A Project report on

OBSTACLE DETECTION AND AVOIDANCE IN ROBOTS USING SENSORS

Submitted in partial fulfillment of the requirements

for the award of the degree of

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE & ENGINEERING
(DATA SCIENCE)

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SRINIVASA RAMANUJAN INSTITUTE OF TECHNOLOGY
(AUTONOMOUS)

(Affiliated to JNTUA, accredited by NAAC with 'A' Grade, Approved by AICTE, New Delhi & Accredited by NBA (EEE, ECE & CSE))

Rotarypuram village, B K Samudram Mandal, Ananthapuramu-515701.

2023-2024

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
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Certificate

This is to certify that the project report entitled Obstacle Detection and Avoidance in Robots Using Sensors is the bonafide work carried out by **G. Ushodaya, M. Sai Sreeja, P. Anjali Devi, K. Parthavardhan Yadav** bearing Roll Number **204G1A3260, 204G1A3247, 204G1A3201, 204G1A3235** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering (Data Science)** during the academic year 2023-2024.

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Place: Rotarypuram

DECLARATION

We Ms. G. Ushodaya bearing reg no : 204G1A3260, Ms. M. Sai Sreeja bearing reg no : 2041A3247, Ms. P. Anjali Devi bearing reg no : 204G1A3201, Mr. Parthavardhan Yadav bearing reg no : 204G1A3235 students of SRINIVASA RAMANUJAN INSTITUTE OF TECHNOLOGY, Rotarypuram , hereby declare that the dissertation entitled "OBSTACLE DETECTION AND AVOIDANCE IN ROBOTS USING SENSORS" embodies the report of our project work carried out by us during IV Year Bachelor of Technology under the guidance of Dr. B. Hari Chandana, M. Tech., Ph. D , Department of CSE and this work has been submitted for the partial fulfillment of the requirements for the award of Bachelor of Technology degree.

The results embodied in this project report have not been submitted to any other Universities of Institute for the award of Degree.

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ABSTRACT

Robotics is a quickly growing and fascinating field in the modern world. Among the qualities required for automated mobile robots is obstacle avoidance. An impediment is detected by a single sensor in older systems. The robot will randomly move to the left or right while utilizing just one sensor. We want to use infrared and ultrasonic sensors in our proposed model to identify the obstruction. The robot uses the ultrasonic sensor to measure closeness, which enables it to identify impediments in its local area. Concurrently, an infrared sensor adds further obstacle detecting capabilities, improving the responsiveness of the system. Moreover, the incorporation of a camera augments the robot's sensory capacities, permitting it to discern obstacles through visual means. The robot's method of determining decisions.

Key Words: *Robotics, Object detection, Ultrasonic sensor, Infrared sensor, Arduino*

CONTENTS

List of Figures

List of Tables

List of Abbreviations

IR	Infrared
PIR	Passive Infrared
IDE	Integrated Development Environment
DC	Direct Current
LED	Light Emitting Diode
IoT	Internet of Things
USB	Universal Serial Bus
IC	Integrated Circuit

CHAPTER - 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Robotics

Robotics is a multidisciplinary field that involves the design, construction, operation, and use of robots. Robots are programmable machines that can carry out a range of tasks autonomously or semi-autonomously, often mimicking or augmenting human actions. Robotics draws from various disciplines such as mechanical engineering, electrical engineering, computer science, and artificial intelligence to create intelligent systems capable of sensing, reasoning, and acting in dynamic and unstructured environments.

Obstacle detection and avoidance represent fundamental capabilities for autonomous robots operating in real-world scenarios. Whether navigating indoor environments cluttered with furniture or traversing outdoor terrains with uneven surfaces, robots must be equipped with sensors that enable them to perceive their surroundings and react appropriately to obstacles encountered along their path.

1.2 Objectives

- We develop a small robot with live streaming and automatic obstacle detection and avoidance using Ultrasonic sensor and Infrared sensor.
- We integrate a camera to the robot in order to view the obstacles.

1.3 Problem Definition

Obstacle detection and avoidance is a main feature in robots. Only obstacles present in front of robot are detected. In order to detect the obstacles present in front and on either sides of robot, the proposed model utilizes a combination of ultrasonic, infrared sensors and camera is integrated with an Arduino microcontroller. When an obstacle is present, robot avoids the obstacle automatically with the help of DC motors and Motor Driver. Camera is placed in front of robot, so that user can see the obstacle in the mobile phone. An advanced obstacle detection and avoidance system is developed for robots to navigate safely in dynamic environments.

CHAPTER – 2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

The paper titled "Low-cost Ultrasonic-based Object Detection and Collision Avoidance Method for Autonomous Robots" introduces an innovative approach for detecting and avoiding obstacles. The collaborative effort of Jawad N. Yasin, Sherif A. S. Mohamed, Mohammad-Hashem Haghbayan, Jukka Heikkonen, Hannu Tenhunen, and Juha Plosila is aimed at addressing the challenge of providing effective collision avoidance capabilities without compromising on cost efficiency [1]. The main objective is to minimize the deviation from the vehicle's original path and also to develop an algorithm utilizing ultrasonic sensor for accurate distance measurements. The ultrasonic sensor rotates for shape approximation and edge detection. The paper likely concludes with discussions on the broader applicability of the method, identifying potential use cases such as educational robotics or industrial automation. Under future work authors have suggested on integration with other sensing technologies.

The paper titled "Obstacle Avoidance Robotic Vehicle Using Ultrasonic Sensor, Arduino Controller," authored by R. Vairavan, S. Ajith Kumar, L. Shabin Ashiff, and C. Godwin Jose, presents a comprehensive exploration of a robotic vehicle designed for obstacle avoidance, incorporating ultrasonic sensors and an Arduino microcontroller for control. Atmega328 is used as a microcontroller. The sensor gets the data from surrounding area through mounted sensors. Sensor sends the data to microcontroller and it decides the movement of the robot wheel [3].

In their paper "Obstacle Avoidance Robot Using Arduino" Pavithra A C and Subramanya Goutham V have designed an algorithm for movement of robot where ultrasonic sensor is used for detecting the obstacle. They have tried to minimize the complexity of code. If the obstacle is far from robot it moves forward. Whenever the distance between robot and obstacle is less than 30cm then it stops moving and turns left to take a reading. After that it turns right to take a reading. If the left distance is greater than right then robot moves left side else it moves right side. Servo motor is used in order to change the direction of ultrasonic sensor [2]. In their future work they have mentioned that cameras can be used to detect the obstacle.

In their paper titled "Obstacle Avoiding Robotic Vehicle with Arduino and Ultrasonic Sensor," authored by K. BalaKrishna, K. Rachananjali, and C. H. N. Narasimha Rao, presents a robot which detects and avoid obstacles in its path [4]. Ultrasonic sensor HC-SR04 was chosen after reviewing many articles that pointed out the less accurate operation of IR and PIR sensor HC-SR501.

The paper titled "Obstacle avoiding robot" a robot is build. Depending on the input signal received, the micro-controller redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver[5].

The paper titled " A Literature Survey On Obstacle Detection For Mobile Robots" by V.C. Chijindu, has provided a comprehensive overview of obstacle detection techniques tailored for mobile robots. The survey categorized obstacle detection methods based on sensor modalities, including ultrasonic sensors, infrared sensors, LIDAR, and vision-based approaches [6]. Each technique was evaluated based on its strengths and limitations, considering factors such as environmental conditions and computational complexity.

In their paper " A novel dynamic obstacle avoidance algorithm based on collision time histogram" C. Zhuge, Y. Cai and Z. Tang have introduced a novel dynamic obstacle avoidance algorithm based on the collision time histogram for mobile robots navigating in complex environments. By dynamically updating the collision time histogram based on real-time sensor measurements, our approach enables the robot to adapt its trajectory and velocity to avoid collisions proactively [7]. Furthermore, the incorporation of a dynamic thresholding mechanism enhances the algorithm's robustness to varying environmental conditions and obstacle dynamics.

The paper titled "Maze Solving by an Autonomous Robot" Chatelais Q, Vultur H and Kanellis E have focused on designing and implementing efficient algorithms for maze solving, with a particular emphasis on real-time decision making and path optimization. Through extensive simulations and physical experiments, they have evaluated the performance of our algorithm under various maze configurations and environmental conditions [8].

CHAPTER – 3

PLANNING

CHAPTER 3

PLANNING

3.1 Existing System

In the existing system only one sensor is used to detect the obstacle. It can be either ultrasonic sensor or IR sensor. When obstacle comes near to robot, sensor detects the obstacle and sends the data to Arduino. The movement of robot will be dependent on instructions specified in Arduino. If the obstacle is encountered in front of robot it moves either left or right randomly. This is the main drawback in existing system.

