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THE INTELLIGENT CAR WITH ACCIDENT ALERT AND DRIVER ASSISTANCE SYSTEM

Mr. M . Ravi[1], Ch.Sohan[2], B.Aryan[3], M. Vaishnavi[4], B.Srinu[5]

Assistant Professor, Department of Information Technology, Vidya Jyothi Institute of Technology (A), Hyderabad, Telangana, India[1]

UG Students, Department of Information Technology, Vidya Jyothi Institute of Technology (A), Hyderabad, Telangana, India[2,3,4,5]

Abstract – Road accidents Road accidents continue to be a major cause of injuries and fatalities worldwide due to driver negligence, poor visibility, and delayed obstacle detection. Traditional vehicle safety systems mainly focus on minimizing accident impact rather than preventing collisions. This paper presents an **IoT Based Intelligent Car with Driver Assistance System**, an intelligent and cost-effective solution developed using the **ESP32 microcontroller**, **HC-SR04 ultrasonic sensor**, **SG90 servo motor**, **L298N motor driver**, and the **built-in Bluetooth** of the ESP32. The ultrasonic sensor continuously scans the surroundings by rotating through the servo motor to detect nearby obstacles. Based on the measured distance, the ESP32 controls the vehicle to avoid collisions automatically. Users can also operate the vehicle manually through Bluetooth using a smartphone application. Experimental testing demonstrated reliable obstacle detection, smooth Bluetooth communication, and efficient autonomous navigation. The proposed system is affordable, portable, and suitable for educational, research, and intelligent transportation applications. By integrating embedded systems with IoT technology, the system enhances driver safety and contributes to the development of smart transportation.

Key Words: Internet of Things (IoT), ESP32, Intelligent Car, Driver Assistance System, Obstacle Avoidance, Ultrasonic Sensor, Bluetooth Control, Servo Motor, L298N Motor Driver, Embedded Systems.

1. INTRODUCTION

Road accidents are one of the major causes of injuries and fatalities worldwide. Factors such as driver negligence, poor visibility, overspeeding, and delayed obstacle detection contribute significantly to these accidents. Conventional vehicle safety systems mainly reduce the impact of accidents but do not actively assist drivers in preventing collisions.

Recent advancements in the Internet of Things (IoT), embedded systems, and wireless communication have enabled the development of intelligent vehicle safety solutions. By integrating sensors, microcontrollers, and communication technologies, vehicles can detect obstacles and assist drivers in real time.

The proposed **IoT Based Intelligent Car with Driver Assistance System** is developed using an **ESP32 microcontroller**, **HC-SR04 ultrasonic sensor**, **SG90 servo motor**, **L298N motor driver**, and the **built-in Bluetooth** feature of ESP32. The ultrasonic sensor continuously scans the surroundings to detect obstacles, while Bluetooth allows users to control the vehicle manually using a smartphone. The system also supports autonomous obstacle avoidance, making vehicle navigation safer and more efficient.

The proposed system provides a low-cost, reliable, and user-friendly solution suitable for educational projects, research applications, and prototype intelligent transportation systems.

1.1 Objectives of the Study

The primary objective of this study is to design and develop an **IoT Based Intelligent Car with Driver Assistance System** that enhances vehicle safety through real-time obstacle detection and autonomous navigation.

The specific objectives are:

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1. To develop an intelligent vehicle using the ESP32 microcontroller.
2. To detect nearby obstacles using the HC-SR04 ultrasonic sensor.
3. To provide wider obstacle scanning using an SG90 servo motor.
4. To enable Bluetooth-based manual control using the built-in Bluetooth feature of ESP32.
5. To implement autonomous obstacle avoidance for safer navigation.
6. To improve driver assistance through real-time obstacle monitoring.
7. To develop a low-cost, reliable, and user-friendly intelligent transportation system.

1.2 Scope of the Work

The scope of this work is to develop an intelligent vehicle capable of operating in both manual and autonomous modes. The system continuously monitors its surroundings using an ultrasonic sensor to detect obstacles and avoid collisions. The built-in Bluetooth feature of the ESP32 allows users to control the vehicle wirelessly through a smartphone.

The proposed system is suitable for educational projects, embedded systems research, robotic applications, and prototype intelligent transportation systems. Future enhancements may include GPS navigation, cloud connectivity, AI-based obstacle recognition, and mobile application support.

2. LITERATURE REVIEW

The rapid advancement of IoT, embedded systems, and wireless communication has significantly contributed to intelligent transportation systems. Researchers have developed various vehicle safety solutions that improve obstacle detection, collision avoidance, and autonomous navigation.

