LINE FOLLOWING ROBOT USING ARDUINO

A PROJECT REPORT

Submitted by

M.JEFRIN JEYA

(421122102069)

S. PADMAPRIYA

(421122102109)

&

S. RAGAVI

(421122102112)

BACHELOR OF TECHNOLOGY

In

COMPUTER SCIENCE AND ENGINEERING

IFET COLLEGE OF ENGINEERING

(An Autonomous institution)

Approved by AICTE, New Delhi and Accredited by NAAC & NBA

Affiliated to Anna University, Chennai-25

Gangarampalayam , Villupuram – 605 108

NOVEMBER 2024

BONAFIDE CERTIFICATE

Certified that this project report "**LINE FOLLOWING ROBOT USING ARDUINO**" is the bonafide work of M.JEFRIN JEYA(421122102069), S.PADMAPRIYA (421122102104) and S.RAGAVI (421122102112) who carried out the project work under my supervision.

SIGNATURE	**SIGNATURE**
MS.A. INBAVALLI, M.E.	**MR.D. RAGHU RAMAN,**
SUPERVISOR,	**HEAD OF THE DEPARTMENT**
Assistant Professor,	Assosciate Professor,
Department of CSE,	Department of CSE,
IFET College of Engineering,	IFET College of Engineering,
Villupuram.	Villupuram.

Submitted for Project Work and Viva-Voice Examination held on ……………..

INTERNAL EXAMINER **EXTERNAL EXAMINER**

CERTIFICATE OF EVALUATION

College name : IFET College of Engineering, Villupuram.

Branch : B.E CSE

Month & Year : NOVEMBER 2024

Sub. Code & Name : 19UECMP301/MINI PROJECT-II

Name of the Student	Register Number	Title of the Project	Name of the Supervisorwith Designation
M.JEFRIN JEYA S. PADMAPRIYA S. RAGAVI	421122102069 421122102104 421122102112	LINE FOLLOWING ROBOT USING ARDUINO	**MRS.INBAVALLI, M.E** **Assistant Professor**

The report for the Mini project-II submitted for the fulfillment of the award of the degree of Bachelor of Technology in Information Technology of IFET College of Engineering (Autonomous), permanently affiliated to Anna University was evaluated and confirmed to be the work done by the above student.

ABSTRACT

A robust and efficient robotic navigation system is designed and developed, enabling safe and accurate path tracking. The robot will be equipped with an infrared sensor array to detect the black line on the ground, and an ultrasonic sensor to detect obstacles. A micro controller will be used to process the sensor data and generate control signals for the robot's motors. The robot's behavior will be determined by a set of algorithms that combine line following and obstacle avoidance techniques. This research will demonstrate the feasibility of designing an autonomous robot that can navigate through a track with a black line while avoiding obstacles. In this study, a line-following, obstacle-avoidance robot that serves as a nursing assistant is developed. The robot can safely move food, medicine, blood samples, and other items around a hospital on its own initiative and in accordance with user instructions. A nurse can call the robot from any location using wireless connectivity. The robot will automatically travel a path to the caller nurse in response to the call. After that, the caller placed any further materials.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

IOT	INTERNET OF THINGS
DC	DIRECT CURRENT
ADC	ANALOG TO DIGITAL CONVERTER
SPP	SERIAL PORT PROTOCOL
EDR	ENHANCED DATA RATE
AFH	ADAPTIVE FREQUENCY HOPPING
AC	ALTERNATING CURRENT
GPS	GLOBAL POSITIONING SYSTEM
PID	PROPORTIONAL INTEGRAL DERIVATIVE

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The integration of Arduino in a line-following robot gives rise to autonomous robotic system designed to follow a predetermined path marked by a line, typically on the floor. In the context of a hospital, such robots can be used for a variety of tasks such as transporting medical supplies, guiding patients, or assisting staff with routine duties. The robot's ability to follow a line makes it ideal for navigating hospital corridors, where it can avoid obstacles and deliver items with minimal human intervention.

The basic components of a line-following robot include an Arduino micro controller, infrared (IR) sensors, motors, and motor drivers. The IR sensors are mounted on the robot and are used to detect the line on the floor. These sensors work by emitting infrared light, and when the sensor is above the line (which is usually darker), the reflected light signals a change in the sensor's output. The Arduino processes the data from the sensors and makes decisions to control the motors' speed and direction, ensuring the robot stays on track.

The robot can be programmed to follow the line either using simple algorithms like "if-else" statements or more complex control systems like PID (Proportional-Integral-Derivative) controllers for smoother and more accurate motion. In a hospital setting, this technology can improve efficiency by automating the delivery of medications, samples, and documents, freeing up human resources for more critical tasks.

1.1 OVERVIEW

In the role of scientific development taking place today in this world, robots have become one of the basic requirements for use in various fields of industry, but that the use of the robot was not limited to industry alone, but also entered in the field of restaurants, laboratories, hospitals, educational fields, etc.A Line following robot is a type of autonomous robot that follows a predefined path or line, typically marked on the ground. This path is usually a black line on a white surface or a white line on a black surface, and the robot uses sensors to detect the line and adjust its movement accordingly. In a Line Following Robot using Arduino, an Arduino micro controller is used to process input from sensors and control the motors that drive the robot. The robot is equipped with sensors (typically infrared sensors) to detect the line and decide whether to move straight, turn, or adjust its direction based on the line's position.