3.1.1 System Architecture

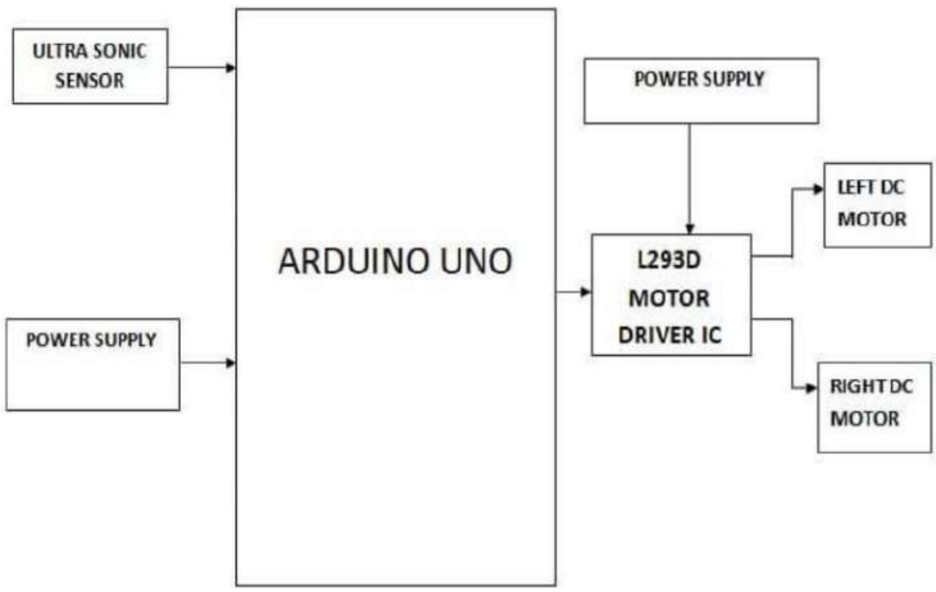


Fig 3.1: Architecture of the existing system

3.1.2 Software Arduino IDE:

- Arduino IDE is an open source software which makes easy to write code for microcontroller Atmega 328 and allows to upload on board. The environment is written in java and based on processing and other source software.
- Arduino IDE can be used on Windows, Linux (Both 32 and 64 bits), and Mac OS. Current versions are Arduino 1.0x or Arduino 1.5x Beta Version.

3.1.3 Hardware

- Microcontroller (Arduino Atmega 328P): with 23 general purpose input output lines.
- Ultrasonic sensor: HC-SR04
- DC Motors: 12V, 45RPM
- Voltage Regulator: L7805C, 5V
- Dual Motor Driver IC: L293D
- Lead Acid Battery: 12V, 1.3 Ah
- Battery: 9V

3.1.4 Disadvantages

- In this system only one ultrasonic sensor is used to detect the obstacle. Sensor is placed at the head part of robot.
- When an obstacle is detected by the sensor, robot moves either right or left side randomly.

3.2 Proposed System

The proposed system uses two sensors. First Ultrasonic sensor is used for proximity measurement. Infrared sensor is used to provide additional obstacle detection capabilities, enhancing the system's responsiveness. If any obstacle is detected by ultrasonic sensor, then IR sensor need to detect whether there is any obstacle in left or right of robot. If the obstacle is identified on left of the robot, it moves right side and if any obstacle is identified on right side of robot, it moves left side. Integration of a camera enhances the robot's perception capabilities, enabling it to visually identify obstacle

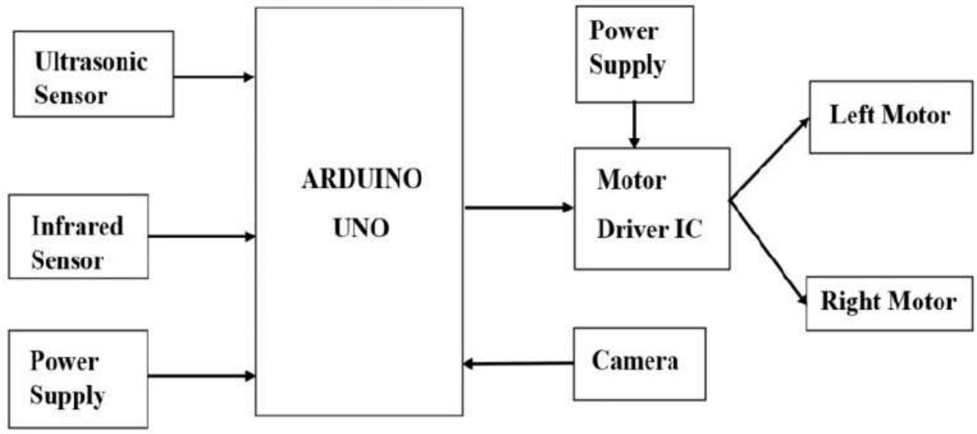


Fig 3.2: Architecture of the proposed system

3.2.1 Advantages

- This system uses ultrasonic and infrared sensor to detect the obstacle.
- When an obstacle is detected in front of robot, now robot need to move either left or right. Rather than moving randomly infrared sensor is placed at right side of robot. Now based on infrared sensor output, robot will be moved.

3.3 Hardware

- Microcontroller (Arduino UNO, ATmega328P)
- Ultrasonic Sensor (HC-SR04)
- Infrared Sensor (Active IR)
- Motor Driver (L293D)
- DC Motors
- Camera (ESP-32)
- Lead Acid Battery
- Voltage Regulator (5V – 12V)
- Robot car chassis
- Buzzer

3.3.1 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 quartz crystal, a USB connection, a power jack, an ICSP header and a reset button [1]

Table 3.1 Arduino UNO specifications

Microcontroller	ATmega328P
Operating Voltage	5v
Input voltage	7-12v
Input voltage limit	6-20v
Digital I/O Pins	6
Analogue input Pins	6

Fig 3.3: Arduino UNO

3.3.2 Ultrasonic sensor

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats or dolphins do. This sensor has two openings one sends the sound waves and other receives the sound wave. Its ranging distance is 2cm to 400cm [14]. It operation is not affected by sunlight or black material like Sharp rangefinders. In order to find out the distance, time is multiplied with speed of sound and it is divided by 2.

Fig 3.4: Ultrasonic Sensor

3.3.3 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. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined [14].

Fig 3.5: Infrared Sensor

3.3.4 L293D Motor Driver

L293D motor driver, typically used to control motor speed and rotation direction. It can also be used for other products such as with LED arrays, relays, and solenoids, etc. It's a powerful little motor driver with a heavy duty heat sink. Capable of powering 5-35V motors with a max of 2A.

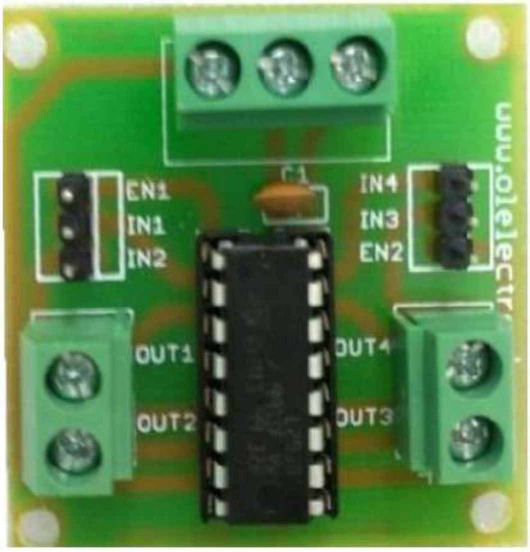


Fig 3.6: L293D Motor Driver

3.3.5 DC Motor

The DC motor wheel is controlled by L298 H-bridge. The direction of motor is controlled by sending a HIGH or LOW signal to the drive for each motor or channel.

- Move: Both robot1 and robot2 are set high.
- Back: Both robot1 and robor2 are set low.
- Right: Robot1 is set high and robot2 is set low.
- Left: Robot1 is set low and robot2 is set high.

Fig 3.7: DC Motor

3.3.6 ESP-32 CAM

The ESP32-CAM is a versatile and compact development board based on the ESP32 microcontroller. It is specifically designed for camera applications and is equipped with an OV2640 camera module. The ESP32-CAM is commonly used for building IoT cameras for surveillance, monitoring, or other visual applications [15].

Fig 3.8: ESP-32 CAM

3.3.7 Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, train and confirmation of user input such as a mouse click or keystroke.

Fig 3.9: Buzzer

3.4 Software

3.4.1 Arduino IDE

The Arduino Uno software, often referred to as the Arduino IDE (Integrated Development Environment), is a software application that allows you to write, compile, and upload code to the Arduino board. The Arduino IDE provides a simple code editor where you can write your programs using the Arduino programming language, which is based on a simplified version of C++.

