INTEL UNNATI INDUSTRIAL TRAINING PROGRAM 2024 PROJECT REPORT ON

“GPS TOLL BASED SYSTEM SIMULATION”

Submitted by

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PROBLEM STATEMENT

Title: GPS Toll based System simulation using Python

The project aims to develop a Python-based simulation of a GPS toll collection system for a 100 km by 100 km area. This system seeks to address inefficiencies in traditional toll methods by simulating vehicle movements along predefined routes, implementing dynamic pricing based on congestion and time, and automating toll calculations and collections. The simulation will include features such as real-time vehicle tracking, toll zone definitions, parallel non-toll road options, speed limit monitoring, and support for multiple payment vendors. It will also incorporate an app for users to query toll costs and potential time savings.

The overall goal is to create a more efficient, accurate, and user-friendly toll management solution that reduces congestion, lowers operational costs, and enhances the driving experience. This project aims to provide a flexible platform for testing and optimizing toll collection strategies in a simulated environment, ensuring robustness and scalability in managing future urban transportation challenges.

ABSTRACT

The advancement in Global Positioning System (GPS) technology has enabled innovative approaches to toll collection, offering significant improvements over traditional toll systems. This project presents a simulation of a GPS Toll-based System using Python, aimed at demonstrating the efficiency, accuracy, and convenience of GPS-based toll collection.

The simulation encompasses several key components: vehicle movement simulation, toll zone definition, distance calculation, toll charge computation, and payment simulation. Utilizing Python libraries such as SimPy for event-driven simulation, Geopandas and Shapely for geospatial analysis, Geopy for distance calculations, and Pandas for data management, the project effectively models vehicle interactions within a toll system. Visualization of vehicle movements and toll zones is achieved using Matplotlib and Folium.

Chapter 1

INTRODUCTION

The "GPS Toll-based System Simulation using Python" project aims to create a comprehensive simulation framework for managing toll collection using GPS data. This system involves several key components: simulating vehicle movement along predefined routes with GPS coordinates, defining toll zones with specific GPS points, calculating the distance traveled by vehicles within these zones, computing toll charges based on the distance traveled or zones crossed, and simulating the payment process by deducting toll charges from user accounts. The simulation utilizes various Python libraries and frameworks, including SimPy for event-driven simulation, geopandas and shapely for geospatial analysis, geopy for distance calculations, pandas for data management, and matplotlib and folium for visualization.

In this project, the simulation workflow begins with setting up the environment by defining the road network and toll zones using geospatial coordinates and initializing vehicles with their starting locations and destinations. SimPy is then used to simulate vehicle movements along the network, updating GPS coordinates over time. The system detects toll zone crossings using shapely and geopandas, and calculates toll charges based on predefined rates. The simulation also includes a payment process where toll charges are deducted from simulated user accounts, followed by generating reports on vehicle movements, toll collections, and system performance.

The project addresses challenges such as ensuring accuracy in simulating realistic vehicle movements and detecting toll zone crossings, optimizing performance to handle large numbers of vehicles and transactions, and integrating various components seamlessly. This simulation framework provides a basic structure for a GPS-based toll collection system and can be expanded to include more complex scenarios and additional features, such as dynamic pricing based on congestion levels.

Chapter 2

OBJECTIVES

The primary goal is to create a simulation that accurately models a GPS-based toll collection system. This involves simulating vehicle movements along predefined routes with GPS coordinates, defining toll zones or points, calculating distances traveled within these zones, and computing toll charges accordingly. The simulation should also include a payment system to deduct toll charges from user accounts. Key objectives include developing a realistic vehicle movement simulation, implementing accurate geospatial analysis for toll zone detection, calculating distances and tolls precisely, and managing data related to vehicles, transactions, and user accounts. The project aims to tackle challenges such as ensuring accuracy in vehicle movement and toll zone crossing detection, optimizing performance for large-scale simulations, and integrating various components seamlessly. Additionally, the simulation should incorporate features like dynamic pricing based on congestion levels, support for multiple payment vendors, emergency contingencies, and an app interface for user queries. The ultimate objective is to create a comprehensive, scalable, and innovative simulation that demonstrates the benefits of GPS-based toll calculation, such as real-time accuracy, convenience, reduced congestion, increased transparency, and improved customer experience.