1.2 OBJECTIVE

The objective of creating a Line Following Robot using Arduino is to design an autonomous system that can detect and follow a predefined path or line on the ground with minimal human intervention. The robot should track the line using infrared sensors, process the sensor data through the Arduino micro controller, and make real-time decisions to control the motors for navigation. The goal is to ensure the robot moves smoothly along the path, adjusting its direction as needed to stay on track, while also introducing fundamental robotics concepts such as sensor feedback, motor control, and simple control algorithms.

CHAPTER 2
LITERATURE SURVEY

2.1 REVIEW OF LITERATURE

[1] Title: Adaptive PID Control for Line-Following Robots

Authors: R.T Suhendra

Year: 2022

Summary: This study presents an adaptive Proportional-Integral-Derivative (PID) control system for line-following robots to enhance stability and accuracy in various track conditions. The approach dynamically adjusts PID parameters using real-time feedback.

Drawbacks:

- Complexity in parameter tuning.
- Reduced performance on highly irregular paths

[2] Title: Intelligent Control System for Line-Following Robots

Authors: R. A. Castaneda

Year: 2022

Summary: This work integrates artificial intelligence (AI) with traditional control systems, enabling the robot to adapt to diverse track conditions using machine learning algorithms.

Drawbacks:

- High computational requirements.
- Dependence on extensive training data

[3] Title: Obstacle Avoidance Integration for Line-Following Robots

Authors: M. S. V. Sai

Year: 2023

Summary: This research combines line-following with obstacle avoidance features. The system uses infrared and ultrasonic sensors for detecting paths and obstacles, enhancing flexibility in real-world scenarios.

Drawbacks:

- Increased hardware cost.
- Reduced speed in environments with frequent obstacles

[4] Title: Path Optimization for Line-Following Robots

Authors: S. Mukherjee .

Year: 2023

Summary: The study focuses on optimizing path-following efficiency using a hybrid algorithm that blends graph-based planning with sensor input.

Drawbacks:

- High dependency on algorithm fine-tuning.
- Limited scalability to complex networks

[5] Title: Vision-Based Line-Following Robot Using Neural Networks

Authors: D. H. Lee

Year: 2023

Summary: This study introduces a robotic navigation system that utilizes CNNs for vision-based line detection and tracking.

Drawbacks:

- Requires significant computational resources.
- Performance limitations in low-light environments.

2.2 EXISTING SYSTEM

This System has no micro controller, it consists of an IR-LED and Photo diode arrangement for each motor which is controlled by the switching on and off of the transistor. The IR LED on getting proper biasing emits Infra red light. This IR light is reflected in case of a white surface and the reflected IR light is incident on the photo diode. The resistance of the photo diode decreases, which leads to an increase in current through it and thus the voltage drop across it. The photo diode is connected to the base of the transistor and as a result of increased voltage across the photo diode, the transistor starts conducting and thus the motor connected to the collector of the transistor gets enough supply to start rotating. In case of a black color on the path encountered by one of the sensor arrangement, the IR light is not reflected and the photo diode offers more resistance, causing the transistor to stop conduction and eventually the motor stops rotating. It may not move properly if the black line drawn is of low intensity. The IR sensors may sometimes absorb IR rays from surroundings also. As a result, robots may move in improper way.

2.3 DISADVANTAGE

- Controlling the line follower robot with the remote “Web Server”
- Proceeding the Path planning of line follower robot
- The structure of Arduino is its disadvantage as well. During building a project you have to make its size as small as possible.
- Cost of this system is high by using more packages in the program

CHAPTER 3

SYSTEM REQUIREMENTS

3.1 HARDWARE REQUIREMENTS

ARDUINO UNO

The Arduino Uno is a micro controller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Simply connect it to a computer with a USB cable or power it witha AC-to-DC adapter or battery to get started.

FIGURE 3.1 ARDUINO UNO

Processor: 16 MHz ATmega328

Flash memory: 32 KB

SRAM: 2KB

EEPROM: 1KB

Clock Speed: 16 MHz

Operating Voltage: 5V

Input Voltage: 7-12 V

Number of analog inputs: 6

Number of digital I/O: 14 (6 of them PWM)

IR SENSOR

A sensor that emits infrared light to detect objects in the environment is a type of electrical equipment. The location of a line follower in relation to the robot position is determined using infrared ray sensors.The IR sensors used in line-following robots typically consist of an infrared LED emitter and a photo diode or photo transistor (the detector). The infrared light emitted by the LED is reflected off the surface the robot is moving on, and the detector measures the intensity of the reflected light. The behavior of the sensor changes depending on the color or contrast of the surface:

L293D

One of the simplest and chip-based methods for controlling DC motors is L298N. DC motors' speed and direction of rotation are controlled by a two channel motor driver.A high-power motor driver module, the L298N Motor Driver. It's employed to power DC and stepper motors. This motor driver is made up of an integrated circuit with an L298N motor driver IC, a 78M05 5V voltage regulator, resistors, capacitor, power LED, and a 5V jumper.

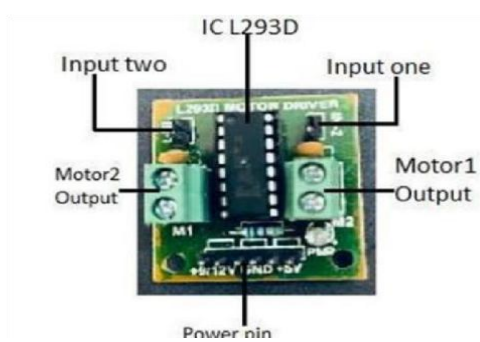

FIGURE 3.2 L293D

ULTRASONIC SENSORS

Ultrasonic sensors are electronic devices that use the emission of ultrasonic sound waves to determine a target's distance before converting those waves into electrical signals. The speed of travelling ultrasonic waves is greater than the speed of audible sound. The idea behind how ultrasonic sensors operate is that they produce waves with a higher frequency than humans can hear.Ultrasonic sensors help the robot detect objects in its path. This is particularly useful if the robot encounters obstacles while following the line. The sensor can measure the distance to objects in front of the robot and allow the system to react accordingly (e.g., stop or turn to avoid a collision).Some line-following robots use ultrasonic sensors to detect whether they are drifting off the track.

