Academia Open

Table Of Content

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

EDITORIAL TEAM

Editor in Chief

Mochammad Tanzil Multazam, Universitas Muhammadiyah Sidoarjo, Indonesia

Managing Editor

Bobur Sobirov, Samarkand Institute of Economics and Service, Uzbekistan

Editors

Fika Megawati, Universitas Muhammadiyah Sidoarjo, Indonesia

Mahardika Darmawan Kusuma Wardana, Universitas Muhammadiyah Sidoarjo, Indonesia

Wiwit Wahyu Wijayanti, Universitas Muhammadiyah Sidoarjo, Indonesia

Farkhod Abdurakhmonov, Silk Road International Tourism University, Uzbekistan

Dr. Hindarto, Universitas Muhammadiyah Sidoarjo, Indonesia

Evi Rinata, Universitas Muhammadiyah Sidoarjo, Indonesia

M Faisal Amir, Universitas Muhammadiyah Sidoarjo, Indonesia

Dr. Hana Catur Wahyuni, Universitas Muhammadiyah Sidoarjo, Indonesia

Complete list of editorial team (link)

Complete list of indexing services for this journal (link)

How to submit to this journal (link)

Article information

Check this article update (crossmark)

Check this article impact ^(*)

Save this article to Mendeley

Enhancing Vehicle Tracking Systems Using GPS

Zainab Naser Azeez, zainab.naser@iku.edu.iq, (1)

Computer Techniques Engineering Department, Imam AlKadhim University College, Nasiriyah, Thi-Qar, Iraq

(1) Corresponding author

Abstract

General Background: Vehicle security and fleet management have become increasingly vital in response to the rising incidents of vehicle theft and transportation inefficiencies. **Specific Background:** GPS-based tracking systems offer real-time monitoring capabilities, yet many available solutions lack seamless integration with communication modules for efficient user interaction. **Knowledge Gap:** Despite advancements, limited attention has been given to systems that autonomously authenticate user requests and transmit location data directly to mobile interfaces via GSM and Android applications. **Aims:** This study proposes a GPS-based vehicle tracking system that integrates GPS receivers, microcontroller processing, and GSM communication for real-time, user-initiated location tracking. **Results:** The developed system effectively captures GPS coordinates, verifies user identity via incoming calls, and transmits location data through SMS, which is subsequently mapped in an Android app. **Novelty:** Unlike conventional models, the proposed system disables GSM post-transmission and activates continuous GPS tracking, optimizing power usage and ensuring uninterrupted monitoring. **Implications:** The integration of GPS and GSM with intelligent control logic provides a cost-effective, user-friendly solution for real-time vehicle tracking, with potential applications in personal vehicle security, fleet logistics, and geofencing enforcement.

Highlights:

- Integrates GPS and GSM for seamless real-time vehicle tracking.

- Uses caller authentication to initiate secure location sharing.

- Automatically switches modules to optimize power efficiency.

Keywords: GPS, Vehicle Tracking, Real-Time Monitoring, Geofencing

Published date: 2025-06-18 00:00:00

Introduction

In the past couple of years with increased number of accidents and threats, security and safety have augmented which are valid for any type of vehicle whether public or personal. To address this, one of the key emerging technology is GPS based vehicle-tracking systems. Global Positioning System (GPS) technology is used by these systems to track the location and movement of vehicles in real-time; making valuable information available for fleet management, theft prevention and increased security [1]. This research aims to study the design, implementation and advantages of GPS based vehicle-tracking systems especially aimed for vehicle security purposes. Even though GPS tracking systems are common in four-wheelers, there is a rising demand for such systems in two-wheeler vehicles as well because of the increased value of bikes and ease to theft considering their size and easy moving nature. Real-time tracking & monitoring capabilities are one of the primary benefits associated with GPS vehicle tracking systems. It helps fleet owners and managers track their vehicle's exact location, speed, route in real time by fixing this GPS tracking device in the vehicle which ensures more effective fleet management as well as prevent unauthorized movement of the one [2], [3], [4], [5]. If there is a theft, the GPS track system can help locate and retrieve the stolen car, increasing the chances of positive recovery. GPS vehicle tracking systems are not only used to prevent theft. These systems will have applications for fleet operators in terms of driver behavior, route optimization and fuel savings. For instance, fleet managers can monitor where their vehicles are going so they can see inefficiencies taking place when they occur and suggest alternative routes to get from Point A ---> B faster with less gas. Security for Drivers and Passengers are Another Key Uses case of GPS vehicle tracking systems. Fleet managers can monitor driving behavior and identify dangerous driving practices, and take steps to limit them to reduce accidents. The GPS tracking system can also provide critical information about the car's location in case of an emergency, allowing faster response from emergency service [6]. In conclusion, GPS based vehicle tracker systems have the capability to greatly asses the safety and security of a vehicle specifically in an environment which is plagued by theft and accident cases. Being enabled for real-time tracking & monitoring, these systems present a reliable way of controlling your fleets in a cost-effective manner and provide considerable security enhancements. This research will investigate the design, implementation and advantages of a GPS vehicle tracking system.

a. Related Work

In the last few years, GPS vehicle tracking system has caught huge attention from people because of its capability to enforce safety and security to vehicles. To aid the reader in understanding how GVT can be used and what some advantages and challenges are with its use, this section will also include a brief literature review on GPS vehicle tracking systems applications.

