

AUTONOMOUS VEHICLE: LINE FOLLOWER ROBOT

Submitted in partial fulfillment of the
requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering

By

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SCHOOL OF COMPUTING**

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
CATEGORY -1 UNIVERSITY BY UGC
Accredited with Grade “A++” by NAAC | 12B Status by UGC |
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **G V SAI CHAITANYA (40110360)** and **JASWANTH REDDY V (40110482)** who carried out the Project entitled **"AUTONOMOUS VEHICLE: LINE FOLLOWER ROBOT"** under my supervision from November 2023 to April 2024.

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DECLARATION

I, **G V SAI CHAITANYA (Reg. No- 40110360)**, hereby declare that the Project Report entitled “**AUTONOMOUS VEHICLE: LINE FOLLOWER ROBOT**” done by me under the guidance of **Dr. L. K. JOSHILA GRACE, M.E., Ph.D.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in **Computer Science and Engineering**.

DATE:

PLACE: Chennai

SIGNATURE OF THE CANDIDATE

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ABSTRACT

The aim of the project is to build a simple Autonomous Line Following Robot. Line Following is one of the most important aspects of robotics. A **Line Follower Robot (LFR)** is a simple autonomously guided robot that follows a line drawn on the ground to either detect a dark line on a white surface or a white line on a dark. It is designed to move automatically and follow the line. The robot uses arrays of optical sensors to identify the line, thus assisting the robot to stay on the track. The array of two sensor makes its movement precise and flexible. Line follower actually senses the line and follows it. Though the idea sounds simple, with a little more development. The robot is driven by DC gear motors to control the movement of the wheels. The dc gear motor is driven by the motor driven circuit. In general robots incomes are voltages of the circuits and sensors voltages variations. This project aims to implement the algorithm and control the movement of the robot by proper tuning of the control parameters and thus achieve better performance. It can be used industrial automated equipment carriers, small household applications, tour guides in museums and other similar applications, etc. These types of robots are very simple to build and is often the first choice for beginners who are getting started with robotics. The Line Following Robot using Arduino Uno project presents a robust solution for automated navigation through predefined paths. The primary objective is to design and implement a cost-effective, yet efficient, autonomous robot capable of following a black line on a contrasting surface. The hardware comprises an Arduino Uno microcontroller board, infrared sensors, motors, and wheels. The infrared sensors detect the line beneath the robot, providing feedback to the Arduino Uno, which then processes this information to control the motors. Based on the sensor readings, the Arduino Uno adjusts the motor speeds to keep the robot aligned with the line. The software is developed using Arduino IDE, involving programming logic to interpret sensor data and generate corresponding motor control signals.

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
LFR	Line Follower Robot
DC	Direct Current
IC	Integrated Circuit
LED	Light Emitting Diode
IR	Infrared Sensor

CHAPTER 1

INTRODUCTION

The main aim of any robot is to reduce human effort. According to the purpose different types of robots are designed for practical applications. In any work environment proper monitoring is always needed for better results.

Line follower is a machine that can follow a path. The path can be visible like a black line on a white surface. Sensing a line and maneuvering the robot to stay on course, while constantly correcting wrong moves using feedback from the sensor forms a simple yet effective system. It can be used in automobile, industrial automations, guidance, etc. Line Follower is one of the most important aspects of robotics. A Line Following Robot is an autonomous robot which is able to follow either a black or white line that is drawn on the surface consisting of a contrasting color. It is designed to move automatically and follow the plotted line. It enhances interdisciplinary approach to mechanical, electronic, electrical and programming skills. The application of the project is range from the individual domestic appliance to automation and control aspect of large industry. Human are intelligent natural machine but it has serious limitation of efficiency and reliability. Robots are made to replace dependency of human force partially. The project is somehow designed to perform the similar task.

A line following robot is a small robot that can autonomously navigate along a designated path. Typically, these robots use Arduino boards as their brains and infrared (IR) sensors to "see" the line. The IR sensors emit light and detect the reflected light. When the robot is on the white part of the surface, both sensors will receive a strong reflection. If the robot strays onto the black line, one sensor will receive less reflected light. The Arduino code interprets these signals and controls the motors to steer the robot back onto the line. These robots are a great introduction to robotics and can be built with relatively inexpensive components. You can find many resources online that detail the parts list, construction process, and Arduino code to build your own line following robot.

Line following robots are a captivating introduction to the world of robotics, offering a

glimpse into the fascinating realm of autonomous navigation. At their core, these miniature marvels utilize an Arduino board as their intelligent center, coordinating the actions of various components to meticulously follow a designated path. The secret sauce behind their line-tracing prowess lies in the strategic placement of infrared (IR) sensors. These sensors act as the robot's eyes, constantly emitting and detecting infrared light. When the robot traverses a white surface, both IR sensors are greeted by a strong reflection of the emitted light. However, the moment it deviates onto the designated black line, the story takes a turn. The sensor positioned directly above the black line encounters a significant drop in reflected light, as the black surface absorbs a larger portion of the emitted IR rays.

This crucial information, the varying intensity of reflected light, is meticulously captured by the Arduino board. The onboard code serves as the robot's decision-making unit, meticulously analyzing the data from the IR sensors. Imagine the code as a detective, piecing together clues – in this case, the light readings – to solve the mystery of where the line is. Based on this analysis, the code dictates the movement of the robot's motors. If one sensor detects a significant drop in reflected light, signifying the robot has strayed off course, the code springs into action. It skillfully adjusts the speed and direction of the motors, effectively steering the robot back onto the desired line. This intricate interplay between sensors, code, and motors allows the robot to navigate the path with remarkable precision.

Building a line following robot with Arduino is an incredibly rewarding experience, fostering a deeper understanding of electronics, programming, and even problem-solving. The beauty of this project lies in its accessibility. The required components – Arduino board, IR sensors, motor driver module, and a basic robot chassis – are readily available and relatively inexpensive. Furthermore, the online community offers a wealth of resources, providing detailed step-by-step guides, comprehensive parts lists, and readily available Arduino code. These resources not only equip you with the knowledge to construct your robot but also empower you to customize it. You can experiment with different line colors, sensor configurations, or even introduce additional functionalities like obstacle detection.

As we embark on this captivating journey of building our own line following robot, remember that the process itself holds immense value. Troubleshooting challenges, fine-tuning the code, and witnessing your creation come to life – these are experiences that spark curiosity, ignite creativity, and solidify your understanding of the fundamental principles of robotics.

1.1 BACKGROUND AND MOTIVATION

Some of the motivations we can bring up from the various backgrounds are:

Educational Tool:

Line follower robots serve as an excellent educational tool for students and hobbyists interested in robotics and automation. Building and programming a line follower robot provides hands-on experience in electronics, programming, and control systems, making it an engaging way to learn STEM (Science, Technology, Engineering, and Mathematics) concepts.

Introduction to Robotics:

Line follower robots often serve as an entry point for individuals to delve into the field of robotics. They offer a relatively simple yet practical platform for beginners to understand basic robotic principles, including sensors, actuators, feedback control, and algorithm development.

Problem-Solving Challenge: Designing an efficient line follower robot presents a compelling problem-solving challenge. Engineers and enthusiasts are motivated to develop innovative solutions to navigate the robot along a predefined path, overcome obstacles, and optimize performance metrics such as speed and accuracy.

Technological Innovation:

The development of line follower robots drives technological innovation in areas such as sensor technologies, control algorithms, and hardware design. Researchers continually explore novel sensing modalities, advanced control strategies, and lightweight materials to enhance the capabilities and efficiency of these robots.

Practical Applications:

While initially developed for educational and recreational purposes, line follower robots have found practical applications in various industries. They can be employed in warehouse automation for material handling, in agricultural settings for crop monitoring and spraying, or in surveillance systems for patrolling predefined routes.

Automation and Efficiency:

Line follower robots contribute to automation and efficiency in tasks that involve following predefined paths or lines. By autonomously navigating along designated routes, these robots can reduce manual labor, improve productivity, and enhance safety in environments such as manufacturing facilities or distribution centers.

Inspiration from Nature:

The concept of line following in robotics draws inspiration from nature, where animals like ants and insects use similar mechanisms to follow trails or pheromone paths. Mimicking these natural behaviors in robotic systems not only serves practical purposes but also deepens our understanding of biological systems and biomimicry principles.

In summary, the background and motivation behind line follower robots encompass a blend of educational, technological, and practical considerations, driving innovation, learning, and problem-solving in the field of robotics and automation.

1.2 OBJECTIVE AND SCOPE

The objectives of the project are:

- It should be capable of taking various degrees of turns.
- The robot must be insensitive to environmental factors such as lighting and noise.
- It must allow calibration of the line's darkness threshold.
- The robot must be capable of following a line.

- It should be moving only on black line.

The primary aim of the project is to design, develop, and implement a line-following robot capable of autonomously navigating predefined paths by detecting and tracking lines on the ground. The robot will utilize sensors and control algorithms to interpret line positions and adjust its motion to stay aligned with the desired path.

Scope:

The project will focus on creating a robot that can effectively follow lines of contrasting colors or materials on various surfaces, such as floors or tracks. The robot's sensors will detect these lines, allowing it to make real-time adjustments to its trajectory. The scope includes designing and integrating the necessary hardware components, such as infrared or color sensors, motors, wheels, and a microcontroller unit (MCU). Special attention will be given to ensuring robustness, reliability, and compatibility among the hardware elements.

Scalability must be a primary concern in the design. The robot must be capable of following the line. This technique can be incorporated into the Automated Guided Vehicles (AGV) for providing the easy way of operation. Generally, the AGV is integrated with the microprocessor and computers for controlling its system. It also uses a position feedback system for traveling in the desired path. In addition, the electric signals and RF communication are needed for communicating with the vehicle and system controller. Such awkward functions are completely not required in this line following robot, and it just uses the IR sensors to travel on the black lines.

Unlike room-exploration robots that often get stuck against chairs and carpet edges, you don't have to chase after a well-designed line-following robot. Most line-following robots have two motors, two front sensors, and a basic electronic circuit for autonomous control. But, a great thing about this type of robot is that it is easy to make small changes for added complexity. Simple improvement is to install the robot in a decorative container, along with colorful LEDs. More advanced designs add various sensors and a programmable microcontroller for faster speed, smoother turning, or

maze-solving.

