# DESIGN AND IMPLEMENTATION OF AN EMBEDDED MODEL WITH LINE FOLLOWING FEATURE AND LIVE STREAMING

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## ABSTRACT

This project proposes the design and implementation of an embedded system capable of both line following and live streaming video. This robot car will navigate autonomously by tracking a designated line path while simultaneously transmitting real-time video footage of its surroundings. This abstract outline the key components, functionalities, and potential applications of the system the research paper presents the design and implementation of an AI Surveillance car that can perform, line following, and live streaming.
The proposed system is based on Embedded technology, which allows the car to be remotely controlled and monitored. The car's capabilities include real-time object detection, which enables it to detect and track objects in its surroundings, line following, which allows it to follow a predefined path, and live streaming, which provides remote access to the car's camera feed. The results show that the proposed system can accurately detect obstacles and follow lines, while

also providing high- quality live-streaming capabilities. Overall, the research provides a comprehensive and practical approach to designing an AI Surveillance car using Embedded technology.
**Keywords**: IR sensors, Ultrasonic sensor, omnidirectional mobile robot, mecanum wheels, dc motor, Proteus.

## 1. INTRODUCTION

A line follower robot is a robot designed to follow a line or a path already predetermined by the user. This type of robot is used mainly in semi to totally autonomous factories.[2] In this environment, these robots function as carriers of materials to deliver products from one point of manufacture to another, but its use can be generalized in any field in our daily lives. In addition to the simple line tracking ability, this robot must also have the aptitude to navigate in a line crossover and take the necessary steps to find the right

Path to follow after a crossover when the other paths are occupied by one or more obstacles.[1] There are several techniques for line tracking robots", such as using a camera that takes instant images of the line, or using a light source with an LDR or using IR sensors that are more accurate than LDRs and cheaper than a camera. We have therefore chosen to use digital infrared sensors for line detection. Many systems based on IR sensors use discrete methods to follow a line, which can often generate a discontinuity or oscillation in the behaviour of the line follower robot.[5] Our proposed solution is therefore the use of a method based on the instant calculation of the radius of curvature of the line taking into account several geometric parameters as well as a time counter from the control system based on a microcontroller. For obstacle detection, an ultrasonic sensor mounted on a servomotor was used to scan an angle of 180 degrees and to be able to detect several obstacles, instead of using several ultrasonic sensors. [7]The robot can follow a black line on a white background. The robot is driven two differential wheels driven by two geared motors. These geared motors are controlled by the microcontroller after processing the information acquired by the various sensors. A line follower robot is a robot designed to follow a line or a path already predetermined by the user. This type of robot is used mainly in semi to totally autonomous factories. In this environment, these robots function as carriers of materials to deliver products from one point of manufacture to another, but its use can be generalized in any field in our daily lives.

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The integration of IoT and AI technologies has revolutionized the field of surveillance and monitoring. With the increasing need for security and safety, innovative solutions are being developed to address various challenges in this domain. One such solution is an AI Surveillance car, which is designed and implemented in this research paper. The AI Surveillance car is equipped with multiple functionalities, including object detection, line following, and live streaming capabilities. The system utilizes various sensors such as IR and ultrasonic sensors, which allow the car to navigate through its surroundings and detect obstacles in real-time. The ESP32- CAM is used for live streaming, providing remote access to the car's camera feed. An Arduino microcontroller is employed for obstacle detection and line following, which enables the car to follow a predetermined path while avoiding obstacles. The findings of this research demonstrate that the system accurately detects obstacles and follows lines while providing high-quality live-streaming capabilities.

This approach presents a practical and comprehensive solution for designing an AI Surveillance car that employs IoT technology to meet various surveillance and monitoring needs. The system can be further enhanced by incorporating advanced AI algorithms and machine learning techniques, providing more sophisticated surveillance capabilities. A line follower robot is a robot designed to follow a line or a path already predetermined by the user. This type of robot is used mainly in semi to totally autonomous factories.

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The robot is driven by two differential wheels driven by two geared motors. These geared motors are controlled by the microcontroller after processing the information acquired by the various sensors. Robotics is an improvement portion devoted to the plan, building, administration, creation, and arrangement of robots. Robotics is worried about the gadgets, designing, mechanics, and programming sciences. In robotics, aversion of obstructions is the errand of accomplishing some objective of the control subject to limitations on the area of non-convergence or non-impact. Snag evasion is one of the key examination regions and is likewise an establishment for a development robot's victories. Due to its high proficiency and unwavering quality Robotics is currently ordinarily utilized in numerous enterprises. [15]All versatile robots are intended to keep away from impediments. The engineering of an independent robot needs a few sensors and actuators to be arranged by their errands. Each independent robot must distinguish hindrances principally. The fundamental motivation behind why this framework is utilized for shipping merchandise is that it fits and fails to remember that the machine's activity is completely programmed after the gadget is put down on the predetermined way. The development of a robot to detect snags and edges is totally independent. As a result of these components, the most common way of following the line has numerous valuable applications

## 2. LITERATURE SURVEY

In this section of our paper, we have discussed various ways to design an IoT-based AI surveillance car. The research has highlighted that the model can be built in several ways using different microcontrollers, such as the Arduino UNO, NodeMCU (ESP8266), ESP32, and Raspberry Pi. Each of these microcontrollers has its strengths and weaknesses that need to be taken into account when designing the system. Moreover, we have pointed out that the choice of microcontroller also affects the programming language used to develop the prototype. For example, the programming language used by Arduino is C/C++, the scripting language used by NodeMCU is Lua, and the programming languages used by Raspberry Pi include Python, C, and Java .