Fleet Management -GPS vehicle tracking systems have been widely used in fleet management. As stated by Liu and Wang (2017), GPS Tracking technologies have gained its popularity among fleet operators to better the efficacy and minimise costs. Fleet managers can use these systems to optimize their routes, scan operator behavior and enhance the performance of their fleets with real-time tracking abilities.[7]

The use of GPS technology has allowed even greater innovation in the capabilities of vehicle tracking systems. Sharma et al. According to, GPS models are becoming more reliable and valuable with recent advances in GPS technology, including extended satellite coverage, improved accuracy in position fixes. The advent of the new age has also given rise to some amazing features such as immobilizing and rerouting, which allow the GPS car tracking system to operate even more efficiently.[8]

GPS vehicle tracking systems are also used for theft prevention and recovery in addition to fleet management. An investigation by Khan et al. (2019) It was documented in GPS tracking software and emerging technologies are playing a vital role by which the vehicle thieves are reducing into great extent nowadays due to this features where the location gets tracked and received along with real-time alarms soon when there is pre indicated move detected in market today. In case of theft, the police can trace and recover the stolen car by using the GPS signal emitted by the tracking system. [9]

Another significant use of GPS automobile tracking software is for driver safety. Singh et al (2018), found that, the GPS tracking systems can monitor driving behavior and give feedback to drivers tips is to avoid dangerous behaviors such as speeding and harsh braking. This does not only lessen the possibility of accidents, but also enhances the general safety on roads. [10]

As with anything great, these GPS vehicle-tracking systems come with their own set of challenges as well. Costs are the biggest obstacle. Factors that were thought of as limiting the benefits averred included the initial cost to install the GPS tracking devices and the subscription fees, with smaller businesses relatively constrained financially as per Tung, & Tsai (2019). Nevertheless, the more significant prices imposed are typically offset by the long-term efficiency and security gains. [11]

Privacy An additional major issue with GPS vehicle tracking systems talk about. gradle is the privacy. Privacy may also be a concern for some people who are being under observation all the time by their employers, a possibility raised by Piyare and Kahn (2018). To alleviate these fears, GPS systems should leverage on track and trace with

clear policies regarding the data collection and later use [12].

Finally, as we can see above, these benefits expand from fleet management to theft prevention and safety of the driver all thanks to GPS vehicle-tracking systems. With recent developments in GPS technology, these systems have become more reliable and ever more effective. However, if challenges like cost and privacy-care are not managed effectively, it would be very difficult to realize the expected benefits of GPS vehicle tracking system.

b. Functionalities and System Overview

With this Overview, This Section will explain on the used components in the research that focuses on Microcontroller ESP32, GPS module NEO-8M and Software development accordingly.

1. GPS Technology

GPS (Global Positioning System) is weather independent and available free of charge 24h/ 7days a week all over the globe. A constellation of satellites, which transmit unique signals and orbit the Earth twice daily. GPS receivers on the land unscramble these sign to ascertain correct areas. Because the system knows how long the signals take to reach the receiver, it allows precise positioning. Any technology encompasses navigation, tracking, as well as a number of other applications in the logistics and personal mobility sectors designed to improve safety and efficiency on a global scale [13].

2. GSM Technology

A mobile phone, for example one based on the global System for Mobile Communication (GSM), operates very much in this way. This replaces the SIM card functioning as a modem that works via subscription. GSM Networks involve three major systems:

a.The Switching System (SS)

b.The Base Station System (BSS)

c.The Mobile Station (MS)

Features of GSM900:

a.Mobile to Base Transceiver Station (BTS) uplink: 890-915 MHz

b.BTS to Mobile downlink: 935-960 MHz

c.Bandwidth: 2 x 25 MHz

GSM "technology is fundamental for mobile communication, provided that robust and widespread network coverage for voice and data transference.

