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IoT-Based Anti-Theft GPS Tracking System for Real-Time Vehicle Monitoring

Omkar Ramesh Tupke[1,*], Kunal Dipak Randhawane[1], Gaurav Sudhakar Zalte[1], Vaibhav Navnath Arane[1], Vivek Vilas Bagal[1], Naveen Kumar[2]

Abstract

For the last six decades, advances in global positioning systems (GPS) technology for tracking vehicles have greatly enhanced their ability to secure, monitor, and track vehicles. However, many conventional methods using GPS to track vehicles have been limited by the scope of their/its operational communication range. This has reduced their effectiveness in terms of being able to track those vehicles once they are out of the limits of the original areas in which they were set to be tracked. Therefore, an Internet of Things (IoT)/GPS-based real-time positioning system was developed, based on a range-independent method of tracking the vehicle. The vehicle tracking system consists of four main components: a GSM SIM800L communication module, a GPS Neo-6M receiver module, an Arduino Uno microcontroller, and an active SIM card. Each device provides input data to be used for computing the current geographic location (i.e., latitude and longitude) of the vehicle. The GPS module obtains a precise latitude and longitude from the GPS, and the GSM module transmits this data instantaneously to the Android smartphone of the vehicle owner for continuous tracking, as long as there is a network connection from the vehicle. Not only does the system offer tracking capabilities, but it is also encased in a uniquely engineered case to reduce vibration and shock impact, as well as to protect against environmental stresses, which enhances the durability of the electronics inside the case and increases reliability over time. Further, through the integration of real-time communication and rugged hardware design, the tracking solution helps improve vehicle security. This tracking solution helps prevent theft while also providing parents with a tool to monitor their children while they drive and to promote safe driving.

Keywords: Anti-theft system, Arduino Uno, GPS tracking, IoT, real-time monitoring, vehicle security

INTRODUCTION

In today's world of high population density, the number of vehicles is also significantly increasing, and there might be chances of vehicle theft. To resolve this problem, there is a need to have an intelligent system that is capable of providing constant surveillance of the vehicles after they have been stolen and rapid response to attacks by maintaining constant communication with the vehicle owners. Therefore, GPS technology is used, and this technology has been evolving over the past six decades for the advanced safety of vehicles [1–5]. The first use of GPS technology in vehicles for safety purposes is credited to the U.S. Department of Defense, which initially used GPS for military purposes, including tracking vehicles. Along with defense, GPS technology is widely used in navigation, surveying, mapping, precision agriculture, emergency services, and autonomous

***Author for Correspondence**
Omkar Ramesh Tupke
E-mail: tupkeomkar@gmail.com

[1]Student, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, Maharashtra, India
[2]Assistant Professor, Mechatronics Engineering Department, Sanjivani College of Engineering, Kopargaon, Maharashtra, India

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vehicles [6–15]. The GPS tracker is also helpful for parents to track the travel activity of their children; therefore, if any child is visiting any place daily that is dangerous, parents can take necessary action [16–20].

Multiple researchers have developed GPS- and GSM-based vehicle tracking system methodologies. Musa developed a real-time vehicle tracking and anti-theft management system using GPS and GSM modules to send location information via short message service (SMS) and enable distant vehicle management [21]. A vehicle tracking solution based on Arduino Uno, GPS, and GSM modules enabled users to receive their positions through SMS, allowing them to view locations on Google Maps [1]. Salih et al. developed a smart vehicle tracking framework that joins an Internet of Things (IoT) platform for real-time monitoring and alert features [22]. Osman et al. designed a tracking system in which GPS data were sent via GSM to a server for live monitoring [2]. Hlaing et al. demonstrated a user-friendly tracking solution that used Arduino, GPS, and GSM to provide real-time updates and Google Maps integration via SMS [23].

Our developed GPS tracker delivers high reliability at a lower cost for real-time vehicle tracking throughout an infinite distance range. The project utilizes Arduino Uno as a controller together with a GPS Neo-6M module and GSM SIM800L, jumper wires, and a breadboard. The specialty of our project is its simplicity, efficiency, and lack of range limitations. The GPS Neo-6M module captures the live coordinates of the position where our vehicle is running or in a steady state and then sends them to the GSM SIM800L module for further processing. Then, this GSM module sends the coordinate data to the predefined mobile number set in the Arduino program. The Arduino is programmed in such a way that whenever a user sends the message ‘get location’ to the mobile number in the GSM SIM800L module, the process mentioned above happens within a fraction of a second. By using the GSM module, we do not need any cloud platform or application, ensuring rapid delivery of location data in real time. Our project circuit prioritizes ease of deployment, affordability, and real-time tracking accuracy, making it suitable for both personal use and vehicle companies.