MOTOR

The term "BO Motor" refers to battery-operated motors. These motors are frequently employed in hobby-grade applications when a tiny DC motor is needed as a straightforward actuator.

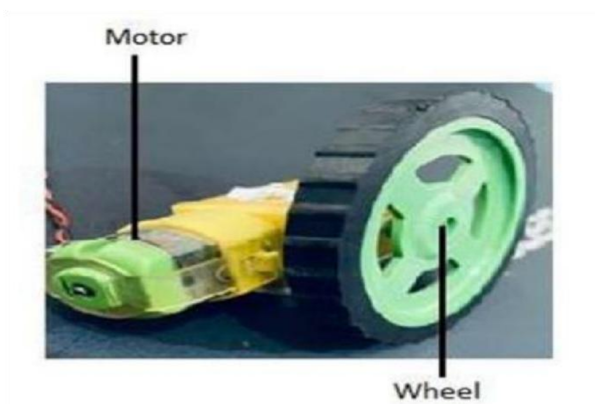

FIGURE3.3 MOTOR AND WHEEL

Good torque and rpm are available with BO series linear motors at lower operating voltages. There are three different types of BO motors: single shaft, dual shaft, and DC plastic gear BO. These motors only draw small current.

SERVOMOTOR

Servo motors, or "servos" as they are sometimes referred to, are electrical gadgets and rotary or linear actuators that precisely spin and push elements of a machine. The sensors detect the line and send signals to the robot's controller. The controller processes the sensor data and sends commands to the servo motor.The servo motor then adjusts the steering mechanism (usually a wheel or a mechanism for turning the front wheel) to keep the robot following the path.

FIGURE 3.4 SERVOMOTOR

POWER SUPPLY

A 9-volt battery powers the line-following robot by supplying energy to its motors and control circuits. The battery connects to a voltage regulator to provide a stable supply to sensors and the microcontroller. Its compact size and capacity make it ideal for small robots. Proper connection and monitoring prevent battery depletion during operation.

FIGURE 3.5 9V Battery

HC-05 BLUETOOTH MODULE

An accessible Bluetooth SPP (Serial Port Protocol) module, the HC-05 is intended for setting up transparent wireless serial connections. A serial port with a comprehensive 2.4GHz radio transceiver and base band, the Bluetooth module is fully certified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation. It makes use of an AFH (Adaptive Frequency Hopping Feature)-equipped CSR Blue core 04-External single chip Bluetooth system. Its footprint is just 12.7 mm × 27 mm. I hope it will make the entire design/development cycle simpler.

FIGURE 3.6 Bluetooth Module

3.2 SOFTWARE REQUIREMENTS

ARDUINO IDE

The text editor, notification area, text content panel, toolbar with buttons for writing code, menus, and odd localization are all included in the Arduino Compiler or Arduino Software (IDE). The Arduino compiler is used to generate packages and to comfortably use the hardware sensor. This compiler read input from the sensors, and it activates other sensors connected to the main sensor. The Language we use to write the program is Embedded C, a version of the C programming language.

