Mini-Project Report On

Automatic Braking System using IoT Technology

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CERTIFICATE

This is to certify that the mini-project report entitled ***"Automatic Braking System using IoT Technology"*** *is a bonafide work done by* ***Mr. Albin Rony (U2003021), Ms. Annmaria Jaxon (U2003039), Ms. Ashmi Jomon (U2003045), Mr. Christy Varghese Chacko (U2003063)****, submitted to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2022-2023.*

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ABSTRACT

This mini project presents the development and evaluation of an Automatic Braking System using Ultrasonic Sensor to address the issue of delayed braking and reduce accidents. The system utilizes ultrasonic sensors, an Arduino UNO microprocessor, a 12 V DC motor, and a braking mechanism. It operates by emitting ultrasonic waves, detecting obstacles, calculating distances, and applying gradual braking if a collision is imminent. The project involves design, simulation, physical prototype implementation, and effectiveness evaluation through field tests and data analysis.

The Automatic Braking System offers advantages such as accurate distance measurement, resistance to external disturbances, and a maintenance-free lifespan. It remains unaffected by environmental factors such as dust, dirt, or moisture. Through this mini project, the effectiveness of the system is demonstrated, providing valuable insights into its practical application for improving vehicle safety. This research lays the foundation for further advancements in the field of automated braking systems and their potential adoption in real-world scenarios.

Contents

Acknowledgements **ii**

Abstract **iii**

List of Figures **vii**

1 Introduction **1**

1.1 Background . . . 1

1.2 Existing System . . . 2

1.2.1 Collision Mitigation Braking System (CMBS) . . . 2

1.2.2 Autonomous Emergency Braking System (AEB) . . . 2

1.3 Problem Statement . . . 2

1.4 Objectives . . . 3

1.5 Scope . . . 4

2 Literature Review **5**

2.1 Demerits of Existing Systems . . . 5

2.2 Comparison of Existing Systems with the Mini Project . . . 6

3 System Analysis **8**

3.1 Feasibility Analysis . . . 8

3.1.1 Technical Analysis . . . 8

3.1.2 Operational Analysis . . . 8

3.1.3 Economical Analysis . . . 9

3.2 Hardware Requirements . . . 9

3.2.1 Ultrasonic Sensors . . . 9

3.2.2 Arduino UNO . . . 10

3.2.3 12 V DC Motor/Servomotor and Braking System . . . 10

3.2.4 L293D Motor Driver . . . 11

3.2.5 Piezoelectric Buzzer . . . 12
3.3 Software Requirements . . . 13
3.3.1 Arduino Compiler . . . 13

4 Methodology **14**
4.1 Proposed Method . . . 14
4.1.1 Enhanced Safety . . . 14
4.1.2 Accessibility and Compatibility . . . 14
4.1.3 Cost-effective Solution . . . 15
4.2 Module Divison . . . 15
4.2.1 Microprocessor Programming and Control Logic . . . 15
4.2.2 DC Gear Motor Integration . . . 15
4.2.3 Ultrasonic Sensors and Buzzer Integration . . . 16
4.2.4 Implementation on Braking System . . . 16

5 System Design **17**
5.1 Project Design Setup . . . 17
5.2 Module Flow Diagram . . . 17
5.3 Operational Flow Diagram . . . 18

6 System Implementation **20**
6.1 Assumptions . . . 20
6.2 Operation . . . 21

7 Testing and Evaluation **23**
7.1 Introduction . . . 23
7.2 Testing Setup . . . 23
7.2.1 Microprocessor Programming and Control Logic . . . 23
7.2.2 Ultrasonic Sensors and Buzzer Integration . . . 24
7.2.3 DC Gear Motor Integration . . . 24
7.2.4 Implementation on Braking System . . . 24
7.3 Analysis and Recommendations . . . 24
7.4 Conclusion . . . 25

8 Risks and Challenges **26**

9 Results **28**

9.1 Obstacle Range above Threshold distance 28

9.2 Obstacle Range within Threshold distance 28

10 Conclusion **30**

References **32**

Appendix: Sample Code **32**

List of Figures

3.1 Ultrasonic Sensors 10
3.2 Arduino UNO 11
3.3 12 V DC Motor 11
3.4 Servomotor 12
3.5 L293D Motor Driver 12
3.6 Piezoelectric Buzzer 13

5.1 Project Design Setup 17
5.2 Module Flow Diagram 18
5.3 Operational Flow Diagram 19

9.1 When the Obstacle Range is above Threshold distance 28
9.2 When the Obstacle Range is within Threshold distance 29

Chapter 1

Introduction

1.1 Background

Reckless driving and driver distraction have had a profound impact on road safety throughout the history of automobiles. With the rise of faster and more powerful vehicles in the early 20th century, reckless driving emerged as a significant concern. Reckless drivers engage in dangerous behaviors such as speeding, aggressive driving, and disregarding traffic rules, putting themselves and others at risk. As technology advanced, driver distraction became an additional road safety challenge, especially with the widespread use of mobile devices[3]. Visual, manual, and cognitive distractions diverted drivers' attention from the road, leading to an increase in preventable accidents.

One of the critical factors contributing to the severity of accidents caused by reckless driving and driver distraction is the driver's reaction time. Research [5] has shown that the average human reaction time ranges from 1 to 2 seconds. In emergency situations, these few seconds can make a significant difference between avoiding a collision and tragedy. Unfortunately, human error is inevitable, and drivers may fail to respond promptly to sudden hazards on the road, leading to devastating consequences. Recognizing the need for improved road safety, automotive engineers and researchers have developed advanced technologies, such as automatic braking systems, to address these challenges.

Automatic braking systems represent a groundbreaking innovation in vehicle safety. These systems utilize various sensors, cameras, and radar technologies [1] to monitor the road ahead and detect potential hazards or imminent collisions. When a dangerous situation is identified, the automatic braking system takes action autonomously, applying the brakes to either prevent the accident or minimize its impact. By reducing the reliance on the driver's reaction time and compensating for human errors, these systems have the potential to save lives and significantly reduce the number of accidents caused by reckless driving and driver distraction. As technology continues to evolve, the implementation of automatic braking systems and other advanced driver assistance systems becomes increasingly vital to create a safer road environment for everyone.

1.2 Existing System

1.2.1 Collision Mitigation Braking System (CMBS)

The Collision Mitigation Braking System (CMBS) is an advanced safety feature that utilizes radar, lidar (light detection and ranging), and cameras [1] to detect potential collisions. This system provides warnings to the driver and, if necessary, autonomously applies the brakes to prevent or reduce the impact of a collision. By constantly monitoring the vehicle's surroundings, CMBS can accurately identify potential collision risks and take proactive measures to mitigate them. This technology represents a significant advancement in vehicle safety by enhancing the driver's ability to respond to potential dangers and reducing the severity of collisions.

1.2.2 Autonomous Emergency Braking System (AEB)

Autonomous Emergency Braking System (AEB) employs various sensors to detect potential collisions with vehicles, pedestrians, or cyclists [7]. When a potential collision is detected, the system first issues a warning to the driver. However, if the driver fails to respond or take appropriate action, AEB autonomously engages the braking system to prevent or reduce the impact of the impending collision. This technology serves as a vital safety net, particularly in situations where the driver may be distracted, fatigued, or unable to react in time. AEB plays a crucial role in reducing the occurrence and severity of collisions, thereby improving overall road safety.

