Periodica Polytechnica Transportation Engineering, 52(4), pp. 372–381, 2024

TariqAmn's Innovative Road Safety Paradigm through Smart Technology

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Received: 22 April 2024, Accepted: 27 August 2024, Published online: 03 September 2024

Abstract

In response to escalating road safety challenges within Algeria, marked by rising traffic volumes and urban development, the "TariqAmn Algeria" initiative emerges as a groundbreaking approach in traffic management. This study delineates the development and deployment of this innovative system, which leverages intelligent traffic signs, LiDAR (Light Detection and Ranging, using laser light to measure distances) radar, and proactive brake control technologies, embedded within a robust traffic management framework. The system's dynamic adaptation to real-time traffic conditions and its enforcement of speed compliance are central to its design. Rigorous evaluations through SUMO (Simulation of Urban Mobility, a traffic simulation software) simulations and field tests in high-risk urban settings affirm its efficacy, demonstrating a 60% reduction in traffic incidents and a 50% reduction in speeding violations. By marrying local cultural insights with cutting-edge technology, "TariqAmn Algeria" not only enhances immediate road safety but also establishes a new paradigm in traffic management systems. The findings illuminate the significant scalability potential of the system, promising broader applications in enhancing road safety and adherence to traffic regulations across various regions, such as densely populated urban areas, high-traffic corridors, and accident-prone black spots. This initiative underscores the critical role of Intelligent Transportation Systems (ITS) in modern road safety strategies and sets a precedent for future technological advancements in the field.

Keywords

Intelligent Transportation Systems, road accidents, road safety, Intelligent Speed Adaptation (ISA), Intelligent Road Signalization, Radar LiDAR

1 Introduction

Globally, road traffic accidents are a significant public health challenge, leading to substantial mortality, injuries, and economic costs (World Health Organization, 2018). These incidents not only result in personal loss but also impose considerable societal financial burdens. In Algeria, road traffic accidents continue to be a critical concern. In 2021, there were 7186 reported accidents, leading to 2643 fatalities and 11479 injuries (Algerian National Gendarmerie, 2022). These figures highlight a severe road safety crisis and the urgent need for innovative, context-specific solutions. Traditional strategies, often static and lacking effective use of Information and Communications Technology (ICT), fail to address the dynamic nature of modern road environments.

The "TariqAmn Algeria" initiative, meaning "road safety" in Arabic, offers a promising solution to Algeria's road safety challenges. Combining advanced technology with local cultural values, it addresses the country's unique issues. Core components include intelligent traffic signs adapting to real-time conditions, advanced radar speed enforcement, and proactive LiDAR detection. These elements work together to mitigate excessive speeding, a primary cause of accidents, and promote a safer driving environment.

"TariqAmn Algeria" could redefine traffic management and accident prevention, potentially saving lives and reducing casualties on Algerian roads. It represents a significant advancement in utilizing technological innovation to tackle Algeria's road safety problems. The goals of this study are to develop and deploy the "TariqAmn Algeria" system, evaluate its effectiveness in reducing traffic incidents, and explore its scalability for broader applications.

Following the introduction, Section 2 reviews related works. Section 3 outlines the key components of "TariqAmn Algeria". Section 4 focuses on the integration of intelligent

Cite this article as: Ahmed Malek, N., Boudour, R. (2024) "TariqAmn's Innovative Road Safety Paradigm through Smart Technology", Periodica Polytechnica Transportation Engineering, 52(4), pp. 372–381. https://doi.org/10.3311/PPtr.37171

traffic systems and speed control mechanisms. Section 5 presents simulations, Section 6 discusses results, and Section 7 summarizes the work and explores future directions, emphasizing the need for engaging authorities for implementation in high-risk areas.

2 Related works

2.1 Overview of ISA systems

Intelligent Speed Adaptation (ISA) systems are vital components of Intelligent Transportation Systems (ITS), enhancing road safety by alerting drivers or automatically regulating speed to comply with limits. Studies by Carsten (2012) and Regan et al. (2006), demonstrate ISA's potential to reduce accidents and fatalities, necessitating further exploration of its capabilities.

Recent advancements in ISA research have reinforced these findings. Hazoor et al. (2024) introduced a novel ISA variant designed for visibility (V-ISA), which adjusts speed based on real-time sight conditions along curves, significantly influencing drivers' speed choices and enhancing road safety. Additionally, Tate et al. (2024) project a 40% reduction in deaths and serious injuries by 2030 with ISA, highlighting its potential in improving road safety.

The "TariqAmn Algeria" initiative seeks to capitalize on these insights by incorporating advanced ISA features into a comprehensive traffic management system. This approach is particularly relevant for Algeria, where diverse road conditions and urban development present unique challenges. By aligning ISA implementations with local driving behaviors and traffic patterns, the initiative can effectively enhance road safety and reduce traffic incidents.

