IOT based Autonomous Location Surveillance System Using PNT Services

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Abstract:

The entire set of interconnected devices as well as the technology enabling communication between the devices and the cloud. This article presents an innovative Internet of Things (IOT)based autonomous location monitoring system that is made possible by Positioning, Navigation, and Timing (PNT) services. The system allows for real-time tracking and surveillance of objects or persons by combining Internet of Things sensors and communication modules with PNT technologies like GPS, Galileo, or GLONASS. The technology uses advanced machine learning techniques and algorithms to automatically identify and evaluate anomalies in the monitored area. It then swiftly reports these findings to the relevant authorities.PNT services are seamlessly linked to ensure accurate and reliable location, even in challenging Environment. In addition to being adaptable, scalable, and compatible with existing infrastructure, the Technology has a wide range of applications, including border security, asset protection, and perimeter monitoring. This work advances the possibilities of autonomous surveillance systems. In depth features provided by the research include mobile number identification (subject to legal and regulatory constraints), real-time location visualization, and centralized vehicle data management for enhanced fleet management, security, and operational effectiveness The development of sophisticated solutions that make use of precision navigation and timing (PNT) and the internet of things (IOT) has been spurred by the growing need for effective location based surveillance systems. Edge computing units, a central control unit and a monitoring and control user interface are important parts of the system. Data is processed locally with edge computing, which lowers latency and improves response times. to create a self-contained location monitoring system using precise PNT services and IOT technology.

Keywords: IOT, Real-Time Tracking, Vehicle Management, Python Flask, Mobile Number Tracking, Data Fetching

1. Introduction:

The increasing quantity of automobiles on the road demands strong and effective management systems.[4] Fleet managers gain important insights into vehicle position through real-time vehicle tracking, which facilitates better route planning, quicker reaction times, and increased security [5]. To meet these important objectives, this research suggests a web-based system that combines Python Flask, IOT, and a database. Using positioning, navigation, and timing (PNT) services, an IOT-based autonomous location surveillance system is intended to track and monitor an asset's or object's geographic location in real-time. This system provides precise and trustworthy location data for a range of applications, including fleet management, asset tracking, and security. It does this by combining IOT device sensors with PNT technology.

Python is a pretty interesting language with an abundance of libraries. One of the modules with many features is phone numbers; it can validate phone numbers and provide basic information about them.. With Flask Libraries, developers can quickly and simply create lightweight web apps using the Flask web framework[13]. Leader of the International Group of Python Enthusiasts (POCCO), Armin Ronacher, created it. Its foundation is essentially the Jinja2 templating engine and the WSGI tools.It offers a simple method for launching a web application with all the capabilities required to get going. In essence, data fetching is the process of obtaining data and providing it to the application from the database [8]. One of the main aspects influencing an application's performance is optimizing its fetching mechanism. Pandas is an open-source software library designed for the Python programming language that is used for data analysis and processing [9It provides a range of data structures and methods for working with time series and numerical tables. It can read, filter, reorganize, and export datasets in a variety of formats, such as Excel, JSON, and CSV, for both small and large datasets. After reading an excel file with some fictitious data using the pandas read excel() function, we convert the excel file to CSV using the CSV() function[8]. The index row at the beginning is absent from the final CSV file if the index is supplied as a false option. To check if the values from the excel file were transferred into the CSV file, we next transformed the CSV to a data frame.

Through the use of a microcontroller, the Global Positioning System (GPS) and the Global System Mobile Communication (GSM) technologies are combined to create the position tracking system. It is employed to find a tracking device-attached object's GPS location, such as a car. The suggested method effectively utilized a widely used technology that pairs an Arduino UNO with a smartphone[11]. GPS is a satellite-based navigation system that offers precise data and location. An update is sent and received from the object position to a database via the GSM module. A GPS receiver receives data in the National Marine Electronics Association (NMEA) protocol form from many satellites[6].The main hardware used in this work is a GPS receiver and an Arduino Uno training board. The hardware description language utilized to design the little digital circuit is simple C programming language. Initially, the Arduino programmable microcontroller board is updated with the sketch. Subsequently, the Arduino UNO receives a GPS receiver tracking the satellite data [13].

