Revolutionizing Vehicle Oversight: Redefining Safety, Monitoring, and Reporting Through Advanced System

Shanthi Munaganooru[1], Tanusha Meka[2], Pallavi Nooka[3], Elabotharam Tejasri[4], Lakshmi Raja Vaisali Marepalli[5]

[1]Assistant Professor, G. Narayanamma Institute of Technology and Science, shanthimunaganooru@gmail.com
[2-5]UG Students, ECE, G. Narayanamma Institute of Technology and Science, Hyderabad, India

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Abstract - *The vehicle tracking, accident prevention, and detection system using IoT is a next-generation safety solution that leverages IoT technology to enhance road safety and reduce the risk of accidents. The system is designed to monitor and track vehicles in real-time, detecting potential hazards and providing alerts to drivers and emergency services when necessary. The system uses a variety of IoT devices, including GPS trackers, GSM modules, Accelerometers, and Gyroscopes, to track and analyze vehicle movements, speed, and direction. It also includes a reporting module that enables drivers to report incidents or hazards to authorities quickly. This system is created to oversee multiple aspects, encompassing vehicle positioning, vehicle temperature, the driver's alcohol intake, as well as their vigilance and signs of drowsiness. Overall, an Advanced vehicle tracking, safety, and reporting system is an innovative safety solution that utilizes advanced IoT technology to enhance road safety and prevent accidents.*

Key Words: IoT, Smart Vehicle, Arduino UNO, GPS trackers, GSM modules, Accelerometers, ThingSpeak cloud, Alcohol sensors, eye-blink sensors, temperature sensor, vibration sensor, gas sensors, LCD Display, LEDs, Buzzer, DC motor

1. INTRODUCTION

The escalation in vehicle usage is a prevailing trend in today's contemporary world. This surge in vehicular activity has led to an upswing in traffic congestion, consequently resulting in a surge in road accidents. This burgeoning issue has both material and human repercussions, notably the absence of timely preventive and safety mechanisms. While achieving complete accident prevention is an elusive goal, it is possible to mitigate its aftermath. This integrated system is geared toward not only averting accidents but also incorporating robust preventive measures. The system disseminates the vehicle's pinpoint location to smart devices at ambulance services and police stations, along with a Google Maps link, leveraging a mobile network connection to facilitate swift response. The system also enables us to track the real-time coordinates of the vehicle using the ThingSpeak app. The system encompasses an array of sensors, including an alcohol sensor, eye-blink sensor, temperature sensor, and accelerometer or Vibration Sensor. These sensors interface with a central microcontroller, namely the Arduino UNO board, which orchestrates the system's functionality. Additionally, the system is equipped with an LCD display, LEDs, a buzzer, and a DC motor to enhance its capabilities.

1.1 Problem Statement

Presently, there is a notable absence of advanced accident detection and prevention technology, resulting in a high death toll during the critical initial time period following accidents. Individuals who find themselves in accidents often rely on the goodwill of others for transportation to medical facilities, which can be a life-or-death situation. In addition, accidents frequently go unreported for extended periods, exacerbating the risk of fatalities among those involved. Additionally, Rush hour traffic in the vicinity of accident scenes can lead to considerable holdups in ambulances reaching hospitals, thus significantly increasing the likelihood of tragic outcomes. This overall scenario underscores the urgent need for innovative solutions to address these pressing issues and save lives. Aside from the immediate impact on victims, there are broader societal consequences, such as increased healthcare costs, lost productivity, and emotional distress for victims' families. The current state of affairs highlights the critical need for innovative solutions and technological investments to address these critical challenges and, ultimately, save lives, reduce healthcare costs, and reduce the overall social impact of accidents.

1.2 Proposed Solution

Conceive an affordable IoT-based real-time system for vehicle tracking, safety, and reporting, centered on the Arduino UNO board. This initiative provides a platform to integrate state-of-the-art technologies for the prevention and detection of accidents. Within our project framework, we've leveraged sensor technologies, electronic components, and a central microcontroller unit to proactively avert accidents while ensuring swift notification to the ambulance service in case of an incident. Incorporating this smart maintenance module will be seamlessly integrated into our IoT-based platform, making it easy to manage and ensuring vehicles are well-maintained for enhanced safety.

