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Arduino-Based Vehicle Tracking and Theft Detection System

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Abstract - Car theft is a big problem worldwide pushing for better security and tracking systems. This paper presents a cheap and easy-to-use GPS-GSM Vehicle Tracking and Theft Detection System based on Arduino. It gives real-time location updates and theft alerts through SMS. The system uses the TinyGPS++ library, a SIM800L GSM module, and an LCD screen to allow remote monitoring without needing internet. Users can track vehicles by texting a specific word, and if stolen, the system sends location updates every 30 seconds. This solution works well for personal cars managing fleets and tracking assets. It offers a reliable standalone security system that doesn't need internet. The system is simple to set up, affordable, and can be used for more than just tracking vehicles, like keeping an eye on kids or managing logistics.

Keywords - GPS Tracking, GSM Communication, Arduino, SMS Based Security, Vehicle Theft Prevention, Fleet Management, Real-Time Monitoring.

INTRODUCTION

Car theft has become a bigger problem around the world. Regular anti-theft systems like alarms and locks often don't work well enough because thieves can get past them. This means we need better real-time tracking solutions to make cars safer. This paper suggests a car tracking system based on Arduino that uses GPS and GSM tech to track location live through SMS. It has a theft alert mode that keeps sending GPS coordinates, user checks to stop people who shouldn't use it, and works on its own without needing internet. The system uses a SIM800L GSM module for SMS and a Neo-6M GPS module to get location info. An Arduino Uno acts as the main microcontroller to handle data and show real-time updates on an LCD screen.

The system works in two main ways: User Mode and Theft Mode. In User Mode, people who have permission can find out where the vehicle is by texting "LOCATION." Theft Mode starts when someone pushes a button. If someone turns on the car in this mode, it keeps sending GPS updates to an emergency contact. This two-way system makes sure you can keep tabs on your vehicle as it moves, which is handy for users and boosts security if someone tries to steal it.

The setup is budget-friendly using cheap and easy-to-find parts, and it's simple to put in place. This means it can work for lots of different things, like keeping your own car safe managing a bunch of vehicles or keeping track of valuable stuff.

Literature Review

2.1 Existing Vehicle Tracking and Theft Detection Systems

Car theft has become a big problem pushing researchers to come up with electronic tracking and theft detection systems. Old-school security tricks, like steering locks and alarms, don't work well because thieves can get around them. This has led to GPS and GSM-based car tracking systems becoming more common. Firas Zeki (2022) came up with a car tracking system that used Arduino, GPS, and GSM tech to track locations in real-time through SMS. But the system didn't have advanced security features like geofencing or the ability to control the ignition from afar. In a similar way, Htwe Thin Thin and Hlaing Kyaw Kyaw (2019) created an Arduino-based car tracking system that relied on SMS to communicate. While it worked well, the system cost a lot to run because it had to send and receive so many text messages.

2.2 GPS and GSM-Based Tracking Solutions

GPS and GSM-based tracking systems have gained popularity because they're cheap and good at keeping tabs on vehicles. Boxall (2013) showed how to combine Arduino microcontrollers with GPS modules to track in real-time. These setups work well because they don't need the internet, which makes them great for out-of-the-way places. But here's the thing: most GPS-GSM trackers just tell you where something is. They don't have features to stop theft, like sending alerts or emergency tracking if someone who shouldn't be there tries to use it.

2.3 Limitations of Existing Systems

Even with the latest technology, today's car tracking systems have their limitations. The majority of GPS tracking systems require internet access, which is not always

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present, particularly in rural areas. SMS tracking systems are fine, but expensive if you require a lot of location updates. Furthermore, most tracking solutions only show the location of the vehicle and lack theft-deterrent features such as automatic notification, remote immobilization of the vehicle, or tracking during theft. These shortcomings indicate that we require a more affordable and effective security solution.

2.4 Contribution of the Proposed System

The Arduino-based vehicle tracking and theft detection system proposed aims to overcome these limitations by offering a low-cost, independent security solution. Unlike traditional tracking systems, it does away with the need for an internet connection, opting for SMS communication for real-time tracking. One of the system's innovative aspects is its "Theft Mode," which automatically sends continuous location updates on detecting any unauthorized movement of the vehicle. The system has also been made low-cost and easy to implement, making it applicable for personal vehicle security, fleet management, and asset tracking. By integrating theft detection with GPS tracking features, this system enhances vehicle security immensely and provides a low-cost, dependable alternative to current solutions.