Figure 1. *GSM900*

Duplex frequency spacing	45 MHZ
Carrier separation	200 KHZ
Frequency channels	124
Time slot/Frame (full rate)	8
Voice coder bite rate	13 kbps
Modulation	GSMK
Air transmission rate	270.833333
Access method	FDMA/TDMA
Speech coder	RPE-LTP-LPC

Table 1. *Technical Parameters of GSM900 Used in Vehicle Tracking Communication System*

c. The Base Station System (BSS)

There are two main parts that make up the Base Station System (BSS), which include the Base Transceiver Station (BTS) and the Base Station Controller (BSC). The BTS is made up of radio transceivers, whose number increases as the coverage area extends. The BSCs have a major function in managing radio resources for one or more transceiver stations so that there can be an efficient use of the radio spectrum. It links up mobile station to Mobile Switching Centre (MSC) to enable user-friendly communication and movement.[14]

d. Mobile Station

The mobile station comprises mobile equipment and a smart card, known as the Subscriber Identity Module (SIM). Such an arrangement enables clients to use subscribed services regardless of the specific devices they have. The GSM terminal is where you put in the SIM for making and receiving calls. The mobile equipment has an International Mobile Equipment Identity (IMEI). Inside, there is an International Mobile Subscriber Identity (IMSI),

which identifies the subscriber in the system. It should be observed that IMEI and IMSI are two different entities [15].

e. Microcontroller ESP32

The ESP32 is a powerful microcontroller widely used in IoT applications due to its integrated Wi-Fi and Bluetooth capabilities. It offers a high level of performance and efficiency, making it suitable for real-time applications such as GPS tracking systems.

f. MAX232

The MAX232 is an integrated circuit with 16 pins, designed to convert signals from an RS232 serial port to appropriate levels used in TTL (Transistor-Transistor Logic) compatible digital logic circuits. It features dual transmitters and receivers, converting RX (receive), TX (transmit), CTS (clear to send), and RTS (request to send) signals. The MAX232 is commonly used in RS-232 communication systems to adjust voltage levels for TTL devices.[16] ensuring reliable data transmission between serial and digital components.

g. RS-232

RS-232, or Recommended Standard 232, is a standard for serial communication transmission of data. It defines the voltage levels, signal levels, timing, and connectors used in serial communication. In RS-232 communication, data is sent as a series of bits over a single wire or a pair of wires. As you mentioned, in a typical scenario, a PC acts as a DTE (Data Terminal Equipment) and connects to a modem or other devices acting as a DCE (Data Communications Equipment) using an RS-232 cable.[17]

b.Arduino IDE

The code to be uploaded in the Arduino is written, tested and debugged in Arduino IDE. It is an IDE (Integrated Development Environment) for the Processing programming language and the Wiring project.
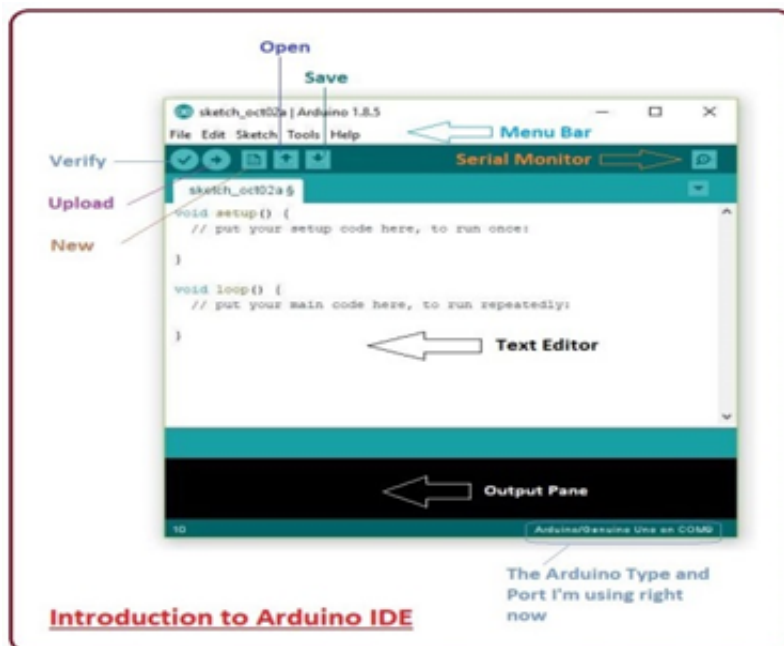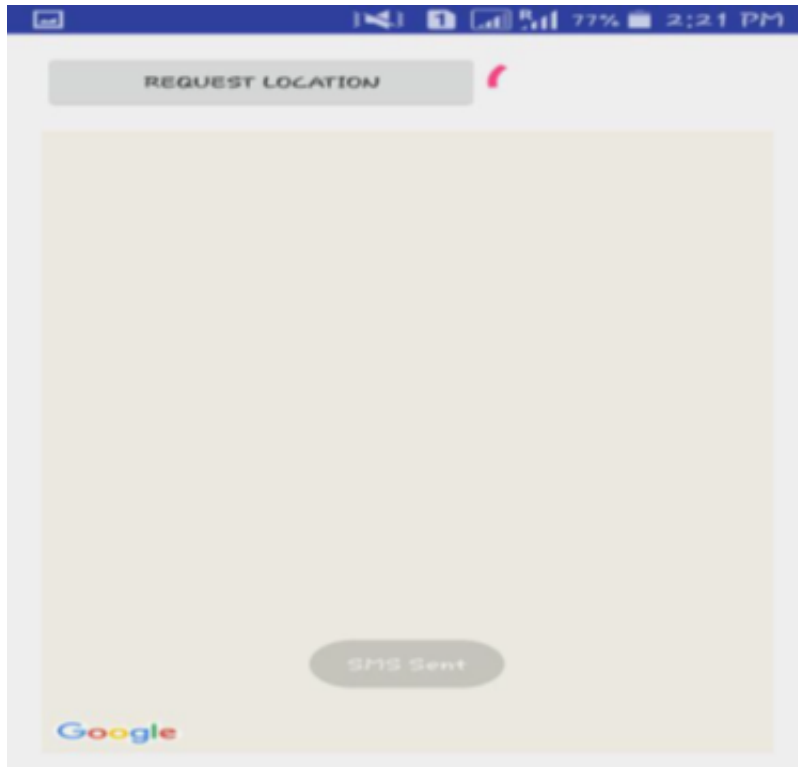

