Moderen Accident Alert System For Vehicles Using GPS Technology

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Abstract— *The presented research paper introduces an innovative accident alert system utilizing GPS technology, mainly integrated with GSM, Arduino, and accelerometer components. The primary objective of this system is to mitigate fatalities resulting from unforeseen accidents in public areas. By promptly notifying emergency services, hospitals, and the police, including the precise accident location, the system aims to address the critical issue of delayed response and limited awareness. The system operates by triggering an alert whenever sudden deacceleration indicative of an accident occurs. In less severe accidents, the system retains the capability to continuously transmit the location This feature is particularly crucial in rural areas during nighttime when accidents often go unnoticed, leading to unfortunate fatalities. It is disheartening to acknowledge instances where individuals succumb to injuries or experience severe consequences hours after the accident due to the absence of immediate awareness. To further enhance the system's capabilities, future improvements can be implemented, such as incorporating shock sensors, fire alarm systems, and smoke-detecting sensors. These additions would extend the system's functionality beyond deacceleration detection, facilitating a more comprehensive approach to accident detection and emergency response.*

The research paper delves into the development, implementation, and potential advancements of this accident alert system. The findings of this study offer insights into the effectiveness and significance of deploying such systems to minimize fatalities, enhance emergency response, and raise awareness regarding accidents, especially in rural and remote areas. By leveraging advanced technologies, this system serves as a crucial step toward mitigating the devastating impact of accidents and ensuring prompt assistance.

Keywords— accident alert system, GPS technology, GSM, Arduino, accelerometer, emergency response, fatalities, awareness, rural areas, advanced technologies.

I. INTRODUCTION

In present times, vehicle accidents have emerged as a significant and alarming threat akin to diseases in Sri Lanka. The statistics report released by the Ministry of Highways and Transport highlights the gravity of the situation. In 2019 alone, the country witnessed 2,641 fatal accidents, 10,691 minor accidents, 7,693 critical accidents, and 9,713 incidents resulting in minor damages. Regrettably, these critical accidents claimed the lives of 2,829 individuals (Ministry of Highways and Transport, 2020). It is crucial to note that these figures reflect the scenario during a year when people predominantly stayed within the confines of their residences due to the prevailing pandemic. It is reasonable to assume that without such restrictions, the statistics would have been even more devastating.

While most accidents occurred during daytime, there were unfortunate instances where accidents transpired in night. Such circumstances pose an elevated risk as passengers may lose consciousness or faint due to the severity of the impact. In cases where bleeding occurs and individuals are immobilized, the potential for severe bodily harm or even fatality becomes distressingly high. Considering the economic landscape of the country, deploying security alert systems along roadsides proves to be an unfeasible solution. Moreover, a significant portion of the population relies on vehicles with inadequate safety infrastructure. Furthermore, the state of safety measures on rural tracks remains alarmingly substandard, characterized by incomplete tracks, drains, and bridges. As responsible citizens, it becomes imperative for us to prioritize our own safety and well-being.

This research paper aims to delve into the pressing issue of vehicle accidents in Sri Lanka, analyzing the causes, consequences, and potential solutions. By exploring innovative approaches to alerting and response, the study seeks to address the inherent challenges faced due to the country's economic constraints and safety infrastructure available of most of legacy vehicles.

II. LITERATURE REVIEW

A smartphone-based automated accident detection system was proposed (Sharma, Reddy and Karthik 2016). There, despite the sensitivity and range restrictions of the numerous smartphone sensors, an algorithm was developed to accurately infer an accident from the data. They followed user activity using a smartphone app, whether they were driving, walking, or jogging. Then another application called ***S-CarCrash*** is used, this collects smart phone built in sensors data and feeds it to the crash detector. Then it analyzed the data collected from multiple sensors by using crash detection algorithm, crash detection algorithm takes 3-axis accelerometer data after filtering noise to extract change in acceleration on the device in all the three axes. In the event of an accident, if smartphones is in direct contact with the vehicle, it is expected to experience similar forces as the vehicle, here moreover said that 20 g-forces (20 times the acceleration due to gravity) deceleration is needed for an accident to consider as critical. But dropping the mobile from the 1m gap is also possible to make significant acceleration. As mobile phones are day today using equipment, we can't say this is a permanent system, and if the mobile is totally damaged due to a severe accident this system is no longer functioning.