SYSTEM COMPONENTS AND ARCHITECTURE

The system consists of a number of significant hardware and software components that communicate with each other in order to provide real-time monitoring of vehicles as well as vehicle theft detection. The system's central microcontroller is the Arduino Uno, which is fed input from the GPS module to process and controls the GSM module for sending SMS. A detailed overview of the hardware components of the system is described below:

3.1 Arduino Uno

The Arduino Uno is an open-source microcontroller board that is developed based on the ATmega328P. It consists of digital and analog I/O pins, which allow it to connect with various sensors and modules. The Arduino Uno is the processing unit of this system, which manages the communication between the GPS module, GSM module, LCD display, and push buttons. It is programmed using the Arduino IDE, which makes it simple to control and automate the tracking system.

3.2 Neo-6M GPS Module

The Neo-6M GPS module is tasked with the retrieval of real-time geolocation data, i.e., longitude and latitude, through its satellite link. It communicates serially (UART) with the Arduino. The module is precise and can function in varying environmental conditions, and thus it can be used in vehicle tracking-related projects. The TinyGPS++ library allows for parsing and formatting the GPS data, thus making it easy to process and visualize.

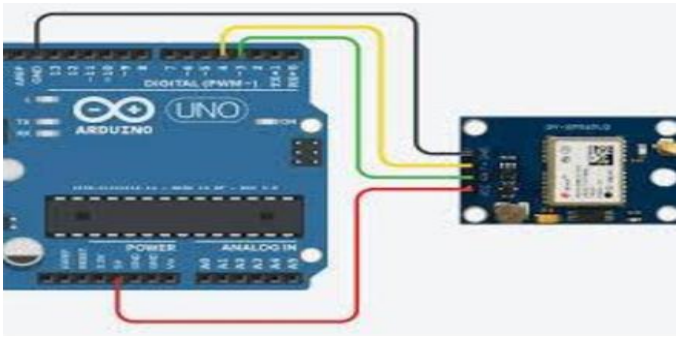

Fig.1: GPS Module connection w/ Arduino Uno

3.3 SIM800L GSM Module

The SIM800L GSM module provides communication between the vehicle tracking system and the user through SMS. It can send and receive messages through AT commands on a serial interface. The module is supported by a 2G network and can be powered by a stable power supply of 4.2V-4.4V, normally regulated by a buck converter to avoid voltage fluctuation. The SIM800L is employed to send location information and alarm on theft mode activation.

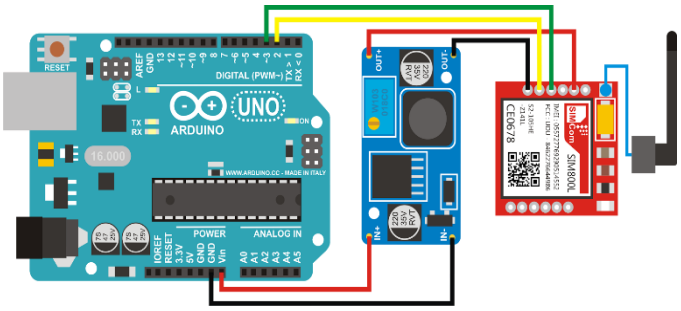

Fig.2: GSM Module connection w/ Arduino Uno

3.4 16x2 LCD Display

LCD 16x2 is utilized to provide immediate feedback to the users about the state of the system. It provides vital information such as the mode of operation of the system in the current situation (User Mode or Theft Mode), the GPS connection state, and notifications of the incoming SMS messages. LCD uses I2C communication and therefore reduces the number of cables required to interface with the Arduino.

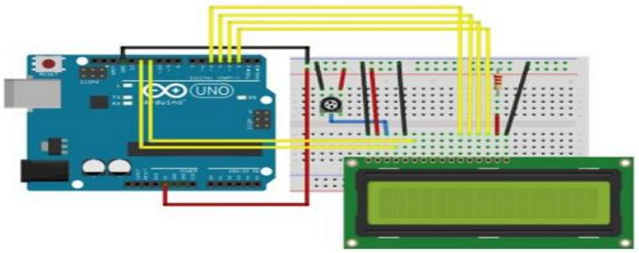

Fig.3: 16x2 LCD connection w/ Arduino Uno

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3.4.1 Modes displayed on LCD:

Fig. 4: User Mode

Fig 5: Theft Mode

3.5 Push Button

The Theft Mode is activated manually by a push button. When activated, the system goes into theft detection mode and begins monitoring the ignition status. When the ignition is switched on, the system continuously reports the position to an emergency contact.