Several studies have used ultrasonic sensors with microcontrollers such as Arduino and ESP32 to detect obstacles and assist drivers in avoiding collisions. These systems provide reliable short-range obstacle detection but often lack integrated manual control and intelligent navigation.

Bluetooth-controlled robotic vehicles have become popular for wireless operation through smartphones. Although these systems offer convenient manual control, they generally rely on user input and do not support autonomous obstacle avoidance.

Recent intelligent vehicle systems combine embedded controllers, ultrasonic sensors, servo motors, and motor drivers to improve autonomous navigation. However, many existing solutions are either expensive or designed for specific industrial applications.

The proposed **IoT Based Intelligent Car with Driver Assistance System** overcomes these limitations by integrating Bluetooth control, ultrasonic-based obstacle detection, servo scanning, and autonomous navigation into a single affordable platform.

Ref.	Focus Area	Technology used	Key Limitation
[1]	Smart Obstacle Detection	Arduino + Ultrasonic Sensor	Manual control only
[2]	Bluetooth Robot Car	HC-05 Bluetooth	No obstacle avoidance
[3]	Autonomous Robot	Ultrasonic + Servo	No manual Bluetooth mode
[4]	Vehicle Navigation	ESP32 + Sensors	Higher High implementation cost
Proposed	IoT Intelligent Car with Driver Assistance	ESP32, Ultrasonic Sensor, Servo Motor, Bluetooth, L298N	Provides both Bluetooth control and autonomous obstacle avoidance

Table -1: Comparative Analysis of Existing Systems

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3. PROPOSED SYSTEM AND METHODOLOGY

The proposed **IoT Based Intelligent Car with Driver Assistance System** is designed to improve vehicle safety by integrating obstacle detection, Bluetooth-based manual control, and autonomous navigation into a single intelligent platform. The system is built around the **ESP32 microcontroller**, which serves as the central processing unit and controls all hardware components.

An **HC-SR04 ultrasonic sensor**, mounted on an **SG90 servo motor**, continuously scans the surroundings of the vehicle to detect nearby obstacles. The servo rotates the sensor to provide a wider scanning range, enabling effective obstacle detection from multiple directions. Based on the measured distance, the ESP32 processes the sensor data and controls the **L298N motor driver** to move the vehicle safely by selecting an obstacle-free path.

The built-in Bluetooth feature of the ESP32 enables users to manually control the vehicle using a smartphone application. The system can operate in both manual and autonomous modes, making it flexible for different operating conditions.

3.1 System Architecture

The proposed system consists of three major sections:

Input Section

- HC-SR04 Ultrasonic Sensor
- Bluetooth Commands from Smartphone

Processing Section

- ESP32 Microcontroller

Output Section

- L298N Motor Driver
- DC Motors
- SG90 Servo Motor

The ESP32 receives data from the ultrasonic sensor and Bluetooth interface, processes the information, and controls the motors for intelligent navigation.

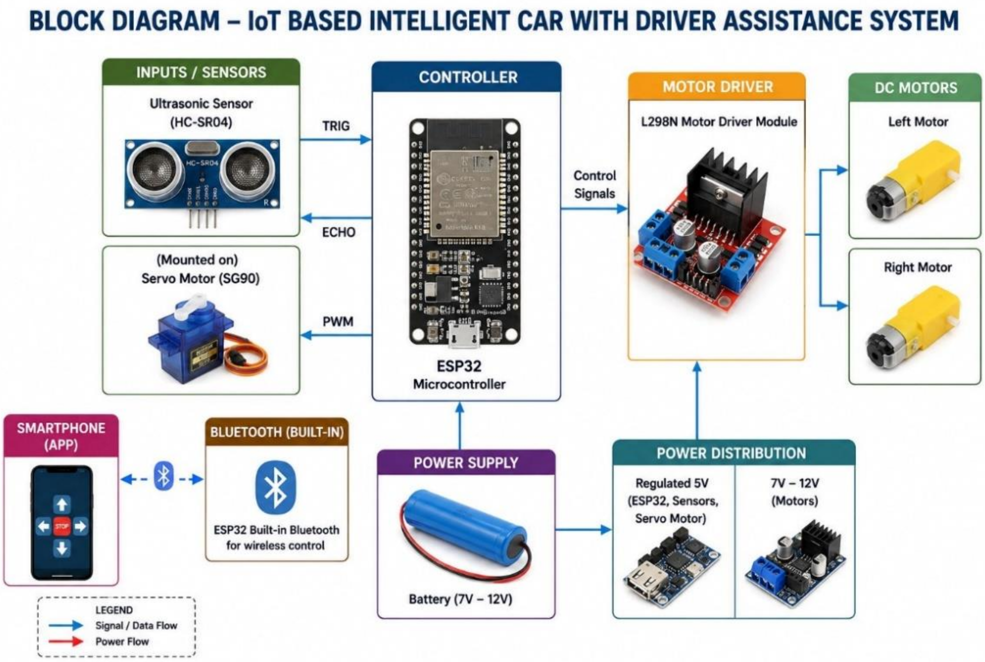

Fig -1: System Architecture of the Proposed IoT Intelligent car with Accident Alert and Driver Assistant System