Sensor Calibration and Signal Processing: Calibration of sensors will be conducted to optimize their performance in detecting line positions accurately. Signal processing techniques will be implemented to interpret sensor data and make informed decisions regarding robot motion and steering adjustments.

Control Algorithms: The project will explore and implement various control algorithms, such as proportional-integral-derivative (PID) control, fuzzy logic, or machine learning-based approaches, to govern the robot's movement. These algorithms will enable the robot to maintain stable and precise line following behavior under different conditions.

Environment Adaptability: The robot will be designed to adapt to diverse environmental conditions, including changes in ambient light, line patterns, and surface textures. The scope encompasses testing and refining the robot's performance across a range of scenarios to ensure robustness and versatility.

In summary, the aim of the project is to develop a line-following robot with robust sensing, control, and adaptability capabilities, while the scope encompasses hardware design, sensor integration, algorithm development, environmental testing, user interaction, educational outreach, and potential future enhancements and applications.

CHAPTER 2

LITERATURE SURVEY

“Algorithm for line follower robots to follow critical paths with minimum of sensors” [1]. This paper introduces an approach which helps a line follower robot to achieve the ability to autonomously follow a path that has straight lines, curves, 90 degree bends, T-junctions and + junctions using minimum sensors. Generally a line follower robot uses a matrix of sensors to achieve this ability. This paper discusses about the algorithm through which a line follower can do the same thing using an array of sensors with a minimum number of sensors.

“Evolving a Line Following Robot to use in shopping centers for entertainment” [2]. In this work the design of a Line Following Robot which is commonly used to carry children through shopping malls entertainment place is discussed as a new commercial product in this field. The robot has five different speed levels, and is able to follow 4.8 cm wide black line carrying nominally 400 kg load. The robot can be operated in two control modes; Line Following Mode and Service Mode. In the Line-Following Mode it follows the path of the black line in a suitable ground, while in the Manual Mode, it can be moved manually forwards, backwards, left and right free from the black lined path by a remote controller.

“Line Follower Robot” [3]. This project has been extensively studied over some of researchers and some literatures to create a useful AGV and analyzing various patterns of using different components. The following robot is an intelligent system as a kind of provisional one, which has robot positions corrective feedbacks, toward the black or white line, and the traits of this robot comparing to the last.

“Line follower robot: Fabrication and accuracy measurement by data acquisition” [4]. The main objective is to design a line follower robot is to carry products in the manufacturing process in industries. In this paper, we mainly focused on the design to work the line follower efficiently with lighter weight. The line follower robot designed with 5 sensors to make the robot move in even complex paths.

“Building an easy Line Follower Robot using Arduino Uno” [5]. This paper discussed the mechanical and technical issues with the line follower robot and applications in various fields. Their work represents a proposed line sensor configuration to improve the navigation reliability of the differential drive line following robot .

“Line Follower Robot Using Arduino” [6]. The concept of the line follower robot is related to light. Here, we use the behavior of light on the black-and-white surface. The white color reflects all the light that falls on it, whereas the black color absorbs the light. In this line-follower robot, we use IR transmitters and receivers (photodiodes). They are used to send and receive the lights. When IR rays fall on a white surface, they are reflected toward the IR receiver, generating some voltage changes. In this project, when the IR sensor senses a white surface, an Arduino gets 1 (high) as input, and when it senses a black line, an Arduino gets 0 (low) as input. Based on these inputs, an Arduino Uno provides the proper output to control the bot.

“Technical report of building a line follower robot” [7]. The following robot is a intelligent system as a kind of provisional one, which has robot positions corrective feedbacks, toward the black or white line, and the traits of this robot comparing to the last ones in this field includes: increasing man oeuvre power with sudden way point changes, excellent and accurate robot renovation and low price for production.

“ A novel design of line following robot with multifarious function ability” [8]. Their work has been designed to build a Line following Robot using IR sensor to follow a designated path which is provided and runs over it. It will move in a particular direction specified by the user to navigate the robot through a black line marked on the white surface. Automatic parking technology can complete parking operations safely and quickly without a driver and can improve driving comfort, while greatly reducing the probability of parking accidents.

“Analysis of Line Sensor Configuration for the Advanced Line Follower Robot” [9]. Navigation is important to many envisioned applications of mobile robots. The variety of navigation tools may vary from expensive high accuracy tools to cheap low accuracy tools. The complexity of these tools would be dependent upon the navigation

requirements. A cheap and simple navigation tool would be the line following sensor. However, the challenge posed in this navigation technique may be complex. A straight or wavy line would be simple to navigate whereas a T-junction, 90 degree bends and a grid junction would be difficult to navigate. This paper presents a proposed line sensor configuration to improve the navigation reliability of the differential drive line following robot.

“A Survey on Shadow Detection Techniques in a Single Image” [10]. This paper attempts to survey the various shadow detection algorithms for a single image. For the purpose of survey, the notable research work in the literature is classified under five major categories: invariant-based detection, feature-based detection, region-based detection, color model based detection and interactive shadow detection.

“Design to Implementation of A Line Follower Robot Using 5 Sensors” [11]. The main objective is to design a line follower robot is to carry products in the manufacturing process in industries. In this paper, we mainly focused on the design to work the line follower efficiently with lighter weight. The line follower robot designed with 5 sensors to make the robot move in even complex paths. This paper discussed the mechanical and technical issues with the line follower robot and applications in various fields.

“An Ultrasonic Line Follower Robot To Detect Obstacles And Edges For Industrial And Rescue Operations” [12]. The goal of this study is to develop a monitoring system that follows certain paths and can detect objects and edges using ultrasonic frequencies. If some object is put, a regular line follower will try to move and smash the obstacle.

2.1 INFERENCES FROM LITERATURE SURVEY

Sensor Integration:

Line-following robots typically use infrared sensors or similar technology to detect the contrast between the line and the surrounding surface.

Autonomous Navigation:

Line-following robots demonstrate a form of autonomous navigation, as they can follow a predefined path without human intervention.

Hardware Platforms:

Literature may discuss different hardware platforms used for building line follower robots, including microcontrollers (e.g., Arduino, Raspberry Pi), motor drivers, chassis designs, and power management systems.

Applications in Industry:

The concept of line-following robots can be extended to various industrial applications, where autonomous vehicles or robots navigate predefined paths for tasks such as material handling, assembly, or inspection.

Emerging Trends:

Recent literature may indicate emerging trends in line follower robot development, such as the adoption of autonomous navigation techniques, swarm robotics concepts for multi-robot coordination, or the use of advanced machine learning algorithms for adaptive control.

Future Directions:

Based on the literature survey, researchers may propose future directions for advancing line follower robot technology, including improving robustness, enhancing real-time decision-making capabilities, exploring novel sensing modalities, or developing energy-efficient designs.

2.2 OPEN PROBLEMS IN EXISTING SYSTEMS

Problems in existing systems are:

- In certain industries carriers are required to carry products from one manufacturing plant to another which are usually in different buildings or separate clocks. Conventionally, carts or trucks were used with human drivers. Unreliability and inefficiently in this part of assembly line formed the weakest

link. This project ensure to automatic this sector of using line following robot.

- Existing line-following robots may struggle in dynamically changing environments where the path or obstacles can change unpredictably. Adapting to such changes in real-time is a challenging problem.
- Balancing speed and precision in line following is a constant challenge. Some robots may struggle to maintain accuracy at high speeds, while others may lack the speed needed for certain applications.
- Many line-following robots are designed for relatively simple and well-defined paths. Adapting to handle these complex pathways with intersections is challenge.
- Improving the accuracy of the robot's localization and mapping capabilities, especially in scenarios where GPS signals are not available. This is crucial for applications where precise positioning is required.
- Developing mechanisms for fault detection and recovery to ensure the robot can handle unexpected failures or issues, such as sensor malfunctions or motor failures, without completely losing functionality.
- Line follower robots often struggle to maintain reliable performance in environments with variable lighting conditions, changes in track surface texture, or ambiguous line markings. Developing robust sensing and control algorithms capable of adapting to such environmental variations remains a challenge.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 FEASIBILITY STUDIES

The system has restricted to the following limitations.

- The ir sensor cannot be work in the day light it works only in the dim light or room light.
- Few curves are not made efficiently, and must be avoided.
- The turning radius should be of minimum 50m to take smooth U-turning of robot.
- The width of the path must be of 35mm so that it can cover minimum 2 sensors.
- The path should be plane and obstacle free.
- The steering mechanism is not easily implemented in huge vehicles and impossible for non-electric vehicles.

3.1.1 Technical Feasibility

Evaluate the technical aspects of the project, including the availability of technology, sensors, and hardware components required for the line-following robot. Assess the feasibility of implementing advanced algorithms for real-time decision-making and control.

3.1.2 Market Feasibility

Analyze the market demand for line-following robots. Identify potential applications and industries where the robot could be deployed. Evaluate existing competitors and assess the market potential for the developed robot.

3.1.3 Financial Feasibility

Estimate the initial investment required for developing the line-following robot, including research and development, hardware, and software costs. Conduct a cost-benefit analysis to determine the potential return on investment.

3.1.4 Operational Feasibility

Evaluate the operational aspects, including the availability of skilled personnel for development, maintenance, and support. Assess the impact of the line-following robot on existing operations and workflows.

3.1.5 Legal and Regulatory Feasibility

Identify and analyze any legal or regulatory constraints that may impact the development and deployment of the line-following robot. Ensure compliance with safety standards and regulations.

3.2. HARDWARE CONFIGURATION

- System: Any processor
- Hard Disk: 256 GB OR Higher
- Input Devices: Keyboard, Mouse
- Ram: 4 GB

3.3 SOFTWARE CONFIGURATION

- OPERATING SYSTEM : WINDOWS 7/8/10/11
- IDE : ARDUINO
- LANGUAGE : C(Programming Language)

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

Line followers can be used to deliver mail within an office building. It can be used to deliver medications in a hospital. The technology has been suggested for running buses and other mass transit systems, and may end up as part of autonomous cars navigating the freeway. The line follower can be used in guidance system for industrial robots moving on shop floor. AN example might be in a warehouse where the robots follow 'tracks' to and from the shelves they stock and retrieve from. A line follower robot can be used in military as spy kids or in many other applications.

