

SMART CAR SYSTEM

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ABSTRACT

The increasing number of road accidents due to delayed human reaction and lack of timely braking has created a need for intelligent vehicle safety systems. This project presents the design and implementation of an automatic braking system using an ESP32 microcontroller integrated with ultrasonic and tilt sensors. The proposed system continuously monitors the surrounding environment by measuring the distance between the vehicle and nearby obstacles using an ultrasonic sensor based on the time-of-flight principle. In addition, a tilt sensor is employed to detect any abnormal inclination or instability of the vehicle, which may indicate unsafe driving conditions. The ESP32 microcontroller acts as the central processing unit, receiving input data from the sensors, analyzing it in real time, and making decisions based on predefined safety thresholds. When the detected distance falls below a critical limit or when a tilt condition is identified, the system automatically activates the braking mechanism by controlling a motor driver connected to a DC motor, thereby reducing or stopping the motion to prevent potential collisions. Furthermore, an LCD display is incorporated into the system to provide real-time feedback, including distance measurements and system status such as safe operation, warning, or brake activation. The entire system is powered by a 3.7V battery, with a DC-DC boost converter used to ensure appropriate voltage levels for all components. The proposed system is cost-effective, compact, and suitable for prototype and low-speed vehicle applications.

It demonstrates the effectiveness of combining sensor-based detection with embedded control for improving vehicle safety. This work also provides a foundation for future advancements, such as integration with IoT platforms, advanced sensing technologies, and intelligent decision-making algorithms for real-world automotive applications.

KEYWORDS

Automatic Braking System, ESP32, Ultrasonic Sensor, Tilt Sensor, Obstacle Detection, Embedded System, Vehicle Safety, Motor Driver, LCD Display, Collision Avoidance

INTRODUCTION

In recent years, road safety has become a major concern due to the increasing number of accidents caused by human error, delayed reaction time, and lack of advanced safety systems in vehicles. Conventional braking systems rely entirely on driver response, which may not always be quick or accurate enough to prevent collisions. As a result, there is a growing need for intelligent and automated safety mechanisms that can assist or override human control in critical situations. This project presents the design and implementation of an automatic braking system using an ESP32 microcontroller integrated with ultrasonic and tilt sensors. The system is capable of detecting obstacles in real time by measuring the distance between the vehicle and nearby objects

as well as monitoring the stability of the vehicle through tilt detection. Based on the sensor inputs, the ESP32 processes the data and activates the braking mechanism automatically when a dangerous condition is detected

The proposed system also includes an LCD display to provide real-time feedback regarding distance and system status, improving user awareness and monitoring. The use of a compact, low-cost embedded system makes this solution suitable for prototype and low-speed vehicle applications. Overall, this work aims to demonstrate an efficient and reliable approach to enhancing vehicle safety through sensor-based automation and real-time control.

Road accidents are increasing rapidly due to human errors and delayed braking response. To overcome this issue, automatic braking systems are being developed to improve vehicle safety. This project focuses on designing a smart braking system using an ESP32 microcontroller, which can detect obstacles and apply brakes automatically. The system uses ultrasonic and tilt sensors to monitor distance and stability, ensuring quick response in critical situations.

Vehicle safety is one of the most important aspects of modern transportation systems. Traditional braking systems depend completely on driver control, which may lead to accidents in emergency situations. To address this problem, an automatic braking system is proposed using ESP32 and sensors. The system continuously monitors the surroundings and activates braking when an obstacle or unsafe condition is detected.

Based on the reviewed literature, it is evident that combining multiple sensors with a powerful microcontroller like ESP32 can significantly improve system performance.

LITERATUREREVIEW

Several research works have been carried out in the field of vehicle safety systems and automatic braking technologies. Many studies focus on reducing road accidents by using sensors and embedded systems to detect obstacles and take corrective actions. Earlier systems primarily used ultrasonic sensors for obstacle detection due to their low cost and simplicity. These systems measure the distance between the vehicle and obstacles and trigger alerts or braking when the distance falls below a certain threshold.