In robotics there are many systems invented which has different applications in different fields. Robotics is very popular field for research and manufacturing. Pakdaman M. et.al has design a small line following robot which used IR sensors to detect the line drawn on floor [1]. Priyank Patil has developed an AVR line following robot which can detect the line drawn on the floor with the help of sensor array. When its sensor is passing through the line drawn on the way then it reads 0 and vice versa [2]. That system has designed for the robot competition. Colak I. et.al has design a line following robot to use in the shopping malls for entertainment. That system used 4.8 cm wide black line to carry maximum load of 400 kg. Two wheels balancing robot has developed by Nor Maniha Abdul Ghani et.al, which has the line following capability and for balancing it, they used infrared distance sensor to solve the problem in inclination [11],

There are many ways to design this prototype, some are listed below.

**Arduino-UNO**:

The Arduino Uno is a widely-used microcontroller board in various electronic projects, including remote-controlled vehicles. Its compact design and compatibility with various electronic components make it a popular choice. Bluetooth technology enables wireless communication between devices, and it is commonly used in remote-controlled devices such as remote-controlled vehicles.

Compared to wired connections, Bluetooth offers more control and efficiency, and it allows for multiple devices to be connected as remote controls. Additionally, Bluetooth is advantageous because physical barriers such as walls and doors do not hinder the control of the vehicle.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. Priyank Patil has developed an AVR line following robot which can detect the line drawn on the floor with the help of sensor array. When its sensor is passing through the line drawn on the way then it reads 0 and vice versa [2]. That system has designed for the robot competition. Colak I. et.al has design a line following robot to use in the shopping malls for entertainment. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages (Embedded C), using a standard API which is also known as the **Arduino Programming Language**, inspired by the Processing language and used with a modified version of the Processing IDE. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE)

Fig 2.1: Arduino UNO


Fig 2.2: ESP 32 CAM

This feature is especially useful when the remote-controlled car needs to be controlled from a distance or in inaccessible areas. To use Bluetooth with the Arduino Uno board, a Bluetooth module needs to be attached, and a specific app on the remote-control device needs to be used. One example of such an app is the CAR BLUETOOTH RC app, which can send signals wirelessly to the Bluetooth module attached to the Arduino board. The Bluetooth module then translates these signals into electrical signals that control the movements of the remote-controlled car.

**ESP32 (WIFI + Bluetooth)**:

The project "Car to Car Communication using IoT" aims to establish a communication channel between two cars to improve road safety and traffic efficiency. The project uses the ESP32 microcontroller which has both Wi-Fi and Bluetooth capabilities. The system is designed to transmit data between two cars through Bluetooth and then upload the data to a cloud server using Wi-Fi. The system consists of two ESP32 boards, one for each car, connected to ultrasonic sensors and GPS modules. The ultrasonic sensor detects the distance between the two cars, while the GPS module provides location data. The ESP32 boards communicate with each other using Bluetooth, exchanging data such as distance and speed. [14]When a car gets too close to another car, an alert is generated to warn the driver of the approaching car. The data collected from the sensors is also sent to a cloud server via Wi-Fi, where it is analysed and used to generate useful information for traffic management. [16]This information can be used to optimize traffic flow and reduce accidents.

The surveillance system proposed in this work is composed of a transmitting unit and a receiving unit. The transmitting unit captures continuous video footage using a camera installed on the robotic vehicle and wirelessly transmits it to the receiving unit. It consists of an Arduino Uno, an ADXL345 accelerometer for hand movement detection, a transmitter, and a power supply battery. Meanwhile, the receiving unit is responsible for receiving the video and control signals from the transmitting unit and controlling the movement of the robotic vehicle.[17] It includes an HC-12 receiver, a motor driver IC, two DC motors, an ESP-32 CAM for vehicle tracking and enemy recognition, a webcam, and a 12V power supply.[20] The HC-12 module is utilized for wireless communication with a range of up to 1.8 km. The cloud server can provide real-time updates on traffic congestion, road accidents, and other relevant information to both drivers and traffic management authorities.

The proposed system enables five different types of hand movements, namely stop, forward, backward, left, and right. To ensure efficient communication between the two units, both the transmitting and receiving ends encode and decode signals using Arduinos. This project aims to develop a wireless control system for a crate, using an ESP8266 Wi-Fi adaptor, an Arduino Uno, and an L293D IC. [22] The ESP8266 serves as a transmitter and receiver, sending signals from PCs or mobile devices to the Arduino Uno. To start, the necessary components, including the Arduino, ESP8266, and L293D IC, must be installed. An HTML page must then be created, containing navigation buttons to control the crate, and a user interface utilizing HTML, CSS, and JavaScript. The ESP8266 must be configured as an access point, creating a Wi-Fi network, setting a network name and password, and assigning an IP address for communication with the Arduino. Once connected to the access point, the IP address of the ESP8266 must be accessed to reach the HTML page and use the navigation buttons to transmit commands to the Arduino. [16] The Arduino will interpret these commands and respond accordingly to control the crate. Finally, the system's range must be tested to ensure that it can respond to commands within a 20-meter range.

## 3. EXISTING SYSTEM

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. This smart and intelligent line follower robot can be used in industries for carrying goods from one place to another. The main reason why this robot can be employed for transportation of goods is its fit and forget ability, which means that once the robot is placed on the desired path the working of the robot is totally automatic, there is no need for controlling the robot manually. This is what makes the line follower robot more efficient and useful when compared to other conventional robots. A traditional obstacle avoiding robot cannot help in transportation of goods because there is no particular path for the robot. It will move randomly by avoiding the obstacles and will not reach the required decision.