4.1 BLOCK DIAGRAM

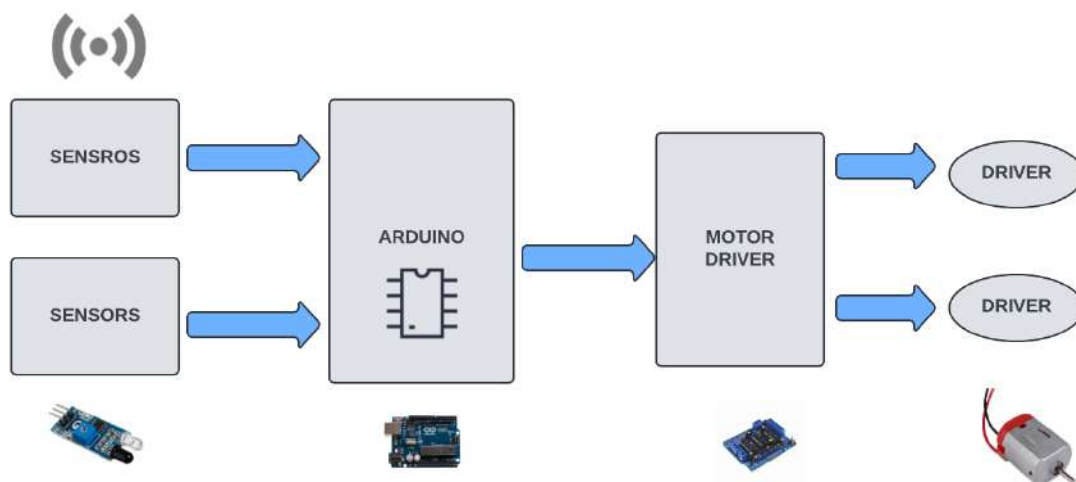


Fig 4.1: Block Diagram

In this block diagram it contains two IR Sensors, one Arduino, one Motor Driver, two Drivers. Sensors are used to sense the surrounding surfaces and Arduino which takes input and gives output to the motor driver which in turn takes the input from Arduino and gives output to the motor. Based on the operations the LFR is moves and works.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

4.2.1 ARCHITECTURE DIAGRAM

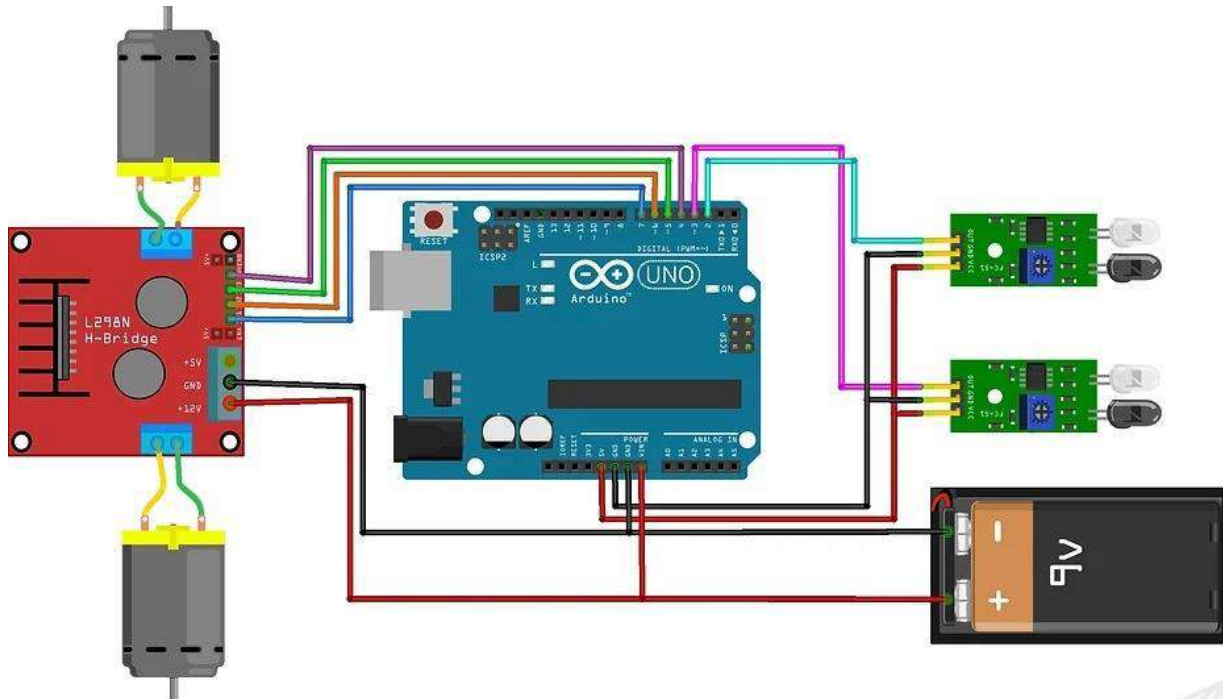


Fig 4.2: Architecture Diagram for LFR

The circuit consists of mainly four parts: Two IR sensors, one motor drive, two motors, one Arduino, a battery and few connecting wires. The sensor senses the IR light reflected from the surface and feeds the output to the onboard op-amp comparator. When the sensor is situated over the white background, the light emitted by the sensor is reflected by the white ground and is received by the receiver. But when the sensor is above the black background, the light from the source doesn't reflect to it. The sensor senses the intensity of reflected light to give an output. The sensor's output is fed to the microcontroller, which gives commands to the motor driver to drive the motor accordingly. In our project, the Arduino Uno is programmed to make the robot move forward, turn right or turn left and stop according to the input coming from the sensor. The output of the Arduino is fed to the motor driver.

4.2.2 Flow chart

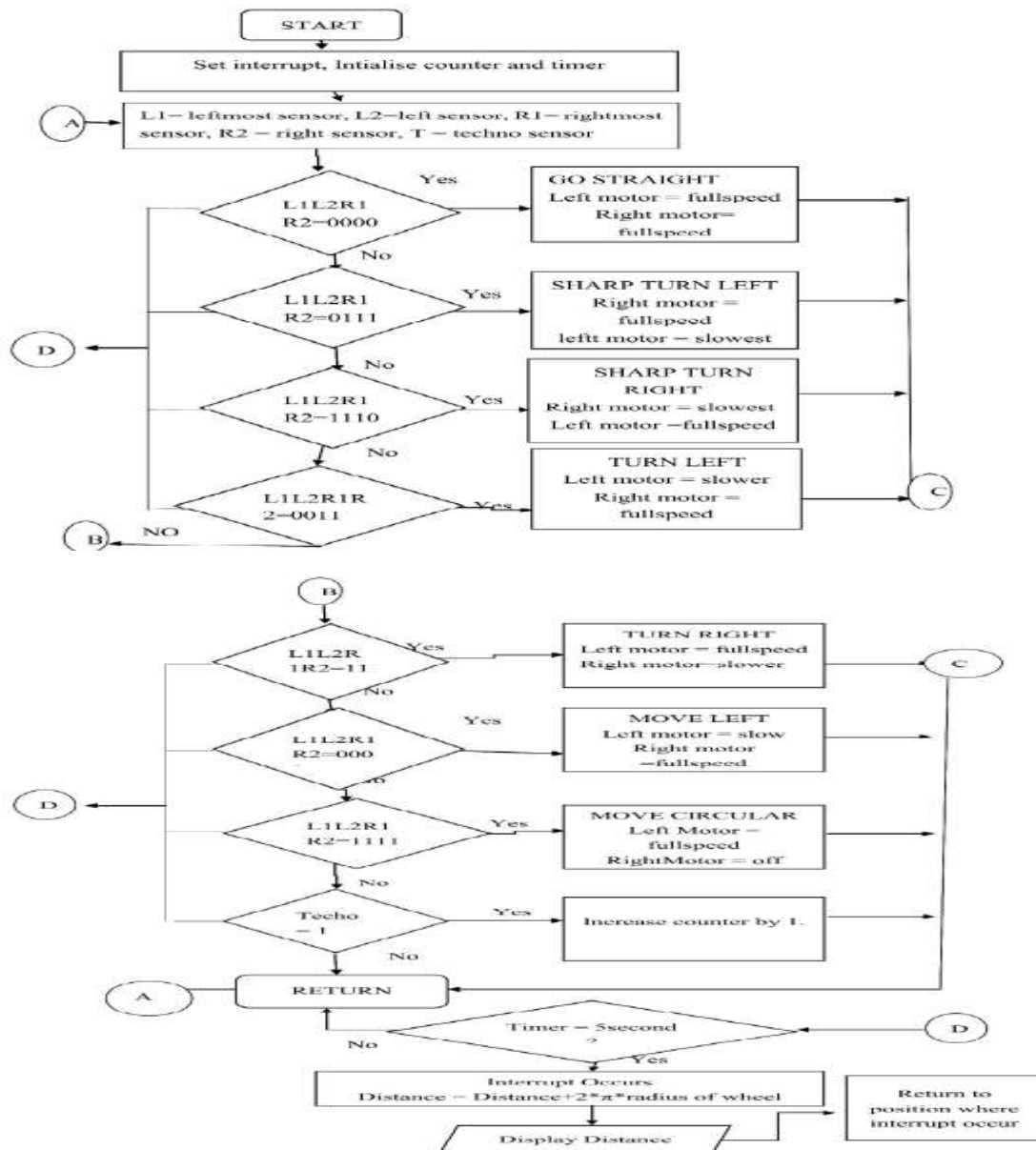


Fig 4.3: Flow Chart for LFR

This flow chart shows that how the LFR will work based on some conditions provided by the user into the Arduino uno IDE. Here, each components gets input from other components outputs.

4.3 DESCRIPTION OF MATERIALS USED

4.3.1 Motor Driver

Motor driver is a current enhancing device; it can also be act as Switching Device. Thus, after inserting motor driver among the motor and microcontroller. Motor driver taking the input signals from microcontroller and generate corresponding output for motor.

IC L293D:

This is a motor driver IC that can drive two motor simultaneously. Supply voltage (V_{ss}) is the voltage at which motor drive. Generally, 6V for dc motor and 6 to 12V for gear motor are used, depending upon the rating of the motor. Logical Supply Voltage deciding what value of input voltage should be considered as high or low .So if the logical supply voltage equals to +5V, then -0.3V to 1.5V will be considered as Input low voltage and 2.3V to 5V is taken into consider as Input High Voltage. The Enable 1 and Enable 2 are the input pin for the PWM led speed control for the motor L293D has 2 Channels .One channel is used for one motor.

