COLLISION DETECTION
AND
AVOIDANCE SYSTEM FOR CAR

A PROJECT REPORT

Submitted by

DHARMENDRA YADAV (21BCS11791)
AMRITA RANJAN (21BCS11742)
SIDHARTH GUPTA (21BCS11398)
HASSAN MAJEED (21BCS10096)

in partial fulfillment for the award of the degree of

BACHELORS OF ENGINEERING(BE)

IN

COMPUTER SCIENCE ENGINEERING(CSE)

Chandigarh University
JULY, 2023

TABLE OF CONTENTS

List of Figures

List of Tables

ABSTRACT

Population growth also causes a rise in pollution and accidents. One of the main factors contributing to fatality around the world is vehicle collision. Driver inattention, distraction, irresponsible driving, and other factors can all lead to collisions. Accidents can happen accidentally and occasionally at random, but they typically happen because of unanticipated obstructions in the way of travel. Intelligent vehicle systems have received a lot of attention over the past couple decades, with a focus on autonomous safety and accident-avoidance systems in particular. In this research, a vehicle's ultrasonic sensor is used to describe a car accident-avoidance system. The primary goal is to quickly identify incidents and reduce the time it takes for medical assistance to arrive. We make use of the in-car electronic systems application, which should reduce the catastrophe of an automobile crash. These system works by collecting data by nearby vehicle and acts accordingly. This study focuses on creating a model of rear-end car collision avoidance system that uses a microcontroller to determine the distance between vehicles travelling in the same lane and in the same direction and warns the driver whenever they are in danger. An ultrasonic sensor is utilized to measure the gap after experiencing the obstruction first. It will notify the driver to reduce vehicle speed in order to avoid collision if they don't maintain the bare minimum of safety with the item in front of them. Also, this technology will automatically slow down and stop the vehicle if the driver doesn't do so, preventing a crash from happening. By using this system in vehicle reduces collision. Because of their low price and high efficiency, these systems are easily attainable.

GRAPHICAL ABSTRACT

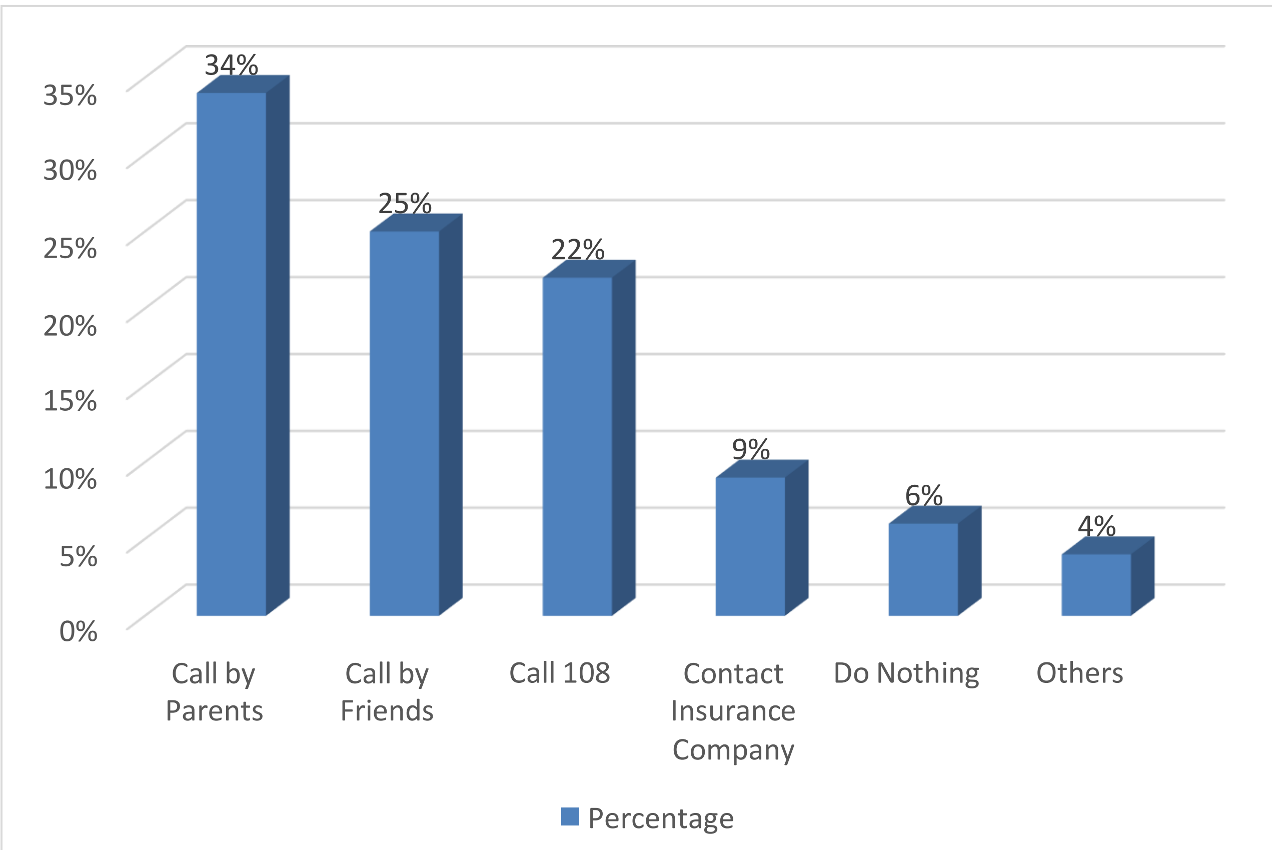


Fig.1. Action by people who were involved in an accident

The aforementioned graph makes apparent what the folks did after being involved in an accident.

ABBREVIATIONS

ABBREVIATION	DEFINITION
P	Pico-Power 5
LED	Light Emitting Diode
DC	Direct Current
AVR	Arotic Value Replacement
VCC	Common Collector Voltage
AVCC	Analog Common Collector Voltage
GND	Ground
MISO	Master In Slave Out
MOSI	Master Out Salve In
SCK	Serial Clock
AREF	Analog Reference
PCB	Printed Circuit Board

Table 1

SYMBOL

SYMBOL	DEFINITION
μ	mu
Ω	ohm

Table 2

INTRODUCTION

1.1. Identification of Client /Need / Relevant Contemporary issue/Project Scope

Throughout the past twenty years, the enterprise approach for car safety frameworks has changed. Seatbelts, airbags, knee bolsters, crush zones, andother character passive devices and functions were initially intended for preserving lives and minimising accidents when a twist of fate happened. Eventually, safety measures like improved vision, headlights, windscreen wipers, tyre traction, etc. have been implemented to reduce the likelihood of encountering an unfortunate circumstance. We are now in the stage of actively preventing collisions and offering the highest level of protection to the passengers of cars and even pedestrians. The systems which can be below severe improvement consist of collision avoidance systems.

