OBSTACLE DETECTION AND ACCIDENT AVOIDING SYSTEM USING RADAR FOR ADVANCED VEHICLES

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Abstract: *The project "Obstacle Detection and Accident Avoiding System Using Radar for Advanced Vehicles" proposes a cutting-edge approach to enhance vehicle safety through the integration of radar-based technology. As the automotive industry shifts toward autonomous and semi-autonomous systems, the need for robust and reliable accident prevention mechanisms has grown significantly. This system leverages radar sensors to detect obstacles in the vehicle's path, such as other vehicles, pedestrians, or stationary objects, in real-time. The radar signals are processed to identify the distance, speed, and relative movement of these obstacles, enabling the system to predict potential collisions. In response, the system activates safety measures, such as automatic braking or steering adjustments, to avoid accidents or minimize impact. This project aims to demonstrate the efficiency of radar systems in dynamic driving conditions, ensuring that the vehicle can respond to sudden and unforeseen obstacles. The proposed system improves upon existing safety technologies by providing a more accurate and responsive solution that works effectively in various environmental conditions, including low visibility scenarios like fog, rain, or night time driving. Ultimately, this research seeks to contribute to the development of safer, more intelligent transportation systems, driving the next wave of vehicle safety and automation.*

Keywords: *Obstacle Detection; Radar; Autonomous; Arduino IDE*

I. INTRODUCTION

Collision avoidance systems concentrate on advanced ideas such as precrash sensing, an ultrasonic sensor is used to sense the object in front of the vehicle and gives the signal to the microcontroller unit. Based on the signal received from the ultrasonic sensor, the microcontroller unit sends a signal to the braking unit for applying the brake automatically. A collision avoidance system, also known as a precrash system, forward collision warning System, or collision mitigating system, is an automobile safety system designed to prevent or reduce the severity of a collision. It uses radar (all weather) and sometimes laser (LIDAR) and camera (employing image recognition) to detect an imminent crash. GPS sensors can detect fixed dangers such as approaching stop signs through a location database. Once an impending collision is detected, these systems provide a warning to the driver. When the collision becomes imminent, they take action autonomously without any driver input (by braking or steering or both). Collision avoidance by braking is appropriate at low vehicle speeds (e.g. below 50 km/h (31 mph)), while collision avoidance by steering may be more appropriate at higher vehicle speeds if lanes are clear. Cars with collision avoidance may also be equipped with adaptive cruise control, using the same forward-looking sensors. There have been several successful attempts in designing obstacle avoiding robots. These works differ by selection of sensors, path mapping process and the algorithms applied to set the operational parameters.

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II. FUNCTIONAL OVERVIEW

Predictive vehicle collision avoidance system using raspberry pi it seemed like to avoid accidents in the blind spot area using ultrasonic sensor using raspberry pi module. The ultrasonic sensor works like radar system to detect the obstacles in the blind spot that can Cause the accidence but it is cheaper than it. In addition to that the ultrasonic sensor is used to measure the distance between the vehicle and the obstacles and saved the distance safe before fatalities happened and alerting the driver before the accidence using two ways visualization using light emitting diode (LED) and make a sound using buzzer and the driver alone apply the brake or steering to controlling on the speed. The main advantage of ultrasonic sensor is that it provides highest reliability in getting proximity and has lesser absorption than RF and IR frequencies. Advanced Accident-Avoidance System for Automobiles. This paper discussed the most important factors of accident due to the intersection accident and the bad weather and this whether to some extent either the heavy rain, huge ice or high darkness. Indeed, this bad weather conditions the driver feel very harsh to drive the vehicle and cannot controlling the car. In this paper there are for types of sensors such as lm35 temperature sensor and humidity sensor and those sensors are used to check the weather states and alert the driver if any thinks happen in the weather. And there are a substation number of ultrasonic sensors to detect the near car and infrared sensors used to detect the forward cars by using burst of light to measure the cars speed, distance and position those sensors were fixed in the both car sides and in the forward of the vehicle to avoid all the cars and any barrier and alert the driver. This system was provided by Global System for Mobile communications (GSM) and Global Positioning System (GPS) module. If the accidence were happened then the system automatically takes position of the car and sends it to the police office and the driver family to save the driver and passenger’s health.