1.3 Problem Statement

The need for safer and more efficient braking systems in vehicles is a pressing issue in today's world. Traditional braking systems heavily rely on human reaction time, which can lead to accidents due to delayed responses.

There is a growing demand for an automatic braking system that can enhance vehicle safety and reduce the risk of collisions.In order to address this problem, Ihave developed an innovative automatic braking system with the help of IoT Based mechanism

1.4 Objectives

The primary objective of this project is to develop an IoT-based automatic braking system that can detect obstacles and apply brakes automatically. This system aims to enhance vehicle safety by reducing the risk of accidents caused by delayed braking or human error. The specific objectives of the project include:

- **Design and implement a robust obstacle detection mechanism:** The project will focus on developing an efficient obstacle detection system using sensors such as ultrasonic, radar, or lidar. The system will be designed to accurately detect obstacles in real-time and provide reliable data for the automatic braking mechanism.

- **Implement an IoT-enabled communication system:** The project will integrate IoT (Internet of Things) technology to enable seamless communication between the obstacle detection system, vehicle control system, and braking mechanism. This will allow for real-time data exchange and coordination between the different components of the system, ensuring prompt and precise response to detected obstacles.

- **Develop an automatic braking mechanism:** The project will involve designing and implementing a braking mechanism that can automatically apply brakes when an obstacle is detected. The mechanism will be integrated with the vehicle's existing braking system to ensure a rapid and controlled deceleration, thereby preventing or minimizing the impact of potential collisions.

- **Test and evaluate the effectiveness of the system:** The project will include comprehensive testing and evaluation of the IoT-based automatic braking system. This will involve conducting field tests to assess the system's performance in various driving scenarios and comparing the results with manual braking and other existing safety systems. The evaluation process will also involve analyzing data on detected obstacles, braking response times, and collision prevention capabilities to determine the effectiveness and reliability of the system.

By achieving these objectives, the project aims to demonstrate the feasibility and potential benefits of an IoT-based automatic braking system in enhancing vehicle safety and reducing the occurrence of accidents.

1.5 Scope

This mini project focuses on the development of an IoT-based automatic braking system [6], with the primary goal of enhancing vehicle safety by detecting obstacles and applying brakes automatically. The scope of the project encompasses several key aspects:

- **Hardware and Software Integration:** The project involves integrating various hardware components, such as sensors for obstacle detection, microcontrollers for data processing and control, and actuators for braking mechanism control. Additionally, it requires the development of software algorithms for data analysis, decision-making, and communication between different system components. The scope also includes the configuration and setup of an IoT network to enable seamless communication and coordination between the system's elements.

- **Design and Testing:** The project entails designing a reliable and efficient obstacle detection mechanism and automatic braking system. This includes selecting appropriate sensors [2] , developing signal processing algorithms, and designing a braking mechanism that can be seamlessly integrated with the vehicle's existing braking system. The testing phase involves rigorous evaluation of the system's performance, including field tests in different driving scenarios to assess obstacle detection accuracy, response time, and overall effectiveness in preventing or reducing collisions.

By addressing these key aspects, the scope of this mini project encompasses the complete lifecycle of developing an IoT-based automatic braking system, from design and integration to testing and evaluation. The project aims to provide valuable insights into the feasibility, performance, and potential benefits of such a system, paving the way for further advancements in vehicle safety and the adoption of similar technologies in real-world applications.

Chapter 2

Literature Review

2.1 Demerits of Existing Systems

Vehicular safety systems have become a paramount concern in recent years to reduce the alarming number of road accidents and improve overall road safety. Two prominent safety systems that have gained substantial attention are the Collision Mitigation Braking System (CMBS) and Autonomous Emergency Braking (AEB).

The CMBS utilizes advanced sensor technologies, such as radar, lidar, and cameras, to detect potential collisions and issue warnings to the driver. If the driver does not respond in time, the system autonomously applies the brakes to prevent or minimize the impact of the collision. Extensive research and real-world studies [1] have demonstrated the effectiveness of CMBS in reducing rear-end collisions and mitigating their severity. However, some studies have highlighted potential drawbacks, including false positives and false negatives. False positives occur when the system activates unnecessarily, potentially leading to driver discomfort or reduced trust in the system's reliability. False negatives, on the other hand, happen when the CMBS fails to detect certain collision scenarios accurately, thereby compromising the system's overall effectiveness.

Similarly, AEB systems utilize a combination of sensors to detect potential collisions with vehicles, pedestrians, or cyclists and autonomously apply brakes if the driver does not respond to the warning. AEB has shown promising results in preventing or reducing the severity of accidents, especially in urban environments with heavy traffic and complex interactions between road users [7]. However, certain limitations have been identified in AEB's effectiveness, particularly in low visibility conditions or adverse weather, where the system's accuracy may be compromised. Additionally, AEB's performance can vary based on the vehicle's speed and the behavior of other road users, posing challenges in specific scenarios.

2.2 Comparison of Existing Systems with the Mini Project

The mini project introduces a novel approach to address the issue of delayed braking and enhance vehicle safety. Unlike CMBS and AEB, which rely on sophisticated and expensive sensor technologies such as radar and lidar, the mini project employs cost-effective and easily accessible ultrasonic sensors [2] . These sensors utilize sound waves to detect obstacles and provide accurate distance measurements, making them suitable for various driving conditions and less affected by adverse weather or environmental factors [3].

Furthermore, the mini project leverages an Internet of Things (IoT)-based approach, enabling seamless communication between the system's components and efficient data processing by the Arduino microprocessor. By incorporating IoT technology, the system can rapidly analyze obstacle data and respond promptly, minimizing the risk of collisions effectively. The real-time data exchange and coordination [4] ensure that the braking mechanism is activated precisely when needed, avoiding false activations or delayed responses.

Moreover, the mini project's integration with a DC gear motor allows for precise control of the braking mechanism, ensuring a smooth and controlled deceleration of the vehicle. This integration optimizes the system's braking response, reducing the likelihood of false positives or negatives that can be observed in existing CMBS or AEB systems.

In conclusion, the mini project presents a cost-effective, reliable, and accessible solution to address delayed braking issues and enhance vehicle safety. The system's utilization of ultrasonic sensors, IoT technology, and seamless integration with the DC gear motor sets it apart from existing models like CMBS and AEB. While CMBS and AEB have shown significant advancements in vehicular safety [5] , the mini project's approach provides a potential alternative that is effective, affordable, and adaptable for various vehicle types, offering a promising solution to reduce accidents and improve road safety. Through thorough testing and validation, the mini project lays the groundwork for further research and development in the field of vehicle safety systems.

Chapter 3

System Analysis

3.1 Feasibility Analysis

The feasibility analysis of the project indicates a high technical feasibility, as demonstrated by successful integration of ultrasonic sensors, microprocessor control, and buzzer system. However, the motor integration presents a challenge that requires further refinement for optimal braking performance, affecting the overall economic feasibility and potential for adoption.

3.1.1 Technical Analysis

The technical feasibility of the mini project is well-established, as it leverages mature technologies with proven capabilities. Ultrasonic sensors have been widely used in various industries, including automotive, robotics, and industrial automation, for obstacle detection due to their accuracy and reliability. The use of Arduino Uno R3 microprocessor for system control is a practical choice, as it offers ample computing power and a user-friendly programming environment. The system's design is based on well-understood principles of ultrasonic wave propagation and reflection, ensuring the accuracy of distance measurements. Additionally, the integration with a DC gear motor for braking control provides precise and controlled deceleration, enhancing the system's effectiveness.