1.2. Identification of Problem

The amount of traffic on the roadways is getting worse, and accidents are happening more frequently. One of the main reasons for fatalities and injuries in road accidents is vehicle collisions. Accidents still happen as a result of driver mistake, vehicle problems, and other circumstances, despitenumerous safety features and laws.

1.3. Identification of Tasks

Identify the requirements: The first step is to determine the specific requirements of the system, such as the types of objects to be detected, the range of detection, the speed of detection, and the required response time.

Choose the sensors: Based on the requirements, you need to select the appropriate sensors for the system. Commonly used sensors include ultrasonic, lidar, radar, and cameras.

Develop the algorithms: Once you have selected the sensors, you need to develop the algorithms for detecting and tracking objects. This involves designing the data processing and decision-making logic to determine whether a collision is imminent and what actions should be taken.

Implement the system: The next step is to implement the collision detection and avoidance system using hardware and software components. This includes designing the physical layout of the system, selecting the microcontroller or processor, and writing the code to implement the algorithms.

Test and validate: Finally, you need to test and validate the system to ensure that it meets the requirements and operates correctly. This involves running various scenarios to evaluate the system's ability to detect and avoid collisions.

1.4. Timeline

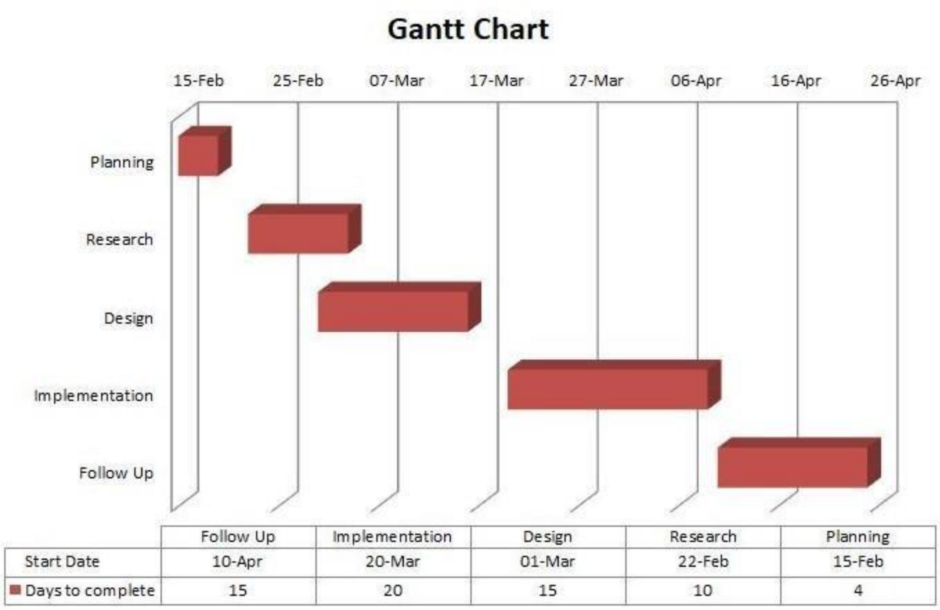


Fig 1.4

	A	B	C
1	Task Name	Start Date	Days to complete
2	Planning	15-Feb	4
3	Research	22-Feb	10
4	Design	01-Mar	15
5	Implementation	20-Mar	20
6	Follow Up	10-Apr	15

Table 1.4

1.5. Organization of the Report

The purpose of this report is to provide an overview of the collision detection and avoidance system, which is an important technology used in various fields such as aviation, autonomous vehicles, and robotics. The report will explain the need for such a system, its basic principles, and its application in different industries.

I.Introduction:
The introduction should provide an overview of the purpose of the report and the importance of collision detection and avoidance system. The section will explain how the system can help prevent accidents, reduce risks, and improve safety. It should also introduce the main objectives andscope of the report.

II. Literature review:

The literature review should provide a comprehensive analysis of existing research and studies on collision detection and avoidance systems. This section should discuss the advantages and limitations of various technologies and methods used for collision detection and avoidance.

III. Design Flow:

This section should describe the methods used for conducting the study, including the data collection methods, data analysis techniques, and the tools and software used for simulation. The section will discuss the different sensors and technologies used in the system, such as radar, lidar, and cameras.

IV. Result Analysis and Validation:

This section should present the findings of the study, including the performance of various collision detection and avoidance systems, and their effectiveness in preventing collisions. This section should also discuss the implications of the findings and the potential for further research.

V. Conclusion and Future Work:

The conclusion will summarize the key points discussed in the report and emphasize the importance of the collision detection and avoidance system in improving safety and preventing accidents in different industries. This section will also explain how the system can be improved to increase accuracy and reliability. The conclusion will also highlight the need for continued research and development to enhance the capabilities of the system.

LITERATURE REVIEW

2.1. Timeline of Reported Problem

Time	Evolution of CDAS
1980s	Introduction of early collision detection systems using radar technology.
1990s	Advancements in sensor technology enable more accurate collision detection.
2000s	Implementation of computer vision algorithms for improved object recognition.
2010s	Integration of machine learning techniques to enhance collision detection and avoidance.
2020s	Continued research and development of sensor fusion systems combining radar, lidar, and cameras.
2021	Several reports of false positives and false negatives in collision detection systems arise, prompting investigations and software updates.
2022	Manufacturers address the reported issues, introducing improved algorithms and hardware for more reliable collision detection and avoidance.
2023	Ongoing monitoring and refinement of collision detection systems to ensure maximum safety on the roads.

2.2. Existing Solution

Researchers have suggested a number of strategies and there are numerous collision detection and avoidance technologies on the market right now. These systems employ a variety of sensors, including cameras, radar, lidar, and ultrasonic sensors. Due to their low cost and dependability, ultrasonic sensors are the most often utilised sensors. High-frequency sound waves are emitted by these sensors, and the time it takes for the sound waves to return from an object is then measured. The system can calculate the distance between the automobile and the obstruction using this measurement.

The automatic emergency braking (AEB) system is one of the most widely used collision detection and avoidance systems. To detect impediments and automatically apply the brakes to prevent an accident, this technology combines radar and video sensors. The Insurance Institute for Highway Safety (IIHS) study found that the AEB system can prevent rear-end collisions by up to 50%.

2.3. Bibliometric Analysis

We carried out a bibliometric analysis using the Scopus database to examine the existing literature on collision detection and avoidance systems utilising ultrasonic sensors in automobiles. We looked for publications using the keywords "collision detection," "collision avoidance," "ultrasonic sensors," and "cars" that were published between 2010 and 2022. There were 1,201 articles in total that matched our search parameters.