2.2 Technologies behind ISA systems

ISA systems utilize diverse technologies to determine and enforce speed limits accurately:

- *GPS technology*: Employs satellite triangulation to pinpoint a vehicle's location and speed, comparing this information against onboard speed limit databases. Despite its utility, GPS faces challenges such as data inaccuracies and the need for updated databases (Ali et al., 2022; Gital et al., 2023; Roberts, 2020; Karthikeyan and Tamileniyan, 2010).
- *RFID and Radio Beacons*: Use radio waves to transfer data between a road tag and a vehicle receiver, broadcasting local speed limits. Its effectiveness is limited by the necessity of proximity between vehicles and tags, reducing its suitability for high-speed areas (Meng et al., 2021; Popova et al., 2021; Yatao et al., 2020).
- *Image recognition*: Vehicle-mounted cameras capture and analyze road images to identify speed limit signs based on their characteristics. This technology struggles with reliability in poor visibility or when signs are obscured (Gao et al., 2022; Ishikawa, 2022; Liu et al., 2022).
- *Dead reckoning*: Estimates a vehicle's position from a known starting point using data from onboard sensors like speedometers and gyroscopes. It provides an alternative in GPS-compromised areas but its accuracy diminishes over time without calibration (Brossard et al., 2020; Freydin and Or, 2022; Yu et al., 2022).

The TariqAmn Algeria initiative proposes a novel approach to speed management by addressing the limitations of these existing technologies. By integrating intelligent traffic signs with proactive brake control systems, the initiative aims to overcome the data inaccuracies of GPS, the proximity limitations of RFID, the visibility challenges of image recognition, and the calibration issues of dead reckoning. This ensures a more reliable and effective ISA system tailored to improve road safety in Algeria.

2.3 Overview of smart traffic signs

Smart traffic signs enhance road safety by offering real-time data and warnings through advanced technology integration:

- *Deep learning in Traffic Sign Recognition*: Utilizes vast visual datasets to automatically recognize and classify road signs, significantly improving detection accuracy and driver responsiveness. Despite its advancements, deep learning requires substantial computational power and ongoing database updates (Le et al., 2021; Megalingam et al., 2023; Tabernik and Skočaj, 2020; Wang, 2018).
- *Google Street View for Traffic Sign Recognition*: Leverages Google Street View imagery for training models, providing an extensive database of street-level images. While beneficial, this method faces challenges in managing large datasets and maintaining accuracy in dynamic traffic environments (Campbell et al., 2019).
- *Multi-agent systems with virtual sensors*: Features an architecture where agents, equipped with virtual sensors, simulate real-world sensor functionality. This approach is innovative but deals with complexities in coordination, communication, and scalability, and is primarily designed for foggy conditions (Outay et al., 2021).

- *Integration of Doppler Radar Technology in traffic signs*: Polish researchers have developed smart traffic signs that incorporate Doppler radar and other technologies to monitor traffic conditions and alert drivers to potential hazards. This system promises real-time hazard prevention but may encounter radio interference and reduced effectiveness under extreme weather conditions (Czyzewski and Sroczynski, 2020).

This section outlines the technologies in ISA systems and smart traffic signs, each with unique benefits and challenges. Ongoing advancement is crucial for improving road safety impact. Further research and development are necessary to fully utilize their potential in protecting road users.

3 System overview of "TariqAmn Algeria"

This research represents progress from a previous study (Ahmed Malek and Boudour, 2023), leading to the development of "TariqAmn Algeria". By integrating radar into traffic signaling and using LiDAR technology, the system enhances road safety in Algeria's high-risk areas. It addresses various road safety challenges, employing advanced technology and strategic approaches to reduce accidents. The initiative considers environmental conditions, traffic patterns, and human behavior, informed by local expertise, demonstrating a proactive approach to road safety management.

3.1 Core components of the "TariqAmn Algeria" system

3.1.1 Vehicle component

The "TariqAmn Algeria" system incorporates critical components within the vehicle to ensure responsive and safe driving. The key elements include:

- *Communication unit*: Facilitates robust two-way communication between the vehicle and intelligent road signs, ensuring that vehicles receive critical speed and safety information.
- *Decoding and processing units*: These units work in tandem to interpret incoming signals and assess the appropriate vehicle response, whether it be adjusting speed directly or providing driver alerts.
- *Limitation system*: Employs both fuel injection adjustments and braking mechanisms to control vehicle speed, with the capacity for nuanced responses based on the specific driving context.
- *Driver interface*: A dedicated display and indicator system provides immediate feedback to drivers, enhancing situational awareness and promoting safer driving practices.

Each of these components ensures that vehicles are equipped to receive and act on critical speed and safety information, thereby reducing the likelihood of accidents.

