Safe Driving Enabled using IoT

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Abstract. Driving can be an enjoyable experience, but it can quickly turn dangerous when the roads are not properly maintained. Potholes, speed bumps, and objects on the road can all pose a risk to drivers, especially in poor weather conditions. Potholes, in particular, are a common problem caused by weather and poor maintenance, and they can lead to serious accidents. While automobile manufacturers do not provide features to detect potholes, a simple ultrasonic sensor can be a valuable tool for alerting drivers to their presence. The objective of this project is to use an ultrasonic sensor to detect potholes and alert drivers, particularly in risky weather conditions, to make driving safer. The importance of this project is underscored by the fact that potholes and objects left on the road have led to thousands of deaths in recent years.

1 Introduction

The Internet of Things (IoT) is a network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, and connectivity, which enable these objects to connect and exchange data. An ultrasonic sensor is one type of sensor commonly used in IoT applications.

An ultrasonic sensor works by emitting high-frequency sound waves and measuring the time it takes for the waves to bounce back after hitting an object. This technology can be used in IoT applications to detect and measure distance, level, or presence of objects. For example, ultrasonic sensors can be used in smart buildings to detect the occupancy of rooms or to monitor the water level in tanks. In smart agriculture, ultrasonic sensors can measure the distance between plants to optimize irrigation and fertilizer usage. In smart cities, ultrasonic sensors can be used to detect the occupancy of parking spaces, reducing congestion and improving traffic flow. By leveraging the power of ultrasonic sensors in IoT, we can gather real-time data and automate decision-making processes, leading to improved efficiency, productivity, and safety. Ultrasonic sensors are an integral part of IoT systems that enable smart and connected devices to interact with the physical world and provide valuable insights into our environment.

This technology can be used in automobiles to detect obstacles and help drivers avoid collisions. An ultrasonic sensor can be installed in the front or rear bumper of a car to detect nearby objects such as pedestrians, other vehicles, or obstacles. The sensor then sends this

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information to the car's onboard computer, which can alert the driver through a visual or audio warning. The use of ultrasonic sensors in automobiles can greatly enhance safe driving by providing real-time information about the environment and allowing drivers to react quickly to potential hazards on the road. Some examples on how an ultrasonic sensor can be used in automobiles to increase overall safety of the journey:

- Blind Spot Detection: Ultrasonic sensors can be used to detect objects in the car's blind spot, alerting the driver if there is a vehicle or obstacle nearby before changing lanes. Sending a notification to the homeowner's smartphone when a door or window is opened.
- Parking Assistance: Ultrasonic sensors can help drivers park their cars safely by detecting nearby objects and providing guidance through audio and visual warnings.
- Collision Avoidance: Advanced collision avoidance systems can use ultrasonic sensors to automatically apply the brakes or adjust the speed of the vehicle to avoid a potential collision.
- Adaptive Cruise Control: Ultrasonic sensors can be used in conjunction with adaptive cruise control systems to maintain a safe distance from the car in front of you, reducing the risk of rear-end collisions.
- Lane Departure Warning: Ultrasonic sensors can detect when a vehicle is drifting out of its lane and alert the driver, helping to prevent accidents caused by drowsy or distracted driving.

2 Existing methods

The authors from [1] proposed an ultrasonic-based obstacle detection and collision avoidance system for automobiles. The system uses ultrasonic sensors to detect obstacles in the vehicle's path and provides visual and audio warnings to the driver. In addition, the system also uses a microcontroller to control the braking system and automatically apply the brakes if a collision is imminent. The authors conducted experiments to evaluate the system's performance and found that it was able to detect obstacles accurately and prevent collisions in real-world scenarios. The system has the potential to greatly enhance road safety by providing an additional layer of protection against accidents caused by driver error. The system may not work as effectively at high speeds since the reaction time for the system and the driver to avoid a collision is significantly reduced. [1].

The authors from [2] proposed an ultrasonic-based blind spot detection system for automobiles. The system uses ultrasonic sensors installed in the vehicle's rear and side-view mirrors to detect objects in the car's blind spots. If an object is detected, the system provides visual and audio warnings to the driver, helping to prevent accidents caused by lane-changing maneuvers. The system may struggle to accurately detect objects in the blind spot if there are multiple objects in close proximity. This could lead to false negatives, where the system fails to detect an object, potentially leading to accidents. [2].

The authors from [3] proposed an ultrasonic sensor-based automatic parking assistance system for automobiles. The system uses ultrasonic sensors installed in the front and rear bumpers of the car to detect nearby objects and guide the driver into a parking space. The system provides audio and visual feedback to the driver, helping to reduce the risk of collisions during the parking process.The system may struggle to guide the driver in complex parking situations, such as parallel parking or parking in tight spaces. This could lead to the system providing inaccurate guidance, potentially causing collisions or damage to the vehicle. [3].