III.METHODOLOGY

PROPOSED SYSTEM

In this project user implements Arduino based obstacle avoiding robot. This robot uses ultrasonic sensor to detect the obstacle in between the path and then avoid them to completes its objective. The obstacle avoidance vehicle uses ultrasonic sensors for its movements. A microcontroller of Arduino family is used to achieve the desired operation. The motors are connected through motor driver IC to microcontroller. The ultrasonic sensor is attached in front of the vehicle. Whenever the vehicle is going on the desired path the ultrasonic sensor transmits the ultrasonic waves continuously from its sensor head. Whenever an obstacle comes ahead of it the ultrasonic waves are reflected from an object and that information is passed to the microcontroller. The microcontroller controls the motors based on ultrasonic signals. The robot makes real-time decisions based on distance measurements, allowing for smooth and efficient navigation through dynamic environments. Below is a detailed breakdown of its features and functionality:

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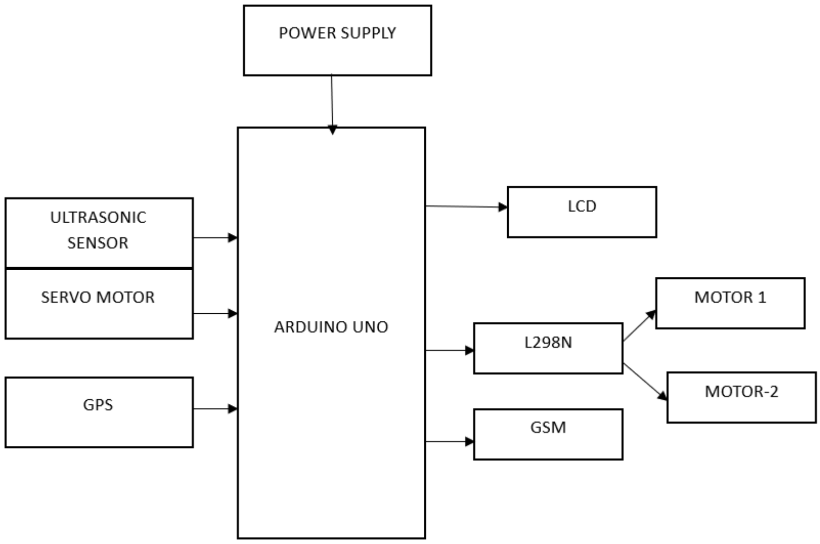

Fig.3.1: Block Diagram of Proposed System

Features:-

1. Obstacle Detection Using Ultrasonic Sensor:

The robot employs an ultrasonic sensor placed at the front to detect obstacles in its path. The sensor sends out ultrasonic waves, which reflect off objects and return to the sensor. The time taken for the waves to return is measured, helping the robot detect obstacles.

2. Automatic Obstacle Avoidance:

The robot can automatically detect obstacles in its path and take appropriate action to avoid them. This is achieved through real-time data processing from the ultrasonic sensor, which prompts the microcontroller to adjust the robot's direction or stop.

3. Arduino Microcontroller for Control:

An Arduino microcontroller (part of the Arduino family) is used to process the signals from the ultrasonic sensor. It makes decisions based on the data received and controls the robot's motors to avoid obstacles.

4. Motor Control via Motor Driver IC:

Motors that drive the robot's wheels are connected to the Arduino through a motor driver IC. The motor driver translates signals from the microcontroller into power for the motors, enabling movement and direction changes.

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5. Continuous Ultrasonic Wave Emission:

- The ultrasonic sensor emits continuous waves, constantly scanning the area ahead of the robot. This ensures real-time obstacle detection as the robot moves forward.

6. Efficient Path Management:

- The robot ensures that its objective is completed by following the optimal path and avoiding obstacles. It uses distance-based data to identify potential blockages and alter its course in real-time.

7. Simple and Cost-Effective Implementation:

- The use of Arduino and basic components (ultrasonic sensor, motors, motor driver) makes the system cost-effective and easy to implement. It is an ideal solution for beginners and educational projects focused on robotics and automation.

8. Dynamic Environment Adaptability:

- The system can work in various environments with dynamic obstacles. The robot's behavior adapts based on the changing location and distance of obstacles in its surroundings.

IV.COMPONENTS

The components in Obstacle Detection and accident avoiding system using radar for advance vehicles is explained in this section. This contain both hardware and software components.