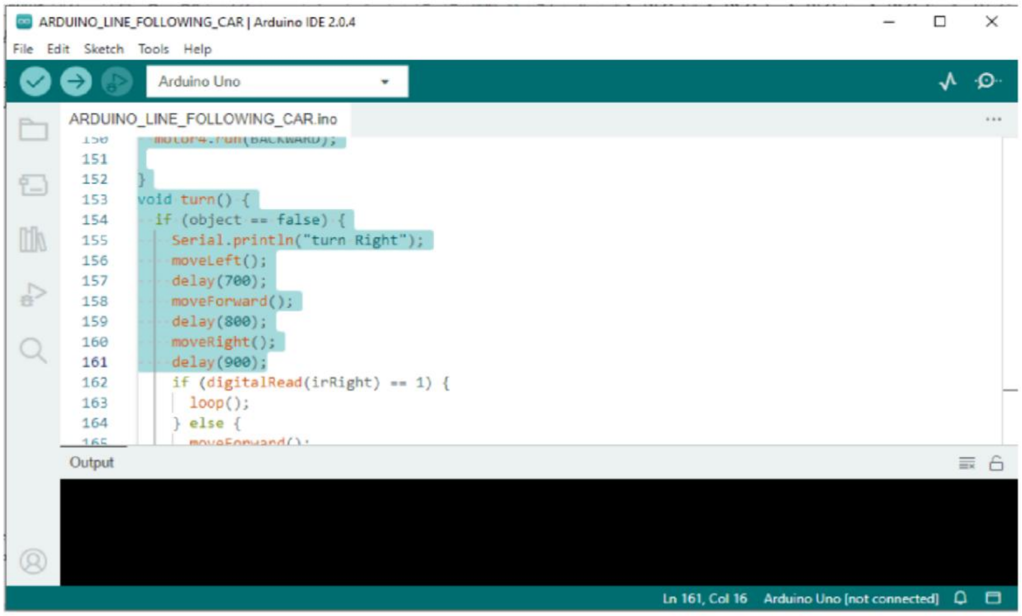

FIGURE 3.7 Arduino IDE Software

NEWPING LIBRARY

A library that provides functionality for using ultrasonic sensors. I wasn't happy with the ultrasonic sensor's subpar performance when I initially got it. I quickly came to the conclusion that the problem wasn't with the sensor itself, but rather with the ping and ultrasound libraries that were readily available. With the help of the New-Ping library, Arduino users may use ultrasonic sensors to detect distances. The New Ping library in Arduino is a powerful tool for integrating ultrasonic sensors, which are essential for obstacle detection in a line-following robot designed for hospital use. By using New Ping, the robot can efficiently and accurately measure distances to nearby objects, helping it avoid obstacles while navigating hospital hallways. The library simplifies sensor control with efficient, non-blocking ping methods, allowing the robot to quickly respond to changes in its surroundings. This ensures safe, smooth operation in dynamic environments like hospitals, enhancing the robot's reliability in automated tasks such as transporting supplies and medications.

EAGLE

Printed circuit board (PCB) designers may easily link schematic designs, component placement, PCB routing, and extensive library material using the electronic design automation (EDA) programmer EAGLE. Using Auto desk EAGLE to design a line-following robot with an Arduino platform for hospitals offers a reliable, efficient solution for automating tasks like medication and supply delivery. In EAGLE, a custom PCB is created to integrate core components: line sensors for path tracking, motor drivers for movement control, and ultrasonic sensors for obstacle detection. This tailored design enables precise navigation within hospital environments. Eagle's schematic capture, PCB layout tools, and design rule checking ensure the board meets high safety and reliability standards essential in healthcare.

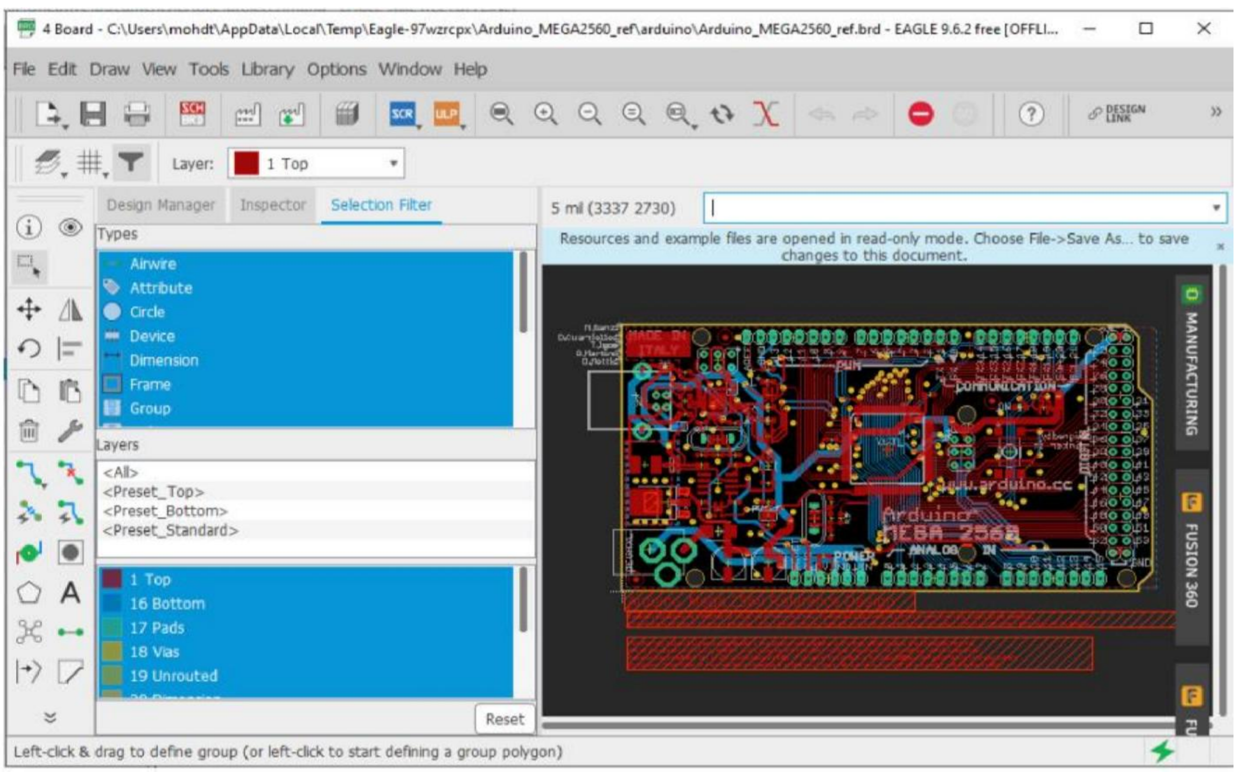

FIGURE 3.8 Eagle Software preview

3.3 WORKING:

Step 1 - Right motor stops while left motor continues to travel when left sensor enters white (for black line tracer) zone, causing the robot to turn to the right and return to the white line.

