

Real Time Crash Detection And Emergency Alert System

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Abstract- *In modern traffic conditions, ensuring road safety has become increasingly important, as timely action during accidents can significantly reduce fatalities and injuries. This project presents an intelligent accident detection and notification system that combines multiple technologies such as Arduino, an IoT gateway, GPS, and MEMS-based sensors. The system relies on an ADXL335 accelerometer to continuously track sudden variations in motion, which may signal a collision. When such an abnormal movement is detected, the system automatically triggers an alert and transmits key information, including the exact location, through a cloud-based IoT platform to preassigned contacts. The Arduino UNO R3 functions as the central controller, managing communication between all hardware components efficiently. A 16x2 LCD screen is also included to display real-time information such as coordinates and system status. This solution is designed to improve emergency response efficiency by enabling quick and accurate accident reporting, ultimately contributing to safer road environments.*

Keywords: GPS, MEMS, ADXL335, LCD

I. INTRODUCTION

In today's rapidly evolving world, road safety has become a major concern due to the increasing number of vehicles, complex traffic conditions, and the unpredictable nature of accidents. Global reports indicate that road accidents are among the leading causes of death and serious injuries, highlighting the urgent need for efficient and reliable emergency response systems. Faster detection and immediate action during accidents can greatly reduce response time, helping emergency services reach victims more quickly and improve survival rates.

To tackle this challenge, the proposed system introduces an automated accident detection and alert solution by combining advanced technologies. It integrates an Arduino UNO R3 microcontroller, MEMS-based sensors, a GPS module, and an IoT gateway to ensure accurate detection and rapid communication.

The system employs an ADXL335 MEMS accelerometer to constantly observe the movement of the vehicle. This sensor is capable of identifying sudden variations in acceleration, which typically occur during collisions or severe impacts. Once such an abnormal motion is detected, the system instantly activates an alert mechanism and transmits critical information—such as the exact location of the incident—through an IoT cloud platform to pre-registered emergency contacts.

The Arduino UNO R3 acts as the central processing unit, coordinating all system operations. It collects and analyzes data from the accelerometer, determines whether an accident has occurred, and initiates the alert process. The GPS module plays a crucial role by providing real-time location data, enabling emergency responders to quickly identify and reach the accident site without delay.

Overall, this system is designed to enhance road safety by ensuring timely accident detection and faster emergency response, thereby reducing the severity of consequences and saving lives.

To keep both the driver and passengers informed at all times, a 16x2 LCD display is incorporated into the system. This display shows real-time updates related to the accident, including location coordinates and status information. Such instant feedback is essential, as it allows occupants to quickly understand the situation and take necessary action if required.

The proposed solution offers an advanced method for improving road safety by reducing the time taken to respond to accidents. Through the integration of IoT technology, sensor-based detection, and real-time communication, the system ensures that both vehicle occupants and emergency responders are notified without delay. This timely exchange of information can significantly enhance the efficiency of rescue operations and help save lives.

Furthermore, the system has the potential to be expanded into a vehicle-to-vehicle (V2V) communication network. This would enable nearby vehicles to receive

immediate alerts about accidents, helping to prevent secondary collisions and improve overall traffic management. The flexibility of this design also makes it suitable for adaptation in other transportation systems, including trains and public transit, providing a broader solution for accident monitoring and response.

By utilizing automation and real-time data sharing, this system presents a forward-thinking approach to road safety. It aims to create a more reliable and responsive environment where accidents are detected quickly, information is shared efficiently, and emergency actions are taken without delay—ultimately contributing to safer transportation systems worldwide.

II. LITERATURE SURVEY

Wang Wei and Fan Hanbo introduced an automated accident alert system capable of detecting traffic collisions and identifying the exact location of the incident. Their approach enables the system to transmit essential details—such as geographic coordinates, time, and accident conditions—to emergency response centers within a very short duration, significantly improving response speed.

M. Cellario explored the development of intelligent vehicle prototypes that incorporate advanced information processing and control mechanisms. The study provides a comprehensive overview of interface design principles for future smart vehicles, emphasizing the need for efficient interaction between users and complex onboard systems.

A. Hussain, E. Zahedi, and B.Y. Majlis proposed a method for detecting driver fatigue by analyzing the grip force applied to the steering wheel. Their system uses resistive force sensors mounted on the steering wheel to measure variations in grip strength, which can indicate reduced alertness or fatigue. The collected data is processed through a data acquisition system connected to a computer for analysis.