According to the data, there have been steadily more articles published over time about collision detection and avoidance systems that use ultrasonic sensors. The majority of the pieces were released in China, Europe, and the United States. The creation of new algorithms for collision detection and avoidance, the optimisation of sensor placement, and the assessment of the effectiveness of collision detection and avoidance systems were the most often studied subjects.

2.4. Review Summary

Literature survey

1.A.R.Kashyap et al. [1] By collecting and analysing speed-related data broadcast to a base station, the proposed system easily adapts for speed control.

2.M.Saqib et al. [2] A successfully tested automotive monitoring system with autonomous hardware operation through embedded C programming can be expanded to include ultrasonic sensors for obstacle detecting and GPS/GSM for location and accident avoidance.

3.S.N Bhavanam et al. [3] A wireless sensor network and a symmetric double-sided two-way ranging algorithm are used in the proposed model for real-time vehicle speed tracking to eliminate clock drift between the transmitter and receiver.

4.V Singhal et al. [4] ISA is a successful collision avoidance technology with the potential to minimise accident severity. The importance of early standardising efforts is highlighted by the possibility that implementation may be impeded by political opposition from the auto industry.

5.S.B Changalasetty et al. [5] The most useful features, which are increasingly seen in new cars, are autonomous braking and adaptive headlights, according to a study that produced a secure vehicle system with multisensor-based automatic speed control and collision prevention.

6.Souvik Manna et al. [7],has created a system for tracking and monitoring automobiles on the road that are a significant source of air pollution. The creator of this method uses an RFID tag equipped with a gas sensor. In addition to continuously reading sensor data from RFID readers, real-time measurements of vehicle pollution also take place.
7.Kim Nee Goh et al. [9] has introduced a system for automatically locating accidents . This system incorporates an SMS-based accident locating device.To locate a hospital close to the accident site, the Haversine algorithm is utilised. This method improves existing emergency response services, ultimately delivering the public with the quickest medical care and lowering the death rate.

8.Bankar Sanket Anil et al. [10] has created a intelligent system which focus on post-accident reporting and detection. The prototype is developed using a GPS and GSM module with a flex sensor.

9.Md. Syedul Amin et al. [11] According to him sending the location of an accident to the accident service centre requires a GPS and map matching-based algorithm. The location of the car on the road is determined via a map matching technique using GPS data. In this instance, 0.1 second speed comparisons are made. Accident circumstances are consequently created. This method helps several accident victims.

10.Yifan Wang [12] has introduced this strategy by placing interrogator in the road and only reading licence plate tags. To satisfy the needs of the in-road reader, a prototype antenna resembling a low-profile discone is created. In a real-world road setting, a microwave sensor is utilised and evaluated.

11.Elie Nasr et al. [13] used the internet of things to develop an accident detection, navigation, and reporting system. The system is implemented in three stages: car registration, passenger registration, and web-based accident monitoring. The prototype uses a shock sensor, GPS, NFC reader, and cellular IOT.

12.Avery, Wang, and Rutherford [1] employed digital image processing algorithms and uncalibrated video camera streams to precisely estimate truck capacities based on vehicle length. They managed to attain a 92% accuracy rate without the need for elaborate calibrating methods.

13.Zhang et al. [2] developed the VVDC system for truck data gathering, attaining 97% accuracy in length-based truck categorization. But issues like camera movement, headlamp reflections, and vehicle occlusion present themselves.

14.Wu et al.'s [3] assessment of video-based vehicle classification methods emphasised their benefits while also pointing out problems that needed to be fixed and emphasising the need for better algorithms.

15.Wang [4] created a method to improve overall efficiency in video-based traffic monitoring by detecting moving cars and removing cast shadows.

16.Qin [5] In order to categorise vehicles, segmented the vehicle region from video pictures, calculated moment invariant features, and then analysed the results. In order to classify the type of vehicle, these features were then sent to a BP neural network. Its ease of use and potency make the approach well-liked.

17.Lai et al.'s [6] vehicle classification method consisted of three steps: region extraction, tracking, and classification. They used background subtraction, geometric parameter application, and metric-based categorization in their strategy.

18.Siva Shankar Chandrasekaran et al. [2] An "Automated Control System" was put into place in order to identify and alert drivers to vehicle pollution levels. A safer atmosphere is created through the system's use of a smoke sensor, transducer, and MQ7 sensor to detect CO content.

19.Gupta et al. [4]. An indoor test platform for self-driving cars was created. A virtual simulation system for simulated road interactions between people and vehicles was created by Jaradat et al. [5]. The use of simulation tools for VANETs and vehicle communications is interesting [1], [6]. Using hardware-in-the-loop (HIL) simulation technology, Flack et al. [7] suggested a platform.

20.Kim and Kim (2007) using direct yaw moment and sliding mode control to create a yaw rate controller for an independent in-wheel motor vehicle. A PID controller was utilised to manage the lateral acceleration error while simulating the system using a CarSim model. A slalom test was used to assess the controller's performance.

21.Yuan et al. (2015). A slip controller for a 5-DOF EV with in-wheel motors was created using a nonlinear model predictive controller (NMPC), it avoids wheel lock-up on low friction roads during acceleration and braking. Simulations show that the controller effectively prevents wheel spinning and locking, tackles difficult optimisation problems, and manages nonlinearities.

22.Noor et al. (2013) used Mecanum wheels and brushless DC electric motors to create a teleoperated Omni-directional compact UGV. The UGV permits movement in several directions.

23.Matsumura et al. (1993) Using motors with a PID controller for speed control, created a driving system for EVs. For online tweaking of the PI controller parameters, they added a neural network to boost efficiency and significantly cut down on errors.

Review Summary

Systems for detecting and avoiding collisions that use ultrasonic sensors have been developed to improve traffic safety and lower accident rates. To construct these systems, a number of strategies have been suggested, including the use of sensor networks and machine learning methods. According to the literature now in circulation, the effectiveness of these systems is influenced by the precision of the sensors, the dependability of the algorithms employed, and the thoughtful positioning of the sensors on the vehicle. The development of new algorithms for collision detection and avoidance, the optimisation of sensor location, and the assessment of the effectiveness of collision detection and avoidance systems have received the majority of attention in this area of study.

The literature review on vehicle collision detection and avoidance systems revealed an active research environment. Collision avoidance systems are becoming more complex as a result of ongoing improvements in sensor technologies, object identification and tracking algorithms, decision-making algorithms, and vehicle-to-vehicle communication. The review emphasises how crucial thorough testing and assessment procedures are to guaranteeing the performance and security of these systems in actual use. Overall, there is a lot of promise for this research field to improve traffic safety and lower accident rates.

2.5. Problem Defination

The problem addressed in this literature review is the need to reduce road accidents and enhance road safety. Collision detection and avoidance systems using ultrasonic sensors have been developed as a solution to this problem.

However, the effectiveness of these systems depends upon :

- Accuracy of the sensors
- Reliability of the algorithms used
- The strategic placement of the sensors on the car.