2. IoT (INTERNET OF THINGS)

The Internet of Things (IoT) involves connecting everyday objects and devices to the Internet, enabling them to gather and share data. This connectivity facilitates communication between objects and individuals, enhancing convenience and functionality. IoT entails embedding sensors, software, and technology into a variety of products ranging from appliances to cars, allowing them to conduct activities autonomously or in response to user directions. IoT device data provides insights for informed decision-making and process optimization, with the potential to alter industries and elements of daily life through automation and sophisticated interactions[1].

3. LITERATURE REVIEW

An examination of current market offers reveals a substantial restriction in their capacity to efficiently synchronize several factors. Because of their exclusive design focus, these devices frequently demonstrate limited adaptability, catering only to duties such as accident detection, prevention, or reporting [3]. While individual solutions have inherent advantages, their cost-effectiveness is reduced when many functions cannot be performed concurrently[6]. Integrating supplemental features to boost their capabilities may result in system redundancy. To address these constraints, a suggested vehicular monitoring system aims to overcome them by seamlessly combining accident prevention, detection, and reporting processes, hence improving overall functionality and dependability.

Sensors' modern use has exceeded traditional usage, making its way into prosaic goods such as touch-sensitive buttons and responsive bulbs, increasing its utility beyond traditional boundaries. Accelerometers, which have their roots in historical innovations such as George Atwood's 1700s invention, the Atwood machine, continue to play an important role in computing velocity based on displacements. The Global Positioning System (GPS), formerly known as Navstar GPS, was developed by the United States Department of Defense as a satellite-based radio navigation system. Its operational launch in 1993, highlighted by a full constellation of 24 satellites, revolutionized location-based services. The Global System for Mobile Communications (GSM), a standard established by the European Telecommunications Standards Institute, lays out a protocol architecture for 2G cellular networks utilized in mobile devices. GSM's amazing global ubiquity spanning 193 countries and territories since its inception in Finland in 1991 emphasizes its vital role in the growth of mobile communications.

4. PROTOTYPE DEVELOPMENT

As we embark on the development phase, creating a functional prototype will be pivotal.

4.1 Methodology

In this research endeavour, we harnessed the capabilities of Arduino to craft a comprehensive system dedicated to preventing accidents, detecting incidents when they occur, and promptly reporting them to smart vehicles.

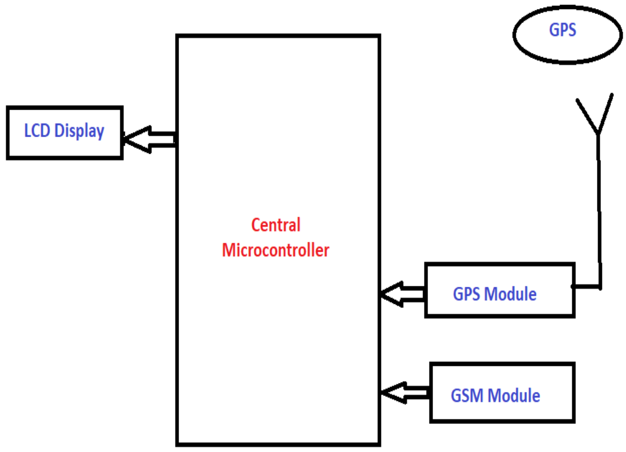

Fig -1: Block diagram of the existing model for the Accident Reporting system

In addition, we put in place a state-of-the-art vehicle tracking system that easily connects to an IoT cloud, specifically the ThingSpeak application. As illustrated in Figure 1, our existing model features an array of sensors and peripherals intricately connected to the central microcontroller. These sensors gather data, and the microcontroller processes and displays it on an LCD screen, also integrated with the Arduino UNO. To facilitate vehicle tracking, the end user can readily access the SIM number stored within the system's GSM module.

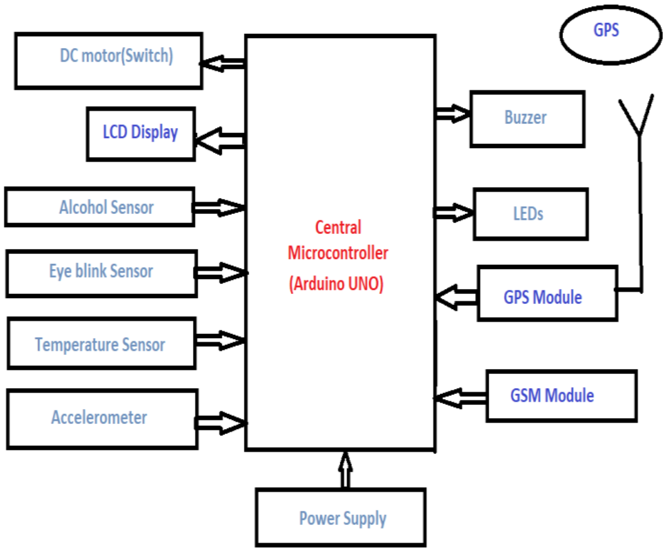

Fig -2: Block diagram of the proposed model for the Accident Detection and Prevention System