The movement of obstacle avoiding robot cannot be controlled. Considering this factor line follower robot has more useful applications. This conventional line follower robot can be made smart and intelligent by giving it the ability to detect obstacles. This improves the working of the line follower robot, because in any work environment obstacles are common, so if the line follower is not able to detect any obstacles on its path it will collide with it and will be severely damaged. Adding the features of obstacle avoiding robot to a traditional line follower robot prevents any damage to the robot. This intelligent robot can also be installed for health care management in hospitals, which decreases the human effort in monitoring patients and delivery things or medicines. The workers can be used for other tasks instead of transporting goods from one place to other which can be carried out with this smart and intelligent line follower robot

The growth of the development mobile robot become the phenomena as most of the scientist show the interest for developing world with robot as assistant. Robotics are interdisciplinary and have gradually become a part of our lives. Nowadays, robot is a reality of the present not more vision of the future. Robot become important in daily life as it will help to lighten burden of human especially when it comes to the limitation of human strength for example in search and rescue in disaster place. Robot can perform their task efficiently and can contribute to our lives. Mobile robots are usually those robots that can travel from place to place to accomplish desired and complex tasks. Mobile robot is a machine that have been supervised by running of software and combination of sensors, wheels and dc motors to move around its environment. Mobile robot mostly uses in agriculture, industrial field, military, search and rescue which can help to human to complete the complex task. For example, the application of mobile robot is used in Urban Search and Rescue(USAR) for emergency situation such as earthquake or terrorist attack that will help to locate, extricate and find the victims of the incidents. Omnidirectional mobile robots(OMR) have an ability that can move in any direction and its turning radius can be zero compared to the traditional mobile robot currently used. OMR is developed from combination of 4 mecanum wheels and actuation of dc motor that can make the mobile robot move in all direction.

The project used the mecanum wheel developed by Mecanum AB'S Bengt Iion in 1973. OMR can be produced by applying different rotating force to dc motor that can create the mobile robot move freely in a different direction, in other words, this mobile robot can slide regularly perpendicular to the vector of the torque. The 4 wheels of mecanum wheels more stable and produced more accuracy of direction compared to the 3 mecanum wheels. Figure 1 shows the mechanism of the mobile robot with the mecanum wheels. The figure shows the rotation of the mecanum wheels that will produce various of movements for the mobile robot. The combination of actuation dc motor

Will produce different movement of the mobile robot. The forward and inverse kinematics equations of a mecanum wheeled robot are indicated as equation and, which are used for robot control process. According to the equation and, the variation of movement will be produced by the mobile robo. The movement of the mobile robot depending on the combination of the dc motor that will produce several movements.

The robot's aim is to follow a line as quickly as possible, while maintaining the highest possible linear velocity with an angular velocity equal to the curvature of the path. This mobile robot will detect the line by using IR sensor to detect the line at the floor. When the switch is on, IR sensor will sense the color of the surface and when the sensor detects the black color, IR ray getting deflected back form the surface which is observed by Photo diode and then the signal will be sent to the comparator, the result in form of signal will sent to the microprocessor Arduino to make decision based on the input signal. The arrangement of sensors is important as it will determine the accuracy of the mobile robot to follow the line. According to, the most suitable array design is to use single line sensor array because it uses less sensor but can navigate efficiently. Based on the experiment done by Seyed Ehsan Marjani Bajestani, 29 Infrared sensors used for line detection as it can detect the line accurately.

The project purposed the design of the line follower that able to follow predetermined track on the floor, 90˚ and 110˚ robot turning and capable to find a way when the built track colour has been upturned. For the obstacle avoidance purpose, a few articles have been reviewed to decide whether to choose IR sensor or Ultrasonic sensors are the best choice to detect the obstacles. In order to achieve this purposed, obstacles sensor must be placed to the mobile robot to detect the obstacles and send the signal to the microcontroller. Ultrasonic sensor have been compared to the IR sensor to test the functionality of the sensor based on the type of the material of obstacles, based on the result shown the Ultrasonic sensor is more suitable sensor to detect the obstacles compared to the IR sensor. Moreover, the advantages of using Ultrasonic sensor also have less consumption of power, affordable and can operate at various condition even at smoked environment. However, the disadvantage of the ultrasonic sensor is this sensor cannot detect the soft material and limited angle of detection. In that case, Ultrasonic sensor is more suitable compared to IR sensors for the obstacle detection purposed. In this project, the mobile robot will be embedded with 4 mecanum wheels, square type of body structure, 4 IR sensors used of in front side and 4 IR sensors used left side of mobile robot and two Ultrasonic sensors used for the obstacle avoidance purpose. However, the Proteus Software will be used to simulate the actual concept of the project.

## 4. PROPOSED SYSTEM

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. [16] 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.

As stated earlier, line follower robot (LFR) follows a line, and in order to follow a line, robot must detect the line first. Now the question is how to implement the line sensing mechanism in a LFR. We all know that the reflection of light on the white surface is maximum and minimum on the black surface because the black surface absorbs maximum amount of light. So, we are going to use this property of light to detect the line. To detect light, either LDR (light-dependent resistor) or an IR sensor can be used. For this project, we are going with the IR sensor because of its higher accuracy. To detect the line, we place two IR sensors one on the left and other on the right side of the robot as marked in the diagram below. [2]We then place the robot on the line such that the line lies in the middle of both sensors. [6] We have covered a detailed Arduino IR sensor tutorial which you can check to learn more about the working of IR sensors with Arduino Uno.

Infrared sensors consist of two elements, a transmitter and a receiver. The transmitter is basically an IR LED, which produces the signal and the IR receiver is a photodiode, which senses the signal produced by the transmitter. [9]The IR sensors emits the infrared light on an object, the light hitting the black part gets absorbed thus giving a low output but the light hitting the white part reflects back to the transmitter which is then detected by the infrared receiver, thereby giving an Analog output. Using the stated principle, we control the movement of the robot by driving the wheels attached to the motors, the motors are controlled by a microcontroller.

Moving Forward:

**Line Follower Navigation**

In this case, when both the sensors are on a white surface and the line is between the two sensors, the robot should move forward, i.e., both the motors should rotate such that the robot moves in forward direction (actually both the motors should rotate in the opposite direction due to the placement of motors in our setup. But for the sake of simplicity, we will call the motors rotating forward.)

**Turning LEFT:**

Line Follower Left Navigation

In this case, the left sensor is on top of the dark line, whereas the right sensor is on the white part, hence the left sensor detects the black line and gives a signal, to the microcontroller. Since, signal comes from the left sensor, the robot should turn to the left direction. Therefore, the left motor rotates backwards and the right motor rotates in forward direction. [26] Thus, the robot turns towards left side.