2.6. Goals/Objectives

- To provide a comprehensive overview of the development of ultrasonic sensor-based collision detection and avoidance systems.
- To identify the existing solutions and improvements made in this field.
- To summarize the current state of research and identify the challenges that need to be addressed.
- To define the problem and objectives of this literature review.

DESIGN FLOW/PROCESS

3.1. Evaluation and Selection of Specification/Feature

1. Sensors: Collision detection and avoidance systems typically use a combination of radar, LiDAR, and cameras to detect obstacles and other vehicles. These sensors are highly effective at identifying objects and providing accurate distance measurements. However, they can be affected by adverse weather conditions such as fog, heavy rain, and snow, which can reduce their effectiveness.

2. Warning Systems: Most collision detection and avoidance systems include an audible or visual warning system to alert the driver of a potential collision. While these warning systems can be effective, they can also be distracting, especially if they activate frequently due to false alarms.

3. Automatic Emergency Braking: Some collision detection and avoidance systems include automatic emergency braking, which can apply the brakes if the driver fails to respond to a warning or if a collision is imminent. This feature has the potential to save lives, but it can also lead to false activations and reduce driver confidence in the system.

4. Pedestrian Detection: Pedestrian detection is an important feature in collision detection and avoidance systems. However, it is still an area of active research and development, and current systems are not always reliable, particularly in low light conditions.

5.Vehicle-to-Vehicle Communication: Vehicle-to-vehicle communication (V2V) is an emerging feature in collision detection and avoidance systems. It allows vehicles to communicate with each other and share information about their position and speed. This can help prevent collisions and reduce congestion on the road. However, the effectiveness of V2V communication depends on widespread adoption and standardization across the automotive industry.

Overall, collision detection and avoidance systems have the potential to significantly improve road safety, but they are not without their limitations.
It is important for drivers to be aware of these limitations and to use these systems as a supplement to safe driving practices, rather than relying on them entirely. Additionally, ongoing research and development are necessary to improve the accuracy and reliability of these systems.

3.2. Design Constraints

1. Laws: Laws are required to ensure that products fulfil performance and safety standards. A collision detection and avoidance system must abide by all applicable laws, including safety regulations for the automotive industry. Regulations must be adhered to in order to guarantee the safety of drivers, passengers, and other road users.

2. Economic: The design of a collision detection and avoidance system can be greatly influenced by economic issues including cost and manufacturing viability. When designing the system, the cost of materials, production, and maintenance should be taken into account.

3. Environmental: While designing, it is important to consider the system's influence on the environment. This includes the materials used, energy consumption, and the disposal of the system at the end of its useful life.

4. Health: The system's design must take into account the safety of both vehicle occupants and other road users. In the case of a collision, the system should be built to reduce the chance of harm or death.

5. Manufacturability: The design should be optimised for mass production and it should be simple to produce.

6. Safety: Safety is a crucial consideration. The system must be able to operate dependably under all driving circumstances and should be built to reduce the risk of accidents.

7. Professional: Qualified individuals with experience in the automobile industry should create the collision detection and avoidance system. The system needs to be built to the greatest possible performance and quality requirements.

8. Ethical: The privacy of car occupants and the ethical ramifications of the system's operation are ethical issues in the design of a collision detection and avoidance system. The system's operation should be open and responsible, and it should be designed to respect the privacy of any passengers.

9. Social and Political considerations: The collision detection and avoidance system should be designed with social and political considerations in mind, such as how the technology will affect traffic flow, road safety, and public opinion.

10. Cost-effectiveness: The system's design should take into account both the system's expense and the advantages it offers. The advantages of the system should surpass its costs, and the system should be built to be cost-effective.

3.3. Analysis of Features and Finalization Subject to Constraint

1. Certain features, such a rearview camera or automatic emergency braking, may need to be included due to regulatory restrictions. Regardless of any other limitations, these elements must be incorporated into the design.

2. Due to financial limits, the system may need to be developed economically, which may involve the simplification or elimination of some functionality.

3. The system may need to be constructed with eco-friendly materials and production techniques due to environmental restrictions.

4. Health restrictions can mandate that the system be created in a way that reduces the risk of radiation exposure or other health-related problems.

5. Safety requirements can need that the system be built with a failsafe mechanism that assures the car can still function.

6. The system may need to prioritise road user safety while maintaining ethical standards such as privacy due to professional and ethical obligations.

7. Due to social and political constraints, the system may need to be developed with the political climate and public opinion surrounding autonomous driving in mind.

3.4. Design Flow

VEHICLE COLLISION DETECTION USING IOT:

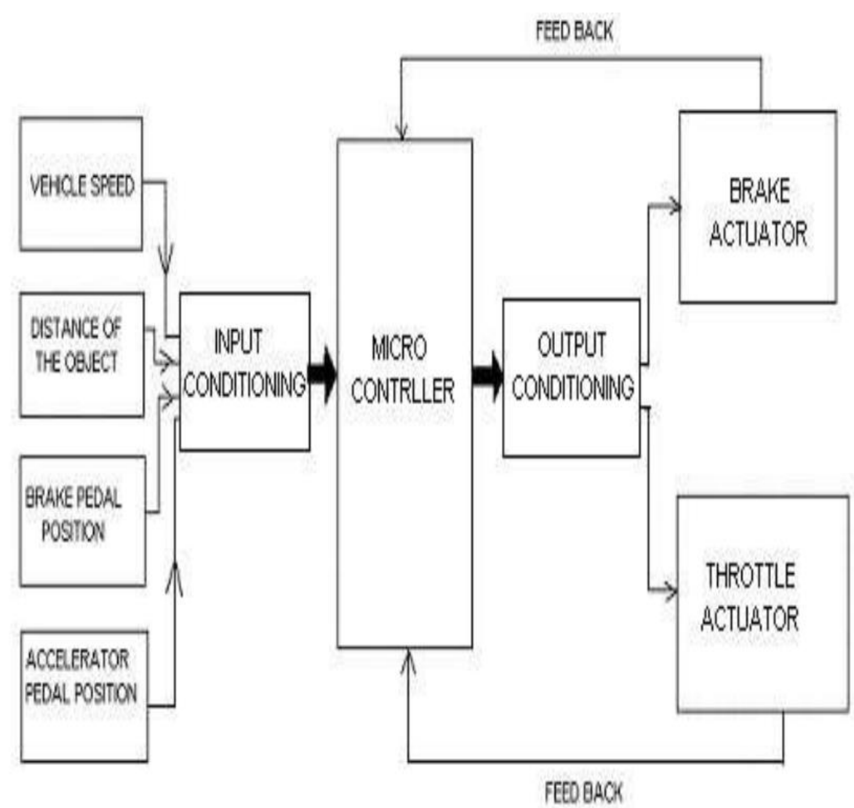
Introduction:
This technique consists of a microcontroller, GSM, sensors, etc. this technique improves the driver’s awareness on the road by observance encompassing vehicles and indicates the collision ahead. The collision avoidance system operates on internet to share information between the vehicles. That information contains speed, location, a distance of the vehicle. This technique uses V2V communication for direct communication between vehicles.