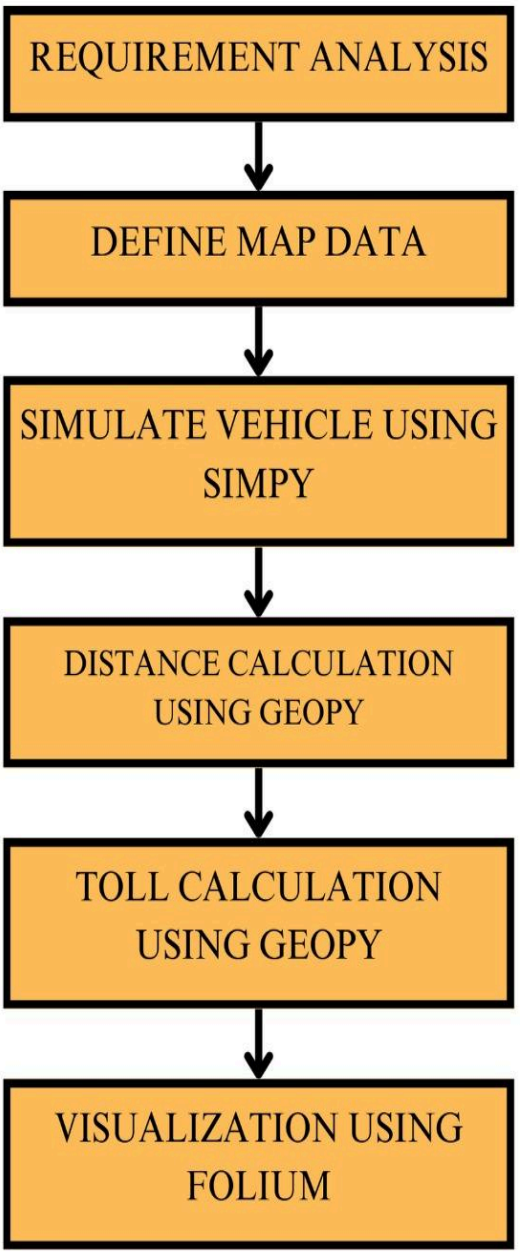
Chapter 3

LITERATURE REVIEW

Sr No.	Name of the Paper	Year of Publication	Description	Name of Authors
1	GPS-based highway toll collection system: Novel design and operation	2017	Developed from electronic components, the system traces vehicles and collects toll fees at predefined points. It also includes 3G internet and GPS connectivity detection.	Pin Jern Ker
2	Automated Toll Collection System Using GPS and GPRS	2018	Method debits vehicle owners' accounts via GPRS SIM, sends acknowledgments, eliminates traffic jams, ensures accurate computerized tolls, and allows uniform fares nationwide.	Sudheer Kumar Nagothu