The following are some of the primary features of Arduino IDE:

- A vast collection of libraries simplifies integration of pre-written code for various sensors, modules, and functionalities into projects.
- The IDE compiles human-readable code into machine code and facilitates easy uploading to Arduino boards via USB.
- Users can select the specific Arduino board model and the communication port before uploading code, ensuring compatibility.
- The IDE is open-source, fostering collaboration and allowing developers to contribute to its improvement and customization.
- The IDE includes a simple code editor for writing Arduino programs using a simplifies version of C++.

3.4.2 Pros of Arduino IDE:

- The IDE offers a simple and intuitive environment, making it accessible for beginners and those new to programming and electronics.
- Arduino IDE is available for Windows, macOS, and Linux, allowing users on different operating systems to write and upload code to Arduino boards.
- The built-in Serial Monitor facilitates debugging and monitoring of program output, helping users troubleshoot their projects effectively.

3.4.3 Cons of Arduino IDE:

- The IDE may be resource-intensive for some older or less powerful computers, leading to slower performance in certain cases.

- Advanced debugging features are somewhat limited in comparison to more professional IDEs, making it challenging to diagnose complex issues.

3.5 Functional Requirements

3.5.1 Sensor Integration

- The system shall integrate ultrasonic and infrared sensors to detect obstacles in the robot's environment.

3.5.2 Obstacle Detection

- The system shall be able to accurately detect obstacles within a specified range using sensors.

3.5.3 Obstacle Avoidance

- The robot shall autonomously navigate around detected obstacles to avoid collisions.

3.5.4 Arduino Integration

- The solution shall be based on the Arduino platform for sensor data processing, motor control, and overall system coordination.

3.5.5 Real-time Monitoring

- The ESP32 Cam should provide real-time video feed for monitoring obstacles ahead of the robot.

3.6 Non-Functional Requirements

3.6.1 Cost

- The overall cost of implementing the obstacle detection and avoidance system shall be within a specified budget.

3.6.2 Safety

- The robot shall be designed with safety mechanisms to prevent collisions with humans or other robots.

3.6.3 Robustness

- The system shall be robust enough to handle variations in environmental conditions.

3.7 Scope

- The integration of ultrasonic and infrared sensors allows the robot to detect obstacles in its environment, enabling it to navigate and avoid collisions.
- The used of both sensors provides versatility in detecting obstacles in different environment.
- Incorporating a camera into the project introduces a visual component to obstacle detection and avoidance.

3.8 Peformance

The performance of the project is efficient by the following:

- Integrating data from multiple sensors (ultrasonic and infrared) to enhance obstacle detection accuracy. Combining sensor inputs can compensate for individual sensor limitations and provide more reliable information about the environment.
- Implementing intelligent decision-making algorithms that take into account data from both sensors and the camera. Using algorithms that prioritize certain sensor inputs based on the robot's context, allowing it to make informed decisions about obstacle avoidance strategies.
- Implementing a user-friendly interface, either through hardware controls or a software application, that allows users to configure and fine-tune the robot's behavior based on specific requirements and environmental conditions.

3.9 Methodology

To implement this project Iterative Model is used. It involves continuous cycle of Planning, Analysis, Implementation and Evaluation.

The Iterative Model allows the accessing earlier phases, in which the variations made respectively. The final output of the project renewed at the end of the Software Development Life Cycle (SDLC) process.

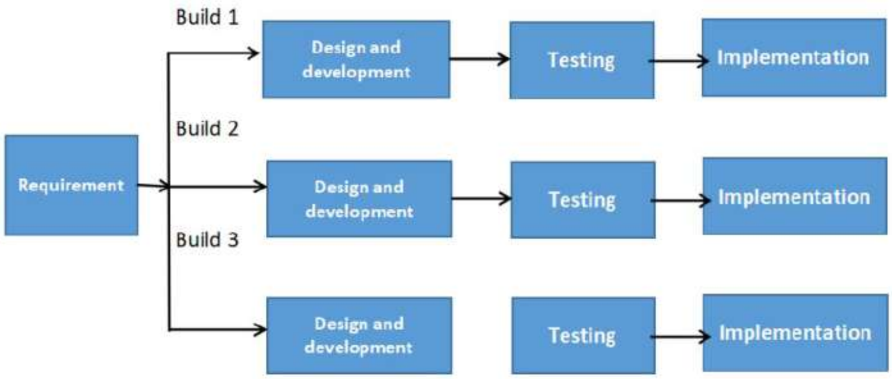


Fig 3.10: Iterative Model

3.9.1 Advantages

- It is easily acceptable to ever-changing needs of the project.
- Testing and debugging during smaller iteration is easy.
- A parallel development can plan.

3.10 Cost Estimation

Table 3.2: Estimated cost of the equipment

S.No	Component	Cost (Rs)	Quantity	Total Cost (Rs)
1.	Robot car chassis	800	1	800
2.	Arduino UNO	800	1	800
3.	IR Sensor	25	1	25
4.	Motor Driver	150	1	150
5.	Ultrasonic Sensor	60	1	60
6.	Buzzer	20	1	20
7.	Voltage Regulator	140	1	140
8.	Connecting Wires	10	20	200
9.	Soldering Iron, Soldering Stand and Wire	600	1	600

10.	Lead Acid Battery	700	1	700
11.	DC Motors	80	2	160
12.	Toggle Switch	70	1	70
13.	Camera	500	1	500
14.	Shipping	400	-	400
	Total Cost			**4625**

3.11 Time Estimation

Basically our project is divided into two phases.

- Phase – 1: Pre-requisites, Planning and Designing

Table 3.3: Activities performed in Phase – 1

S. No	**Activity**	**Duration**
1.	Domain Selection	1 Week
2.	Literature Survey and Problem Definition	2 Weeks
3.	Planning and Designing	2 Weeks

- Phase – 2: Developing the model.

Table 3.4: Activities performed in Phase – 2

S. No	**Activity**	**Duration**
1.	Gathering all the Components	1 Week
2.	Developing the Robot chassis system	3 Weeks
3.	Integrating camera to the Robot chassis system	1 Week
4.	Implementing the System	2 Weeks
5.	Testing and Finalizing the System	1 Week

CHAPTER – 4

DESIGN

CHAPTER 4

DESIGN

4.1 System Architecture

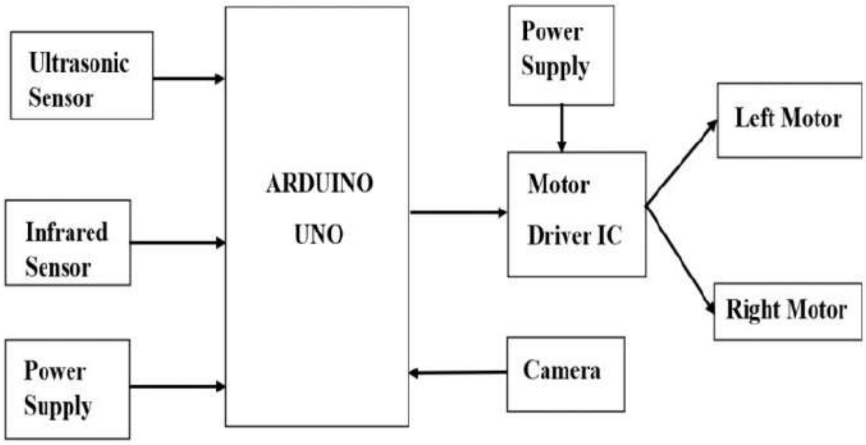


Fig 4.1: System Architecture

- The system architecture shows that ultrasonic and infrared sensors are connected to the Arduino UNO. Two sensors will send the information to the microcontroller and then according to the instructions the robot changes its direction. Ultrasonic sensor is placed in front of the robot which is used for proximity measurement. Infrared sensor is placed on the right side of robot. H-bridge Motor driver is responsible for movement of robot as it controls the two DC motors. Lead acid battery is used to provide power to the robot.

- ESP32 Cam need to be connected to local Wi-Fi network. Using a USB cable the power bank is connected to the ESP32 Cam module. The connection should be secure and should provide power to the Esp32 Cam. The code should include instructions to initialize the camera module, connect to Wi-Fi, start a web server and to display the IP address of the ESP32 Cam. Code should be compiled and uploaded to the ESP32 Cam using Arduino IDE. Need to access the Serial Monitor to view the IP address of the ESP32 Cam. Copy the IP address and open it in web browser in order to view the video stream from the Esp32 Cam.