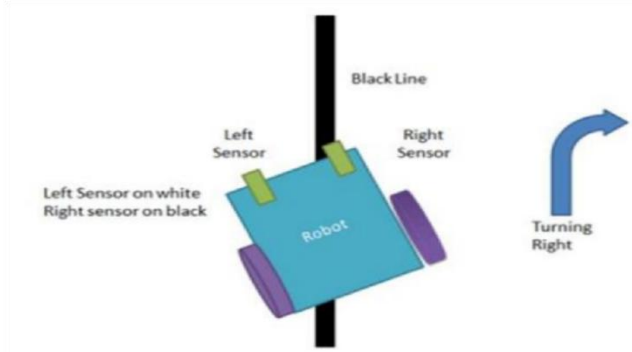

FIGURE 3.9 Turning left

Step 2 - Since the first sensor on the right is facing the black line, its response will be low, while that of the other sensors will be high. i.e., the left wheel is allowed to move while the right wheel is kept stationary until the center sensor's reaction drops.

Step 3 - When the right sensor enters the white area, the left motor stops while the right keeps moving, causing the robot to turn to the left and return to the white line.

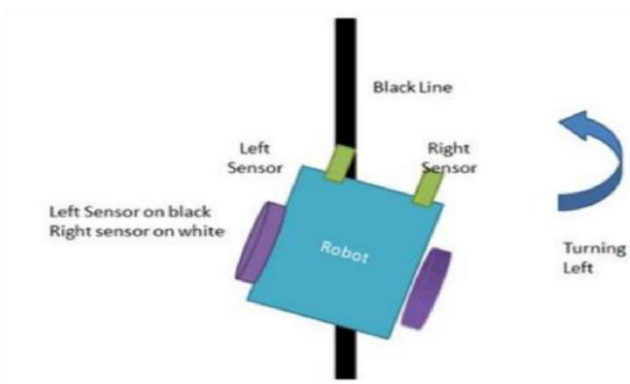

FIGURE 3.10 Turning right

Step 4 - The middle sensor will always be on the line, and as the line is black in color, it won't reflect the radiation back, thus its response will always be low. In contrast, the responses of the other two sensors, which will be on the bright surface, will always be high. Robot advances when both sensors are on the black line.

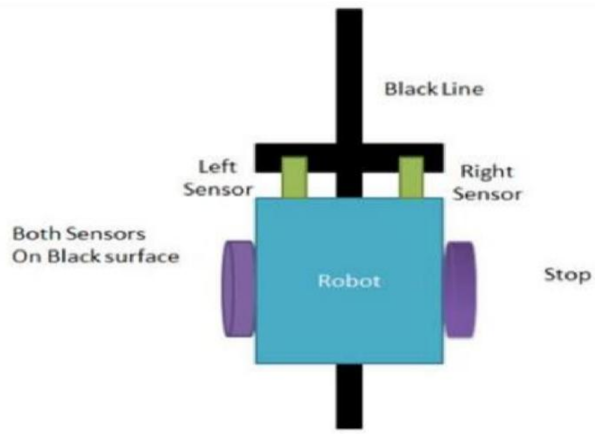

FIGURE 3.11 Stop the robot

Step 5 - When none of the three lines are identified, the robot moves in a circle until one is located if all three sensors are on a brighter surface in which case, they will all be high.

Step 6 - To examine the impediment from three aspects, the robot head rotates 180 degrees. This robot's brain is an Arduino board that uses information from an ultrasonic sensor to determine how far an obstacle is from the robot.

Arduino determines the direction of the obstacle based on the servo motor's angle.

Step 7 - Measuring the distances in both directions, it chooses the path that passes through the obstruction with the biggest gap. It finds the black line and continues along its path. When the distance between the object and the robot is closer than the threshold distance, which is set in the programmer.

CHAPTER 4
PROPOSED SYSTEM

The proposed system for a line-following robot using Arduino aims to automate the transport of supplies within hospitals, enhancing efficiency and allowing healthcare staff to focus more on patient care. The robot will use infrared (IR) sensors to detect and follow lines on hospital floors, enabling it to navigate predetermined paths with high accuracy. An Arduino micro controller will process sensor data to guide the robot along these paths, with a proportional-integral-derivative (PID) control system to maintain stability on turns and ensure smooth navigation. For safety in high-traffic areas, the robot will incorporate ultrasonic sensors to detect and avoid obstacles, preventing collisions with staff, patients, and equipment. Additionally, a feedback control mechanism will be included to adapt the robot's speed and direction in real time, ensuring it can respond to unexpected environmental changes. This system is designed to be versatile, allowing it to carry lightweight supplies such as medications, documents, or small equipment, reducing the workload of hospital staff and contributing to a more streamlined workflow.

4.1 SYSTEM ARCHITECTURE

A user can communicate with the robot through Bluetooth while using an Android device, the Bluetooth input is read by the micro controller, which can then transfer the detected signal in the proper format to the robot circuit.

