor Wheel

2.5 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 circuit as FIG:2.9 electrical energy.[3] Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell.

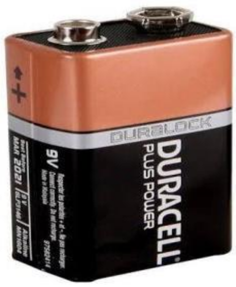

Fig -2.7: Batteries

2.6 WITCH BUTTON

In electrical engineering, a switch is an electrical component that can "make" or "break" an electrical circuit, interrupting the current or diverting it from one conductor to another.[1][2] The mechanism of a switch removes or restores the conducting path in a circuit when it is operated. It may be operated manually, for example, a light switch or a keyboard button, may be operated by a moving object such as adoor, or may be operated by some sensing element for pressure,

DOI: 10.17148/IJIREEICE.2026.14818

temperature or flow. A switch will have one or more sets of contacts, which may operate simultaneously, sequentially, or alternately. Switches in high-powered circuita must operate rapidly to prevent destructive arcing, and may include special features to assist in rapidly interrupting a heavy current. Multiple forms of actuators are used for operation by hand or to sense p[osition, level, temperature or flow.

Fig -2.8: Switch Button

2.7 BO MOTOR

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.

Fig -2.9: BD Motor

2.8 CHASSIS

Basic chassis for building your own Arduino, Raspberry-Pi (Not Included) robot car etc. Acrylic base that is pre drilled & routed to mount the gear motor/Tire assemblies, the switch, a 4 “AA” cell battery holder (Batteries Not Included) and a small caster for rear wheel. Motors: 5-10VDC with Tach disks Includes: 2 motors/tires, Battery Holder, Caster, Switch and Mounting hardware L: 8-1/4” W: 6-1/8” H: 2-3/4” WT: .62

Fig -2.10: Chasis

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 14, Issue 8, August 2026

DOI: 10.17148/IJIREEICE.2026.14818

3. WORKING

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. 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.

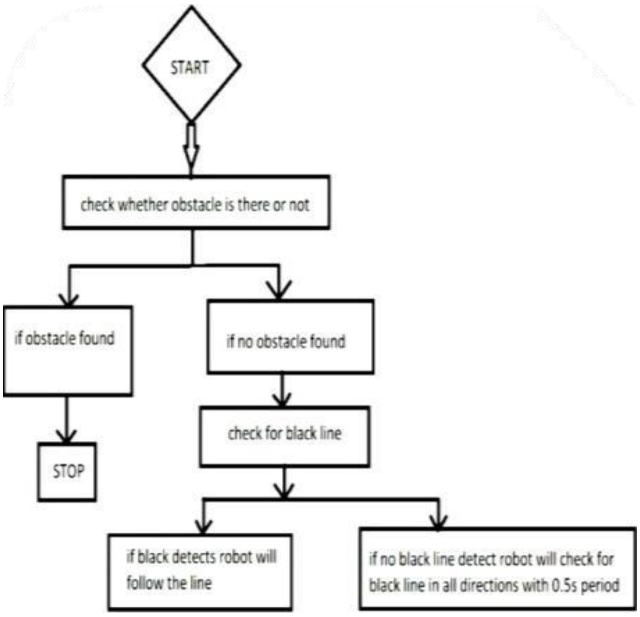

Fig -3.1: Flow Diagram

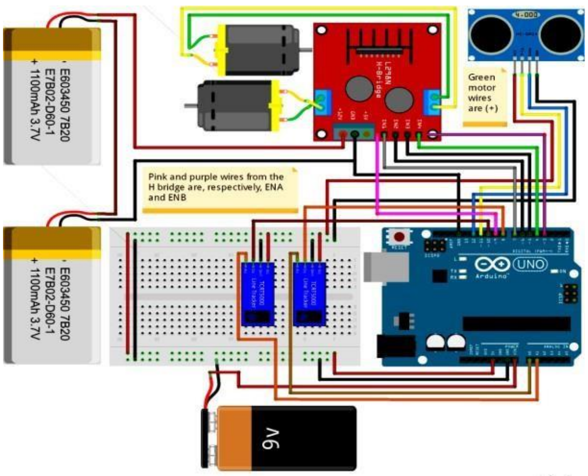

Fig -3.2: Assembly

DOI: 10.17148/IJIREEICE.2026.14818

4. RESULT

Following figures are the results of specimen. It was working fine by avoiding obstacles and following the path.