Another system using raspberry pie was introduced (Phoon and Lau 2019) to avoid getting close to other vehicles while driving. This system proposed a Forward Collision Alert System (FCAS). Simply the system alerts the driver when getting close to the front vehicle by estimating the speed of the car in the front using a loud beep sound. This proposed system consists of 5 major steps: step 1 : video acquisition, step 2 : speed acquisition, step 3 : FCAS-ROI segmentation, step 4 : vehicle detection and step 5 : alert system.

Accident alert system for bike accidents was proposed in 2013 (Basheer, Alias, Favas, Navas, Farhan, and Raghu, 2013). This system implemented that when accident occurs definitely some physical damage is caused, and this is used as a parameter in understanding of plausibility of an accident. And an accelerometer and as well as impact sensor is used to detect the scenario. A tilt sensor is also used to find the inclination of the motorcycle which can give greater inside the problem. A GPS system is adopted here to locate the location of the accident. GSM is used to send the alert message and the whole system is centrally controlled by a micro-controller.

III. METHODOLOGY

The sensors like accelerometer and gyroscope are very much familiar to us with our day-to-day work. When came to the mobile phone industry the gyroscope was almost already providing its contribution in various fields like, mobile gaming, drone controlling etc. When it comes to accelerometer it does same as gyroscope but additional feature as sensing the acceleration or deacceleration. In this proposed method the accelerometer is used as the main parameter measuring component. All the other components like Arduino uno, GSM module and GPS module provide variety of functionality to the main system (figure 1).

Arduino Uno board: Serving as the primary microcontroller board, the Arduino Uno incorporates the ATmega328P microcontroller. Boasting an array of digital and analog input/output pins, a USB interface for programming and serial communication, as well as a power supply circuit, this board stands as a versatile tool for prototyping and DIY electronics projects. Programmed using the user-friendly Arduino Integrated Development Environment (IDE), it seamlessly integrates with various sensors, actuators, and electronic components.

GPS Module: The GPS module assumes a pivotal role by enabling precise positioning and time information. It receives signals from GPS satellites and employs sophisticated trilateration techniques to calculate the device's exact location. Comprising a GPS receiver, antenna, and processing unit, this module is widely employed in navigation systems, tracking devices, and location-based services.

GSM Module: The GSM module plays a critical part in facilitating wireless communication over GSM networks. Consisting of a GSM modem and a SIM card holder, this module establishes seamless interaction with the GSM network. It enables the transmission and reception of SMS messages and voice calls through the utilization of a SIM card. GSM modules find extensive application in mobile phones, IoT devices, and a myriad of applications necessitating wireless communication capabilities.

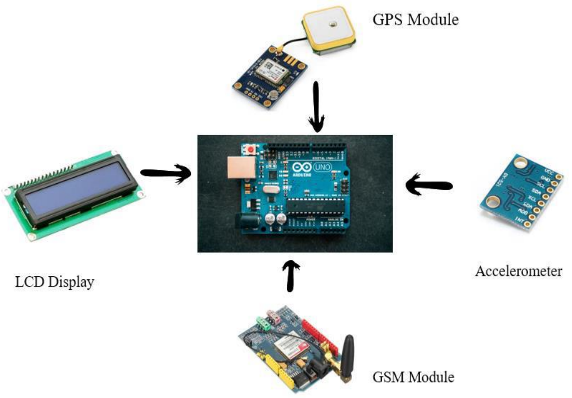

Figure 1. Functionality diagram

The system's software would run an accident detection algorithm that processes data from the accelerometer receiver and sensors. Here's a simplified example of how this algorithm might work:

- **Sudden Deceleration:** If the accelerometer detects a rapid decrease in speed (deceleration) beyond a certain threshold (in this the threshold value was taken as $-3m/s^2$), it may indicate a collision. This could be caused by a vehicle hitting an obstacle or another vehicle.
- **Impact Angle:** The gyroscope can help determine the angle at which the impact occurred. This information might be valuable in assessing the severity of the collision.
- **Location Data:** The GPS receiver continuously provides accurate location data. If the vehicle's sudden deceleration is accompanied by a significant change in its location, it might indicate an accident.

As mentioned, the accelerometer is the key component of this research. A model called ADXL335 is used here, and it is 3 axis accelerometers with sensitivity range of +3g to -3g for each axis. The operating voltage is about (1.8 to 3.6) v in normal atmospheric conditions. The accelerometer is kept on a flat surface and connected to a serial monitor that shows the acceleration values for each axis. As the accelerometer is kept on a flat surface the first values shown are 'Y' axis values, then turned either side and measured ‘X’ and ‘Z’ values as well. The values obtained by serial plotter are.