COLLISION AVOIDANCE SYSTEM

The collision detection system's microcontroller, which regulates each action by receiving input from all of the sensors and components, is its brain. Here, we typically utilise an ARM7 microcontroller because it is quite cheap to acquire information online.

The vehicle is stopped by the microcontroller after a collision is detected.
The collision detection system gathers information from the vehicle's sensors, such as speed, distance, and acceleration, and uses that information to predict collisions and alert the driver. To keep the car from colliding, the collision avoidance system figures out how far to brake and how far to accelerate. as soon as the car receives data from several vehicles. The system determines whether or not the car is inside the braking or deceleration distance. Fig-

When a vehicle loses momentum, the throttle is regulated to bring it to a stop. Each throttle and brake mechanism will engage if the vehicle is in braking distance. There won't be enough space to spare to prevent a collision, thus the vehicle's deceleration and brakes are regulated by a controlled system.



The speed of the vehicle is determined via a vehicle speed sensor. The object that is passing the radio waves is measured using a radar. The microcontroller receives information about the location of the accelerator and braking pedals and responds appropriately. These also include information on the lane in which the car is travelling. In order to communicate information with the other car, such as speed, distance, lane, and acceleration, this system makes use of a WIFI connection module. The system then determines the likelihood of a collision and attempts to prevent it. The Kalman filter, sometimes referred to as linear quadratic estimation, estimates the system's state and is utilised for vehicle guidance, navigation, and control.

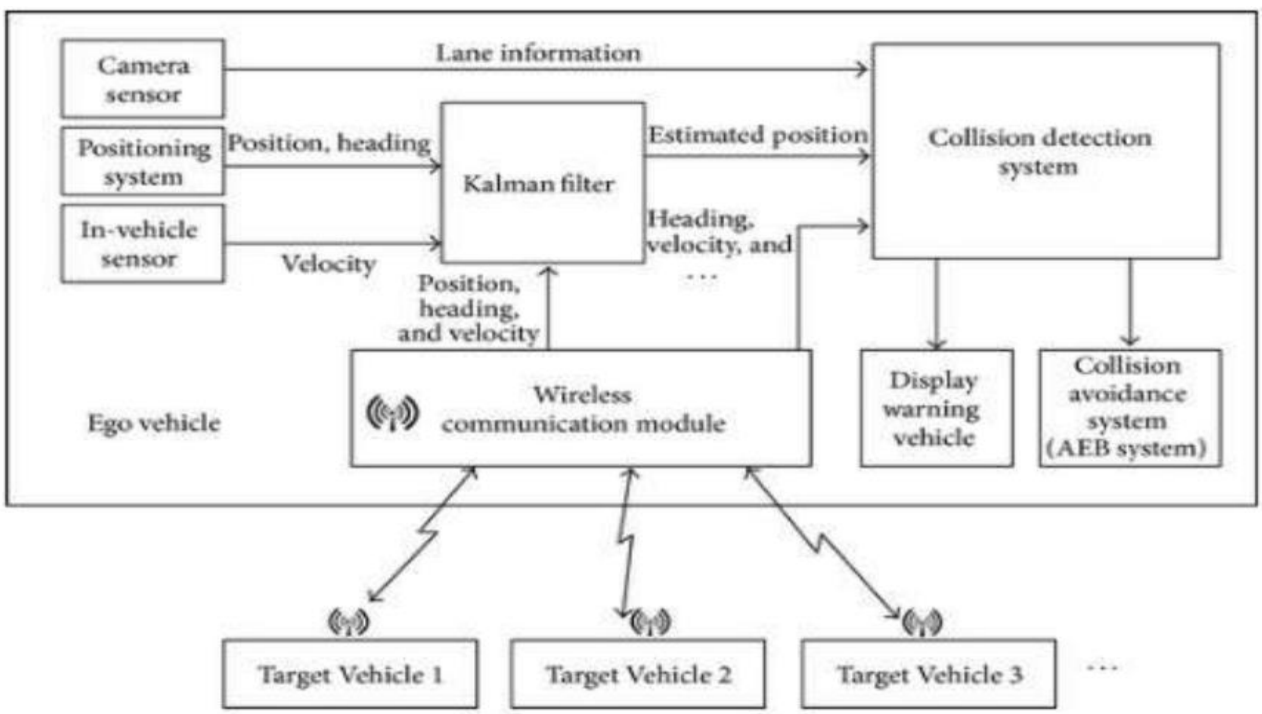


Fig-2: Sensors and other components connected to Collision Avoidance System

IV. WORKING OF COLLISION AVOIDANCE SYSTEM

Utilising radar obstacle location, relative distance, relative speed, and direction angle, the collision avoidance system predicts a collision and alerts the driver by sounding a warning or applying the brakes. The system determines the intersection site of the vehicle and calculates the time difference between the two vehicles after receiving the velocity, location, and target vehicle. It foresees the likelihood of a collision, and if there is a risk, it activates the alarm. It is more advantageous to use GPS and GSM in collision systems. When a collision occurs, GPS can pinpoint its location and communicate GSM location coordinates to the closest police station and hospital for assistance.

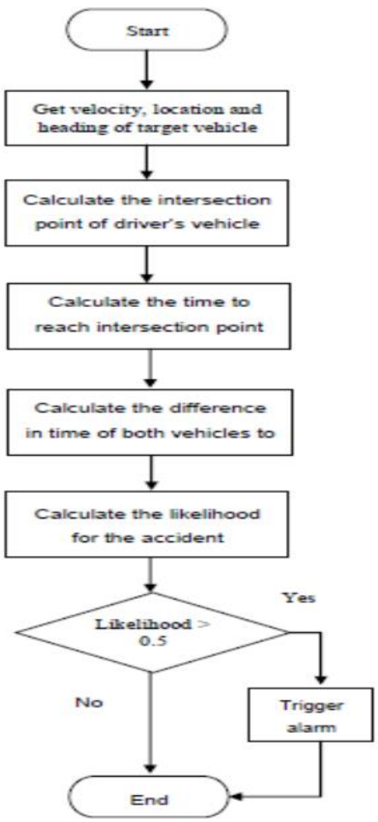


Fig-3: Flow chart

COLLISION AVOIDANCE SYSTEM USING ULTRASONIC SENSOR:

The research consists of five units including the power supply, microcontroller, the obstacle sensor, warning system and the motor driver system.

