Design and Implementation of Geo-Fencing Technology For Vehicle Tracking System and Accident Alert System Using GPS and GSM

Krishna S. Gondkar[1], Padmashree M. Sutar[2], Vrushabh B. Aralappanavar[3], Sakshi J. Chougule[4], Soumya Gokak[5], Nisarga Madihalli[6]
[1,2,3,4,5,6] *Department of ECE Jain College of Engineering and Research Belagavi, India*

Abstract*—In recent times, the quick rise in automobile theft and cases of road accidents has thrown light on the urgent requirement of advanced vehicle tracking and safety systems across the globe. The paper proposes a Geo-Fencing Technology-based Vehicle Tracking System and Accident Alert System designed to provide enhanced security for the vehicle and communicate accidents at the right time. It employs a GPS NEO-6M module for finding the real-time location of the vehicle and a GSM 800L module for communicating the alert. Accident Detection: The accelerometer sensor can be incorporated for accident detection and subsequent sending of messages to emergency services in the surrounding locality. A virtual boundary, also called a geo-fence, can also be designed around the operational zone of the vehicle. This will alert the system if the system crosses this boundary. In an accident, the system also transmits the vehicle's live location to a nearby hospital, which will help rescue services get to the location even faster. The system developed utilizes components such as Arduino Uno, GPS NEO-6M, GSM 800L, accelerometer sensor, buzzer, and DC motor so that it could be developed into a well-working system. The provided system has addressed some of the most important concerns: safety, displaying an efficient theft prevention mechanism, quicker response to accidents, and an all-round real-time monitoring of the vehicle. This project should ultimately serve to make the roads safer and enhance car security across the globe.

Keywords*—GPS NEO 6-M, GSM 800L, Accelerometer sensor, Arduino uno.

I. INTRODUCTION

A geo-fencing is a predetermined virtual geographical area defined by GPS. Using this feature, the program can generate an alarm when the subject/about the object enters/exits a specified region. It can be helpful in the management of some livestock and other animals. It may also be used, and especially by parents, for the monitoring of their children's location. This paper refers to or analyzes a geo-fencing system created to address certain issues that car rental companies and their client's encounter. Let us consider a scenario: when a car is given for rent, the owner places a limitation on movement outside a 50-kilometer radius of a specific city. Then the "Geo-Fencing" technology establishes the virtual fence using the GPS NEO-6M module. If a customer accidentally or intentionally crosses this barrier, the system activates an alert mechanism that warns the customer via a buzzer. Following a 10-second countdown, the car engine will automatically go off condition, guaranteeing that the rental terms are not met. Concurrently, an alert message and live location are sent to the owner over GSM 800L, telling them that the car has left the designated region. So this much is our project. Now, beyond our project, we are implementing one more feature to our project, which is an accident alert system. Today, many accidents take place across the world, so to avoid that, we build a project. For that, we are using the Accelerometer GY-16 sensor to avoid the collision. The sensor will detect using X, Y, and Z parameters, then it will act if any object gets hit by the sensor, then it will send a call to the nearest hospital using the GSM800L. This is about all the project stands to be.

PROBLEM STATEMENT

As per the survey, the worldwide automobile sector is facing a lot of issues happening regarding accidents and vehicle robbery. The need for advanced tracking and alarm systems has increased dramatically as concerns about automobile theft, accidents, and safety have spread around the world. As per World Health Organization (WHO)-provided data, more than ten lakhs of cars are stolen every year, and more than 1.3 million people are killed in traffic accidents worldwide. The following project uses techniques such as GPS NEO-6M, GSM 800L, and accelerometer sensors to build a geo-fencing-based vehicle tracking and accident alarm system. In addition to determining accidents and alerting authorities, the technology will

draw virtual boundaries and audio warnings when a car passes over them. This method is intended to prevent accidents.