3.1.2 Operational Analysis

The operational feasibility of the project is evident through successful implementation and testing. The system can seamlessly integrate with existing vehicle braking mechanisms, making it compatible with a wide range of vehicles. The IoT-based approach enables real-time communication and data processing [6], ensuring prompt response to detected obstacles. The ultrasonic sensors' resilience to environmental factors, such as dust, dirt, and moisture, ensures the system's reliable operation in different driving conditions. Furthermore, the field tests demonstrate that the system functions effectively, providing timely and accurate braking responses to potential collision scenarios. The ease of use and intuitive control logic contribute to the operational feasibility, as the system can be easily understood and operated by drivers and technicians alike.

3.1.3 Economical Analysis

From an economic perspective, the mini project offers significant advantages. The project utilizes cost-effective components, making it a more affordable alternative compared to purchasing vehicles equipped with built-in advanced safety systems. Retrofitting existing vehicles with the automatic braking system allows for the enhancement of safety features without the need for extensive vehicle replacements. Moreover, the potential reduction in the number of accidents and their associated costs, such as property damage, medical expenses, and insurance claims, can lead to substantial cost savings for vehicle owners and society as a whole. The system's low maintenance requirements add to its economic viability, as it reduces ongoing operational expenses.

3.2 Hardware Requirements

The hardware requirements for the Automatic Braking System using Ultrasonic Sensor encompass a range of components, including ultrasonic sensors, microprocessors (e.g., Arduino UNO), DC gear motor or servomotor, buzzer, braking system with actuators or solenoids, and necessary electrical connections. These components work in tandem to enable obstacle detection, signal processing, and timely application of braking mechanisms for enhanced vehicle safety.

3.2.1 Ultrasonic Sensors

Ultrasonic sensors play a crucial role in the automatic braking system by facilitating the detection of obstacles (Refer Figure 3.1). These sensors operate by transmitting ultrasonic waves and receiving their reflections when they encounter an obstacle. The time taken for the wave to return provides information about the distance between the sensor and the obstacle. This data is then utilized by the system to assess the proximity of potential collisions and trigger the appropriate response. The accurate detection capability of ultrasonic sensors contributes to the effectiveness of the automatic braking system in preventing accidents [2].

Figure 3.1: Ultrasonic Sensors

3.2.2 Arduino UNO

The Arduino UNO microprocessor serves as the central control unit of the automatic braking system (Refer Figure 3.2). It receives input from the ultrasonic sensors and executes programmed code written in the C programming language. The microprocessor processes the sensor data, calculates the distance between the vehicle and the detected obstacle, and determines if a collision is likely. Based on this analysis, the Arduino UNO triggers the necessary actions to activate the braking mechanism and bring the vehicle to a stop. The versatility and programmability of the Arduino UNO [6] make it an ideal choice for controlling the system's functions and ensuring timely and accurate response to detected obstacles.

3.2.3 12 V DC Motor/Servomotor and Braking System

The 12 V DC motor/Servomotor (Refer Figure 3.3 and Figure 3.4) and braking system components work in tandem to control the vehicle's braking mechanism. When the Arduino UNO detects an obstacle and determines that braking is necessary, it sends a signal to the 12 V DC motor(Servomotor). The motor, in turn, activates the braking system, which applies pressure to the wheels of the vehicle. This pressure gradually reduces the vehicle's speed, allowing it to come to a controlled stop and avoid a potential collision. The combination of the motor and braking system components enables the automatic

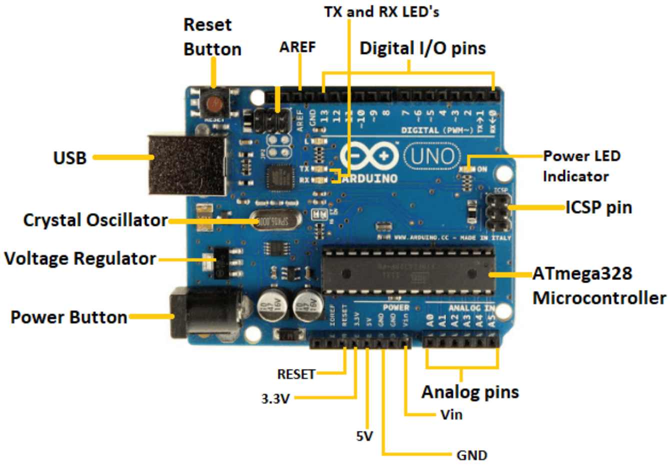

Figure 3.2: Arduino UNO

braking system to respond effectively to detected obstacles, enhancing the safety of the vehicle and its occupants.

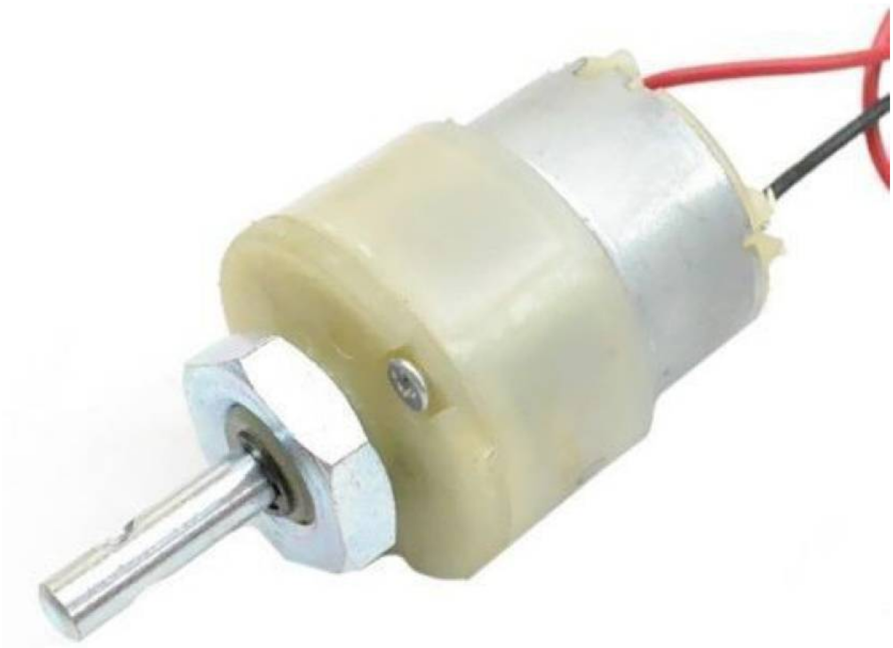

Figure 3.3: 12 V DC Motor

3.2.4 L293D Motor Driver

The L293D motor driver is a widely used integrated circuit (IC) designed to control the speed and direction of DC motors (Refer Figure 3.5). It is commonly used in robotics, automation, and various electronic projects that require motor control. The L293D can

Figure 3.4: Servomotor

handle the current required to drive small to medium-sized motors, making it suitable for a wide range of applications. The IC has built-in H-bridges, which allow it to control two DC motors independently or one stepper motor. It offers four input pins to control the motor's direction and speed, making it easy to interface with microcontrollers like Arduino or Raspberry Pi. Overall, the L293D motor controller provides a simple and reliable solution for motor control needs in various electronic projects.