2. Related work:

The study clarifies how important it is for a vision-based highway intersection monitoring and management system to extract important traffic flow information from video situations. because it makes dynamic intelligent transportation systems (ITS) possible, which is crucial for smart cities.The process of re-identifying detected objects and linking them to the peers that match the best over a series of frames is known as vehicle tracking. Bounding box (Bbox) information, pixel, shape, and color information are frequently utilized to track identified objects and retrieve their trajectories. While tracking methods based on pixels, shapes, and colors are thought to be reliable for tracking objects across a series of frames, their slowness makes them insufficient for real-time video analysis applications.. However, because they only analyze the coordinate information of the detected objects, methods like the Kalman or Particle Filter tracking algorithms—which use bounding box information—process data slightly faster than pixel, shape, or color-based approaches. Furthermore, due to problems like partial or complete object occlusion, illusions, camera shaking, extremely high or low-quality pictures, and different weather conditions like wind, rain, and snow that complicate vehicle detection, tracking, and data association processes, vehicle detection and tracking have been difficult tasks of classical computer vision and image processing research. In some cases, these problems even cause such systems to fail completely. These factors make a strong and real-time tracking algorithm essential to powerful and efficient video analysis tools.[1]

The goal of the intended model is to follow a car using an Arduino Mega. Several modules, such as SIM 808[7], are used in conjunction with the model, as are inexpensive IOT websites like thinger.io and the Blynk android app. The Pi is far more expensive than the Arduino and requires an external interrupt for the program to operate, but it has many more features. An assessment of the ATMEGA328P microprocessor is the Arduino. The Arduino boards came in UNO and Nano varieties. For tracking, the ESP8266 is also taken into account. We create a low-cost tracking kit using the Arduino UNO and SIM 808. To manage our own IOT devices, we can register an account and generate a token on the android-based services Code Bender, Blynk, and Frame IOT. The Arduino is thought to be controlled by the Blynk Android, which also configures the Arduino to transmit speed, latitude, longitude, and attitude. Through Android Mobile's Graphics User Interface (GUI), the user may see the device's location. Even in developed nations these days, automobile theft is on the rise. It is necessary to create a cost-effective GPS tracker that is intelligent, dependable, and efficient. The current system includes SMS-based car tracking, false alarms, inaccurate GPS location, and no GUI interface.[2]

A study conducted by Jahangir Azimjonov The vehicle type and location within camera frames are determined by the vehicle detection scheme. HVD-net is a single-stage detector that predicts class labels and multiple targeted vehicles by taking advantage of a CNN. In the future, infrared cameras—which are less problematic in low light—will be employed as an alternative to create an effective vision-based system for estimating nighttime speed. These days, losing one's phone has become a big issue. Since we store a lot of important data on our phones, this application will provide additional security in the event that a phone disappears. The system's operation is actually quite straightforward: in order to prevent user distraction, our program will operate in the background while on standby and monitoring commands received via SMSBy utilizing these commands, the user can lock his phone, set an alarm, retrieve his phone data, erase his phone data, and discover where his phone was last seen. This program also has the capability to lock the phone when the SIM card is changed and to alert the owner to the new number linked to the phone. When the phone's latitude and longitude are requested by the system, it uses GPS to ascertain the device's location before secretly transmitting the data to the user. [3]

