ISSN 2277-2685
IJESR/April-June. 2026/ Vol-16/Issue-2/258-266
Kotha Prerna *et. al.,* / International Journal of Engineering & Science Research
Full Length Article

AcciSense: Real Time Accident Detection and Alert

Ms. K Virija[1], Kotha Prerna[2], Alishetty Sai Ruthvika[3], Vadthya Sangeetha[4]
[1]Assistant Professor;Department of Electronics and Communication Engineering Bhoj Reddy Engineering College for Women Hyderabad India
[2,3,4]B.Tech Students; Department of Electronics and Communication Engineering Bhoj Reddy Engineering College for Women Hyderabad India
Mail Id; kothaprerna@gmail.com[2],Sairuthvikaalishetty@gmail.com[3],vadthyasangeetha14@gmail.com[4]
Accepted 13-04-2026

Abstract
Road traffic accidents remain a major global concern, causing significant loss of life and property each year. Rapid accident detection and timely emergency response are crucial in reducing fatalities and minimizing damage. This research presents an Internet of Things (IoT)-based intelligent vehicle safety and accident detection system built around the ESP32 microcontroller. The proposed system is capable of identifying accident events, monitoring engine temperature, detecting structural damage, and identifying possible gas leakage while simultaneously transmitting emergency alerts with GPS location information.The system integrates an MPU6050 accelerometer and gyroscope sensor to recognize abrupt motion changes, tilt variations, and high-impact collisions that may indicate accidents. Engine temperature is monitored continuously to prevent overheating conditions that could lead to mechanical failure or fire hazards. A flex sensor is incorporated into the vehicle body to detect deformation caused by impacts, enabling dent detection during collisions. Additionally, an MQ2 gas sensor monitors combustible gases such as LPG or fuel vapors, which may leak during severe accidents.The ESP32 serves as the central processing unit and communicates with the Blynk IoT platform via Wi-Fi to transmit real-time sensor readings and alert notifications to a user's smartphone. When abnormal conditions such as accidents, gas leaks, or excessive engine temperature are detected, the system activates a buzzer and red LED for immediate local warning while sending emergency notifications containing GPS coordinates to the mobile application. A green LED indicates normal system operation.Furthermore, the system supports remote ignition management through the Blynk IoT interface. A relay-controlled DC motor is used to simulate the vehicle ignition mechanism, allowing users to remotely enable or disable the engine. This functionality can help prevent theft or mitigate hazards during emergencies. The GPS module continuously tracks vehicle location and transmits real-time coordinates to the mobile platform, enabling quick identification of accident locations by emergency responders and family members.The proposed system demonstrates how integrating IoT technologies with smart sensing modules can significantly enhance vehicle safety, accident response efficiency, and remote monitoring capabilities.
Keywords
IoT, Accident Detection System, ESP32, Vehicle Safety, GPS Tracking, Blynk IoT Platform, Gas Leakage Detection, Smart Transportation