II. LITERATURE REVIEW

It enhanced vehicle tracking and monitoring, coupled with the application of real-time data through the application of mobile devices. Increasing tracking capability also represents hybrid models that use the application of wireless sensor networks as well as GPS. Monitoring within geofencing will provide locations on defined boundaries. It automatically sends alerts in cases of infringements. Accuracy stands at nearly 95% for the proposed system positions. Testing was quite robust in proving its successful monitoring and alerting capability when vehicles left the geofenced areas [1]. GPS technology permits location tracking in real time due to signals from satellites, and the user can track their position by means of web applications. Actually, geofencing creates boundaries around virtual devices and, hence, lets the devices know when they are leaving the bound areas, thus promoting the security applications. To increase the accuracy of the GPS, Kalman filtering and moving average methods are used to reduce the error margins significantly. The user-friendly tracking systems developed are possible because of this integration of hardware and software, such as Arduino and NodeJS. An important usage range from the vehicle to personal safety shows how much these technologies are needed in every field [2]. This paper is going to give an overall view of various methodologies that can help develop better road safety through effective accident detection. It breaks down road traffic accidents into several categories, among which are the pedestrian, cyclist, and vehicle accident types, thereby reflecting the richness of the situations requiring specific mechanisms of detection. From the identified common factors that have resulted in accidents, such as the error on the part of the driver, bad and dangerous road conditions, and distraction, the authors drive home the critical necessity of timely detection and prevention of risks. The paper critiques the following technology approaches, such as use of a mobile phone, GSM and GPS technologies, VANET, and mobile applications that would enable faster and more prompt communication of accidents with the concerned emergency services. In addition, it presents a low-cost ultrasonic sensor solution for accident detection but concedes that its range of detection and placement of sensors do not completely cover accidents and sometimes give false alarms. The conclusion highlights the need for further research in order to enhance the performance of these technologies, indicating that although the present techniques can function well enough, there is much that needs improvement before such events are witnessed accidentally and precisely in real time. [3]. Geofencing technology implementation for pet tracker using Arduino based on Android" Paper The paper "Geofencing technology implementation for pet trackers using Arduino based on Android" suggests all the different reasons pertaining to the need for efficient solutions for tracking pets since the problem that pet owners face when their animals stray away. Conventional methods of holding inquiries within the neighborhood or putting up fly posters are ineffective and time-consuming, and this is a huge shortage of technology innovation in this field. The research study primarily utilized the use of the GPS technology in tracking the moving pet in real-time through signals sent by satellites. A great focus on geofencing technology is being discussed, which creates virtual boundary marks that alert the owner in case one's pet leaves a designated area, hence offering a proactive approach to pet safety. The paper further goes into detailing the development of an Android-based application integrated with an Arduino system with its stages, beginning from analysis through design, implementation, and testing, which will be very crucial for understanding the practical application of this technology. It shows that the system effectively monitors people at times when their pets leave the designated fence, which therefore promotes its practical use in improving pet security. Such findings can form a valid starting point for presenting your literature review on the relevance of geofencing, especially GPS technologies, in tracking pets [4]. The research paper "Tracking of Customers Using Geofencing Technology" examines how geofencing might become a very modern application of LBSs. After the development of geofencing, CASs, which aim to more comprehensively improve the experiences of a user by considering various contextual parameters like time and weather conditions, have appeared. However, the paper also confronts other major challenges, such as privacy issues and the relative augmentation of battery use to continuously monitor people's locations in the background. For instance, although it allows retailers to send more targeted messages and promotions to customers when they enter specific areas, it raises the question of the appropriateness of such communications as well as a significant potential to overwhelm users with

unwanted notification.[5]. Within this context, the development of sales tracking applications has more and more been relevant for the objective of optimizing a company's operational efficiency, particularly within the sales sector. PT. Remaja Rosamaria is a publisher and printing house that had significant problems with the location and the activities of the sales personnel when they were out of office duty.[6].

III. METHODOLOGY

The Fig1. Shows the block diagram of geofencing system. Arduino Uno Microcontroller it acts as the CPU to interface with input and output modules. The GPS module provides location information, and the GSM module provides communication functionality for updates. The Accelerometer serves to track motion or orientation changes. The LCD shows system status. Outputs like a Buzzer and DC Motor are sent on to control associated actions like motor control or causing alert according to the status of the geofence or system.