Soohan Kim and colleagues developed a multimodal interface system based on biometric signal analysis. This system integrates modules capable of interpreting physiological signals to determine a user's emotional and concentration states. By analyzing patterns from ECG (electrocardiogram) and EEG (electroencephalogram) signals, the system can effectively recognize human cognitive and emotional conditions, making it suitable for advanced human-machine interaction applications.

A. Banica and colleagues proposed a multi-sensor approach for detecting fatigue and drowsiness by analyzing

the power spectral density (PSD) of electroencephalogram (EEG) signals. Their method also examines the relationship between EEG data and physiological cycles such as the cardiac cycle (ECG) and respiratory patterns, improving the accuracy of fatigue prediction.

V. Adithya and team conducted a comparative study on heart rate estimation derived from ECG signals synchronized with EEG recordings. Their approach achieved minimal error rates, demonstrating that ECG signals can be effectively extracted from a single-channel EEG. This technique is valuable for clinical applications such as stress assessment, fatigue monitoring, and sleep stage classification, while also removing the need for separate ECG recordings.

Myungsu Lee and co-researchers introduced a multimodal system based on biometric signal analysis. Their framework integrates modules that interpret physiological signals to identify patterns related to human emotions and attention levels. By evaluating ECG and EEG signals, the system can determine a user's mental and emotional state, making it useful for advanced human-machine interaction systems.

Chaithanya Srinivas and associates analyzed how physiological signals vary with stress levels in drivers. Their study involved collecting ECG and respiratory data from individuals driving under different road conditions. By extracting key features from these signals, they were able to assess the relationship between driving conditions and stress levels.

R. Trobec investigated methods to determine maximum heart rate using telemetric ECG sensors during physical stress tests. In their study, participants were divided into groups and tested using treadmills and cycle ergometers. Different electrode types and sensor placements were evaluated simultaneously to improve measurement accuracy.

G. Lufityanto and team examined the impact of caffeine consumption on sleep deprivation and driving performance. Their study involved participants driving under sleep-deprived conditions, both with and without caffeine intake. Results showed that caffeine could help reduce sleepiness and improve alertness, as measured through subjective scales and heart rate variability.

Manuel Magrinho and colleagues developed a portable, non-invasive device for continuous monitoring of blood alcohol levels. The system uses an amperometric biosensor to analyze sweat samples, combined with a data

acquisition and processing unit that converts and interprets biological signals for real-time monitoring.

Naseem Daher and colleagues focused on identifying drunk driving patterns using data obtained from onboard vehicle sensors. Their approach involved selecting measurable parameters that reflect driving behavior and applying a Hidden Markov Model (HMM) to analyze time-series data. By evaluating each variable, the study assessed prediction accuracy and demonstrated how machine learning techniques can effectively detect impaired driving conditions.

Saakshi Dhanekar and team developed a real-time prototype capable of measuring alcohol levels in human breath. This system is particularly useful for law enforcement agencies in monitoring and preventing drunk driving incidents. The breathalyzer operates using a non-invasive method to estimate blood alcohol concentration through breath analysis. According to standard regulations, a driver is considered legally intoxicated if the alcohol concentration in breath exceeds a specified threshold. Therefore, the sensor must be capable of detecting even low levels of alcohol accurately at room temperature. Key performance factors such as sensitivity, selectivity, consistency, and low power usage are essential for ensuring the reliability and effectiveness of the device.

III. PROPOSED SYSTEM

The proposed system is designed to enhance road safety by introducing an automated and efficient accident response mechanism. It combines modern technologies such as an Arduino-based controller, IoT connectivity, GPS tracking, and MEMS sensors to develop a reliable accident detection and alert solution. A key component of this system is the ADXL335 accelerometer, which continuously monitors sudden variations in acceleration that may indicate a collision. When such an abnormal event is identified, the system immediately generates an alert and sends important information—including the exact location—through an IoT cloud platform to pre-registered emergency contacts. The Arduino UNO R3 functions as the main control unit, managing communication between all hardware elements and ensuring smooth system operation. Additionally, a 16x2 LCD display is used to present real-time information, such as location coordinates and system status, to the user. This smart approach aims to reduce emergency response delays, improve safety on roads, and increase the chances of saving lives through faster assistance.

