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Integrated Vehicle Security And Monitoring System Using Arduino Mega: A Geo-Fencing And Real-Time Tracking Approach

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Abstract: This project is related to the invention of a vehicle security and monitoring system that integrates geo-fencing and real-time tracking. Through the use of Arduino Mega 2560, GPS, GSM, and sensors, the system offers theft detection, accident monitoring, and secure access control. In geo- fencing, boundary alerts are obtained, and, whereas, load monitoring is unauthorized use. The system fuses various security technologies executing an excellent and cost-efficient solution for both fleet management and the use of passive theft prevention, along with real-time vehicle tracking

Index terms—Geo-fencing, Vehicle Security, Theft Detection, Accident Monitoring, Boundary Alerts, Load Monitoring.

I. Introduction

The integration of GPS, GSM, and environmental sensors has seen significant advancements in recent years, leading to innovative solutions for real-time tracking, geofencing, and emergency alert systems. A growing number of applications, particularly in safety and security domains, leverage these technologies to provide precise location tracking, immediate communication, and environmental monitoring. Here we examine various works that explore the use of GPS and GSM modules for location-based services, with a focus on their application in geofencing systems. Additionally, we review research on integrating environmental sensors, such as speed detection, to enhance emergency response capabilities. These systems are commonly employed in industries such as transportation, asset tracking, where real-time monitoring and quick intervention are critical. We aim to identify current trends, challenges, and potential solutions that inform the development of a GPS geofencing system with real-time location tracking and emergency notifications. The objective is to consolidate the knowledgebase and highlight the most promising techniques that contribute to the effectiveness of such systems.

II. Literature Survey

On the one hand, Geo-fencing technology is used to create digital borders of the area and many telecommunications services benefit from it. In [1], the writer examines the roles of geo-fencing in the tracking of cell phones with the help of the GPS receiver, A-GPS, Wi-Fi, and Cell-ID. By using predefined geo-fences, alarms are triggered when a device moves beyond them. Examples of the application of technology are child safety, fleet management, compliance monitoring, and law enforcement. Both fixed and resizing geometry-based tracking functions are available through Geo-fencing, making it easy to keep the location of the device known and the person secure. To make this mobile application, the author of [2] has considered the use of geo-fencing and Global Positioning System (GPS) technologies with Android mobile devices. The attendance app is custom- built to permit the recording of real-time attendance by supervising staff to swipe seamless clock in and out, only when they are at the pre-specified location. The data collected includes IMEI numbers, GPS coordinates, date, and time. The managers can manage the employee details, allocate the location boundaries and the attendances can be viewed. This system is a secure and inexpensive remote and off-site worker tracking solution. The research in [3] develops a real-time GPS tracking system by using an Arduino and SIM908 module to send GPS data to a remote server via GSM and GPRS. A web application with the use of Node.js and Leaflet.js visualizes the tracked location. Moreover, a function called geo-fencing warns users when the device moves out of the range it was previously set in. Conversely, moving average filters, Kalman filters, and logistic regression are used to filter false positive/negative location results, and to make regression analysis effective, and the one that seems to have the best results is the Kalman filter. The system is up for grabs for tracking purposes of all sorts of vehicles, children, and patients. In [4], a GPS-based vehicle tracking and security system comprises of hardware – (ESP8266 NodeMCU, GPS module) and software like: Ubidots IoT cloud (Google Maps). Geo-fencing allows us to be notified of a vehicle's moving out of the particular area or through the or into the forbidden zone. In the real-time tests, it became clear that the accuracy was at the level of 95%, which makes it excellent for both preventing theft and surveillance of the location.The system in [5] covers women by monitoring the area with safety features using geo-fencing. The system sends a notification message to the users when they arrive or leave the area and also provides rescue alerts in emergencies. To present audio/video evidence to the police. This kind of forward approach raises security to a new level by utilizing the GPS and connectivity properties of smartphones.

III. PROBLEM IDENTIFICATION

- The system currently doesn’t support real-time GPS tracking along with geofencing.
- It can't detect sudden weight loss in an object, making it hard to identify theft.
- There’s no way to sense vehicle impacts, which means accidents might go unnoticed.
- Without authentication, anyone could access or modify the system, posing security risks.
- These limitations reduce the system’s ability to fully protect both goods and vehicles.