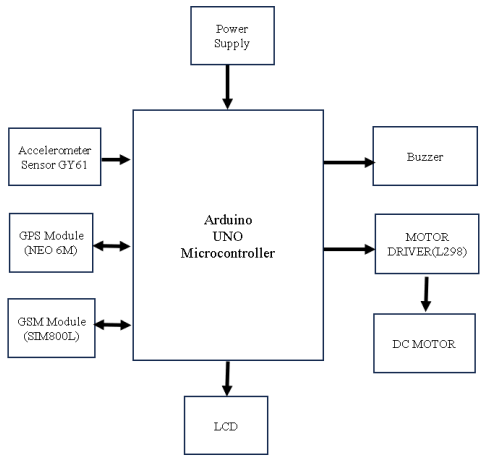

Fig1.1Block Diagram of Geofencing System

HARDWARE AND SOFTWARE COMPONENTS

1. Arduino Uno: It is the microcontroller which is work on ATMEGA32P IC. It receives the program for particular sensors or actuators then synthesis it as per given command in the program. Again, it collects the data from those sensors like GPS and accelerometer, then processes it, and controls other parts: the buzzer and LCD. The Arduino is responsible for the logic related to checking whether it's inside or outside a virtual boundary of geofencing.
2. SIM800L GPRS GSM Module: The GSM module is used for transmitting or receiving data of location updates through mobile networks. It suffices that the geofence includes real-time information or alerts and pictures even in areas without Wi-Fi.
3. Ublox NEO-6M GPS Module: The specific role of the GPS module is to track the precise location of the device. It enables tracking in real time and tells if a device or a vehicle has gone beyond or into a particular zone, which is necessary for the boundary in geofencing.
4. Buzzer: The buzzer will be audible whenever a specified action has been triggered that may be by a device crossing the boundary of geofence. It is one of the simplest but really effective notification system in alerting users or operators about certain events, such as unauthorized access or boundary breach.
5. 16x2 LCD Display with I2C Module: It works mainly as a stock in performing its functions such as showing the current geographical coordinates of the device, position status of the device in geogrid and notification in case the device moves beyond the pre-programmed limits. This I2C module is utilized to minimize the amount of wiring that needs to be deployed in connecting the LCD to the microcontroller.
6. GY-61 DXL335 3-Axis Accelerometer Module: It is an accelerometer that senses the motion or angle of the device. It enhances the location monitoring precision as it can detect little motion of the device, so an individual will not be inappropriately invited because of minimal motion.
7. Arduino IDE: It is an open-source platform which is used to write program, compile it and upload the program to the Arduino UNO. Programming using the Arduino IDE is therefore a good way of developing the logic of how each of the components; GPS, GSM, accelerometer, etc., should interact with each other. The IDE loads libraries that make all communication between modules easier. After compilation, it ensures a clean program with no errors before uploading. It will then upload this code to the microcontroller. With this, the specified geofencing system may then work as needed. Also Arduino IDE is support for the ESP-32 like a many more microcontroller which has the all access of IDE like this a above software is used to upload the specified program which we written and want to convert it to action.

SOFTWARE CONFIGURATIONS

As we have used Arduino UNO in our project, so it needs to be prorammed by installing the libraries needed through Arduino IDE software. Apart from that, installation of the additional library needs the

very first step to Run the Arduino IDE software and from the software go to Tools > Manage Libraries. At this step the Library Manager will popup. The library installed is shown in Figure 2.

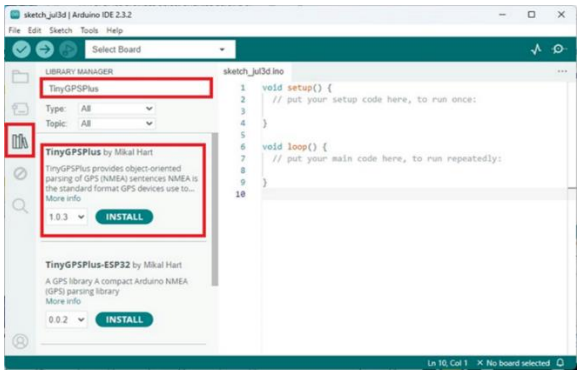

Fig 2.2 Library for the GPS

III HARDWARE IMPLEMENTATION

For this project, we are using the Arduino Uno as a microcontroller, and the connection would be as follows: We are connecting the VCC pin of the GPS module with the 5V pin of the Arduino with the sole purpose of providing it with a needed power supply.RX pin-Receive: the GPS module is connected on pin 9 of the Arduino; therefore, the GPS module receives data from the Arduino. The TX pin of the GPS module is connected to pin 8 of the Arduino. In this way, data from the GPS module will be