Introduction

Road transportation has become an essential component of modern society, enabling faster mobility, economic development, and improved connectivity between regions. However, the rapid growth in the number of vehicles has also resulted in a significant rise in road accidents across the world. These accidents lead to substantial loss of human life, severe injuries, and economic damage. According to global safety reports, road accidents remain one of the leading causes of mortality, particularly among young adults. A major factor contributing to accident-related fatalities is the delay in notifying emergency services and providing timely medical assistance, especially in remote areas or during nighttime.To address these challenges, advanced technologies such as the Internet of Things (IoT), sensor networks, and wireless communication systems have been increasingly adopted to develop intelligent accident detection and alert mechanisms. These systems are capable of identifying accident conditions automatically and sending immediate notifications to emergency responders, thereby reducing the time required for rescue operations. Early detection and rapid communication play a crucial role in improving survival rates and minimizing the consequences of severe road accidents.The system proposed in this research focuses on developing an IoT-based accident detection and vehicle safety monitoring framework using the ESP32 microcontroller. The system integrates multiple sensors to monitor different safety parameters of a vehicle. An MPU6050 accelerometer and gyroscope sensor is used to detect sudden changes in motion, such as abrupt acceleration, impact, or abnormal tilt that may indicate a collision. In addition, a flex sensor is used to detect structural deformation or denting of the vehicle body during an accident. Engine temperature monitoring is incorporated to identify overheating conditions that may lead to engine failure or fire hazards, while an MQ2 gas sensor detects the presence of combustible gases that could indicate fuel leakage after a collision.The ESP32 microcontroller acts as the central processing unit of the system and communicates with the Blynk IoT platform through Wi-Fi connectivity. When abnormal conditions such as accidents, gas leakage, or excessive temperature are detected, the system generates an alert through a buzzer and LED indicators and simultaneously sends emergency notifications to the user's smartphone along with real-time GPS location data. This feature enables quick identification of the accident site by rescue teams and family members. Furthermore, the system provides remote ignition control through the mobile application, allowing the user to disable the vehicle in case of theft or hazardous conditions. By integrating sensing, communication, and IoT technologies, the proposed system aims to improve vehicle safety, reduce accident response time, and enhance emergency management.

Literature Survey

A literature survey is essential for understanding the existing research and technological developments related to accident detection and vehicle monitoring systems. Previous studies have explored various approaches for improving road safety using embedded systems, sensor technologies, and wireless communication modules. Many researchers have proposed intelligent systems capable of detecting accidents automatically and transmitting emergency alerts to authorities or family members.Most accident detection systems rely on motion sensors such as accelerometers and gyroscopes to identify sudden changes in vehicle movement that indicate a collision. In addition, GPS modules are widely used to determine the geographical location of the accident site, enabling faster emergency response. Communication technologies such as GSM, Wi-Fi, or other wireless networks are typically integrated to transmit alert messages containing accident information and location coordinates.Recent advancements in IoT technology have further improved the capabilities of such systems by enabling real-time data monitoring and cloud-based processing. IoT platforms allow sensor data to be continuously transmitted, analyzed, and accessed remotely through mobile applications or web interfaces. Despite these advancements, several limitations still exist in current systems, including false accident detection, reliance on fixed threshold values, and communication delays.Considering these limitations, the proposed ystem attempts to improve reliability by integrating multiple sensors with an ESP32 microcontroller and IoT connectivity. The literature survey provides valuable insights into existing approaches and highlights the need for a more efficient and comprehensive accident detection and monitoring system.

Review of Existing Work

Several research studies have focused on developing systems that can detect vehicle accidents automatically and notify emergency services. Earlier research conducted in 2012 proposed an accident detection and reporting mechanism using GPS technology. In this system, the vehicle speed was continuously monitored using a GPS receiver. When an abnormal decrease in speed was detected, the system assumed that a collision had occurred. The microcontroller then processed the GPS data and transmitted the accident location and time through a GSM network to an alert service center.Another study in 2019 introduced a real-time vehicle collision detection system that also relied on GPS-based speed monitoring. In this approach, the vehicle speed was calculated continuously, and if a sudden drop in speed was observed, an accident alarm was triggered. The system provided a short time interval for the driver to cancel the emergency alert if the situation was not critical. If no response was received, the accident information and location were automatically transmitted to emergency authorities.Some researchers have also focused on preventing accidents by monitoring driver behavior. A system proposed by S. Kaithaam and colleagues utilized a night vision camera to detect driver drowsiness by analyzing eye blinking patterns. The system monitored the driver's facial features and used image processing techniques to determine whether the driver was alert. If signs of fatigue were detected, warning signals were generated and vehicle speed was automatically reduced until the driver regained awareness.Other research efforts have explored systems that combine accelerometers, GPS, and GSM modules for accident detection. For example, a system developed by Rajavardhan Rish and co-authors used an accelerometer to identify sudden changes in motion, while GPS provided location information. In case of an accident, the system sent a Google Maps link containing the accident location to nearby hospitals, police stations, and emergency contacts.Another study highlighted that many modern vehicles include built-in safety systems; however, such technologies are often expensive and not accessible to all users. To overcome this limitation, researchers proposed low-cost accident detection systems that utilize embedded sensors and microcontrollers to monitor vehicle conditions and detect collisions. These systems aim to provide affordable safety solutions for vehicles that do not have advanced safety features.

