Smart Vehicle Crash Detection System with Instant Alert Transmission Via GSM & GPS Module

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Abstract:

Road accidents remain one of the leading causes of premature death globally, claiming thousands of lives every day and often leaving survivors with lifelong disabilities. A considerable part of these deaths is linked to the lag in delivering prompt medical help, especially in rural or isolated regions where witnesses might not be available to notify others of the occurrence. In such circumstances, an automatic accident detection system can be crucial for saving lives by shortening the time it takes to respond in an emergency. This paper puts forward a Vehicle Accident Detection System that utilizes an Arduino microcontroller and is based on an economical embedded platform. The system integrates the MPU6050, which combines a gyroscope and accelerometer for real-time motion and orientation tracking; a GPS module for accurate location monitoring; and a SIM900A GSM module to send instant SMS alerts. To identify occurrences like unexpected collisions, rollovers, or unusual changes in orientation, the system continuously monitors the vehicle's acceleration and tilting behaviour. When a potential accident is confirmed, the system automatically dispatches a text message with precise GPS coordinates to emergency contacts that have been preconfigured. The system guarantees quicker communication with emergency responders and enhances accident victims' survival chances by removing the necessity for manual accident reporting. Moreover, the suggested system establishes a solid basis for future developments, including Internet of Things (IoT) integration, real-time data recording, cloud-based emergency services, and machine learning-driven accident prediction and categorization. The prototype that was developed shows great reliability in accident detection and could greatly improve road safety and emergency response systems in various situations.

Keywords: MPU6050 Sensor, GSM SIM900A, GPS M8N Module, Arduino Uno

1. Introduction:

The World Health Organization (WHO) estimates that around 1.3 million individuals die annually as a result of road traffic accidents, and many others sustain serious injuries and endure long-term disabilities. These events result in the tragic loss of life and place a significant financial strain on people, families, and healthcare systems at the national level. One of the main reasons for road accidents' high death impact is that timely medical help does not arrive quickly enough. This is particularly true of rural and remote areas, where witnesses may be lacking. In numerous instances, victims go without care for long durations, which greatly diminishes their survival odds. The slowness in responding to emergencies underscores the pressing requirement for an automated system that can identify accidents and alert authorities independently of human involvement. The evolution of embedded systems and wireless communication has made it possible to create smart accident detection and notification systems. These systems utilize a variety of sensors and modules to identify abnormal vehicle behaviour and send immediate notifications to emergency services or designated contacts. Arduino stands out as a particularly promising platform for such applications. It is a widely used, open-source microcontroller that is affordable and supports integration with various sensors and communication modules. This research introduces a Vehicle Accident Detection System that is efficient, dependable, and economical, utilizing an Arduino microcontroller. The system uses an MPU6050 sensor to track acceleration and orientation, a GPS M8N module for pinpointing the vehicle's location, and a SIM900A GSM module to dispatch SMS alerts to designated emergency contacts. The system automatically sends an alert message with the precise location upon detecting a potential accident through sudden changes in motion or tilting, ensuring a quick response from emergency services. This paper details the

design, implementation, and testing of the proposed system, highlighting its effectiveness in real-time accident detection and reporting.