The sensors were easily integrated into our architecture through quick development and testing utilizing a MATLAB/Simulink environment. A quadrotor vehicle is used to carry out the performance of our plan. Future developments might focus on improving the precision of real-time tracking and integrating machine learning to make better predictions. The scientific community regularly discusses the useful advantages of unmanned aerial vehicles (UAVs), and it is reasonable to argue that the topic is now taken for granted in the academic community. Despite this status quo, UAVs continue to yield technological advances and theoretical advancements that leverage their use at an exponential rate. This is largely because these vehicles are so versatile and have applications in almost every engineering domain, from delivery services to precision agriculture. Accurate vehicle plants and complete status input are typically unachievable in real-world UAV controller designs. As a result, precise disturbance estimates and consistently dependable linear velocity information are required, particularly in situations where the dynamic model is unknown in whole or in part (see, for example, Abdessameud and Tayebi, 2010,Doetal.,2003). there are several uses for these observers and their modifications; see, for example, Chen et al., 2016, Xu et al., 2020, and the cite d works therein.. Additionally, the neural network (NN) paradigm has become very popular lately (Bisheban & Lee, 2021).[4]

To increase tracking control accuracy on ramps, a tridimensional trajectory tracking control strategy is suggested for fully autonomous vehicles. Controlled is a predicted trajectory tracking model. Future developments in trajectory tracking algorithms may lead to the creation of more resilient autonomous vehicles with enhanced capacity to follow intended pathsSince the globe is a three-dimensional sphere, roadways are not always level and straight in the real world (Zhang et al., 2019). The hypotenuse is always greater than either right-angle side, as per the Pythagorean Theorem. Higher speed is necessary to counteract the increase in driving distance brought on by the road slope for the trajectory tracking control with needs between time and the

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corresponding vehicle position. As a result, those two-dimensional tracking methods are inappropriate for such control demands. The current two-dimensional trajectory tracking control does not account for the slope of the road and so does not describe variations in the vertical vehicle speed. The issue of the vehicle not arriving at the destination within the allotted time arises when a self-driving car obeys the two-dimensional demand speed. The trajectory tracking inaccuracies on ramps will increase in size in this scenario. Furthermore, the vertical knowledge of roadways in space is especially crucial for trajectory tracking control of the entire self-driving car in traffic scenarios including urban overpasses, suburban curving mountain routes, and mining areas. To enhance autonomous navigation in difficult terrain, a model predictive path planning technique has been researched (Shin, Kwak, & Kwak, 2021). Tridimensional level research has been done on multi-level fusion networks for vehicle recognition based on image and point clouds (Zhao et al., 2022). [5]

3. Methodology:

Using Positioning, Navigation, and Timing (PNT) services, an IOT-based autonomous location surveillance system aims to achieve a number of goals, including precise location tracking, real-time monitoring, security and safety, geo-fencing, customization, and redundancy. Permit accurate and ongoing tracking of items or people in different settings. creating an intuitive user interface that would enable operators to effectively view and interact with the surveillance data. creating a system that can autonomously decide what to monitor and how much of it, using criteria that have already been established and data that has been gathered.

GPS facilitates your journey from point A to point B.Three distinct parts, referred to as segments, combine to make GPS and deliv er location data.

The three segments of GPS are:

- **Space (Satellites) —** The satellites circling the Earth, transmitting signals to users on geographical position and time of day.
- **Ground control —** The Control Segment is made up of Earth-based monitor stations, master control stations and ground antenna. Control activities include tracking and operating the satellites in space and monitoring transmissions. There are monitoring stations on almost every continent in the world, including North and South America, Africa, Europe, Asia and Australia.
- **User equipment —** GPS receivers and transmitters including items like watches, Smartphone and telemetric devices.

A broad range of features are available in the system to improve fleet management operations. a user friendly map interface allows users to examine the current location of their cars in real time, which helps with dispatch optimization, route monitoring, and emergency response times.Mobile Number Tracking API Integration: Based on a vehicle's location data, the system may be able to identify the registered mobile number linked to it by integrating with a mobile number tracking API, subject to legal and regulatory limitations.. Tracking authorized people and security issues can both benefit from this feature. The central database contains detailed vehicle information that users can view and control. This contains registration information, maintenance logs, and other pertinent information that is essential to fleet management. The system has features that allow historical location data to be shown. Users can use this to analyze vehicle movement patterns, spot any inefficiencies, and increase operational efficiency by optimizing routes..