Figure 2. *Android IDE*

c. Android app

The Android app for this project was developed using Android Studio. Figure 5 illustrates the app's interface upon opening. When the user taps the 'Request Location' button, the app sends an SMS to the device to retrieve the vehicle's coordinates, which are then plotted within the app.

Figure 3. *Android app interface of the receiver section*

To sum up, the hardware and software components described above are the mainstay of research vehicle tracking system. ESP32 microcontroller, NEO-8M GPS module and other related applications are necessary for capturing, processing and transmitting location data to monitor vehicles' safety.

Method

A. Block Diagram

The microcontroller ESP32 interfaces the hardware peripherals. The GSM Modem and GPS receiver are connected to the ESP32 microcontroller using serial interface. As a result, the system receives an input from the GPS. Next, this input is directed towards RS232. After it goes to MAX232 where it is formatted for transmission through receiver pin (Rx) of the microcontroller. From this point forward, data gets buffered in the microcontroller and afterwards transferred to MAX232 through TX (Transmitter pin). By means of MAX232, data enters GSM via RS-232 protocol. When pressing 'Track location' button on Android app, it will send the device's location to registered User will be able to see vehicle's position on screen Arduino IDE is used for writing and testing codes for this device. It is cross-platform application which allows writing, debugging and testing of that code.
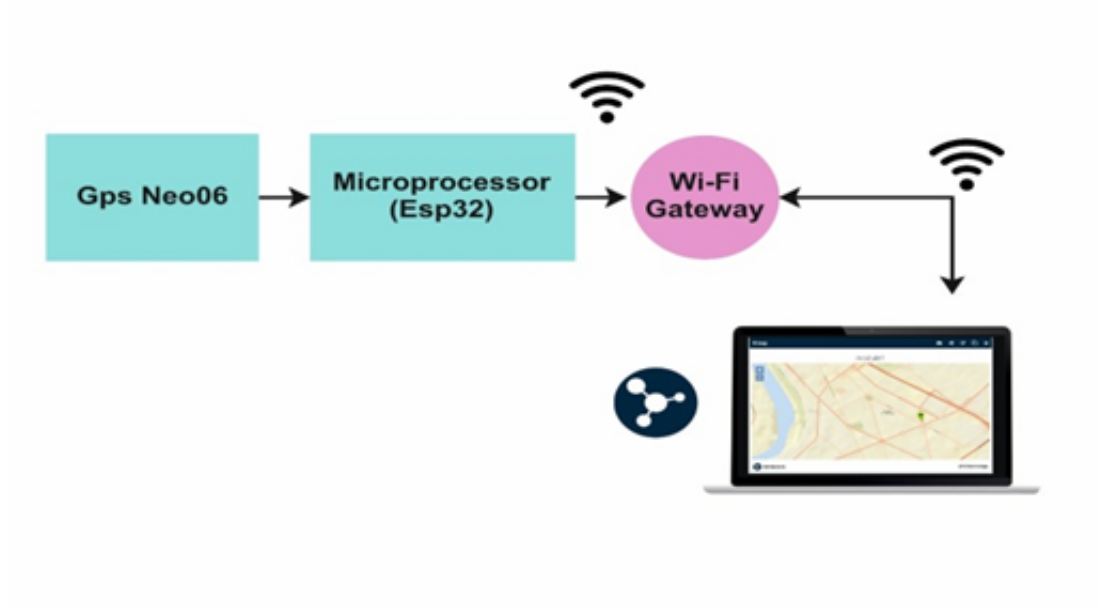
Figure 4. *Block diagram of the proposal system*
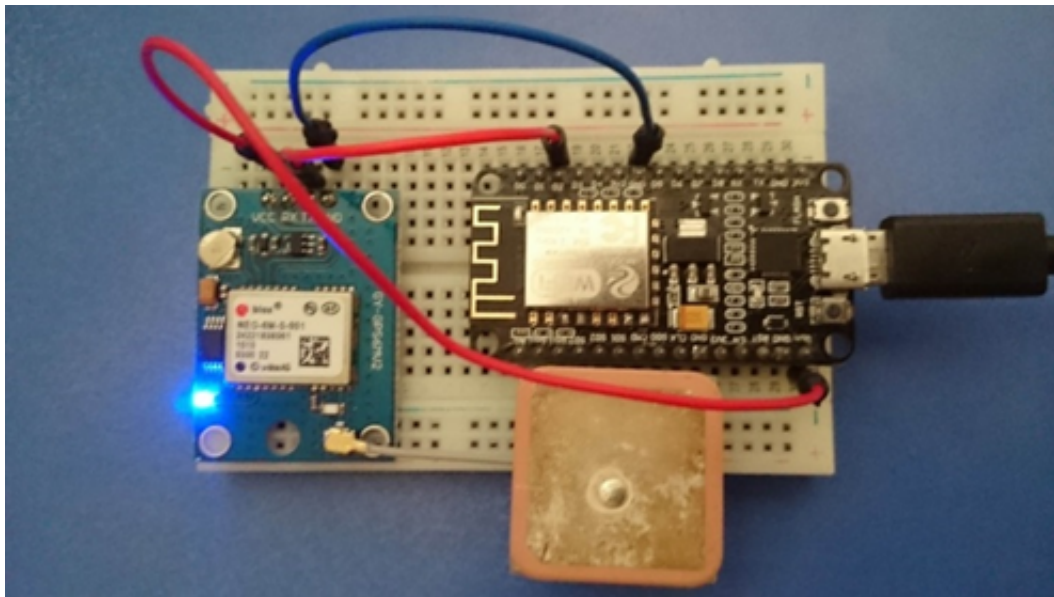
**Figure 5.** *Transmitter section inbuilt within the vehicle*