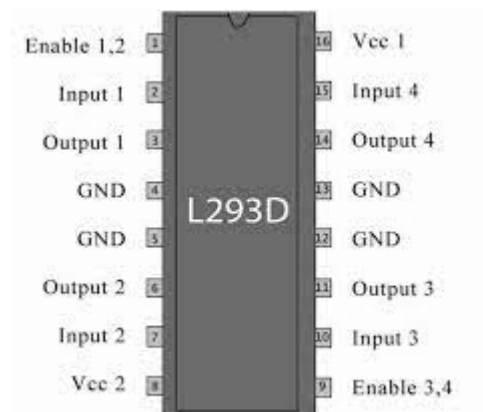


Fig 4.4: IC L293D Motor Driver

4.3.2 Gear DC Motor

Motor is a device that converts any form of energy into mechanical energy or imparts motion. In constructing a robot, motor usually plays an important role by giving movement to the robot. In general, motor operating with the effect of conductor with

current and the permanent magnetic field. The conductor with current usually producing magnetic field that will react with the magnetic field produces by the permanent magnet to make the motor rotate. There are generally three basic types of motor, DC motor, even servomotor and stepper motor, which are always being used in building a robot. DC motors are most easy for controlling. One DC motor has two signals for its operation. Reversing the polarity of the power supply across it can change the direction required. Speed can be varied by varying the voltage across motor.



Fig 4.5: DC Motors

SPECIFICATION OF DC GEAR MOTOR –

Voltage of the dc motor- 9/12 volts

Number of gear motors used – 2

Number of rotation – 300-500 RPM

4.3.3 Infrared sensor

An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measure only infrared radiation, rather than emitting it that is called a passive IR sensor. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode that is sensitive

to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.



Fig 4.6: IR Sensors

This circuit comprises of the following components:

1. LM358 IC 2 IR transmitter and receiver pair
2. Resistors of the range of kilo-ohms.
- 3 . Variable resistors.
4. LED (Light Emitting Diode).

In this project, the transmitter section includes an IR sensor, which transmits continuous IR rays to be received by an IR receiver module. An IR output terminal of the receiver varies depending upon its receiving of IR rays. Since this variation cannot be analyzed as such, therefore this output can be fed to a comparator circuit. Here an operational amplifier (opamp) of LM 339 is used as comparator circuit. When the IR

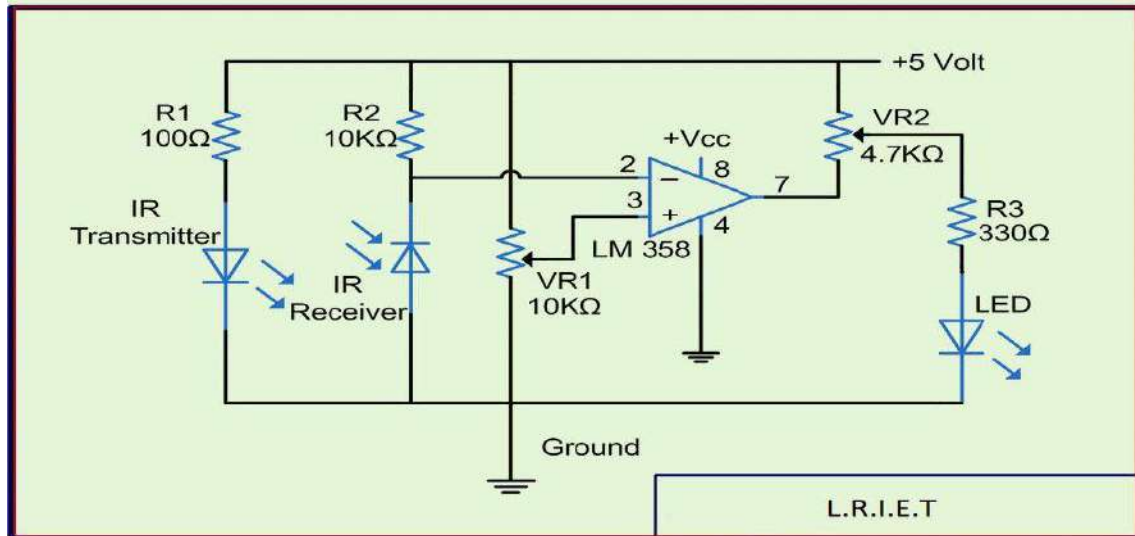


Fig 4.7: Circuit Diagram of Sensors

receiver does not receive a signal, the potential at the inverting input goes higher than that non-inverting input of the comparator IC (LM339). Thus the output of the comparator goes low, but the LED does not glow. When the IR receiver module receives signal to the potential at the inverting input goes low. Thus the output of the comparator (LM 339) goes high and the LED starts glowing. Resistor R1 (100 Ω), R2 (10k Ω) and R3 (330 Ω) are used to ensure that minimum 10 mA current passes through the IR LED Devices like Photodiode and normal LEDs respectively. Resistor VR2 (preset=5k Ω) is used to adjust the output terminals. Resistor VR1 (preset=10k Ω) is used to set the sensitivity of the circuit Diagram.

4.3.4 Power supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely toothers. Here in our application we need a 9v DC power supply for all electronics involved in the project. This requires step down transformer, rectifier, voltage regulator, and filter circuit for generation of 5v DC power. For our project we have used one 9V battery .



Fig 4.8: 9V Battery

4.3.5 Battery Snap

Probably the easiest way to connect our DC LEDs to power is using a 9V battery, with these nice long battery snaps. As you can see from this photo, the battery snap is designed to snap onto the leads on the terminal end of any standard 9V battery. These battery straps have two leads, a red "positive" wire and a black "negative" wire. Each of our pre-wired LEDs also come with a red positive wire and a black negative wire.



Fig 4.9: Battery Snap

4.3.6 Robotic Chassis

This robotic chassis kit contains of an acrylic base with two gear motors, two compatible wheels, a ball caster, and other accessories.

4.3.7 Wheel specification

Width: 30mm

Diameter: 65mm

4.3.8 Jump wire

It is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.



Fig 4.10: Jump Wires

4.3.9 Arduino UNO

Arduino UNO is a microcontroller 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 ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Fig 4.11: Arduino uno

Arduino Vs Raspberry Pi:

Arduino and Raspberry Pi are two of the most popular single-board computers used by electrical engineers for various projects. Both have their own strengths and weaknesses, and choosing between the two depends on the specific requirements of a project.

Arduino Uno is a microcontroller board that was designed to provide a simple and accessible platform for beginners to learn electronics and programming. It has a straightforward programming environment based on a simplified version of the C programming language, and a limited number of input/output (I/O) pins that make it well-suited for simple projects that require basic control over sensors and actuators.

Raspberry Pi Zero, on the other hand, is a small and inexpensive single-board computer that runs a full operating system, such as Raspbian, which is based on Linux. Unlike Arduino Uno, Raspberry Pi has a more powerful processor, more memory, and a greater number of I/O pins, making it ideal for complex projects that require higher processing power and connectivity options.

One of the key differences between Arduino and Raspberry Pi is the type of microcontroller used. Arduino Uno uses a microcontroller that is designed to be simple and easy to use, with a limited number of I/O pins. Raspberry Pi Zero, on the other hand, uses a more powerful system-on-a-chip (SoC) that provides more processing

power and memory, and a greater number of I/O pins.

Operating Systems (OS) & approaches to software:

Arduino IDE and Raspberry Pi microcontrollers have different operating systems (OS) and approaches to software.

Arduino has a simplified software environment known as the Arduino Integrated Development Environment (IDE), which is used to write and upload code to the board. The Arduino IDE is based on a simplified version of the C programming language and provides a user-friendly interface for programming and controlling the board's inputs and outputs.

Raspberry Pi, on the other hand, runs a full operating system, such as Linux, which provides a more powerful and versatile environment for software development. Raspberry Pi can run multiple applications and services simultaneously, and its operating system can be extended and customized as needed. This makes it an ideal platform for complex projects that require a lot of processing power and memory.

In summary, Arduino has a simpler software environment that is well-suited for basic control of inputs and outputs, while Raspberry Pi has a more powerful and versatile operating system that provides greater functionality for complex projects.

4.4 DESCRIPTION OF SOFTWARE FOR IMPLEMENTATION

As we work on the Line Follower Robot project, we rely on software like Arduino IDE for everything. The microcontroller uses this Arduino IDE which generates code and gives inputs to the microcontroller and works on.

4.4.1 *Arduino IDE*

Arduino IDE (Integrated Development Environment) is a software application used to program and design electronics and automation projects using Arduino hardware. The

Arduino IDE is available for Windows, Mac, and Linux and allows users to create and debug their code, view and edit digital and analog input/output (I/O) pins, and simulate their projects before uploading them to the Arduino hardware. Additionally, the Arduino IDE includes features for creating libraries to extend the functionality of the Arduino platform, and sharing and collaborating on projects.

- **Features of Arduino IDE: Programming and Design:** Arduino IDE allows users to write, compile, and upload code to Arduino boards.
- **Interactive Interface:** It provides an interactive environment for working with Arduino hardware.
- **Code Editing:** Users can edit, debug, and manage their code efficiently within the IDE.
- **I/O Pin Control:** The IDE enables users to view and control digital and analog input/output pins.
- **Simulation:** Users can simulate their projects before uploading the code to actual Arduino hardware.
- **Platform Availability:** Arduino IDE is compatible with Windows, Mac, and Linux operating systems, making it accessible to a wide range of users regardless of their preferred OS.
- **Library Support:** Arduino IDE facilitates the creation and integration of libraries to extend the functionality of the Arduino platform, enabling users to leverage pre-existing code for their projects.
- **Collaborative Environment:** The IDE supports project sharing and collaboration, allowing users to work together on Arduino projects, share code snippets, and benefit from the collective knowledge of the Arduino community.
- **User-Friendly Interface:** The Arduino IDE features a user-friendly interface, making it suitable for beginners and experienced users alike to program and develop projects efficiently.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 ASSEMBLING THE HARWARE COMPONENTS

Assembling parts refers to the process of putting together various components or elements to form a complete product or structure. This can involve physical assembly, where individual pieces are connected or bolted together. To make this robot, first we need a robot body; here I am using a homemade chassis. You can either use a readymade chassis or build one yourself.