Fig 2 depicts the block diagram of the sensors and peripherals interfaced with the central microcontroller Arduino UNO for the proposed model. In addition to the accident detection system, it provides an enhanced accident prevention system

4.2 Hardware Components Required

The hardware components required for implementing the prototype Arduino UNO, GPS trackers, GSM modules, Accelerometers, Alcohol sensors, eye-blink sensors, temperature sensors, vibration sensors, gas sensors, LCD Display, LEDs, Buzzer, and DC motor.

4.2.1 Eye-blink Sensor

Typically, an eye blink sensor operates by releasing a signal, such as infrared light, toward the eye. When the user blinks, the eyelid stops the signal, causing the sensor's readings to shift. The sensor's circuitry detects and processes these disruptions, which are subsequently interpreted as eye blinks.

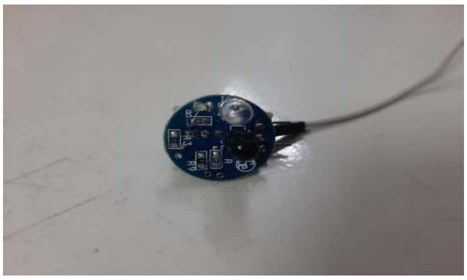

Fig -3: Eye-blink sensor

4.2.2 Temperature Sensor (LM35)

A temperature-sensitive diode is used to power the LM35 temperature sensor. It produces a voltage that varies in proportion to temperature, with a linear connection of 10 mV per degree Celsius. A microcontroller or analog-to-digital converter may readily convert this analog output to temperature, allowing for exact temperature observations.

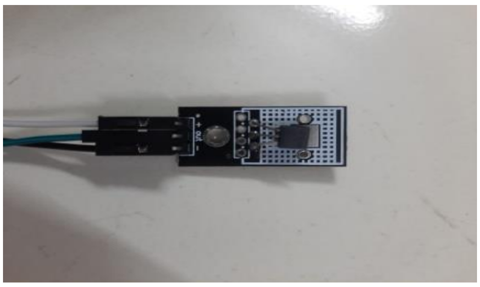

Fig -4: Temperature Sensor (LM 35)

4.2.3 Alcohol Sensor (MQ-3)

The MQ-3 alcohol sensor detects vaporized alcohol by measuring changes in the electrical conductivity of a sensing element coated with a reactive substance. It generates an analog output voltage proportional to the concentration of alcohol, which is useful for applications like breathalyzers and safety systems.

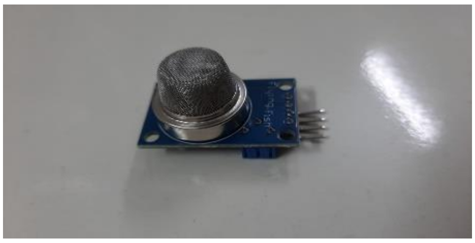

Fig -5: MQ-3

4.2.4 Accelerometer or Vibration Sensor

The accelerometer ADXL335 MEMS (Micro-Electro-Mechanical Systems) or ADXL345 detects acceleration in three axes: X, Y, and Z. The ADXL335 detects acceleration using a capacitive sensing principle, whereas the ADXL345 uses microelectromechanical structures. Both sensors produce analog or digital signals that indicate acceleration forces.

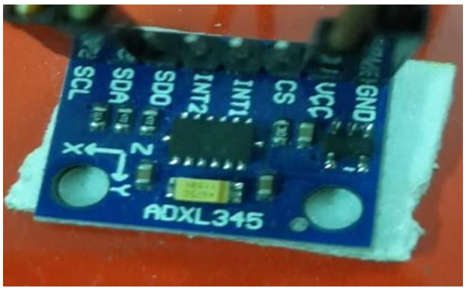

Fig -6: Accelerometer (ADXL 345)

4.2.5 GPS Module (SIM 28ML or NE06M)

The SIM28ML and NEO6M GPS modules provide precise worldwide positioning and navigation. Both modules use GPS satellite signals to calculate precise location, speed, time, and altitude. The NEO6M is popular for a variety of applications such as vehicle tracking, mapping, geocaching, and outdoor navigation because of its compact form, efficient power consumption, and UART communication interface. The SIM28ML performs comparable functions but may have unique features or communication protocols.