**Turning RIGHT:**

Line Follower Right Navigation

This case is similar to the left case, but in this situation only the right sensor detects the line which means that the robot hence the left sensor detects the black line and gives a signal, to the microcontroller. should turn in the right direction. [14]To turn the robot towards the right direction, the left motor rotates forward and the right motor rotates backwards and as a result, the robot turns towards the right direction.

Stopping:

**Line Follower STOP Navigation**

In this case, both the sensors are on top of the line and they can detect the black line simultaneously, the microcontroller is fed to consider this situation as a process for halt.

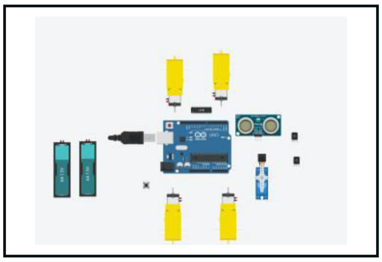

Fig 4.1: Components

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 Hence, both the motors are stopped, which causes the robot to stop moving.The reason to use a motor driver here is because the output signal of an Arduino is not sufficient to drive the motor, furthermore, we need to rotate the motors in both directions, therefore we use a motor driver to drive the motor as required and also the motor driver is able to supply sufficient current to drive the motor. [18] Here, we are using a L293D motor driver which is a dual h bridge motor driver and is sufficient for our 2 motors. which causes the robot to stop moving.The reason to use a motor driver here is because the output signal of an Arduino is not sufficient to drive the motor,

The L293D has 16 pins, the pinout of L293D is shown in the below diagram.

Here, we are using a 7.4 li-ion battery to power the whole circuit. You can use any battery type from 6-12 volt. [34]To move the robot, we need to use motors with low RPM but torque high enough to carry the weight of the robot. So, I chose two 60 RPM 6V Battery Operated, geared motors for this robot.

Once we have understood the connection of all the components, we can start assembling our LFR. [26]I have explained the step-by-step assembly procedure of the Robot in the video provided at the bottom of the page.

Arduino based Line Follower Robot

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.

Now, place the BO motors to the chassis with the help of some hot glue as shown in the image below.

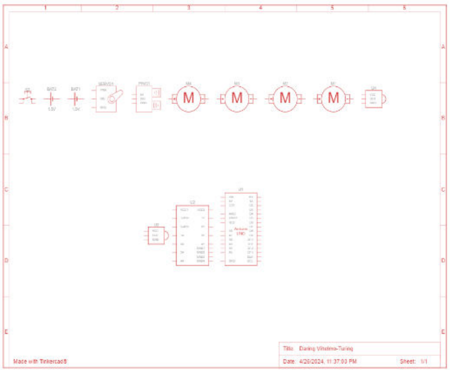

Fig 4.2: Components Circuit Diagrams

Connect the VCC pins to 5volt and the ground pins to ground. [7]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.
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.
International Journal of Advance Research, Ideas and Innovations in Technology with an H-bridge, a microcontroller, logic chip, or remote control can electronically command the motor to go forward, reverse, brake, and coast. [18] 5.3 HC-SR04 (Ultrasonic Sensor) Ultrasonic sensor is a device which can measure the distance to an object by using sound waves. It will measure the distance by sending out a sound wave at a particular frequency and listening that wave when it bounces back.[19] IR Sensor The Infrared (IR) sensors consist of Infrared (IR) LED and Infrared (IR) photodiodes. The IR LED is called photoemitter and IR photodiode is called receiver. The IR light emitted by the LED strikes the surface and gets reflected back to the photodiode. Then the photodiode gives an output voltage which is proportional to the reflectance of the surface which will be high for a light surface and low for dark surface. Light colored objects reflect more IR light and dark colored objects reflect less IR light.[20]
A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It converts a positive voltage (7-29V) to +5 volts. Heat sink provided in the center to release heat generated due to drop across the IC. Input voltage of about 5 to 18 V is given, Ground is 0 V and regulated output of +5V. [22] This is a Motor driver IC that can drive two motors simultaneously. Motors are arranged in a fashion called H-Bridge. H-Bridge-It is an electronic circuit which enables a voltage to be applied across a load in either direction. It allows a circuit full control over a standard electric DC motor. That is with an H-bridge, a microcontroller, logic chip, or remote control can electronically command the motor to go forward, reverse, brake, and coast. [18] A battery is a device consisting of one or more electrochemical
Cells with external connections provided to power electrical devices such as flashlights, mobile phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.
Now turn the board upside down and with the help of hot glue gun, attach the castor wheels as shown in the image below.
Finally, add the wheels. For extra safety, I have added a plastic sheet as a bumper too. The programming part of line follower robot is very simple and we require only basic Arduino functions. [18]The complete program for this project can be found at the bottom of this page. The explanation of this program is as follows:
First step is to defined every Arduino pin that we are using. I started with motoring the driver pins and sensor pins. [29] Here, I have commented on each line of code for your easy understanding.
In the loop section, declare the pin modes of each pin. Here, we need to read the output of IR sensors, hence I have defined those pins as an input. [24] The motor needs to be driven by the Arduino, thus defining the motor driver pins as output. Finally, I pulled enable pin to high.
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.[28] 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.[14] 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.

The complete making of the line follower robot can be found in the video linked at the bottom of this page. [16] If you have any questions leave them in the comment section. A line following robot usually consists of the following elements: Sensors (usually infrared and ultrasonic); Microcontroller or Microprocessor; Actuators (motors); Wheels; Chassis and Batteries.