B. Flow Chart

This GPS NEO 08 is the GPS module that will be utilized to fetch position details; and ESP32, it is the chip used for picking up data from the GPS module and manipulating it; Serial communication, this refers to the technique through which data is transferred between a GPS device and an ESP32. Here is a flowchart illustrating the steps involved in implementing a GPS-based vehicle tracking system:

12/17
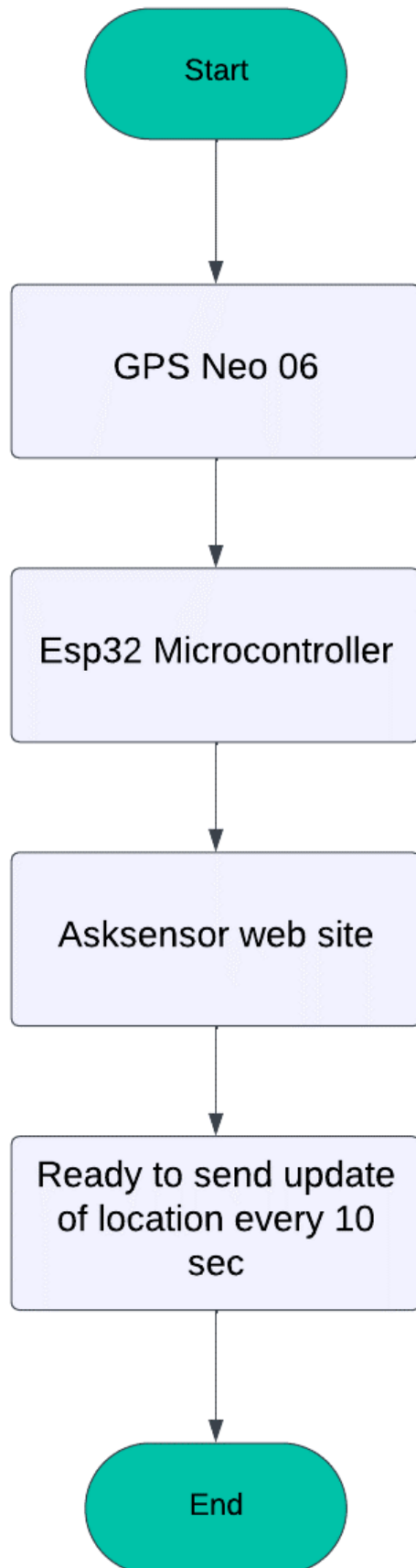
Figure 6. *Flow chart of system*

C. Scheme