IV. OBJECTIVE

1. To set a virtual boundary around the object using GPS geofencing technology.
2. To send an SMS alert, including the object’s current location, if it crosses the defined boundary.
3. To provide real-time location tracking by receiving suitable prompts.
4. To detect any unusual reduction in the weight of the load, potentially indicating theft or tampering.
5. To detect any impact to the vehicle, indicating possible accidents or collisions.
6. To implement authentication mechanisms to control access and ensure that only authorized personnel can edit or access the program, thereby enhancing the system’s security.

METHODOLOGY

5.1 Block diagram

Fig 1. Transmitter Block diagram

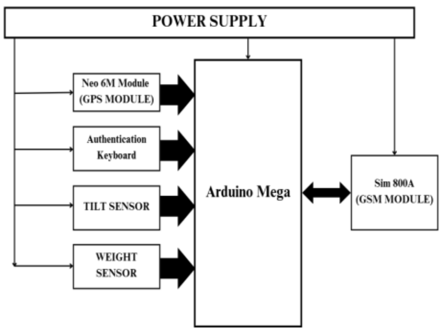

Fig 2. Receiver Block diagram

5.2. Flowchart

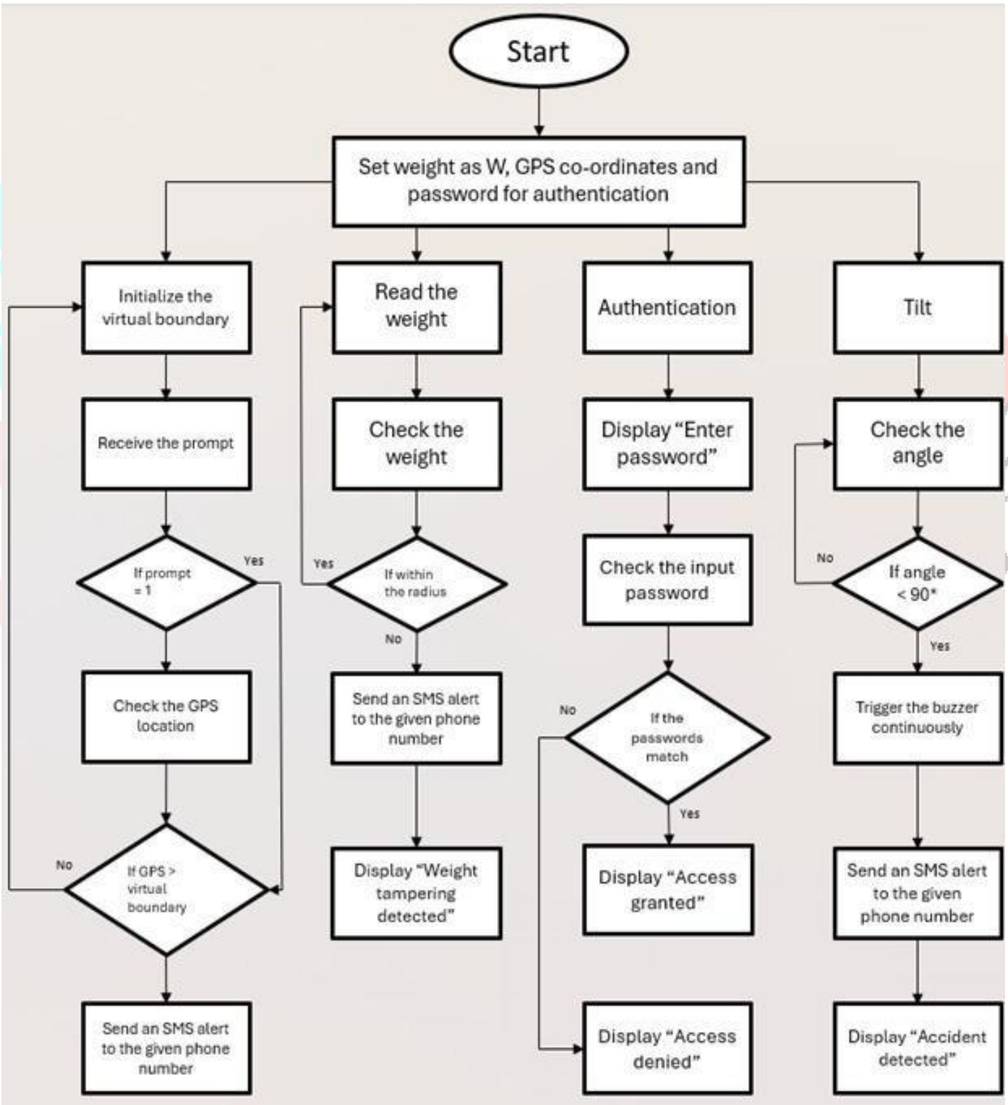

Fig.3. Flowchart

5.3. Working

The "Integrated Vehicle Security and Monitoring System Using Arduino Mega: A Geo-Fencing and Real-Time Tracking Approach" offers an integrative solution to improve automobile safety by integrating GPS, GSM, load sensors, and motion detectors. It uses the Arduino Mega 2560 microcontroller and includes facilities such as geo-fencing, where a virtual fence is created and alerts the user when the vehicle exceeds that fence. It features real-time location tracking through the NEO-6M GPS module, theft notification through a 5kg load cell that detects improper weight changes, and accident notification through an ADXL345 accelerometer that detects unusual