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Original Article

IOT Based Smart Vehicle Accident Detection and Tracking Using Arduino Uno and GPS Modem

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Abstract - *Lives are now better compared to the infrastructure's and technology's rapid progress. However, due to inadequate emergency facilities, road accidents regularly result in significant loss of life and property, and the introduction of technology has significantly exacerbated traffic risks. This project will provide the most effective solution to this problem. An accelerometer can be used in a car alarm system to detect unsafe driving. It can be installed on the vehicle as a rollover or collision detector prior to, during, and following an incident. Accelerometer measurements can be used to identify a significant accident. A microcontroller notifies a police control center or a rescue squad of an emergency via the GSM MODEM, along with the location. In order for the police to track down the position, as soon as they receive the information, they can use the GPS MODEM. The required actions will then be taken following the location's conformance. The driver can deactivate the alarm message using the given switch if there is only a minor accident or no major threat to anyone's life. This will help save the medical rescue team's crucial time.*

Keywords - *GSM, GPS, Vibration sensor, Arduino Uno.*

1. Introduction

IoT based smart vehicle accident detection and tracking with voice assistance is done using an Arduino Uno application with a GPS modem. The Internet of Things (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure [1]. Smart vehicle accident detection and tracking using Arduino Uno and GPS modem can detect accidents in significantly less time and send the information to the emergency center in a few seconds that covers the exact accident location.

Arduino Uno is used to doing all the processing, and the system integrates SIM808 GSM/GPRS/GPS modules to retrieve accident site coordinates and transmit them to registered numbers and neighboring ambulances so they can receive emergency assistance at the scene. Arduino Uno communicates MEMS accelerometer sensors to measure vehicles' velocity orientation and acceleration so that accidents are detected [2]. The GPS module is used to locate the accident, and the GSM module is used to transmit the message. A vibration sensor and a Micro Electro Mechanical System (MEMS) sensor can be used to pinpoint the accident. The information from the MEMS sensor can also show the angle of the car's rollover [3]. Car accidents occur regularly, a huge societal issue requiring immediate attention. The Internet of Things, the current technological trend, is one of the answers to this subject. Many studies have been conducted using IoT technology for this aim [8]. When working with the unintentional management system, Akriti et al. [10] discovered a number of tradeoffs, including high cost, non-portability, false delivery, etc. They measured the impact of an accident using a severity scale in their method. As a result, the cloud server's load was lowered by 30%. The system faced many shortcomings due to a lack of resources. We have adopted the idea of the Internet of Things so that we may use adjacent sensors to assist vehicles that have crashed or require assistance.

In an accident, there will be some impact on the car, which the sensors will detect [10]. Two components make up the framework that Chatrapathi et al. [11] created. The accident detection and alerting system is the first. The ambulance's traffic management is the second. The ambulance is routed using the effective routing method. The method works at signalized road intersections. It does not, however, apply to the signal-free sectors. [8].

Hamid M. Ali, and Zainab S. Alwan reported using infrared sensors to analyze the driver's behavior by observing how their eyes blinked. Attached to the driver's forehead, the accelerometer records head motions and calculates the angles the head makes. This device is impractical since it would be uncomfortable for the driver always to have an accelerometer affixed to their forehead. Moreover, driving behavior is the only factor considered for accident detection. Sandeep et al. [12] proposed a solution for accidents mainly caused by intoxicated driving. They interfaced an Arduino Uno with three alcohol sensors, a touch sensor, and a heartbeat sensor. The writers' work solely considered the conditions surrounding occurrences involving drunk driving. [8] A system developed by Pratiksha R et al. [13] can detect an accident and assess the engine condition of the car, warning the operator if smoke or flames are detected.

The technology effectively monitors any general irregularities that might occur in a car. Conversely, the system's accident detection component is given less consideration. Khaliq et al. included a few sensors and extra hardware in their discussion of accident detection techniques, and they confirmed the generated results. They included an assessment of the accident's severity in their methodology [8]. Namrata H. et al. use in-car detecting equipment to locate the collision. The authors built the device as a push-on pair of switches that sense impediments and trigger the microcontroller (AT8952) to turn on the buzzer immediately.