Table 1. Accelerometer values from serial plotter

Gravity	Z axis	X axis	Y axis
+1g	270	265	260
-1g	405	408	402

Those values in table 1 are in the unit of mV/g , that means it changes according to the operating voltage. These are stationary values, but as per the data sheet this has the sensitivity of +3g to -3g that means those mV/g values should be three times larger when considering the maximum. Here a crash detection algorithm is used to determine the magnitude of the force impact when accident occurred. Accident means sudden deacceleration that means within very small time, speed is reduced. It meant that the speed in a particular axis may suddenly change. Time gap between after and before was selected as 2 milliseconds for the detection purpose.

deltx = xaxis - oldx;

delty = yaxis - oldy;

deltz = zaxis - oldz;

The magnitude of the force of impact was calculated by using the following equation.

magnitude = sqrt(sq(deltx) + sq(delty) + sq(deltz));

At the beginning according to the road condition, the sensitivity should have to be set, assume the road is rough and with considerable slopes then the sensitivity should have been set up to some extent, if the vehicle overcome this value due to accident or something, the alert should be sent. The sensitivity range was taken as 80Mv/g to 180Mv/g. If even small impact occurs the system is shown as accident occurred when the sensitivity is 80. Then the sensitivity is 180 means a considerable amount impact is needed to overcome this value and shown as accident occurred.

When it comes to estimating impact angles using sensors like accelerometers and gyroscopes, angular velocity plays a crucial role. Here's how it generally works:

- Gyroscope Data: Gyroscopes measure angular velocity. They tell you how quickly the vehicle is rotating around its various axes (pitch, roll, and yaw). During an impact, the vehicle might experience rotations that are related to the impact angle.
- Sensor Fusion: By combining the data from the accelerometer, which provides information about linear acceleration, and the gyroscope, which provides information about angular velocity, you can create a more complete picture of the vehicle's motion during the impact.
- Incorporating Physics: With the information from both sensors, the system can use physics principles to estimate the likely impact angle. For instance, if the accelerometer indicates a strong deceleration and the gyroscope shows a specific type of rotation, the system can use trigonometry and other mathematical calculations to estimate the angle of impact.

During an impact, certain ranges of angular velocities might suggest different types of collisions or impact angles. Example: An angular velocity exceeding 100°/s on the roll axis might indicate a significant impact. An algorithm is used to combine accelerometer and gyroscope data, taking into account the physics of collisions and rotations.

A_x = filtered X-axis acceleration data
A_y = filtered Y-axis acceleration data
A_z = filtered Z-axis acceleration data

$$\text{Angle X} = arctan\left(\frac{A_x}{\sqrt{A_y^2 + A_z^2}}\right)$$

$$\text{Angle Y} = arctan\left(\frac{A_y}{\sqrt{A_x^2 + A_z^2}}\right)$$

$$\text{Angle Z} = arctan\left(\frac{\sqrt{A_x^2 + A_y^2}}{A_z}\right)$$

Figure 2. Angle equations

These acceleration values are calculated by the accelerometer itself and by using the equation mentioned, the inclination angle is measured. When it goes beyond the threshold value indicated earlier stage the alarm operates.