Step 1: Now, place the BO motors to the chassis with the help of some hot glue.

Step 2: Place the motor driver on chassis and connect the motor wires to the output of the motor driver.

Step 3: Bend the IR LED and sensor .Then place the sensors on the downside of the robot, adjust the sensors according to the track width and robot width. Remember that one sensor is for left side detection and another is for the right side detection.

Step 4: Now place the Arduino uno using glue and connect the sensor output pins to digital pin 2 and 4 of the Arduino. Connect the VCC pins to 5volt and the ground pins to ground.

Step 5: Now, connect the enable pins of the motor driver to pin 5 and 8 of Arduino and connect the motor driver input pins to pin number 6, 7, 9 and 10 of Arduino respectively.

Step 6: Finally, connect the battery with the circuit and place the battery on chassis. Here, I have connected everything with jumper wires. To make a permanent setup, you can directly solder everything together.

Step 7: Now turn the board upside down and with the help of hot glue gun, attach the castor wheels. Finally, add the wheels.

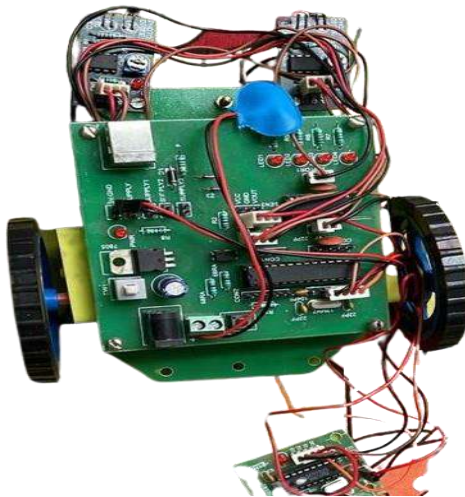


Fig 5.1: Line Follower Robot

5.2 WORKING OF PROJECT

A "line follower" robot is a type of autonomous robot designed to follow a line or path on the ground. The working methodology of a line follower robot typically involves the following steps:

Sensor Detection:

The robot is equipped with sensors, often placed at the bottom, that can detect the line or path it needs to follow. These sensors are usually infrared (IR) sensors or similar devices that can differentiate between light and dark surfaces.

Data Processing:

The sensor data is collected by a microcontroller, such as an Arduino, Raspberry Pi, or similar control unit. The microcontroller processes the sensor inputs to determine the robot's position relative to the line.

Decision Making:

Based on the sensor data, the microcontroller decides how to adjust the robot's movement to stay on the line. This decision-making process often involves implementing algorithms such as PID (Proportional Integral Derivative) control or

simpler logic to determine the appropriate motor commands.

Motor Control:

The microcontroller sends signals to motor drivers, which control the robot's motors. By adjusting the speed and direction of the motors, the robot can turn left, right, or move forward to stay on the line.

Feedback Loop:

The robot continuously repeats the process of sensing the line, processing the data, making decisions, and adjusting its movement. This creates a feedback loop that allows the robot to dynamically adjust its behavior and maintain its position on the line.

Testing and Calibration:

Before deployment, the robot may undergo testing and calibration to ensure that it can effectively follow the line under various conditions such as different line colors, widths, and surface textures.

Overall, the working methodology of a line follower robot relies on the integration of sensors, microcontrollers, motor control systems, and algorithms to enable autonomous navigation along a predefined path. By continuously sensing and responding to its environment, the robot can follow the line with precision and accuracy.

5.3 IMPLEMENTING THE PROJECT

In this line follower robot we have used IR Transmitters and IR receivers also called photo diodes. They are used for sending and receiving light. IR transmits infrared lights. When infrared rays falls on white surface, it's reflected back and catch by photodiodes which generates some voltage changes. When IR light falls on a black surface, light is absorb by the black surface and no rays are reflected back, thus photo diode does not receive any light or rays. Here in this line follower robot when sensor senses white surface then IC gets 1 as input and when senses black line IC gets 0 as input.

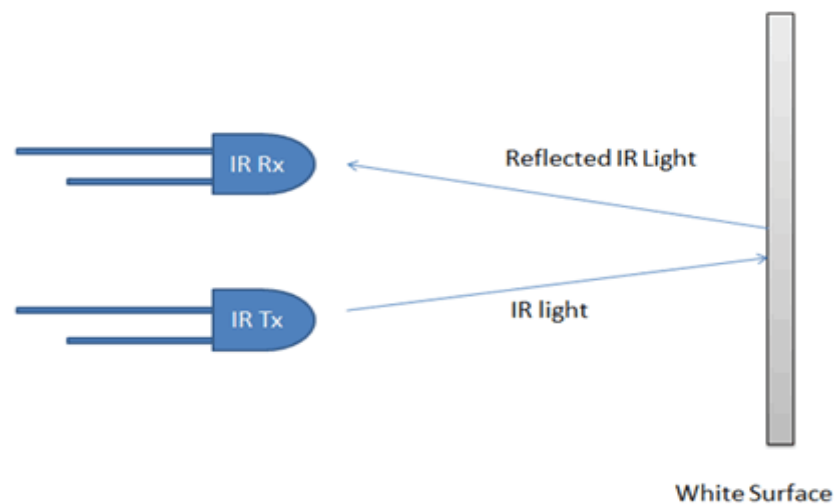


Fig 5.2: Reflected IR light

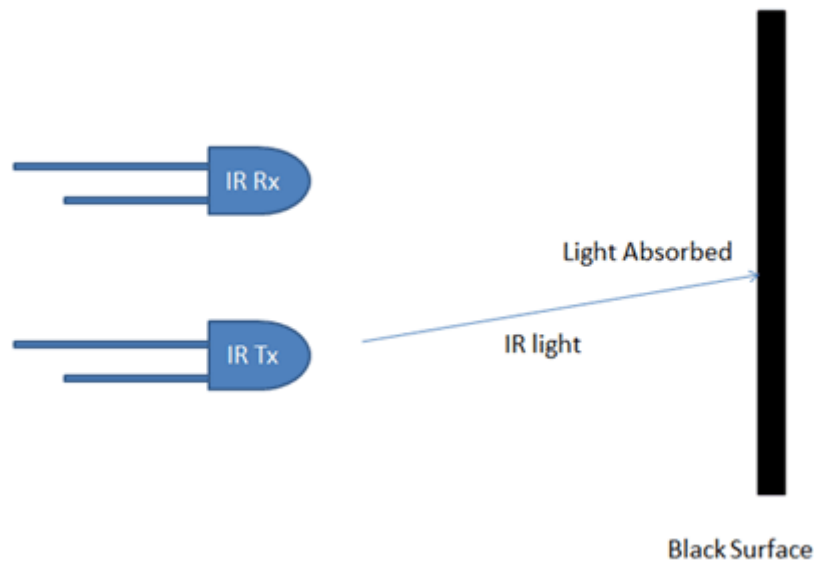


Fig 5.3: Absorbed IR light

The whole line follower robot can be divided into 3 sections:

- **Sensor section:**

This section contains 2Array IR Sensors which includes IR diodes, potentiometer, Comparator (OpAmp) and LED's. Potentiometer is used for setting reference voltage at comparator's one terminal and IR sensors are used to sense the line and provide a change in voltage at comparator's second

terminal. Then comparator compares both voltages and generates a digital signal at output. Here in this line follower circuit we have used two comparator for two sensors. LM 358 is used as comparator. LM358 has inbuilt two low noise Op-amps.

- **Control Section:**

IC L293D is used for controlling whole the process of line follower robot. This IC reads these signals and send commands to driver circuit to drive line follower.

- **Driver section:**

Driver section consists motor driver and two DC motors. Motor driver is used for driving motors. So we add a motor driver circuit to get enough voltage and current for motor. IC L293D sends commands to this motor driver and then it drive motors. Here in this project we are using two IR sensor modules namely left sensor and right sensor. When both left and right sensor senses white then robot move forward. forward.

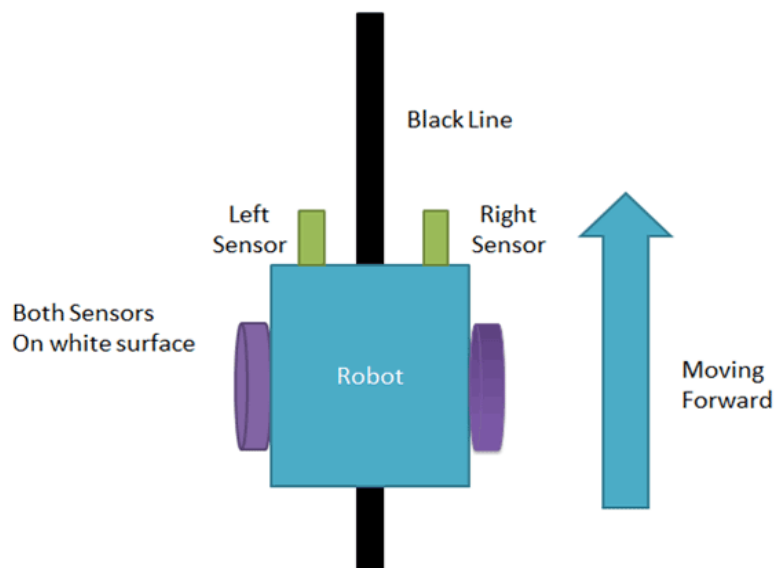


Fig 5.4: Robot Moving forward

If the left sensor comes on a black line then the robot turn the left side.

