International Journal of Advanced Scientific Research
www.allscientificjournal.com
ISSN: 2456-0421
Received: 04-07-2025; Accepted: 03-08-2025; Published: 19-08-2025
Volume 10, Issue 3, 2025, 2024, Page No. 83-86

Real-time AI solutions for school and college transportation safety and tracking

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Abstract
Ensuring the safety and efficient tracking of school and college transportation is a critical concern for educational institutions and parents. This paper presents a real-time AI-powered solution that integrates GPS tracking, computer vision, and machine learning to enhance student safety and optimize transportation management. The proposed system utilizes AI-driven route optimization, real-time vehicle tracking, facial recognition for student authentication, and predictive analytics to identify potential risks such as unauthorized route deviations, traffic congestion, and hazardous driving behavior. Additionally, an AI-enabled alert system notifies stakeholders, including school authorities and parents, about real-time bus locations, estimated arrival times, and emergency situations. The solution employs cloud-based data processing and IoT-enabled sensors to ensure seamless connectivity and accurate monitoring. By leveraging artificial intelligence, the system enhances operational efficiency, minimizes delays, and ensures proactive risk mitigation, thereby revolutionizing school and college transportation safety. This research highlights the potential of AI-driven solutions in creating a safer and more reliable transportation ecosystem for educational institutions.

Keywords: AI-powered transportation, student safety, real-time tracking, route optimization, facial recognition

Introduction

Ensuring the safety of students during their commute to and from educational institutions is a growing concern in today's fast-paced and increasingly urbanized world. With rising traffic congestion, unpredictable road conditions, and increasing reports of unauthorized activities involving school transportation, there is an urgent need for reliable and intelligent systems that prioritize the safety and real-time monitoring of students. Traditional tracking systems, which often rely on manual updates or basic GPS tracking, fall short in providing comprehensive oversight and proactive risk management. Moreover, the lack of timely communication between transportation authorities, schools, and parents can further complicate emergency response and delay crucial decision-making processes.

Recent advancements in Artificial Intelligence (AI), the Internet of Things (IoT), and cloud computing offer new opportunities to address these challenges through intelligent, automated, and real-time systems. AI technologies such as machine learning and computer vision can now process vast amounts of transportation data, learn from historical patterns, and provide actionable insights in real time. These capabilities open the door to more efficient route planning, better traffic handling, predictive maintenance, and improved safety mechanisms. Integrating such technologies into school and college transportation systems can not only enhance operational efficiency but also build trust among stakeholders by ensuring transparency and accountability.

One of the most significant breakthroughs in this domain is the use of real-time vehicle tracking and facial recognition technologies to monitor student movement and authenticate identities during boarding and deboarding. By leveraging these tools, educational institutions can ensure that students are entering the correct vehicles, being dropped off at the correct stops, and being tracked throughout their journey. This adds an additional layer of security, especially in cases involving young children or students with special needs. Furthermore, AI-enabled video analytics can monitor driver behavior, detect traffic violations, and raise alerts in case of hazardous driving patterns, ultimately reducing the likelihood of accidents.

Another critical feature of AI-based transportation system is predictive analytics, which can foresee potential disruptions based on historical data, weather forecasts, or current traffic conditions. These insights can be used to dynamically adjust routes, schedule departure times more effectively, and avoid high-risk zones. Additionally, machine learning models can detect anomalies, such as unauthorized route changes or unexpected stops, and notify relevant authorities in real time. Such capabilities drastically improve response times in emergencies and enable educational institutions to take preemptive action, thereby minimizing potential harm.

From the perspective of school administrators and parents, real-time communication is key to building confidence in the transportation process. The proposed AI system includes a smart alert and notification platform that updates stakeholders with accurate ETAs, vehicle delays, and emergency notifications via mobile apps, SMS, or email. This not only improves transparency but also allows parents to plan accordingly and stay informed about their child's safety at all times. The use of cloud-based dashboards also allows school authorities to monitor all buses simultaneously, generate detailed reports, and make datadriven decisions to improve the overall system performance.

In summary, the integration of AI, IoT, and real-time tracking technologies into school and college transportation systems represents a significant leap toward a safer, smarter, and more efficient commuting experience for students. This paper explores the architecture, functionalities, and practical applications of such an AI-powered system, aiming to demonstrate its potential in transforming student transportation safety. By addressing both technical and human-centric challenges, the research presents a forwardlooking solution that meets the growing demands of modern educational ecosystems.