changes in the tilt of the vehicle. A 4x4 password-protected keypad ensures only the authorized person is able to start the vehicle. Boundary breach, theft, or accident notifications are sent via the GSM SIM800 module by SMS. Furthermore, the system incorporates a 16x2 LCD that presents live system information. The installation has been proven to successfully verify entry, track geofence infringements, notify against improper removal of cargo, and sense possible accidents, hence becoming a strong and effective security system for both personal and commercial cars

V. **RESULTS**

1. AUTHENTICATION

A. SETTING PASSWORD

PASSWORD: "1234"

Fig 4: Setting up the password for authentication

B PASSWORD VERIFICATION

Fig5.The password is authenticated

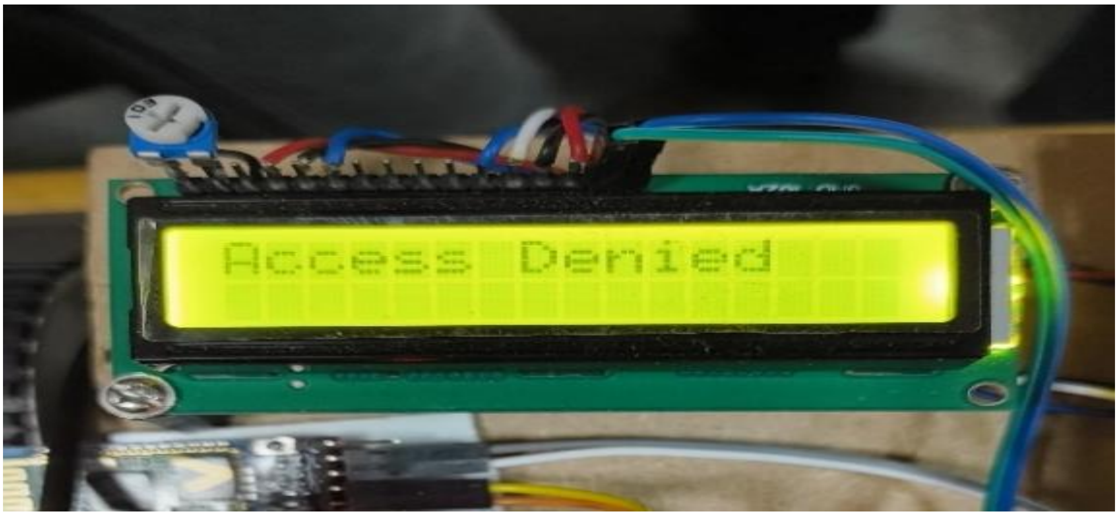

Fig6. The password is not authenticated

Table no 1: security system's password authentication results.

Sl. No	Password	Status
1	1234	Access granted
2	3456	Access denied
3	1214	Access denied

Table 1 presents a security system's password authentication results. The input password is “1234”. The Status column indicates whether access was granted or denied based on the correctness of the password. In this case, the password "1234" was successfully authenticated, resulting in "Access granted." However, the passwords "3456" and "1214" were incorrect, leading to "Access denied." This table demonstrates controlled access system where only predefined credentials allow entry. And the results are shown in fig.4, 5 & 6.