The system efficiently keeps an eye out for any general anomalies in automobiles. On the other hand, the accident detection part of the system receives less attention. In their discussion of accident detection systems, Khaliq et al. integrated a few sensors along with additional hardware, and they verified the resulting data. As part of their technique, they evaluated the accident's severity [8]. Namrata H. et al. use in-car detection technology to pinpoint the collision. The authors designed the gadget as a push-on set of switches that, upon sensing obstructions, cause the microcontroller (AT8952) to turn on the buzzer immediately.

2. Literature Review

The rapid progression of IoT technology has brought about a transformation in several fields, such as transportation and safety management. IoT, which is defined as a network of linked devices with the ability to sense and send data over the internet, offers creative ways to monitor and react in real-time to important situations like car accidents [35]. Accident detection systems play a critical role in reducing the effect of road accidents by allowing for quick emergency interventions. Dogru et al. stress the value of these technologies in alerting highway management in advance, which cuts down on reaction times and improves overall road safety measures [36]. In order to precisely identify events and provide vital information to emergency personnel and other cars, these systems use technologies such as GPS and GSM [36].

Using ARM controllers, GSM, and GPS modules, Jaahnavi et al. provide a full IoT-based system for automatic accident detection and emergency messaging, building on these ideas. In order to expedite medical help and optimize rescue operations, their technology guarantees exact position monitoring of cars involved in accidents and timely communication of emergency contacts [37].

Arduino Uno microcontrollers have recently been integrated into the Internet of Things (IoT)-based accident detection systems, providing scalable and affordable solutions [38]. The Arduino Uno's flexibility makes integrating it with GPS modems and GSM modules easy, providing real-time data transfer and remote control features essential for efficient accident management [38].

Furthermore, recent studies demonstrate how machine learning algorithms can improve accident detection systems' accuracy. These algorithms minimize false alarms and optimize resource allocation by differentiating between typical driving behavior and major occurrences like rollovers or accidents by assessing sensor data in real-time [39].

3. Related Works

Research on VANET (Vehicular Ad-hoc Network) technology has increased in popularity as a result of the growing need for applications in areas such as traffic control and management and road safety. It facilitates the formation of a network or a group of autonomous entities having intercommunication capabilities. To put it succinctly, it makes communication between cars and their infrastructure easier [6].

The study's foundation was a VANET-based Smart City framework [22]. VANETs contributed to increased road safety by enhancing mobility. This lessened the effects of growing population-related transportation issues like traffic congestion. A WSN roadside design for intelligent transportation systems was put out in a different research [23], enabling accident prevention and post-accident investigation.

In one study on emergency braking [24], the various VANET concepts served as the foundation for the investigation. The study examines complicated emergency braking applications by integrating a driver's behavior model, vehicle dynamics, and mobility into a comprehensive networking simulator (ns-3). However, it was set aside for future study because of security issues with VANETs and the difficulty of creating a safe protocol.

RFID (Radio Frequency Identification) tags and an RFID reader were employed in a dependable, less expensive traffic management system to monitor, control traffic, and identify collisions. It also unveiled the network of smart cities [25]. This work was significantly more dependable than a method that used CCTV cameras. Emergency vehicles bypass traffic signals faster and arrive at the hospital sooner because of the Geo-fencing technique [7]. Using this method, a contained area surrounding a certain location is shown to alert people when a vehicle with the necessary equipment enters or leaves the region. The perimeters may be dynamically created with RFID technology, creating a radius around the desired site. There has also been research on identifying accident-prone spots. The technology uses smartphone data on traffic congestion to identify accident-prone areas with an 80% success rate using machine learning algorithms [26].