Motivation

The motivation behind this research arises from the growing number of road accidents and the need for faster emergency response systems. As the number of vehicles continues to increase due to population growth and economic development, traffic congestion and accident rates have also risen significantly. Two-wheeler vehicles in particular are more vulnerable to accidents and often result in severe injuries or fatalities.A major factor contributing to the high mortality rate in road accidents is the delay in providing medical assistance. Many accidents occur on highways or remote roads where immediate help may not be available. In such situations, the absence of an automated system to report accidents can significantly delay rescue operations.Real-time accident detection systems can play a critical role in addressing this issue by automatically identifying collisions and sending alerts to emergency services. By providing accurate information about the accident location and severity, such systems enable quicker dispatch of ambulances and medical support. This can greatly improve the chances of survival for accident victims.Statistical data from road safety reports also highlight the seriousness of this issue. According to reports published by the National Crime Records Bureau (NCRB), thousands of lives are lost every year due to road accidents in India. Although some reduction in accidents was observed during periods of restricted movement, the severity of accidents and the proportion of two-wheeler fatalities remain significant concerns. These statistics emphasize the importance of implementing intelligent safety systems that can assist in accident detection and emergency response.

Problem Statement

Despite improvements in vehicle safety technologies and traffic regulations, road accidents continue to cause significant loss of life and injuries. One of the primary challenges in accident management is the delay in notifying emergency services and providing medical assistance to victims. In many cases, accidents occur in isolated areas where there are no witnesses available to report the incident. As a result, valuable time is lost before emergency responders become aware of the situation.Research studies indicate that reducing the emergency response time even by a small margin can significantly increase the chances of survival for accident victims. It has been estimated that reducing accident response time by just one minute can increase survival rates by approximately six percent. Therefore, developing systems that can automatically detect accidents and send immediate alerts is crucial for improving road safety.Traditional accident reporting methods rely heavily on manual communication, which may not always be possible if the driver is injured or unconscious. Additionally, existing systems often use limited sensing mechanisms that may produce inaccurate results or false alarms. Low-quality sensors and inefficient communication technologies further reduce the reliability of these systems.Another challenge is the lack of integrated solutions that combine accident detection, vehicle monitoring, and location tracking in a single platform. Many systems focus only on accident detection without providing additional safety features such as vehicle status monitoring, theft prevention, or remote control capabilities.To overcome these limitations, there is a need for a cost-effective and reliable accident detection system that can continuously monitor vehicle conditions, accurately detect collisions, and provide precise location information to emergency responders. The proposed project addresses this need by developing an IoT-based accident detection and vehicle safety monitoring system using the ESP32 microcontroller and multiple sensors. The system aims to improve emergency response efficiency, enhance vehicle safety, and reduce accident-related fatalities.

Advanced Safety Shield for Drivers

Road traffic accidents represent a critical global issue, resulting in significant loss of human life, serious injuries, and economic damage each year. Various factors contribute to these incidents, including poor road visibility, driver fatigue, alcohol consumption, inadequate traffic monitoring, and delayed emergency response services. The risk becomes even more severe on narrow roads, curved highways, and mountainous regions where drivers may fail to notice approaching vehicles in time. In many developing regions, insufficient safety infrastructure and the absence of intelligent monitoring systems further increase accident risks.To mitigate these challenges, researchers have proposed various technological solutions that focus on accident detection, alert generation, and vehicle tracking. However, many existing solutions address only a single aspect of road safety rather than offering a comprehensive protection mechanism. Therefore, there is a growing need for an integrated safety system capable of both preventing accidents and ensuring rapid emergency response when accidents occur.The system proposed in this study introduces an Internet of Things (IoT)-based vehicle accident prevention and detection framework designed to enhance driver safety. The system integrates sensors, a microcontroller unit, GPS technology, and wireless communication modules to monitor the vehicle’s condition and surrounding environment continuously. Sensor data is analyzed to identify potential risk situations and provide warnings to the driver before an accident occurs. If an accident is detected, the system automatically transmits the vehicle’s location and emergency information to predefined contacts and rescue services. Through this integrated approach, the system aims to minimize accident risks, improve emergency response time, and ultimately reduce the number of road fatalities.