Our study was tested on a test prototype designed for this research. This prototype is a mobile robot with two independent drive wheels, containing all the components necessary for its operation. The whole is protected by a hand-cut plexiglass frame used the following essential components:

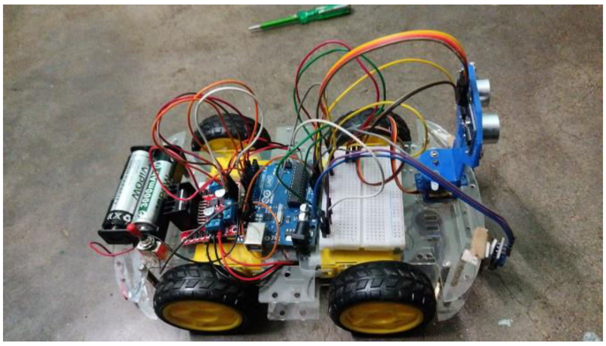

Fig 4.3: Obstacle Detection, Line Following, and Live Streaming Robo

The main goal of any robot is to minimize human effort. Depending on the purpose, different types of robots are designed for practical applications. In any work environment, proper supervision is essential for the best results. This smart and intelligent line robot can be used in industries to transport goods from one place to another. The main reason why this robot can be used to transport goods is the ability to set it up and forget it, which means that once the robot is placed on the desired path, the robot's operation is fully automatic. It is not necessary to control the robot manually. This makes line tracking robots more efficient and useful than other conventional robots. Traditional obstacle avoidance robots cannot help transport goods because there is no separate path for the robot. It will move randomly to avoid obstacles and will not reach the necessary decision. It is not possible to control the movement of the obstacle avoidance robot. Meanwhile, this line-following robot has more useful applications. This common path robot can become smart and intelligent by giving it the ability to detect obstacles. This improves the operation of the line robot because in any working environment there are obstacles, so if the line follower fails to detect an obstacle in its path, it will hit it and be severely damaged the best results.

Adding the functionality of an obstacle avoidance robot to a traditional runner robot will prevent any damage to the robot. Workers can be used for other jobs instead of transporting goods from one place to another, which can be done with this intelligent bot.

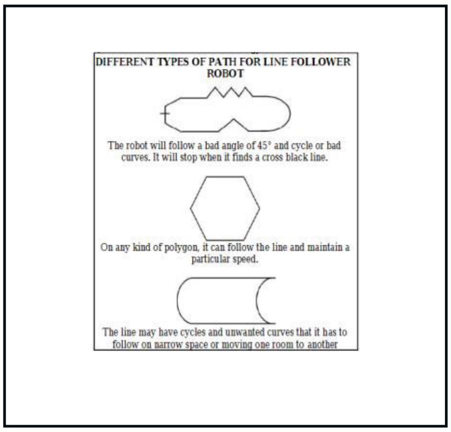


Fig 4.4: Types of paths

When two infrared sensors connected to both sides of the robot detect a white line, the two motors rotate clockwise, and the robot moves forward. Similarly, when both infrared sensors detect a black line (that is, the intersection of black lines), both motors also rotate clockwise, and the robot moves forward.

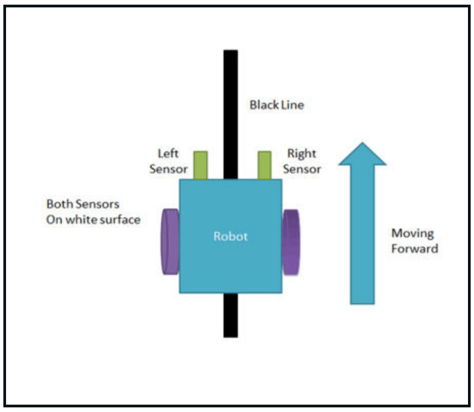


Fig.4.5: Forward movement

When one of the infrared sensors (say the one on the right) detects a black line while the other (the one on the left) detects a white line, then that path turns to the right, for the robot to turn to the right. To move the robot to the right, the right motor is stationary, and the left motor rotates clockwise, so the robot rotates to the right. To make a sharp right turn, turn the left motor clockwise while turning the right motor counterclockwise.

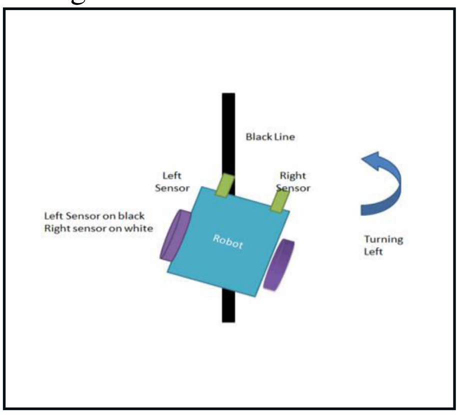


Fig.4.6: Turning right

When one of the infrared sensors (say the one on the left) detects a black path while the other sensor (right) detects a white path, then that path turns left, let the robot move to the left. To make the robot move to the left, the left motor is stationary, and the right motor rotates clockwise, so the robot rotates to the left. To make a sharp left turn, turn the right motor clockwise while turning the left motor counterclockwise.

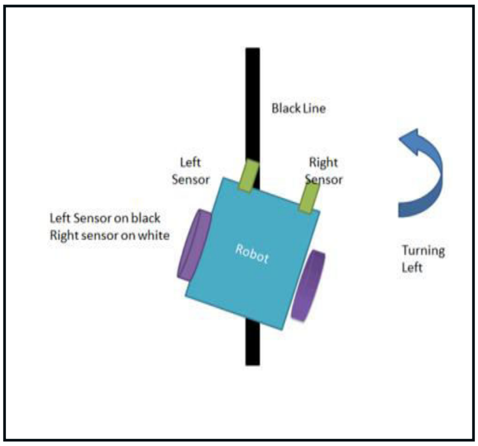


Fig.4.7: Turning left

When the ultrasonic sensor in front of the robot detects an obstacle (within programmed range) while moving forward, the engine stops spinning, and the robot stops. The robot starts moving as soon as the obstacle is removed.