3.6 Power Supply

The system is powered using a 9V source, which can either be supplied through an adapter or a battery. A voltage regulator is used for the reason of supplying the SIM800L module with a steady 4.2V and thus preventing the device from any harm. Power efficiency of the system allows the system to last for a very long period without the need for frequent recharging.

3.7 Circuit Diagram

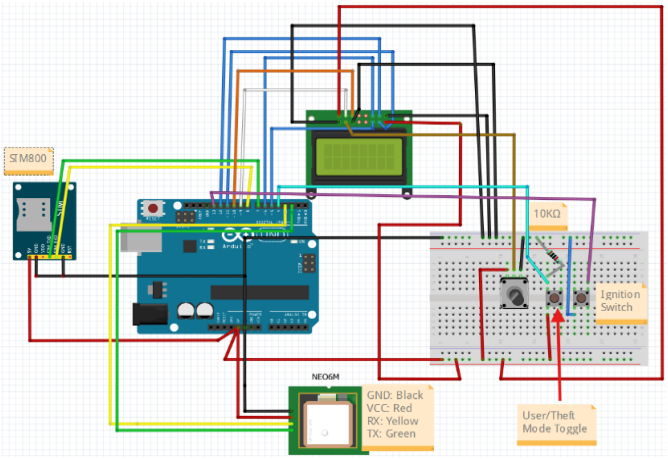

Fig. 6: Circuit Diagram

3.8 Pin Configuration

Component	Arduino Pin
GPS Module (TX)	2
GPS Module (RX)	3
GSM Module (TX)	7
GSM Module (RX)	8
LCD (RS)	9
LCD (E)	10
LCD (D4-D7)	5, 6, 11, 12
Push Button	4
Ignition Switch	13

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SYSTEM BLOCK DIAGRAM

The block diagram illustrates the functional dynamics of the Arduino-Based Vehicle Tracking and Theft Detection System with a GPS module, an Arduino Uno, an LCD display, and a GSM module for enabling real-time vehicle tracking and theft prevention through SMS communication. The system operates primarily by continuously fetching location information from the GPS module, processing the information through the Arduino microcontroller, and displaying system status on an LCD display, while simultaneously performing communication with a mobile device through the GSM module.

The GPS module, the Neo-6M GPS, is responsible for capturing satellite signals to determine the exact geographical location of the car, i.e., its longitude and latitude. The geographical locations are then communicated to the Arduino Uno, the system's processing unit. The Arduino interprets incoming GPS data and uses it to construct an SMS response to be sent to the user. Additionally, it shows the system's working status on an LCD display, thus allowing the user to see system operations visually in real-time. The LCD provides feedback in the form of display of messages such as "System Ready," "Tracking Activated," or "Location Sent," thus showing whether the system is in normal tracking mode or whether it has been activated in theft detection mode.

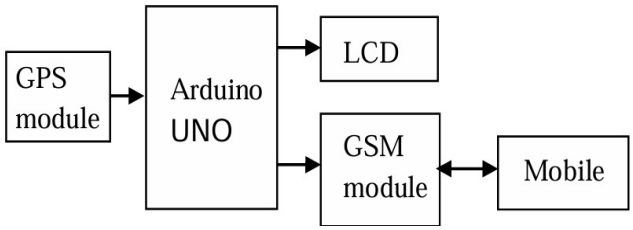

Fig. 7: System Block Diagram

The GSM module (SIM800L GSM) is required for remote notification of the user to the system. On receiving an SMS from the registered user with the keyword "LOCATION," the GSM module reads the message and passes it to the Arduino to process. The Arduino gets the identity of the sender and, after successful authentication, gets the GPS location of the vehicle. The coordinates are then translated to a Google Maps link and passed back to the user via SMS, thus enabling real-time tracking of the location of the vehicle without the use of an internet connection. Also, on powering up the system in Theft Mode, which is triggered by the detection of unauthorized movement of the vehicle, the system sends periodic location updates every 30 seconds to a pre-configured emergency contact.

