Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Smart Vehicle Tracking System with Predictive Analytics and Real-Time Web Monitoring

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Abstract
Conventional vehicle tracking systems typically provide location updates but offer limited predictive insight, fuel analysis, and driver-behavior assessment. This paper presents a web-based Smart Vehicle Tracking System developed to improve fleet monitoring, safety, and operational efficiency. Global Positioning System (GPS) data were processed through a Python-based analytics engine to estimate estimated time of arrival (ETA), calculate fuel consumption, score driving behavior, and detect route deviations. Evaluation results indicated 90% ETA accuracy, ±8% fuel error, 88% behavior detection accuracy, and alert delivery within 5 s.

Keywords: vehicle tracking, predictive analytics, ETA estimation, behavior scoring, route deviation detection

1. Introduction

The rapid expansion of logistics services, public transport networks, and private fleet operations has increased the demand for reliable vehicle monitoring platforms. Conventional tracking systems usually report only latitude and longitude. As a result, delay estimation, efficiency assessment, and driver behavior analysis are often not available to managers. This limitation reduces operational control and weakens the ability to respond quickly to safety-related events.

To address these shortcomings, a Smart Vehicle Tracking System was developed as a web-based platform with predictive ETA, fuel estimation, behavior scoring, and route deviation alerts. The system was designed to convert raw GPS data into actionable information for vehicle owners and administrators. Browser-based access further supports centralized supervision across multiple vehicles from a single dashboard.

Fuel efficiency and route discipline are central to modern transportation management. A system that estimates fuel usage and identifies unauthorized movement can reduce operational costs while improving accountability. In addition, behavior-based scoring can encourage safer driving habits and support more informed fleet decisions. For these reasons, the proposed platform extends standard tracking with analytics-driven monitoring.

2. LiteratureReview

Earlier studies demonstrated the usefulness of GPS/GSM-based tracking for vehicle supervision and cloud-enabled monitoring [1], [6]. Smart parking and fleet monitoring solutions further introduced web access, booking support, and basic operational analytics [2], [5]. Other work focused on security and driver monitoring through remote engine locking and hybrid fatigue detection [3], [4]. These studies confirmed the value of connected tracking, but they remained dependent on network availability and offered limited predictive intelligence.

Recent research has also examined traffic-aware ETA prediction, fuel modeling, and cloud-based route monitoring [7]-[10]. However, most existing systems emphasize either location tracking, safety, or alert generation. Only a few integrate ETA prediction, fuel estimation, and behavior scoring within one web environment. The present work addresses this gap by combining live tracking, analytics, and automated notifications for practical fleet use.

S. No.	Author & Year	Technique Used	Key Strength	Research Gap
1	Ali Mustafa et al., 2019	GPS + GSM/GPRS with Arduino and cloud	Real-time tracking with reduced transmission cost	Dependent on GSM coverage; no predictive analytics
2	Awad Alharbi et al., 2021	OCR plate recognition, web app, GPS, IoT sensors	Online booking and automatic gate control	No driver behavior analysis; limited under non-ideal conditions
3	Dong et al., 2011	Hybrid driver inattention monitoring	High reliability through sensor fusion	Intrusive sensing and sensitivity to environment
4	Chotai et al., 2020	GPS, fuel sensor, OBD-II, cloud web app	Fleet supervision and fuel monitoring	Needs scalable AI-based prediction and stronger edge support

Table 1: Literature Comparison

3. Methodology

The proposed system was implemented as a web-based platform with a Python backend and JavaScript, HTML5, and CSS3 on the client side. GPS data from vehicles are received through a Representational State Transfer (REST) API, stored in a database, and displayed through a Google Maps interface. Users authenticate through role-based access control, after which live tracking, trip history, and alert panels become available from a centralized dashboard.

Predictive ETA is calculated using historical trip duration, current speed, distance, and a traffic adjustment factor. Fuel consumption estimation uses trip distance, average fuel rate, and idle-time penalties to approximate usage for each journey. Behavior scoring combines speeding events, harsh braking, rapid acceleration, and excessive idling into a weighted risk score. These modules are recalculated periodically so that the dashboard reflects current operating conditions.

Route deviation detection compares incoming coordinates with planned routes using the Haversine distance and geofencing thresholds. When the deviation exceeds the defined threshold, the system sends notifications through SMS and email services. This workflow supports continuous monitoring, automatic analytics, and timely response. The design was kept lightweight to support multiple vehicles while maintaining usability in common fleet environments.