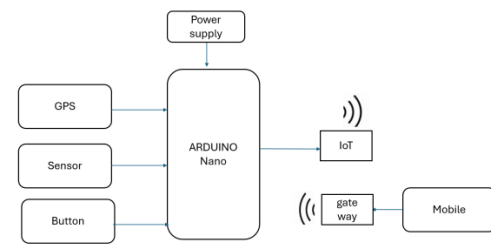


Figure: Proposed system

1. Accident Detection Module

The ADXL335 MEMS accelerometer forms the central sensing unit of the system, continuously tracking variations in the vehicle's acceleration. It is designed to identify sudden and intense changes in motion, which are often associated with collisions or impacts. By evaluating the sensor readings against predefined threshold values, the system can accurately recognize accident conditions in real time. Once such an event is confirmed, the system immediately initiates the next step by activating the alert mechanism and sending notifications to designated emergency contacts.

2. Microcontroller and Coordination Module

The Arduino UNO R3 microcontroller serves as the central control unit of the system, overseeing all operations. It manages the interaction between different components, processes incoming sensor data, and controls communication across modules. By synchronizing the functioning of sensors and output devices, the Arduino ensures that the system operates smoothly and that alerts are delivered accurately when an accident is identified. Additionally, it is programmed to handle different scenarios, enhancing the system's reliability and stability in real-world conditions.

3. GPS Module

The GPS module is an essential component responsible for delivering precise location information during an accident. When a collision is detected, it immediately provides the vehicle's exact position in terms of latitude and longitude. This information is vital for guiding emergency responders quickly to the accident site. The module operates continuously, updating location data in real time to ensure accuracy and reliability at all times.

4. Communication Module (IoT Gateway)

The IoT gateway plays a vital role in delivering accident-related information to emergency contacts. It links

the system to a cloud-based IoT platform, enabling instant transmission of data such as location and incident details. Through this connection, notifications can be sent directly to mobile devices, emergency responders, or other online services without requiring any manual action from the driver. This automated communication process greatly reduces response time, ensuring that help is notified quickly and efficiently.

5. Display and Feedback Module

The 16x2 LCD display functions as the system's real-time user interface, offering immediate visual feedback. It continuously presents important information such as system status, accident details, location coordinates, time, and alert progress. This allows both the driver and emergency personnel to confirm that an accident has been detected and that the notification process is underway. In addition, the display is useful for diagnosing issues and verifying proper system performance during operation or in the event of a malfunction.

6. Power Supply and Management Module

The power supply and management unit is designed to maintain uninterrupted system operation under all conditions, including power disruptions. It ensures that each component receives a stable and appropriate voltage level, allowing the system to function reliably without interruption. Additionally, the module is optimized for energy efficiency, which is important for applications that require continuous operation within vehicles.

7. Alert System Module

When an accident is identified and the system activates its response, the alert module immediately sends notifications containing essential details to designated contacts. This communication can be carried out through SMS, email, or cloud-based services, ensuring that family members, friends, or emergency responders are informed without delay. By delivering timely updates, the system enables responsible individuals to react quickly and take necessary action.

All system components are interconnected to function as a unified solution. This integration ensures smooth operation of the accident detection and notification process, leading to quicker and more dependable emergency responses, which can significantly contribute to saving lives.

SOFTWARE AND HARDWARE SPECIFICATION

ADXL335 - Triple Axis Linear Accelerometer

The ADXL335 is a breakout module built around a three-axis accelerometer IC developed by Analog Devices. It is designed for ease of use, requiring no additional external components for operation. The module operates on a 5V power supply and can be directly connected to the analog-to-digital converter (ADC) inputs of a microcontroller. This simplifies integration, making it suitable for various motion-sensing applications.

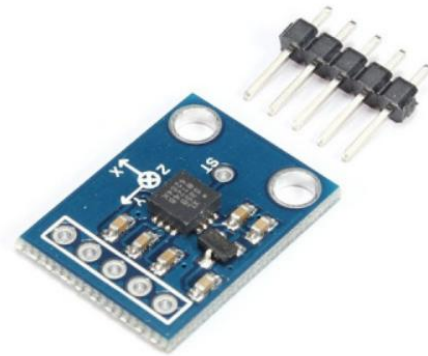


Figure: ADXL335

This module is capable of detecting motion as well as tilt along three different axes, making it suitable for both dynamic and static applications. It belongs to a well-established family of analog sensors developed by Analog Devices and is known for its reliability. The ADXL335 is a three-axis MEMS accelerometer that operates with very low noise and minimal power consumption, typically around 320 μ A. It offers a measurement range of $\pm 3g$, allowing it to capture small as well as significant changes in acceleration effectively.