Existing System

Current accident detection systems typically rely on simple sensor-based monitoring and communication mechanisms. Most traditional approaches use embedded microcontrollers combined with accelerometers, GPS modules, and GSM communication units to detect accident events and notify emergency contacts. These systems identify accidents by monitoring sudden variations in acceleration or orientation using sensors such as accelerometers and gyroscopes.When abnormal motion patterns exceed predefined threshold values, the system assumes that a collision has occurred and triggers an alert. The GPS module determines the geographical location of the vehicle, and the GSM module transmits an alert message containing the coordinates to emergency responders or family members. Although this approach provides a basic accident notification mechanism, it often suffers from limitations such as false detections and delayed communication.Some systems also incorporate alcohol detection sensors to identify whether the driver is under the influence of alcohol. In such cases, the system may activate an alarm or disable the vehicle engine. However, these systems are generally limited in functionality and lack advanced monitoring features such as real-time data analysis, cloud connectivity, and integrated safety mechanisms.

Technologies Used in Existing Systems

Several technologies are commonly employed in conventional accident detection systems. These include microcontrollers such as the ESP32 or Arduino platforms for system control and processing. Motion sensors like the MPU6050 accelerometer and gyroscope are used to detect sudden changes in vehicle movement. GPS modules are integrated to obtain real-time location information, while communication modules such as GSM enable the transmission of emergency messages. Additionally, alcohol sensors such as the MQ3 module may be used to identify alcohol vapors near the driver. Basic alert mechanisms such as buzzers are also incorporated to provide local warnings when abnormal conditions are detected.

Working Mechanism of Existing Systems

In conventional systems, the accident detection process begins with continuous monitoring of vehicle movement and driver conditions through sensors. Motion sensors measure acceleration and tilt angles to determine whether the vehicle experiences sudden impact or unusual orientation changes. When sensor values exceed predefined threshold levels, the system interprets the event as a potential accident.Alcohol detection modules operate by sensing the presence of alcohol vapors in the surrounding air. If the detected concentration surpasses a predetermined limit, the system activates warning alarms or restricts vehicle operation. Meanwhile, the GPS module continuously retrieves latitude and longitude coordinates, which are updated periodically and stored for emergency use.When an accident is detected, the microcontroller triggers the communication module to transmit an alert message. The message typically contains information such as the vehicle's current location and the time of the incident. This message is sent through a GSM network to emergency services, family members, or other predefined contacts.

Key Features of Existing Systems

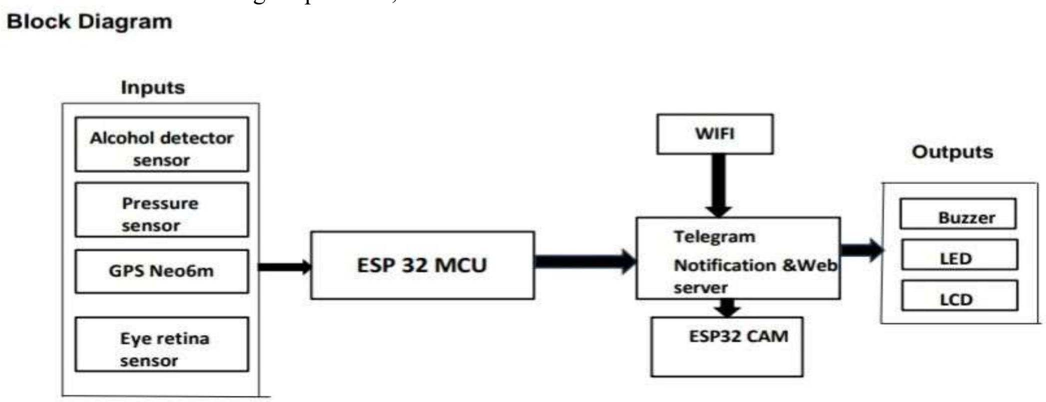
Traditional accident detection systems generally incorporate basic features such as sensor-based accident identification, location tracking through GPS modules, and emergency message transmission via GSM communication. These systems often use microcontrollers as their processing units and rely on accelerometers and gyroscopes to detect sudden motion changes. Some systems also include alcohol detection units and local alert mechanisms such as buzzers. However, these systems often lack real-time monitoring capabilities, advanced user interfaces, and comprehensive safety features.