Let us talk about them one by one:

HARDWARE COMPONENTS

(1)Arduino Uno:-

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Fig.4.1: Arduino Uno R3 Front & Arduino Uno R3 Back

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The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers.

(2) LCD(Liquid Crystal Display):-

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. A program must interact with the outside world using input and output devices that communicate directly with a human being.

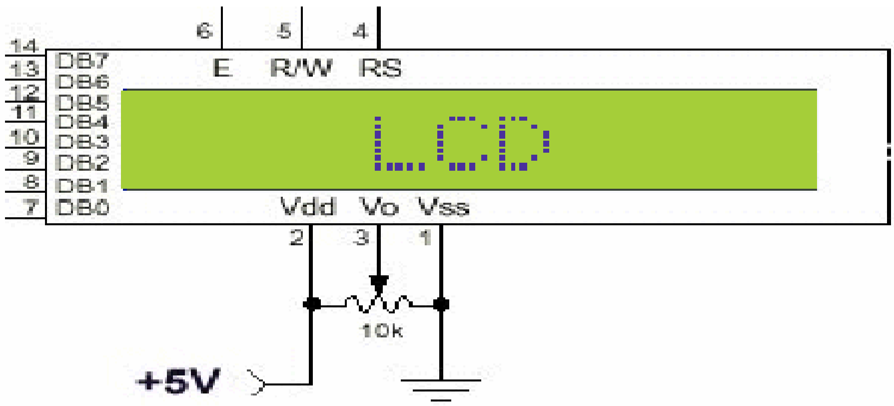

Fig.4.2: Pin Diagram Of 1x16 Lines Lcd

(3) DC Motor:-

A Direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy. An Inductor (coil) inside the DC motor produces a magnetic field that creates rotary motion as DC voltage is applied to its terminal. Inside the motor is an iron shaft, wrapped in a coil of wire. This shaft contains two fixed, North and South, magnets on both sides which causes both a repulsive and attractive

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force, in turn, producing torque. ISL Products designs and manufactures both brushed DC motors and brushless DC motors.

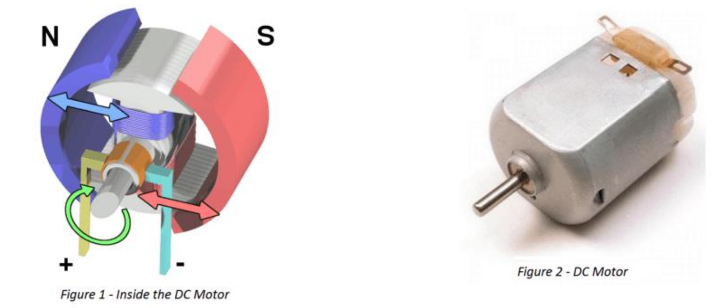

Fig.4.3: DC Motor

(4) GSM Module:-

GSM is a mobile communication modem; it stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is a widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operate at the 850MHz, 900MHz, 1800MHz, and 1900MHz frequency bands.

Fig.4.4: SIM900 GSM Module

(5)Servo motor:-

Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counterclockwise direction.

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Fig.4.5: Servo Motor

(6)Ultrasonic Sensor:-

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sensor and the object.

Fig.4.6: Ultrasonic sensor

(7) L293D Motor Driver IC:-

The L293D is a popular 16Pin Motor Driver IC. As the name suggests it is mainly used to drive motors. A single L293D IC can run two DC motors at the same time also, the direction of these two motors can be controlled independently. So, if motors have operating voltage less than 36V and operating current less than 600mA, which are to be controlled by digital circuits like OpAmp, 555 timers, digital gates or even Micron rollers like Arduino, PIC, ARM etc... this IC will be the right choice. The Enable pins (Enable 1,2 and Enable 3,4) are used to Enable Input pins for Motor 1 and Motor 2 respectively. Since in most cases robot will be using both the motors both the pins are held high by default by connecting to +5V supply. The input pins Input 1,2 are used to control the motor 1 and Input pins 3,4 are used to control the Motor 2. The input pins are connected to the any Digital circuit or microcontroller to control the speed and direction of the motor. You can toggle the input pins based on the following Table to control your motor.