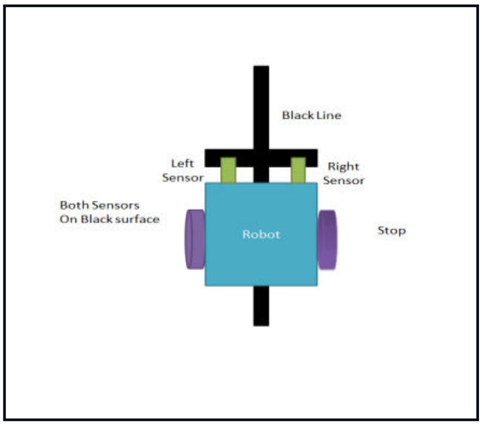


Fig.4.8: Stop

**SYSTEM IMPLEMENTATION**

LINE FOLLOWING:

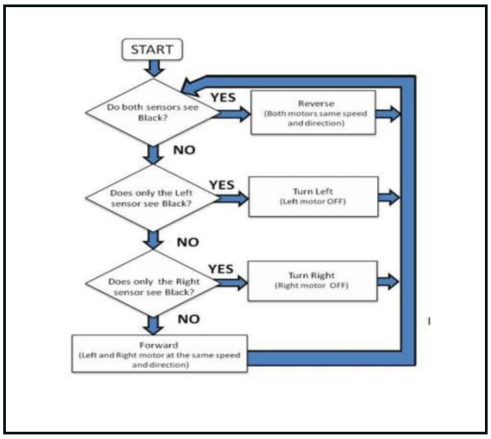


Fig.4.9: Flowchart for Line Following

The Line Following Robot is an autonomous robot that detects a path and according to the path drawn, it follows the path with the help of an IR sensor attached to the robot. The path can be either a Blackline drawn over a white surface or a white line drawn over a black surface thus avoiding any detection error. Line follower robot also consists of an obstacle sensor that detects any obstacle in front of the Robot thus avoiding any unnecessary accidents.

**OBSTACLE AVOIDING**

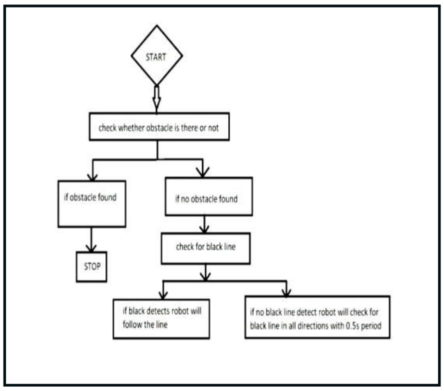


Fig4.10: Flowchart for Obstacle

**ESP32 CAM Pin Assignment**

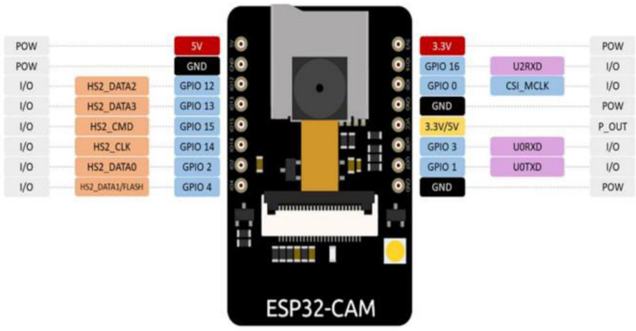


Fig 4.11: ESP32 Cam Pin Assignment

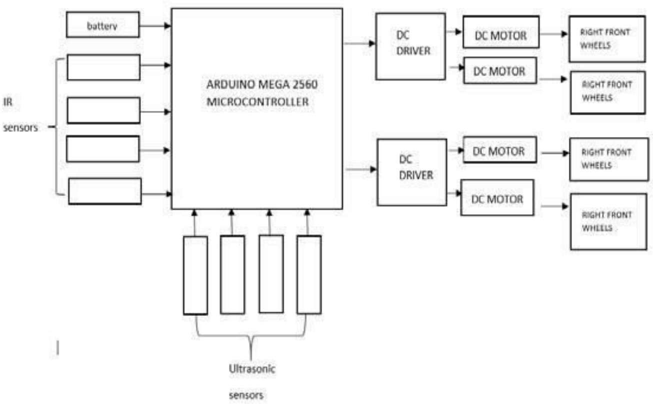


Fig 4.12: Block diagram of mobile robot

The objective of this research paper is to design and implement an Internet of Things (IoT)-based artificial intelligence (AI) surveillance car with obstacle detection, line following, and live streaming capabilities. The proposed system is developed using the Arduino-UNO microcontroller, L298N motor driver, IR sensors, buzzer, TT-Gher motor, 5200mAh Li-ion battery, jumper wire, and ESP32-CAM. [10] The system is designed to monitor and record live videos of the surrounding environment with obstacle detection and linefollowing capabilities. To achieve this, the system employs an ultrasonic sensor for obstacle detection, 3- IR sensors for line following, and ESP32-CAM for live streaming using the Camera Webserver.[9] The methodology involves the development of the hardware components, programming, and integration of the system. The performance of the system is evaluated using various scenarios to ensure its functionality, reliability, and accuracy. The proposed system can be used in various applications such as surveillance, security, and monitoring in hazardous environments.

The line follower car is a simple yet interesting prototype that is designed to follow a black tape using three IR sensors, an Arduino UNO, and an L298N motor driver. The car is programmed to move forward until it detects an obstacle using an ultrasonic sensor.[15] The three IR sensors are placed underneath the car and are positioned in such a way that the left and right sensors are angled toward the car's left and right sides, respectively, while the middle sensor is aligned with the car's centreline. These sensors detect the black tape and send signals to the Arduino UNO. When the middle IR sensor detects the black tape, it sends a signal to the Arduino UNO, which in turn sends a signal to the L298N motor driver to keep the car moving forward. If the left IR sensor detects the black tape, it sends a signal to the Arduino UNO, which then sends a signal to the L298N motor driver to turn the car left. Similarly, if the right IR sensor detects the black tape, it sends a signal to the Arduino UNO, which sends a signal to the L298N motor driver to turn the car right. The ultrasonic sensor is used to detect obstacles in front of the car. When an obstacle is detected at a distance of less than 10 cm, the ultrasonic sensor sends a signal to the Arduino

UNO, which then sends a signal to the L298N motor driver to stop the car. The car's movement is controlled by the L298N motor driver, which is connected to the car's DC motors. [21] The motor driver is controlled by the Arduino UNO, which sends signals to the motor driver to control the car's speed and direction. The ESP32-CAM is a small-sized camera module powered by the ESP32 microcontroller.