Proposed System

The proposed system aims to enhance the reliability and effectiveness of accident detection by integrating multiple sensors and communication technologies within an IoT-based architecture. Instead of relying solely on a single sensor parameter, the system combines accelerometer and gyroscope data to improve detection accuracy. By analyzing both acceleration and orientation information simultaneously, the system can distinguish between normal road disturbances such as potholes or speed breakers and actual collision events. This approach significantly reduces the occurrence of false alarms.Another advantage of the proposed system is the use of the ESP32 microcontroller, which provides built-in Wi-Fi connectivity. This enables faster and more efficient data transmission compared to traditional GSM-based communication systems. Sensor data can be transmitted directly to cloud platforms or mobile applications, ensuring that alerts are delivered without delay.The system also supports continuous monitoring and data storage through IoT platforms. Parameters such as acceleration values, alcohol detection levels, and location coordinates can be stored in cloud databases for future analysis. This data can be useful for accident investigation, driver behavior analysis, and identifying accident-prone areas on road networks.

Additionally, the system includes a user-friendly mobile application interface that allows users to monitor vehicle status and receive alerts in real time. The application displays sensor data, warning notifications, and vehicle location in a clear and accessible format. Even users without technical expertise can easily understand the information provided.Another important advantage of the proposed system is its scalability. The system can be expanded by integrating advanced technologies such as machine learning algorithms for accident prediction or vehicle-to-vehicle communication systems that enable information sharing among nearby vehicles. These enhancements could further improve accident prevention capabilities.By combining accident detection, preventive monitoring, location tracking, and IoT communication within a single platform, the proposed system provides a comprehensive safety solution. The rapid transmission of accident alerts and location data enables emergency responders to reach accident sites quickly, thereby increasing the chances of saving lives.

Block Diagram



Block Diagram

The system architecture is represented through a block diagram that illustrates the interaction between various hardware components and the ESP32 microcontroller. The sensors collect real-time environmental and motion data, which is processed by the microcontroller to determine whether abnormal conditions exist. If an accident or hazardous condition is detected, the microcontroller activates alert devices such as buzzers and LEDs while simultaneously transmitting emergency notifications through the communication module.The circuit diagram provides a detailed representation of the electrical connections between system components. It shows how sensors, display modules, communication units, and alert mechanisms are integrated with the ESP32 microcontroller to form a complete embedded safety system.