Recent advancements have introduced microcontrollers such as ESP32 and Arduino for real-time data processing and control. Researchers have developed smart braking systems where sensor data is continuously analyzed to improve response time and accuracy. Some studies also incorporate additional sensors like infrared sensors, cameras, or tilt sensors to enhance system reliability by detecting multiple conditions such as object proximity and vehicle instability. Several existing systems also incorporate IoT-based monitoring and wireless communication to enhance vehicle safety. These systems allow remote monitoring and data analysis, improving overall system efficiency. The proposed project builds upon these concepts by integrating ultrasonic and tilt sensors with real-time processing to develop a cost-effective and efficient automatic braking system.

Various studies have focused on developing automatic braking systems to reduce road accidents caused by human error. Many researchers have used ultrasonic sensors for obstacle detection due to their low cost and ease of implementation.

These systems measure the distance to nearby

Recent research in vehicle safety systems highlights the importance of integrating multiple sensors for improved reliability. In addition to ultrasonic sensors, tilt sensors and infrared sensors are used to detect vehicle instability and environmental conditions. Embedded systems process this data and make quick decisions to prevent accidents. The use of ESP32 has become popular due to its fast processing speed, low power consumption, and built-in communication features.

Advanced vehicle safety technologies such as RADAR and LiDAR provide high accuracy in obstacle detection but are costly and complex. Therefore, many researchers focus on low-cost alternatives using ultrasonic sensors and embedded controllers for prototype development. These systems are effective for short-range detection and are widely used in academic projects. The integration of real-time processing and automatic control improves response time and enhances safety.

Several existing systems also incorporate IoT-based monitoring and wireless communication to enhance vehicle safety. These systems allow remote monitoring and data analysis, improving overall system efficiency. However, for small-scale applications, simple sensor-based systems using ESP32 provide a practical and cost-effective solution. The proposed project builds on these ideas by combining obstacle detection and tilt sensing for better safety performance.

The proposed system is an automatic braking mechanism designed using an ESP32 microcontroller integrated with ultrasonic and tilt sensors to enhance vehicle safety. The system continuously monitors the distance between the vehicle and nearby obstacles using an ultrasonic sensor, while a tilt sensor is used to detect any abnormal inclination or instability. These sensors provide real-time input data to the ESP32, which processes the information and compares it with predefined threshold values.

objects and trigger braking or warning signals when the distance becomes critical.

PROPOSED SYSTEM

The proposed system is an automatic braking mechanism designed using an ESP32 microcontroller integrated with ultrasonic and tilt sensors to enhance vehicle safety. The system continuously monitors the distance between the vehicle and nearby obstacles using an ultrasonic sensor, while a tilt sensor is used to detect any abnormal inclination or instability. These sensors provide real-time input data to the ESP32, which processes the information and compares it with predefined threshold values.

When the system detects that the obstacle distance is below a critical limit or a tilt condition occurs, the ESP32 immediately activates the braking mechanism. This is achieved by sending control signals to a motor driver module connected to a DC motor, which simulates the braking action by stopping or reducing the motor speed. Under normal conditions, the motor operates continuously, representing vehicle motion.

Additionally, an LCD display is incorporated to provide real-time feedback to the user, including distance measurements and system status such as "Safe," "Warning," or "Brake Applied." The entire system is powered by a 3.7V battery, supported by a DC-DC boost converter to supply the required voltage levels to all components. The proposed system offers a simple, cost-effective, and efficient solution for collision avoidance and vehicle safety in prototype and low-speed applications.

The system is developed as a low-cost and efficient solution for vehicle safety. It uses ultrasonic and tilt sensors for real-time detection of obstacles and instability. The ESP32 acts as the decision-making unit and controls the braking system through a motor driver. The LCD provides visual output, and the system is powered using a regulated battery supply.

The proposed automatic braking system integrates sensing, processing, and control units into a single embedded system. The sensors continuously provide input to the ESP32, which analyzes the data and takes immediate action during critical conditions. The braking mechanism is implemented using a motor driver and DC motor, and the system status is displayed on an LCD. This setup ensures quick response and improved safety.

The ultrasonic sensor measures the distance between the vehicle and obstacles, while the tilt sensor detects imbalance. The ESP32 compares these values with predefined limits and sends signals to stop the motor when danger is detected. The system also includes an LCD display for monitoring and is powered by a 3.7V battery with a boost converter.

