A PROJECT REPORT

ON

GPS TOLL BASED SYSTEM SIMULATION

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ABSTRACT

GPS-based toll collection systems have gained significant popularity in recent years due to their ability to provide seamless and efficient payment processing for highway and bridge tolls. These systems leverage the power of Global Positioning System (GPS) technology to precisely track and locate vehicles, enabling tolls to be collected electronically without the need for manual transactions. GPS-based toll collection systems have the benefit of high level of accuracy, which can be further tailored to accommodate various vehicle types and toll charges. Furthermore, these systems offer flexibility and scalability, easily adapting to fluctuating traffic volumes. In this innovative system, a GPS device is installed on the vehicle, establishing communication with a central server that calculates the toll fee based on the distance travelled. The fee is then deducted from a preloaded account linked to the vehicle owner or charged to a designated credit card. By eliminating the necessity for cash exchanges, this method not only enhances convenience for drivers but also reduces traffic congestion and saves valuable time and the environmental impact associated with traditional toll collection methods. Embracing this technology holds the potential to revolutionize the way tolls are managed and improve overall transportation experiences.

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Chapter 1 INTRODUCTION

1.1 Project Summery

The GPS Toll System Simulation project aims to create a robust simulation model for a GPS-based toll collection system. Utilizing GPS technology, the system automates toll collection, reduces congestion, and enhances the efficiency of transportation networks. The project evaluates the system's performance under various traffic conditions, estimates operational costs and potential revenues, and identifies potential challenges.

1.2 Proposed System

The proposed GPS Toll System leverages GPS technology to streamline toll collection processes, enhance traffic management, and improve user convenience. This section outlines the system's design, components, and operational framework to demonstrate how it achieves these objectives.

System Design:

The GPS Toll System consists of the following main components:

- GPS-Enabled Vehicles:
  Vehicles equipped with GPS devices capable of transmitting location data to the central system.

- Central Processing Unit (CPU):
  A centralized server that processes incoming data from vehicles, calculates toll charges, and manages system operations.

- Toll Management Application:
  A software platform that interfaces with the CPU to provide real-time data visualization, user account management, and financial transactions.

- Communication Network:
  A reliable network infrastructure that ensures seamless data transfer between vehicles and the central system.

- User Interfaces:
  Mobile and web applications that allow users to manage their accounts, view toll charges, and make payments.

Operational Framework:

- Vehicle Tracking:
  GPS devices transmit real-time location data.

- Route and Toll Zone Identification:
  CPU checks if vehicles enter toll zones.

- Toll Calculation:
  Calculates toll fees based on predefined rates.

- Notification and Payment:
  Notifies vehicle owners of toll charges.

- Data Storage and Analysis:
  Stores transaction data for analysis.

System components:

- Toll Zones
  The system defines 8 toll zones with specific coordinates (latitude and longitude) and toll rates. The toll zones are represented as a dictionary, where each key is a zone identifier and the value is a list of two coordinates (latitude and longitude) that define the zone.

- Toll Rates
  The system defines toll rates for each zone, represented as a dictionary where each key is a zone identifier and the value is the toll rate.

- Vehicle Path
  The system simulates a vehicle's path as a sequence of GPS coordinates.

  Functions

  The system has two main functions:

  - `is_in_toll_zone`: checks if a vehicle is within a toll zone based on its GPS coordinates.
  - `calculate_toll`: calculates the total toll for a vehicle's path by iterating through the path and checking if each point is within a toll zone.

  Visualization
  The system includes a function `plot_toll_system` to visualize the toll zones and vehicle path using Matplotlib.

1.3 Existing System

Existing toll collection systems primarily rely on physical toll booths or RFID-based electronic toll collection (ETC) systems. These systems often lead to congestion and require significant infrastructure investment. The GPS Toll System overcomes these limitations by automating toll collection and reducing the need for physical infrastructure.

1.4 Advantages

- Efficiency: Automated toll collection reduces congestion and improves traffic flow.
- Real-Time Monitoring: Provides real-time tracking and toll collection.
- Scalability: Handles high traffic volumes and can expand to new areas.
- User Convenience: Offers seamless toll payment via mobile and web applications.
- Data Insights: Provides valuable data for traffic management and revenue optimization.