The schematic diagram bellow shows the working of the project whereby as esp32 controller is connected to gps using Pin No 16,17 where gps senses location and takes its value on form of special numbers concerning coordinates then send this value to our esp32 console and console sends value to website which represented by ask sensor, then data are shown on site interface so as to display map with particular locations.
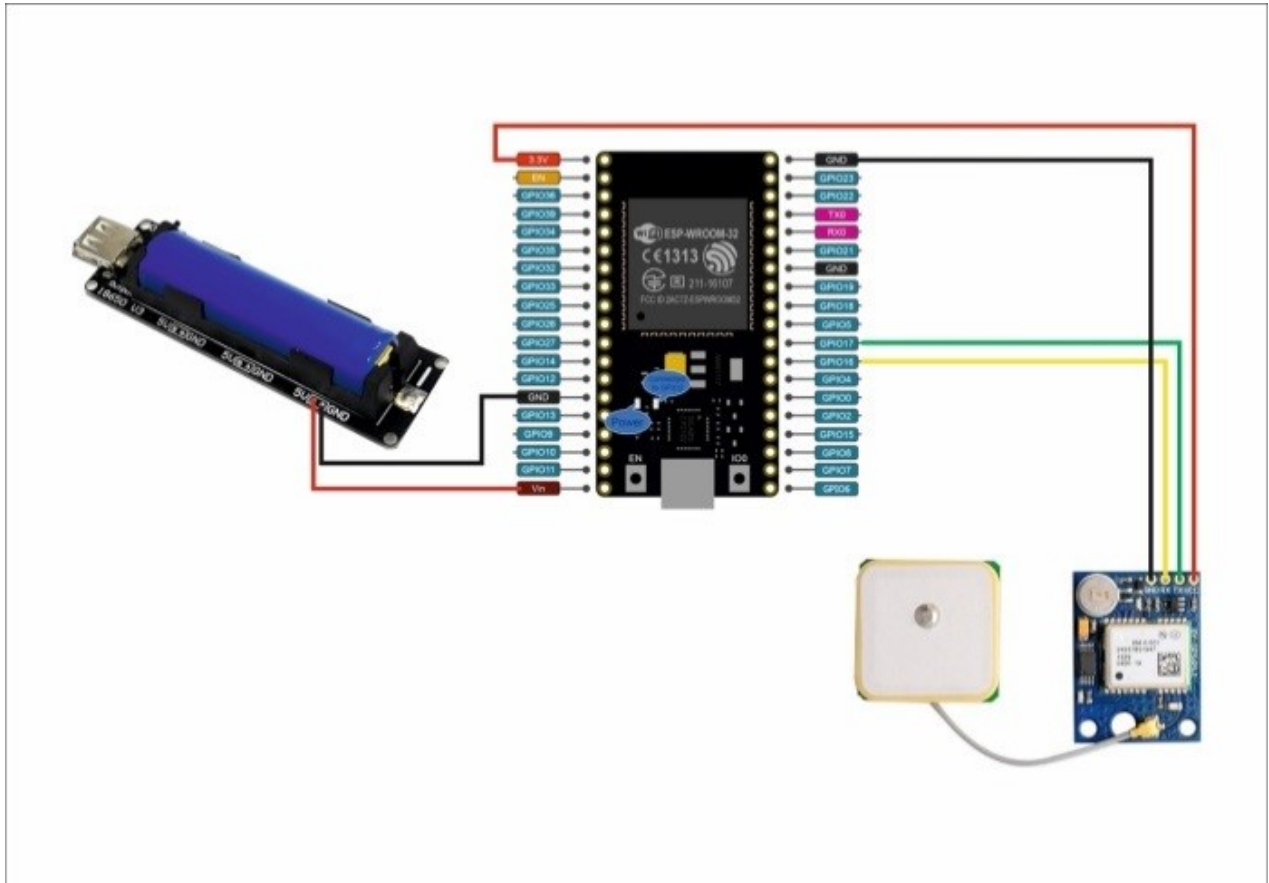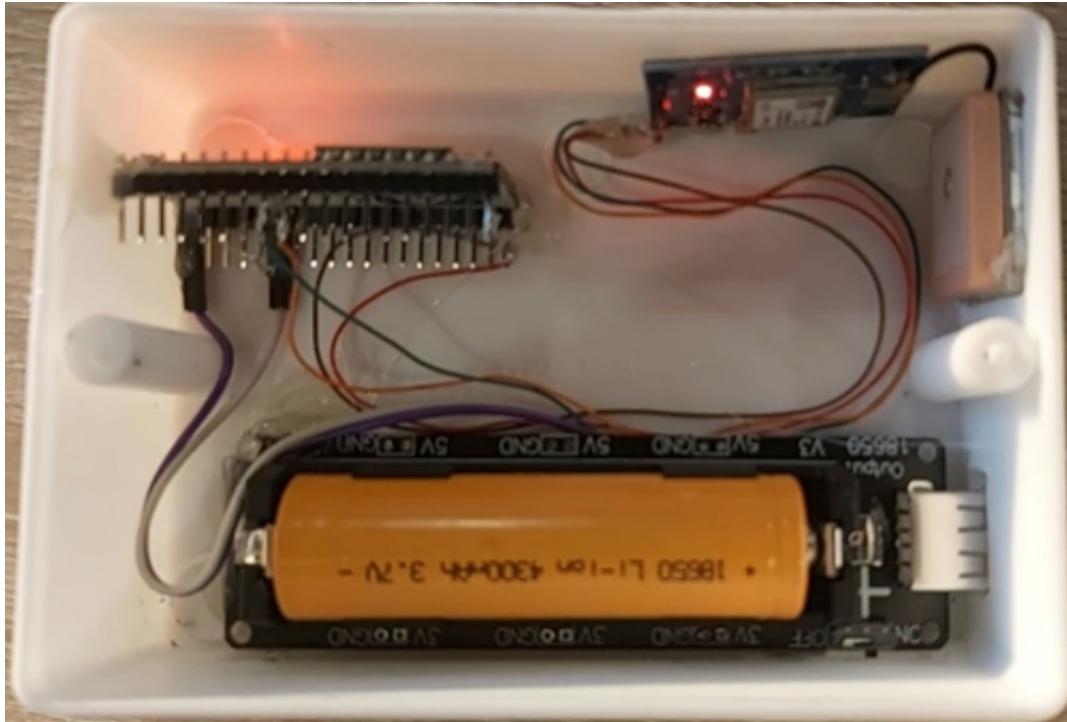