METHODOLOGY

The methodology of the proposed automatic braking system is based on real-time sensing, processing, and control using an ESP32 microcontroller. The system integrates an ultrasonic sensor and a tilt sensor as input devices to continuously monitor the environment and vehicle condition. The ultrasonic sensor measures the distance between the vehicle and nearby obstacles using the time-of-flight principle, while the tilt sensor detects any abnormal inclination or instability.

The ESP32 processes the data received from these sensors and compares it with predefined threshold values to determine the safety condition. If the measured distance falls below a critical limit or if a tilt condition is detected, the system identifies it as a potential danger. Based on this analysis, the ESP32 generates control signals to activate the braking mechanism.

The braking action is implemented using a motor driver connected to a DC motor. When a critical condition occurs, the ESP32 sends signals to the motor driver to stop or reduce the motor speed, simulating automatic braking. Additionally, an LCD display is used to show real-time distance and system status, providing feedback to the user.

The entire system is powered by a 3.7V battery, and a DC-DC boost converter is used to provide the required operating voltage for all components. The system operates continuously in a loop, ensuring quick response and reliable performance for improved safety.

The methodology of the Automatic Braking System explains how the system is designed, implemented, and operates in real-time. The system mainly focuses on detecting obstacles and preventing collisions using sensors and microcontroller-based control.

The smart car system is built using an ESP32 microcontroller as the central processing unit. It collects input data from different sensors such as ultrasonic sensor and tilt sensor, processes the information, and controls the motor driver to manage vehicle movement.

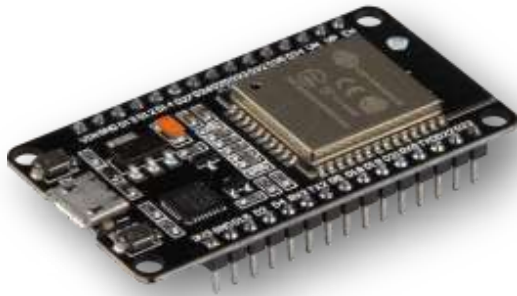
The methodology of the Automatic Braking System (Smart Car System) describes the step-by-step process used to design and implement the project. The system is developed using an ESP32 microcontroller as the main control unit, which continuously monitors sensor inputs and controls the movement of the vehicle. The ultrasonic sensor is used to detect obstacles in front of the vehicle by measuring the distance between the car and nearby objects. This real-time distance data is sent to the ESP32 for processing. When the distance is greater than the predefined safe limit, the vehicle moves normally without interruption.

However, when the distance becomes less than or equal to the safe threshold, the ESP32 immediately

activates the automatic braking system by sending

HARDWARE COMPONENTS

ESP32 microcontroller



The ESP32 plays a central and most important role in the Automatic Braking System (Smart Car System). It acts as the main controller or “brain” of the entire system, responsible for receiving input data from all sensors, processing that data, and generating appropriate control signals for the output devices. In this project, the ESP32 continuously collects information from the ultrasonic sensor to measure the distance between the vehicle and any obstacle in front. It also reads signals from the tilt sensor to detect any imbalance or accident-like conditions.

After processing the sensor inputs, the ESP32 makes real-time decisions based on programmed logic. If an obstacle is detected within a unsafe range, it immediately sends signals to the motor driver to slow down or stop the BO motors, enabling automatic braking. Similarly, if the tilt sensor detects a sudden tilt or instability, the ESP32 quickly stops the vehicle to ensure safety. Along with this, it also controls the LCD display to show real-time status such as distance readings and system alerts. Overall, the ESP32 is responsible for data processing, decision-making, sensor integration, and motor control, making it the core component that enables intelligent and automated functioning of the smart car system.

Ultrasonic sensors



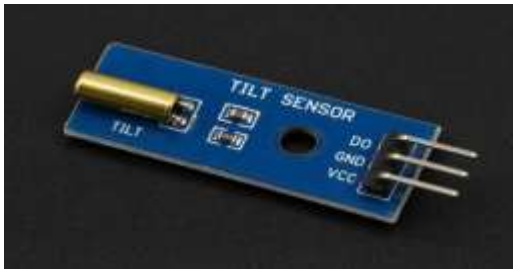
In the Automatic Braking System (Smart Car System), the ultrasonic sensor plays a key role in detecting obstacles and measuring distance in real time. It works on the principle of sound wave reflection. The sensor consists of a transmitter and a receiver. The transmitter sends high-frequency ultrasonic sound waves toward the front direction. When these sound waves hit an object or obstacle, they are reflected back toward the receiver of the sensor.