Chapter 4

BLOCK DIAGRAM

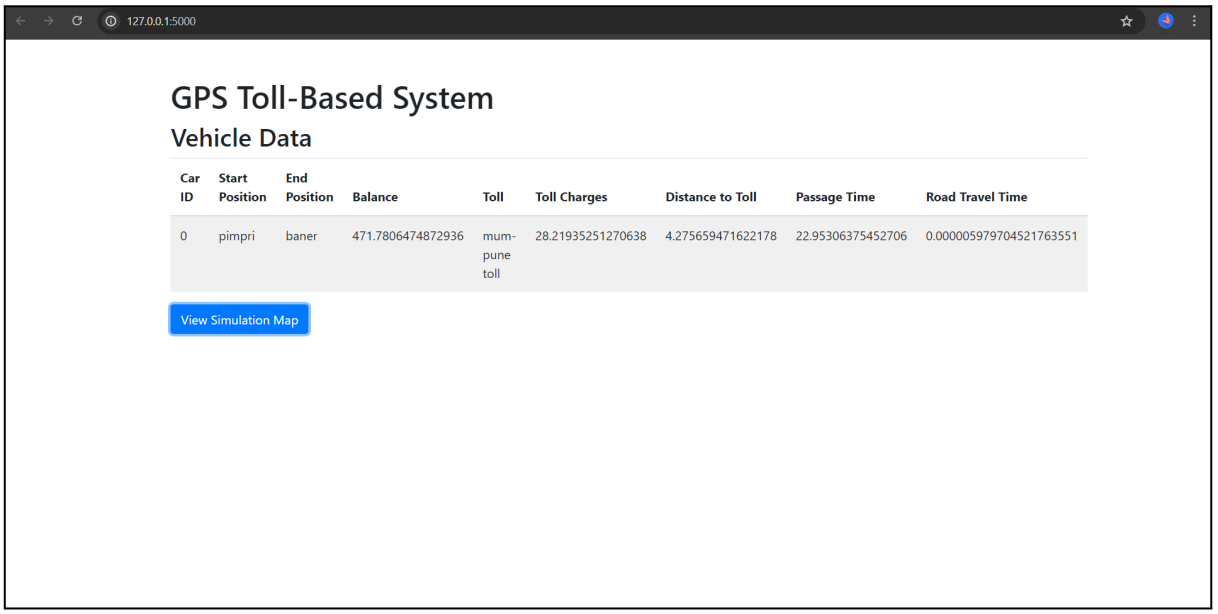


Chapter 5

RESULT AND ITS WORKING

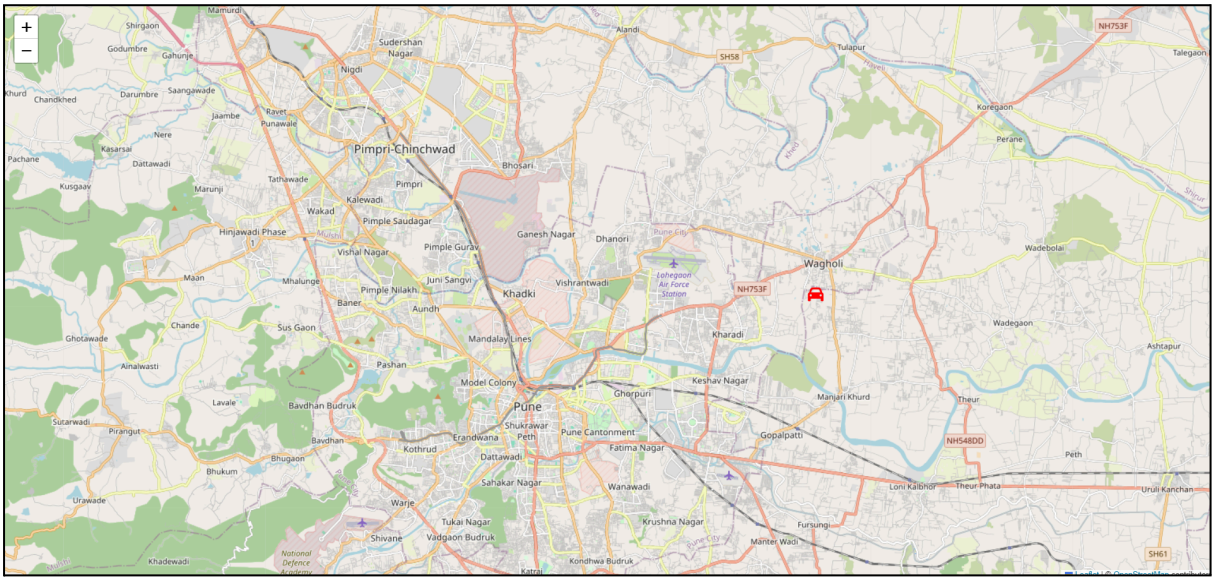
Our Frontend Page:

The front page of the project is described in the tabular form. The table consists of Car ID, the place which it starts its journey and ends its journey, also displays which toll zones it goes through while reaching the destination ,charges that are paid at the toll zones , time interval needed to reach the destination place.



The Visualization page:

The visualization page describes the map of the range 100 X 100km. In the given map places that fall in this region are mentioned and also the toll zones. This project tracks the vehicles .It also tracks which routes it is travelling in and which toll zones it has crossed.



Chapter 6

CONCLUSION

The project successfully demonstrates the potential of GPS-based toll collection systems through a comprehensive simulation developed using Python. By simulating vehicle movements, toll zone crossings, and the associated toll calculations, the project highlights the significant advantages of GPS-based toll systems over traditional methods.

In conclusion, the GPS Toll-based System simulation project effectively showcases the benefits of using GPS technology for toll collection.The methodology and results presented in this report offer a foundation for future research and development in GPS-based tolling systems, contributing to the advancement of smart transportation technologies.

Chapter 7

REFERENCES

Sr no.	Reference Link	Description
1.	https://youtu.be/clP6W7W79MM?si=O6aouvRt7sQC3Qjq	We learned to create routes in geojson.
2.	https://youtu.be/NyNq3uLfsG0?si=KU0-Q70MkgMco3T2	We learned to create routes and toll zones in geojson.io.
3.	https://youtu.be/0osGrraoCX0?si=p2hd_0fHByULRu1g	Using this we understood the use of simpy.
4.	https://www.geeksforgeeks.org/python-getting-started-with-sympy-module/	We learned how to use simpy.
5.	https://youtube.com/playlist?list=PL-2EBeDYMIbRppDpfO5osdSeUFIOuZz-2&feature=shared	We learned to use geopy , geopandas and folium correctly.
6.	https://github.com/python-visualization/folium	We took some knowledge about visualization using folium.

FUTURE SCOPE

1. Integration with Real-time Traffic Data:

   Integrate APIs that provide live traffic updates to simulate more realistic vehicle movements and congestion patterns. This will improve the accuracy of toll calculations and enable dynamic toll pricing based on current traffic conditions.

2. Advanced Visualization Tools:

   Develop more sophisticated visualization tools using libraries like D3.js or Plotly to provide interactive maps and dashboards. These tools can help in analyzing vehicle movements, toll zone effectiveness, and overall system performance.

3. User Feedback and Adaptation:

   Develop a module where users can provide feedback on their toll road experiences. Use this feedback to adapt and improve the toll system, ensuring it meets user needs and preferences.

4. Security and Privacy Enhancements:

   Implement advanced encryption techniques and privacy-preserving algorithms to protect user data. Ensure compliance with data protection regulations and address potential vulnerabilities in the system.

5.Global Adaptation and Localization:

   Adapt the system for use in different countries and regions.Modify the toll calculation algorithms to comply with local tolling regulations and standards. Localize the user interface and support multiple languages to make the system globally applicable.

6. Eco-friendly Tolling Solutions:

Develop toll discount schemes for eco-friendly vehicles or for drivers who follow certain eco-friendly driving practices. This can encourage the use of electric vehicles and reduce the carbon footprint of road transportation.

7. Mobile Application Development:

Create a mobile app that allows users to view their toll history, manage their accounts, receive real-time notifications about toll charges, and plan their routes considering toll costs and traffic conditions. This will improve user convenience and engagement.

ACKNOWLEDGEMENT

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