Fig -7: GPS module (NE06M)

4.2.6 GSM Module (SIM 800L)

The SIM800L is a GSM (Global System for Mobile Communications) module that allows for wireless connection through cellular networks. It supports voice calls, text messaging (SMS), and data transmission over GPRS (General Packet Radio Service). The module includes a GSM/GPRS modem that may communicate with microcontrollers or other devices through UART. It connects devices to the cellular network, allowing data exchange and communication beyond geographical boundaries.

Fig -8: GSM Module (SIM 800L)

4.2.7 Central Microcontroller (Arduino UNO)

A sophisticated microcontroller, the Arduino UNO is powered by the ATmega328P processor. It adheres to a recommended input voltage spectrum of 7–12V while operating at a 5V working voltage, with a permissible range of 6–20V. With 14 digital I/O pins, 6 PWM outputs included, and an additional 6 analog input pins, this adaptable board allows for simple interfacing with a variety of components. It provides plenty of storage and processing power with a 32 KB flash memory capacity (including a 0.5 KB bootloader reserve), 2 KB SRAM, and 1 KB EEPROM. Programming and communication tasks are streamlined by the inclusion of the ATmega16U2 processor for USB-to-Serial conversion, which operates at 16 MHz clock speed.

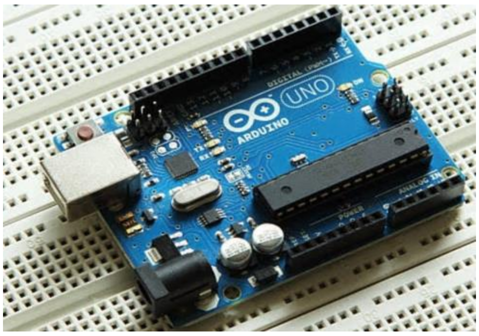

Fig -9: Microcontroller (Arduino UNO R3)

4.2.8 Buzzer

A buzzer is an electromechanical device that produces sound by rapidly vibrating a diaphragm. When an electric current is passed via the buzzer, the diaphragm vibrates, producing audible sound waves. Buzzers are extensively employed in electronic devices and systems to generate auditory alerts, notifications, or alarms.

Fig -10: Buzzer

4.2.9 Control Switch

A direct current motor (DC) is a mechanical device that converts direct current (DC) electrical energy into motion. It is made up of a rotor and a stator, and its rotation direction and speed can be adjusted by adjusting the voltage levels and polarities applied to the motor's terminals. In electronic circuits, a control switch, which is frequently implemented using transistors or relays, is used to manage the motor's on/off state or rotational direction.

4.2.10 LCD display

An LCD (Liquid-Crystal Display) is employed to graphically display information. It is made up of liquid crystals sandwiched between two layers of material with the ability to modify the orientation of light traveling through them. Segments of the display can be triggered to form characters, symbols, or pictures by applying electric power, allowing data and messages to be displayed on electronic devices.

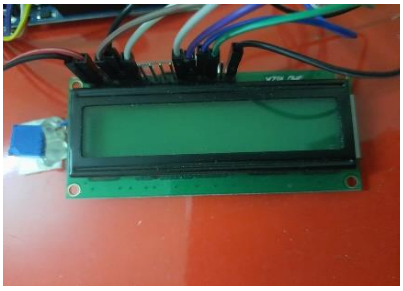

Fig -11: LCD display

4.2.11 Gas or Smoke Sensor

A gas or smoke sensor detects the presence of certain gases or smoke particles in the air. Gas sensors of various types employ diverse technologies to recognize and quantify the concentration of gases, such as chemical processes or optical approaches. These sensors are critical for assuring safety in areas where gas leaks or smoke creation could be dangerous, such as residences, industrial settings, and automotive applications.

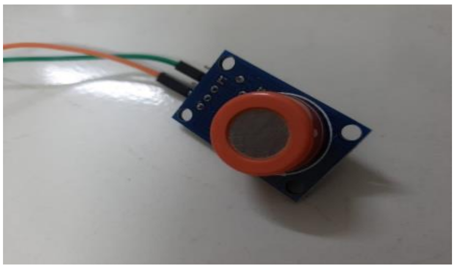

Fig -12: Gas Sensor

4.3 Software Requirements

The software requirements to implement this prototype are ThingSpeak Cloud, Google Maps, Messaging app, and Arduino IDE.