4.2 Flow Diagram of Robot System

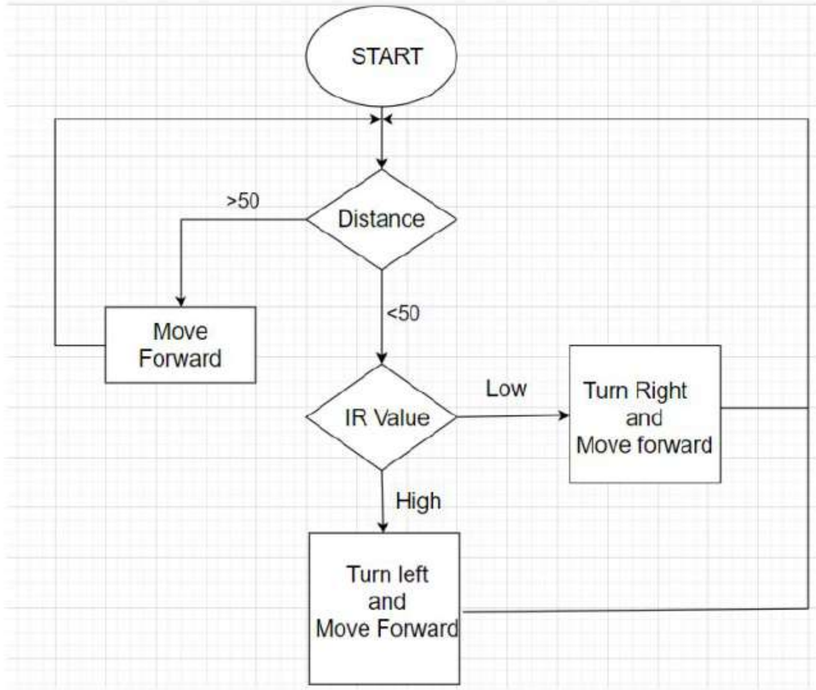


Fig 4.2: Flow chart of Robot System

- The robot starts by moving forward. Ultrasonic and Infrared sensors are used to measure the distance from robot to the obstacle.
- If the distance is greater than 50cm, the robot moves forward. This indicates that there are no obstacles within a safe range in front of the robot. If the distance is less than 50cm robot moves backward which indicates there is a potential obstacle ahead.
- When an obstacle is detected by the ultrasonic sensor, the robot moves backward and it need to move either left or right. In order to move either left or right, infrared sensor is used which is placed on right side of robot.
- If the infrared sensor detects a low IR value, the robot turns right and moves forward. A low IR value typically indicates that there is no obstacle present on right side of robot. If the infrared sensor detects a high IR value, the robot turns left and moves forward. A high IR value typically indicates that there is obstacle present on right side of robot.
- By continuously repeating this process, the robot can navigate its way through an environment cluttered with obstacles.

CHAPTER - 5

IMPLEMENTATION

CHAPTER 5

IMPLEMENTATION

5.1 Hardware Implementation

- The Arduino Uno board is connected to a DC power supply which provides 12V. The ground (GND) pin on the power supply is connected to the GND pin on the Arduino. The 12V pin on the power supply is connected to the Vin pin on the Arduino.
- The H bridge is connected to the Arduino Uno. The specific connection points will vary depending on the H bridge model being used, but they typically connect to the Arduino's digital I/O pins. In the image, the H bridge is connected to pins 9, 10, and 11.
- The DC motors are connected to the H bridge. The H bridge is responsible for controlling the direction and speed of the DC motors.
- The UV sensor is connected to the Arduino Uno. The positive (5V) pin on the UV sensor is connected to the 5V pin on the Arduino. The ground (GND) pin on the UV sensor is connected to a GND pin on the Arduino. The output signal pin of the UV sensor is connected to an analog input (A0) pin on the Arduino.

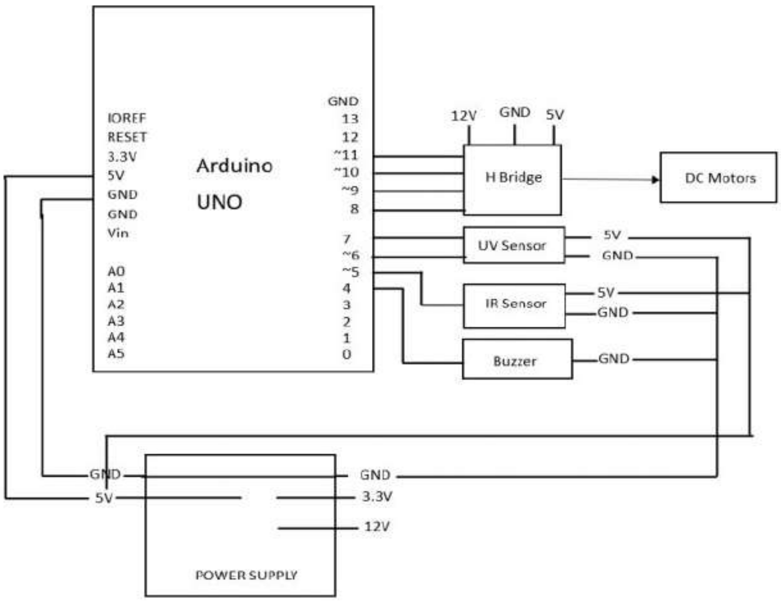


Fig 5.1: Circuit Diagram of the robot system

- The IR sensor is connected to the Arduino Uno. The positive (5V) pin on the IR sensor is connected to the 5V pin on the Arduino. The ground (GND) pin on the IR sensor is connected to a GND pin on the Arduino. The output signal pin of the IR sensor is connected to an analog input (A3) pin on the Arduino.
- The buzzer is connected to the Arduino Uno. The positive (+) pin of the buzzer is connected to a digital I/O pin (A4) on the Arduino. The negative (-) pin of the buzzer is connected to a GND pin on the Arduino.

5.2 Software Implementation

5.2.1 Installation of Arduino IDE (Windows PC)

To install Arduino IDE on your Windows PC, follow the next instructions:

1.Go to the Arduino.cc website and click on the Download link.

2.Begin the download and installation process.

3.Choose the installation path and launch the Arduino IDE.