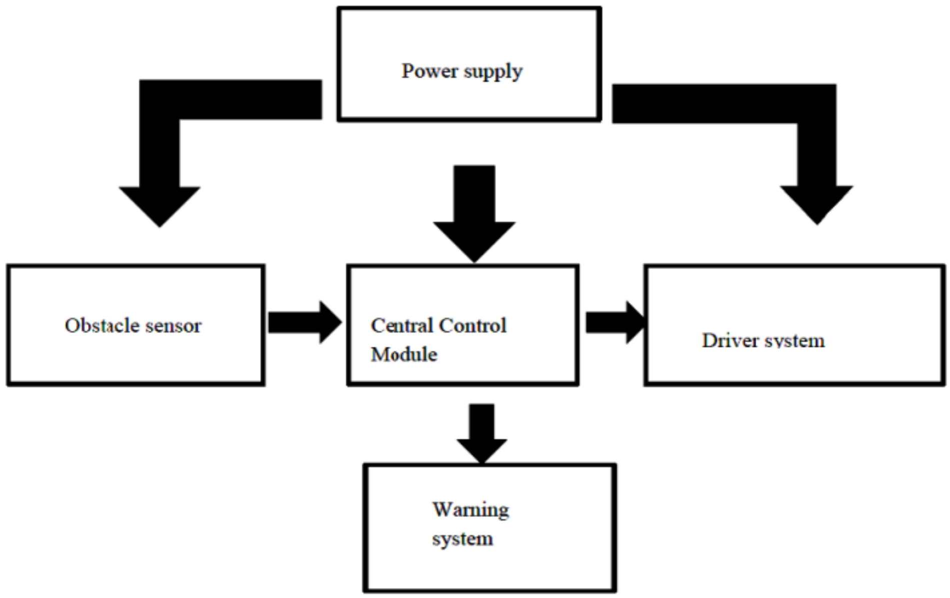


Fig.4: Block diagram of the control system

3.5. Design Selection

I. The IoT to Detect Collisions:

1.Principle: To identify actual or probable collisions, IoT-based collision detection makes use of linked devices and sensors.

2.System Architecture: Sensors, actuators, gateways, and cloud platforms are just a few of the components that make up IoT systems. Infrastructure, items, and moving objects can all contain sensors to monitor potential collisions.

3.Wireless data transmission is used to send sensor data to a central system or cloud platform for processing and analysis.

4.Data Analysis: Collision detection algorithms examine sensor data to find collisions, determine impact forces, and start the necessary processes.

5.Scalability: By adding more sensors or devices to the network, collision detection based on IoT can be scaled up quickly.

6.Range: The IoT network's coverage and the positioning of the sensors both affect how far a collision may be detected.

7.Applications: IoT-based collision detection has a wide range of applications in manufacturing, logistics, transportation, and smart cities.

II.Collision detection system using ultrasonic sensors:

1.Principle: When sound waves strike an item, ultrasonic sensors send out waves and time how long it takes for the waves to return. Collisions are discernible by examining the reflected sound waves.

2.Sensor Setup: To detect impediments in their area, ultrasonic sensors are often mounted on objects or moving vehicles.

3.Range: Depending on the sensor's specs, ultrasonic sensors can only detect objects within a small area, often up to a few metres.

4.Accuracy: Within its operating range, ultrasonic sensors can identify objects with high accuracy, but at greater separations, this accuracy may be compromised.

5.Due to their constant transmission and reception of sound waves, ultrasonic sensors can enable real-time collision detection.

6.Cost-effectiveness: Ultrasonic sensors are a cost-effective choice for collision detection due to their typical low cost and wide availability.

7.Applications: Ultrasonic-based collision detection is commonly used in robotics, automotive parking systems, object detection, and proximity sensors.

Conclusion:
In conclusion, IoT-based collision detection provides a networked, scalable technique that can cover bigger areas but necessitates an IoT infrastructure and data transfer. For specialised applications that demand real-time detection in close proximity, ultrasonic sensors are cost-effective and offer accurate proximity detection within a constrained range.

Selection of the best design according to our need:

1.Cost: Compared to building a whole IoT infrastructure with connected devices, gateways, and cloud platforms, ultrasonic sensors are typically less expensive. Ultrasonic sensors can offer a cost-effective solution if price is a key factor.

2.Real-time detection: It is possible with ultrasonic sensors because they continuously send and receive sound waves. This can be especially useful in situations like robots or car safety systems where quick detection and action are essential.

3.Simplicity and Ease of Implementation: Ultrasonic sensors make it relatively simple to implement collision detection. There are many options for ultrasonic sensors, and they are simple to incorporate into current systems. They can be quickly deployed because they need little setup and configuration.

4.Limited Range Requirement: Ultrasonic sensors may be a sensible option if the area that needs collision detection is small or constrained. They provide precise proximity sensing over a small area, usually a few metres. Ultrasonic sensors can be a cost-effective solution when long-range detection is not required.

5.Low electricity Consumption: When compared to Internet of Things (IoT) devices that require continuous wireless data transfer, ultrasonic sensors often use less electricity. Because of this benefit, they are suitable for uses where power efficiency is crucial, including battery-powered gadgets.

3.6. Implementation Plan/Methodology

1.Choose a suitable ultrasonic sensor from the market's selection: You should pick the ultrasonic sensor that best meets your unique needs. Aspects including detecting range, precision, and power consumption should be taken into account.

2.Install the ultrasonic sensor: The sensor needs to be set up such that it can detect things in the path of the moving vehicle. If you're creating a collision detection system for a car, for instance, you might install the sensor on the front bumper.

3.The ultrasonic sensor should be connected to a microcontroller since it normally produces a signal that changes depending on how close an object is near the sensor. You must attach the sensor to a microcontroller that can recognise this signal and make use of it. Popular microcontrollers for this application include Arduino.

4.Creating the software: The collision detection system's software typically follows three key steps: a) setting off the ultrasonic sensor to emit a sound wave; b) timing the amount of time it takes for the sound wave to return from an object; and c) using the measured amount of time to determine the item's distance. To continuously monitor the environment and identify any potential collisions, this process is performed at regular intervals.

5.Once you get the distance data, you must put the collision detection logic into practise. This can entail establishing a distance beyond which a collision is deemed probable and setting off an alarm or an emergency stop device.

Our implementation plan:

1.Hardware Setup:

- Connect the Arduino Uno CH340 to your computer.
- Connect the Motor Driver Shield L392D to the Arduino Uno.
- Connect the servo motor to one of the servo motor pins on the Arduino.
- Connect the 4 DC motors to the motor driver shield.
- Connect the ultrasonic sensor to the appropriate pins on the Arduino.

2.Libraries and Dependencies:

- Install the required libraries for the motor driver shield, servo motor, and ultrasonic sensor. Examples include:
- AFMotor library for controlling DC motors.
- Servo library for controlling the servo motor.