Hardware and Software Requirements

Hardware Requirements

The hardware components of the system are responsible for sensing environmental conditions, processing data, and generating alerts. Each component performs a specific function that contributes to the overall operation of the system.The ESP32 microcontroller serves as the central processing unit of the system. It collects sensor data, analyzes the information, and determines whether abnormal conditions exist. The ESP32 also enables wireless communication through built-in Wi-Fi capabilities, allowing the system to send real-time notifications and GPS location data via the internet.A 16×2 LCD display with an I2C interface is used to present system information and alert messages. The I2C communication protocol reduces the number of connections required between the display and the microcontroller by using only two data lines, making the system wiring simpler and more efficient.An infrared sensor module is used to detect nearby objects or obstacles using reflected infrared light. The sensor consists of an infrared transmitter and receiver that work together to determine the presence of objects in front of the vehicle or device.A buzzer is included as an audio alert mechanism that generates warning sounds when abnormal conditions are detected. It operates on low DC voltage and converts electrical energy into sound signals through electromechanical vibration or the piezoelectric effect.The L298N motor driver module is used to control the speed and direction of DC motors. It operates on the H-bridge switching principle, which allows the motor to rotate in both clockwise and counterclockwise directions depending on the applied voltage polarity.The system also uses a DC motor to simulate mechanical movement or engine operation within the prototype model.Motion detection is achieved using the MPU6050 sensor, which combines a three-axis accelerometer and a three-axis gyroscope. This sensor measures acceleration, tilt, and rotational movement, making it suitable for detecting sudden impacts and abnormal motion patterns that may indicate an accident.Environmental monitoring is supported by the BMP180 sensor, which measures atmospheric pressure and temperature. This sensor can also be used to estimate altitude and environmental conditions.Location tracking is performed using the NEO-6M GPS module, which determines the device's position by receiving signals from multiple GPS satellites. The module calculates latitude, longitude, altitude, and time information through trilateration and transmits the data to the microcontroller using serial communication.

Software Requirements

The system software is responsible for controlling hardware components, processing sensor data, and generating alerts when necessary.

Arduino IDE

The Arduino Integrated Development Environment (IDE) is used for writing, compiling, and uploading programs to the microcontroller. It provides a simple interface and supports programming languages based on C and C++. The software is widely used in embedded systems development because of its open-source nature and extensive community support.The Arduino IDE enables developers to monitor system behavior through a serial monitor and install external libraries required for sensors and communication modules. Libraries such as TinyGPS++ and LiquidCrystal_I2C simplify the process of interfacing GPS modules and LCD displays with the microcontroller.

Programming Language

The firmware for the system is developed using the C programming language within the Arduino IDE environment. Embedded C is commonly used in microcontroller-based applications because it allows direct control of hardware registers and efficient execution of real-time tasks.The programming language enables communication with sensors, control of output devices, and implementation of system logic. It also supports modular programming through functions and libraries, which improves code readability and reusability. The flexibility and efficiency of C programming make it suitable for developing embedded safety systems such as the proposed accident detection framework.

Applications

The proposed accident detection and driver safety system can be applied in several real-world domains where vehicle safety and monitoring are critical. One of the primary applications is in smart vehicles, where the system can be integrated with modern automotive technologies to automatically detect collisions, monitor driving conditions, and enhance overall driver protection. By providing real-time monitoring and emergency alert capabilities, the system can significantly improve safety standards in intelligent transportation systems.Another important application is in emergency response systems. When an accident occurs, the system can automatically send alerts containing location information to emergency services. This enables rescue teams, hospitals, and law enforcement agencies to reach the accident site quickly and provide immediate medical assistance. Reducing the response time can significantly increase the chances of survival for accident victims.The system can also be implemented in fleet management systems, where companies operating large numbers of vehicles can monitor vehicle conditions and driver safety remotely. Fleet operators can track the movement and safety status of multiple vehicles simultaneously, improving operational efficiency and reducing accident risks.In public transportation systems, such as buses and taxis, the proposed system can enhance passenger safety by detecting accidents and instantly notifying authorities or transportation control centers. This ensures timely response during emergencies and improves public trust in transportation services.The system is also highly suitable for integration within smart city infrastructure. By collecting accident data and transmitting it to centralized traffic management systems, authorities can analyze accident patterns and identify high-risk areas on roads. This information can be used to improve road design, traffic regulations, and safety measures.In the insurance industry, accurate accident data generated by the system can assist insurance companies in verifying claims and analyzing accident conditions. This can help reduce fraudulent claims and improve the efficiency of insurance processing.Furthermore, the system can support traffic monitoring and safety analysis by providing valuable data on accident-prone locations and traffic patterns. Transportation authorities can use this information to implement preventive measures and improve road safety policies.Another potential application is in ambulances and emergency vehicles, where the system can assist in monitoring location and ensuring rapid response during emergency operations. Similarly, in logistics and delivery services, the system can help track vehicles transporting goods while ensuring driver safety during long-distance travel.