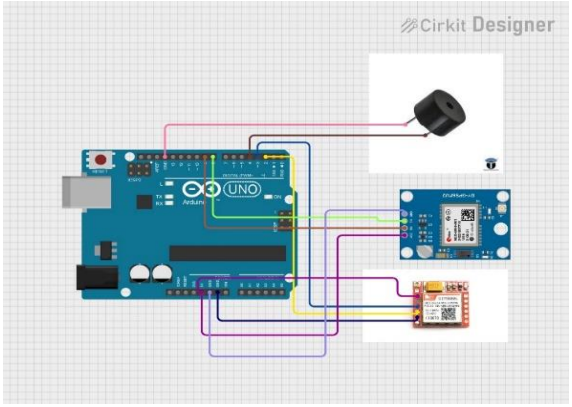

Fig: 3.1 Project hardware connection

transmitted to Arduino. The GND pin of the GPS module is linked to the GND pin of the Arduino, thereby making the grounding circuit complete for effective communication between the GPS module and the Arduino.

This wireless communication uses GSM (Global System for Mobile Communications) technology to send messages via the cellular network. Figure 1 shows how the GSM module, such as the SIM800L, is attached to the Arduino that sends a message in case specific conditions, such as a short circuit condition, are encountered. The GSM module will send text or call a particular number with SMS over a cell phone network. The VCC pin of the module is given to the 5V pin of the Arduino for efficient power supply. To start the communication between the Arduino and GSM module, it is connected to the TX pin of the GSM module to pin 2 of the Arduino so that it can send its data. The RX pin on the side of the GSM module is connected to Pin 3 of the Arduino so that the module receives the information from the Arduino. The GND pin of the GSM module connects to the GND pin on the Arduino to ensure a proper ground circuit. In using the GSM module, the Arduino commands it through AT commands to send real-time messages or alerts over the cellular network, thus also establishing communication on time. Finally, the buzzer's positive terminal is linked to pin 3 of the Arduino, allowing it to be controlled via digital signals. The negative terminal is linked to the GND pin, completing the circuit. When pin 3 is set HIGH, the buzzer sounds; when set LOW, the buzzer turns off.

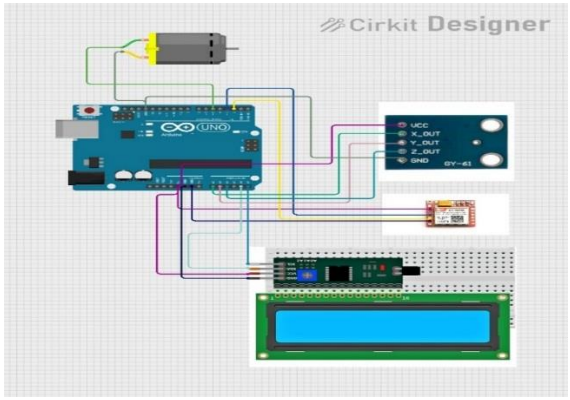

Fig 3.2 Project hardware connection

As depicted above in the fig.3.2, the connections are as described below: the accelerometer sensor is connected to the Arduino in such a way that the VCC pin is connected to the 5V pin through which power is given to the Accelerometer, and GND pin is connected to the Arduino's ground for a common reference. The accelerometer is passed out through the analog pin A0 for X-out, Y-out into A1, and Z-out to A2. This means that from now on, the Arduino will read all the analog signals coming from the accelerometers along its X, Y, and Z axis readings. Hence, it will be able to measure movement and orientation along three axes. The GSM module sends SMS or dials a cell number using a cellular network. To power this module, one should connect directly the module's VCC pin to the

Arduino's 5V pin. All communications with the Arduino and GSM module shall be through a connection between the pin 2 of the Arduino to the TX pin of the GSM. This will enable it to transmit data from the module towards the Arduino. The receiving of data coming from the Arduino shall allow the GSM module by its RX pin connected to pin 3 of the Arduino. The GND pin of the GSM module is connected to that of the Arduino in order to close the ground circuit. The Arduino operates the GSM module with AT commands, thus sending the time-bound messages or alerts in order to communicate at the proper time through the cellular network.

In this system, the I2C module was used in connecting the LCD microcontroller. This mode simplifies communication between modules because it requires only two wires, namely SCL and SDA. The SCL of the I2C module is connected to pin A3 in the microcontroller, while the SDA of the I2C module is connected to pin A4. The VCC pin is brought out to the 5V power source, and consequently, it supplies the necessary voltage, but the GND pin is shorted to the circuit's GND. This way, the microcontroller controls the LCD with the least number of wires over I2C.