The authors from [4] an ultrasonic sensor-based intelligent adaptive cruise control system for automobiles. The system uses ultrasonic sensors installed in the front of the car to detect the distance to the vehicle in front and adjust the speed accordingly, maintaining a safe distance and reducing the risk of rear-end collisions. The system also provides audio and visual feedback to the driver, helping to improve road safety. In heavy traffic situations, the system may struggle to maintain a safe distance from the vehicle in front due to frequent and sudden stops and starts. This could lead to the system providing inaccurate speed adjustments, potentially causing collisions. [4].

3 Proposed method

3.1 Problem statement

Despite the significant advances in automotive technology, accidents caused by driver error remain a major concern. According to the National Highway Traffic Safety Administration (NHTSA), over 90% of accidents are caused by human error, with common factors including distracted driving, speeding, and impaired driving. Many of these accidents occur due to a lack of visibility or awareness of obstacles on the road, especially in adverse weather conditions or low-light environments. The NHTSA estimates that rear-end collisions account for approximately 29% of all crashes, and that 87% of these crashes are due to driver inattention or following too closely. To address this problem, there is a need for a reliable and efficient obstacle detection system that can alert the driver of potential hazards in real-time and prevent collisions. Existing solutions such as radar and camera-based systems have shown promise, but they have limitations in certain conditions such as heavy rain, fog, or glare. An ultrasonic sensor-based obstacle detection system can be an effective solution to this problem by providing accurate and timely information about obstacles in the vehicle's path, regardless of weather conditions or lighting. According to a study by the Insurance Institute for Highway Safety (IIHS), forward collision warning systems can reduce rear-end crashes by up to 27%, while automatic emergency braking systems can reduce such crashes by up to 50%.

3.2 Objectives

The project's goal is to develop a reliable, accurate, and cost-effective ultrasonic sensor-based obstacle detection system for automobiles that can enhance road safety by providing timely warnings to the driver. The system should be capable of detecting a range of obstacles, including vehicles, pedestrians, and stationary objects, and should be optimized to minimize false alarms and reduce the risk of driver distraction. The goal is to provide an additional layer of protection against accidents caused by human error and to help reduce the overall number of traffic-related injuries and fatalities. The system should be designed with scalability and ease of integration in mind, allowing it to be easily installed on a wide range of vehicles and adapted to different driving conditions and environments. The following are the project's objectives:

- To develop a reliable and accurate ultrasonic sensor-based obstacle detection system that can detect obstacles in the vehicle's path and provide timely warnings to the driver.
- To evaluate the effectiveness of the system in real-world driving scenarios and identify any potential safety concerns or limitations.
- To ensure that the system is easy to use and understand for drivers, and that it does not distract or overwhelm them with excessive warnings or information.
- To ensure that the system is robust and reliable, with built-in fail-safe mechanisms to prevent system failure or malfunction.
- To evaluate the effectiveness of the system in real-world driving scenarios and identify any potential safety concerns or limitations.

- To optimize the performance of the system by improving the accuracy and range of ultrasonic sensors and minimizing false alarms.

3.3 Architecture diagram

With the help of ESP32 Dev module, ultrasonic sensor, OLED display, and mobile app, we can create an ultrasonic-based obstacle detection system for automobiles. The ESP32 Dev module can be used as the main control unit for the system, allowing it to interface with the ultrasonic sensor and other components. The ultrasonic sensor is used to detect obstacles in the vehicle's path and provide real-time feedback to the driver. The sensor emits high-frequency sound waves that bounce off obstacles and return to the sensor. By measuring the time, it takes for the sound waves to travel back, the sensor can calculate the distance to the obstacle and provide accurate distance readings. The OLED display can be used to provide visual feedback to the driver, such as distance readings and warning messages. And the mobile app can be used to provide additional feedback and control options to the driver. The mobile app can be designed to display distance readings, warning messages, and other relevant information in real-time. The project flow is depicted in Figure 1.
The ultrasonic sensor used here is HC-SR04 sensor. It's a popular ultrasonic sensor module used for distance sensing applications. It is a low-cost, easy-to-use module that operates at a frequency of 40 kHz and can accurately measure distances from 2 cm to 400 cm with an accuracy of up to 3 mm.