It has a built-in WIFI module that enables it to transmit data over the internet. With the help of the Camera Webserver library, the ESP32-CAM can be used to create a web server that streams live video. Connect the ESP32-CAM to your computer using a USB cable and upload the CameraWebserver sketch to it. The sketch is available in the examples section of the Arduino IDE. Once the sketch is uploaded, disconnect the ESP32-CAM from the computer and connect it to a power source. The ESP32-CAM will start a WiFi access point that you can connect to with a smartphone or computer. The access point is named "ESP32-CAM". Once connected to the access point, open a web browser and enter the IP address of the ESP32-CAM (you can find the IP address in the serial monitor). This will open a web page with a live video stream from the camera. [11] The Camera Webserver sketch uses the OV2640 camera module to capture images and encode them in JPEG format. These JPEG images are then sent over HTTP to the web browser, which displays them as a video stream. [9] The web page also contains controls that allow you to change the resolution and quality of the video stream, as well as take a snapshot of the current frame Since our prototype offers three features, i.e, Obstacle Detection, Line Following, and Live Streaming. So there exist three different types of accuracy.

The Raspberry Pi is a more powerful and versatile microcontroller that can handle more complex tasks and add new features to the system. Some additional features that we will add to the system are Object recognition: [5] The system can be enhanced to recognize specific objects in the environment and respond accordingly. For example, the system can be trained to recognize a specific vehicle or person and send alerts if it detects their presence. GPS tracking: The system can be equipped with a GPS module to track its location and transmit the location data to a remote server. This feature can be useful in surveillance and monitoring applications where the car needs to be tracked in real-time.

In conclusion, the future scope of the project involves the development of a more advanced surveillance car using a Raspberry Pi and the addition of new features such as object recognition, GPS tracking, autonomous navigation, facial recognition, voice control, and integration with other IoT devices. These features can enable the system to perform more complex tasks and be used in a wider range of applications.

In terms of infected patients, specifically, virus-infected patients, it is always risky to reach them as a first-person. But it is also important to offer them their medicinal products on time at the same time. A line follower robot can come handy in these kinds of situations. As it can treat certain patients without the supervision or control of any human being. It can easily follow the lines through the cabins and reach medicines to the infected patients to their cabin and return safely.

This line follower robot can be used in industries or factories to automate the transport of parcels or goods from one place to another, using the crane system.

This line follower robot can be used to pick up material from the mine. It is the position in which the edge mechanism of the robot sets in. The mine is full of impediments and holes. In this case the robot will use the tool for the detection of obstacles and edges to pick up materials from the mine quickly.

We reviewed various microcontrollers such as ESP32, ESP8266, and Arduino, and chose Arduino UNO as the platform for our prototype. We discussed the hardware components and software algorithms used in the system and tested the system in various scenarios. [19] Furthermore, we proposed the future scope of the project, which involves the development of the same surveillance car using a Raspberry Pi instead of an Arduino UNO. We suggested adding new features such as object recognition, GPS tracking, voice control, and integration with other IoT devices.

## 5. RESULTS

The figure shown below shows the working of the Robot which follows a specific line and encounters the obstacle coming in its path simultaneously. As it detects obstacle, the bluetooth module enables and the user manually avoids the obstacle with the help of an Android Device. The way the system is designed, the robot will move in that direction automatically if any one of the IR sensors detects the black path. The ultrasonic sensor has also been positioned so that it can determine whether or not there are any obstacles in the way. The servo motor rotates to the right to check if there is an obstacle if one is detected. It moves from the right side, avoids the obstacle, and returns to the original path if there is no obstruction on the right side. If the obstacle is present on both the right and left sides, the ultrasonic sensor rotates through the servo motor to check the left side once more before returning to the original path. By dodging the obstacles, the robot is able to follow the line.

Here, we installed an ESP 32 Wi-Fi camera so that, in the event of an obstruction in the path, it will immediately capture an image of the obstruction and send it to the associated device. Additionally, the camera has a buzzer that notifies the immediate vicinity of the obstacle's detection.[35] Through the code that is loaded into Arduino, all the components are controlled. DC motors are also used to propel the robot forward. Additionally, the DC motors are driven by the L298N motor driver module, which produces the high-current signal for the DC motors after converting the low-current signal to it. Line Following Accuracy: The accuracy of a line follower with three IR sensors and 180 RPM will vary depending on a number of variables, including the sensors' quality, resolution, line-following algorithm, microcontroller programming, and the surface the robot is working on.

The way the system is designed, the robot will move in that direction automatically if any one of the IR sensors detects the black path. [33] The ultrasonic sensor has also been positioned so that it can determine whether or not there are any obstacles in the way. The servo motor rotates to the right to check if there is an obstacle if one is detected. It moves from the right side, avoids the obstacle, and returns to the original path if there is no obstruction on the right side.

The type of sensing element utilized, the materials used to build the sensor, the electronics and signal processing involved, as well as the environmental conditions the sensor is operating, can all have an impact on response time. In our instance, the lowest and greatest reaction times were 0.84 and 1.63 seconds, respectively Obstacle Detection Accuracy: The accuracy of obstacle detection using an ultrasonic sensor depends on various factors, including the quality of the sensor, the distance between the sensor and the obstacle, the orientation of the sensor, and the surrounding environment. [31] Ultrasonic sensors can generally detect objects within a specific range of up to a few meters, with distance measurements being generally accurate within a few centimeters.

However, accuracy may be impacted by variables such as ambient noise, temperature, and humidity. [29] In this specific case, the prototype is designed to detect obstacles within a range of 10 cm. However, it is important to note that other factors can still affect accuracy, and it is crucial to calibrate the sensor, account for environmental variables, and use reliable algorithms to process the sensor data. Additionally, the use of multiple sensors can improve accuracy and reduce blind spots.