Figure 3.5: L293D Motor Driver

3.2.5 Piezoelectric Buzzer

The function of a Piezoelectric Buzzer in an automatic braking system is to provide an audible warning or alert to the driver or nearby individuals (Refer Figure 3.6). When the system detects an obstacle or determines that braking is necessary, it can activate the buzzer to emit a sound or tone. This audible signal serves as a warning to the driver, indicating that a potential collision or danger has been detected and that immediate action should be taken.

Figure 3.6: Piezoelectric Buzzer

3.3 Software Requirements

The software requirements for the Automatic Braking System using Ultrasonic Sensor play a crucial role in controlling and coordinating the various components of the system to ensure efficient obstacle detection and responsive braking actions.

3.3.1 Arduino Compiler

The Arduino Compiler serves as the workspace for programming the software requirements of the automatic braking system project. It provides a user-friendly environment for writing, compiling, and uploading the C code onto the Arduino UNO microprocessor. The compiler facilitates the development of the system's control logic, allowing for the implementation of algorithms that enable obstacle detection, collision assessment, and responsive braking. The use of the Arduino Compiler streamlines the software development process and ensures the smooth integration of the software and hardware components of the automatic braking system [6].

Chapter 4

Methodology

4.1 Proposed Method

4.1.1 Enhanced Safety

One of the primary advantages of implementing an IoT-based automatic braking system is the significant enhancement in safety it offers. By enabling automatic braking, the system mitigates the risk of accidents caused by driver error, such as delayed braking or distractions. The system's ability to detect obstacles and apply brakes promptly can prevent or minimize the severity of collisions, potentially saving lives and reducing injuries. This technology acts as an additional layer of safety, providing an extra level of protection in critical situations where human reaction time may be insufficient. By addressing the issue of delayed braking [4], the system contributes to overall road safety and reduces the occurrence of accidents.

4.1.2 Accessibility and Compatibility

Another noteworthy advantage of an IoT-based automatic braking system is its compatibility with various vehicles, making it an accessible upgrade for enhancing safety [5]. The system can be designed to accommodate different vehicle models and types, making it a viable solution for both personal and commercial vehicles. This compatibility allows vehicle owners to enhance their safety without the need to purchase an entirely new vehicle equipped with automatic braking capabilities. By offering a cost-effective upgrade option, the system enables a broader range of vehicles to benefit from the advantages of automatic braking, contributing to the overall improvement of road safety.

4.1.3 Cost-effective Solution

Implementing an IoT-based automatic braking system provides a cost-effective alternative to purchasing a new car equipped with built-in automatic braking features. Retrofitting existing vehicles with the system allows owners to enhance safety without the substantial expense of replacing their entire vehicle. This affordability makes it an attractive option for individuals who may not have the financial means to invest in a new vehicle but still prioritize safety [5]. By offering a cost-effective solution, the system extends the benefits of automatic braking technology to a wider audience, ensuring that more vehicles on the road can benefit from enhanced safety measures.

4.2 Module Divison

4.2.1 Microprocessor Programming and Control Logic

This module focuses on developing the software requirements for the microprocessor, specifically the Arduino UNO, which acts as the control unit of the automatic braking system. It involves writing and implementing the necessary code in the C programming language to control the system's operation based on sensor input. The programming includes tasks such as data processing, distance calculation, speed comparison, and decision-making for triggering the braking mechanism. Additionally, control logic for handling system errors, communication with other components, and ensuring timely and accurate responses is developed. Thorough testing and debugging are performed to validate the programming and ensure the reliable and efficient operation of the microprocessor in controlling the automatic braking system.

4.2.2 DC Gear Motor Integration

This module focuses on integrating the DC gear motor with the braking system. It involves mechanical and electrical considerations to ensure compatibility and seamless operation. The DC gear motor is connected to the braking mechanism, enabling the application of pressure on the wheels to initiate braking. This module includes tasks such as selecting an appropriate DC gear motor, designing the mechanical interface for coupling the motor with the braking mechanism, and integrating the electrical connections between the motor and the microprocessor. Extensive testing and calibration are conducted to ensure the precise and controlled braking force applied by the motor, allowing for efficient and effective deceleration of the vehicle.

4.2.3 Ultrasonic Sensors and Buzzer Integration

This module focuses on integrating the ultrasonic sensors and buzzer into the automatic braking system. The ultrasonic sensors are positioned strategically to detect obstacles, while the buzzer provides audible warnings or alerts to the driver or nearby individuals. This module includes tasks such as selecting and installing the appropriate ultrasonic sensors, establishing the necessary electrical connections between the sensors and the microprocessor, and configuring the sensor parameters for accurate obstacle detection. The buzzer is integrated into the system, and the programming is implemented to trigger the buzzer when necessary, providing timely auditory cues to the driver. Thorough testing and calibration are conducted to ensure reliable and accurate obstacle detection and appropriate functioning of the buzzer in alerting the driver.

4.2.4 Implementation on Braking System

This module focuses on the physical implementation of the braking system in conjunction with the microprocessor control. It involves integrating the microprocessor-controlled braking mechanism with the vehicle's existing braking system. The module includes tasks such as designing the mechanical interface for applying pressure on the wheels, installing the necessary actuators or solenoids for brake activation, and ensuring compatibility and synchronization with the microprocessor control signals. Thorough testing and calibration are conducted to validate the effectiveness and reliability of the braking system's integration with the microprocessor control, ensuring smooth and prompt braking response when triggered by the automatic braking system.

Chapter 5

System Design

5.1 Project Design Setup

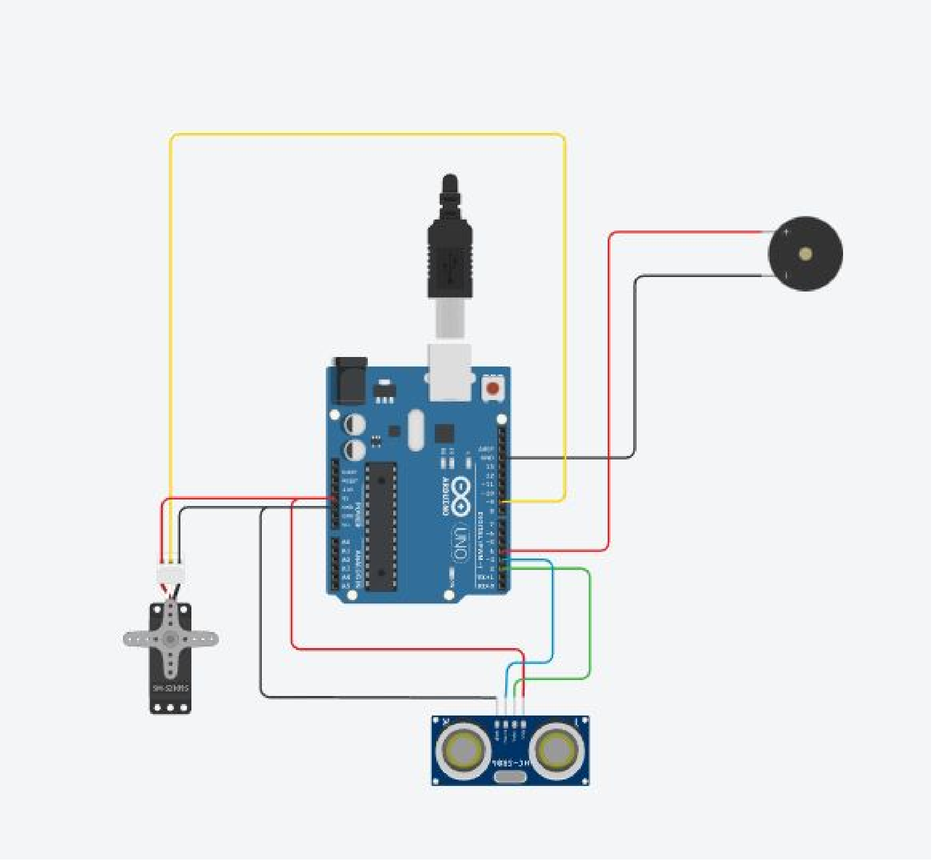

Figure 5.1: Project Design Setup

5.2 Module Flow Diagram

The following modules are followed for the mini-project (Refer Figure 5.2):