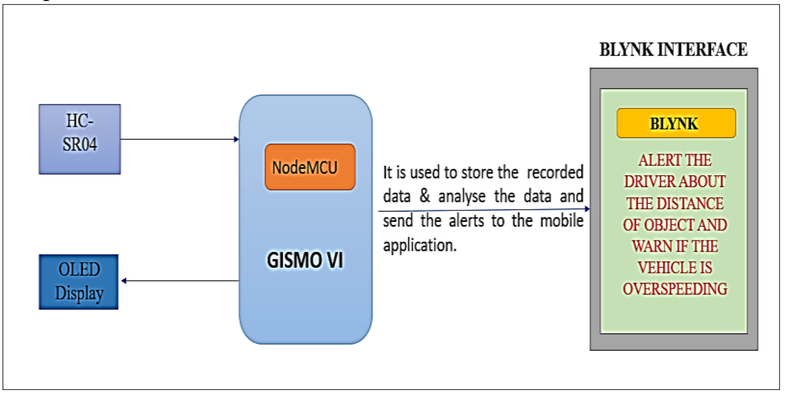

Fig. 1. Architecture diagram.

The flow of this proposed method is as follows:

- Install Ultrasonic Sensors: Install ultrasonic sensors on the front of the car. Ultrasonic sensors emit high-frequency sound waves and detect the time it takes for the sound waves to bounce back after hitting an object. This allows the sensor to calculate the distance to the object.
- Collect Sensor Data: Collect the sensor data using a microcontroller. The microcontroller will receive the data from the ultrasonic sensors and process it to determine if there is an obstacle in front of the car.
- Analyse Sensor Data: Analyse the sensor data to determine the distance to the obstacle. If the distance is less than a certain threshold value, then the system will determine that an obstacle is present.
- Alert the Driver: If an obstacle is detected, the system will alert the driver by providing visual and audio warnings. This can be in the form of a dashboard display, warning the driver to slow down or stop the vehicle.

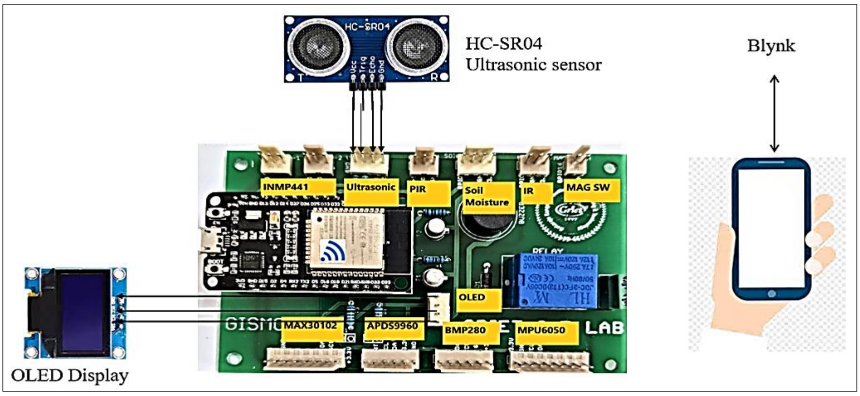

Fig. 2. Connectivity diagram of the proposed system.

3.4 Modules - connectivity diagram

The modules-connectivity diagram is a visual representation of how the various components are connected in the air pollution monitoring system. It shows how the OLED display and HC-SR04 sensor are connected to the ESP32 Node MCU microcontroller. The microcontroller is connected to the internet through Wi-Fi, enabling it to transmit data to the Blynk application. The Blynk application then displays the distance and alerts the user on the interface, allowing users to monitor any obstacles on road. If there is an obstacle on the road, the Blynk application can alert the user and send notifications to their device. The modules-connectivity diagram is an essential reference for understanding the system's architecture. It provides a clear visual representation of how the different components are interconnected in the system, making it easier to understand and maintain the system.

The ESP32-Dev module is the central control unit of the project. It is connected to both the HC-SR04 sensor module and the OLED display. In addition, the module is connected to a mobile app using Wi-Fi communication. HC-SR04 Ultrasonic Sensor module is connected to the ESP32-Dev module using two pins: Trig and Echo. The Trig pin of the sensor is connected to GPIO pin 27 of the ESP32-Dev module, while the Echo pin is connected to GPIO pin 26. The OLED display is connected to the ESP32-Dev module using the I2C communication protocol. The SDA (serial data) pin of the display is connected to GPIO pin 21 of the ESP32-Dev module, while the SCL (serial clock) pin is connected to GPIO pin 22. The mobile app is used to receive real-time obstacle detection data from the ESP32-Dev module. The app communicates with the module using Wi-Fi and displays the obstacle distance on the user's mobile device. This allows the system to detect obstacles in real-time and display the data on the OLED display and the user's mobile device.