Chapter 2 SYSTEM REQUIREMENT STUDY

2.1 Feasibility Study

- Technical Feasibility:
  The system leverages existing GPS technology and communication networks, making it technically feasible.

- Economic Feasibility:
  Reduces operational costs and increases toll collection efficiency, ensuring economic viability.

- Operational Feasibility:
  Simplifies toll collection processes, making it easier to implement and manage.

2.2 Tools & Technology

- Programming Language: Python

- Libraries: `geopy` for distance calculations, `matplotlib` for visualization

- Hardware: GPS-enabled devices, central processing unit

- Software: Toll management application, communication network infrastructure

Chapter 3 IMPLEMENTATION

- **Toll Zones and Rates Definition:**

```
toll_zone = {
    "zone_1": [(37.7749, -122.4194), (37.7849, -122.4094)],
    "zone_2": [(34.0522, -118.2437), (34.0622, -118.2337)],
    # Additional zones...
}
toll_rates = {
    "zone_1": 2.5,
    "zone_2": 3.5,
    # Additional rates...
}
```

- **Toll Zone Check:**

```
def is_in_toll_zone(vehicle_location, zone_coordinates):
    (lat1, lon1), (lat2, lon2) = zone_coordinates
    return (lat1 <= vehicle_location[0] <= lat2) and (lon1 <= vehicle_location[1] <= lon2)
```

- **Toll Calculation:**

```
def calculate_toll(vehicle_path):
    total_toll = 0
    for location in vehicle_path:
        for zone, coordinates in toll_zone.items():
            if is_in_toll_zone(location, coordinates):
                total_toll += toll_rates[zone]
                break
    return total_toll
```

- **Simulation and Visualization:**

```
vehicle_path = [
    (22.562627, 88.363044),
    (12.977063, 77.587106),
    # Additional coordinates...
]
total_toll = calculate_toll(vehicle_path)
print(f"Total toll for the vehicle's path: ${total_toll:.2f}")

def plot_toll_system(vehicle_path):
    fig, ax = plt.subplots()
    for zone, coordinates in toll_zone.items():
        (lat1, lon1), (lat2, lon2) = coordinates
        ax.plot([lon1, lon2], [lat1, lat2], 'ro-', label=f"{zone} Toll Zone")
    lons, lats = zip(*vehicle_path)
    ax.plot(lons, lats, 'bo-', label="Vehicle Path")
    ax.set_xlabel("Longitude")
    ax.set_ylabel("Latitude")
    ax.set_title("GPS Toll System Simulation")
    ax.legend()
    plt.show()

plot_toll_system(vehicle_path)
```

Result:

The system calculates the total toll for the simulated vehicle path and visualizes the toll zones and vehicle path.

<u>Output</u>

Total toll for the vehicle's path: $17.00

```
E:\INTEL UNNATI>python gps1.py
Total toll for the vehicle's path: $17.00
```