METHODOLOGY

A real-time GPS vehicle tracking system based on IoT principles constitutes the main objective of this investigation, which involves designing and evaluating its implementation. The system exploits GPS technology together with GSM to monitor locations across unlimited geographical areas. This section elaborates on the methodology used in system development, including hardware and software selection, system architecture, circuit integration, data transmission, enclosure design, and validation procedures. The setup is shown in Figure 1.

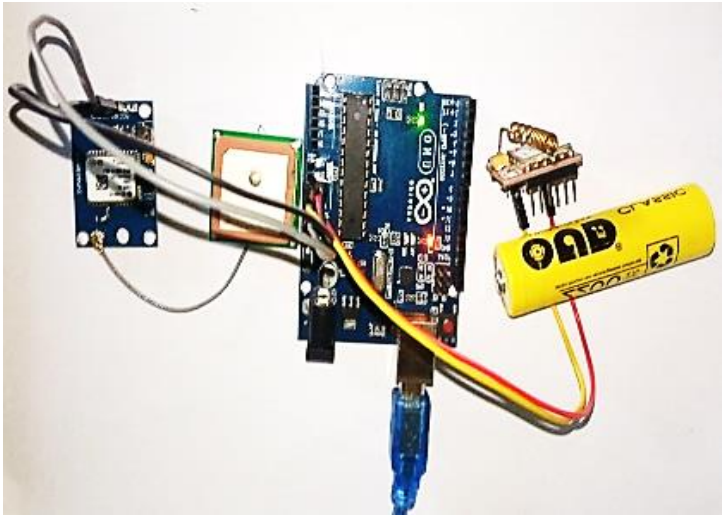

Figure 1. Setup.

System Architecture

The proposed system consists of three functional layers arranged from top to bottom:

1. *Data acquisition layer:* Captures real-time geolocation data using the GPS Neo-6M module.
2. *Processing and control layer:* An Arduino Uno microcontroller is used to process the incoming data and prepare it for transmission.
3. *Communication layer:* The GSM SIM800L module transmits the processed data via SMS to the end users through the mobile network.

This architecture enables continuous tracking and real-time communication of vehicle locations regardless of distance using the existing mobile network infrastructure.

Hardware Components

The hardware components were selected based on their availability, compatibility, low power consumption, and suitability for embedded systems. The following components were used:

GPS Module (Neo-6M)

- The device uses signals received from several GPS satellites to determine its present position before generating latitude and longitude data.
- It communicates using the National Marine Electronics Association (NMEA) protocol, sending continuous streams of data to the microcontroller through serial communication.

GSM Module (SIM800L)

- Data is sent to the user's mobile device using the SMS.
- Requires a micro-SIM card with active mobile data or text plan.
- It operates on 3.7–4.2 V and is powered by a separate battery or voltage regulator to prevent power dips during GSM transmission.

Arduino Uno

- The system utilizes this component as its central computing unit with programming in C/C++, written in the Arduino IDE [24, 25].
- The system receives GPS data, automatically filters the significant coordinates, and instructs the GSM module to send the information through its transmission channel.
- The system employs the Software Serial library for separate communication between the GPS and GSM modules through different pins.

Hardware Integration

Connecting Neo-6M GPS Module to Arduino Uno:

1. TX pin of Neo-6M → RX pin of Arduino (pin 4 or via Software Serial)
2. RX pin of Neo-6M → TX pin of Arduino (pin 3)
3. VCC and GND to Arduino 3.3 V and GND, respectively

Connecting SIM800L GSM Module to Arduino:

1. RX TX pin of SIM800L → RX pin of Arduino
2. Pin of SIM800L → TX pin of Arduino
3. Power through an external 3.7 V–4.2 V source (as SIM800L is sensitive to overvoltage)
4. Common ground with Arduino

Software Development

Arduino IDE is used to develop the firmware code.

Libraries Used

1. SoftwareSerial.h—for serial communication with GPS and GSM modules.
2. TinyGPS++ or NeoGPS—to parse GPS data.

Testing

To ensure reliability, the system underwent both controlled and real-world testing phases.

Laboratory Testing

- The GPS module is tested for cold and warm start times.
- The GSM module is tested for SMS transmission under low and high signal conditions.
- Power consumption is monitored to ensure efficiency and system uptime.