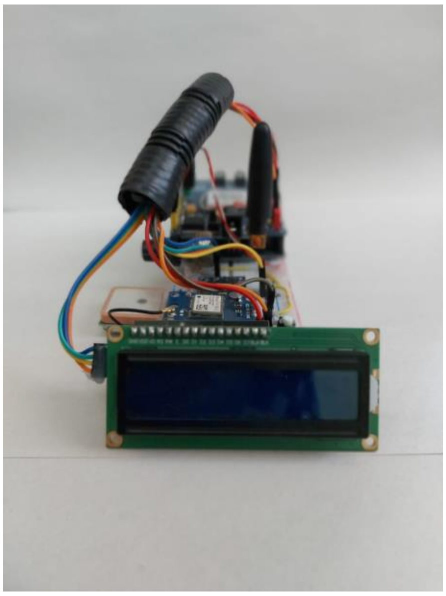

Figure 3. Circuit diagram

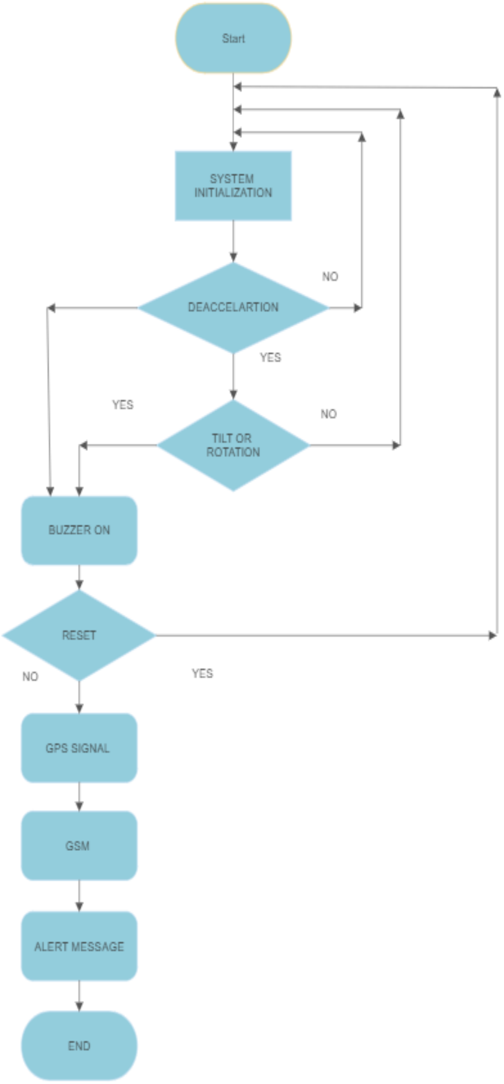

Figure 4. Flow chart

IV. Results and Analysis

When the vehicle is moving in a area like upcountry (Kandy), the road the always compiled with heavy slopes and bends , but when consider northern or any other costal area the road has not much severe slopes. Like this according to the road condition we have to consider about the sensitivity of the component. Then the vehicle was commenced to move and then suddenly crash happen, still the system don't know whether this is critical or not, this decision-making part was given to driver himself with a push button. In this prototype scenario 10 seconds was given after this time duration the alert message is sent automatically to the respective services or police. The reason, for given time duration is normally if the accident or crash is terrible and it caused a huge destruction for the passengers, mostly bleeding or internal organs can be damaged and due to this.

The overall results can be simply shown as in the table. Only one type of occurrence is enough to send the alert. Like 'OR' gate, in the case of both didn't happen, the alert won't send, other than that alert will be send.

Table 2. Results table

Deacceleration component	Inclination angle component	Results
0	0	0
0	1	1
1	0	1
1	1	1

They may face unconsciousness or faint problems without any clear mindset, so the 'beep' sound is continuously alerting inside the vehicle and if driver is in better condition without any severe injuries then can switch off the alarm and can stop sending the alert. So the initial step of the system is to identify the accident is in the given range of sensitivity. When at the beginning the sensitivity is need to be changed as per the road condition, so if the high sensitivity is selected then even for small deviation (small accident) the alert is sending, this high sensitivity is started from 80mV/g. like this the low sensitivity scenario is working , then a considerable amount of crash should happen to overcome the low sensitivity level and get alert (Figure 4).

The test was conducted using an actual car and the system was set up in the vehicle and sudden deacceleration was checked, the tilt and rotation scenario was checked using the prototype vehicle. The deacceleration scenario was checked in the following road(red colour line) as in the figure,