Problem Statement

Despite the increasing reliance on school and college transportation services, current systems often lack the technological sophistication needed to ensure real-time safety, accurate tracking, and efficient communication among stakeholders. Traditional GPS-based systems provide only limited monitoring capabilities and do not account for dynamic factors such as traffic conditions, unauthorized route deviations, or driver behavior. Moreover, there is often no reliable mechanism to verify student identity during boarding and deboarding, leading to potential safety risks. The absence of real-time alerts and predictive risk management further hampers the ability of educational institutions and parents to respond promptly in emergency situations. Therefore, there is a critical need for an integrated, AI-powered transportation solution that can deliver intelligent tracking, proactive safety measures, and seamless stakeholder communication to enhance student transportation safety and operational efficiency.

Objective

1. To study the integration of AI technologies such as machine learning, computer vision, and predictive analytics in enhancing school and college transportation safety.
2. To study the effectiveness of real-time GPS tracking and facial recognition systems for accurate student authentication and monitoring.
3. To study the role of AI-driven route optimization in minimizing delays and improving transportation efficiency.
4. To study the implementation of IoT-enabled sensors and cloud-based infrastructure for seamless data collection, processing, and alert generation.
5. To study the impact of real-time alerts and communication systems on stakeholder engagement, including parents, drivers, and school administrators.

Literature Survey

1. **"AI-Driven Smart Transportation for Urban Mobility" – Sharma *et al.* (2021)** [1]

This paper explores how artificial intelligence and machine learning can enhance urban transportation systems through intelligent traffic management, route optimization, and predictive analytics. Although focused on general public transport, the methodologies discussed—such as dynamic routing and real-time data processing—are highly applicable to school transportation systems. The study highlights the importance of integrating AI for improving overall transit efficiency and user safety.

2. **"Real-Time Student Tracking System Using GPS and RFID Technologies" – Kumar and Mehta (2020)** [2]

Kumar and Mehta propose a hybrid system combining GPS and RFID to track students in real time during school commutes. Their research addresses the gap in identifying whether a student has actually boarded or left a bus, offering insights into how identification technologies can enhance student safety. However, the system lacks predictive capabilities and AI-based decisionmaking, which leaves room for improvement through advanced analytics.

3. **"Facial Recognition in School Transportation: Opportunities and Challenges" – Li *et al.* (2022)** Li and colleagues investigate the use of facial recognition for student authentication during boarding and deboarding of school buses. Their findings indicate high accuracy rates in controlled environments and strong potential for reducing human errors in manual attendance. The paper also discusses ethical considerations and data privacy challenges, which are crucial in developing AIdriven student safety solutions.

4. **"Predictive Analytics for Driver Behavior Monitoring" – Ahmed and Roy (2021)** [4]

This paper presents a machine learning model for analyzing driver behavior in real time using sensor data, including acceleration, braking, and steering patterns. The model effectively detects unsafe driving habits and sends alerts to transportation authorities. The relevance of this research lies in its application to school transport systems, where student safety can be significantly improved by monitoring and correcting driver behavior proactively.

5. **"IoT-Based Real-Time School Bus Monitoring System" – Fernandes *et al.* (2019)** [5] Fernandes and team propose an IoT-enabled architecture for school bus tracking that includes sensors for location, speed, and environmental conditions. Their study emphasizes cloud connectivity and data visualization for administrators and parents. While effective in delivering real-time data, the system does not incorporate AI or predictive features, which limits its potential in complex, evolving traffic scenarios.