1. GEOFENCING

A. SET UP THE VIRTUAL BOUNDARY

$V_M = 200\text{m}$

B. LIVE TRACKING

$$If\ prompt = Location$$

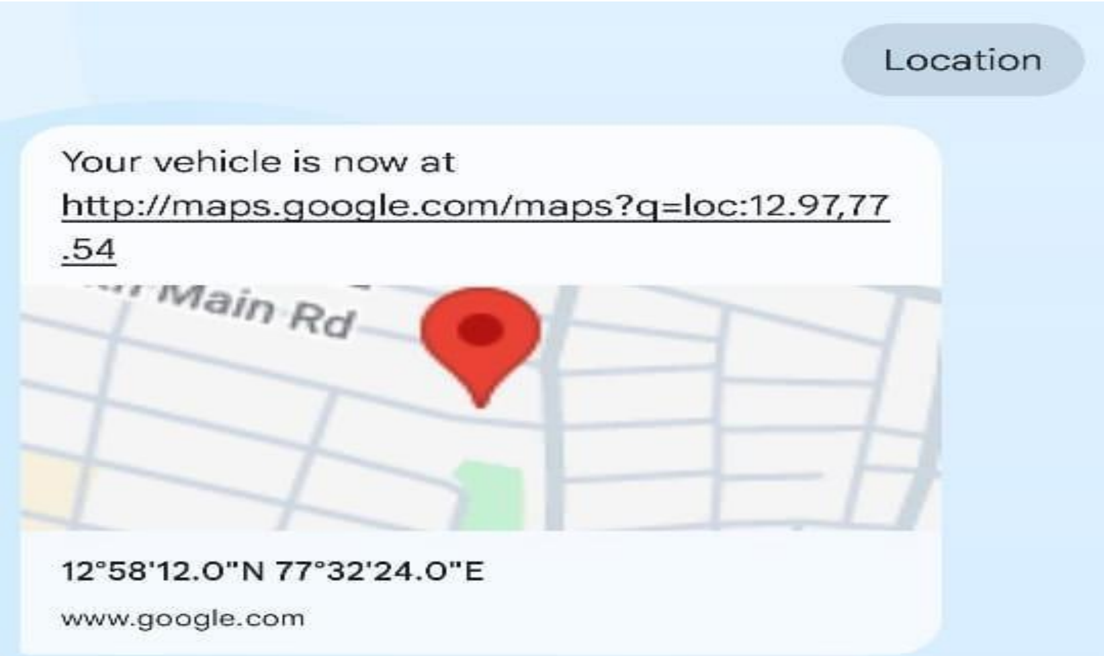

Fig.7. Live tracking of the vehicle within the geofenced area

The process outlines a geo-fencing system that establishes a virtual boundary (VM) of 200 meters for vehicle monitoring. Through live tracking, if the prompt "Location" is given, the real time location of the vehicle is sent as shown in fig.7

C.BOUNDARY VERIFICATION

$Current\ location = V'$

$If\ V'_m > V_m$

$send\ the\ message$

$else\ Repeat\ the\ process$

Consider $V'_m = 200m$

Table no 2: verification process, showing that for locationsTable no 2: verification process, showing that for locations

Sl. No	Current Location V'_m	Status
1	$90m$	SMS not sent
2	120m	SMS not sent
3	150m	SMS not sent
4	200m	SMS sent
5	250m	SMS sent

Fig.8. Tracking the vehicle's location and sending an alert whenever it crosses the virtual boundary.

In fig.8 the process outlines a geo-fencing system that establishes a virtual boundary (VM) of 200 meters for vehicle monitoring. Through live tracking, the system continuously checks the vehicle's current location ($'$). If the vehicle remains within the boundary, the process repeats without triggering an alert. However, if V' exceeds , an SMS alert m M is sent. Table 2 demonstrates this verification process, showing that for locations 90m, 120m, and 150m, no SMS was sent since the vehicle was within the boundary. Once the vehicle reached 200m and exceeded it at 250m, an alert was triggered, notifying the owner of a boundary breach.

1. Theft identification

A. Measure the initial weight

$W = 2.5Kg$

B. Measure the current weight W'

$If\ W' < W$

$send\ the\ message$

$else$

$repeat\ the\ process$

Table no 3: weights

Sl. No	Measured Weight W'	Status
1	1Kg	SMS sent
2	1.5Kg	SMS sent
3	2Kg	SMS sent
4	2.5Kg	SMS not sent
5	3Kg	SMS not sent

The process describes a load monitoring system that detects unauthorized weight reduction in a vehicle. The system first records an initial weight (W) of 2.5 kg and continuously measures the current weight (W'). If W' is less than W, an SMS alert is sent as shown in the fig.11, indicating possible load loss. Otherwise, the system continues monitoring. Table 3 shows that for weights 1kg, 1.5kg, and 2kg, an SMS was sent, signaling a decrease in load. However, when the weight remained at or exceeded 2.5kg (initial weight), no SMS was sent, as no loss was detected.