The time taken for the sound waves to travel to the object and return is measured by the ESP32 microcontroller. Using this time value, the system calculates the exact distance between the vehicle and the obstacle. If the distance is greater than the safe limit, the vehicle continues to move normally. However, when the distance becomes too small, the ESP32 activates the automatic braking system to slow down or stop the vehicle.

In this project, a commonly used sensor such as the HC-SR04 Ultrasonic Sensor is used due to its accuracy, low cost, and reliability. It continuously provides real-time distance data, which helps the smart car system to detect obstacles early and avoid collisions effectively.

Overall, the ultrasonic sensor acts as the “eyes” of the system, enabling safe navigation and supporting automatic braking decisions.

Tilt Sensor



In the Automatic Braking System (Smart Car System), the tilt sensor is used to detect the orientation or inclination of the vehicle and ensure safety during unstable conditions. It works on a simple principle: when the sensor is in a normal (horizontal) position, its internal circuit remains either open or closed depending on the design. When the sensor is tilted beyond a certain angle, the internal connection changes, which alters the output signal.

In this project, the tilt sensor continuously sends its output to the ESP32 microcontroller. Under normal conditions, when the vehicle is stable, the sensor maintains a constant signal. However, if the vehicle tilts due to an obstacle, uneven surface, or accident-like situation, the sensor changes its state (HIGH to LOW or LOW to HIGH). The ESP32 detects this change immediately.

Once a tilt condition is detected, the ESP32 processes the signal and sends a command to the motor driver to stop all the BO motors instantly. This prevents further movement of the vehicle and reduces the risk of damage or accidents. At the same time, the system can display a warning message such as "TILT DETECTED" on the LCD display.

Thus, the tilt sensor acts as a safety component in the system by monitoring vehicle stability and triggering an emergency stop whenever abnormal tilt is detected.

LCD Distance Display



In your Automatic Braking System (Smart Car System), the LCD is used to display real-time distance information measured by the ultrasonic sensor. A commonly used display is the 16x2 LCD Display Module, which can show 16 characters per line across 2 lines.

The LCD is connected to the ESP32 microcontroller, which controls what is shown on the screen. The ultrasonic sensor continuously measures the distance between the vehicle and any obstacle, and this data is sent to the ESP32. The ESP32 then processes this data and sends it to the LCD for display.

In the Automatic Braking System (Smart Car System), the LCD distance display is used to show real-time information about the distance between the vehicle and nearby obstacles. A commonly used module like the 16x2 LCD Display Module is connected to the ESP32 microcontroller, which controls all display operations.

The working begins with the ultrasonic sensor, which continuously measures the distance by sending and receiving sound waves. This distance data is sent to the ESP32. The ESP32 processes the received time signal and converts it into distance (in centimeters). After calculating the distance, the ESP32 formats the data into readable text.

Thus, the LCD distance display provides a clear visual interface for the user, helping to monitor obstacle distance and understand the system's real-time actions effectively.

Motor Drive



In the Automatic Braking System (Smart Car System), the motor driver is used to control the movement of the motors based on signals from the ESP32. A commonly used module like the L298N Motor Driver Module acts as an interface between the low-power ESP32 and the high-power DC motors.

The ESP32 cannot directly drive the motors because it provides very low current. Therefore, the motor driver is used to amplify the current and control the direction and speed of the motors. The motor driver receives input signals from the ESP32 through control pins (IN1, IN2, IN3, IN4). Based on these signals, it controls the rotation of the motors connected to its output terminals.

BO Motor



In the Automatic Braking System (Smart Car System), the BO motor (Battery Operated motor) is responsible for driving the wheels and enabling movement of the vehicle. A commonly used motor like the BO DC Gear Motor is preferred because it is lightweight, low-cost, and provides sufficient torque for small robotic cars.