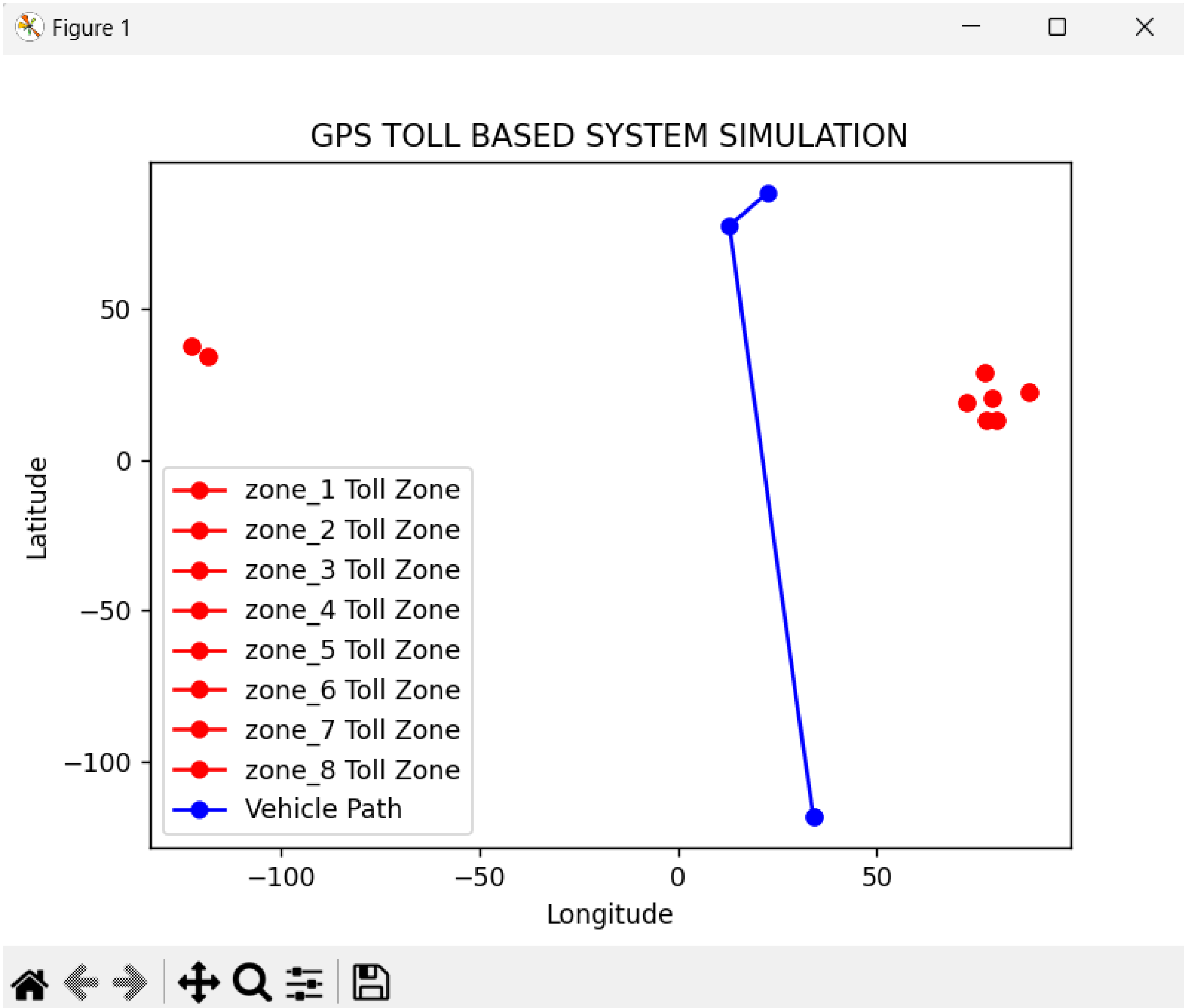
Figure 1
GPS TOLL BASED SYSTEM SIMULATION
Latitude
Longitude
50
0
−50
−100
−100
−50
0
50
zone_1 Toll Zone
zone_2 Toll Zone
zone_3 Toll Zone
zone_4 Toll Zone
zone_5 Toll Zone
zone_6 Toll Zone
zone_7 Toll Zone
zone_8 Toll Zone
Vehicle Path

Chapter 4 CONCLUSION

The GPS Toll System Simulation project demonstrates a modern approach to toll collection, utilizing GPS technology to enhance efficiency, reduce congestion, and improve user experience. The provided code forms the foundation of this system, highlighting its feasibility and benefits. By addressing potential challenges and continuously optimizing the system, the GPS Toll System has the potential to revolutionize toll management and improve transportation efficiency.

Chapter 5 FUTURE SCOPE

- **Integration with Smart Cities:**
  Incorporating the GPS toll system into smart city infrastructure to provide real-time traffic management and improve urban mobility.

- **Dynamic Pricing:**
  Implementing dynamic toll pricing based on traffic conditions, time of day, and congestion levels to optimize road usage.

- **Advanced Data Analytics:**
  Utilizing advanced data analytics and machine learning to predict traffic patterns, optimize toll rates, and enhance system performance.

- **Cross-Border Tolling:**
  Expanding the system to support cross-border tolling for international transportation routes.

- **Enhanced User Interfaces:**
  Developing more intuitive and user-friendly mobile and web applications to improve user experience.

- **Environmental Impact Assessment:**
  Analysing the environmental impact of the GPS toll system and implementing measures to reduce emissions and promote sustainable transportation.

- **Integration with Autonomous Vehicles:**
  Adapting the system to work seamlessly with autonomous vehicles, ensuring automated toll collection without human intervention.

These future developments will further enhance the efficiency, scalability, and user experience of the GPS Toll System, making it a vital component of modern transportation networks.