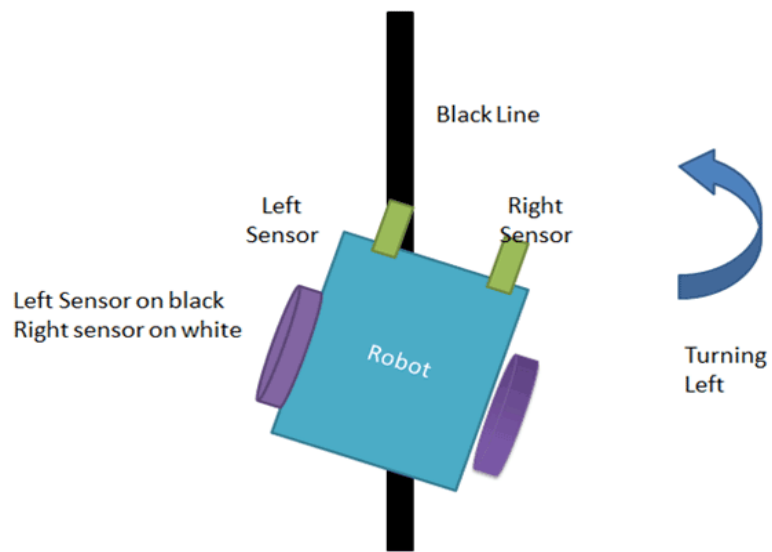


Fig 5.5: Robot Turning Left

If the right sensor sense black line then robot turn right side until both sensors comes at the white surface. When the white surface comes robot starts moving on forward again.

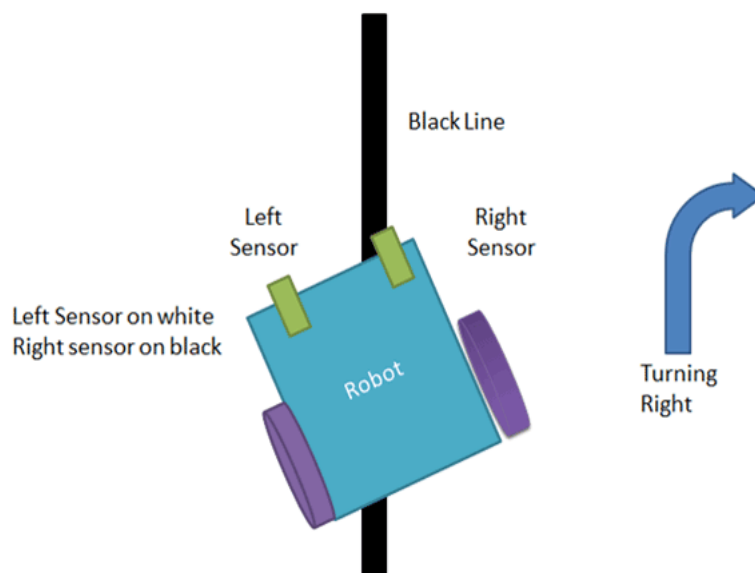


Fig 5.6: Robot Turning Right

If both sensors come on the black line, the robot stops.

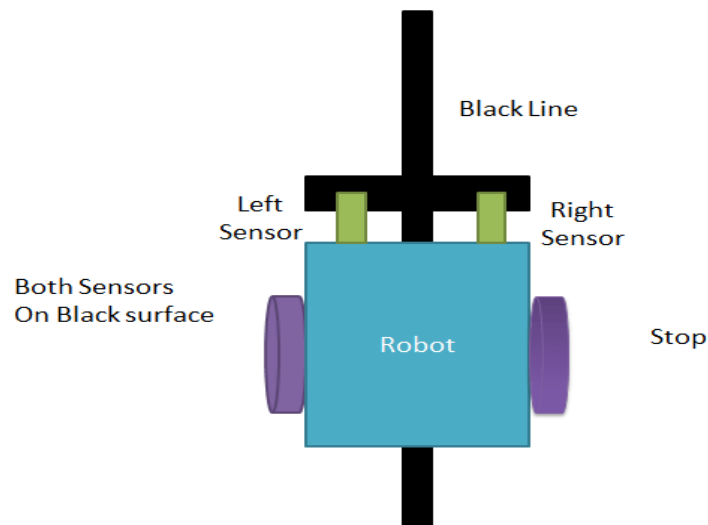


Fig 5.7: Robot Stops moving

5.4 TESTING PLAN OF THE PROPOSED SYSTEM

We have assembled the robot and uploaded the code, so now its time to see it in action and if it is unable to follow the line then we'll have to calibrate the robot. For that first place robot on a black surface (both sensors should be on top of the black surface) then adjust the variable resistor of IR Module until the output led of IR module become off.

Next, place the robot on a white surface and check whether the led is turning on, if not, then just adjust the variable resistor. Repeat the process once again to be sure that the output LED is operating as per the requirement. Now,

since we have calibrated the robot, all we need to do is place the robot on top of the black line and see it in action.



Fig 5.8: Line Track for LFR

The testing plan for the line follower robot involves a comprehensive evaluation of its performance under various conditions to ensure reliable and accurate line tracking. Initially, the robot will undergo basic functionality tests to verify sensor calibration, motor control, and communication between components. Subsequently, it will be tested on different surfaces with varying line widths, and textures to assess its adaptability and robustness. Additionally, tests will be conducted to evaluate the robot's response to environmental factors such as ambient light levels and obstacles along the path. Special attention will be given to cornering performance, ensuring smooth and precise maneuvers without deviating from the line. Furthermore, endurance tests will be conducted to validate the battery life and overall system durability over extended periods of operation. Throughout the testing process, data will be collected to identify any anomalies or performance issues, which will be addressed through iterative improvements and adjustments to the robot's hardware and software configurations.

CHAPTER 6

RESULTS AND DISCUSSION

Our project is an innovative idea of intelligent system which has basically line detection feature and will provide help in various fields like hospitals and service sectors. The sensors in this system are a type of infrared sensor that senses the line and gives the feedback to the microcontroller unit.

1. The battery activates the circuit.
2. The sensor transmitter transmits the frequency, which reflects from the surface. Sensor receiver receives the reflected frequency and gives it to the microcontroller.
3. The microcontroller processes it and gives the signal to motor driver IC.
4. Motor driver IC rotates the motors as per the signal receive and then the wheels rotates.

6.1 RESULT

The Line Following Robot which can meet out all the objectives we specified like robot must be capable of following a line, be capable of taking various degrees of turns, be insensitive to environmental factors like lighting and noise, be moving only on black line, allow calibration of the line's darkness threshold.

The path following accuracy of a line following robot using Arduino can vary depending on several factors including the quality of the sensors, the design of the control algorithm, and the mechanical construction of the robot.

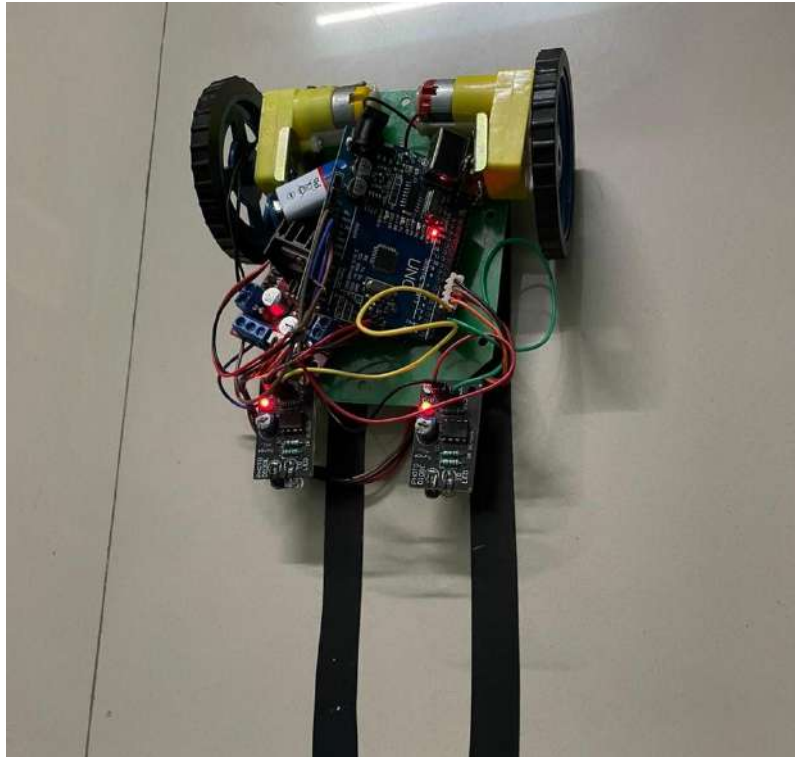


Fig 6.1: LFR

- Path Following Accuracy:
This could be measured in terms of how closely the robot tracks the line, deviations from the path, and any instances of losing track of the line.
 - **Accuracy:** 70%
- Speed and Efficiency:
Evaluate the speed at which the robot is able to follow the line while maintaining accuracy. This can involve measuring the time taken to traverse a certain distance or complete a specified course.
 - **Speed and efficiency:** 300 rpm max.
- Robustness to Disturbances:
To Test the robot's ability to handle various environmental conditions and line types. This can involve testing on different surfaces (e.g., white paper, black tape, colored surfaces), different lighting conditions, and introducing obstacles or distractions on the track. The project works well with the different lighting conditions and different obstacles or coloured surfaces.

- **Sensor Performance:**
This can include factors such as sensitivity to different colors, response time, and reliability in different environmental conditions. The Sensor performance is in average condition and it sometimes gives the best performance based on the black line surface path.
- **Response Time:**
Measure the time taken by the robot to detect changes in the line and adjust its course accordingly. This can involve introducing sudden turns or intersections on the track and observing how quickly the robot reacts to these changes.
- **Power Consumption:**
Monitor the power consumption of the robot during operation, especially if you're using batteries. This can be done using a multimeter or a power monitoring module connected to the Arduino power supply. Here, in this project we used 9v dc battery. So needs to be changed after the usage.
- **Code efficiency:**
It has less code and takes less time to compile by making the code with optimized loops, minimize blocking operations, avoids busy waiting and optimize sensor readings.

6.2 ADVANTAGES AND DISADVANTAGES

Advantages:

- Robot movement is automatic.
- Fit and Forget system.
- Cost effective.
- Simplicity of building

Disadvantages:

- LFR follows a black line about 1 or 2 inches in width on a white surface.
- LFR are simple robots with an additional sensors placed on them.
- Needs a path to run either white or black since the IR rays should reflect from

the particular path.

- Slow speed and instability on different line thickness or hard angles.