4.3.1 Google Maps

Google Maps is a popular map service that provides interactive maps, satellite views, and route planning. It delivers real-time traffic updates, location searches, company information, and navigation. Its capabilities can be integrated by developers via the Google Maps API, making it a versatile mapping and navigation tool.

4.3.2 Messaging app

A messaging app is a piece of software that allows users to send and receive text, multimedia, and other forms of communication over the Internet. These apps allow users to exchange messages in real-time, generally through individual or group conversations, and provide instant communication. Among the most popular messaging apps are WhatsApp, Facebook Messenger, Telegram, and Signal

4.3.3 Arduino IDE

Arduino IDE, short for Integrated Development Environment, serves as a software tool for crafting and building projects with Arduino microcontroller devices. It provides an easy-to-use environment for authoring, compiling, and uploading code to Arduino boards. The IDE provides a simpler programming language based on C and C++, making it suitable for both novice and expert developers. For communicating with the Arduino board, it provides a text editor, a code library, and a serial monitor.

4.3.4 ThingSpeak Cloud

ThingSpeak is an Internet of Things platform and cloud service that enables data gathering, processing, and visualization from connected devices. It makes IoT application development and sensor data monitoring easier. It collects data from sensors and devices using HTTP or MQTT protocols, arranging it into channels with several fields to track different data types. ThingSpeak includes built-in visualization features like line charts and bar graphs, as well as the ability to perform basic data analysis using MATLAB® scripts. This adaptable platform finds use in home automation, environmental monitoring, industrial automation, and other areas. It offers APIs for programmatic data interaction and can be self-hosted for greater data control. ThingSpeak, in essence, enables IoT enthusiasts, developers, and organizations to effectively manage and analyze IoT data.

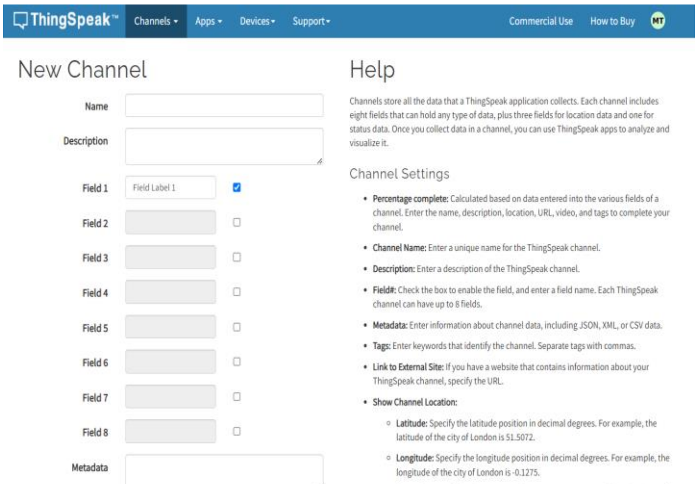

Fig -13: ThingSpeak application

4.4. Prototype Description

The vehicle's precise whereabouts are perpetually monitored through the GPS module, leveraging the capabilities of the ThingSpeak cloud. This system perpetually deduces the vehicle's coordinates, facilitating the determination of its velocity, geographical position, traversed path, and fuel consumption metrics. Furthermore, the ThingSpeak application can keep an exhaustive historical record of these geographical coordinates. An innovative eye blink sensor, purposefully designed to detect subtle drowsiness, is integrated to ensure driver attentiveness. When a driver becomes fatigued, a vigilance-enforcing mechanism is immediately activated which means that this sensor is 1time-bound and if the eyes are closed above the threshold limit, the alarm is activated. The system also includes a temperature sensor capable of measuring engine temperature and sending alerts if temperature readings deviate from optimal operating parameters. The alcohol sensor, a critical safety component, is responsible for determining the driver's sobriety. When the system detects a deviation from sobriety, it activates an early warning system, followed by an automatic engine shutdown mechanism. The accelerometer takes center stage for collision detection, quickly transmitting a distress signal to the microcontroller in the event of an impact or collision. The GPS module consistently transmits a comprehensive dataset containing geographical coordinates, velocity, temporal data, and chronological details in real-time. In the event of an accident, this critical information is quickly relayed to the appropriate authorities. In the event of a minor accident, the driver has the option to deactivate the audible alert and continue their journey if the safety assessment is favorable. However, in the event of a more serious accident, the appropriate authorities and emergency services are promptly notified and mobilized.