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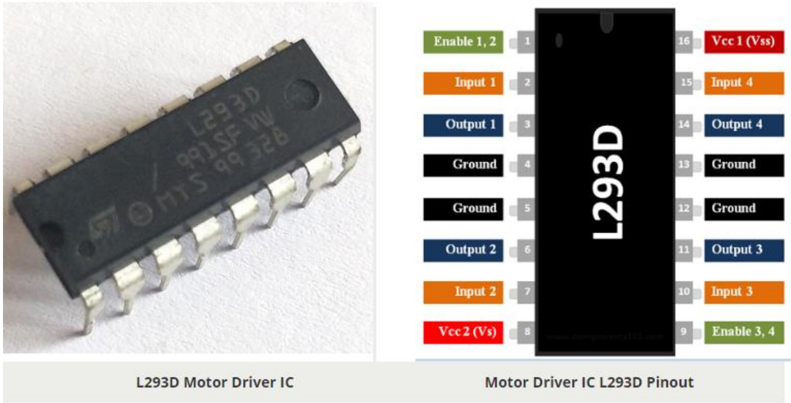

Fig.4.7: L293D Motor Drive & Pins

SOFTWARE COMPONENTS

Arduino IDE:-

The Arduino IDE provides a user-friendly interface for programming Arduino boards, making it accessible to beginners and experienced developers alike. It supports a wide range of Arduino-compatible boards, including the popular Arduino Uno, Nano, Mega, and others, as well as third-party boards based on the Arduino platform. The IDE is available for Windows, macOS, and Linux operating systems, allowing users to develop Arduino projects on their preferred platform.

One of the key features of the Arduino IDE is its simplicity and ease of use. The IDE includes a text editor with syntax highlighting and autocompletion features, making it easy to write and edit code in the Arduino programming language, which is based on Wiring and C/C++. Users can write sketches (Arduino programs) using familiar programming constructs such as functions, variables, loops, and conditional statements.

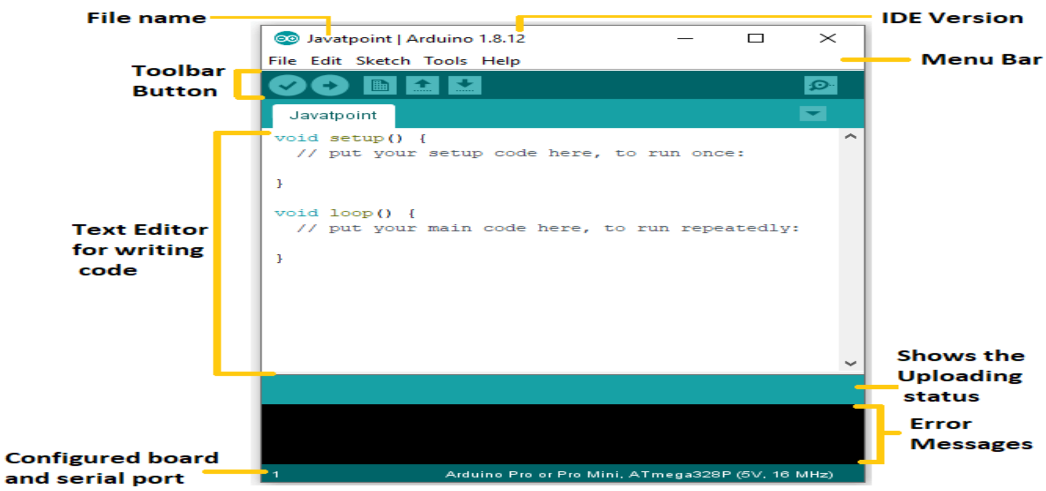

Fig.4.8**:** Arduino IDE

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V. WORKFLOW OF PROPOSED SYSTEM