Much research has also been done on drivers' use of smart gadgets. A triaxial accelerometer was used to create the "Konnect" smart helmet, an Internet of Things device that uses tilt to detect collisions depending on the driver's angle with regard to the ground [27].

The driver might stop the accident detection system and send the required notifications to the emergency contacts. It was discovered to be inexpensive and efficient for two-wheelers. Another research that employed smartwatches to track the driver's hand movements was able to determine "unsafe" hand positions with a 97% accuracy rate [28]. Several studies have explored the development of IoT-based systems for smart vehicle accident detection and tracking using Arduino Uno and GPS modems. [29] Proposed a system that utilizes Arduino Uno and GPS technology to detect accidents in real-time and track the vehicle's location.

Similarly, [30] presented a monitoring and tracking system for vehicles using IoT, integrating GPS modules with Arduino platforms to provide real-time location updates and accident detection capabilities. [31] Devised an accident detection and reporting system leveraging IoT technologies. Arduino-based sensors were employed to detect sudden impacts indicative of accidents, with GPS modules facilitating location tracking for prompt emergency response.

Furthermore, [32] developed a vehicle accident detection system based on IoT principles, employing Arduino boards and GPS modules to detect accidents and relay location information to emergency services. Furthermore, [33] proposed an Internet of Things (IoT)-based method for tracking and detecting car accidents. This method uses GPS and Arduino platforms to guarantee prompt accident reaction by automatically notifying the appropriate authorities of the incident's precise location. These studies collectively underscore the potential of IoT-enabled systems in enhancing vehicle safety through real-time accident detection and efficient tracking capabilities.

Currently, there are not many mechanisms in place that allow victims of auto accidents to call for emergency medical assistance. On the other hand, [34] suggests a comprehensive system for tracking each patient's unique health and an emergency reaction that is Bluetooth-activated. The system is linked to the hospital and uses several sensors, including car collision sensors and cardiac monitors. There is an enhancement in the EMS's overall efficiency.

4. Methodology

The components of the suggested system are shown in the block diagram: push button, power supply, GPS modem, vibration sensor, Arduino Uno, and SIM808. The above components are integrated as per the block diagram given in Figure 1.

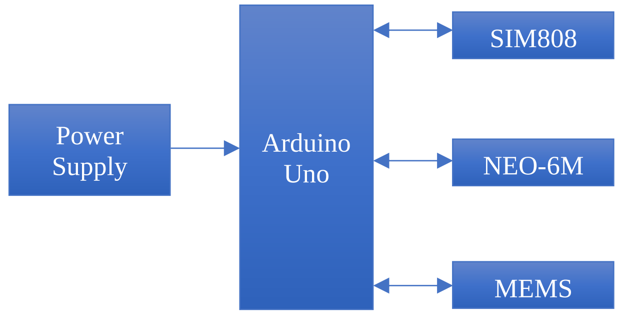

Fig. 1 Block diagram of SVADTs

4.1. Arduino Uno

Hardware and software that are easy to use form the foundation of Arduino, an open-source electronics platform. Arduino boards can receive inputs, such as a sensor's light, a finger pushing a button, or a message from Twitter, and convert them into outputs, like an LED going on a motor starting or an internet post.

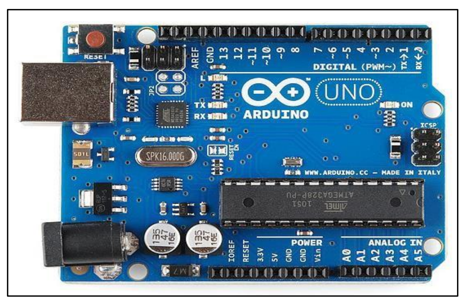

Fig. 2 Arduino Uno

4.2. SIM808

The SIM808 module is a single item that integrates GSM and GPS functions. It is based on the latest SIMCOM GSM/GPS module, SIM808, which combines GPS and satellite navigation and supports the GSM/GPRS Quad-Band network.