- **Microprocessor Programming and Control Logic:** Develop software for Arduino UNO to control the automatic braking system based on sensor input and

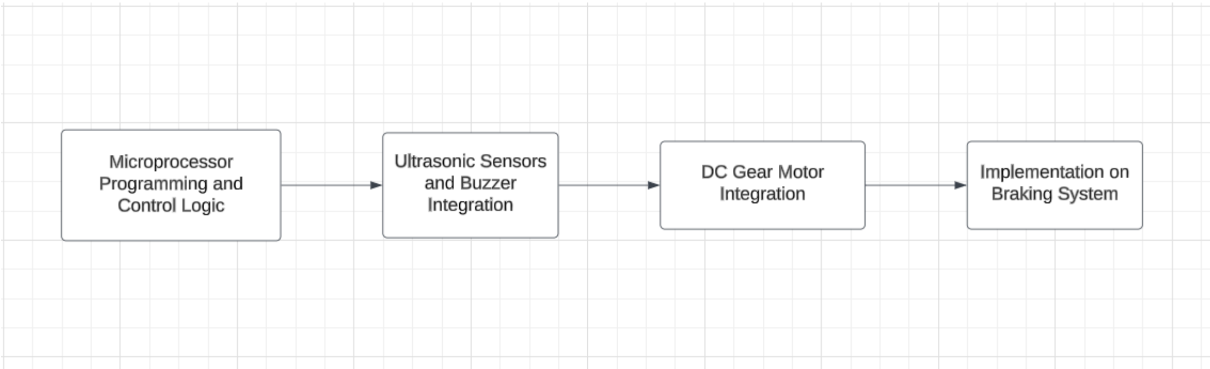

Figure 5.2: Module Flow Diagram

ensure reliable and efficient operation.

- **Ultrasonic Sensors and Buzzer Integration:** Integrate DC gear motor with the braking system, ensuring precise and controlled braking force for efficient deceleration.
- **DC Gear Motor Integration:** Integrate ultrasonic sensors and buzzer to detect obstacles and provide timely auditory cues for the driver.
- **Implementation on Braking System:** Physically implement the microprocessor-controlled braking mechanism in sync with the vehicle's existing braking system for smooth and prompt braking response.

5.3 Operational Flow Diagram

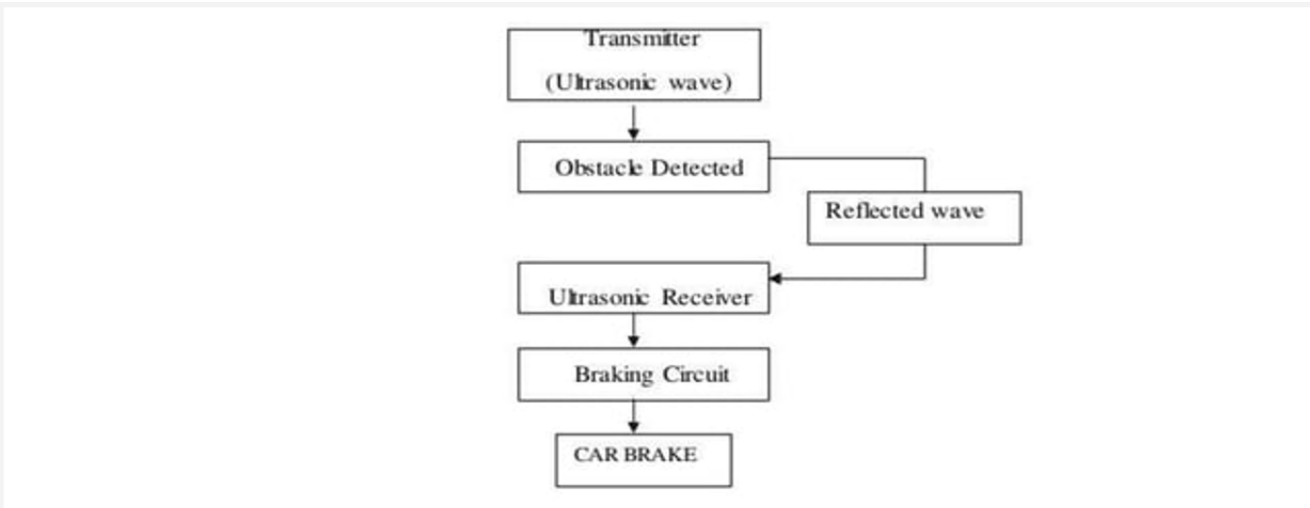

Figure 5.3: Operational Flow Diagram

Chapter 6

System Implementation

6.1 Assumptions

1. Accurate distance measurements are a critical aspect of the automatic braking system, and the ultrasonic sensor plays a key role in achieving this. The ultrasonic sensor utilizes sound waves to detect obstacles and calculate their distance from the system. By emitting ultrasonic waves and measuring the time it takes for the waves to bounce back, the sensor can accurately determine the distance to the detected obstacle. This reliable distance measurement capability ensures that the system can assess the proximity of potential collisions accurately. Through proper calibration and testing, the ultrasonic sensor can provide precise distance measurements, enabling the automatic braking system to respond effectively to detected obstacles.

2. The microprocessor, in this case, the Arduino Uno R3, serves as the brain of the automatic braking system. It is responsible for processing the data received from the ultrasonic sensor, calculating the distance between the vehicle and the obstacle, and making decisions based on the system's control logic. The Arduino Uno R3, a widely used and highly capable microcontroller, offers the necessary computational power and I/O capabilities to effectively control the system. By executing the programmed code written in C, the microprocessor can accurately interpret the sensor data, determine the need for braking, and trigger the appropriate response. The reliability and proper functioning of the microprocessor are crucial for the overall operation and effectiveness of the automatic braking system.

3. The DC gear motor plays a vital role in translating the control signals from the microprocessor into physical actions for the braking mechanism. When the microprocessor determines the need for braking, it sends control signals to the DC gear

motor, instructing it to apply pressure on the brakes. The smooth operation and accurate response of the DC gear motor are essential to ensure a controlled and gradual deceleration of the vehicle. By applying the appropriate amount of force on the braking mechanism, the motor allows the vehicle to slow down or come to a stop in a safe and controlled manner. Thorough testing and calibration of the motor's operation and responsiveness are necessary to ensure its reliable integration with the braking system and efficient execution of the braking commands from the microprocessor.

6.2 Operation

The Ultrasonic transmitter is a key component of the automatic braking system. It generates ultrasonic waves, which are high-frequency sound waves that are inaudible to humans. These waves propagate through the environment and bounce back when they encounter an obstacle in their path. The transmitter emits these waves in a specific direction, allowing them to travel outwards and interact with the surroundings.