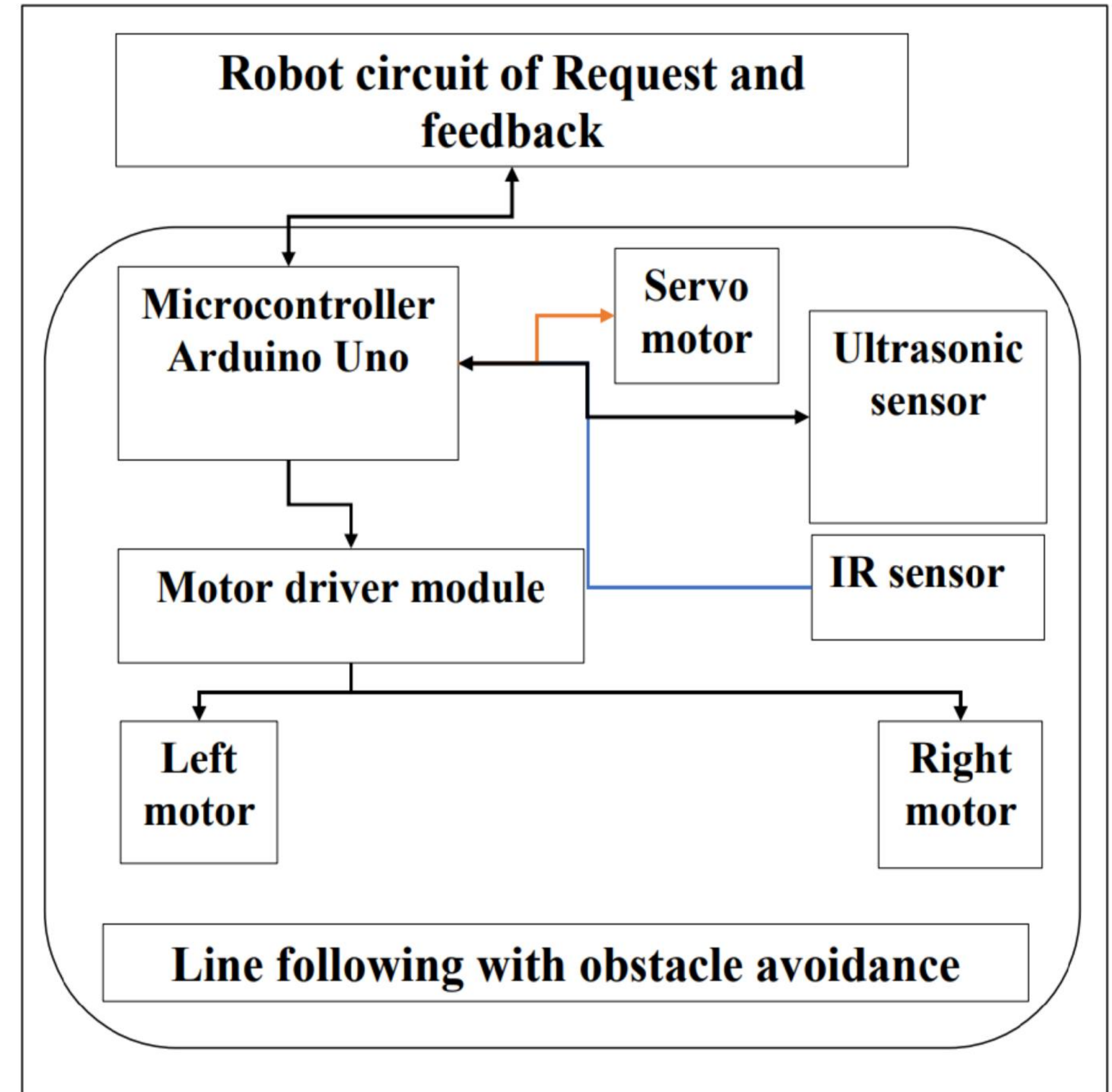

FIGURE 4.1 Block Diagram of Robot

4.2 EXPLANATION:

The block diagram represents the working of a Line Following Robot with Obstacle Avoidance. The system is centered around the Arduino Uno microcontroller, which acts as the brain of the robot. It processes signals from various sensors, such as IR sensors and ultrasonic sensors, to control the robot's movement. The IR sensors detect the line (usually black) on the surface, sending signals to the Arduino to guide the robot in following the path. The motor driver module receives signals from the Arduino to control the left and right motors, allowing the robot to move forward, turn left, or right depending on the sensor feedback.

Additionally, the robot is equipped with an ultrasonic sensor to detect obstacles in its path. When an obstacle is detected, the Arduino processes this input and triggers the servo motor for scanning the surroundings. The robot evaluates which direction (left or right) has fewer obstacles and adjusts its path accordingly. Once the obstacle is avoided, the robot resumes its line-following behavior, continually adjusting its course with the help of the sensors and motors to ensure smooth navigation and obstacle-free movement.

CHAPTER 5

MODULES

1.Black line follower

A black line-following robot is designed to detect and follow a black line on a lighter surface using IR sensors. The Arduino microcontroller processes data from these sensors and adjusts the robot's motor speed to maintain alignment with the line. This functionality is crucial for automated delivery systems in controlled environments. The robot's accuracy depends on sensor calibration and proper placement. Challenges include ensuring the system performs well under varying lighting conditions and surface textures.

2.Receiving request from patient using IR sensor.

Patients can request assistance by triggering an IR signal, which the robot detects using an IR receiver. The Arduino interprets these signals to determine the specific request and activates the appropriate action. For instance, the IR system can differentiate between signals for delivering water or medication. This feature enhances usability in healthcare environments by providing patients with non-contact assistance. Ensuring reliable IR signal detection even at a distance or through obstructions is key to efficiency.

3.Obstacle detection using IR proximity sensor.

To navigate safely, the robot uses IR proximity sensors that detect obstacles by emitting infrared light and analyzing reflections. Upon detecting an obstacle, the Arduino commands the motors to slow down, stop, or reroute the robot. This ensures the robot can operate autonomously in dynamic environments, such as hospitals or homes. Proper placement of these sensors allows for 360-degree detection. Challenges include avoiding false positives caused by reflective surfaces and fine-tuning sensitivity.

4.Serving the patient using servo motors.

The robot employs servo motors to deliver items such as food or medicines to patients. Controlled by the Arduino, the servos enable precise movements like lifting, rotating, or opening compartments. This functionality adds versatility to the robot, making it suitable for healthcare and home applications. Servos are chosen for their accuracy and ability to hold positions under load. Ensuring seamless coordination between the servo mechanisms and sensors is vital for effective operation.