2. Literature review

Many researchers have focused their work on an accident monitoring system to control road accidents and save lives. Some of the work has been discussed in this section. In one of the work [3], the author proposed the concept of GPS receiver to get information about vehicle speed to detect an accident. The GPS system monitors and compares with previous values with Microcontroller. Decrease of speed to a certain limit then this is declared to be an accident. In [4], the author proposed the concept of the incident detection system to detect the accident by using the car airbag sensor with GPS and GSM. In another paper [5], the author proposed the accident detection system by using the Smartphone. In [6], the author uses the sensor to prevent the accident, and the wireless module is used for reporting purposes. The main drawback of this technique is it is very much expensive and difficult to install. In [7], the author discusses the accident is detected by using the accelerometer and flex sensor after that the location is provided to the nearest hospital, police station by using the GPS system and GSM module. In one work [8], the author proposes that the accident is detected by using the GPS speed and map-matching algorithm. Finally, that data is sent to the Server. In this system, the GPS will automatically track the position and the vehicle speed in every 0.1-second time interval to observe the vehicle. In another work [9], the author discusses the Real-Time Embedded System for Accident Prevention. Here the author designs an Atmega328P microcontroller system to track the location and alert corresponded people. Here the total process is done automatically which is very much helpful as after the accident the person may not able to send the location information to others [10]. Here the total process is divided into two parts one is the Receiver side and another one is the Transmitter side. Here in the transmitter side, the speed of the vehicle controlled by using the RF transmitter, which is placed at a fixed distance from the zone. Here for the security system, different types of sensors are used such as smoke sensors, alcohol sensors, and eye sensors. Here the piezoelectric sensor is used which will automatically detect the signal when the collision occurs and then it sends the information to the Atmega320P microcontroller [11]. Finally, the location of the place is estimated by using GPS and sends information to previously stored numbers (house, hospital, etc.) [12]. In [13], the author proposed the concept of the automatic smart accident detection system. In this work, the sensor continuously observed the change in speed, movement which is analyzed in the Smartphone application. In another work [14], the author proposed the Smoothed Particles Hydrodynamics (SPH) based accident detection system. Here at first, the motion flow is captured from the videos. After that, the coherent motion field is extracted from thermal diffusion and the moving particle is approximated. Then the potential particle is obtained to detect the accident from the video. The authors [15] propose an automatic accident detection system by using street surface estimation of traffic. The technique is not effective because there was a chance of false alarming and then it will be not sure to prevent or report an accident. In [16], the author proposes which uses module such as GPS, accelerometer, gyroscope, GSM, and auto-dialer. In this system, the MPU6050MEMS sensor is used to detect the accident by using the 3-axis accelerometer and gyroscope. And the GPS module tracks the location of the accident which is sent to emergency providers. After that, the auto-dialer feature automatically informs the victim's family about the accident. In one of the works [17], an application was developed to detect the accident and provides the notification to the medical associates timely. In [18] the author proposed the concept of fog based accident management system using the smartphone inbuilt sensor is used to detect the accident. In another paper [19] the author proposed the concept of smart accident detection system by using the vehicle sensor which continuously observes the speed, pressure, rotation movement of the vehicle. After that, the Smartphone analyzes the sensor data. Here the app is designed to analyze the data of the sensor to detect the accident.

3. System design

This work's primary goal is to automatically notify victims of traffic accidents so that medical assistance can be given as quickly as feasible. This technique greatly aids in lowering the number of fatalities from traffic accidents. Currently, the majority of automakers concentrate their efforts on developing effective safety features for cars. The suggested system can be highly useful in detecting vehicle crashes, and in the event of one, it will promptly give medical assistance to the passengers by using text messages to notify the family, hospital, police station, etc. The system is constructed on a microcontroller and communicates with a variety of sensors and modules, including a GPS system, GSM module, and accelerometer.

3.1 Block diagram

The different parts of the proposed scheme has been discussed in the following section:

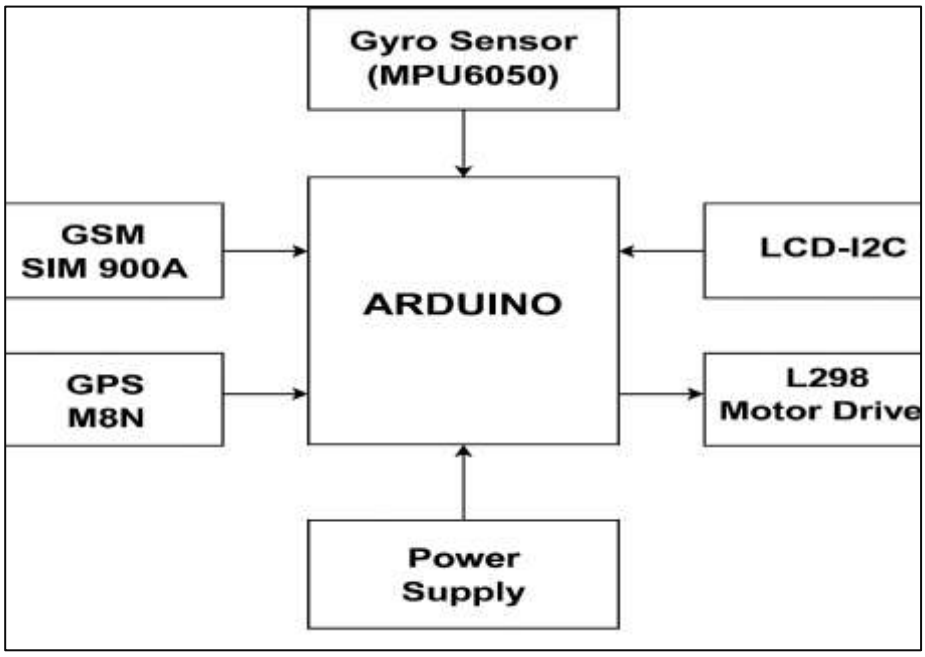

Fig.1. Block diagram of Hardware Setup

3.1.1 Arduino UNO

As the primary microcontroller that unifies and manages all connected components, the Arduino Uno is essential to the accident detection system. It is in charge of continuously obtaining data from the MPU6050 sensor, which picks up on variations in acceleration and orientation that could point to an accident or unusual vehicle movement. To ascertain whether an accident has occurred, the Arduino runs a decision-making algorithm based on the sensor information. The Arduino then connects to the M8N GPS module to obtain the vehicle's present location if an accident is verified. The SIM900A GSM module transmits this location data to designated emergency contacts via a Google Maps link. The Arduino Uno also controls the output to the LCD display, which shows real-time information such sensor readings, accident alerts, and system status. The Arduino Uno is the perfect microcontroller for this real-time embedded system application because of its easy-to-use programming interface, low power consumption, and dependable I/O handling.

Fig.2. Arduino UNO

3.1.2 MPU6050:

Combining a 3-axis accelerometer and a 3-axis gyroscope, the MPU6050 is a very flexible sensor module that is perfect for real-time motion and orientation detection applications. The MPU6050 is the main sensor used in the accident detection system to track the vehicle's motion and angular velocity. The Arduino initiates further operations, such as acquiring GPS coordinates and issuing an alert via the GSM module, when the sensor readings surpass a predetermined threshold, suggesting a possible mishap. The MPU6050 is an essential part of assuring precise and prompt accident detection because of its real-time responsiveness and sensitivity.

Fig.3. MPU6050 Gyroscope Sensor

3.1.3 GPS M8N MODULE

In order to provide real-time location monitoring within the accident detection system, the GPS M8N module is essential. The GPS module is turned on to get the exact geographic coordinates of the vehicle's present position as soon as the MPU6050 sensor detects an accident and the Arduino Uno confirms it. Even in difficult conditions, the M8N can provide precise latitude and longitude data because of its excellent sensitivity and quick satellite acquisition. Rescue crews or emergency contacts can then quickly and easily reach the location by formatting these coordinates into a Google Maps link.

Fig.4. GPS M8N MODULE

3.1.4 GSM SIM 900A

Using a normal SIM card, microcontrollers such as Arduino may send and receive data via a cellular network thanks to the SIM900A GSM module, a small and affordable communication device. It can operate efficiently in the majority of areas with all the type of networks because it supports quad-band GSM/GPRS. The module may be used to send and receive SMS messages, make and receive calls, and connect to the internet via GPRS. It interfaces with the Arduino by serial UART and can be controlled with AT instructions. When an accident is detected, it plays a crucial part in accident detection systems by sending an SMS alert to a pre-designated emergency contact with the vehicle's GPS location. It is an essential part of safety and emergency response because of its integration, which guarantees real-time communication even in places without internet or Wi-Fi.