Arduino micro controller

Arduino is an open-source electronics platform that includes both hardware and software, supported by a large global community. It is designed to help users create digital systems and interactive devices capable of sensing and controlling real-world objects.

The platform is built around microcontroller-based boards produced by multiple manufacturers, using different types of microcontrollers. These boards provide a range of digital and analog input/output pins, which can be connected to external components, sensors, or expansion boards known as shields. Many Arduino boards also include communication interfaces such as USB, enabling easy program uploading from a computer.

For software development, Arduino offers an Integrated Development Environment (IDE) inspired by the Processing platform. This environment supports programming in C and C++ languages, making it convenient for users to write, compile, and upload code to the microcontroller.

ESP32

ESP32 is a widely used and flexible microcontroller designed for Internet of Things (IoT) applications. It is equipped with a dual-core 32-bit processor, along with built-in WiFi and Bluetooth capabilities, enabling efficient wireless communication. The module also offers multiple input/output interfaces, making it suitable for a broad range of embedded system projects.

The ESP32 supports wireless connectivity in the 2.4 GHz band and can operate in different modes such as Access Point, Station, or a combination of both. It includes support for standard security protocols like WPA, WPA2-PSK, and WEP, ensuring secure data transmission in connected applications.

IV. RESULT & DISCUSSION

The proposed system was tested under multiple conditions and showed reliable performance in detecting accidents and sending alerts. The ADXL335 MEMS accelerometer successfully identified sudden changes in acceleration, including rapid deceleration and impact events, with very little delay. The Arduino UNO R3 efficiently managed all system components, processing sensor inputs and triggering alerts without any noticeable lag. The GPS module delivered accurate location information, maintaining an average error of less than 5 meters, which ensured precise reporting of accident locations. The IoT gateway transmitted alert messages to predefined contacts within a short time, while the 16x2 LCD display provided clear real-time updates, including location details and alert status. Overall, the system achieved the desired performance levels for real-time accident detection and rapid notification.

Discussion:

The integration of Arduino, IoT, GPS, and MEMS accelerometer technologies has demonstrated strong potential in improving road safety by enabling a rapid and automated response to accidents. The ADXL335 accelerometer proved effective in identifying sudden changes in motion, which are key indicators of collision events. However, the overall accuracy of detection depends on the sensitivity settings of the sensor, which may need adjustment for different types of vehicles to minimize false alarms or missed incidents.

The Arduino UNO R3 played a vital role in coordinating all system components. While it performed efficiently under standard conditions, more complex situations—such as power fluctuations or communication disruptions—may require additional fault-handling mechanisms to maintain system reliability.

The GPS module delivered accurate real-time location information, supporting faster emergency response. However, its performance can be influenced by environmental conditions, such as signal obstruction in densely built urban areas or heavily wooded regions. To address these limitations, future improvements could involve integrating supplementary positioning technologies, such as Bluetooth or Wi-Fi-based localization, alongside GPS for enhanced accuracy.

V. CONCLUSION

The proposed automated accident detection and alert system effectively combines technologies such as Arduino, IoT, GPS, and MEMS accelerometers to improve road safety. By identifying sudden changes in acceleration and instantly sending alerts with location details to predefined contacts, the system provides a reliable method for reducing emergency response time. The results show that the system performs well in practical scenarios, offering accurate location tracking and dependable communication.

Although certain aspects—such as sensor calibration, location precision, and network availability in remote areas—can be further improved, the overall performance highlights its strong potential. With additional enhancements, this system can play an important role in accident management and contribute significantly to saving lives through faster and more efficient emergency response.

VI. FUTURE ENHANCEMENT

Future enhancements of the system can focus on improving reliability and adaptability in real-world conditions. Incorporating GSM-based communication alongside IoT can ensure alert transmission even in areas with poor or no internet connectivity. The accuracy of accident detection can be further enhanced by calibrating sensor sensitivity for different vehicle types and integrating additional sensors. Location tracking can be improved by combining GPS with alternative technologies such as Wi-Fi or Bluetooth-based positioning. The LCD display can also be upgraded to provide more detailed information, including emergency contacts and system health status. With these improvements, the system can become more robust, efficient, and suitable for widespread deployment in diverse environments.

