Green University of Bangladesh

Department of Computer Science and Engineering (CSE)
Semester: (Fall, Year: 2024), B.Sc. in CSE (Day)

Advanced AI-driven Vehicle Tracking System for Efficient Customer Services using Machine Learning, and IoT Integration

Course Title: Integrated Design Project I
Course Code: CSE 324
Section: 213 D7

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1 Introduction

Fleet management and transportation logistics have become increasingly complex, demanding more efficient, real-time solutions to meet the growing needs of businesses. Traditional vehicle tracking systems often fall short in their ability to process vast amounts of data, offer predictive insights, and seamlessly integrate emerging technologies like Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) [1] [2]. These limitations result in common industry challenges such as unexpected vehicle breakdowns, inefficient fuel usage, suboptimal routing, and difficulty in monitoring driver compliance with safety standards [3]. The cumulative effect of these issues leads to operational inefficiencies, increased costs, delivery delays, and reduced transparency in fleet operations.

To address these challenges, this project proposes the “Advanced AI-driven Vehicle Tracking System for Efficient Customer Services using Machine Learning, and IoT Integration” (AVTS). AVTS is an innovative, AI-driven platform designed to go beyond conventional tracking by integrating real-time analytics, predictive maintenance [4], optimized routing, and comprehensive driver behavior monitoring [5]. By leveraging cutting-edge AI and ML algorithms, AVTS aims to predict maintenance needs, minimize vehicle downtime, and provide dynamic route optimization, all while ensuring real-time monitoring of fleet operations. The system’s IoT integration will allow seamless data collection from vehicles, enabling actionable insights for fleet managers [6].

Ultimately, AVTS is designed to enhance decision-making capabilities, reduce operational costs, improve safety, and ensure customer satisfaction by offering a scalable and intelligent vehicle tracking solution that meets the evolving demands of modern fleet management.

2 Literature Review

Significant research has focused on recent advancements in vehicle tracking systems, particularly the integration of AI, Machine Learning (ML), and the Internet of Things (IoT). These studies highlight the need for improved efficiency, predictive analytics, and real-time monitoring in fleet management systems, which align closely with the goals of the Advanced AI-driven Vehicle Tracking System (AVTS). The following are key studies that form the foundation of this project.

- Maximize Fleet Value and Safety with AI: Real-Time Vehicle Tracking, Telematics, and Compliance Solutions by Venkata Praveen Kumar Kaluvakuri et al. (2024): examines how AI enhances fleet management by improving real-time vehicle tracking, telematics, and compliance. The study highlights AI’s role in optimizing routes, predicting maintenance needs, and ensuring legal compliance, resulting in greater efficiency and cost reduction. While the benefits are clear, the paper notes challenges such as data quality and financial constraints for smaller companies. Case studies from UPS, DHL, and the City of Los Angeles demonstrate significant improvements in fuel efficiency, route optimization, and maintenance costs through AI integration.

- Predictive Maintenance of Bus Fleet by Intelligent Smart Electronic Board Implementing Artificial Intelligence by Massaro et al. (2020): This study focuses on the development of a smart electronic control unit (ECU) integrated with IoT and Artificial Intelligence (AI) for predictive maintenance in bus fleets. The system extracts vehicle data using OBD-II and SAE J1939 standards, which is processed using a Multilayer Perceptron Artificial Neural Network (MLP-ANN) for predictive maintenance. The driver behavior is classified using a k-means algorithm based on the data collected. The predictive system accurately identified vehicle wear and maintenance needs with a low mean square error (MSE) of $10^{-}3$, ensuring timely maintenance scheduling. Additionally, it monitored driver behavior, identifying patterns that contribute to vehicle stress. The study demonstrates that the AI-based system can enhance fleet efficiency by optimizing maintenance schedules and driver behavior, though scalability to larger fleets and diverse vehicle types remains a challenge.

- Real-time GPS Tracking System for IoT-Enabled Connected Vehicles by Moumen et al. (2023): The study presents a real-time GPS tracking solution for connected vehicles, leveraging Internet of Things (IoT), Vehicle-to-Everything (V2X) communication, and Vehicular Ad Hoc Networks (VANET). The system employs Arduino Uno R3, SIM800L GSM, and Neo6M GPS modules, alongside a web interface powered by Node.js, Firebase, and WebSocket connections for real-time data transmission and visualization. The system facilitates dynamic routing, energy-efficient driving, and smart charging station integration, contributing to reduced fuel consumption and fleet emissions. It also supports intelligent traffic management by enhancing data exchange between vehicles and infrastructure. The solution demonstrates robust performance for vehicle tracking, resource management, and promoting energy efficiency across connected vehicle networks. However, the study highlights challenges in system scalability and security, which require further research.