Fig.5. SIM900A GSM Modul

4. Hardware Setup

Working:

The goal of the accident detection system is to spot accidents as they occur and notify the appropriate authorities or individuals right away. The MPU6050 accelerometer and gyroscope, GPS module (M8N), GSM module (SIM900A), and Arduino-based microcontroller are some of the essential parts used in this system. These components are all necessary for monitoring the state of the vehicle, spotting collision warning signs, and responding to help requests. The system starts by tracking the vehicle's motion continuously with the MPU6050 sensor, which combines an accelerometer and a gyroscope. While the accelerometer identifies variations in acceleration on the three axes (X, Y, and Z), the gyroscope measures angular velocity and detects rotational movements like tilting, rolling, or abrupt changes in direction. The system can identify unusual actions, like quick slowing down, abrupt collisions, or tipping motions—signs of an accident—by keeping track of the vehicle's orientation changes. The microcontroller (usually an Arduino) is continuously supplied with data from the MPU6050 sensor for examination. The microcontroller monitors the acceleration and rotational values for significant changes that exceed preset threshold values, suggesting a potential accident. Upon detection of an abnormal occurrence (for example, a crash or the vehicle being tipped over), the dc motor suddenly stops and system immediately activates the GSM module to dispatch an emergency message. The GSM module, which is linked to the microcontroller, interacts with the mobile network to dispatch an SMS containing the accident's location to preset phone numbers, including emergency services or relatives. This process depends on the GPS module (M8N) to supply real-time geographic coordinates of the vehicle. The moment when an accident is detected, the GPS module acquires the vehicle's current location along with latitude and longitude. The location data is sent with the emergency message through the GSM SIM900A module. This guarantees that those receiving the alert message are equipped with exact information about where the accident occurred, facilitating a speedier reaction from emergency services. In the event of an accident arise, the system dispatches an automated SMS that contains the incident's geographical coordinates (latitude and longitude). The message can be structured as: "Accident detected! Location: Latitudinal value: X. XXXX, Longitudinal value: Y. YYYY." This message goes to emergency contacts. By utilizing GPS coordinates, responders can pinpoint the precise site of the accident, regardless of whether the vehicle is on an unknown road or in a secluded location. By continuously monitoring the vehicle's condition, tracking its location in real-time, and using an alert system, assistance can be rendered as quickly as possible following an accident. The system is built to operate on its own, requiring only a small amount of human involvement. Combining these elements—the MPU6050 for accident detection, GSM for messaging, and GPS for tracking position—yields a powerful safety mechanism that boosts the vehicle's responsiveness in crises. The whole procedure is seamless; the system works with just the detection of an accident. The system's automatic nature provides particular advantages in scenarios where the driver cannot respond to the emergency due to incapacitation. Additionally, the system can be integrated into different kinds of vehicles, ranging from cars to motorcycles, making it a flexible solution for enhancing road safety. Besides its primary functions of detecting and reporting accidents, the system can be enhanced with additional features like real-time monitoring, data logging, and integration with other emergency services to guarantee that the best safety measures are implemented. This system is not only highly effective but also widely applicable in various environments, particularly in areas with limited access to immediate assistance, due to the use of GSM and GPS technologies. In summary, the Accident Detection System that leverages GPS, GSM, and MPU6050 provides a practical, efficient, and trustworthy solution for vehicle safety. By integrating real-time accident detection, automated alerts, and accurate location tracking, assistance can be rendered swiftly, thereby enhancing the likelihood of a successful and timely rescue when an accident occurs.