Fig.9. Measuring the initial weight for theft detection

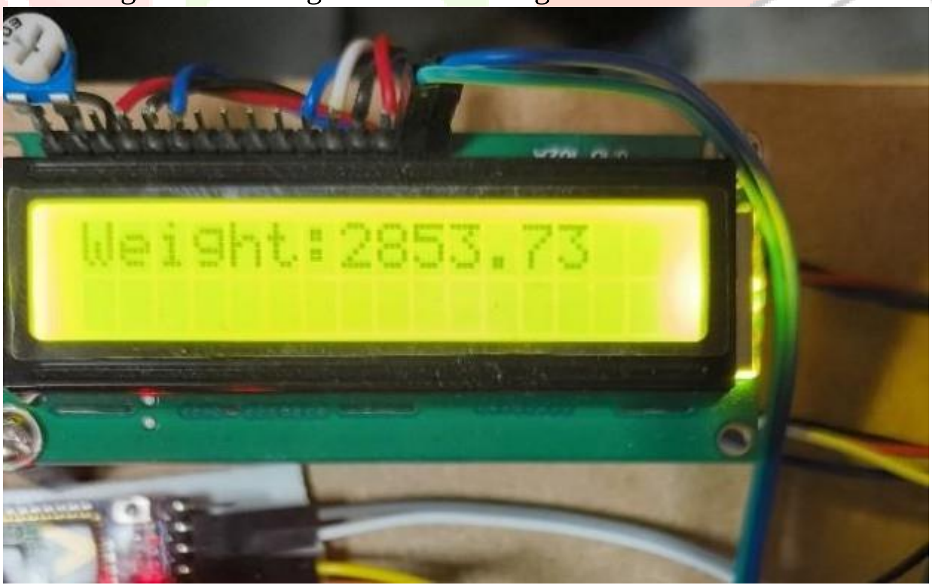

Fig.10. Checking the current weight to detect unauthorized removal

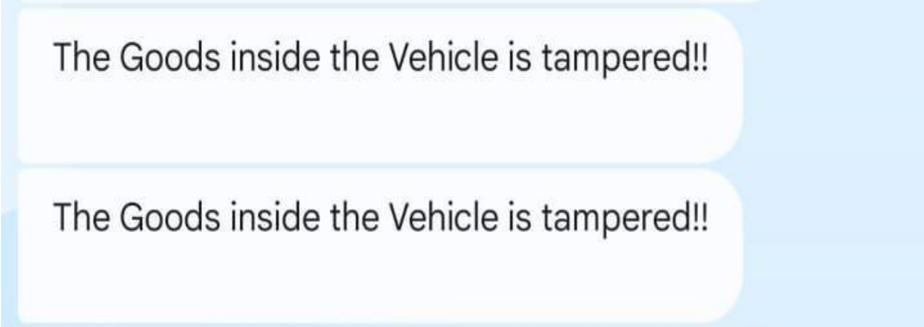

Fig.11. SMS alert sent when a change in weight indicates possible tampering with the goods.

Table no 4: angles and the status

Sl. No	Measured Angle $t'\theta$	Status
1	30	SMS not sent
2	45	SMS not sent
3	60	SMS not sent
4	75	SMS not sent
5	90	SMS sent