This setup connects the positive terminal of the motor to a 5V power source; it should provide enough voltage to run the motor. Connect the negative terminal to ground (GND) to close the electric circuit to run the motor. Additionally, when the vehicle crosses a specific boundary, a message is sent to the admin. The message was likely to be passed to the GPS or a location-based tracking system integrated with the control circuitry. It continuously tracks the position of the vehicle and sends an alert or notification when the vehicle crosses the set boundary so that the admin is well aware of it in real time.

Table 1. Pin configuration of vehicle tracking system

SL NO	*Components*	*Pin Label*	*Arduino UNO Pin*
1	GPS NEO-6M	GND	GND
		VCC	5V
		TX	9
		RX	8
2	GSM 800L	GND	GND
		VCC	5V
		TX	2
		RX	3
3	Buzzer	+ve	3v
		-ve	GND

Table 2. Pin configuration of accident alert system

SL NO	Components	Pin Label	Arduino UNO Pin
1	Accelerometer	GND	GND
		VCC	5V
		X-OUT	A0
		Y-OUT	A1
		Z-OUT	A2
2	LCD Display	GND	GND
		VCC	5V
		SDL	A3
		SDA	A4
3	DC Motor	+ve	5v
		-ve	GND

IV WORKING PROCESS

1. Configuration of GPS and GSM Modules

A program running in the microcontroller Arduino incorporates the usage of a GPS module, NEO6M, and a GSM module, SIM800, for the sense of real-time tracking and communication. The GPS module will provide the current location in latitudes and longitudes, where the GSM module sends an alert message through SMS when a violation of the geofence is sensed.

2. Center and boundary of the geofence configuration

Compute the center coordinate of the geofence by using the start latitude and longitude values 15.819854 and 74.498329; the max distance is assigned equal to 50 meters so that the distance from the center of the geofence to any point in the circumference of the geofence is 50 meters. In this respect, it leaves less room for mistakes since it is observed that, as mentioned, "Özdemir and Tuğrul in their research regarding the inaccuracy of GPS about the weather condition and

3. Acquisition of GPS Data

The getGps () function accepts the current GPS coordinates, latitude, and longitude from the GPS module through the TinyGPS++ library. It refreshes each datum after a few seconds.

4. Distance Calculation based on the Haversine Formula

This method, getDistance (), calculates the distance covered by the geofence center and the current location according to the GPS by the use of the Haversine formula. The distance between the two points is in meters.

The formula for this is

$$d = 2r.\arcsin\sqrt{sin^2\left(\frac{\Delta\emptyset}{2}\right) + (\cos(\emptyset_1).\cos(\emptyset_2).sin^2(\frac{\Delta\lambda}{2})}$$

Where,
d=distance between two points (in meters)
r=Earth's radius (mean radius=6,371 km or 6,371,000 meters)
$\emptyset_1$,$\emptyset_2$=latitudes of the two points in radius
$\Delta_\emptyset$=difference in latitude (in radians) between the two points
Δ_λ=difference in longitude (in radians) between the two points

5. Where the Alarm is Activated

It checks whether the distance covered in this time cycle is more than or equal to the defined midstance, which is 50 meters. This condition arises when a device leaves the fence. It follows all these events logged at this point. Buzzer is activated by writing HIGH to BUZZER using digital Write (BUZZER, HIGH). Ending a message by a sending function called send Alert () to the defined number, which carries a link from Google Maps that indicates the location of the mobile device. The alert only needs to be triggered once when the device leaves the geofence and it returns. Abbas et al. have researched strengthening real-time tracking coupled with geofencing, where the systems monitor objects or vehicles and send alerts if the boundaries are crossed. This is reflected in the code below, where the combination of GPS data and the Haversine formula detects geofence accurately.

6. Alert Reset

When the gadget returns inside to the geofence, this will reset the alarm, and further alarms will be disabled until the geofence is breached again geofencing applications and IoT platforms are sometimes incorporated into research articles. Even though this project provides the participant with SMS alarms, it can be extended further to support platforms like Google Maps or any other cloud-based services to better manage alarms and location data.