4. Open your first project.

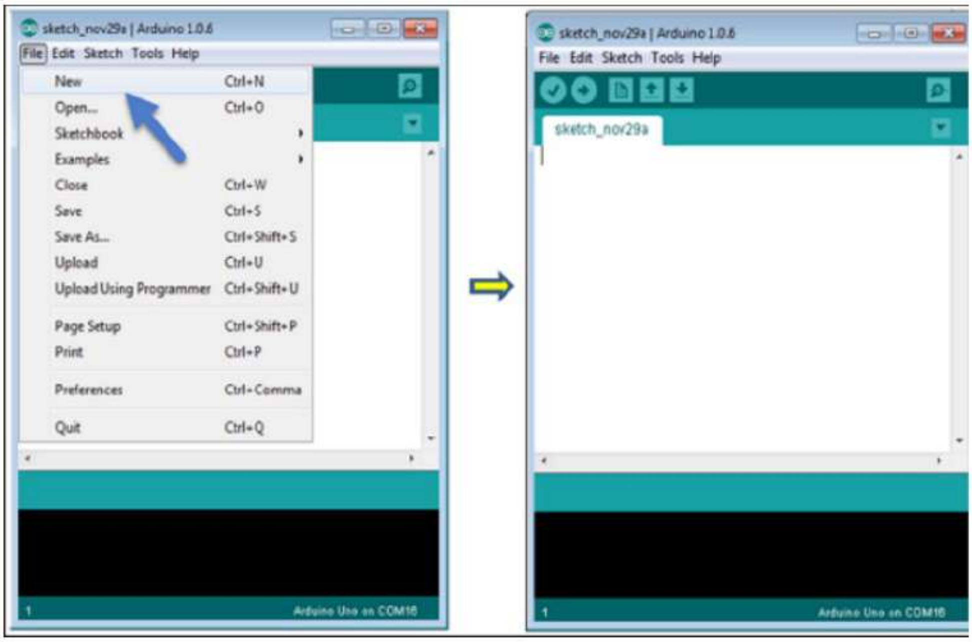


Fig 5.2: Creating a new project

5. Select your Arduino board.

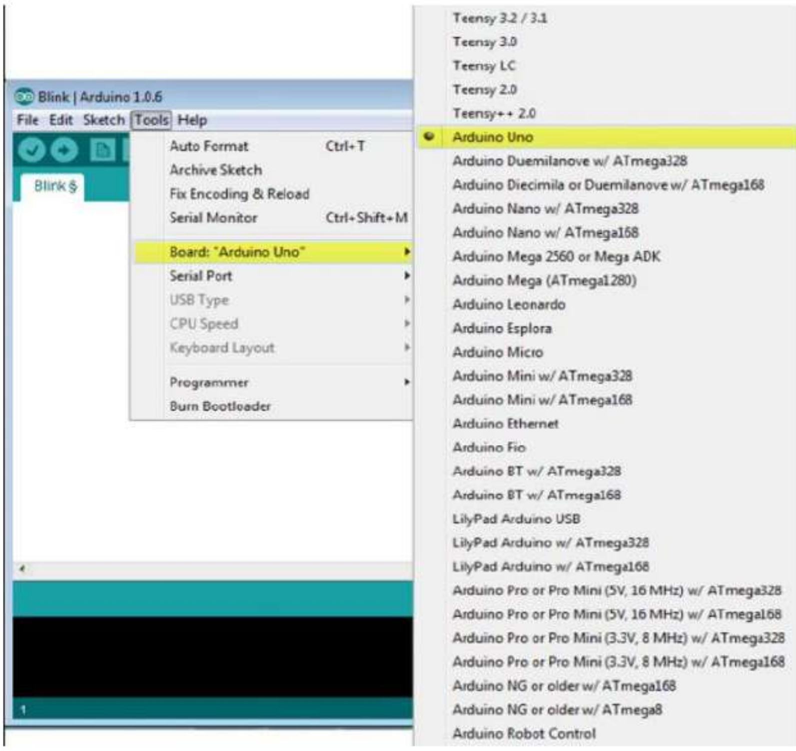


Fig 5.3: Selecting the type of Arduino board

6. Select the serial device of the Arduino board and upload the program to your board.

5.2.2 Arduino code

Source code for robot system

```
int robot1=8;// pin used for robot movement

int robot2=9;

int robot3=10;

int robot4=11;

int buzzer=4;

int ir=5;

int pingPin = 6;

int echoPin = 7;

long duration, cm;
```

```
void setup() {
        Serial.begin(9600);
        pinMode(robot1,OUTPUT);  //declearing all pins using as output
        pinMode(robot2,OUTPUT);
        pinMode(robot3,OUTPUT);
        pinMode(robot4,OUTPUT);
        pinMode(buzzer,OUTPUT);
        pinMode(pingPin, OUTPUT);
        pinMode(echoPin, INPUT);
        pinMode(ir, INPUT);
        digitalWrite(robot1,LOW);  // initially sending LOW signal to all pins
        digitalWrite(robot2,LOW);
        digitalWrite(robot3,LOW);
        digitalWrite(robot4,LOW);
        digitalWrite(buzzer,LOW);
        Serial.println("OBSTACLE AVOIDANCE ROBOT");
}
void loop(){
        robot_move(); // calling robot movement function
        //  delay(1000);
        digitalWrite(pingPin, LOW);
        delayMicroseconds(2);
        digitalWrite(pingPin, HIGH);
        delayMicroseconds(10);
        digitalWrite(pingPin, LOW);
```

```
duration = pulseIn(echoPin, HIGH);
//  inches = microsecondsToInches(duration);
cm = microsecondsToCentimeters(duration);
Serial.print("dist=");
Serial.print(cm);
Serial.print("cm");
Serial.println();
delay(100);
If(cm<50){
        digitalWrite(buzzer,HIGH);
        robot_stop();
        delay(2000);
        digitalWrite(buzzer,LOW);
        robot_back();
        delay(2000);
        robot_stop();
        delay(2000);
        if(digitalRead(ir)==LOW){
                robot_left();
                delay(3000);
                robot_stop();
                delay(2000);
                robot_right();
                delay(3000);
                robot_stop();
```

```
                delay(2000);
                robot_move();
                delay(1000); }
        else{
                robot_right();
                delay(3000);
                robot_stop();
                delay(2000);
                robot_left();
                delay(3000);
                robot_stop();
                delay(2000);
                robot_move();
                delay(1000);  }
        }
    }
long microsecondsToCentimeters(long microseconds) {
    return microseconds / 36 / 2;
}
void robot_move() {  // function definition for robot movement
    digitalWrite(robot1,LOW);
    digitalWrite(robot2,HIGH);
    digitalWrite(robot3,HIGH);
    digitalWrite(robot4,LOW);
    }
```

```
void robot_back()  { // function definition for robot movement
        digitalWrite(robot1,HIGH);
        digitalWrite(robot2,LOW);
        digitalWrite(robot3,LOW);
        digitalWrite(robot4,HIGH);}
void robot_right(){   // function definition for robot movement
        digitalWrite(robot1,HIGH);
        digitalWrite(robot2,LOW);
        digitalWrite(robot3,HIGH);
        digitalWrite(robot4,LOW);}
void robot_left(){  // function definition for robot movement
        digitalWrite(robot1,LOW);
         digitalWrite(robot2,HIGH);
        digitalWrite(robot3,LOW);
        digitalWrite(robot4,HIGH);}
void robot_stop() {  //function definition for robot stop
        digitalWrite(robot1,LOW);
        digitalWrite(robot2,LOW);
        digitalWrite(robot3,LOW);
        digitalWrite(robot4,LOW);
        delay(1000);}
```

CHAPTER – 6

TESTING

CHAPTER 6

TESTING

6.1 Testing Approach

We will test the project in two stages: software and hardware. The software part is to be tested via the Thonny IDE, whereas the hardware part has to be tested physically. It is necessary to check whether the system is working properly or not.

6.2 Features to be tested

After building the whole circuit we test it, this project should satisfy some features. Features to be tested as follows:

- The ultrasonic sensor should detect the obstacle when an obstacle is present in the range of 50cm.
- The infrared sensor should detect the obstacle when an obstacle is present on right side of robot.
- Check the working of camera.

6.3 Testing tools and environment

For testing the project we require some tools, like to test Arduino program we require software called Thonny IDE. Using this we can check the program that program is working properly or not. For hardware checking we require power supply and threshold values are fixed manually.

6.4 Test cases

In this section we discuss about the inputs, expected output, testing procedure.

6.4.1 Inputs

Power supply: Power supply is the basic need of any electronic circuit. Whole circuit requires 12v power. So, we are using 12v Lead acid battery to supply power to the circuit.

6.4.2 Expected Output

The expected output of this project is to detect the obstacles by the robot when the distance between obstacle and robot is less than 50cm. If the distance between robot and obstacle is more than 50cm, then the robot should move forward. The obstacles should be seen on computer screen.

6.4.3 Testing Procedure

Summary of the testing procedure :-

- Connect the circuit according to the diagram.
- Give power to the system.
- Place obstacles at different places and angles from the robot.
- Check whether the robot is detecting and avoiding the obstacles when the distance between robot and obstacle is less than 50cm.
- Robot should produce buzzer sound when it detect the obstacle.
- The obstacle should be seen on computer screen.

CHAPTER – 7
RESULTS & ANALYSIS

CHAPTER 7

RESULTS & ANALYSIS

In this we are implementing the module by using Arduino UNO microcontroller. The Arduino UNO carries all the instructions given through code and works accordingly. In the robot system the detection of the vehicle is determined by the Ultrasonic and Infrared sensor and passes the information to the microcontroller and then the microcontroller sends the commands to DC motors. H-Bridge motor driver is used to control the directions of wheels of robot. According to the instructions send by the Arduino, motor driver changes the direction of wheels. Two DC motors are used to for movement of robot.

When an obstacle is present in front of a robot, if the distance between the obstacle is less than 50cm then IR values will be considered. As there is no obstacle on right side of robot, IR value will be low. So, robot moves right side.

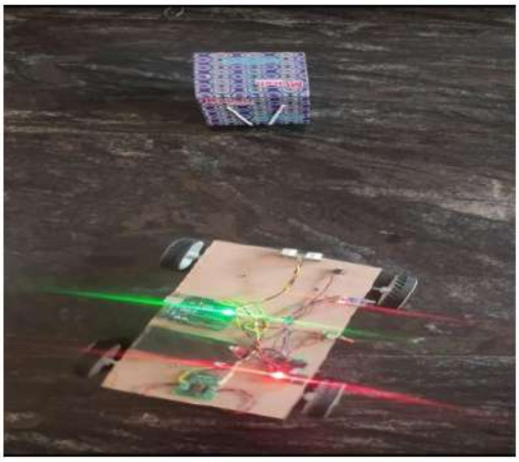


Fig 7.1: Obstacle present in front of robot

When an obstacle is present on right side of robot, simply IR sensor values will be considered. As the obstacle is present, IR value will be high. As the IR value is high, robot moves left side.