Fig. 3 SIM808

4.3. MEMS

When linear motion-such as movement, shock, or vibration-needs to be measured without a fixed reference, MEMS accelerometers are employed everywhere. In this system, Arduino Uno communicates a MEMS accelerometer sensor to measure the velocity orientation and acceleration of the vehicle so that an accident can be detected.

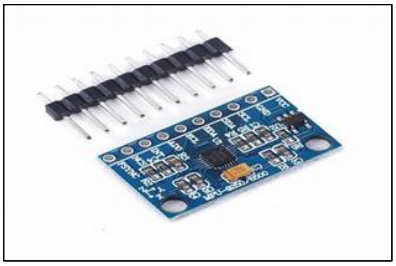

Fig. 4 MEMS accelerometer sensor

4.4. NEO-6M GPS

The NEO-6M GPS module, which has an inbuilt 25 x 25 x 4 mm ceramic antenna, is a potent satellite search instrument. It is a comprehensive GPS receiver with good performance. You can monitor the status of the module with the help of the power and signal indications.

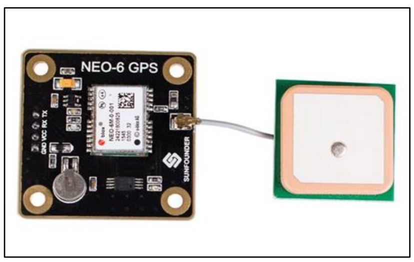

Fig. 5 NEO-6M GPS

4.5. Push Button

Tactile switches, or push buttons, are often in the open position. A push button is the only way to turn on the circuit or make a particular connection. Put simply, when pressed, the circuit is connected, and when it is released, the circuit is disconnected. A gate terminal can also activate the SCR by pressing a push button. These are the most common buttons that are always seen on the electronics that we use daily. The essay's conclusion covers a few applications for the push button.

Fig. 6 Push button

Electrical and electronic devices are designed, built, and maintained using circuit diagrams.

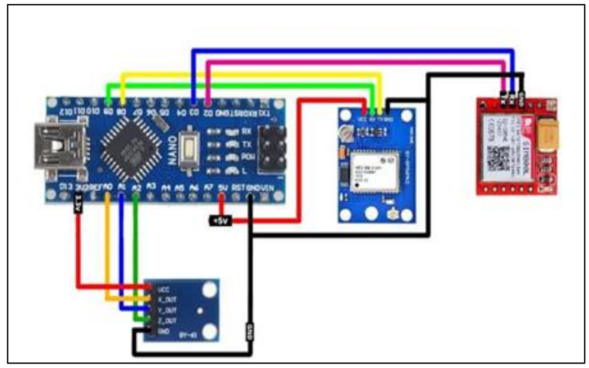

Fig. 7 Circuit diagram of SVADTs

5. The Proposed Framework

In the Internet of Things architecture. An IoT framework is a middleware layer that sits underneath one or more IoT applications and acts as a network-facing application interface, allowing peer framework nodes to talk to one another. Frameworks are often used to handle several message passing mechanisms and communication technologies.