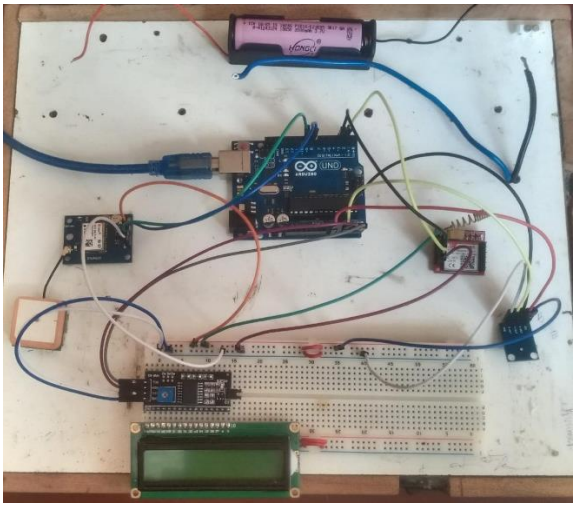

Fig. 4.1 Working Model

Now the above Figure 4.1 it shows the working model of our entire project based on Geo-Fencing technology for vehicle tracking and the accident alert system.

V. RESULTS AND DISCUSSION

Geo-Fencing Vehicle Tracking System:

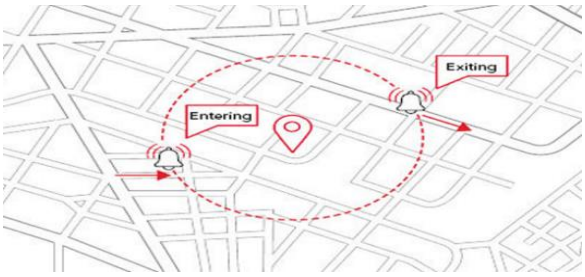

Fig. 5.1 Geo-Fencing Virtual Boundary

This project utilizes the GPS, GSM and accelerometer sensor to detect the particular object then convert into actions which we mentioned in the program. The diagram above depicts (5.1) a geo-fencing concept by drawing an imaginary boundary around an area of interest where a central pin depicts the location identified and a dotted circle shows the geo-fenced boundary. It shows both cases, "Entering" and "Exiting." Whenever an object, vehicle, or person tries to exist in the defined area, this configuration triggers an alert, which then notifies the system. The alert can further, optionally, trigger activities such as notifications, event logging, or launching location-based services. In leaving the geofenced region, it alerts, and the system can continue with the actions such as issuing alert messages to individuals, disabling particular features, or tracing other movements. It is highly helpful in various sectors such as location tracking, security, vehicle monitoring, and automatic

warnings that provide safety and control within place-based systems.

Accident Alert System:

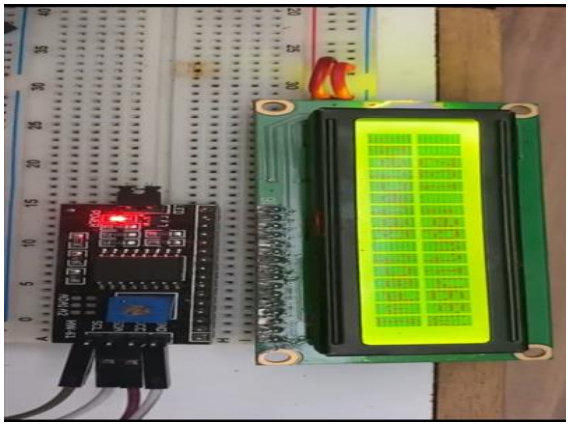

Fig. 5.2 Collision Alert Message On LCD

The above figure (5.2) shows the collision alert message displayed on the LCD when there is an accident after a tremendous rise in acceleration by the accelerometer that exceeds its threshold value. In such a case, the acceleration signifies an accident has occurred. Hence, the system immediately shows an alert message on the screen. The module simultaneously sends an automatic call alert message to the owner, thus promptly notifying the incident. The system allows fast and prompt action in line with the accident and through reporting the same to the owner. This accident alert system enhances the safety of a vehicle by making sure that help is notified without delay in a situation where the driver might not be able to make that call themselves because of automated communication combined with real-time data coming from the accelerometer.