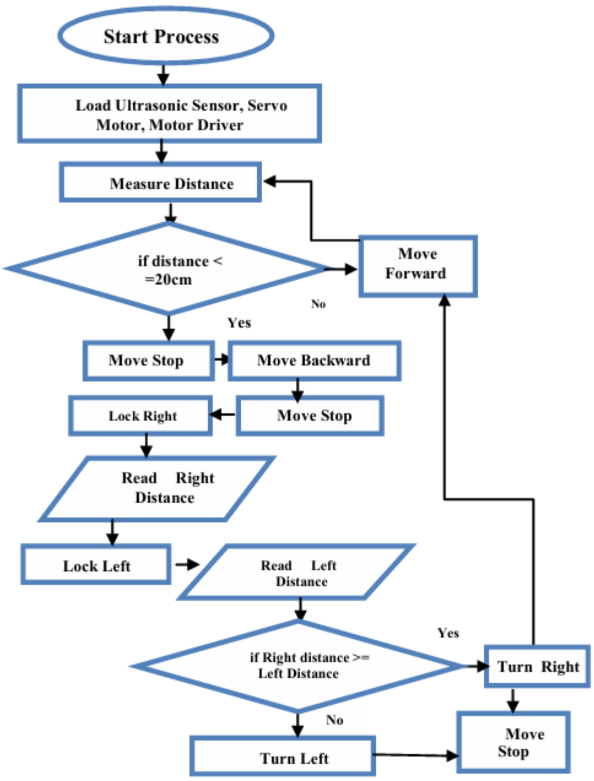

Fig.5.1: Workflow of Proposed System

1. If no interrupt from any side, then robot is move in straight direction. The obstacle detection is carried out by software, which analyzes and processes scene images captured by an Ultrasonic Sensor installed on the ceiling inside the site, where the robot and the obstacles are located. After building a computer model of the site with its different objects (the robot and the obstacles), the system starts planning the routing path that reaches from the current point to other possible end points. The methods and techniques used for building the model are image processing and computer vision. The former involves manipulating a digital image to generate a second image that differs in some respects from the original one.

2. If interrupt from left side, then robot is move to right direction. It checks resolution between 640 * 480-pixel format. From above resolution x-axis is 355 and y axis is 150 therefore for area is 136327. This gives response of red color because coding design for red color configuration. Object gives interrupt from left side. By RS 232 serial communication, it takes command from Arduino to L293D IC to avoid collision. Therefore, with the help of coding it gives command to system to move in right direction.

3. If interrupt from right side, then robot move to left direction. It checks resolution between 640 * 480-pixel format. From above resolution x-axis is 128 and y axis is 205 therefore for area is 103648. This gives response of red color because coding design for red color configuration. Object gives interrupt from right side. By RS 232

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serial communication, it takes command from Arduino to L293D IC to avoid collision. Therefore, with the help of coding it gives command to system to move in left direction

4. If interrupt from opposite side, then robot is stop. It checks resolution between 640 * 480-pixel format. From above resolution x-axis is 260 and y-axis is 198 therefore for area is 144591. This gives response of red color because coding design for red color configuration. Object gives interrupt from opposite side. By RS 232 serial communication, it takes command from Arduino to L293D IC to avoid collision. Therefore, with the help of coding it gives command to system stop.

When we supply the power to the controlling device, which includes the Arduino UNO board, then it tends to move the servo motor as per the source code of the programming, and initially, we are placing the ultrasonic sensor on the servo motor for the rotation that accurately measures the circumvolution of the sensor for the observation. As per the working principle of an ultrasonic sensor, it emits radio waves through the transmitter, and those waves strike the stationary object and initially detect the obstacle. Simultaneously, the buzzer turns on and gives alertness. We are establishing the ultrasonic sensor range to the 1meter (100 cm) distance, and that distance can be calculated through the sensor distance formula. Through the productive nature of the LCD display, it displays the object distance and the angle of rotation.

The workflow of the radar-based obstacle detection and accident-avoidance system involves real-time monitoring, continuous assessment of collision risks, and proactive safety measures. By integrating radar data with vehicle control systems and leveraging advanced algorithms, the system ensures that the vehicle responds dynamically and effectively to avoid accidents, ultimately enhancing vehicle safety in various driving conditions

Implementation:-

The controlling section of the system is programmed in Arduino then this microcontroller module setup on digital I/O pins of 4–7 of the UNO board. So, the Arduino digital I/O pins 4 is linked to the motor to move left forward, 5 is linked to the motor to move left backward, 6 is linked to the motor to move right forward and 7 is linked to the motor to move left backward that are programmed as output pins in this architecture of a system.

The construction of a smart autonomous vehicle initializes with an ultrasonic sensor, micro-servo motor, and motor driver. The implementation of an ultrasonic sensor measures the distance of an obstacle. If the measured distance is less than or equal to within 20 cm then the motor movement is stopped. When it is stopped, then it is moved to backward, locked in the right direction which needs to read right and left distance. If the right side of the measured distance is greater than or equal to the left side of the measured distance, then the motor turns to the left again to measure the distance of an obstacle. But if the measured distance is not less than or equal to 20 cm, then the vehicle can move forward, which is shown in flowchart.