The implementation details can be given by:

- **IOT Device Selection:** It is essential to select a GPS-enabled IOT device that has low power consumption, secure data transmission methods, and dependable connectivity. You can use open-source platforms like Raspberry Pi and Arduino to create unique solutions.
- **Python Flask Web Application:** The web application can be constructed on a lightweight and adaptable base thanks to the Python Flask framework. To facilitate real-time communication between the client-side application and the server, libraries such as Flask-Socket IO can be utilized.
- **Data Fetching:** A sample CSV file database including the name of the vehicle's owner, contact information, the vehicle's city, email address, and its number. In Python programming, the CSV library can be utilized to obtain data from a CSV file.
- **Map Integration:** To display car positions on a map interface that is easy to use, web mapping APIs such as Google Maps or Folium Maps can be incorporated.

The system offers a comprehensive suite of functionalities to enhance fleet management operations:

- **Real-Time Location Tracking**
- **Mobile Number Identification**
- **Vehicle Data Management**
- **Data Visualization**

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3.1 Real-Time Location Tracking:

A user-friendly map interface allows users to examine the current location of their cars in real time, which helps with dispatch optimization, route monitoring, and emergency response times.

3.2 Mobile Number Identification:

By integrating with a mobile number tracking API (subject to legal and regulatory considerations), the system can potentially identify the registered mobile number associated with a vehicle based on its location data. This functionality can be valuable for security purposes and authorized personnel tracking.

3.3 Vehicle Data Management:

The central database contains detailed vehicle information that users can view and control.This contains registrat ion information, maintenance logs, and other pertinent information that is essential to fleet management.

3.4 Data Visualization:

This enables users to examine the movements of vehicles, spot possible inefficiencies, and enhance routes for better operational effectiveness.

For example:

- **Logistics and Transportation:** Real-time tracking improves delivery efficiency and fleet management.
- **Rental Car Companies:** Track rental vehicles, ensure timely return.
- **Public Transportation:** Real-time bus or taxi tracking for passenger experience and route planning.
- **Construction and Mining:** Monitor heavy machinery movement and optimize operations.
- **Emergency Services**: Track emergency response vehicles and optimize dispatch.

The system architecture is designed to integrate various technologies for the purpose of collecting, processing, and visualizing geospatial data. **Figure 3.1** illustrates the workflow, which is described in detail below.