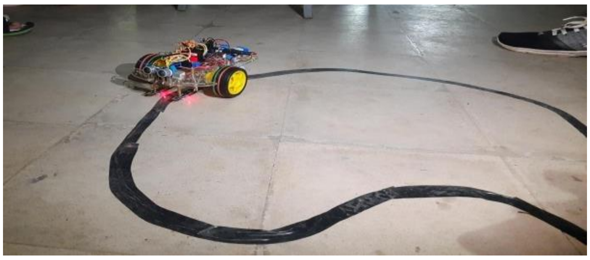

Fig -4.1: Demo1

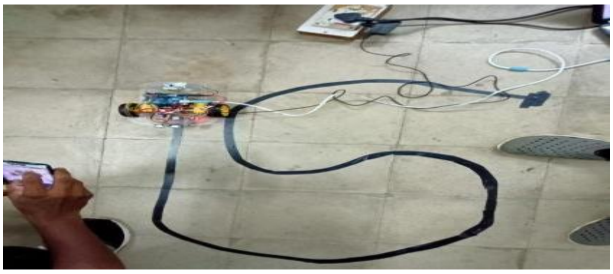

Fig -4.2: Demo2

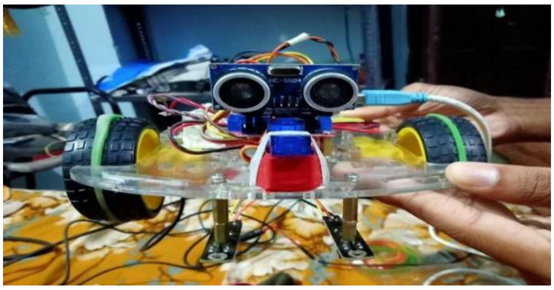

Fig -4.3: Model

CONCLUSION

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.

REFERENCES

[1]. Inteligent Line Follower Mini-Robot System Román Osorio C., José A. Romero, Mario Peña C., Ismael López-Juárez, International Journal of Computers, Communications & Control Vol. I (2006), No. 2, pp. 73-83.
[2]. Development and Applications of Line Following Robot Based Health Care Management System by Deepak Punetha, Neeraj Kumar, Vartika Mehta, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 2, Issue 8, August 2013.
[3]. HCSR04 Ultrasonic Sensor Elijah J. Morgan Nov. 16 2014.
[4]. S I M P L E D E L I V E R Y R O B O T SYSTEM BASED ON LINE MAPPING METHOD EndrowednesKuantama, Albert Brian Lewis Lukas and Pono Budi Mardjoko E lectr ical E ngineer ing, U niver s it ie s PelitaHarapan, Jl. M.H. Thamrin Boulevard, Lippo Karawaci, Tangerang Indonesia.

DOI: 10.17148/IJIREEICE.2026.14818

[5]. Obstacle Avoiding Robot By Faiza Tabassum, Susmita Lopa, Muhammad Masud Tarek & Dr. Bilkis Jamal Ferdosi, Global Journal of Researches in Engineering.

[6]. Two wheels balancing Robot with Line Following Capability NorManiha Abdul Ghani, FaradilaNaim, Tan Piow Yon, World Academy of Science, Engineering and Technology International Journal of Mechanical and Mechatronics Engineering Vol:5, No:7, 2011.

[7]. OBSTACLE AVOIDING ROBOT - A PROMISING ONE Rakesh Chandra Kumar1, Md. Saqddam Khan2, Dinesh Kumar3, Rajesh Birua4, Sarmistha Mondal5, Manaskr. Parai6.

[8]. Design and implementation of RGB color line following Robot GADHVI SONAL PUNIT RANINGA HARDIK PATEL,Proceedings of the IEEE 2017 International Conference on Computing Methodologies and Communication(ICCMC).

[9]. Colak, I., Yildirim, D., “Evolving a Line Following Robot to use in shopping centers for entertainment”, Industrial Electronics, 2009. IECON ‘09. 35th Annual Conference of IEEE, pp.3803 - 3807, 3-5 Nov. 2009.