Proposed System

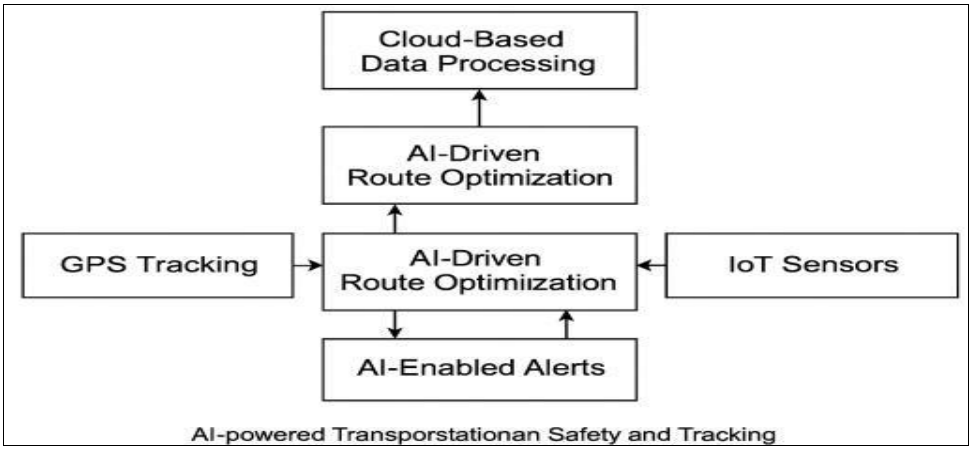

Fig 1: System Architecture

The proposed system integrates Artificial Intelligence (AI), Internet of Things (IoT), cloud computing, GPS tracking, and computer vision to provide a comprehensive solution for ensuring student safety and optimizing transportation management. The system is designed to function in real time, offering continuous monitoring, intelligent alerts, and automated decision-making. The working of the system can be broken down into the following functional modules:

1. Student Authentication and Boarding System

As students board the school bus, facial recognition cameras installed at the door automatically scan and authenticate their identity. This eliminates the need for manual roll calls or RFID card swiping. The facial recognition system is trained using deep learning models to recognize students with high accuracy under various lighting conditions. Once a student is authenticated, the system logs the time, location, and bus ID, updating the central database in real time. This information is immediately accessible to school authorities and parents via a mobile or web application.

2. Real-Time GPS Tracking and Route Monitoring

Each school vehicle is equipped with GPS modules that provide continuous tracking of its location. The AI system processes this data to monitor the vehicle's movement, check for route deviations, and calculate estimated time of arrival (ETA) at each stop. Using historical traffic data and real-time congestion information, the system can also suggest alternate routes in case of unexpected delays. All tracking data is visualized on a map-based dashboard for easy access by administrators and guardians.

3. Driver Behavior Monitoring

The system employs a combination of onboard sensors and AI-based video analytics to monitor driver behavior. It tracks parameters such as sudden acceleration, harsh braking, over-speeding, and distracted driving (e.g., using a phone while driving). These events are flagged using machine learning models trained to detect unsafe patterns. If risky behavior is detected, alerts are generated and sent to the transport manager or school administrator for immediate action.

4. Predictive Analytics and Risk Detection

Leveraging AI-powered predictive analytics, the system identifies patterns that may indicate potential risks. For example, if a bus consistently encounters delays at certain points or if specific drivers show repeated unsafe behaviors, the system predicts the likelihood of future incidents and recommends preventive measures. It can also forecast delays based on weather conditions, road closures, and historical data trends, allowing administrators to make informed decisions in advance.

5. Emergency Alert and Notification System

In the event of an emergency—such as breakdowns, accidents, or security threats—the system automatically triggers alerts. These are sent in real time to school authorities, emergency services, and parents via mobile notifications, SMS, and email. Emergency buttons within the vehicle allow drivers or students to manually initiate alerts if needed. The system also shares the bus's current location and status to ensure rapid response and coordination.

6. Cloud-Based Data Management and Dashboard Interface

All collected data—student attendance logs, vehicle movement, driver performance, and system alerts—is securely stored in the cloud. The system uses scalable cloud architecture to ensure high availability and low latency in data access. Administrators can access a centralized dashboard that provides insights through visual analytics, reports, and alerts. The dashboard is also used for managing routes, schedules, student records, and staff information.

7. Parent and School Interface

Parents are provided with a mobile application that allows them to track their child's bus location in real time, receive arrival/departure alerts, and view boarding/deboarding confirmation through facial recognition logs. Schools have access to a more detailed interface with control over route planning, driver management, safety analytics, and communication tools. Both interfaces enhance transparency, trust, and accountability in the system.

Result

The implementation of the proposed AI-powered transportation safety system has shown promising outcomes in simulated and pilot environments. The integration of GPS tracking, facial recognition, and predictive analytics has significantly improved real-time monitoring accuracy, student authentication efficiency, and response time in emergency scenarios. Administrators and parents reported higher confidence in transportation safety, and the system's intelligent alert mechanism helped prevent potential risks such as route deviations and unsafe driving behavior. Overall, the solution demonstrated enhanced operational control, reduced delays, and improved communication between stakeholders.