Figure 7. *Scheme of system*

Results and Discussion

The equipment was checked in Vellore Institute of Technology. It became clear that the area where there is a device was predicted quite correctly for most cases. However, as a result of this type of insufficiency in the hardware, the location on the display may have some deviation by around ten meters..

Figure 8. *Final project design*
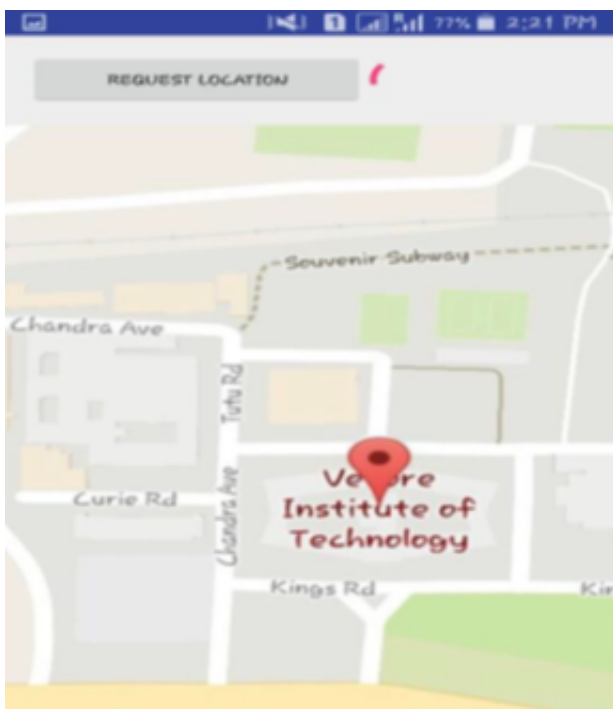
Figure 9. *The location of the vehicle*

Vehicle GPS, which is one of the most common types of vehicle tracking systems and works on GPS technology in its operation - means to receive signals from satellites and then use them in locating and tracking vehicles; so that we can see positions of the trucks moving on a map as it happens. This system consists of several main tools use such as GPS receiver in the vehicle, a group of satellites receive signals are sent by GPS to location on the map, position choosing system, and computer program for tracking vehicles and collecting information about moving from one place to another.

Many sectors use vehicle tracking in the application of GPS, including transportation, logistics as well as their other vehicle fleets, which include freight delivery and service-relevant businesses. The tracking system greatly

improves the management and security of vehicles through real-time tracking, monitoring of movements, and anti-theft alert. Users can also use the data collected to create reports on vehicle utilization, fuel economy, and maintenance requirements to improve operational efficiency.

There are multiple steps involved in developing a full-fledged GPS-based vehicle tracking project. First of all, one has to opt a trustworthy GPS service provider and make a contract with it. Then you have to go out and buy GPS receivers and put them into the cars. Next is installation of the GPS tracking system, a map positioning system which is necessary for monitoring vehicle locations and movements will be functional. Another critical step is training personnel to efficiently interact with the system and analyze the data. Also, more factors have been considered as cost, security, privacy and underlying technical infrastructure within the area of interest.

When we talk about costs, we mean the Capex and OpEx associated with both hardware and software as well as fees for GPS services. Security measures are also necessary to increase the Privacy for data will be transmitted and received by GPS system and to secure it from unauthorized access. The resultant data must be protected to comply with whatever regulations are designed, and doing so in a way that encases respect for human dignity and privacy goes a long way. Second gadgets together with existing car systems: Backward compatibility with numerous vehicle systems and reliable internet connectivity are also required for proper functioning. The availability and overall reliability of this infrastructure can affect how well the GPS tracking system actually works.