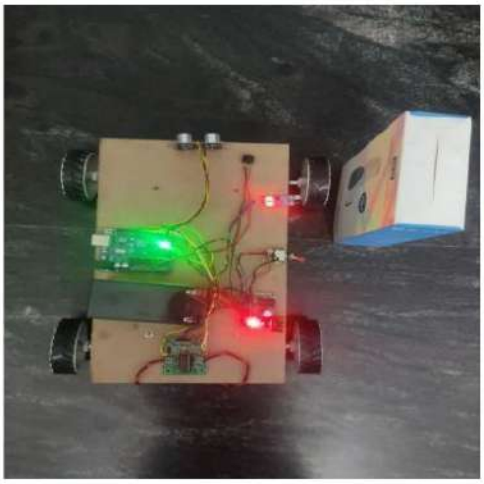


Fig 7.2: Detection of obstacle on right side of a robot by IR sensor

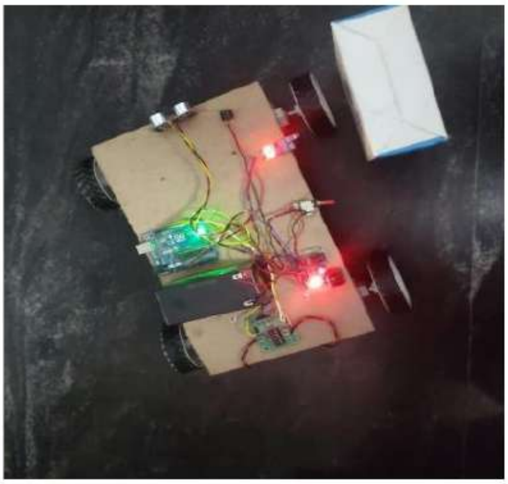


Fig 7.3: Change in direction of a robot

When an obstacle is present in front and right side of a robot, it turns left and proceeds forward in order to encounter barriers.

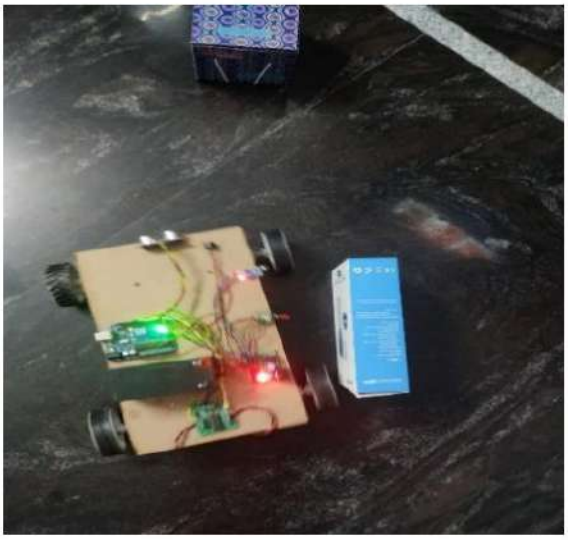
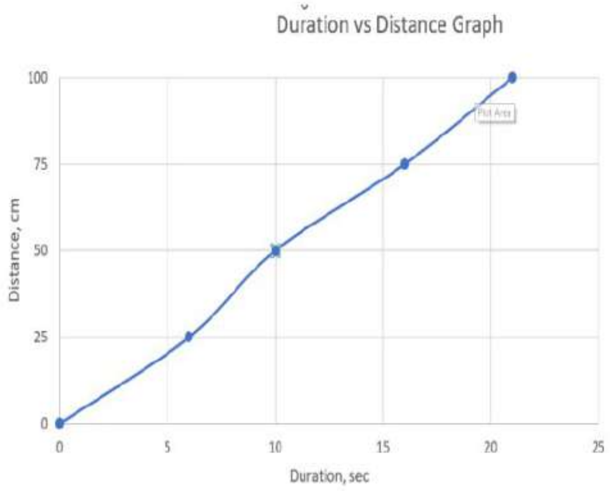


Fig 7.4: Movement of robot when obstacles are present in front and right side of a robot

Fig 7.5: Distance and Duration Graph



The above graph shows time taken by the robot to detect the obstacle and change its direction in order to avoid the obstacle, when the obstacle is present in different distances. The angle range of ultrasonic sensor is between 0 to 15 degrees.

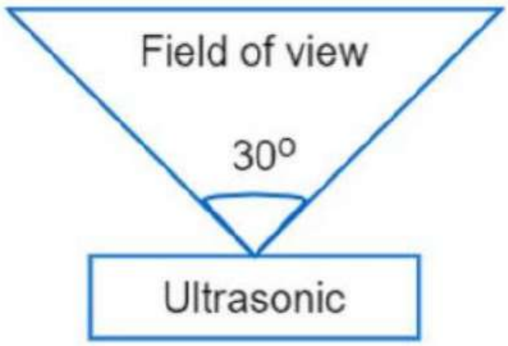


Fig 7.6: Angle range of Ultrasonic Sensor

We placed an obstacle at different angles from robot and noted the amount of time taken by the ultrasonic sensor to detect the obstacle. Below table tells about the time taken by the sensor to detect the obstacle when obstacle is present at different angles from robot.

Table 7.1: Time taken to change direction when obstacle is placed in different angles

S. No	Angle (degrees)	Time Taken (microseconds)
1.	3	39
2.	6	96
3.	9	171
4.	12	264
5.	15	375

When an obstacle is placed in different angles, time taken by robot to detect the obstacle is noted. The time taken to detect the obsatcle increases as the angle between the robot and the obsatcle increases.

CONCLUSION

In the proposed system a robot is developed by integrating ultrasonic sensor and infrared sensor which is capable of detecting and avoiding the obstacles. Need for a servo motor is eliminated to enhance simplicity and cost effectiveness. The robot dynamically changes direction in response to detected obstacles in varied environments. Through this proposed system, we achieved accurate perception of obstacles in various environments, enhancing the safety and autonomy of robotic navigation. Additionally, a camera module is incorporated to provide visual feedback, extending the system's capabilities for enhances perception.

In our proposed model we have used camera in order to visualize the obstacle. But we can apply machine learning algorithms on visual input. Convolutional Neural Networks (CNNs) or deep learning models can improve the system's ability to recognize and respond to different types of obstacles.

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Obstacle Detection and Avoidance in Robots Using Sensors

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Abstract:

Robotics is a quickly growing and fascinating field in the modern world. Among the qualities required for automated mobile robots is obstacle avoidance. An impediment is detected by a single sensor in older systems. The robot will randomly move to the left or right while utilizing just one sensor. We want to use infrared and ultrasonic sensors in our proposed model to identify the obstruction. The robot uses the ultrasonic sensor to measure closeness, which enables it to identify impediments in its local area. Concurrently, an infrared sensor adds further obstacle detecting capabilities, improving the responsiveness of the system. Moreover, the incorporation of a camera augments the robot's sensory capacities, permitting it to discern obstacles through visual means. The robot's method of determining decisions.

Keywords:

IOT (Internet of Things), Object detection, Ultrasonic sensor, Infrared sensor, Arduino

1 INTRODUCTION

In the dynamic landscape of IoT-based robotics, the integration of sensors and smart algorithms is key to developing intelligent and autonomous for object detection and avoidance, utilizing Arduino Uno microcontroller, an ultrasonic sensor, an infrared sensor, and a camera. The core objective of the robot is to navigate its environment, autonomously detecting obstacles in real-time and executing avoiding actions to prevent collisions. The Arduino Uno, a widely-used microcontroller known for its simplicity and versatility, serves as the central processing unit for the integration of sensors and the overall control of the robotic system.

The chosen sensors for this work include an ultrasonic sensor for measuring proximity and an

infrared sensor for robust obstacle detection. This combination enables the robot to perceive its surroundings effectively and respond promptly to potential obstacles, ensuring safe and efficient movement within its environment. To enhance the robot's perceptual capabilities, a camera is integrated into the system. Camera captures the images when obstacles are detected, providing a visual record of the environment. The fusion of sensor data and visual information empowers the robot to make informed decisions, contributing to a more comprehensive understanding of its surroundings.

This aims to showcase the feasibility of integrating multiple sensors and a camera into an Arduino Uno-based robotic system, demonstrating its potential applications in areas such as surveillance, monitoring, and autonomous navigation within confined spaces.

2 RELATED WORK

This research paper aimed at addressing the challenge of providing effective collision avoidance capabilities without compromising on cost efficiency [1]. The main objective is to minimize the deviation from the vehicle's original path and also to develop an algorithm utilizing ultrasonic sensor for accurate distance measurements.

The ultrasonic sensor rotates for shape approximation and edge detection. The paper likely concludes with discussions on the broader applicability of the method, identifying potential use cases such as educational robotics or industrial automation. Under future work authors have suggested on integration with other sensing technologies.

The paper titled "Exploring Obstacle Avoidance in Robotic Vehicles with Ultrasonic Sensors and Arduino Control" delves into a detailed examination of a robotized vehicle engineered to navigate obstacles. The system integrates ultrasonic sensors and an Arduino microcontroller, specifically utilizing the Atmega328 as the microcontroller. Information about the surroundings is collected by the sensors and transmitted to the microcontroller, enabling it to determine the appropriate movement for the robot wheels. [3].