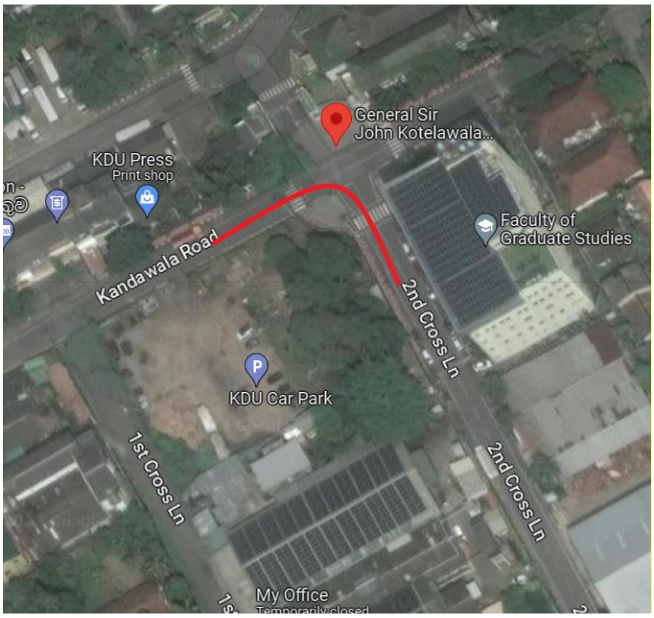

Figure 5. Location map

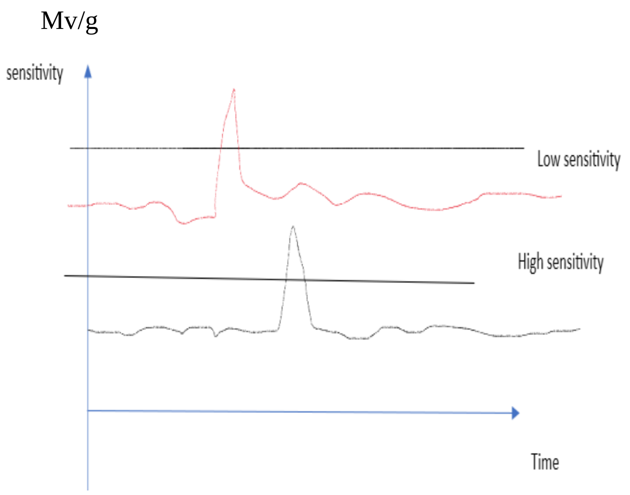

Figure 6. Sensitivity graph

When the system identified accident occurred and then the GSM module send the alert message with the GPS location (figure 4). We also can provide the required contact information of the emergency services.

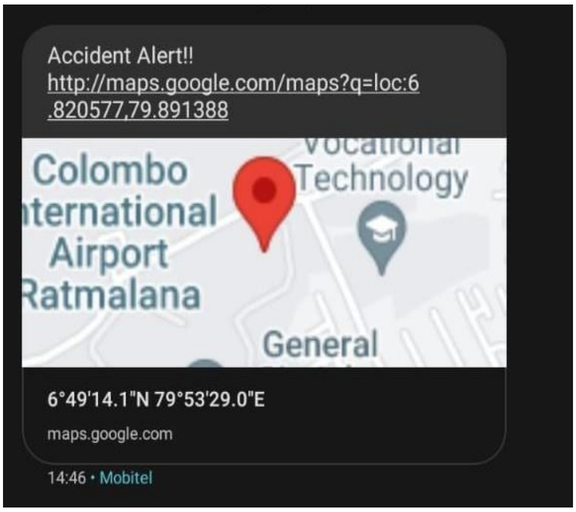

Figure 7. Message with GPS location 1

V. Outcomes And Discussion

An accident alert system project holds immense significance as it has the potential to save lives during emergencies. The system is purposefully designed to automatically detect and report accidents, enabling swift dispatch of emergency responders to the scene. In conclusion, the accident alert system project emerges as a critical tool for safeguarding individuals on the road. By leveraging advanced technologies such as GPS, sensors, and real-time communication, this system can accurately identify and promptly report accidents, facilitating rapid and effective emergency response. Its implementation stands to significantly reduce emergency service response times, ultimately translating into lives saved. Undoubtedly, prioritizing the development and deployment of accident alert systems is crucial for governments and private organizations alike, ensuring enhanced safety and security on our roads.

By adding the buzzer with reset button we can minimize the occurrence of false positives when travel. At the beginning of the journey the sensitivity can be adjusted and that will help the system to become more accurate and less false.

VI. Future Works

Integration of advanced sensors and technologies: While the current systems utilize GPS and accelerometers for accident detection, future iterations could incorporate additional sensors such as lidar, radar, or cameras. This would increase the system's capabilities by giving more thorough and reliable information on incidents. Using machine learning and artificial intelligence Future systems could examine enormous volumes of accident data to find patterns and anticipate possible accident hotspots by utilizing artificial intelligence and machine learning. The prevention of accidents may be considerably aided by this proactive strategy. Integration with driverless cars: Accident alert systems might be created to connect with autonomous vehicles as they become more common. By warning autonomous vehicles and launching preventative procedures, this integration would enable proactive accident prevention measures.

Enhancement of communication capabilities: The use of cutting-edge communication technologies like 5G and 6G networks could be made by future accident alert systems. This would lead to quicker response times and more dependability, facilitating effective communication between the system, emergency services, and accident-related cars. Enhancement of user interfaces: Accident alert systems can serve a wider range of users, including those with little technical expertise, by emphasizing intuitive and user-friendly interfaces. This would guarantee usability and accessibility, enabling people from all walks of life to take advantage of the system's possibilities.

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As electronics and telecommunication undergraduate, I have gained a solid foundation in both theoretical principles and practical applications. I have had the opportunity to work on projects that involve designing and implementing electronic circuits, analyzing and optimizing communication systems, and exploring the latest advancements in telecommunication technologies.

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