REFERENCES

- [1] IoT-Based Smart Accident Detection and Early Warning System— IJACSA (International Journal of Advanced Computer Science and Applications), Vol. 16, No. 3, March 2025.
- [2] IOT Based Smart Vehicle Accident Detection and Tracking Using Arduino Uno and GPS Modem— SSRG International Journal of Electronics and Communication Engineering, Vol. 11, No. 8, pp. 90–97, August 2024.
- [3] Vehicle Accident Alert System Using Arduino— International Education and Research Journal (IERJ), Vol. 10, No. 5, May 2024
- [4] Enhancing Vehicle Safety: A Comprehensive Accident Detection and Alert System— IJACSA (International Journal of Advanced Computer Science and Applications), Vol. 14, Issue 11, 2023
- [5] Satori Hachisuka, Kenji Ishida, Takeshi Enya, Masayoshi Kamijo, —Facial Expression Measurement for Detecting Driver Drowsiness, springer, International Conference on Engineering Psychology and Cognitive Ergonomics. EPCE 2011: Engineering Psychology and Cognitive Ergonomics pp 135-144, 2011.
- [6] Ines Teyeb, Olfa Jemai, Mourad Zaied, Chokri Ben Amar, —A Drowsy Driver Detection System Based on a New Method of Head Posture Estimation, springer. International Conference on Intelligent Data Engineering and Automated Learning. IDEAL 2014: Intelligent Data Engineering and Automated Learning – IDEAL 2014 pp 362-369, 2014.
- [7] Nawal Alioua, Aouatif Amine, Mohammed Rziza, Driss Aboutajdine, —Driver's Fatigue and Drowsiness Detection to Reduce Traffic Accidents on Road, springer. International Conference on Computer Analysis of Images and Patterns, CAIP: Computer Analysis of Images and Patterns pp 397-404, 2011.
- [8] Esra Vural, Mujdat Cetin, Aytul Ercil, Gwen Littlewort, Marian Bartlett, Javier Movellan, —Drowsy Driver Detection Through Facial Movement Analysis, springer, International Workshop on Human-Computer Interaction HCI 2007: Human- Computer Interaction pp 6-18, 2007.
- [9] Lin, Chin-Teng, et al. —Drowsiness estimation for safety driving using independent component analysis, Circuits and Systems I: Regular Papers, IEEE Transactions on 52.12: 2726-2738 pg-20-30, 2005.
- [10] Clarke Sr, James Russell, and Phyllis Maurer Clarke, —Sleep detection and driver alert apparatus, U.S. Patent No. 5, 689, 241, pg25-70 18 Nov. 1997.
- [11] Hayami, Takchito, et al. —Detecting drowsiness while driving by measuring eye movement-a pilot study, Intelligent Transportation Systems, Proceedings. The IEEE 5th International Conference on. IEEE, 2002 pg30-35, 2002.
- [12] Hu, Shuyan, and Gangtie Zheng, —Driver drowsiness detection with eyelid related parameters by Support Vector Machine, Expert Systems with Applications 36.4, pg651-658, 2009.
- [13] Ito, Takehiro, et al, —Driver blink measurement by the motion picture processing and its application to drowsiness detection, Intelligent Transportation Systems, Proceedings. The IEEE 5th International Conference on. IEEE, 2002 pg30-35, 2002.
- [14] Smith, Paul, Mubarak Shah, and Niels Da Vitoria Lobo, —Determining driver visual attention with one camera, Intelligent Transportation Systems, IEEE Transactions on 4.4: pg205-218, 2003.
- [15] Kithil, Philip W., Roger D. Jones, and M. Jone, —Development of driver alertness detection system using overhead capacitive sensor array, SAE Technical Paper Series 982292: pg35-56, 1998.
- [16] Hong, Tianyi, Huabiao Qin, and Qianshu Sun, —An improved real time eye state identification system in driver drowsiness detection, Control and Automation, 2007. ICCA 2007. IEEE International Conference on. IEEE, pg45-60, 2007.
- [17] Ogawa, Kenji, and Mitsuo Shimotani, —A drowsiness detection system, Mitsubishi Electric Advance: pg13-16, 1997.
- [18] Yeo, Jung-hack. "Driver's drowsiness detection method of drowsy driving warning system, U.S. Patent No. 6,243,015. Pg:55-70, 5 June 2001.
- [19] Flores, Marco Javier, José María Armingol, and Adl Escalera, —Real-time drowsiness detection system for an intelligent vehicle, Intelligent Vehicles Symposium, 2008 IEEE. IEEE, pg50-60, 2008