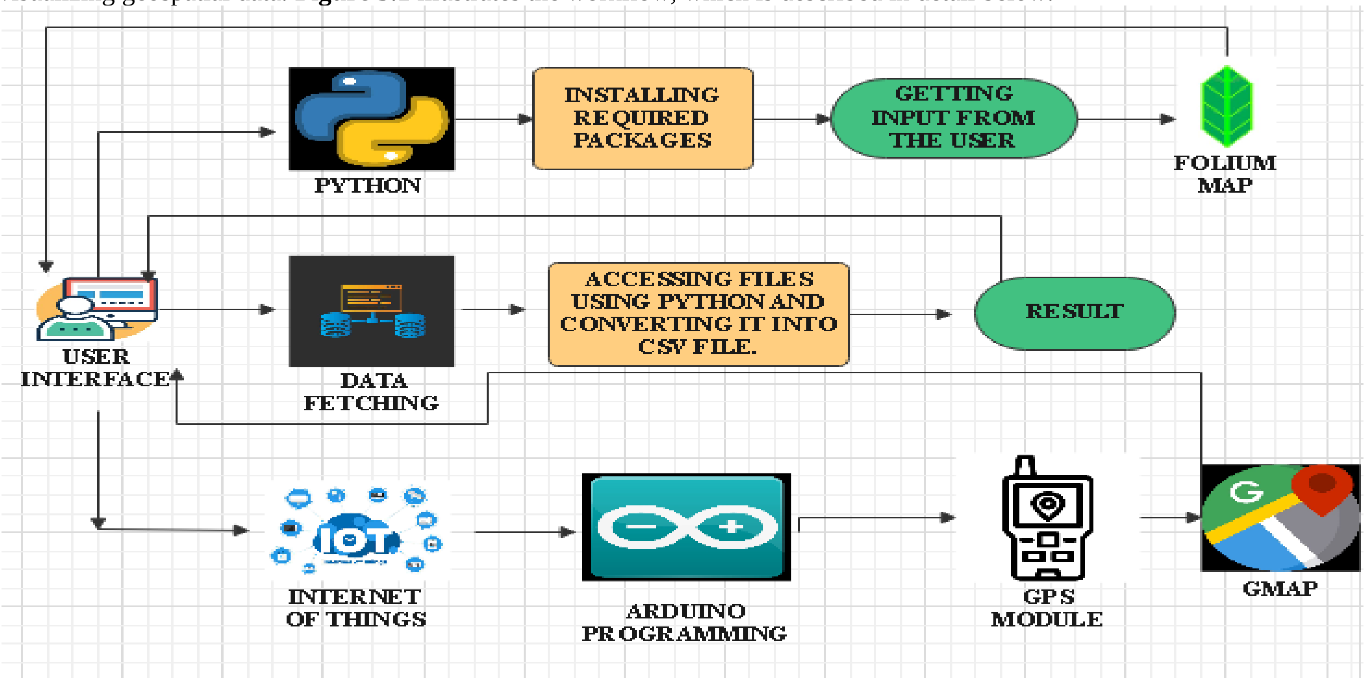


Figure 3.1 The working model of system which integrates several technologies and services culminating in the visualization of geospatial data

3.5.1 User Interface:

- The user interface (UI) is the point of human-computer interaction and communication in a device.
- It is also the way through which a user interacts with an application or a website.

- It comprises of three options:
  1. Phone number tracking
  2. Data fetching
  3. Internet of things

3.5.2 Phone number tracking:

Using Python to find the location of a phone number. We will be building a Python application that can be track the position of any phone number in the world utilizing libraries for Python such as folium, phonenumbers, and open cage. Using the phone numbers library, we will go over the fundamentals of formatting and processing phone numbers. next discuss geolocation and how Open Cage can be used to determine a phone number's latitude and longitude. We'll also use Folium to plot the phone number's location on a map. We also want to add personalized markers and pop-ups to our map.

3.5.3 Data fetching:

Comma-separated values, or CSV files for short, are files with the.csv suffix that have a collection of CSV values that are used to store data. When using Python, reading a.csv file can be done in two popular ways. Using the CSV library for the first example, and the Pandas library for the second. Here, we're importing the CSV library so that we can read the CSV file using the. reader method it contains. We use r for read, but since r is assumed by default, you can skip this step. Next, we go through each row one more.

3.5.4 Internet of things:

Vehicle tracking systems are widely used in fleet management and asset tracking applications. These days, these systems can track a vehicle's location, report on its speed, and even offer remote control. Latitude and longitude, or GPS coordinates, are commonly used in car tracking to determine the vehicle's location. The GPS coordinates of a place represent its worth.GPS coordinates, or longitude, are a very useful tool. The GPS coordinates of a place represent its worth. When utilized outside, the device is incredibly effective. In order to advance GPS technology, we are using Arduino in this project to create a GSM and GPS-based car tracking system. This GPS and GSM automobile tracking system can also be used to track a vehicle with a few easy hardware and software changes. Among many other uses, it can be employed as a tracking system for soldiers and as an alert system for accident detection. The kind of vehicle monitoring system project is frequently used to track stolen vehicles, school buses, college buses, and taxis.