6.3 FUTURE SCOPE

- Line tracking robotic vehicle can be used in the medical store to pick up the medicine from a particular drawer for this one has to just add some robotic-arm to it.
- Can be further extended for color detection operations or lane detection on highways. It can be used in shopping malls for carrying different types of products.
- It can be developed so that it can be used in hospitals where patients are needed to take medicines every regular interval of time so one can take what they want.
- Further development of this vehicle can be made , so that it can be used in defense industries for carrying the hazardous materials like radioactive materials and poisonous gas cylinder.
- Digital camera can be attached to the vehicle for real time monitoring of the traffic.

CHAPTER 7

CONCLUSION

A line-following robot utilizing Arduino is a common project in the field of robotics and electronics, where sensors are employed to detect and follow a line on a surface.

The robot operates by continuously scanning the surface beneath it using the IR sensors. When a contrast between the line and its surroundings is detected, the robot adjusts its movement to stay on the line. This adjustment is achieved by controlling the motors based on the sensor readings.

- The objective of line tracking robotic vehicle is to follow a line on its given path which is obtained for which it uses IR sensors which detects the line and sends the information to L293 motor driver IC and then H-bridge which controls the working of the wheel.
- Arduino Uno controls the other operations .The line tracking robotic vehicle was finally completed. A lot of effort was put into the design, implementation and days of toil in front of the computer, writing and debugging the code.
- The robot was finally running with a few glitches here and there which were sorted in the later revisions of the firmware. The line tracking robot still has a few shortcomings but achieves most of the objectives.
- A lot of knowledge on micro-controllers, a deeper & clearer view of the architecture, ports & all other functional blocks was achieved. Also had a peek look at all simple functional parts of the project like the crystal oscillator, logic gates and the works.

In conclusion, building a line-following robot using Arduino offers an excellent introduction to robotics and programming for enthusiasts and beginners alike. Through this project, individuals can learn about sensor interfacing, motor control, and programming concepts such as loops, conditionals, and functions.

Moreover, the project can be expanded and customized in various ways:

- For instance, additional sensors could be incorporated for more precise navigation or to detect obstacles. Advanced programming techniques such as PID (Proportional-Integral-Derivative) control can also be implemented to enhance the robot's performance and responsiveness.
- The line following project can be incorporated with DTMF Controlled robot by adding dtmf modules to our project using mobile connection we can access the robot from any location and control the robot.

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APPENDIX

A. SOURCE CODE

```
//LINE FOLLOWER ROBOT

#define LS 2 // left sensor

#define RS 3 // right sensor

#define LM1 5 // left motor M1a

#define LM2 4 // left motor M2a

#define RM1 7 // right motor M2a

#define RM2 6 // right motor M2b

void setup()

{

  pinMode(LS, INPUT);

  pinMode(RS, INPUT);

  pinMode(LM1, OUTPUT);

  pinMode(LM2, OUTPUT);

  pinMode(RM1, OUTPUT);

  pinMode(RM2, OUTPUT);

}

void loop()

{

  if(digitalRead(LS) && digitalRead(RS)) // Move Forward on line

  {
```

```

digitalWrite(LM1, HIGH);

digitalWrite(LM2, LOW);

digitalWrite(RM1, HIGH);

digitalWrite(RM2, LOW);

}

if(digitalRead(LS) && !(digitalRead(RS))) // turn left by rotating left motors in forward
and right ones in backward direction

{

digitalWrite(LM1, HIGH);

digitalWrite(LM2, LOW);

digitalWrite(RM1, LOW);

digitalWrite(RM2, HIGH);

}

if(!(digitalRead(LS)) && digitalRead(RS)) // Turn right by rotating right motors in forward
and left ones in backward direction

{

digitalWrite(LM1, LOW);

digitalWrite(LM2, HIGH);

digitalWrite(RM1, HIGH);

digitalWrite(RM2, LOW);

}

if(!(digitalRead(LS)) && !(digitalRead(RS))) // Finish line, stop both the motors

```

```
{  
  digitalWrite(LM1, LOW);  
  digitalWrite(LM2, LOW);  
  digitalWrite(RM1, LOW);  
  digitalWrite(RM2, LOW);  
}  
}
```

B. SCREENSHOTS

```
1  #define LS 2 // left sensor
2  #define RS 3 // right sensor
3  #define LM1 5 // left motor M1a
4  #define LM2 4 // left motor M2a
5  #define RM1 7 // right motor M2a
6  #define RM2 6 // right motor M2b
7  void setup()
8  {
9    pinMode(LS, INPUT);
10   pinMode(RS, INPUT);
11   pinMode(LM1, OUTPUT);
12   pinMode(LM2, OUTPUT);
13   pinMode(RM1, OUTPUT);
14   pinMode(RM2, OUTPUT);
15 }
16 void loop()
17 {
18   if(digitalRead(LS) && digitalRead(RS)) // Move Forward on line
19   {
20     digitalWrite(LM1, HIGH);
21     digitalWrite(LM2, LOW);
22     digitalWrite(RM1, HIGH);
23     digitalWrite(RM2, LOW);
24   }
25   if(digitalRead(LS) && !(digitalRead(RS))) // turn left by rotating left motors in forward and right ones in backward direction
26   {
27     digitalWrite(LM1, HIGH);
28     digitalWrite(LM2, LOW);
29     digitalWrite(RM1, LOW);
30     digitalWrite(RM2, HIGH);
31   }
32   if(!(digitalRead(LS)) && digitalRead(RS)) // Turn right by rotating right motors in forward and left ones in backward direction
33   {
34     digitalWrite(LM1, LOW);
35     digitalWrite(LM2, HIGH);
36     digitalWrite(RM1, HIGH);
37     digitalWrite(RM2, LOW);
38   }
39
40   if(!(digitalRead(LS)) && !(digitalRead(RS))) // Finish line, stop both the motors
41   {
42     digitalWrite(LM1, LOW);
43     digitalWrite(LM2, LOW);
44     digitalWrite(RM1, LOW);
45     digitalWrite(RM2, LOW);
46   }
47 }
```

C. RESEARCH PAPER

AUTONOMOUS VEHICLE: LINE FOLLOWING ROBOT

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Abstract— A self-driving vehicle referred to as a "line-following robot" navigates across illuminated or white surfaces through the identification of black lines. In this study, the line-following robot is constructed with an Arduino Uno microcontroller as its central element, incorporating two fundamental DC motors, two infrared (IR) sensors, four wheels, and an Arduino Uno board and serving with robot's chassis. The infrared sensors detect the black line on a white surface, as the infrared signal reflects off a white surface but not when it encounters a black surface. This detection method facilitates the movement of the robot car in three directions: left, right, and forward, utilizing four basic DC motors linked to four wheels. In the vehicle design process, it is imperative to ensure that the selected equipment possesses all the essential features and specifications for efficient assembly. The automated guided vehicle (AGV) must be capable of adapting to the operational environment and navigating precisely within an industrial warehouse. Additionally, this paper outlines a line-following method as the fundamental operational principle and discusses an optimal plan for path tracking based on the drive and turning mechanisms. The embedded system's development should focus on seamlessly integrating the hardware components with the software.

Keywords—IR sensor, L293D motor driver, Arduino Uno board.

I. INTRODUCTION (HEADING 1)

Any robot's primary thing is to minimize mortal labor. Colorful robot kinds are erected for practical operations grounded on their intended use. For better issues, proper monitoring is always

needed in any kind of work terrain. It's possible to see the path as a black track on a white surface. A complicated but efficient system is formed by the robot detecting a line, moving to stay on course, and continuously correcting incorrect movements using the detector's feedback. It can be applied to artificial robotization, automotive robotization, guiding, etc. One of the crucial factors of robotics is the line follower. An independent robot follows a black or white line drawn on a area with a differing color is called a path-following robot. It's intended to follow the drawn line and move automatically. It improves the multidisciplinary approach to programming, electronics, mechanical, and electrical chops. The design's operations gauge from the robotization and control of major diligence to the individual ménage appliance. Although humans are largely sophisticated natural machines, their responsibility and effectiveness are oppressively limited. Robots are designed to incompletely replace mortal labor reliance. The design is in some ways intended to carry out the same function. The objects of the design are • It ought to be suitable to rotate in different degrees. • The robot needs to be vulnerable to external stimulants like noise and light. Expandability needs to be the design's first precedence. • Although humans are highly sophisticated natural machines, their dependability and efficiency are severely limited. Robots are designed to partially replace human

labor dependency. It must enable the line's darkness threshold to be calibrated. Scalability needs to be the design's first precedence. The robot needs to be suitable to trace the line. The robot needs to be suitable to follow the line. This system can be applied to Automated Guided Vehicles (AGV) to offer a simple operating system. For system control, the AGV is generally combined with a microprocessor and computers. For it to follow the intended route, a position feedback system was also enforced.

This line-following robot only uses the IR detectors to follow the black lines; it does not need any delicate functions of that kind. A well-designed line-following robot does not bear you to chase after it, unlike room-disquisition robots that constantly get caught against chairpersons and carpet edges. Two motors, two frontal detectors, and a simple EC for independent control are set up in the maturity of line-following robots.

A. LITERATURE SURVEY

This design has been considerably studied over some of the experimenters and some literatures to produce a useful AGV and analyzing colorful patterns of using different factors. (1) penetrated on October 28, 2022. This robot is a mobile equipment which detects and follow the path. Robot should read for some time to determine his position, and also the control system (PIC18F) will produce some commands for robot to admire factors in order to make accurate movements of the robot. (2) Line follower is a smart independent robot that detects or follows a visible line embedded in the ground. The trail is destined and can be named with a high discrepancy color or with a black line visible on the trail surface. Infrared detectors are used to detect these lines. Generally speaking, sensors are used to detect the path to follow. It's movement is automatic and can be used for operations of long distances. It is a fundamental line follower robot's function. The device proposed for marketable, medical, deliverance and military operations are extremely useful.

B. METHODOLOGY

Mail can be delivered within an office building using line followers. In a hospital, it can be used to give drugs. The technology has been proposed for use in bus and other mass transport systems, and it may eventually be used in self-driving automobiles on the freeway. It can also be used in a MGS for industrial robots that move about the shop floor. In inventory to track the wares. This robot can be used in the military as spy children or for a variety of other purposes.