If the obstacle is present on both the right and left sides, the ultrasonic sensor rotates through the servo motor to check the left side once more before returning to the original path. By dodging the obstacles, the robot is able to follow the line. Here, we installed an ESP 32 Wi-Fi camera so that, in the event of an obstruction in the path, it will immediately capture an image of the obstruction and send it to the associated device. Additionally, the camera has a buzzer that notifies the immediate vicinity of the obstacle's detection. [27] Through the code that is loaded into Arduino, all the components are controlled. DC motors are also used to propel the robot forward. Additionally, the DC motors are driven by the L298N motor driver module, which produces the high-current signal for the DC motors after converting the low-current.

Live Streaming: The delay rate for live streaming with an ESP32-CAM and a 2MP camera is impacted by a number of factors, including the

quality of the internet connection, the stream resolution, the microcontroller's processing capability, and the system's programming.
Typically, the ESP32-CAM can transmit video at up to 640x480 at 25 frames per second (fps) or 320x240 at 50fps. Depending on these conditions, the delay rate might range from a few milliseconds to many seconds. In our case, the greatest latency for live streaming was measured to be 15 seconds. It is advised that a dependable and high-speed internet connection be used, that lower resolution and frame rates be used, that programming be optimized, and that the microcontroller's processing capacity be sufficient to handle streaming. [23] The actual delay rate, however, may be affected by external variables such as network congestion and signal interference.
It is critical to test the system under actual settings and to set acceptable delay rate thresholds depending on the application's needs. [21] Overall, the ESP32-CAM may deliver low delay rates for live-streaming applications when suitable steps are taken.

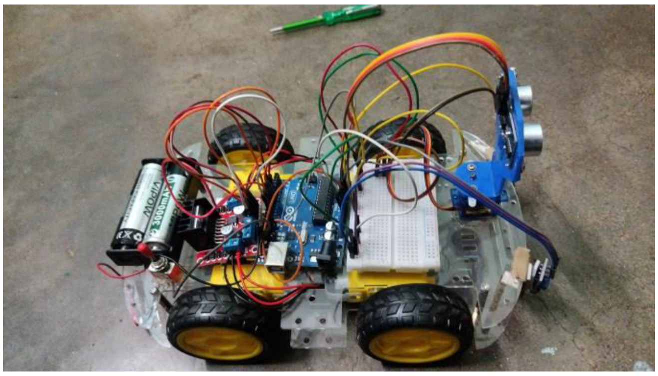

Fig 5.1: Obstacle Detection, Line Following, and Live Streaming Robo

## 6. CONCLUSION AND FUTURE SCOPE

### 6.1 CONCLUSION

Robotics have a huge impact in the worldwide economy and daily existence. One more test of robotics research is to be fruitful and to foster licenses as per the intricacy of their applications for worldwide ventures. The market for robotics innovation is ascending in a wide assortment of uses and human exercises, especially for the assembling, clinical, utility, safeguard and purchaser enterprises. This line adherent and deterrent with edge distinguishing robot is the model of robots for modern use. [17] This shrewd and wise robot has more advantages since it doesn't devour a lot of force. Our task targets making an independent robot that insightfully faculties the impediment and the edge in its way and explores as indicated by the conduct that we have set for it. Along these lines, what this framework gives is an option in contrast to the current framework by supplanting skilled work with mechanical apparatus, which thusly can deal with more patients quicker than expected with better precision and a lower cost. Execution can be improved by utilizing great materials and incredible detecting power likewise works on engine development. The arrangement cost of the line adherent robot relies fundamentally upon the expensive hardware, property, and building and staff nonstop to keep up with and utilize the apparatus.
In conclusion, this research paper discussed the design and implementation of an IoT-based AI surveillance car with obstacle detection, line following, and live streaming capabilities. We reviewed various microcontrollers such as ESP32, ESP8266, and Arduino, and chose Arduino UNO as the platform for our prototype. We discussed the hardware components and software algorithms used in the system and tested the system in various scenarios. [19] Furthermore, we proposed the future scope of the project, which involves the development of the same surveillance car using a Raspberry Pi instead of an Arduino UNO. We suggested adding new features such as object recognition, GPS tracking, voice control, and integration with other IoT devices. [9]The arrangement cost of the line adherent robot relies fundamentally upon the expensive hardware, property, and building and staff nonstop to keep up with and utilize the apparatus.
These features can enable the system to perform more complex tasks and be used in a wider range of applications. Overall, this research paper provides a comprehensive overview of the design and implementation of an IoT-based AI surveillance car and its future scope.
The system can be used in surveillance and monitoring applications to detect obstacles and follow lines, and the addition of new features can

enhance its capabilities and make it more versatile. [8]The proposed future scope can serve as a basis for further research and development in this area.

## 6.2 FUTURE SCOPE

The future scope of the project involves the development of the same surveillance car using a Raspberry Pi instead of an Arduino UNO. The Raspberry Pi is a more powerful and versatile microcontroller that can handle more complex tasks and add new features to the system. Some additional features that we will add to the system are

**Object recognition**: The system can be enhanced to recognize specific objects in the environment and respond accordingly. For example, the system can be trained to recognize a specific vehicle or person and send alerts if it detects their presence GPS tracking: The system can be equipped with a GPS module to track its location and transmit the location data to a remote server. [36] This feature can be useful in surveillance and monitoring applications where the [1] car needs to be tracked in real-time In conclusion, the future scope of the project involves the development of a more advanced surveillance car using a Raspberry Pi and the addition of new features such as object recognition, GPS tracking, autonomous navigation, facial recognition, voice control, and integration with other IoT devices. [26]These features can enable the system to perform more complex tasks and be used in a wider range of applications This paper is all about Line Follower and Obstacle [5]Avoidance Bot using Arduino which will follow a specific line or path and avoids obstacles which it encounters.[3] In future this project can be enhance by connecting Bluetooth module and a camera so that the user can see the detected obstacle on his screen by sitting at just one place.

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