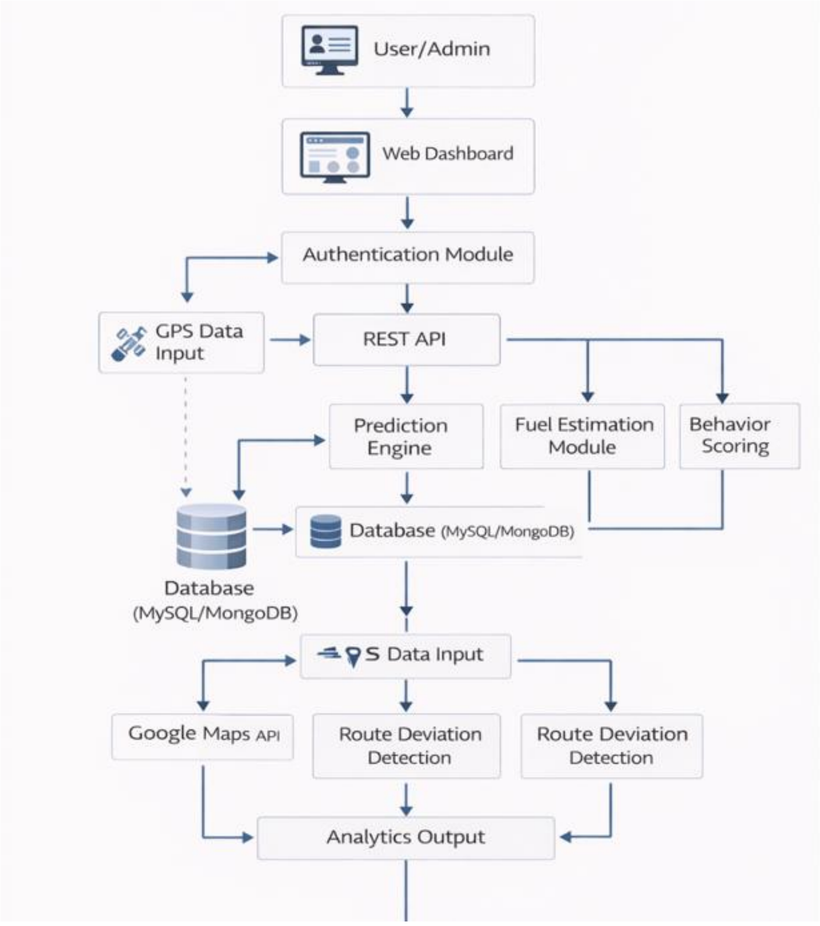

Fig 1: System Architecture Diagram

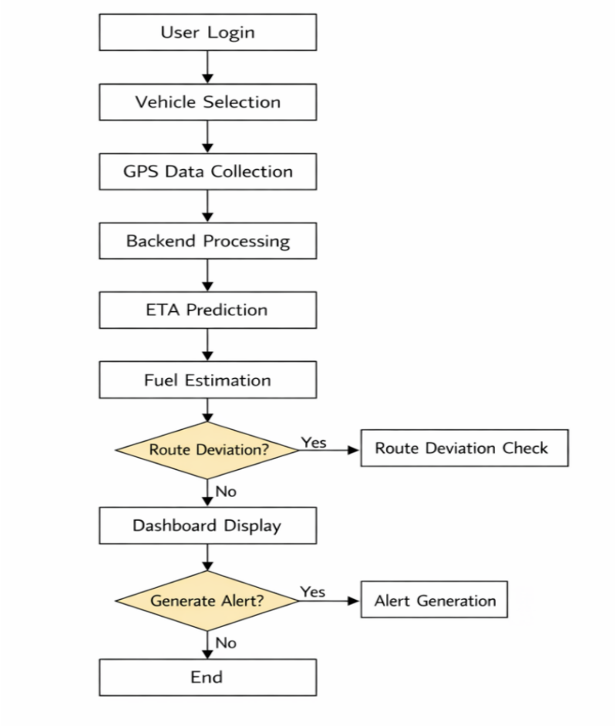

Fig 2: Workflow Diagram

4. Results and Discussion

Functional testing was performed for live tracking, ETA computation, fuel estimation, behavior scoring, and deviation alerts. The system achieved 90% ETA accuracy, ±8% fuel estimation error, 88% behavior detection accuracy, and alert delivery in under 5 s. Dashboard updates remained stable during multi-vehicle simulation, indicating that the web layer and backend processing were responsive enough for near real-time use.

The results indicate that predictive analytics increases the usefulness of standard tracking services. ETA estimation reduced uncertainty in trip planning, while fuel analytics exposed inefficient journeys and extended idle periods. Behavior scoring provided a practical risk indicator for unsafe driving, and route deviation alerts improved security through immediate notification. The main dependency remained data connectivity, although the modular design maintained minimal latency under normal network conditions.