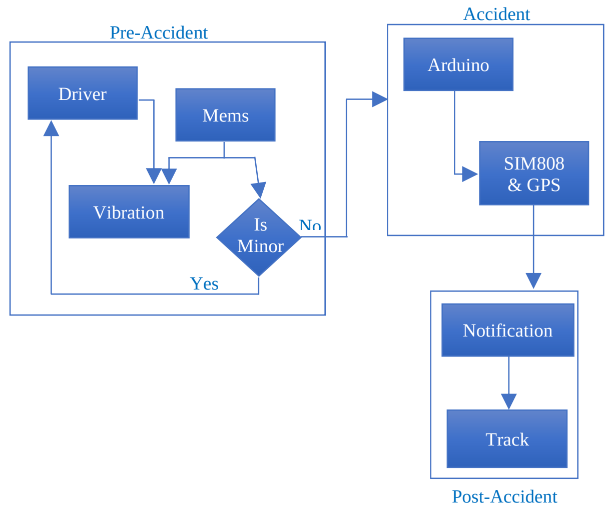

Fig. 8 Framework diagram of SVADTs

6. Result of the Study

This project involves 5 use cases: Drivers, Car, Family and Ambulance. The driver and car can detect an accident, send the information to the family member and nearest ambulance, and notify emergency contacts; if the car detects the accident is minor, the driver presses the "I am ok" button. Family and Ambulance can navigate through the shortest route to track the driver. An activity diagram is a version of a status chart diagram that schematically depicts a series of consecutive system actions that are executed. Activity diagrams define machine functions at a high level, usage situations, and concurrent and conditional operations.

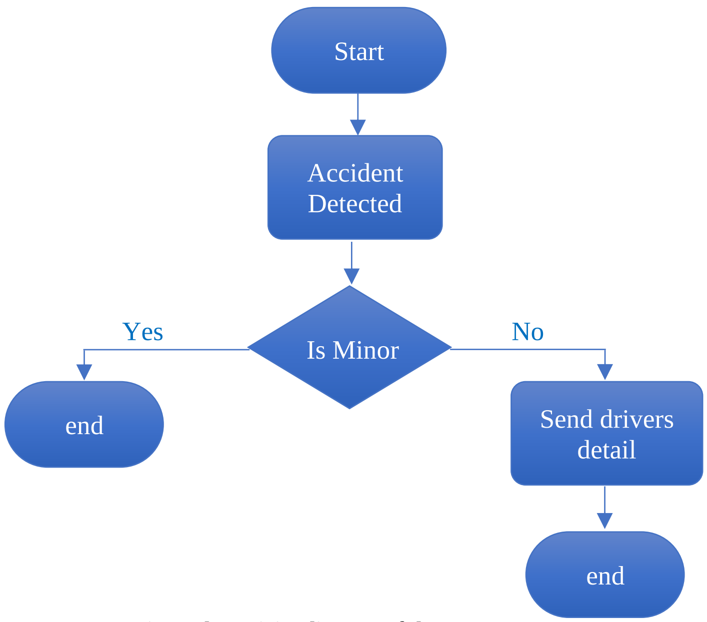

Fig. 9 The activity diagram of the SVADAT system

In this study, an experimental automotive system designed to broadcast the accident site continuously is developed. In order to ascertain whether the position is accurate given the time delay, the experiment is conducted at five different sites and is then repeatedly reviewed. The observations and information obtained from the suggested model lead to some conclusions. The system logs the latitude and longitude of the sites where accidental vehicle monitoring is required by creating a virtual environment. In this experiment, fifty observations were taken at each location to find the instrument's average time delay and accuracy. The system has been modified to minimize the possible delay to finish the rescue mission as quickly as possible following an accident. The time interval between when the sensors identify an incident and when the notification is received is as short as feasible. It is, therefore, an advantage of the proposed model. The experimental results are displayed in Table 1.

Table 1. Experimental observation

Place	Latitude	Longitude	Delay
PL1	2.03711	45.34375	4.0s
PL2	2.012370747959197	45.30674763792194	8.0s
PL3	2.016838072288746	45.297407829901196	7.6s
PL4	2.041076560806946	45.34478770056739	3.8s
PL5	2.0419947154388267	45.30831995722837	7.0s

It is noted that the outcome demonstrates extremely good location accuracy of the accident site. The system has sufficient intelligence to recognize when an accident will occur and prevent erroneous notifications. The five separate places where the experiment is carried out are PL1, PL2, PL3, PL4, and PL5. The image provided below conveys the accident location through a link, offering recipients immediate access to the precise incident site. Individuals can effortlessly view the location on a digital map by clicking on the link, gaining clear insight into the accident's vicinity. This method ensures swift and accurate navigation for emergency responders or concerned parties, enabling them to assess the situation and provide assistance quickly. Utilizing a linked location enhances communication efficiency, facilitating rapid response efforts and potentially minimizing further risks or delays in providing aid.