The radar-based obstacle detection system shares data with other ADAS systems like adaptive cruise control, lane-keeping assistance, and automatic parking. If an obstacle is detected and preventive actions are triggered, the system records key data points such as vehicle speed, obstacle location, and actions taken (e.g., braking or steering

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intervention). As the vehicle continues to drive, the system adapts and recalculates the safest path. It continuously monitors the surroundings and adjusts vehicle control if necessary to ensure safety.

The Smart Autonomous vehicle moves forward and automatically calculate the distance of an obstacle. When an obstacle is found within 20 cm through ultrasonic sensor then the collected message frames are forwarded to the controller. The controller is received the message using CAN protocol that instruct the command to control the movement of motor in left forward, left backward, right forward and right backward. Due to the successful implementation of collision avoidance algorithm, we can minimize the cause of mishap.

To assess the system's real-time performance, the sensor fusion and clustering algorithms were optimized for computational efficiency. The following results were obtained from testing in a simulated environment:

Processing Time: The average processing time for sensor fusion was 12ms per frame, while the clustering algorithm processed the data in 8ms. This allows the system to operate at a frame rate of approximately 60 frames per second, ensuring real-time obstacle detection. Algorithms can be used to search path and good adaptability.

Latency Reduction: By using parallel processing and data down sampling techniques, the overall system latency was reduced by 25% compared to traditional obstacle detection methods that rely solely on RADAR.

Given the need for obstacle detection to operate in real-time, the proposed methodology is optimized to ensure low latency processing. The key strategies for real-time optimization include:

1.Algorithmic Efficiency: The sensor fusion and clustering algorithms are optimized for computational efficiency, reducing the time required for data preprocessing, association, and clustering.

2.Parallel Processing: The sensor fusion process is parallelized using multi-threading to handle RADAR data simultaneously, minimizing delay.

The implementation of a radar-based obstacle detection and accident-avoidance system enhances vehicle safety by offering real-time monitoring of the surrounding environment and taking appropriate actions to prevent collisions. Integrated with advanced vehicle systems, it provides an essential layer of protection for both drivers and pedestrians, contributing to the development of safer, smarter vehicles. The system is useful for the other devices requiring distance measurement of a moving or stationary object or obstacle. The accuracy is sufficient for normal practical uses. There was no significant difference in driving behaviors. It is also important that the design consider both subjective evaluation and driving behavior.

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VI. CONCLUSION & FUTURE SCOPE

Conclusion: -

Obstacle avoidance capability needs to be considered when designing mobile robots for different applications. The low-cost ultrasonic sensor for mobile robot is aim to design and implement a helpful tool that improves the ability of mobile robot to avoid obstacle successfully. A series of test were done to check the reliability of the system. In our experiment the ultrasonic distance sensing element was accustomed to offer a large field of detection. Which can be implemented on mobile robots both remotely controlled and also on autonomous mode, once in the autonomous mode, the initial loading of the code needs no user intervention throughout its operation. When it is placed in an unknown setting with obstacles, it runs while avoiding all obstacles with significant accuracy.

Presented a sensor fusion framework for obstacle detection in autonomous vehicles, leveraging the strengths of both LIDAR and RADAR sensors. The fusion of spatially rich LIDAR data with velocity informed RADAR data enables the system to detect obstacles with greater accuracy and reliability than using individual sensors alone.

The results demonstrated that the fused data improved obstacle detection precision to 92%, a significant increase compared to LIDAR only or RADAR only approaches. Additionally, the system operates in real-time, processing data at a rate of 60 frames per second with a 25% reduction in latency, making it Suitable for dynamic environments where real-time decision making is critical.

Future Scope: -

By combining sensor fusion with clustering techniques, the proposed system ensures robust performance in diverse conditions, including low visibility and complex urban environments. This work provides a foundation for further advancements in autonomous vehicle perception systems, contributing to the development of safer and more efficient navigation technologies. Future work could focus on expanding the sensor fusion to include cameras and exploring deep learning techniques to improve obstacle recognition and classification.

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