The system is designed to operate in two primary modes of operation: User Mode and Theft Mode. In User Mode, the system is in sleep mode and is waiting to receive location requests from a legitimate user. When the keyword "LOCATION" is received via SMS, the system sends back the current GPS coordinates. Theft Mode is activated when a special push button is pressed, indicating unauthorized entry into the vehicle. When the vehicle ignition is turned on in this mode, the system sends automatic transmission of real-time location updates to the preprogrammed emergency contact, thus allowing the owner to track the stolen vehicle in real time.

The combination of the GPS, GSM, and Arduino technologies ensures that the system can function as a low-cost, stand-alone security system that does not depend on internet connectivity. This feature makes it highly suitable in instances of personal car security, fleet tracking, and asset tracking, thus providing the user with a viable and reliable method of remote tracking of their vehicles.

5. WORKING PRINCIPLE

The system operates in two modes: User Mode and Theft Mode. In User Mode, a registered user can send an SMS with the keyword "LOCATION" to the system. The system checks the sender's number and sends a Google Maps link of the current GPS location of the vehicle. The feature allows users to track the location of the vehicle in real-time without the use of an internet connection. In contrast, in Theft Mode, which is triggered by a push button press, the system is always on the lookout, continuously checking the status of the vehicle's ignition. If the ignition is switched on, the system immediately sends GPS location updates every 30 seconds to a specified emergency contact, thus allowing the vehicle to be tracked in the event of theft.

The system algorithm begins with the initialization of the GSM and GPS module, followed by a continuous check for received SMS messages. Upon detection of an SMS, it reads the sender's number and message text carefully, checks the authority of the sender, and obtains GPS information when the message contains the keyword "LOCATION" as a substring. If Theft Mode is enabled, the system keeps a continuous check on the ignition status and sends periodic GPS updates whenever the ignition is switched on. The system also has error handling to handle connectivity problems and unauthorized access by applying message filtering

6. IMPLEMENTED CIRCUIT

The Circuit used is a chain of modules, which comprises an Arduino Uno, a SIM800L GSM module, a GPS module, an LCD display, and some push buttons, all firmly mounted on a prototyping breadboard. This is meant to monitor and send the vehicle location data efficiently and show real-time data on the LCD display.

The heart of the system is the Arduino Uno, a processor that receives input from the GPS module, processes the coordinates efficiently, and forwards them to the GSM module to be transmitted. It is connected to the LCD display, giving the user important updates on the status of the system. The Arduino is powered by a 9V DC power

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adapter and receives a constant power supply, enabling it to run uninterruptedly.

The GPS module is also essential, running continuously to capture the car's real-time actual latitude and longitude coordinates. In the photo provided, the module, which has an external ceramic antenna, receives signals from multiple satellites so that it can calculate accurate location data. The data is then communicated to the Arduino through serial communication to be processed.

For distant communication, the system uses a SIM800L GSM module, which sends location details as an SMS to a registered number. With a power supply in the form of a 12V adapter, the module provides stable operation. In addition, the external antenna included with the GSM module provides improved network reception, thus enabling sure communication.

A 16x2 LCD has been integrated in the circuit very well, and it is a real-time user interface. In the given figure, the LCD shows the message "Mode: USER" and "Ignition: OFF," which means the system is in user mode and the ignition of the vehicle is also off. The LCD display is used for system feedback, including tracking updates, mode, and operation status.

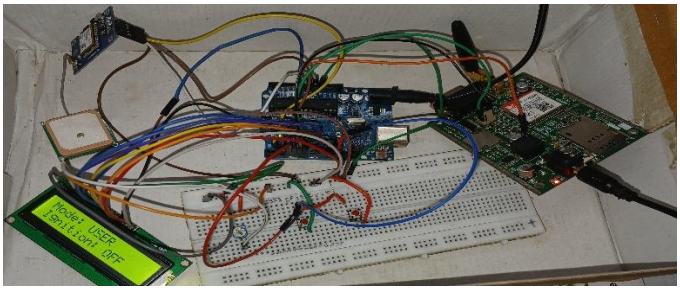

Fig. 8: Implemented Circuit (Prototype)

The design incorporates various push buttons to allow users to interact with the system comfortably. The buttons are used for mode selection, manual location requests, and system reset. The tactile switches provide a simple and effective means of user control.