4.5 Algorithm for System Operation

i. Commence

ii. Initiate the system by supplying the appropriate power.

iii. Upon system activation, the alcohol sensor evaluates the driver's level of intoxication i.e.it assesses the driver's sobriety. If the driver is significantly impaired, the system issues a warning and initiates an engine shutdown. Terminate operations.

iv. In the absence of alcohol detection, the vehicle starts or continues running as usual.

v. Employ the Temperature Sensor to always monitor engine temperature. If overheating occurs, an orange warning signal is displayed.

vi. Eye blink sensors track the driver's level of alertness. An orange warning light and alarm are activated by the system if signs of sleepiness or drowsiness are noticed.

vii. In the event of an accident, the accelerometer or the vibration sensor records the impact and transmits a signal to the microcontroller for additional examination.

viii. Utilize the Global Positioning System module (GPS) to pinpoint the vehicle's location, and employ the GSM module to transmit a message using the messaging app containing latitude coordinates, longitude coordinates, speed of the vehicle, and a Google Maps link to emergency services and law enforcement. The GPS module is used to track the real-time location of the vehicle using the thingSpeak app.

5. RESULTS AND DISCUSSIONS

Simply power on the circuit after connecting the components and uploading the code to observe some notification messages on the LCD. Now launch a web browser and enter the IP address. There will be a link that will take you to a Google map showing the vehicle's current location, as illustrated in the figures below. After successfully connecting to Wi-Fi, the IP address is displayed on the LCD. Then we can see the location of the vehicle on the ThingSpeak app and an associated link directed to the Google map as shown in Fig 15 below.

The GPS module delivers precise data in a live, dynamic context, including geographical coordinates, velocity, temporal details, and date, as illustrated in Figure 15. In the unfortunate event of an accident, the GPS coordinates associated with the incident are transmitted to both emergency services and law enforcement agencies via the GSM module, as shown in Figure 16. This deployment leads to a meticulously calibrated and exact system for the prevention, detection, and reporting of accidents.

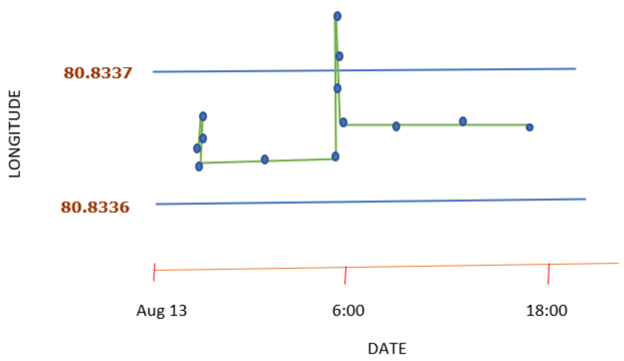

Fig -14: The history of the vehicle location in the thingSpeak app

Fig -15: The vehicle's geographical position on Google Maps.

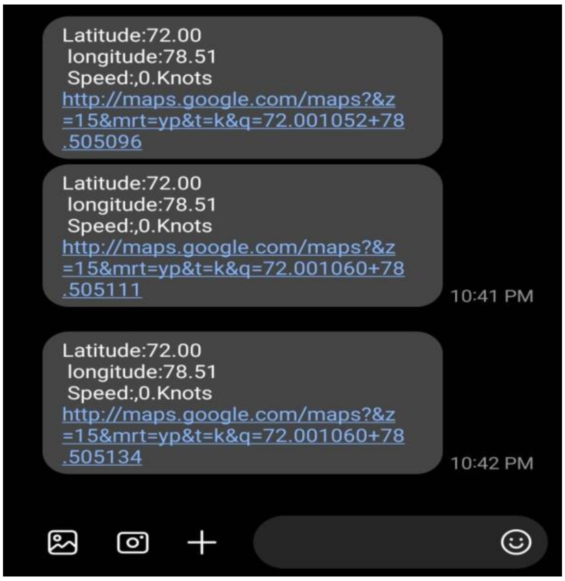

Fig -16: The messages generated by the GSM module

5. CONCLUSION

Hence, the principal objective of this research is to mitigate accidents stemming from driver inebriation, drowsiness, and engine overheating. Furthermore, in the event of an accident caused by another factor, the integrated electronic devices will send distress signals and accurate location information to both law enforcement and emergency medical personnel. This holistic approach strives to improve road safety by addressing numerous potential causes of accidents and allowing for rapid response and aid, reducing potential injury and improving overall public safety.

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