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3.2 Hardware Components

The proposed system is implemented using affordable and easily available hardware components. The major components are listed below:

- **ESP32 Microcontroller** – Acts as the central controller of the system. It processes sensor data, controls vehicle movement, and provides built-in Bluetooth connectivity for wireless communication.
- **HC-SR04 Ultrasonic Sensor** – Measures the distance between the vehicle and nearby obstacles to support obstacle detection and autonomous navigation.
- **SG90 Servo Motor** – Rotates the ultrasonic sensor to scan obstacles in multiple directions, improving the vehicle's ability to identify a safe path.
- **L298N Motor Driver Module** – Controls the speed and direction of the DC motors based on commands received from the ESP32.
- **DC Gear Motors** – Drive the wheels of the intelligent car, enabling forward, backward, left, and right movement.
- **Robot Chassis** – Provides structural support for mounting all electronic and mechanical components securely.
- **Breadboard** – Used for assembling and testing the electronic circuit without soldering. It allows easy modification of connections during prototype development.
- **Power Switch** – Used to turn the system ON and OFF safely without disconnecting the battery, providing convenient operation.
- **Rechargeable Battery Pack** – Supplies power to the ESP32, motor driver, and other electronic components.
- **Jumper Wires** – Used for making electrical connections between the ESP32, sensors, motor driver, and other hardware components.

3.3 Software Platform

The software is developed using the **Arduino IDE** with **Embedded C/C++** programming language.

The ESP32 continuously reads ultrasonic sensor data, processes obstacle information, controls the motors through the L298N motor driver, and receives Bluetooth commands from a smartphone. The built-in Bluetooth feature allows wireless communication without requiring an external Bluetooth module.

3.4 Working Principle

The proposed **IoT Based Intelligent Car with Driver Assistance System** operates through the following steps:

- The proposed **IoT Based Intelligent Car with Driver Assistance System** operates through the following steps:
- The **ESP32 microcontroller** initializes all connected hardware components, including the ultrasonic sensor, servo motor, motor driver, and built-in Bluetooth module.
- The **HC-SR04 ultrasonic sensor** continuously measures the distance between the vehicle and nearby obstacles.
- The **SG90 servo motor** rotates the ultrasonic sensor to scan the **left, front, and right** directions, providing a wider field of obstacle detection.
- The ESP32 continuously receives and processes the distance values from the ultrasonic sensor in real time.
- If the detected distance is greater than the predefined safety limit, the vehicle moves forward normally.
- If an obstacle is detected within the safety range, the ESP32 immediately stops the vehicle to prevent a collision.
- The servo motor rotates the ultrasonic sensor to scan both the left and right sides of the vehicle.
- The ESP32 compares the measured distances on both sides and identifies the direction with more free space.
- Based on the comparison, the ESP32 controls the **L298N motor driver** to turn the vehicle toward the safer direction and continues its movement.

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- In **manual mode**, the user connects a smartphone to the **built-in Bluetooth of the ESP32** and sends movement commands such as **Forward, Backward, Left, Right,** and **Stop**.
- The ESP32 receives these Bluetooth commands and controls the DC motors accordingly, allowing the user to operate the vehicle wirelessly.
- The system continuously repeats the obstacle detection, path selection, and movement process, ensuring smooth navigation and effective obstacle avoidance.

3.5 Control Algorithm

The simplified control algorithm of the proposed system is given below:

Step 1: Initialize the ESP32, ultrasonic sensor, servo motor, Bluetooth, and motor driver.

Step 2: Read the distance from the ultrasonic sensor.

Step 3: Rotate the servo motor to scan the surroundings.

Step 4: Compare the measured distance with the predefined safety limit.

Step 5: If the path is clear, move the vehicle forward.

Step 6: If an obstacle is detected:

- Stop the vehicle.
- Scan the left and right directions.
- Select the safer path.
- Turn the vehicle and continue moving.

Step 7: If Bluetooth commands are received, execute the corresponding movement (Forward, Backward, Left, Right, Stop).