Results and Discussion

Results

ISSN 2277-2685
IJESR/April-June. 2026/ Vol-16/Issue-2/258-266
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Figure 1 Overall Setup

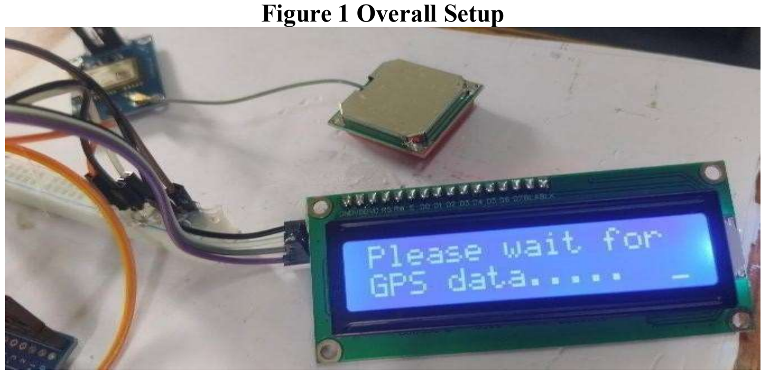

Figure 2 Location Coordinates

Figure 3 Emergency SMS to phone with location and Alert

The accident detection and driver safety monitoring system was successfully designed, implemented, and evaluated using the proposed hardware and software configuration. During experimental testing, the system demonstrated the ability to continuously monitor multiple parameters, including vehicle motion, orientation, obstacle detection, and environmental conditions. The ESP32 microcontroller effectively processed the data received from the sensors and ensured proper communication between the system components.The MPU6050 motion sensor played a crucial role in detecting sudden changes in acceleration and tilt, which are key indicators of collision events. During testing, the sensor successfully identified abnormal motion patterns when threshold values were exceeded, triggering the alert mechanism without noticeable delay. This confirms that motion-based accident detection using accelerometer and gyroscope data is a reliable technique for real-time safety monitoring.

The infrared sensor was used to detect nearby obstacles within a predefined range. The sensor performed efficiently in identifying objects in front of the system, contributing to preventive safety by providing early warnings of potential collisions. This capability allows the system not only to detect accidents but also to reduce their likelihood by alerting drivers before an impact occurs.The GPS module demonstrated satisfactory performance by accurately retrieving location coordinates during the testing phase. It was able to determine latitude and longitude values, enabling precise identification of the accident location. This feature is essential for emergency response systems, as it allows rescue teams to locate accident sites quickly and efficiently.The output devices integrated into the system, including the LCD display, buzzer, and LED indicators, operated as expected. The LCD module displayed system status and alert messages clearly, while the buzzer and LEDs provided immediate audio and visual warnings. These output mechanisms ensure that users are notified instantly when abnormal conditions occur.The overall system showed a fast response time between the detection of abnormal conditions and the activation of alert mechanisms. The minimal delay observed during testing indicates that the system is suitable for real-time accident detection applications where rapid response is essential.