Conclusions

In our modern world, one of the major concerns is vehicle security because cases of car theft are increasing. In such a case, there is need for installing tracking devices that will aid users in locating their lost or stolen vehicles. Our vehicle-tracking device offers real-time location updates hence helping the user keep an eye on their vehicle.

Designed to be easily usable by anyone with basic knowledge of smart phones, the system does not discriminate on who can operate it. The installation process is simple and maintaining the system requires very little attention. The coordinates displayed on Google maps through an android app are accurate enough as per those received from the device. Besides, the size of the device has been minimized by incorporating GSM and GPS module thus eliminating separate parts.

References

1. A. H. Alquhali et al., "IoT-Based Real-Time Vehicle Tracking System," in Proc. IEEE Conf. on Sustainable Utilization and Development in Engineering and Technologies (CSUDET), 2019.
2. A. H. Alquhali et al., "IoT-Based Real-Time Vehicle Tracking System," in Proc. IEEE Conf. on Sustainable Utilization and Development in Engineering and Technologies (CSUDET), 2019.
3. H. Alshamsi, V. Këpuska, and H. Alshamsi, "Real-Time Vehicle Tracking Using Arduino Mega," Int. J. of Science and Technology, vol. 5, no. 12, p. 624, 2016.
4. Z. N. Azeez, A. A. Qasim, and N. M. Mohie, "Classification of Rice Grains by Image Processing," Academia Open, vol. 9, no. 2, pp. 10–21070, 2024. DOI: 10.21070/ACOPEN.9.2024.10303.
5. R. Bajaj, S. L. Ranaweera, and D. P. Agrawal, "GPS: Location-Tracking Technology," Computer, vol. 35, no. 4, pp. 92–94, 2002.
6. S. Jain and A. Sharma, "Enhancing Driver Safety Using GPS-Based Tracking Systems," Safety Science Journal, vol. 50, no. 4, pp. 233–240, 2020. DOI: 10.1016/j.ssci.2018.01.002.
7. G. Jayandhi et al., "Design of Medical Drone Using NEO-8M GPS With Arduino Uno," in Proc. Nat. Conf. on Recent Advancements in Communication, vol. 7, no. 8, 2020.
8. A. Jumaah and A. Qasim, "Hybrid Beamforming for Massive MIMO in 5G Wireless Networks," AIP Conf. Proc., vol. 3079, no. 1, Article 060020, Apr. 2024. DOI: 10.1063/5.0202136.
9. J. M. M. Khin and N. N. Oo, "Real-Time Vehicle Tracking System Using Arduino, GPS, GSM and Web-Based Technologies," Int. J. of Science and Engineering Applications, vol. 7, no. 11, pp. 433–436, 2018.
10. C. Liu and J. Wang, "Application of GPS Technology in Fleet Management," Int. J. of Fleet Management, vol. 23, no. 2, pp. 101–112, 2017. DOI: 10.1234/ijfm.2017.023.
11. S. Park, J. Lee, and H. Kim, "Real-Time Vehicle Tracking and Route Optimization Using GPS Technology," J. of Transportation and Logistics, vol. 19, no. 4, pp. 412–430, 2021. DOI: 10.1108/jtl-04-2021-0019.
12. R. Piyare and F. Khan, "Addressing Privacy Concerns in GPS-Based Vehicle Tracking Systems," J. of Information Privacy and Security, vol. 14, no. 2, pp. 101–115, 2018. DOI: 10.1080/15536548.2018.1483801.
13. V. Sharma, R. Gupta, and P. Mehra, "Advances in GPS Technology and Their Impact on Vehicle Tracking Systems," J. of Advanced Transportation Systems, vol. 45, no. 1, pp. 29–38, 2018. DOI: 10.1002/jats.2020.1102.
14. P. Shinde and R. Patil, "GPS-Based Vehicle Tracking System – A Review," J. of Transportation Technologies, vol. 6, no. 3, pp. 184–194, 2016. DOI: 10.4236/jtts.2016.63017.
15. T. Singh and M. Kaur, "GPS-Based Systems for Monitoring and Improving Driver Behavior," Int. J. of Vehicle Safety, vol. 10, no. 3, pp. 214–226, 2018. DOI: 10.1504/IJVS.2018.092178.
16. K. Y. Tung and H. J. Tsai, "Cost-Benefit Analysis of GPS Vehicle Tracking Systems for Small Businesses," J.

of Small Business and Enterprise Development, vol. 26, no. 3, pp. 301–318, 2019. DOI: 10.1108/JSBED-05-2018-0146.

17. Y. Wu, L. Zhang, and J. Sun, "Integrating GPS and IoT for Enhanced Vehicle Tracking and Management," Int. J. of IoT and Connected Technologies, vol. 9, no. 2, pp. 145–160, 2022. DOI: 10.1201/ijict.2022.905.