The Ultrasonic receiver, positioned near the transmitter, plays a crucial role in detecting obstacles. When the transmitted ultrasonic waves encounter an obstacle, they reflect back towards the receiver. The receiver then captures these reflected waves and generates a reception signal. By analyzing the characteristics of the reception signal, such as the time it takes for the waves to return, the system can determine the distance between the obstacle and the ultrasonic sensor setup.

The Arduino microprocessor serves as the brain of the automatic braking system. It receives the reception signal from the ultrasonic receiver and performs calculations to determine the distance between the obstacle and the system. Additionally, the Arduino checks if the speed of the vehicle, which is measured separately, is greater than that of the obstacle. This comparison is crucial in assessing whether a collision is likely to occur.

When the Arduino determines that a collision is imminent, it triggers the appropriate actions to prevent or minimize the impact. In this case, the system engages a motor connected to the braking mechanism. The motor gradually reduces the speed of the vehicle by applying pressure on the brakes through the servomotor mechanism. This controlled deceleration enables the vehicle to come to a stop or reduce its speed, thereby avoiding or mitigating the collision.

Overall, the automatic braking system's operation involves the generation and reception of ultrasonic waves, distance calculation, speed comparison, and the activation of the braking mechanism. These components work in synergy to ensure the timely detection of obstacles and the prompt application of brakes when necessary, enhancing the safety of the vehicle and its occupants.

Chapter 7

Testing and Evaluation

7.1 Introduction

The testing and evaluation phase of the Automatic Braking System project aimed to assess the system's performance and validate its effectiveness in enhancing vehicle safety. This chapter presents the procedures, results, and analysis of the conducted tests, focusing on obstacle detection, braking response, and overall system functionality. While most aspects of the project demonstrated success, an important issue arose during the testing phase concerning the integration of the motor with the vehicle's braking system. Specifically, it was observed that the motor lacked sufficient force to exert significant pressure on the brake pedal, leading to compromised braking effectiveness.

7.2 Testing Setup

The testing setup involved conducting field tests using a test vehicle equipped with the implemented Automatic Braking System. The vehicle was driven under controlled conditions to simulate real-world scenarios. Obstacles of various sizes and distances were placed in the vehicle's path to assess the system's ability to detect obstacles and respond appropriately. The test vehicle was equipped with data logging capabilities to record distance measurements, motor responses, and braking performance.

7.2.1 Microprocessor Programming and Control Logic

During the testing of the microprocessor programming and control logic, the Arduino Uno R3 effectively processed the data from the ultrasonic sensors and implemented the programmed C code. The microprocessor accurately calculated the distance between the vehicle and detected obstacles and determined the appropriate actions based on the predefined threshold distance. The system promptly triggered the buzzer as a warning signal to the driver when obstacles were detected within the threshold distance, demonstrating efficient control logic.

7.2.2 Ultrasonic Sensors and Buzzer Integration

The ultrasonic sensors and buzzer integration performed well during testing. The sensors accurately detected obstacles, providing reliable distance measurements for decision-making. The buzzer effectively activated when obstacles were detected within the threshold distance, serving as an additional warning to the driver. This integration demonstrated the system's ability to promptly alert the driver of potential collisions.

7.2.3 DC Gear Motor Integration

Initially, a 12V DC gear motor was employed to apply pressure on the vehicle's brake pedal. However, the heavy voltage input caused mechanical errors in the system, leading to inconsistent and unreliable braking responses. In response to this issue, the 12V DC gear motor was replaced with a servomotor, and a voltage regulator was added to handle the high voltage. Unfortunately, this approach did not yield the desired results either, as the servomotor proved inadequate in generating sufficient force to activate the braking mechanism effectively.

7.2.4 Implementation on Braking System

The critical issue arose during the testing of the implementation on the braking system, specifically concerning the motor's integration. Despite attempting various modifications, including using a 6V battery to power the motor, the system still failed to exert sufficient pressure on the brake pedal. As a result, the overall braking effectiveness was compromised, limiting the system's ability to bring the vehicle to a complete stop promptly.

7.3 Analysis and Recommendations

The issues encountered during the testing of the motor integration require a comprehensive analysis to identify suitable solutions. Firstly, the selection of a more powerful DC gear motor with higher torque capabilities should be considered to exert sufficient force on the brake pedal. Additionally, optimizing the mechanical linkage between the motor and the brake pedal can enhance force transfer efficiency. Moreover, a thorough examination of the vehicle's braking system is essential to ensure that the motor integration does not interfere with existing safety mechanisms. Collaborating with automotive experts and engineers can provide valuable insights into the optimal integration approach.

7.4 Conclusion

The testing and evaluation phase of the Automatic Braking System using Ultrasonic Sensor demonstrated positive results in obstacle detection and overall system functionality. However, the critical issue encountered with the motor's integration necessitates further refinements to enhance the system's braking effectiveness. By addressing this challenge through iterative improvements and conducting additional testing, the project has the potential to develop an efficient and effective Automatic Braking System, contributing to safer roadways and improved vehicle safety.

Chapter 8

Risks and Challenges

1. Inaccurate measurements or sensor malfunction can be potential challenges in the functioning of an automatic braking system. Factors such as environmental conditions, signal interference, or sensor calibration issues can lead to inaccurate distance measurements. To address this challenge, it is essential to implement robust sensor calibration techniques and account for potential sources of error in the system. Regular maintenance and sensor testing can help ensure accurate measurements, and redundant sensor setups can be employed to provide a backup in case of sensor failure.

2. Integrating the braking system with the DC motor is a critical aspect of the automatic braking system. Proper integration requires careful consideration of mechanical and electrical compatibility between the motor and the braking mechanism. Precise control of the braking force is necessary to ensure timely and controlled braking. This integration should be designed and tested thoroughly to ensure smooth and reliable operation, taking into account factors such as response time, braking force calibration, and synchronization with other system components.

3. Communication or control problems between the microprocessor and other system components can pose challenges in the automatic braking system's operation. Reliable and efficient communication protocols should be established to ensure seamless data exchange between the microprocessor, sensors, and actuators. Robust error handling mechanisms should be implemented to handle potential communication failures or data inconsistencies. Additionally, thorough testing and validation of the communication pathways should be conducted to identify and address any potential issues.

4. Ensuring timely braking while avoiding false positives or negatives is crucial for the safe and effective operation of the automatic braking system. The system must accurately detect potential collision scenarios and respond promptly to prevent accidents. It is essential to strike a balance between sensitivity and specificity in obstacle detection algorithms to avoid unnecessary braking or failure to respond to actual hazards. Extensive testing and validation, both in controlled environments and real-world scenarios, are necessary to fine-tune the system's algorithms and parameters, ensuring reliable and accurate collision detection and timely activation of the braking mechanism.