5. Results and observations

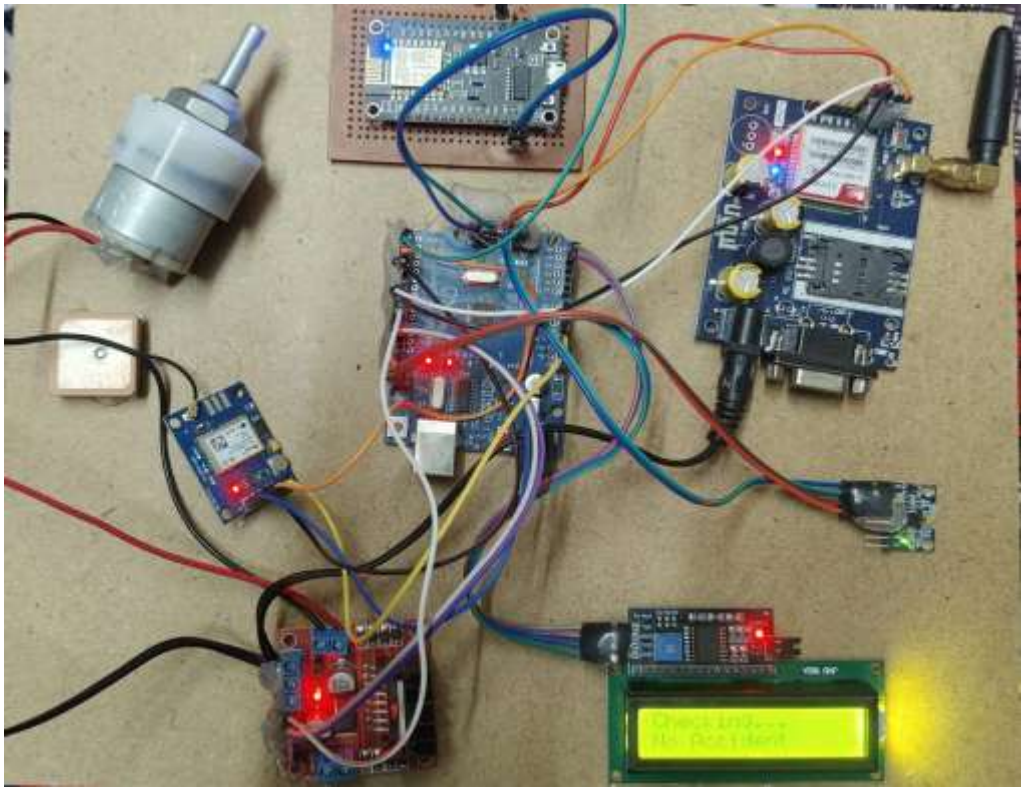

Fig.6. Hardware setup of Smart Automative Accident Monitoring System

5.1 Case I

The system continuously monitors the vehicle condition, if there is no detection of accident it show as shown in fig.7., whenever the accident occurs along its direction it updates the condition of vehicle as shown in Fig.8.

Fig.7. when there is no accident

Fig.8. when an accident occurred

Whenever the accident occurs the GPS location along with coordinates will be sent to the preset emergency mobile number as shown in Fig.9.

Fig.9. GPS coordinates (lat & long)

6. Conclusion

The proposed prototype of a device was successfully created, that not only automatically detects an accident, but also sends an alert message to the concerned authorities and to relatives. This will go a long way to reduce the number of casualties resulting from accidents as it reduces the amount of time it takes for the news of the accident to reach the medical services or the police station. Densely populated and heavily trafficked country like India, locating the accident victim with his vital parameter monitored will absolutely helpful for the paramedic team to track the victim and save the life. The google map link shows the shortest path to the exact location of the accident. Consequently, precious time is saved which in these cases are crucial. Although a lot of research has been conducted on this topic, based on both sensors and image processing, the sensor based approach is more reliable in such a critical situation since image processing requires more time and also requires a camera. On the other hand, the sensor based approaches all use internet access and is dependent on a mobile app. The proposed prototype uses a GSM module for sending a message and GPS module for detecting location, which makes it independent of a mobile which may run out of charge and also, internet access. In the future, our prototype can be connected to an online database which can contain that particular city's list of hospitals. This will expand the sample space of hospitals making it more flexible to be used in different cities. The system can also be connected to the driver's medical record and that can be sent long with the accident notification, which will help in better and faster treatment.

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