Step 8: Repeat the process continuously.

4. IMPLEMENTATION

The proposed **IoT Based Intelligent Car with Driver Assistance System** was implemented by integrating the ESP32 microcontroller, HC-SR04 ultrasonic sensor, SG90 servo motor, L298N motor driver, and DC motors. Each hardware module was tested individually before integrating them into a complete system. The software was developed using the Arduino IDE, and the system was evaluated in both manual and autonomous modes to ensure reliable operation.

4.1 Bluetooth Control Module

The Bluetooth Control Module enables the user to operate the intelligent car wirelessly using the **built-in Bluetooth feature of the ESP32**. A smartphone application is used to establish a Bluetooth connection with the ESP32. Once connected, movement commands such as **Forward, Backward, Left, Right,** and **Stop** are transmitted to the ESP32.

The ESP32 receives these commands and processes them in real time. Based on the received command, it controls the **L298N motor driver**, which drives the DC motors to perform the required movement. This module provides smooth wireless control without requiring an external Bluetooth device.

4.2 Obstacle Detection and Avoidance Module

The obstacle detection module uses the **HC-SR04 ultrasonic sensor** mounted on an **SG90 servo motor** to detect nearby obstacles. The servo motor continuously rotates the sensor to scan the front, left, and right sides of the vehicle.

Whenever an obstacle is detected within the predefined safety distance, the ESP32 immediately stops the vehicle. The servo motor then scans both sides, and the ESP32 compares the measured distances to identify the safest direction. The

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vehicle automatically turns toward the path with greater clearance and resumes its movement. This module enables autonomous navigation and helps prevent collisions.

4.3 Motor Control Module

The motor control module consists of the **L298N motor driver** and **DC gear motors**. The L298N receives control signals from the ESP32 and regulates the direction and speed of the motors.

Depending on the operating mode, the vehicle performs movements such as forward, backward, left turn, right turn, and stop. The motor driver ensures smooth motor operation while protecting the ESP32 from high-current loads. This module provides reliable movement during both manual and autonomous operation.

4.4 Servo Scanning Module

The **SG90 servo motor** plays an important role in increasing the obstacle detection range of the intelligent car. It rotates the ultrasonic sensor between different angles, allowing the system to monitor a wider area instead of detecting obstacles only in the forward direction.

By scanning multiple directions, the ESP32 receives accurate distance measurements and can determine the safest path for navigation. This improves the efficiency of obstacle avoidance and enhances the overall performance of the system.

4.5 System Integration

After testing each module individually, all hardware components were integrated into a single intelligent vehicle. The ESP32 communicates with the ultrasonic sensor, servo motor, motor driver, and built-in Bluetooth module simultaneously.

The integrated system successfully performs obstacle detection, autonomous navigation, and Bluetooth-based manual control. Experimental testing confirmed smooth communication between all components, stable vehicle movement, and reliable obstacle avoidance under different operating conditions.

Fig. 2: Hardware Prototype of the Proposed Intelligent Car

5. RESULTS AND DISCUSSION

After implementing the proposed **IoT Based Intelligent Car with Driver Assistance System**, each hardware and software module was tested individually before integrating the complete system. The Bluetooth control module, obstacle detection module, servo scanning module, and motor control module were evaluated under different operating conditions to verify their performance and reliability.

The Bluetooth module successfully established a stable wireless connection between the smartphone and the ESP32, allowing the user to control the vehicle in real time. The vehicle accurately responded to movement commands such as **Forward, Backward, Left, Right,** and **Stop** without noticeable communication delays.

The obstacle detection system was tested by placing objects at different distances from the vehicle. The HC-SR04 ultrasonic sensor successfully detected nearby obstacles within the predefined safety range. Whenever an obstacle was

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detected, the ESP32 immediately stopped the vehicle and rotated the servo motor to scan both the left and right directions. After comparing the measured distances, the vehicle selected the safer path and continued its movement without collision.

The L298N motor driver provided smooth control of the DC motors in both manual and autonomous modes. The integrated system demonstrated stable performance, reliable obstacle detection, and efficient navigation under different testing conditions.

Overall, the proposed system successfully combined Bluetooth-based manual control with autonomous obstacle avoidance, making it suitable for intelligent robotic vehicle applications and educational projects.