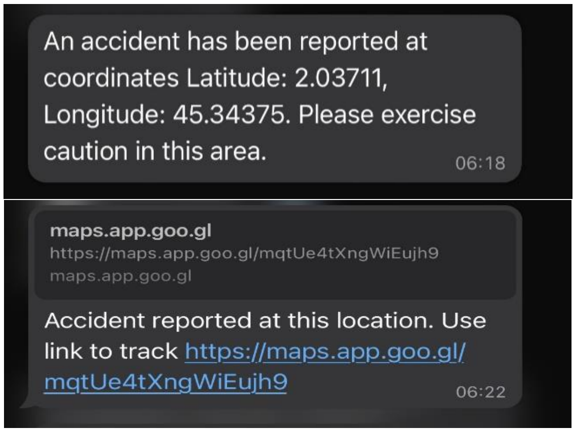

Fig. 10 Receiving accident location message

This picture displays the accident location, accessible for tracking via Google Maps. With this feature, users can swiftly pinpoint the incident's precise coordinates, aiding emergency response and navigation.

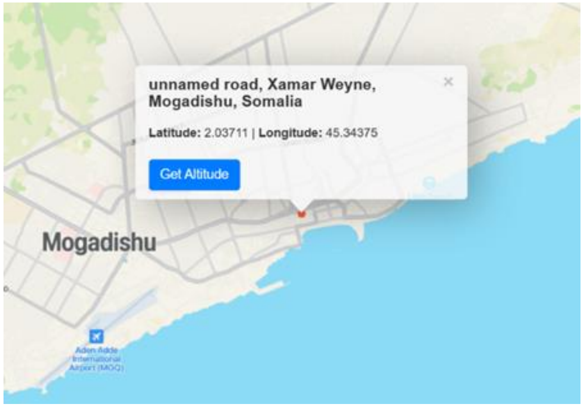

Fig. 11 Google map obtained from message

7. Conclusion

In summary, as infrastructure and technology advance at an accelerated rate and lives change, it becomes increasingly evident that certain aspects of the social structure, particularly emergency response systems, lag behind. Despite technological progress, traffic accidents claim lives and damage property, revealing significant deficiencies in responding quickly and effectively to emergencies. However, research endeavors to address these pressing issues by integrating cutting-edge IoT (Internet of Things) technology and vehicle safety systems. The primary component of the project involves incorporating advanced sensors, such as accelerometers, into car alarm applications. These sensors act as vigilant observers, continuously monitoring driving behavior to detect unsafe or unpredictable habits. By leveraging information from various sensors, the system can accurately identify and predict potential collisions, serving as a preventive measure against imminent danger. Beyond only detection, the Internet of Things (IoT)-driven accident detection and emergency response system provides many capabilities to improve the emergency response procedure. The system utilizes the GSM (Global System for Mobile Communications) modem to immediately alert pre-designated contacts and emergency services when an approaching accident is detected. Moreover, the apparatus relays the exact position of the incident using GPS (Global Positioning System) technology, facilitating emergency personnel's timely arrival to the scene.

Our research is unique in that it approaches emergency response from a comprehensive standpoint. Our solution offers location monitoring and real-time notifications and gives emergency responders access to the victim's critical medical information. This thorough information sharing guarantees that the accident reaction is quick and customized to meet the individual needs of those involved. Our solution enables a smooth transition from accident detection to medical action by exchanging vital health information with hospitals and medical staff, potentially reducing the severity of injuries and enhancing overall results.

In conclusion, our study signifies a paradigm change in emergency response and traffic safety. Using IoT technology successfully created a resilient and flexible system that can effectively reduce the effects of traffic accidents and enhance emergency response times. This research provides practical answers to the urgent problems of road safety and disaster preparedness, serving as a beacon of innovation in the intricacies of a constantly changing technological context.

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