- **IOT Devices:** GPS-enabled IOT devices installed on vehicles continuously collect location data. These devices communicate wirelessly using cellular networks or low-power wide-area networks (LPWAN) protocols like LORAWAN.
- **Web Application:** Developed using Python Flask, the web application serves as the user interface. It receives location data from the python module in real-time by the API key, processes it, and displays it on a map for comprehensive visualization.
- **Database:** A sample database stores critical vehicle information, including registration details, model specifications, and owner information. This database is accessed in python module by extraction and the data is further accessed.

4.Results and evaluation:

In order to obtain location data from mobile devices for phone tracking in Python, third-party libraries and APIs are usually needed. Here's a broad rundown of how to create a Python phone tracker: Acquire API keys: In most cases, you will need to get API credentials from a third-party source, like Google or Apple, in order to get location data from mobile devices. To authenticate your requests for location data, these keys are necessary. Modules for working with phone numbers are available in a phone numbers library. It is employed for parsing, formatting, and validating phone numbers according to regional and national norms and regulations. Additionally, the library features a geocoder module that, depending on the nation of origin of the phone number, can yield information about its geographic location.

Classes to read and write tabular data in CSV format are implemented by the csv module. Without being aware of the specifics of the CSV format that Excel uses, programmers can state things like, "write this data in the format preferred by Excel," or "read data from this file which was generated by Excel." Additionally, programmers can build their own special-purpose CSV formats or describe the CSV formats that are understood by other applications.

An ATmega328P-based microcontroller board is the Arduino UNO. It features a 16 MHz ceramic resonator, 6 analog inputs, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything needed to support the microcontroller; all you need to do is power it with a battery or an AC-to-DC adapter or connect it to a computer via a USB cable to get going. The Global Positioning System, or GPS, is a satellite-based global navigation system that synchronizes time, location, and velocity. GPS is widely used. GPS systems are present in watches, smartphones, and automobiles.

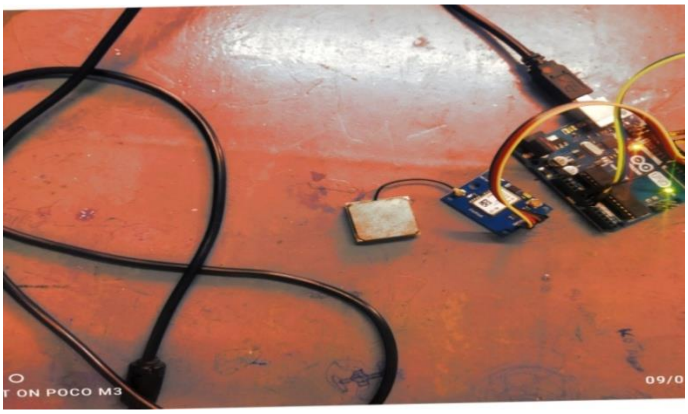
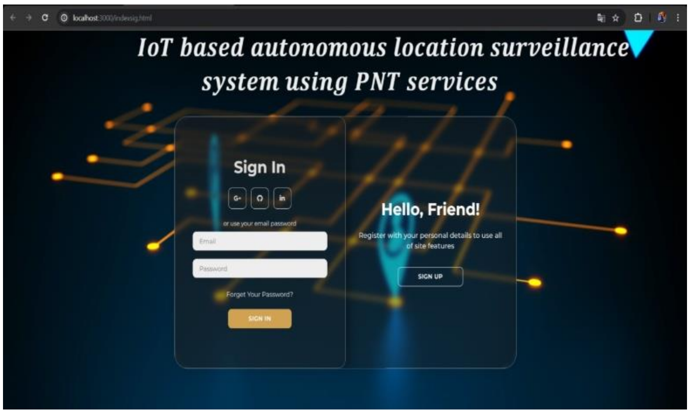