The HC-SR04 sensor module consists of four pins: VCC, GND, Trig, and Echo. The VCC and GND pins are used to power the module, while the Trig and Echo pins are used for interfacing with a microcontroller or other control unit. To measure distance, the Trig pin is first set to a high level for at least 10 microseconds, which triggers the sensor to emit an ultrasonic pulse. The pulse travels through the air until it hits an object and is then reflected back to the sensor. The Echo pin is then set to a high level, and the duration of the high signal is measured using a timer. This duration corresponds to the time it takes for the ultrasonic pulse to travel to the object and back, which can be used to calculate the distance to the object using the speed of sound. The following formula can be used to calculate the distance between the sensor and the item based on the timer's count: $D=(S*T)/2$.

3.5 Modules and description

3.5.1 Module 1: Detection of obstacle distance from the vehicle

Module one describes the finding of distance by the ultrasonic sensor. The average height of the bumper to the road is 56cm approx. The ultrasonic sensor is placed at an angle of 25 degrees. For example, if the sensor is placed at the mentioned angle and it is set to give an alert between 3 meters to 4 meters. If any pothole is present in the path of the ultrasonic sound wave, then the overall distance from the sensor to the road is increased then a notification is sent to the driver about the distance of the obstacle on the road.

3.5.2 Module 2: Displaying distance on the OLED display

In this module, the ultrasonic sensor measures the distance and sends it to the esp32 module and the module sends the data to the OLED display and displays the distance on the screen.

- Module 2 sends all the data collected by the ultrasonic sensor to OLED.
- The OLED screen displays the distance thereby giving the driver an idea about how far the object is located.
- The OLED Displays the distance in cm.

3.5.3 Module 3: Updating the distance in the Blynk interface for the user to access

Update the distance into Blynk App and at user can now see the distance of the obstacle ahead in the mobile phone if the user does not have a digital display in the vehicle. In the app, the user gets an alert of ‘Too Close’ is the obstacle is at a distance of 0-100 cm, ‘Close’ is the obstacle is at a distance of 100-500 cm, ‘Far’ if the obstacle is at distance of 500-1000 cm and ‘Too Far’ if the obstacle is at a distance of 1000 cm and above. This provides different scenarios where the user can adapt accordingly.

4 Results and discussions

4.1 Description about Dataset

The following formula is used to compute the distance measured by the ultrasonic sensor. The distance that the sound has travelled is calculated using the equation Distance = (Time x Speed of Sound) / 2. The "2" is added since the sound must be repeated in the formula. The sound first departs from the sensor, then moves away before coming back after striking a surface. The size of the area can be used to gauge the need for a particular distance.

$$\text{Distance} = (\text{speed of sound} * \text{time})/2$$

The experimental setup involves placing obstacles of varying sizes and distances in the path of the vehicle and measuring the accuracy of the system's obstacle detection and distance measurement capabilities. The response time of the system in providing visual warnings can also be evaluated to ensure that it is fast enough to provide the driver with sufficient time to react and avoid a collision. Module one describes the finding of distance by the ultrasonic sensor. The average height of the bumper to the road is 56cm approx. The ultrasonic sensor is placed at an angle of 25 degrees. At this angle the we can get a maximum range of 4m in front of the vehicle to detect the obstacle. The results depict that as the obstacle distance changes, the value of the distance displayed in the OLED change at a very fast refresh rate. In the app, the user gets an alert of ‘Too Close’ is the obstacle is at a distance of 0-100 cm, 'Close' is the obstacle is at a distance of 100-500 cm, 'Far' if the obstacle is at distance of 500-1000 cm and 'Too Far' if the obstacle is at a distance of 1000 cm and above.