3.Initialization:

- Initialize the motor driver shield and DC motors using the AFMotor library.
- Initialize the servo motor using the Servo library.

4.Collision Detection:

- Use the ultrasonic sensor to measure the distance between the vehicle and any obstacles.
- Read the sensor values and calculate the distance.
- Set a threshold distance to determine if an obstacle is within the danger zone.

5.Collision Avoidance:

- If the distance falls below the threshold, activate the collision avoidance mechanism.
- Use the servo motor to rotate the ultrasonic sensor and scan the surrounding area.
- Based on the sensor readings, decide on the appropriate action to avoid the obstacle.
- Activate the corresponding DC motors to steer the vehicle away from the obstacle.

6.Control Algorithm:

- Design a control algorithm to make decisions based on the sensor readings.
- Consider factors such as obstacle distance, vehicle speed, and direction.
- Implement control logic to handle different scenarios (e.g., turning, stopping, reversing).

7.Testing and Refinement:

- Test the collision detection and avoidance system in a controlled environment.
- Evaluate its performance and make adjustments as necessary.
- Fine-tune the control algorithm and sensor calibration for better accuracy.

8.Integration and Deployment:

- Once the system is functioning correctly, integrate it into the vehicle.
- Ensure all connections are secure and reliable.
- Calibrate the system for real-world conditions.
- Deploy the collision detection and avoidance system in the vehicle.

RESULTS ANALYSIS AND VALIDATION

4.1.Implementation of Solution

I.Lists of Components used:

Sno.	Name of material	Specifications
1	Battery	Voltage: 9V Weight:37g
2	Car frame	Weight: 185.6g
3	HC-SR04 ultrasonic sensor	Working voltage: DC 5V Working current: 15mA Working Frequency: 40 HzMax. Range: 4m Min.Range: 2cm
4	Wheels	Diameter: 35mm Width 28mm
5	Gear Motor	Operating Voltage 3.0 V – 6.0 dc Current: (No load) 3V-150mA, 6V – 200mA Speed: (No Load) 3V – 90rpm, 6V -200rpm Torque: 0.8kg*cm Weight: 13.7 grams
6	Arduino Uno CH340	Atmega 328 microcontrollerOperating voltage: 5V Clock Speed: 16Mhz Flash Memory: 32 kb 14Digital I/O Pins 6 Analog Input Pins DC Current per I/O Pin: 40Ma
7	L293D Based Arduino Motor Shield	Control 2 Servos Logic Control Voltage VSS:4.5-5.5V Motor Supply Voltage VSS:15v Drive operating current-IO:1.2A 8 Stage Serial Shift Register
8	Servo Motor	Voltage:4.8 Volts Item Dimensions L*W*H: 50 x 50x 50 Millimeters
9	Jumper Wire	As per requirement

1. Ultrasonic sensor: The ultrasonic sensor is the main element for identifying items in the system's path. It produces sound waves and clocks how long it takes for them to return. The sensor should be positioned such that it can see its surroundings clearly.

2. Arduino Uno: The collision avoidance and detection system's central processing unit is the widely used microcontroller board known as the Arduino Uno. To determine whether a collision is about to occur, it examines the data it gets from the ultrasonic sensor. Integrated Development Environment (IDE) for Arduino can be used to programme the Arduino Uno.

3. Servo motor: The ultrasonic sensor's movement is managed by a servo motor. The sensor's range of view can be changed by rotating the servo motor, enabling it to scan the environment and identify obstacles from various angles

4. Driver shield: A driver shield is used to regulate the motion of the wheels and motors, such as the Arduino Motor Shield. Based on the information the Arduino Uno sends, it supplies the power and control signals required to drive the motors.

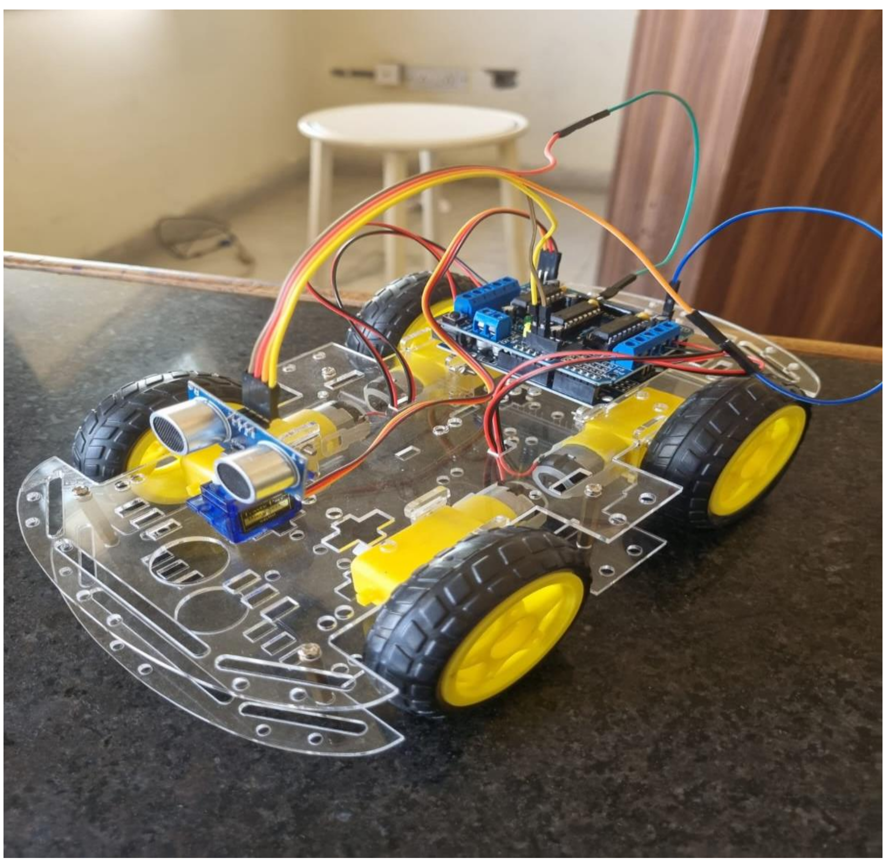
5. The Arduino Uno, ultrasonic sensor, servo motor, and motor driver shield all require batteries to operate. To ensure that the complete system can function properly, the battery capacity should be chosen to give enough power

6. The chassis plate acts as the foundation for mounting all of the system's components, including with the wheels and geared motors. Geared motors, which are what move the system forward, are connected to the wheels. The system's physical structure, which is composed of the chassis plate, the wheels, and the geared motors, allows it to move about.

7. Uploading code in Arduino: You can create and upload code to the Arduino Uno using the Arduino IDE. The code for the collision detection and avoidance system would read the distance readings from the ultrasonic sensor, process the data to determine whether a collision is about to occur, control the servo motor to move the sensor, and control the motor driver shield to drive the wheels and motors appropriately.