Field Testing

- The system was installed in a vehicle and driven across urban, rural, and highway environments.
- The coordinates received on the Android device were compared with the actual locations on Google Maps for accuracy.
- System performance is evaluated under different speeds, temperatures, and network conditions.

RESULT AND DISCUSSION

Whenever a vehicle is stolen, the device sends a message to the given smart device. The message for the location is as shown in Figure 2.

My current location is
Latitude: 19.901506
Longitude: 74.495041

For the live location on Google Maps, a link is provided, as shown in Figure 3.
Live Location: http://maps google.com/maps?q=0000000, 0.000000.

This service shows the location and coordinates of the vehicle on the smart device connected to it and sends it to check if the device is working or not. The system's message responses and features are shown in Table 1.

The proposed system implements GPS- and GSM-based hardware. The GSM module processes user messages or calls into vehicle positioning coordinates, which become available to users for tracking the vehicle location.

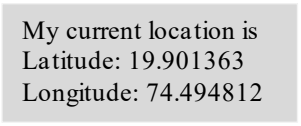

Figure 2. Live location sharing results.

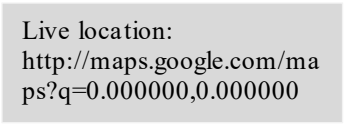

Figure 3. Live location Google Map link.

Table 1. System message responses and features.

Scenario	Device response
Theft or unauthorized movement	Sends SMS to the user's smart device.
Location information via SMS	"My current location is\nLatitude: 19.901506\nLongitude: 74.495041."
Google Maps tracking link	http://maps.google.com/maps?q=0000000,0.000000 (Note: Example coordinates placeholder).
System status check	Also sends location info to verify if the device is working properly.
Communication mode	Uses SMS via GSM module for communication with the user device.

First, we examined how our project functioned before we encountered difficulties that stemmed from both the GSM module and the network problems affecting the GPS modem, which failed to operate effectively in or near buildings or areas with congested regions that had poor connectivity. The GSM model encounters network problems with service provider networks, which requires us to check various types of SIM cards to determine optimal coverage. Using a signal booster is one way to address network-related problems.

Drawbacks

- Signals can lose strength, and the receiver system is unable to provide location; this type of situation occurs in dense areas where vegetation is dense.
- Large or tall buildings situated nearby or closely together can cause large multipaths and fading errors that cause the system to lose its ability to track the offender.
- Signals can be lost or weakened when the user approaches an enclosed means of transport.
- Signal strength gets affected when raining heavily, snow falls, and in foggy areas.

The device mainly focuses on vehicle tracking and anti-theft of vehicles to track, and we have focused our system to be cost-effective. The development of this device has become more feasible due to the availability of robust and inexpensive tools for building both software and hardware, making it accessible to a wider audience, including large corporations.

SMS systems were employed for information transmission instead of GPRS technologies. SMS is the world's leading data application because all its users total 3.6 billion people, making up 77% of smartphone and smart device owners. However, GPRS fails to match SMS reliability because of its unreliable performance in developing nations. The use of SMS can increase the probability of a large number of vehicle owners using the device.

CONCLUSIONS

The integration of Arduino Uno and GSM technology provides a compelling solution for an anti-theft GPS tracking system that is more affordable, versatile, and scalable. The existing technology exploration and literature review demonstrate that this system offers vast possibilities across different areas, including vehicle tracking, asset management, personal safety, and security.

The Arduino Uno is compact in size and consumes minimal power. Arduino programming is easier than other programming languages, making it easy to code and user-friendly. When an Arduino is connected to GPS and GSM modules for satellite connectivity, these systems provide real-time location tracking and monitoring of any area that is under network coverage. Additionally, the versatility of the Arduino Uno allows seamless integration with various sensors and modules, enhancing the functionality and adaptability of the GPS tracking system to specific user requirements.

This study aims to develop a tracking system for vehicles that are lost or stolen. Once an automobile is stolen, the owner executes a command to the GSM module to obtain the current coordinates of the vehicle based on the latitude and longitude. The satellite view in Google Maps enables users to detect the present position of their vehicle. The road appearance on the mapping interface helps users shorten their search time for finding their stolen vehicles. This solution allows users to determine the location of their vehicle.

There are various ways to enhance this system. First, using a high-precision GPS module helps establish a stable connection with satellites, ensuring accurate location data collection. Next, integrating this system with cutting-edge technology and implementing a mechanism to send location data to a server via the IoT will enable real-time tracking and monitoring of the system.

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