Figure 4.1 Representation of networks



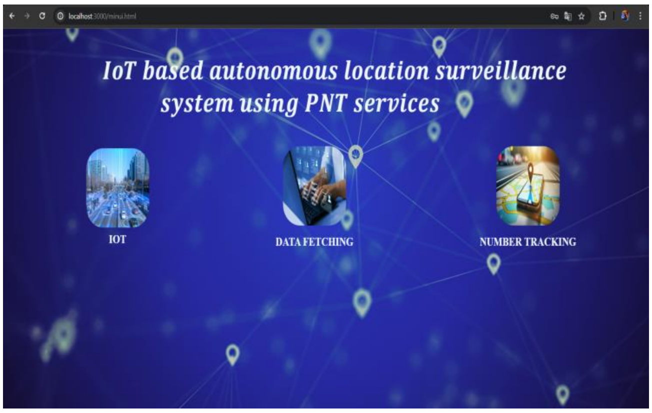
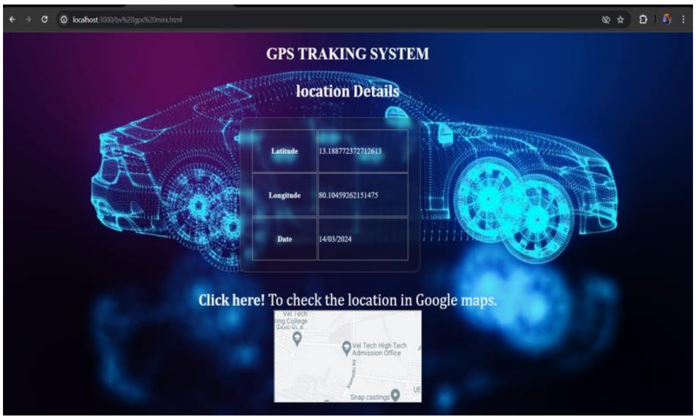


Figure 4.2 Login page **Figure 4.3 Website's user interface**



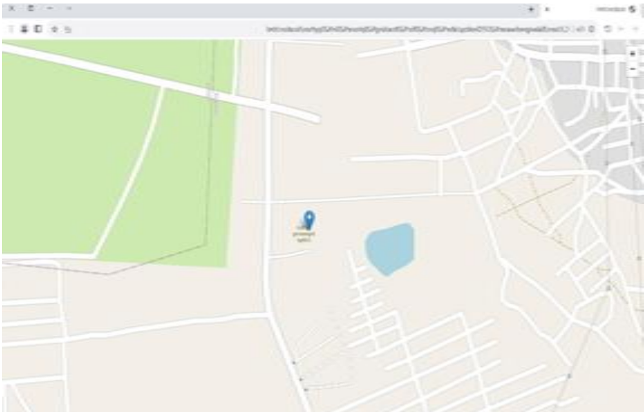


Figure 4.3 IOT GPS tracking

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Figure 4.4 Data-fetching output.

Figure 4.5 Number tracking

Test cases	Latitude	Longitude
Test 1	**13.15603557452315**	**80.09573120571713**
Test 2	**12.832982410126471**	**79.68361836924814**
Test 3	**13.08341692208108**	**80.02778234041978**
Test 4	**13.139591495216862**	**79.89594641153238**
Test 5	**13.116186982217949**	**79.84788122912552**
Test 6	**13.21246552267248**	**80.00992955838295**
Test 7	**13.0258915974021**	**80.22347630296919**

Table 4.1 The reading for several test cases

5. Future scopes :

Use geofencing features to create virtual boundaries around specific places, such as work sites and restricted zones. When a car enters or leaves one of these geofences, the system can sound an alert, increasing security and keeping track of compliance. Real-time fuel usage monitoring can be achieved by integrating gasoline level sensors with the system. Utilizing this data will enable you to plan maintenance on time, optimize routes for fuel efficiency, and spot possible fuel theft. Think about including features for driver behavior monitoring. The system may be able to identify abrupt acceleration, braking, or cornering by evaluating data from sensors such as accelerometers and gyroscopes. This might provide valuable information on driving patterns and encourage cautious vehicle operation.