The BO motor works on the principle of converting electrical energy into mechanical energy. When electrical power is supplied to the motor, it creates a magnetic field inside the motor, causing the rotor to rotate. This rotation is transferred through a built-in gearbox, which reduces speed and increases torque, making it suitable for driving wheels.

3.7V Li-ion Battery



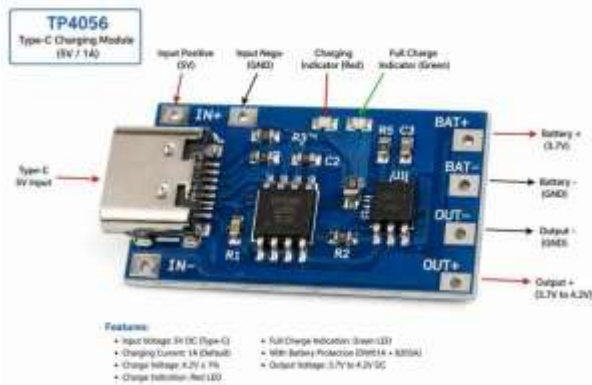
In your Automatic Braking System (Smart Car System), the 3.7V battery acts as the main power source that supplies electrical energy to all components. A commonly used battery like a Lithium-ion 3.7V Battery stores energy chemically and converts it into electrical energy when connected to the circuit.

The 3.7V battery works on the principle of electrochemical reaction. Inside the battery, lithium ions move between the anode and cathode, generating a flow of electrons. This flow of electrons creates electric current, which powers the circuit.

The 3.7V battery is the heart of the power system. It supplies energy to all components, enabling the smart car to operate, detect obstacles, and perform automatic braking efficiently.

Charging Module

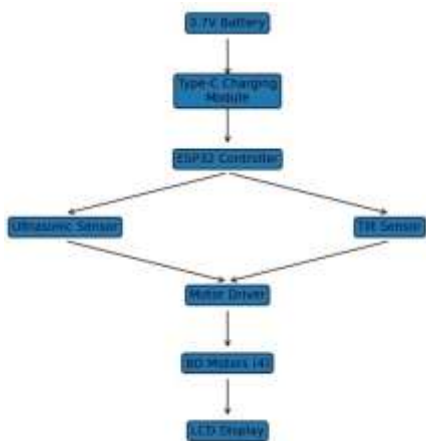
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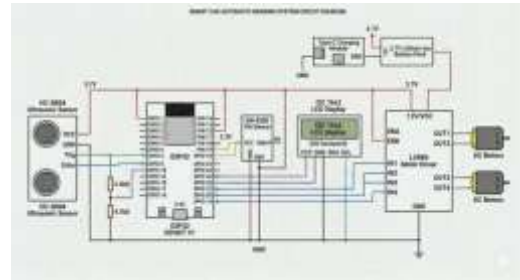
In your Automatic Braking System (Smart Car System), the Type-C charging module plays an important role in safely charging and managing the 3.7V battery. A commonly used module like the TP4056 Type-C Charging Module is designed specifically for lithium-ion batteries

BLOCK

DIAGRAM



CIRCUITDIAGRAM-



Conclusion

The automatic braking system developed using the ESP32 microcontroller, ultrasonic sensor, and tilt sensor provides an effective solution for improving vehicle safety. The system successfully detects obstacles and unstable conditions in real time and responds quickly by applying braking action. The integration of sensors with an embedded control unit ensures accurate detection and fast decision-making.

This project demonstrates a low-cost, compact, and reliable system suitable for prototype and low-speed applications. The use of a 3.7V battery with proper voltage regulation ensures efficient operation of all components. Overall, the system helps in reducing accidents caused by human error and delayed response. It also provides a strong foundation for future improvements using advanced technologies such as IoT and intelligent control systems. The proposed automatic braking system using an ESP32 microcontroller, ultrasonic sensor, and tilt sensor effectively enhances vehicle safety by detecting obstacles and unstable conditions in real time. The system processes sensor data quickly and applies braking automatically, reducing the risk of accidents caused by human delay. The integration of a motor driver, DC motor, and LCD display ensures proper control and monitoring of the system. Powered by a 3.7V battery with voltage regulation, the system is cost-effective, compact, and suitable for prototype applications, with potential for further improvements in advanced vehicle safety systems.

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