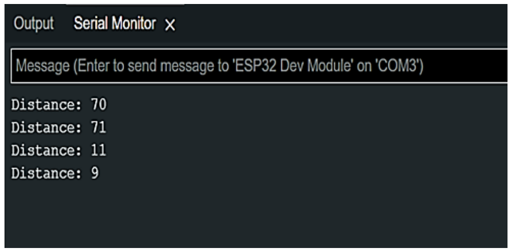

Fig. 3. Readings from the sensors in Serial Monitor

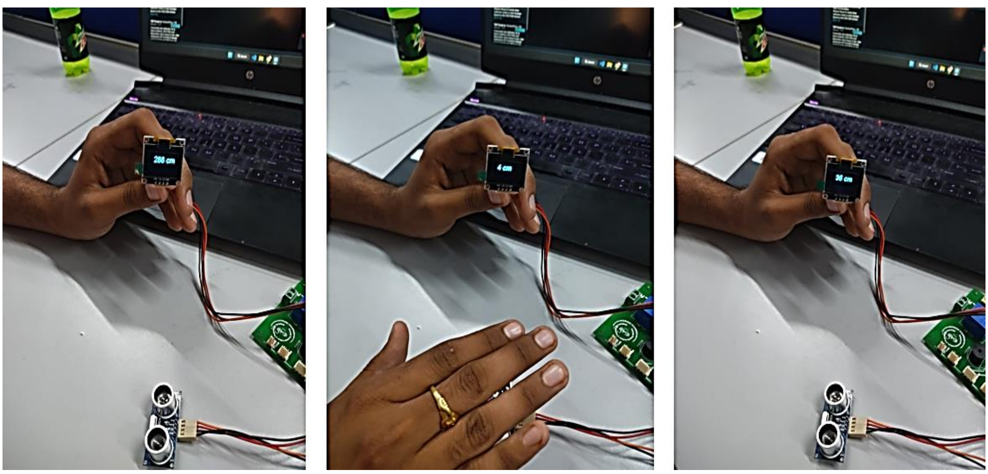

Fig. 4. Displaying distances on the OLED display.

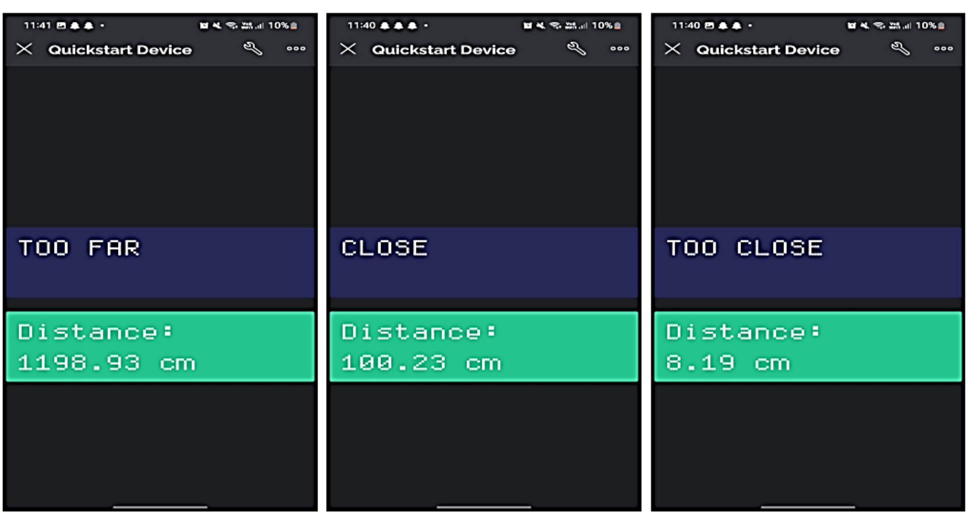

Figure 5. Displaying distances in the Blynk app along with the alerts of the type of distance based on where the obstacle is present.

4.2 Significance of proposed method with advantages

The proposed model of using an ultrasonic sensor in automobiles for obstacle detection and collision avoidance has significant importance in terms of improving road safety. The use of such a system can greatly reduce the risk of accidents caused by driver error or inattention, as the system provides real-time information about obstacles in the vehicle's path and warns the driver accordingly.

The proposed model is also significant in terms of its cost-effectiveness and ease of implementation. The use of an ESP32-Dev module, HC-SR04 ultrasonic sensor, OLED display, and mobile app provides an efficient and effective solution for obstacle detection and distance measurement, which can be easily integrated into existing automobile designs. This makes the proposed model accessible to a wide range of users and manufacturers, allowing for the potential of widespread adoption.

Moreover, the use of an ultrasonic sensor in automobiles is a non-invasive technology, which means that it does not interfere with the normal operation of the vehicle. This is significant as it allows for the system to be installed without causing any additional safety risks or technical complications. Overall, the proposed model is significant in terms of its potential to greatly improve road safety, reduce the risk of accidents, and save lives, while also being cost-effective, easily implementable, and non-invasive.

5 Conclusion

In conclusion, the use of an ultrasonic sensor in automobiles for obstacle detection has the potential to greatly enhance road safety by providing an additional layer of protection against accidents caused by driver error. The proposed method of using an ESP32-Dev module, HC-SR04 ultrasonic sensor, OLED display, and mobile app provides an effective and efficient solution for real-time obstacle detection and distance measurement. This system can be easily integrated into existing automobile designs and can greatly benefit both drivers and pedestrians by reducing the risk of accidents. Overall, the implementation of this proposed method has the potential to greatly improve road safety and save lives.

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