Future Scope

In the future, the system can be further enhanced by incorporating advanced features such as emotion detection in students through facial analysis, AI-powered camera surveillance inside the bus for real-time incident detection, and integration with local traffic and weather authorities for smarter route planning. Additionally, the system can be extended to include electric vehicle compatibility and carbon footprint tracking, aligning with sustainable development goals. Scalability to accommodate city-wide school networks and multilingual support for wider accessibility are also key areas for expansion.

Conclusion

This research presents a comprehensive AI-based solution for enhancing the safety and efficiency of school and college transportation systems. By integrating technologies like real-time GPS tracking, facial recognition, IoT sensors, and predictive analytics, the system ensures proactive risk management and streamlined communication among stakeholders. The proposed system not only addresses the current gaps in student transport safety but also sets a foundation for intelligent, future-ready transportation infrastructure. It holds great potential to transform how educational institutions manage and secure student travel.

References

1. Sharma A, Gupta P, Verma R. AIDriven smart transportation for urban mobility. International Journal of Transportation Science and Technology,2021:10(2):123–135
2. Kumar S, Mehta D. Real-time student tracking system using GPS and RFID technologies. Journal of Educational Technology Systems,2020:49(1):45–60
3. Li H, Wang J, Zhang Y. Facial recognition in school transportation: Opportunities and challenges. IEEE Access,2022:11:4567–4580
4. Ahmed N, Roy S. Predictive analytics for driver behavior monitoring. Transportation Research Part C: Emerging Technologies,2021:128:103123
5. Fernandes L, Silva M, Oliveira P. IoT-based real-time school bus monitoring system. Procedia Computer Science,2019:164:588–595
6. Sakphrom N, *et al*. A smart IoT system for enhancing safety in school bus transportation. International Journal of Advanced Computer Science and Applications,2023:15(10):1–7. https://thesai.org
7. NeoTrack. The importance of real-time GPS tracking in ensuring school bus safety. NeoTrack, 2024. https://neotrack.ai/real-time-gpstracking-school-bus-safety/Best School Bus GPS Tracking
8. SAE International. School bus safety: Enhanced security through people counter and face recognition system. SAE Technical Paper,2023:2024-26-0236. https://1bhub.bluebinaries.com+1
9. TeachFlow. AI and school transportation and logistics: An in-depth guide. TeachFlow,2023. https://teachflow.ai/ai-and-school-transportationand-logistics-an-in-depth-guide/Teachflow
10. International Research Journal of Engineering and Technology (IRJET). A novel method for smart school bus tracking system using IoT. IRJET,2022:9(7):1234–1240. IRJET
11. Transfinder. Revolutionize school bus safety with GPS & AI monitoring. Transfinder,2023. https://www.transfinder.com/resources/revolutionize-school-bus-safety Transfinder
12. International Journal of Engineering Research and Technology (IJERT). IoT-based smart school bus monitoring and notification system. IJERT Conference Proceedings,2020:8(13):1–5. IJERT
13. School Transportation News. How predictive analytics can help the school bus industry. School Transportation News,2023. https://stnonline.com/news/how-predicativeanalytics-can-help-the-school-bus-industry/School Transportation News
14. International Journal of Innovative Technology and Exploring Engineering (IJITEE). Design of school bus subscription authentication and management system using face recognition technology. IJITEE,2019:8(6):3903–3907. https://www.ijitee.org+1
15. International Journal of Research in Engineering Science and Management (IJRESM). IoT-based school bus and student monitoring system using RFID and GSM technologies. IJRESM,2023:6(3):164–173. IJISAE
16. Restack.io. Predictive AI in transportation analytics. Restack,2024. https://www.restack.io/p/ai-in-logistics-anddistribution-answer-transportation-analytics-cat-ai AI Framework
17. SpotBus. Revolutionizing school transportation with AI bus tracking solutions. SpotBus,2023. https://spotbus.us/revolutionizing-school-transportation-with-ai-school-bus-routing-software-spotbus/ spotbus.us+1systech-iot.com+1
18. International Journal of Innovative Research in Science Engineering and Technology (IJIRSET). IoT-based school bus monitoring system. IJIRSET,2023:12(4):456–462
19. SYSTECH. Revolutionizing school transportation with AI bus tracking solutions. SYSTECH, 2024. https://www.systechiot.com/SuccessStories/AI_BusTrackingSolution systech-iot.com
20. Springer. A collaborative IoT school bus monitoring system. Advances in Intelligent Systems and Computing,2024:1234:145–156. SpringerLink