CHAPTER 6

PROTOTYPE

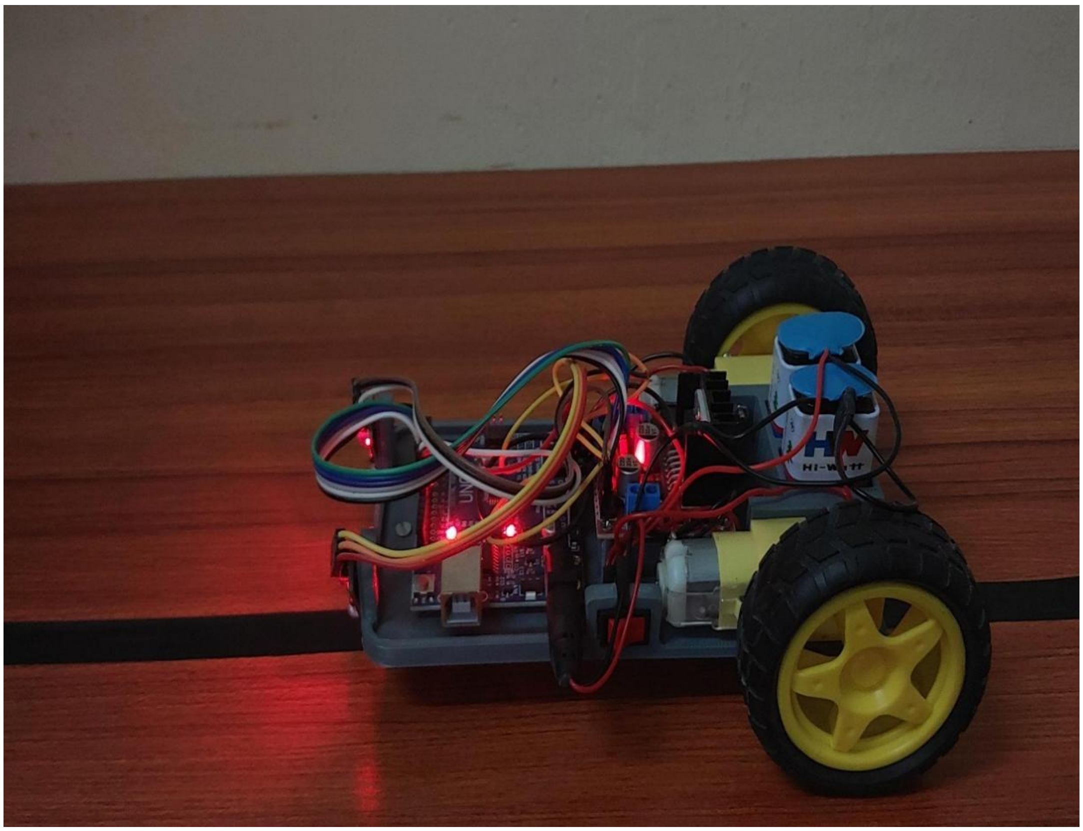

FIGURE 6.1 HARDWARE MODEL

6.1 ADVANTAGES

- Reduces the need for human intervention in transporting medical supplies, medications, and lab samples across departments.
- Arduino components are affordable, making the system an economical option for hospitals compared to complex autonomous robots.

- Minimizes the need for additional staff for transport tasks, allowing personnel to focus on patient care and other critical duties.
- Reduces physical contact by automating deliveries, helping prevent cross-contamination and limiting pathogen spread.
- Easy to add more robots to the system as hospital demand grows, requiring minimal adjustments once infrastructure is in place.
- Arduino’s programmable nature allows for easy adjustments to routes and tasks, making it adaptable to different hospital layouts and needs.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

In comparison to current line-following and obstacle-avoidance robots, the suggested robot performs various duties. We were able to reduce the number of ultrasonic sensors from three to one, spin the robot's head to cover all three directions, and identify the robot's direction of gaze by looking at its head by adding a servo motor. We can detect obstacles at every angle surrounding the robot and determine their locations by making a few adjustments to the robot's code. It can detect impediments and take the appropriate action by using a camera in place of the ultrasonic sensor. The robot may be utilized for a variety of tasks by implementing certain logical commands. By adding more IR sensors, the robot in the line after you can become more exact. This robot may be employed in businesses, medical facilities, and even by the military. Conveyor belts can be replaced by this robot.

7.2 FUTURE WORK

AI-Enhanced Navigation Implements AI for smarter path finding, obstacle avoidance, and dynamic route adjustments. IoT Connectivity Enables centralized monitoring and control through IoT, allowing real-time location tracking and task management. Integration with Hospital Systems gives Seamless connectivity with hospital management software for automatic task assignment and prioritization.

Multi-Functional Capabilities like robotic arms or drawers are added for more versatile tasks, such as handling multiple packages or performing minor tasks. Advanced Battery and Charging Solutions Incorporates improved battery management and wireless charging to minimize downtime and ensure continuous operation. Enhanced Safety and Compliance Equipps robots with disinfection mechanisms (like UV sterilization) to ensure safety in sterile areas or isolation zones. Scalability for Large Networks to Expand the system for use across multiple hospital buildings or networks, optimizing logistics across larger healthcare facilities.