- Cloud-Based Vehicle Tracking System" by Mustafa et al (2019): This study presents a real-time vehicle tracking system using cloud computing for improved scalability, flexibility, and cost-efficiency. The system integrates GPS, GPRS, and an Arduino UNO microcontroller to transmit vehicle location data to a remote server, using reduced data transmission by limiting updates to every 10 seconds when the vehicle is moving. The system incorporates data encryption to enhance security, faking the vehicle's ID and coordinates to prevent unauthorized access. By sending only essential data (vehicle ID and GPS coordinates), the system minimizes data size, reducing both transmission costs and power consumption. Testing showed an average data transmission rate of 1.65 HTTP requests per minute, a significant improvement compared to conventional systems. The cloud-based vehicle tracking system successfully reduces operational costs while providing real-time monitoring and security. However, further research is needed to address scalability challenges in larger fleet applications.

These studies highlight the potential of AI, ML, and IoT in transforming the vehicle tracking domain, providing key insights that will be incorporated into the proposed solution.

3 Methodology

The proposed vehicle tracking system will integrate GPS, AI, and IoT technologies to provide real-time data monitoring and predictive analytics. The system will consist of four main components:

3.1 Data Collection (Phase 1)

Sensors (GPS, IoT-based) will be installed in vehicles to collect real-time data such as location, speed, fuel consumption, engine status, and driver behavior. Data will be sent to a cloud-based platform for storage and processing.

3.2 AI/ML Model Development (Phase 2)

Collected data will be processed using AI and ML algorithms to predict maintenance requirements, optimize routes, and analyze driving behavior. Techniques such as regression models, clustering, and deep learning will be applied to enable real-time decision-making.

3.3 User Interface & Dashboard (Phase 3)

A web-based dashboard will be developed to visualize data in real-time for fleet managers. The system will also offer features like geofencing, route suggestions, live alerts, and fleet status reports. Fleet managers will be able to access vehicle occupancy rates, fuel consumption trends, and other insights through this user-friendly platform.

3.4 IoT Integration & Cloud Platform (Phase 4)

IoT devices will communicate with the cloud to ensure real-time data processing and high scalability. Cloud computing will also enable data backup, analysis, and seamless integration with other business tools (e.g., ERP systems).

4 Feasibility Study

The feasibility of the proposed system will be analyzed in three phases:

4.1 Technical Feasibility

The project will utilize existing GPS technologies, machine learning models, IoT devices, and cloud platforms like AWS or Azure for scalability and data processing. The AI models will be implemented using popular frameworks such as TensorFlow or PyTorch. Real-time data processing will be handled through serverless computing platforms like AWS Lambda to ensure cost-effectiveness.

4.2 Operational Feasibility

The system will offer real-time data visualization, predictive maintenance alerts, and optimized route planning, leading to a significant reduction in fleet operation costs. Fleet managers will be able to monitor the system through a web-based dashboard accessible on any device. AI-driven automation will reduce the need for manual fleet management, allowing for more efficient use of human resources.

4.3 Economic Feasibility

By reducing vehicle downtime through predictive maintenance, optimizing fuel usage, and improving route efficiency, the system will provide significant cost savings to fleet operators. Initial investments in hardware (sensors, GPS, IoT devices) and cloud infrastructure will be offset by long-term savings and improved operational efficiency. The project is expected to deliver a return on investment (ROI) within 2-3 years due to the cost reductions in fuel, repairs, and overall fleet management.

5 Conclusion

The proposed AI-driven vehicle tracking system will revolutionize fleet management by leveraging emerging technologies such as AI, machine learning, IoT, and cloud computing. The system will offer real-time tracking, predictive maintenance, route optimization, and driver behavior analysis, significantly enhancing operational efficiency while reducing costs. As businesses and transportation services face increasing demands, this system will provide a scalable, reliable solution to meet their growing needs. The project will be a step forward in modernizing vehicle tracking, leading to safer, more efficient, and cost-effective fleet management practices.

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