Discussion

The developed accident detection system demonstrates the practical benefits of integrating multiple sensors with embedded technologies for real-time monitoring and safety applications. The ESP32 microcontroller plays a key role in coordinating sensor inputs and executing decision-making processes based on the collected data.The performance of the MPU6050 motion sensor indicates that accelerometer- and gyroscope-based detection methods are effective for identifying sudden impacts and abnormal motion patterns associated with vehicle collisions. However, the accuracy of the detection mechanism depends on the selection of appropriate threshold values. These thresholds may vary depending on road conditions, vehicle type, or external disturbances, making careful calibration essential to avoid false detections.The addition of the infrared sensor enhances the system's preventive capabilities by enabling obstacle detection. Although the sensor performs effectively within a limited range, its accuracy may be influenced by environmental factors such as lighting conditions or reflective surfaces. Therefore, integrating additional sensors or advanced detection algorithms could further improve the system's reliability.The GPS module serves an important role in providing real-time location information. The minimal delay between accident detection and alert generation makes the system suitable for real-time safety applications where immediate response is required.The integration of output devices such as LCD displays, buzzers, and LEDs ensures that alerts are communicated effectively to the user. For practical real-world deployment, additional communication technologies such as GSM modules or smartphone notifications could be incorporated to enhance the alert mechanism.One of the strengths of the proposed system is its simplicity and affordability. By using readily available hardware components and an easy-to-use development environment, the system can be implemented without significant cost or complexity. However, this simplicity also limits the availability of advanced functionalities.While the system performed reliably under normal testing conditions, additional validation is required to evaluate its performance under extreme environments, high-speed scenarios, and varying road conditions. Integrating IoT technologies and cloud platforms could further improve system performance by enabling remote monitoring, data storage, and real-time communication.

Conclusion

The accident detection and driver safety monitoring system proposed in this research provides an efficient and practical solution for improving road safety through the use of embedded systems and sensor technologies. The system integrates multiple hardware components, including the ESP32 microcontroller, MPU6050 motion sensor, infrared sensor, BMP180 environmental sensor, and GPS module, to continuously monitor vehicle conditions and detect abnormal events.The system architecture enables seamless communication between sensors, processing units, and alert mechanisms. Sensor data is continuously collected and analyzed by the ESP32 microcontroller to identify unusual motion patterns, collisions, or other hazardous conditions. When such conditions are detected, the system immediately activates output devices such as LCD displays, buzzers, and LED indicators to generate warnings.One of the most valuable features of the system is the integration of the GPS module, which provides accurate location information during emergency situations. This capability allows emergency responders to quickly locate accident sites and provide timely assistance. The rapid alert mechanism significantly reduces the delay between accident occurrence and emergency response.The experimental results demonstrate that the system operates reliably with effective coordination between hardware and software components. The system continuously monitors environmental and motion parameters and successfully detects abnormal conditions during testing.

Future Scope

The proposed accident detection system provides a strong technological foundation that can be

ISSN 2277-2685
IJESR/April-June. 2026/ Vol-16/Issue-2/258-266
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expanded in several ways to enhance its performance and practical usability. One of the most significant future improvements involves integrating the system with IoT platforms. By connecting the device to cloud-based services, real-time sensor data can be transmitted and stored for remote monitoring and analysis. This would enable authorities and users to track vehicle status and accident information from anywhere.Another potential enhancement is the addition of GSM communication modules that can automatically send emergency SMS alerts to predefined contacts, hospitals, or rescue teams along with GPS coordinates. This feature would improve communication reliability during accident situations.Developing a dedicated mobile application is another promising direction for future development. A smartphone application could receive accident notifications, display vehicle location on digital maps, and allow users to interact with the system more easily.The system's detection accuracy could also be improved by incorporating artificial intelligence or machine learning algorithms. These algorithms can analyze historical sensor data and identify accident patterns more effectively, reducing false alarms and improving decision-making capabilities.Additional sensors such as alcohol detection modules, heart-rate monitors, and camera systems could also be integrated to monitor driver health and behavior. These enhancements would enable the system to detect driver fatigue, intoxication, or medical emergencies that could lead to accidents.Cloud-based data analytics can further enhance the system by enabling authorities to analyze accident trends, identify high-risk road segments, and implement targeted safety measures. Improvements in GPS tracking and real-time mapping integration would also increase the accuracy of location-based services.Furthermore, the system can be redesigned as a compact embedded device that can be easily installed in vehicles. Improving power management through energy-efficient hardware design or battery optimization would increase the system's reliability and operational lifespan.With these improvements, the proposed accident detection system can evolve into a comprehensive intelligent transportation safety platform capable of preventing accidents, improving emergency response, and supporting smart city initiatives.

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