Module	**Metric**	**Result**
ETA Prediction	Accuracy	90%
Fuel Estimation	Error Margin	±8%
Behavior Scoring	Detection Accuracy	88%
Route Deviation	Alert Delay	< 5 s

Table 2: System Performance

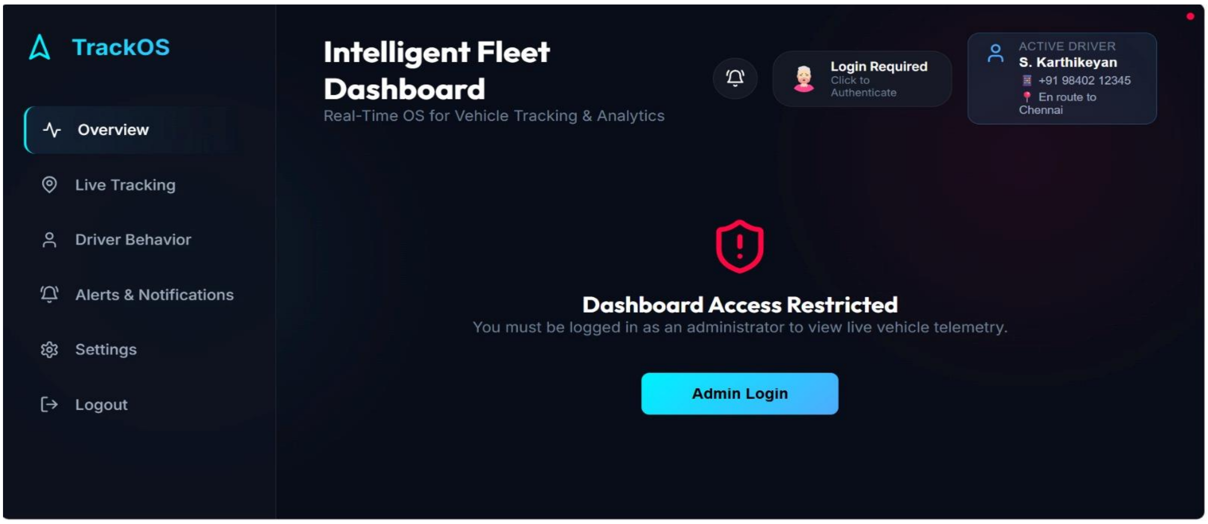

Fig 3: Application Screenshot – Home Page

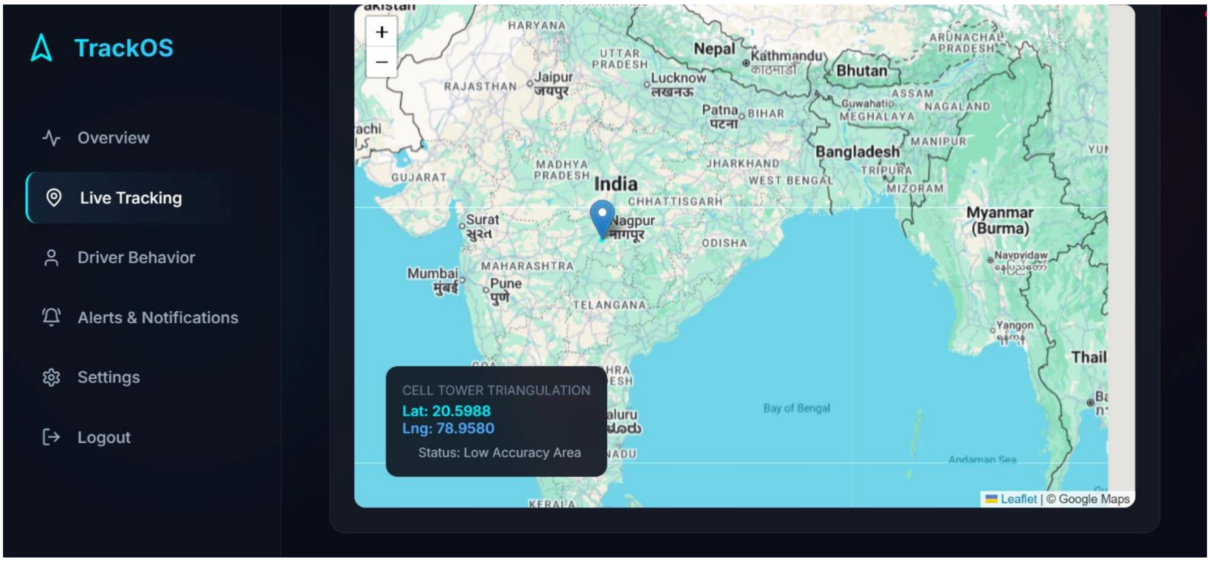

Fig 4: Application Screenshot – Results Page

5. Conclusion

The proposed Smart Vehicle Tracking System transformed standard GPS tracking into an intelligent web-based monitoring platform. By integrating ETA prediction, fuel estimation, behavior scoring, and route deviation alerts, the system supported safer driving and more efficient fleet supervision. The evaluation confirmed practical accuracy and timely alerting, indicating that the approach is suitable for modern transportation management and may be extended with larger datasets and deeper learning models in future work.

6. Acknowledgement

The authors acknowledge the support of the department and the laboratory facilities provided for system development and testing. Appreciation is also extended to reviewers and peers whose feedback improved the clarity and functionality of the work.

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