In their paper "Obstacle Avoidance Robot Using Arduino" Pavithra A C and Subramanya Goutham V have designed an approach for movement of robot where ultrasonic sensor is used for detecting the obstacle. They have made an effort to reduce the code's complexity. The robot advances if there is a gap of more than 30 cm between it and the obstruction. Robot stops moving and turns left to take a reading if there is less than 30 cm between it and the obstruction. It then makes a right turn to take a reading. The robot advances to the left if the left distance is larger than the right; else, it moves to the right. The ultrasonic sensor's direction can be changed using a servo motor [2]. In their upcoming endeavors, they have mentioned that cameras can be used to detect the obstacle.

In their paper titled "Obstacle Avoiding Robotic Vehicle with Arduino and Ultrasonic Sensor," introduced a robot equipped with obstacle detection and avoidance capabilities [4]. The choice of the Ultrasonic sensor HC-SR04 was made after a thorough analysis of numerous publications, all of which emphasized how much less accurate IR and PIR sensors, like the HC-SR501, are in comparison. This decision guarantees improved accuracy in the robot's detection of impediments and efficient path navigation.

In the paper "Robot avoiding obstacle," a robot is constructed. The robot's motors are connected to it via a motor driver, and the microcontroller uses the input signals it receives to control them to change the robot's path [5]. This system improves the robot's overall navigational ability by enabling it to shift orientation in reaction to outside stimuli.

3 EXISTING SYSTEM

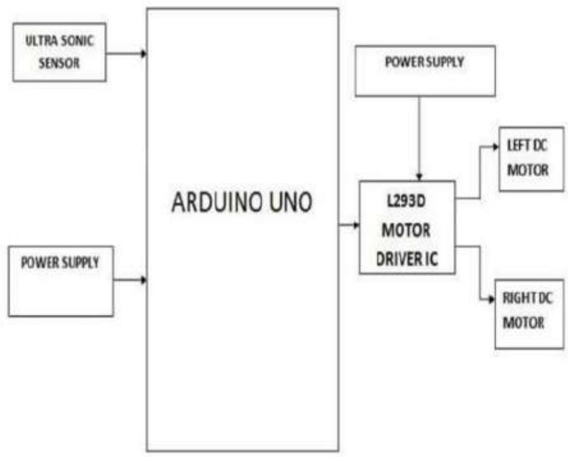

Fig. 1. Block diagram of existing system

In the existing system, only one sensor is used to detect obstacles. It can be either ultrasonic sensor or IR sensor. When obstacle comes near to robot, sensor detects the obstacle and sends the data to Arduino. The movement of robot will be dependent on instructions specified in Arduino. If the obstacle is encountered in front of robot it moves either left or right randomly. This is the main drawback in existing system.

4 PROPOSED SYSTEM

The proposed system uses two sensors. First Ultrasonic sensor is used for proximity measurement. Infrared sensor is used to provide additional obstacle detection capabilities, enhancing the system's responsiveness. If any obstacle is detected by ultrasonic sensor, then IR sensor need to detect whether there is any obstacle in left or right of robot. If the obstacle is identified on left of the robot, it moves right side and if any obstacle is identified on right side of robot, it moves left side. Integration of a camera enhances the robot's perception capabilities, enabling it to visually identify obstacle.

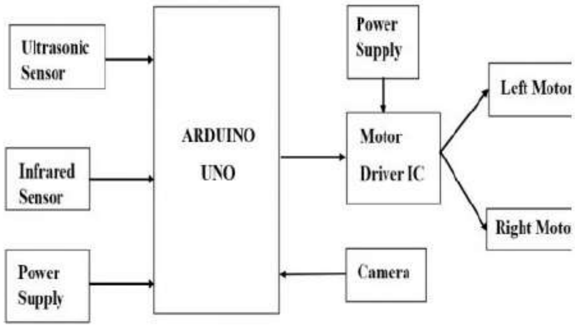

Fig. 2. Block diagram of proposed system

5 HARDWARE COMPONENTS

5.1 Arduino UNO:

A microcontroller board based on the ATmega328P is called Arduino Uno. Six of its fourteen digital input/output pins can be used as PWM outputs. It also has a reset button, six analog inputs, a power jack, an ICSP header, a USB port, and a 16 MHz quartz crystal [12].

5.2 Ultrasonic sensor:

Operating on sonar principles, the HC-SR04 ultrasonic sensor is comparable to how bats and dolphins use echolocation. It has two holes, one for sending and the other for receiving sound waves, and can detect distances between 2 and 400 cm [11]. It is more dependable than sharp rangefinders even when exposed to outside elements like sunshine or the color of the material. The sensor measures the time it takes sound waves to reach an object and back, multiplies this by the sound speed, then divides the result by two to determine distance.

5.3 Infrared Sensor:

An electrical device known as an infrared sensor is designed to sense various components of the surrounding environment by being able to both emit and detect infrared light. This sensor has the ability to measure heat emissions from objects and detect movements. Infrared radiation is produced by an IR transmitter and directed toward an object. Some of this radiation is reflected back to the infrared receiver. The sensor's output, which provides crucial details about the characteristics or movements of the object, is determined by the intensity of the infrared light it receives [11].

5.4 L293D Motor Driver:

One often used part for regulating motor speed and rotation direction is the L293D motor driver. Its usefulness extends beyond motors, as it may be used with LED arrays, relays, and solenoids, among other devices.It can run motors from 5 to 35 volts, and it can run up to 2 amps of current at its maximum. This versatile and dependable option is ideal for a broad range of electronic uses.

5.5 DC Motors:

The L293D motor driver is a frequently used component for controlling motor speed and rotation direction. Its applications go beyond motors; among other things, it can be utilized with LED arrays, relays, and solenoids. Its operating voltage for motors is between 5 and 35 volts, and its maximum current output is 2 amps. For a variety of electronic applications, this adaptable and trustworthy choice is excellent.

Move: Both robot1 and robot2 are set high.

Back: Both robot1 and robor2 are set low.

Right: Robot1 is set high and robot2 is set low.

Left: Robot1 is set low and robot2 is set high.

5.6 ESP-32 CAM:

A development board that is both lightweight and flexible the ESP32-CAM is built on the ESP32 microcontroller. It is specifically designed for camera applications and is equipped with an OV2640 camera module. The ESP32-CAM is commonly used for building IoT cameras for surveillance, monitoring, or other visual applications.

5.7 Lead Acid Battery:

The lead-acid battery serves as the primary power source for the robotic system.

6 IMPLEMENTATION:

6.1 System Design:

The Arduino Uno's VIN pin is connected to the positive terminal of the 12 volt power source. The Arduino Uno, H bridge, DC motors, ultrasonic sensor, and infrared sensor are all connected to each other's ground pins. The direction of Motor A is controlled by the H bridge's IN1 and IN2 pins. The direction of Motor B is controlled by the H bridge's IN3 and IN4 pins. The DC motors are linked to the H bridge's Motor A and Motor B connections. The VCC pin of the infrared sensor, the OUT pin of the ultrasonic sensor, and the OUT pin of the infrared sensor are connected to the 5v, A0, and A2 pins of the Arduino Uno, respectively.

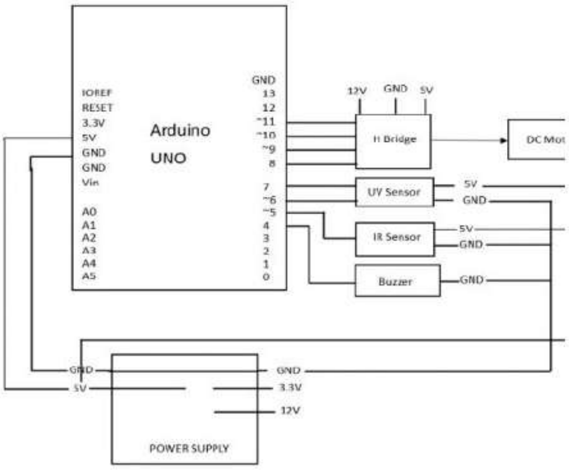

Fig. 3. Circuit diagram of obstacle detection and collision avoidance system

6.2 Methodology:

First hardware components are selected and robot is assembled by connecting the sensors, motors, battery, camera to the Arduino board. Ultrasonic sensor is placed in front of robot in order to calculate the distance between robot and obstacle. The ultrasonic wave emitter dispatches signals that strike an object and rebound back. Arduino then computes the duration it takes for the ultrasonic pulse wave to travel from its point of origin (sender) to the object and return to the detection point (receiver). This calculated time serves as the basis for Arduino to determine the distance between the sensor and the obstructing object.