Module	Test Condition	Observed Behaviour	Result
Bluetooth Module	Smartphone connected to ESP32	Stable Bluetooth connection established	Pass
Manual Control	Forward, Backward, Left, Right, Stop commands	Vehicle responded correctly to all commands	Pass
Ultrasonic Sensor	Obstacle placed in front of vehicle	Obstacle detected successfully	Pass
Servo Motor	Obstacle detected	Sensor rotated to scan left and right directions	Pass
Obstacle Avoidance	Obstacle within safety distance	Vehicle stopped and selected safer path	Pass
Motor Driver	Different movement commands	Smooth control of DC motors	Pass
Autonomous Navigation	Vehicle operated without manual control	Successfully avoided obstacles	Pass
System Integration	Complete system tested	All modules operated correctly without errors	Pass

Table -2: Functional Testing Summary

The experimental results demonstrate that the proposed intelligent vehicle performs efficiently in both manual and autonomous modes. The ultrasonic sensor accurately detected obstacles, while the servo motor improved obstacle detection by scanning multiple directions. The ESP32 processed sensor data in real time and controlled the motor driver effectively, ensuring smooth vehicle movement.

The built-in Bluetooth of the ESP32 provided reliable wireless communication with the smartphone, enabling seamless manual control. The integration of all hardware modules resulted in a stable and efficient intelligent vehicle capable of obstacle detection, autonomous navigation, and wireless operation.

Although the prototype performed well during testing, its performance may be affected in environments with highly reflective or irregular surfaces, where ultrasonic sensing accuracy can vary. Future enhancements can further improve navigation by integrating GPS, computer vision, or artificial intelligence techniques.

6. ADVANTAGES OF THE PROPOSED SYSTEM

- Provides real-time obstacle detection using the HC-SR04 ultrasonic sensor.
- Supports both **manual** and **autonomous** operating modes.
- Uses the built-in Bluetooth feature of the ESP32 for wireless control.
- Automatically avoids obstacles by selecting the safest path.
- Low-cost and easy to implement using readily available components.
- Portable and suitable for educational, research, and robotic applications.
- Energy-efficient with low power consumption.
- Easy to expand by integrating additional IoT sensors and smart technologies.
- Improves navigation efficiency and reduces the risk of collisions.
- Provides a user-friendly platform for learning embedded systems and IoT..

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7. FUTURE SCOPE

The proposed **IoT Based Intelligent Car with Driver Assistance System** successfully provides Bluetooth-based manual control and autonomous obstacle avoidance. However, several enhancements can be incorporated in future versions to improve its functionality and performance.

- **GPS Integration:** A GPS module can be added to provide real-time location tracking and navigation.
- **Mobile Application Development:** A dedicated mobile application can be developed to offer an improved user interface and enhanced vehicle control.
- **AI-Based Navigation:** Artificial Intelligence (AI) and Machine Learning (ML) algorithms can be integrated to enable intelligent path planning, object recognition, and adaptive decision-making.
- **Camera-Based Vision System:** A camera module can be incorporated to recognize traffic signs, lanes, pedestrians, and other road conditions.
- **IoT Cloud Connectivity:** Cloud platforms can be integrated to monitor the vehicle remotely, store operational data, and analyze performance in real time.
- **Voice Control:** Voice recognition can be implemented to allow users to control the vehicle through voice commands, improving accessibility and convenience.
- **Additional Safety Sensors:** Sensors such as infrared, gas, temperature, or vibration sensors can be integrated to enhance safety and expand the vehicle's functionality.

These improvements will make the proposed system more intelligent, reliable, and suitable for advanced autonomous vehicle and smart transportation applications.

8. CONCLUSION

This paper presented the design and implementation of an **IoT Based Intelligent Car with Driver Assistance System** using the **ESP32 microcontroller**, **HC-SR04 ultrasonic sensor**, **SG90 servo motor**, **L298N motor driver**, and the **built-in Bluetooth feature of the ESP32**. The system was developed to improve vehicle safety by combining real-time obstacle detection, autonomous obstacle avoidance, and Bluetooth-based manual control into a single intelligent platform.

Experimental testing demonstrated that the ultrasonic sensor accurately detected nearby obstacles, while the servo motor enhanced obstacle detection by scanning multiple directions. The ESP32 efficiently processed sensor data and controlled the motor driver, enabling smooth and reliable vehicle movement. The built-in Bluetooth feature allowed users to wirelessly control the vehicle through a smartphone, providing flexibility between manual and autonomous operation.

The proposed system is affordable, reliable, portable, and easy to implement using readily available components. It is suitable for educational purposes, research projects, robotic applications, and prototype intelligent transportation systems. Overall, the developed intelligent car demonstrates the effective use of IoT and embedded system technologies to enhance vehicle navigation, improve obstacle avoidance, and contribute toward safer and smarter transportation solutions.

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