The power supply has been made to ensure smooth running of all the components. The Arduino Uno is supplied with power from a 9V DC power supply adapter, and the SIM800L GSM module is supplied with power from a 12V adapter. To provide a steady supply of 4.2V to the GSM module and to prevent any type of damage due to voltage fluctuations, a voltage regulator is used. This ensures the system can run for long hours continuously without requiring frequent recharging.

This circuit, once successfully put in place, effectively combines GPS and GSM technology with Arduino to create an affordable and effective vehicle tracking system. It enables real-time location tracking, allows user interaction, and accommodates remote communication, making it highly applicable for use in vehicle security and fleet management.

6.1 Alerts and Location received on SMS

The location and theft notification of the vehicle is done by tracking via SMS. The user instructs us to get the location by sending a command like "LOCATION." The GPS coordinates are fetched from the GPS module by the system and are sent through the SIM800L GSM module. A Google Maps link is appended in the message so that the user can easily locate the vehicle by clicking on the link once.

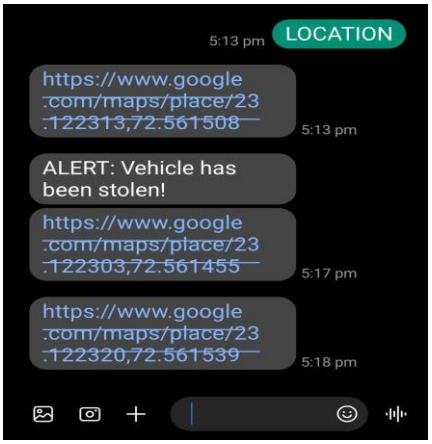

Fig. 9: Location received on SMS

The messages indicate that the system sends a lot of location updates over a period, indicating where the car is located. This provides constant monitoring, and the owner is able to view the location of the car at a moment's notice.

The system is also equipped with an anti-theft feature, which detects any unauthorized motion or ignition of the vehicle. The system automatically sends an ALERT message to the enrolled phone number once it detects any potential theft, indicating that the vehicle may have been stolen. The notification comes with a link to Google Maps, providing the vehicle's last known position. This security feature is paramount when it comes to security and vehicle recovery during a theft.

Fig. 10: Location on Google Maps

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With the use of GPS tracking, GSM communication, and real-time alerts, this system is extremely suitable for car security and fleet management. The automatic alerts ensure that the owner is immediately notified of any misuse, so they can act immediately.

7. RESULT

The system was also tested under various scenarios to verify how efficient it is and how dependable it is. The findings revealed that the system provides accurate GPS tracking and can generate Google Maps links with precise coordinates. The SMS response was rapid, with location requests being processed in 5-10 seconds. In Theft Mode, the system provided continuous GPS updates to the emergency contact when the ignition was started, so the car could be in real-time during theft. Furthermore, the system was power-efficient and operated efficiently on a 9V battery for extended periods. For further testing of the system, various environmental scenarios were simulated, such as urban and rural, and it provided consistent performance.

8. ADVANTAGES AND APPLICATIONS

The system has several benefits. It can track places in real-time with live GPS updates. You can access it remotely through SMS, so you don't need the internet. It safeguards against theft by updating places continuously in Theft Mode. The system is also cost-effective and efficient since it uses low-cost components and simple hardware and software that are simple to install. It can be used for other purposes apart from safeguarding personal cars. It can be used to track company cars, track individuals such as children or the elderly to ensure their safety, and safeguard valuable goods during transit.

9. FUTURE ENHANCEMENTS

The existing system is robust for vehicle tracking and theft detection, but there are a few improvements that can be made. These are integrating it with the internet for real-time tracking, incorporating a mobile app for convenience on smartphones, implementing alerts to notify users if the vehicle moves beyond a specific region, and incorporating a feature to remotely shut down the engine in case of theft. Machine learning can be used to identify suspicious movements of vehicles.

10. CONCLUSION

This paper presents a low-cost and trustworthy vehicle tracking system based on Arduino, GPS, and GSM technologies. It provides real-time tracking, theft alert, and secure entry for authorized personnel. The combination of IoT, geofencing, and mobile applications can greatly enhance security and real-time monitoring.

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