3.1.2 Infrastructure component

The infrastructure of the "TariqAmn Algeria" system integrates advanced technologies for effective road condition management. The essential components are:

- *Location and sensing technologies*: Utilize GPS and a comprehensive array of environmental sensors to gather precise location data and real-time conditions surrounding traffic, weather, and road statuses.
- *Communication and decision units*: These elements ensure the effective transmission of tailored speed recommendations to vehicles, derived from complex data analysis of the current road and environmental conditions.
- *LiDAR radar and power solutions*: The inclusion of LiDAR radar technology for speed detection is pivotal for identifying and addressing speeding violations promptly. Power sourcing from renewable energies and existing infrastructure ensures continuous operation (Srivastava et al., 2023).

These infrastructure components are crucial for monitoring and managing road conditions, enabling real-time decision-making and ensuring reliable operation with sustainable power solutions.

By integrating these vehicle and infrastructure components, the "TariqAmn Algeria" system enhances road safety through precise data collection, real-time communication, and dynamic responses. This comprehensive approach addresses both immediate and systemic factors contributing to road accidents, making it a robust solution for improving road safety in Algeria.

3.2 Operational dynamics and system architecture

The "TariqAmn Algeria" system is an advanced road safety mechanism designed to dynamically respond to environmental inputs and regulate vehicle speed in real time. Fig. 1 shows the system architecture components and communications.

The system process begins by gathering initial road information, such as road characteristics, and road number, using GPS coordinates to determine the initial speed under

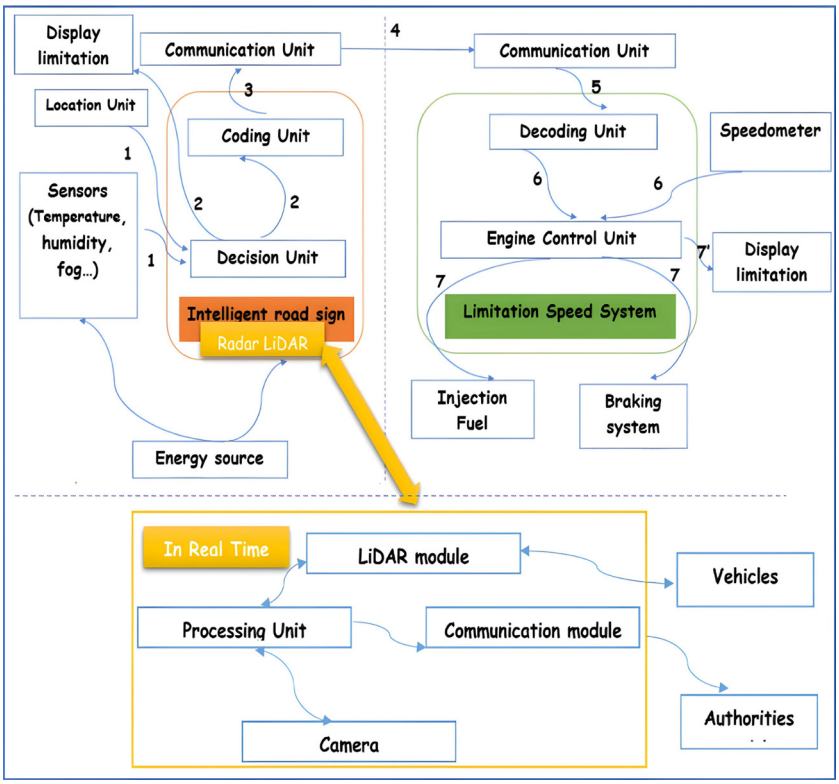

Fig. 1 TariqAmn Algeria's components and communication

normal conditions. Installed sensors collect weather and road condition data (incidents as construction work, collisions, congestion…) (Arrow 1), transmitting it to the decision unit for analysis. The decision unit processes all data to determine the appropriate speed (Arrow 2), codes the signal for real-time display (Arrow 3), and transmits it via the antenna to road users (Arrow 4). The vehicle's antenna receives this information, relaying it to the Engine Control Unit (ECU), which compares it with the vehicle's current speed (Arrow 5). If the vehicle's speed exceeds the indicated limit (Arrow 6), the ECU triggers the fuel injector to reduce speed (Arrow 7). In scenarios like downhill driving, where the fuel injector alone may not suffice, the ECU may intervene with the brake system. Information is displayed on the vehicle's console (LCD Screen), accompanied by an audible alert (Arrow 7'). Using LiDAR, the road sign's integrated radar unit, detects vehicle speeds and violations. Upon detection, the LiDAR activates a camera with license plate recognition to capture images of the offending vehicle, promptly relayed to the nearest authority for action.