Use secure communication methods to transfer data between IOT devices, the web application, and the database, such as HTTPS and TLS/SSL. This prevents illegal access to or interception of private vehicle data. Use role-based access control, multi-factor authentication, and passwords to enforce strong user authentication and authorization procedures. This guarantees that sensitive vehicle data and system functionality are only accessible to authorized persons. When transmitting and storing critical vehicle data, think about encrypting it. This creates an extra security layer to guard against possible data intrusions. It is imperative that you stress the importance of adhering strictly to the applicable legal and regulatory frameworks that control mobile number tracking in your particular area. Before putting this functionality into use, make sure you have the required authorizations and user consent.

As the number of automobiles and data volume increase, the system may require a scalable database solution. Consider options such as cloud-based databases or database sharing to handle future growth in the volume of data that needs to be processed and stored. To ensure flawless real-time performance, think about employing message queuing systems, like Apache Kafka, to buffer and regulate the flow of location data received from IOT devices. This can assist control spikes in the amount of data and enable fast processing for real-time viewing. Make a web application interface that is easy to use and intuitive. Utilize clear visualizations, user-friendly dashboards, and interactive maps to manage and explore data effectively. Give users the option to personalize their experience. This could involve customizing geofence alerts, modifying data visualization settings, or establishing map preferences in order to develop a mobile application that will provide customers access real-time vehicle tracking and management capabilities while they're on the road.

As a result, fleet managers might experience more convenience and flexibility.
Accurate data is increased when new and improved technologies are used. By using the appropriate and updated concepts, cost tracking gadgets can be made more user-friendly. implementing power-saving techniques on sensor nodes to ensure long-term, uninterrupted operation without requiring frequent battery replacements. granting users additional security while maintaining the privacy of all data. making certain that there are no problems or disputes on the back end. By including these additional components and accounting for the previously mentioned advantages, you can create a real-time vehicle tracking and management system that is safe, packed with features, and adaptable enough to handle the shifting needs of fleet management operations.You may build a reliable, safe, and feature-rich real-time vehicle tracking and management system that meets the changing demands of fleet management operations by including these extra details and taking the aforementioned improvements into account.

6. Conclusion:

The article describes a new real-time car tracking and management system that utilizes Python Flask, a central database, and the Internet of Things. To enhance fleet management, security, and operational efficiency, the system provides centralized vehicle data management, real-time position display, and mobile number identification (per rule). Examining sophisticated data analytics features and including extra features like fuel level monitoring and driving behavior analysis are examples of possible research directions. Conventional techniques and approaches used in the live vehicle tracking system.

To provide real-time locations, historical data, and alarms. To minimize drawbacks, the proposed solutions ought to make advantage of state-of-the-art GPS technologies. Businesses will be able to better manage their assets and save operating costs as real-time vehicle tracking technology develop. When utilized appropriately, the ability to trace someone's whereabouts via their phone number is a helpful capability. It's simple to use, but before tracking someone's whereabouts, be sure you respect their privacy and have the required authorization. Never forget that maintaining safety should always come before invading someone's personal space.

The different ways that Python can handle CSV files, including the fundamental method of reading CSV files. Python CSV file reading and writing is a fundamental ability for every data scientist or analyst. It can increase productivity, save time, and streamline data processing. Accurate and timely data is provided by the system's working design. The location tracking was accurate the entire test. During the test, an acceptable average time delay of less than a minute was determined. With this architecture, GPS and GSM modules have shown to be incredibly effective for constructing a car tracker. It is determined that the construction of a vehicle tracker system that makes use of an Arduino, GPS, and GSM module can save time and money while also making fuel management easier, preventing thefts, and improving driver performance.

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