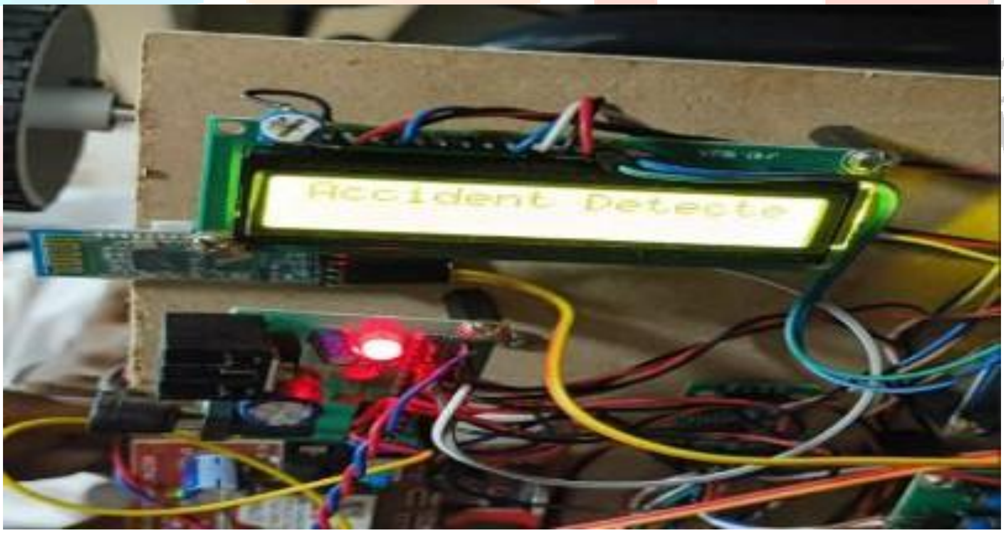

Fig.12. Display indicating that an accident has been detected based on the tilt angle

The process outlines an accident detection system based on the vehicle's tilt angle. The system sets an initial tilt angle ($t\theta$) of 85° and continuously monitors the current angle (t'). If t' is less than $t\theta$, the system continues monitoring without sending an alert. However, if t' exceeds $t\theta$, an SMS alert is triggered as shown in the fig.13, indicating a possible accident or rollover. The table 4 shows that for angles 30°, 45°, 60°, and 75°, no SMS was sent as the tilt remained below the threshold. When the angle reached 90°, an alert was triggered, notifying the owner of a potential accident.

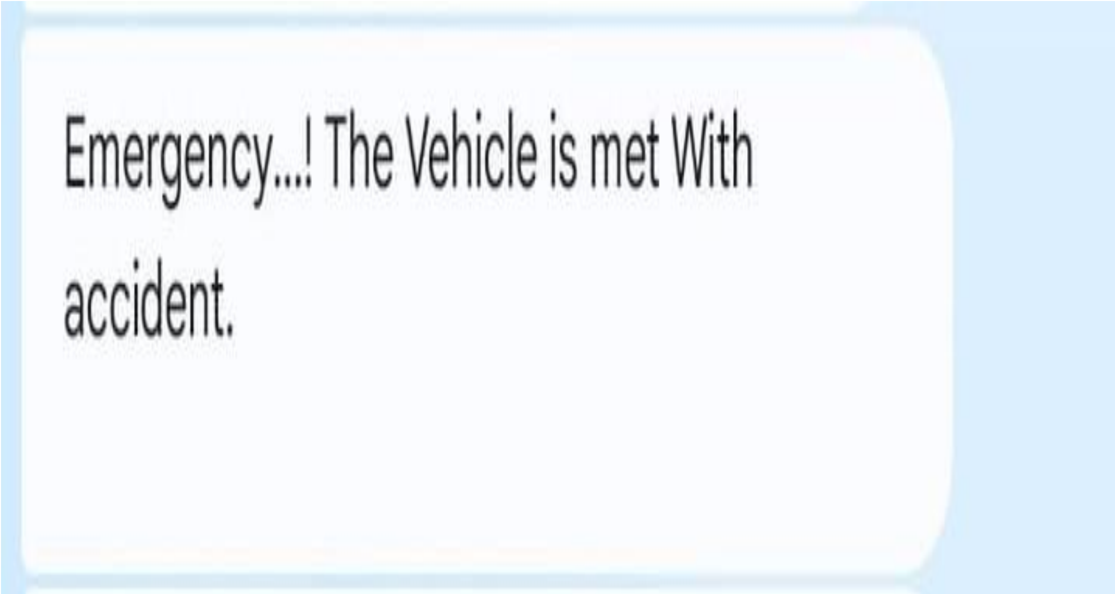

Fig.13. SMS alert sent after an accident has been detected.

VI. CONCLUSION

Geofencing vehicle system is a high-end security enhancement of a vehicle in terms of integrating the GPS tracking, load monitoring, accident detection, and the password-protected ignition. It can guarantee the real-time monitoring, theft detection, and accident reporting making it a strong solution for both the vehicle used in the logistic purpose and personal vehicle security.

VII. FUTURE SCOPE

- Integration with Cloud Services: Storing data in real time to analyse it in the future.
- AI-Based Accident Prediction: Harnessing machine learning for real-time accident alerts.
- Mobile App Interface: User-friendly dashboard to track and manage vehicle security.
- Fuel Monitoring: A fuel sensor can be added for monitoring.

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