6.2.1 Distance calculation using ultrasonic sensor:

$$\text{Distance} = (\text{Speed} * \text{Time}) / 2 \quad (1)$$

Distance is the distance from the sensor to the object.

Time is the time taken for the ultrasonic pulse to travel to the object and back.

Speed is the speed of sound in air. (344meters/second).

6.2.2 Object detection using infrared sensor:

Infrared sensor contains LED and photodiode which are used as transmitter and receiver respectively. The current generated by a photodiode is in relation to the intensity of the light it receives.

$$I_{ph} = h * P * l / hc \quad (2)$$

Where :

I_ph - photodiode current (Ampere)

h - photodiode's quantum efficiency (Unitless)

P - incident light power (Watt)

h - Plank's constant (6.626 x 10^-34 Joule*Seconds)

c - speed of light (3 x 10^8 Meters/Second)

l - wavelength of light (Meters)

Amplifier is used to amplify the weak current from the photodiode. Analog-to-Digital Converter (ADC) is used to change the continuous voltage range into a discrete set of digital codes (high/low).

6.2.3 Working Principle:

IR values will be taken into account if the robot and obstacle are closer than 50 cm. The robot turns right and proceeds forward if the IR value is low. The robot turns left and travels forward if the IR value is high. The robot's heading won't change if the distance is more than 50 cm (Figure I). An Arduino board serves as a system's brain when it is connected to sensors.

These sensors provide information about the environment. With this data, the Arduino can make decisions and control DC motors through an H-Bridge module. Essentially, it senses the surroundings and takes actions, like moving motors, based on that input. Now the lead-acid battery is connected to the power supply circuit. Obstacle detection and avoidance functionality is detected in different environment conditions. In this proposed model, the robot will not change directions randomly. Based on ultrasonic sensor and infrared sensor value, the direction of robot will be changed.

TABLE I. Actions performed by the robot

S.No	Ultrasonic Sensor Centimeter(cm)	Infrared Sensor (High/Low)	Action
1.	>50	-	Move forward
2.	<50	High	Turn left and move forward
3.	<50	Low	Turn right and move forward

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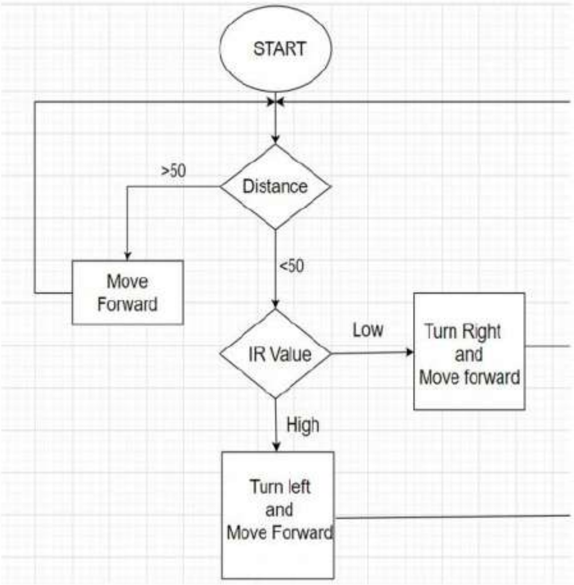


Fig. 4. Flow chart of obstacle detection and collision avoidance system

7. RESULTS AND DISCUSSION

The ultrasonic sensor recognizes obstacles in front of the robot and transmits the distance between the obstacle and sensor to the Arduino. The robot rotates to the right side in accordance with the code's instructions because its right side is clear of obstacles.

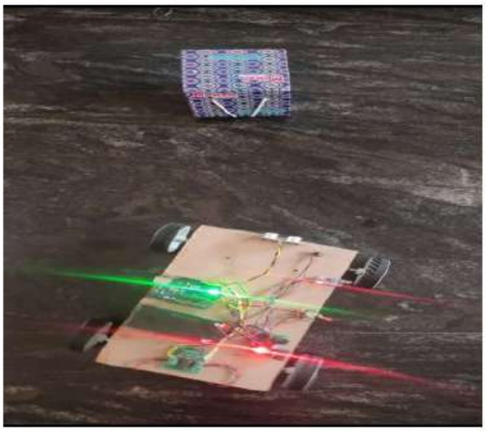


Fig. 5. Obstacle present in front of robot

When an obstacle is present on right side of a robot, IR value will be high, so robot will move left side.

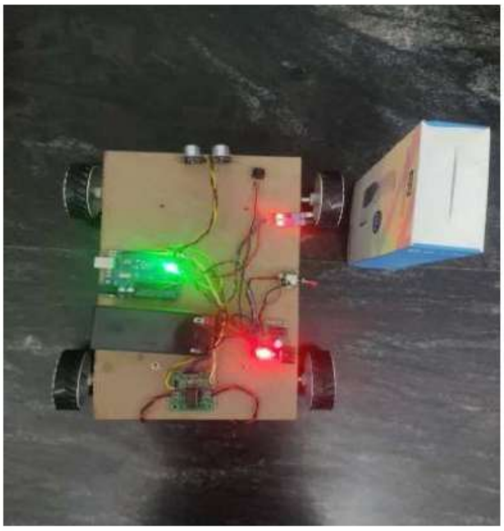


Fig. 6. Detection of obstacle on right side of a robot by IR sensor

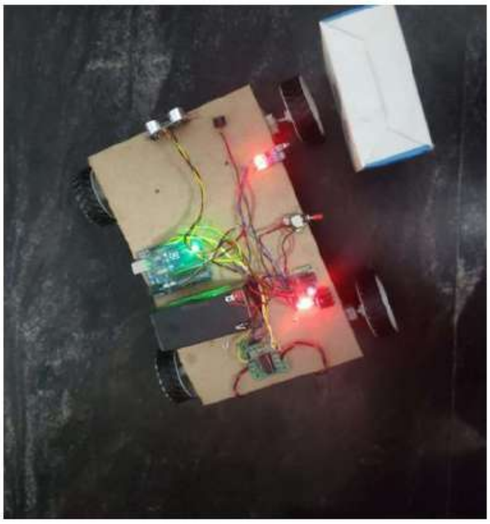
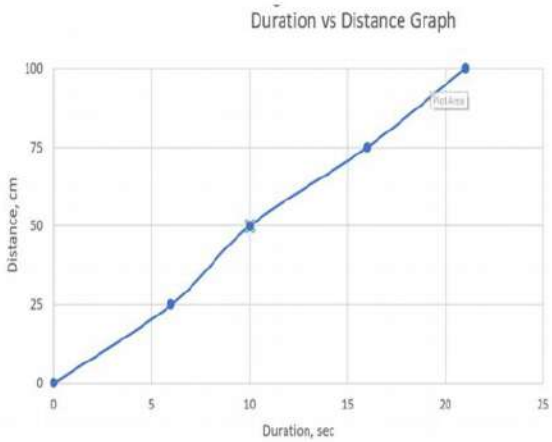


Fig. 7. Change in direction of a robot

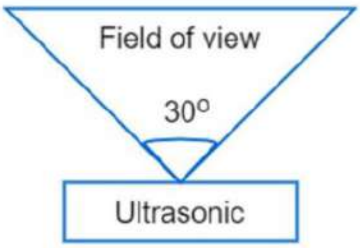
The robot turns left and proceeds forward when it encounters barriers in front of it as well as on its right side.

Fig. 8. Movement of robot when obstacles are present in front and right side of a robot

Graph 1. Distance and Duration Graph



The above graph shows time taken by the robot to detect the obstacle and change its direction in order to avoid the obstacle, when the obstacle is present in different distances. The angle range of ultrasonic sensor is between 0 to 15 degrees.



We placed an obstacle at different angles from robot and noted the amount of time taken by the ultrasonic sensor to detect the obstacle. Below table tells about the time taken by the sensor to detect the obstacle when obstacle is present at different angles from robot.

Table II. Time taken by robot to change direction when obstacle is placed in different angles

S.No	Angle(degrees)	TimeTaken(microseconds)
1.	3	39
2.	6	96
3.	9	171
4.	12	264
5.	15	375

8 CONCLUSION

From this study, a robot is developed by integrating ultrasonic sensor and infrared sensor which is capable of detecting and avoiding the obstacles. Need for a servo motor is eliminated to enhance simplicity and cost effectiveness. The robot dynamically changes direction in response to detected obstacles in varied environments. Additionally, a camera module is incorporated to provide visual feedback, extending the system's capabilities for enhances perception.

9 FUTURE WORK

In our proposed model we have used camera in order to visualize the obstacle. But we can apply machine learning algorithms on visual input. Convolutional Neural Networks (CNNs) or deep learning models can improve the system's ability to recognize and respond to different types of obstacles.

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