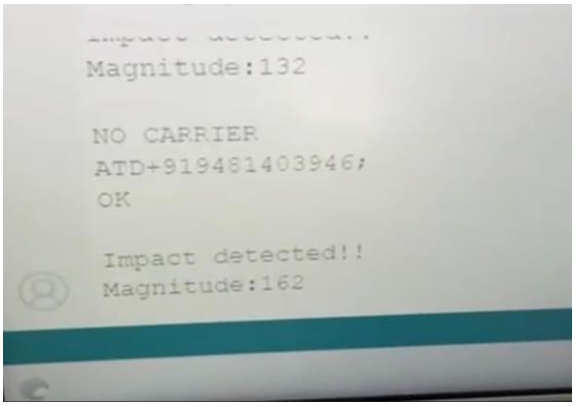

Fig. 5.3 Serial Monitor Data Representation

According to the above Fig (5.3) it indicates that the serial monitor output explains how the accident alert system works, showing how impacts are detected. Being a first-class impact with a magnitude of 132 from the accelerometer sensor that tracks any changes in motion in an event of collision, there then follows an automatic alert sent from the system by the GSM module through dialing the phone number "+919481403946" as indicated by the "ATD" command. The "OK" message reveals that the GSM module had executed the given command. Again, after a short period, a second impact is also recorded, this time with a higher magnitude of 162, reflecting an even more significant impact. The continuous tracking by the system and its attempt to call the owner guarantee the accident would be timely reported, and chances of prompt action in case of emergencies are maintained.

Fig. 5.4 Alert Call Received On Smart Phone

The picture displays a smartphone notification of an incoming call that is sent out by the system when it detects an accident. Regardless of whether the car is inside or outside the predetermined geographic border, this automated call is made. It sends a call alert to inform either the car owner or emergency services immediately after the hit or collision. The message with all critical information relating to the location of the car, the accident, and the condition increases the chances that action may be taken immediately. The system is effective where accident detection and location tracking are combined because it provides immediate, location-sensitive reactions towards the situations that may occur.

VI. CONCLUSION.

Conclusion of this project is a vehicle tracking accident alert system based on Geo-Fencing technology these systems have been equipped with a few major components, including GPS NEO-6M, GSM 800L, and an Accelerometer sensor that are used to trigger real-time tracking and geofencing along with the instant reporting of stealing accidents. This is

especially helpful in industries like car rentals, logistics, and fleet management, where unlawful movement outside of designated zones can result in severe financial loss or operational problems. One of the strongest concepts in the system design is Geo-Fencing feature where the vehicle is pretty much ensured to fall within the set boundaries. If the vehicle leaves the virtual fence, an alert is sent, and after a little wait period, the motor is cut off and disabled to enhance theft prevention and operating control.

It also comes with an accident detection feature, where in the event of a crash, the system will send the live location of the vehicle to emergency services automatically, thus saving more lives and improving response time. This project managed to integrate GPS, GSM, and accelerometer technologies to create a highly efficient and low-cost system for tracking and ensuring the safety of a vehicle. It can be implemented in diverse configurations without much hassle, allowing for a wide range of vehicles and applications. After all, this system addresses very pressing needs to upgrade safety and security and to provide utmost assistance pertaining to road safety as well as check cases related to vehicle crimes around the world.

REFERENCES

[1] Setiawan, D., Sari, M. W., & Hardyanto, R. H. (2021). Geofencing technology implementation for pet tracker using Arduino based on Android. Journal of Physics: Conference Series, 1823(1), 012055. IOP Publishing.

[2] Abbas, A. H., Habelalmateen, M. I., Jurdi, S., Audah, L., & Alduais, N. A. M. (2019). GPS based location monitoring system with geo-fencing capabilities. In AIP Conference Pro ceedings (Vol. 2173, No. 1). AIP Publishing.

[3] Özdemir, Z., & Tuğrul, B. (2019). Geofencing on the real-time GPS tracking system and improving GPS accuracy with moving average, Kalman filter and logistic regression analysis. In 2019 3rd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT) (pp. 1-6). IEEE.

[4] Zuva, K., & Zuva, T. (2019). Tracking of customers using geofencing technology. International Journal of Scientific Research & Engineering Technology (IJSET), 13, 10-15.

[5] Hidayatullah, R., & Maliki, I. (2019). Development of sales tracking application based on Android using location-based service & geofencing technology in PT. Remaja Rosdakarya Bandung. Elibrary. Unikom. Ac. Id. Retrieved fromhttps://elibrary.unikom.ac.id/1151/14/UNIKOM_RIAN_HIDAYATULLAH_JURNAL_DALAM_BAHASA_INGGRIS.pdf

[6] Khalil, U., Javid, T., & Nasir, A. (2017). Automatic road accident detection techniques: A brief survey. In 2017 International Symposium on Wireless Systems and Networks (ISWSN) (pp. 1-6). IEEE.