APPENDIX

A.1

Index.php:

```
const int leftMotorForward = 9;
const int leftMotorBackward = 8;
const int rightMotorForward = 7;
const int rightMotorBackward = 6;
const int leftSensor = 2;
const int rightSensor = 3;
```

A.2

Connect.php:

```
void setup() {
// Set motor control pins as output
pinMode(leftMotorForward, OUTPUT);
pinMode(leftMotorBackward, OUTPUT);
pinMode(rightMotorForward, OUTPUT);
pinMode(rightMotorBackward, OUTPUT);
// Set sensor pins as input
pinMode(leftSensor, INPUT);
pinMode(rightSensor, INPUT);
// Start the motors stopped
stopMotors();
}
```

A.3

Header.php:

```
void loop() {
// Read sensor values (0 if no line, 1 if line detected)
```

```
int leftState = digitalRead(leftSensor);
int rightState = digitalRead(rightSensor);
if (leftState == LOW && rightState == LOW) {
// Both sensors on the line: move forward
moveForward();
}
else if (leftState == LOW && rightState == HIGH) {
// Left sensor off the line, right sensor on the line: turn right
turnRight();
}
else if (leftState == HIGH && rightState == LOW) {
// Left sensor on the line, right sensor off the line: turn left
turnLeft();
}
else if (leftState == HIGH && rightState == HIGH) {
// Both sensors off the line: stop or adjust as needed
stopMotors();
}
}
```

A.4

Result.php:

```
// Functions to control motor movement
void moveForward() {
27digitalWrite(leftMotorForward, HIGH);
digitalWrite(leftMotorBackward, LOW);
digitalWrite(rightMotorForward, HIGH);
21digitalWrite(rightMotorBackward, LOW);
```

```
}
void turnLeft() {
digitalWrite(leftMotorForward, LOW);
digitalWrite(leftMotorBackward, LOW);
digitalWrite(rightMotorForward, HIGH);
digitalWrite(rightMotorBackward, LOW);
}
void turnRight() {
digitalWrite(leftMotorForward, HIGH);
digitalWrite(leftMotorBackward, LOW);
digitalWrite(rightMotorForward, LOW);
digitalWrite(rightMotorBackward, LOW);
}
void stopMotors() {
digitalWrite(leftMotorForward, LOW);
digitalWrite(leftMotorBackward, LOW);
digitalWrite(rightMotorForward, LOW);
digitalWrite(rightMotorBackward, LOW);
}
```

REFERENCES

[1] Line Follower Robots – Controlling, Working Principle and Applications [Online], Retrieved from: HTTPs://www.elprocus.com/line- follower-robot-basics-controlling [April 2, 2018]

[2] M. A. Kader et. al., “Autonomous Fire Extinguisher Robot”, International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering IC4ME2- 2017Rajshahi, Bangladesh, 2017, PP 26-29.

[3] R. H. Rafi, S. Das, N. Ahmed, I. Hossain and S. M. T. Reza, "Design & implementation of a line following robot for irrigation-based application," 2016 19th International Conference on Computer and Information Technology (ICCIT), Dhaka, 2016, pp.480483.doi:10.1109/ICCITECHN.2016.7860245

[4] Schmidt, R.A. Jr.: A study of the real–time control of a computer–driven vehicle, Stanford University, 1971.

[5] J.Thirumurugan et al. “Line following robot for library inventory management system”, INTERACT2010, 3-5 Dec. 2010, Chennai, India.

[6] https://playground.arduino.cc/Main/AdafruitMotorShield

[7] http://www.buildtronix.com/arduino-uno-evelopment-board-withatmega328.html.

[8] International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 2, Issue 8, August 2013 ISSN: 2278 – 1323 https://www.slideshare.net/rehnazrazvi/line-following-robot-16014541

[9] Miller Peter, “Building a Two Wheeled Balancing Robot”, University

of Southern Queensland, Faculty of Engineering and Surveying. Retrieved Nov 18, 2008.

[10] Meh-ran pakdaman ,m. mehdai sanaatiyan, Mahdi ghahroudi, “A line follower robot from design to implementation Technical issues and problems”, Research gate publications, March 2010.

[11] Lawanya Shri M ,”A line following robot for Hospital management”, Research gate publications ,February 2019

[12] M. Kahe ,”Robotic Guide”, Kanone Oloum Publication,2008.

[13] Cao Quoc Huy,”Line Follower Robot”, University UPG din Ploiesti.

[14] M.Zafri Baharuddin,”Analyst of Line Sensor Confiuration for Advanced Line Follower Robot” ,University Tegana Nasional.

[15] P. Heryati , A. Aghagani, “Science of Robot Design and Build Robot”, Azarakhsh Publication,2008.

[16] M. Mashaghi,”Robotic Guide “, Kanone Oloum Publication,2008.A.Kahe,”A V R Microcontroller “ Nas publication,2007.

[17] Bajestani, S.E.M., Vosoughinia, A, Technical Report of Building a Line Follower Robot, 2010 International Conference on Electronics and Information Engineering (ICEIE 2010).

[18] M. ZafriBaharuddin, Izham Z. Abidin, S. SulaimanKajaMohideen, Yap KeemSiah, Jeffrey Tan Too Chuan, “Analysis of Line Sensor Configuration for the Advanced Line Follower Robot”.

[19] Sumit Mittal, Dr.Neelam R. Prakash, Dr. Sanjay P. Sood, “A Line Follower Robot for Transport Applications in Hospital Domain”.

[20] Anand Mahendran , RamyaGovindaraj,”A Study On Various Bio Inspired Computing Models", journal of Theoretical and Applied Information Technology November 2013, Vol. 57. No. 3.