C. SELECTED METHODOLOGY OR PROCESS MODEL

The circuit is mostly composed of four components: an Arduino, two motors, a motor drive, two IR

sensors, a power supply, and a connecting-wires. The output is received by the built-in op-amp comparator. When the sensor is placed over a white surface framework, the light it emits is reflected, and the light is retraced by the receiver. Nevertheless, when positioned over the black background, the light emitted by the source does not result in reflection onto the sensor. The sensor's responsibility is to gauge the magnitude of reflected light in order to produce an output. The microprocessor receives and processes sensor output. In our project, the IC is programmed to move forward, right, left, and stop based on sensor input. The output is sent to the motor driver.

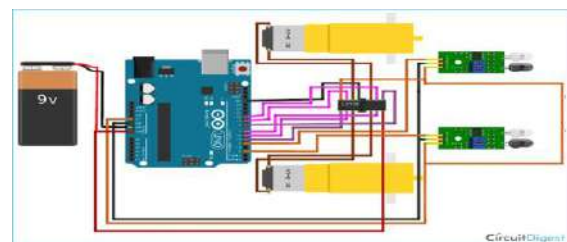


Fig. 1. Line Following Robot Block Diagram

Motor Driver:

A motor driver serves as a current amplifier and a switching mechanism, receiving input from the integrated circuit (IC) and producing the corresponding motor output.

IC L293D:

The motor driver integrated circuit is capable of operating two motors simultaneously. Generally, 6V is used for dc motors and 6-12V for gear motors, depending on the motor. The Vss decides whether an input voltage is positive or negative. Therefore, if the logical supply voltage exceeds 5V, it will be regarded as the input low voltage, while voltages below 5V will be considered the input high voltage.

The pins for the motor PWM led speed control are Enable 1 and Enable 2.

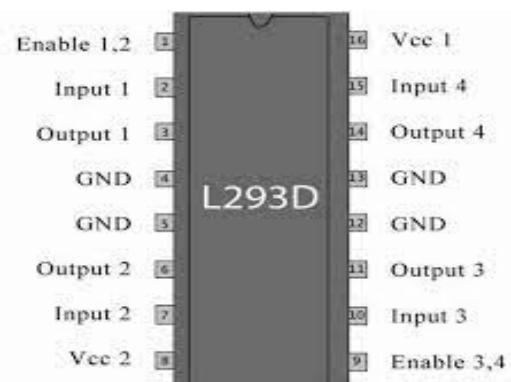


Fig. 2. IC L293D Motor Driver

Gear DC Motor:

An apparatus that generates motion or converts any kind of energy into mechanical energy is called a motor. Since a motor gives a robot movement, it is usually one of the most important parts of the building. In general, a motor functions by using electricity carried by a conductor and a constant magnetic field. The current-carrying conductor generally produces a magnetic field that interacts with the permanent magnet's magnetic field, causing the motor to rotate. 3 basic motor types are usually used in robot design: DC motors, stepper motors, and servomotors. The simplest motors to use are DC motors. One motor requires two signals to run. A single DC motor necessitates the use of two signals for operation. Simply inverting (flipping) the power supply's polarity can modify the desired direction. You may change the velocity of the motor by adjusting the volt across it.

DC Gear Motor Specifications -

The dc motor's voltage is 9-12 volts.

Gear motors used is two.

Rotational speed - 300-500 RPM

Sensors (IR):

An electrical apparatus known as an infrared sensor emits light to discern particular materials within its surroundings. Along with identifying movement, it can also gauge the temperature of an object. These sensors do not emit infrared radiation like passive infrared sensors do. Usually, all objects release a type of infrared thermal radiation. The thing that emits is an IR, and that detects is an IR photodiode which detects IR light of matching wavelength. When the photodiode is struck by infrared light, its resistance changes with intensity.

The following components make up this circuit:

1. LM358 IC 2 pair of infrared transmitter and receiver
2. Resistors in the kilo-ohm range.

Power Supply:

Power Supply or PSU is a mechanism or arrangement designed to furnish electrical or alternative forms of energy to a specified array of loads. This term predominantly finds application in describing electrical energy sources, with less frequent usage in relation to mechanical and sporadically other energy sources. For all of the electronics in this application, a 9volt DC power source is required. Few electrical equipment are required to generate 5 volts of direct current power. Our project required only one 9V battery.

Battery Snap:

Using a 9V battery and these great long battery clips is probably the simplest way to power our LEDs. The battery connector is created to attach to the terminals on the end of a typical 9V battery, as shown in the picture. The two leads on these battery straps are a black "negative" wire and a red "positive" wire.

Robot Chassis:

This robot chassis kit includes an hard base, 2 motors, 2 suitable wheels and a ball-caster. Wheel size is 30mm X 60 mm.

D. WORKING PRINCIPLE

We used infrared transmitters and receivers, LEDs in this project. They send and receive light through them. When IR strikes a white frame, it is retraced back and captured by LEDs, resulting voltage fluctuations. A black surface absorbs infrared radiation and does not reflect any of the light, depriving the photo diode of any beams. In this LFR, an input of 1 is received when the sensor detects a white surface, and an input of 0 is received when sensor detects blackline.

The LFR is divided into 3 segments:

Sensor segment:

This segment has two arrays of infrared sensors, which are made up of LEDs, potentiometers, comparators (OpAmps), and IR diodes. Infrared detectors detect the path and produce a fluctuation at the comparator's terminal 2, while a potentiometer alters the reference voltage at one terminal of the comparator. Following a comparison of the two voltages, the comparator outputs a digital signal. Two comparators are utilized for each of the two sensors in this line follower circuit. A comparator, LM 358, is employed. Two low noise Op-amps are incorporated inside the LM358.

Control Segment:

The entire line follower robot procedure is managed by the IC L293D. This IC informs the driving circuit to drive the line follower after understanding these signals.

Driver Segment:

The driving component consists of 2 DC motors and a motor driver. Motors are driven by motor drivers. Therefore, this driver circuit is included to supply sufficient current to the motor. The IC L293D communicates with this driver, which in turn manages the motors. The left and right infrared sensor modules are being utilized in this project. When the robot senses white light from both its left and right sensors, it advances.



Fig. 3. Robot Moving Forward

Should the left sensor identify a black line, the robot will execute a leftward turn. If detects any black line, it will halt. Upon the detection of a black line by the right sensor, the robot will steer towards the right until both sensors register a white surface. Subsequently, upon identifying the white surface, the robot will proceed with forward motion.

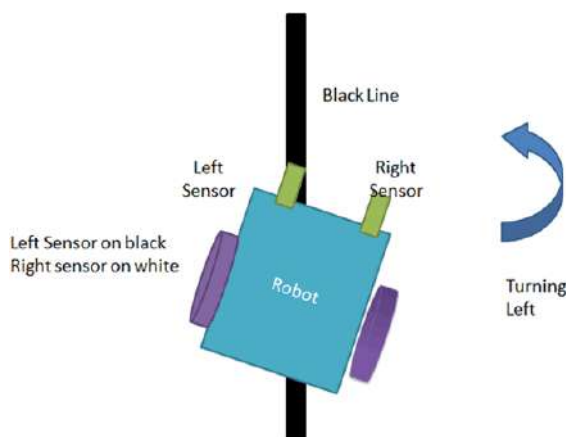


Fig. 4. Robot Turning Left

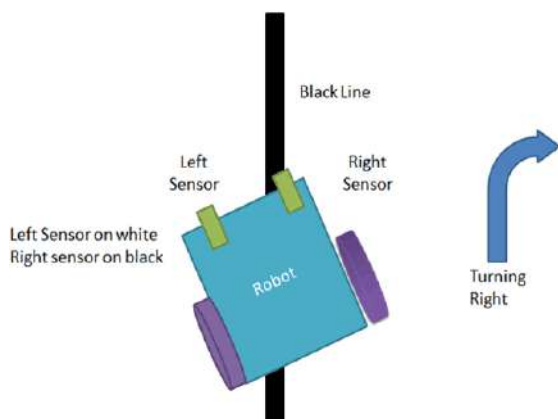
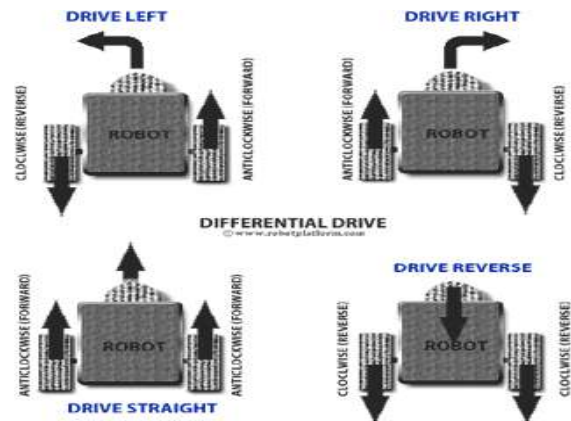


Fig. 5. Robot Turning Right

If both sensors encounter or come into contact with

the black line, the robot halts.



First, we need a robot body, which in this case is a DIY chassis. Create your own chassis or use one that has already been created.

Step 1: Using hot glue, secure the BO motors to the chassis.

Step 2: Install the motor driver on the chassis and attach the motor wires to the driver's output.

Step 3: Bend the sensor and the infrared LED. After that, place the sensors on the underside of the robot and adjust them to fit the track and robot widths. Keep in mind that there are two sensors: one for detection on the left and one for detection on the right.

Step 4: Attach the sensor output pins to the pin 2 and pin 4 of the Arduino Uno with glue. Connect the earth and VCC pins to ground and 5 volts, respectively.

Step 5: Attach the motor driver's enable pins to Arduino pins 5 and 8, and its input pins to Arduino pins 6, 7, 9, and 10, in that order.

Step 6: At last, attach the battery to the circuit and set it on the chassis. I've used jumper wires to connect everything here.

Step 7: Turn the board upside down and secure the castor wheels with a hot glue gun. Add the wheels last.

CONCLUSION

This document outlines the development and assembly of a line-tracking robot, which relies on the Arduino microcontroller for its design. The robot is equipped with four basic DC motors connected to four wheels, enabling it to move left, right, and forward along a black track on a white background. The speed of the motors is regulated by the L293D driver circuit. Direction control for the robot is achieved through an Arduino nano microcontroller, which interprets signals from the infrared sensors. Additionally, three infrared sensors are utilized to detect color, allowing the

robot to move when the color detected is white and stay stationary when the color detected is black.

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D. CERTIFICATE