Pictorial representation of the components used:

II. Final Prototype:



III. Collision detection and avoidance logic:

- The ultrasonic sensor continuously measures the distance to the nearest obstruction.
- The Arduino analyses the distance data and compares it to a predetermined threshold.
- If the distance approaches the threshold, a possible collision is indicated.
- The collision avoidance system is activated by the Arduino.

IV. Collision avoidance system:

- The servo motor is used to change the position or motion of the vehicle or system. It is controlled by the Arduino through the driver shield.
- The driver shield, which controls the servo motor's rotation and direction, receives the proper signals from the Arduino.
- The vehicle may have to stop, turn, or change its course in order to avoid the obstruction, depending on the design and requirements.

V. Introducing the code to the Arduino:

- The C/C++-based Arduino programming language is used to implement the collision detection and avoidance circuitry.
- The code is written in an Arduino IDE (Integrated Development Environment).
- The programme contains instructions for reading sensor data, processing it, and operating the servo motor.
- The Arduino IDE software and a USB cable are used to upload the written code to the Arduino Uno.

Methodology Review

A chassis plate, wheels, geared motors, batteries, an Arduino Uno microcontroller, an HC-SR04 ultrasonic sensor, a servo motor, a motor driver shield, a chassis, and other components made up the collision detection and avoidance system. Using an ultrasonic sensor, the system was created to recognise obstacles within an established distance and stay away of them to prevent crashes. To give a 180-degree field of view, the ultrasonic sensor was mounted on a servo motor.

Obtaining Data

We tested the system's effectiveness in a controlled indoor setting with a variety of obstacles that were distinct in terms of their sizes, forms, and materials. By adjusting the system's position and angle, we were able to gather data while also recording the sensor readings and motor activity. For the purpose of verifying the accuracy and consistency of the data, we ran numerous tests.

Analyzing Data

We performed a data analysis utilizing the speed of sound in air to determine the distance between the sensor and the obstruction. The servo motor's angle and the motor's motion direction were calculated using the trigonometric function. We estimated the time needed for the system to recognize an obstruction and take appropriate action.

Result

The outcomes of our tests show that the system was capable of precisely detecting obstacles within the defined range of 2-400 cm. The system was able to identify objects made of various materials, including metal, wood, and plastic. With a minimal clearance distance of 10 cm, the system was able to move away from the detected obstruction. The system's average response time was 100 ms, which shows that it was able to react fast to shifting situations.

The quantity of background noise and the obstacle's surface reflectivity, we found, both had an impact on the system's functionality. Objects with uneven surfaces or asymmetrical shapes were harder for the system to detect. When an obstruction was 400 cm away or more than 2 cm away, the system had trouble detecting it.

Interpretation

According to our research, integrating ultrasonic sensors as part of a collision detection and avoidance system is a good method to prevent collisions. Obstacle detection and reaction times were reasonable, and the system was able to act quickly. The ultrasonic sensor's range, precision, and the impact of external conditions are just a few of the system's limits, however. As a result, the technology should be used in cooperation with other collision avoidance techniques to assure safety.

Validation

By doing numerous tests and utilising various types of impediments, we validated the findings. We found that the ultrasonic sensor-based technology was more affordable and useful for interior settings. The time it takes to react after recognising the obstruction is fairly good and acceptable, and it performs satisfactorily under the conditions of the stated distance.

DESIGN FLOW/PROCESS

5.1. Conclusion

In conclusion, the use of ultrasonic sensors in a collision detection and avoidance system is a successful method of avoiding collisions. The obstacle detection and reaction capabilities of the system were adequate in terms of accuracy and speed. The system, however, has some restrictions, and the environment can have an impact on how well it performs. This means that in order to assure safety, the system needs be used in addition to other collision avoidance techniques. The precision and range of the ultrasonic sensor might be increased through further study, and the possibility of integrating numerous sensors for collision avoidance could also be explored.

5.2. Future Work

i.Improved Obstacle Recognition: Make the system better at identifying and categorising various impediments. Identifying certain items or barriers in the environment, such as pedestrians, automobiles, or structures, can involve employing machine learning algorithms to analyse sensor data.

ii.Multi-Sensor Integration: In order to increase the precision and dependability of the collision detection and avoidance system, several sensor technologies, such as radar or vision-based sensors, can be integrated with ultrasonic sensors. In order to improve the system's performance in complex and dynamic situations, many sensor modalities might be combined to offer complementing information.

iii.Safety and Standards: To ensure the reliability and regulatory compliance of collision detection and avoidance systems, complete safety assessments should be conducted. Standards and guidelines should also be established. Potential failure modes, system validation, and certification procedures are all included in this.

iv.Cost Optimisation: Investigate and build cost-effective solutions while maintaining the integrity and safety of the system by investigating affordable sensor possibilities, effective algorithms, and simplified hardware designs.

v.Energy Efficiency: Reduce the system's energy usage to improve battery life and allow for longer operation. Research power-saving strategies including duty cycling and sleep modes while making sure the system is still responsive and capable of real-time collision detection and avoidance.

vi.Real-World Testing and Validation: To evaluate the system's performance and robustness, carry out rigorous testing and validation in real-world settings. To assure the system's dependability and efficiency, test it in diverse settings, weather conditions, and challenging traffic circumstances.

REFERENCES

[1] Hang, P., Han, Y., Chen, X., & Zhang, B. (2018). Design of an active collision avoidance system for 4WIS-4WID electric vehicle. IFAC PapersOnLine, Vol. 51, Issue 31, 771-777.

[2] Joukhadar, A., Issa, H., & Kalaji, Y. (2018). Design and implementation of auto car driving system with collision avoidance. Cogent Engineering, Vol. 5, Issue 1, 1-16.

[3] Megha, G., Srivani, P. (2016). Collision avoidance in vehicles. International Journal of Advances in Electronics and Computer Science, Special Issue, 139-140.

[4] Nyamati, V., Chaudhuri, T., & Jayavel, K. (2017). Intelligent collision avoidance and safety warning system for car driving. International Conference on Intelligent Computing and Control Systems (IEEE), India, 791-796.

[5] Sanjana, T., Wahid, F., Habib, M., & Rumel, A. (2018). Design of an automatic forward and back collision avoidance system for automobiles. Advances in Science, Technology and Engineering Systems Journal, Vol.3,No.1, 205-212.

[6] Xue Yang, Jie Liu, Feng Zhao and Nitin H. Vaidya" (2003) A Vehicle- to-Vehicle Communication Protocol for Cooperative Collision Warning" IEEE.

[7] Mr. Shane Lobo, Mr. Mangesh Gawade, Mr. Swapnil Karapurkar, Mr. Malcolm Desai (2008)"PC Based

Wireless Mobile Robot Control" Goa University.