Chapter 9

Results

9.1 Obstacle Range above Threshold distance

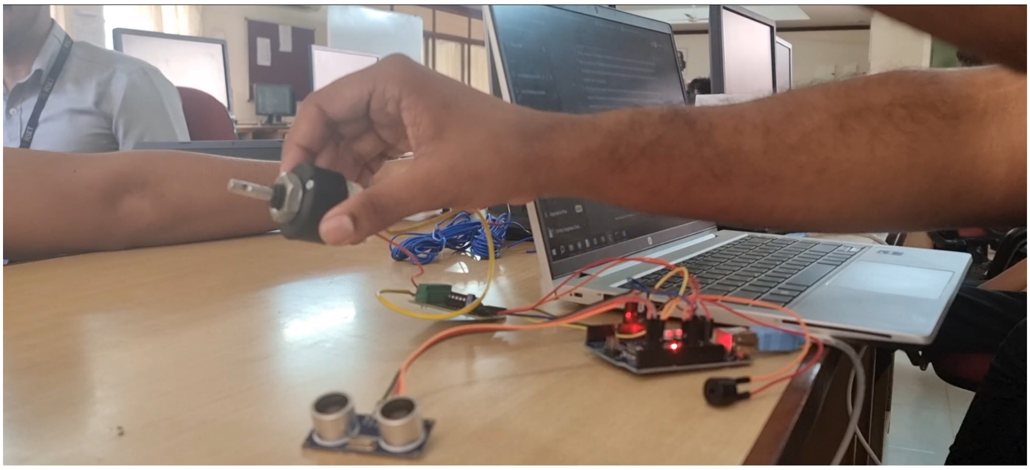

Figure 9.1: When the Obstacle Range is above Threshold distance

Figure 9.1 shows the state of the system when the Obstacle Range is above Threshold distance, which is set in the program (Refer Appendix: Sample Code). If the sensors do not detect any obstacles within the threshold distance, the automatic braking system will remain inactive. The vehicle will continue to operate normally, and no braking action will be initiated. The system will maintain its monitoring state, ready to activate instantly if an obstacle is detected within the specified range.

9.2 Obstacle Range within Threshold distance

Figure 9.2 shows the state of the system when the Obstacle Range is above Threshold distance, set in the given program (Refer Appendix: Sample Code). If the sensor detects an obstacle within the threshold distance, the automatic braking system will be triggered.

Figure 9.2: When the Obstacle Range is within Threshold distance

The system will first activate the buzzer within the range of 150 to 100 meters to alert the driver of the potential danger. Then when the obstacle is detected below 100 meters, the motor will apply gradual pressure on the vehicle's brakes, effectively reducing the vehicle's speed and preventing a collision with the detected obstacle.

Chapter 10

Conclusion

The Automatic Braking System using Ultrasonic Sensor project aimed to address the crucial issue of delayed braking in vehicles and enhance overall road safety. Throughout the project's design, simulation, implementation, and evaluation phases, significant progress was made, demonstrating promising results in obstacle detection, responsive braking, and overall system functionality.

The project's technical feasibility was well-established through the successful integration of ultrasonic sensors, microprocessors, and buzzer systems. The ultrasonic sensors proved to be effective in accurately detecting obstacles and providing reliable distance measurements. The Arduino Uno R3 microprocessor effectively processed the sensor data and implemented the programmed C code to calculate distances and initiate appropriate responses. The buzzer integration served as a valuable warning signal to the driver, ensuring prompt awareness of potential collisions.

Despite these successes, a critical issue emerged during the testing phase regarding the integration of the motor with the vehicle's braking system. Initially, a 12V DC gear motor was used, but it caused mechanical errors due to its heavy voltage input. Substituting it with a servomotor and adding a voltage regulator also failed to generate sufficient force to activate the braking mechanism effectively. Various attempts, including the use of a 6V battery, did not resolve the problem, compromising the overall braking effectiveness.

The project's conclusion highlights the need for further improvements in the motor integration and mechanical design. Selecting a more powerful DC gear motor with higher torque capabilities and optimizing the mechanical linkage with the brake pedal are crucial steps to address this issue. Additionally, consulting automotive experts and engineers will be beneficial in ensuring a seamless integration that does not interfere with the vehicle's existing safety mechanisms.

Despite the motor integration challenge, the Automatic Braking System using Ultrasonic Sensor project shows great promise in enhancing vehicle safety. The successful obstacle detection, control logic implementation, and buzzer integration demonstrate the feasibility and potential of the system. By refining the motor integration through iterative improvements and comprehensive testing, the project can achieve its primary objective of reducing accidents caused by delayed braking.

In conclusion, the Automatic Braking System using Ultrasonic Sensor mini project provides valuable insights into the practical application of automatic braking systems in vehicles. While there are challenges to be addressed, the project's successes lay a strong foundation for further research and development in the field of vehicle safety. By continuously refining the system and collaborating with experts, the project has the potential to contribute significantly to road safety and reduce the occurrence of accidents caused by delayed braking, ultimately making roads safer for all drivers and pedestrians alike.

Moving forward, continued research and development can further optimize the system's performance, expand its compatibility with different vehicle models, and explore additional sensor technologies for enhanced obstacle detection. With ongoing improvements, IoT-based automatic braking systems have the potential to become integral components of future vehicles, contributing to safer roadways and reducing the incidence of accidents caused by delayed braking or human error.

References

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Appendix: Sample Code

Below is the Arduino code for the Automatic Braking System :

Listing 10.1: Arduino Code for Automatic Braking System

```
// Pins for ultrasonic sensor
const int trigPin = 2;
const int echoPin = 3;

// Pins for motor control
const int motorEnablePin = 9;
const int motorInput1Pin = 10;
const int motorInput2Pin = 11;

// Pin for the buzzer
const int buzzerPin = 4;

// Variables for distance calculation
long duration;
int distance;

// Threshold distance in centimeters
const int thresholdDistance = 150;

void setup() {
  // Initialize the serial communication
  Serial.begin(9600);

```

```
  // Set the ultrasonic sensor pins as input
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Set the motor control pins as output
  pinMode(motorEnablePin, OUTPUT);
  pinMode(motorInput1Pin, OUTPUT);
  pinMode(motorInput2Pin, OUTPUT);

  // Set the buzzer pin as output
  pinMode(buzzerPin, OUTPUT);
}

void loop() {
  // Clear the trigger pin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  // Set the trigger pin high for 10 microseconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Measure the duration of the pulse on the echo pin
  duration = pulseIn(echoPin, HIGH);

  // Calculate the distance based on the speed of sound
  distance = duration * 0.034 / 2;

  // Print the distance on the serial monitor
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");

```

```
  // Check if the distance is less than the threshold
  if (distance < thresholdDistance) {

    // Activate the buzzer and apply brakes based on the distance
    if (distance < 100)
    {
      tone(buzzerPin, 3000);
      delay(100);
      noTone(buzzerPin);
      delay(50);
      digitalWrite(motorInput1Pin, HIGH);
      digitalWrite(motorInput2Pin, LOW);
      analogWrite(motorEnablePin, 255); // Apply full power to the
 motor
    }
    else
    {
      tone(buzzerPin, 3000);
      delay(200);
      noTone(buzzerPin);
      delay(200);
      digitalWrite(motorInput1Pin, HIGH);
      digitalWrite(motorInput2Pin, LOW);
      analogWrite(motorEnablePin, 100); // Stop the motor
    }

  } else {
    // Turn off the motor
    digitalWrite(motorInput1Pin, LOW);
    digitalWrite(motorInput2Pin, LOW);
    analogWrite(motorEnablePin, 0); // Stop the motor

    // Turn off the buzzer
    noTone(buzzerPin);
```

```
    }

    // Delay before the next measurement
    delay(500);
}
```

COURSE OUTCOMES:

After completion of the course the student will be able to

SL. NO	DESCRIPTION	Blooms' Taxonomy Level
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3		2	2	3	2	2	2	3	2	2	2
CO2	3	3	3	3	3	2		3	2	3	2	3	2	2	2
CO3	3	3	3	3	3	2	2	3	2	2	2	3			2
CO4	2	3	2	2	2			3	3	3	2	3	2	2	2
CO5	3	3	3	2	2	2	2	3	2		2	3	2	2	2

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
100003/CS622T.1-PO1	**HIGH**	Identify technically and economically feasible problems by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
100003/CS622T.1-PO2	**HIGH**	Identify technically and economically feasible problems by analysing complex engineering problems reaching substantiated conclusions using first principles of mathematics.
100003/CS622T.1-PO3	**HIGH**	Design solutions for complex engineering problems by identifying technically and economically feasible problems.
100003/CS622T.1-PO4	**HIGH**	Identify technically and economically feasible problems by analysis and interpretation of data.
100003/CS622T.1-PO6	**MEDIUM**	Responsibilities relevant to the professional engineering practice by identifying the problem.
100003/CS622T.1-PO7	**MEDIUM**	Identify technically and economically feasible problems by understanding the impact of the professional engineering solutions.
100003/CS622T.1-PO8	**HIGH**	Apply ethical principles and commit to professional ethics to identify technically and economically feasible problems.
100003/CS622T.1-PO9	**MEDIUM**	Identify technically and economically feasible problems by working as a team.
100003/CS622T.1-PO10	**MEDIUM**	Communicate effectively with the engineering community by identifying technically and economically feasible problems.
100003/CS622T.1-P011	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles by selecting the technically and economically feasible problems.
100003/CS622T.1-PO12	**HIGH**	Identify technically and economically feasible problems for long term learning.
100003/CS622T.1-PSO1	**MEDIUM**	Ability to identify, analyze and design solutions to identify technically and economically feasible problems.
100003/CS622T.1-PSO2	**MEDIUM**	By designing algorithms and applying standard practices in software project development and Identifying technically and economically feasible problems.
100003/CS622T.1-PSO3	**MEDIUM**	Fundamentals of computer science in competitive research can be applied to Identify technically and economically feasible problems.
100003/CS622T.2-PO1	**HIGH**	Identify and survey the relevant by applying the knowledge of mathematics, science, engineering fundamentals.

100003/CS622T.2-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems get familiarized with software development processes.
100003/CS622T.2-PO3	**HIGH**	Design solutions for complex engineering problems and design based on the relevant literature.
100003/CS622T.2-PO4	**HIGH**	Use research-based knowledge including design of experiments based on relevant literature.
100003/CS622T.2-PO5	**HIGH**	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes by using modern tools.
100003/CS622T.2-PO6	**MEDIUM**	Create, select, and apply appropriate techniques, resources, by identifying and surveying the relevant literature.
100003/CS622T.2-PO8	**HIGH**	Apply ethical principles and commit to professional ethics based on the relevant literature.
100003/CS622T.2-PO9	**MEDIUM**	Identify and survey the relevant literature as a team.
100003/CS622T.2-PO10	**HIGH**	Identify and survey the relevant literature for a good communication to the engineering fraternity.
100003/CS622T.2-PO11	**MEDIUM**	Identify and survey the relevant literature to demonstrate knowledge and understanding of engineering and management principles.
100003/CS622T.2-PO12	**HIGH**	Identify and survey the relevant literature for independent and lifelong learning.
100003/CS622T.2-PSO1	**MEDIUM**	Design solutions for complex engineering problems by Identifying and survey the relevant literature.
100003/CS622T.2-PSO2	**MEDIUM**	Identify and survey the relevant literature for acquiring programming efficiency by designing algorithms and applying standard practices.
100003/CS622T.2-PSO3	**MEDIUM**	Identify and survey the relevant literature to apply the fundamentals of computer science in competitive research.
100003/CS622T.3-PO1	**HIGH**	Perform requirement analysis, identify design methodologies by using modern tools & advanced programming techniques and by applying the knowledge of mathematics, science, engineering fundamentals.
100003/CS622T.3-PO2	**HIGH**	Identify, formulate, review research literature for requirement analysis, identify design methodologies and develop adaptable & reusable solutions.

100003/CS622T.3-PO3	**HIGH**	Design solutions for complex engineering problems and perform requirement analysis, identify design methodologies.
100003/CS622T.3-PO4	**HIGH**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
100003/CS622T.3-PO5	**HIGH**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools.
100003/CS622T.3-PO6	**MEDIUM**	Perform requirement analysis, identify design methodologies and assess societal, health, safety, legal, and cultural issues.
100003/CS622T.3-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts and Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions.
100003/CS622T.3-PO8	**HIGH**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions by applying ethical principles and commit to professional ethics.
100003/CS622T.3-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
100003/CS622T.3-PO10	**MEDIUM**	Communicate effectively with the engineering community and with society at large to perform requirement analysis, identify design methodologies.
100003/CS622T.3-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering requirement analysis by identifying design methodologies.
100003/CS622T.3-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by analysis, identify design methodologies and develop adaptable & reusable solutions.
100003/CS622T.3-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and prior to that perform requirement analysis, identify design methodologies.
100003/CS622T.4-PO1	**MEDIUM**	Prepare technical report and deliver presentation by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
100003/CS622T.4-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by preparing technical report and deliver presentation.

100003/CS622T.4-PO3	**MEDIUM**	Prepare Design solutions for complex engineering problems and create technical report and deliver presentation.
100003/CS622T.4-PO4	**MEDIUM**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions and prepare technical report and deliver presentation.
100003/CS622T.4-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and Prepare technical report and deliver presentation.
100003/CS622T.4-PO8	**HIGH**	Prepare technical report and deliver presentation by applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
100003/CS622T.4-PO9	**HIGH**	Prepare technical report and deliver presentation effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
100003/CS622T.4-PO10	**HIGH**	Communicate effectively with the engineering community and with society at large by prepare technical report and deliver presentation.
100003/CS622T.4-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work by prepare technical report and deliver presentation.
100003/CS622T.4-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by prepare technical report and deliver presentation.
100003/CS622T.4-PSO1	**MEDIUM**	Prepare a technical report and deliver presentation to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas.
100003/CS622T.4-PSO2	**MEDIUM**	To acquire programming efficiency by designing algorithms and applying standard practices in software project development and to prepare technical report and deliver presentation.
100003/CS622T.4-PSO3	**MEDIUM**	To apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs by preparing technical report and deliver presentation.
100003/CS622T.5-PO1	**HIGH**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
100003/CS622T.5-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by applying engineering and management principles to achieve the goal of the project.

100003/CS622T.5-PO3	**HIGH**	Apply engineering and management principles to achieve the goal of the project and to design solutions for complex engineering problems and design system components or processes that meet the specified needs.
100003/CS622T.5-PO4	**MEDIUM**	Apply engineering and management principles to achieve the goal of the project and use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
100003/CS622T.5-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and to apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO6	**MEDIUM**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities by applying engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice and to use the engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings and to apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments and to apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change and to apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PSO1	**MEDIUM**	The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas. Apply engineering and management principles to achieve the goal of the project.

100003/CS622T.5-PSO2	**MEDIUM**	The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry and to apply engineering and management principles to achieve the goal of the project.
100003/CS622T.5-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur and apply engineering and management principles to achieve the goal of the project.