3.3 Adaptive vehicle modes

The study (Ahmed Malek and Boudour, 2023) surveyed 820 Algerians to understand their views on road safety technologies, influencing the development of "TariqAmn Algeria". Basing on that study the system introduces Alert and Obligatory Modes to encourage speed limit adherence (Ahmed Malek and Boudour, 2023). Transitioning from Alert to Obligatory Mode addresses the challenge of drivers regularly exceeding speed limits by 20 km/h or more. The system's mechanisms, informed by empirical data, aim to reduce traffic accidents by up to 10%, potentially reaching a 20% decrease with strict speed limit adherence. Additionally, the study explored scenarios such as regulating speeds at tunnel and highway entries, improving visibility at intersections, and adjusting speed limits for different vehicle categories, laying the groundwork for the system's design (International Transport Forum, 2018).

With the introduction of "TariqAmn Algeria", we have expanded our system to include two additional scenarios, thus addressing specific needs previously unmet:

- *Sensitive zones such as schools*: "TariqAmn Algeria" innovatively adjusts speed limits around sensitive areas like schools, ensuring heightened safety for children. By dynamically modifying speed limits based on school activity schedules, the system reduces accident risks during peak ingress and egress times. This proactive approach not only protects children but also optimizes traffic flow, leading to a significant reduction in pollution and congestion. Thus,

the system offers a holistic response to safety, environmental, and traffic concerns.

- *Road works or incidents*: excels in proactively managing unforeseen situations like road works or incidents. The system adapts speed limits flexibly to safeguard affected areas, swiftly identifying events and adjusting speeds accordingly. This proactive approach effectively protects road workers, drivers, and passengers, minimizing accident risks in potentially hazardous conditions. The system's dynamic response to unexpected changes demonstrates its commitment to enhanced road safety and secure navigation for all road users.

These developments highlight "TariqAmn Algeria's" innovative and adaptive approach to the complex challenges of road safety, showcasing its ability to efficiently and specifically address the needs of sensitive areas and emergencies.

3.4 Operating scenarios on infrastructures

This subsection presents the operational framework of the intelligent infrastructure, focusing on its primary functions: determining optimal speed limits and detecting violations. Each function is specifically addressed in detail below:

- *Decision unit*: The decision unit of our system uses a hybrid method that combines Case-Based Reasoning (CBR) and the Analytic Hierarchy Process (AHP) to set optimal speed limits. This approach starts with CBR to compare scenarios, which AHP then refines through a weighted analysis to improve decision-making accuracy. By merging CBR and AHP, the system effectively prioritizes key factors for speed regulation, ensuring precise compliance with Algerian traffic laws and enhancing enforceability within the local context (Ramos-Quintana et al., 2019).
- *Speed detection unit (LiDAR)*: The Speed Detection Unit (LiDAR) is pivotal in the "TariqAmn Algeria" system, employing advanced protocols for accurate speed detection and enhanced road safety. It utilizes the UDP protocol for real-time transmission of vehicle speed data, ensuring precision. DSP algorithms are employed for efficient analysis of laser beam return data, extracting precise vehicle speed information. Detected speeding instances are securely transmitted to relevant authorities using HTTPS over the Internet, ensuring data confidentiality and integrity. HTTPS facilitates secure communication, ensuring reliable transmission of traffic violation reports while safeguarding against interception or alteration. These protocols ensure efficient communication, enhanced security, and maximum reliability in detecting and reporting speeding violations on roads.

4 The TariqAmn Algeria's technological integration

The "TariqAmn Algeria" system is designed with a focus on three core functionalities to enhance road safety and compliance with speed limits. It embodies significant technological advancements, as outlined in (Ahmed Malek and Boudour, 2023).

4.1 Panel integration

This system utilizes GPS and the Google Static Maps API for detailed mapping of targeted areas, while a hybrid CBR-AHP algorithm is employed to determine optimal speeds. This methodology lays the foundation for adaptive speed regulation, crucial for road safety (Ahmed Malek and Boudour, 2023).

4.2 Vehicle integration and speed limitation

Additionally, the system communicates the optimal speed directly to vehicles, where an onboard mechanism automatically adjusts the speed, promoting safe driving in compliance with prescribed limits. This vehicle-level integration allows for proactive adaptation to changes in speed limits, significantly increasing the effectiveness of "TariqAmn Algeria" in reducing accident risks and promoting responsible driving (Ahmed Malek and Boudour, 2023).

4.3 Radar integration

The third component concerns the LiDAR (Light Detection and Ranging) unit, pivotal in the "TariqAmn Algeria" system for precise speed monitoring and bolstering road safety.

Operated via sophisticated protocols, this unit utilizes cutting-edge technology to swiftly measure vehicle speeds and detect speeding violations. The radar unit, part of the LiDAR system, accurately gauges vehicle speeds by emitting laser pulses and analyzing their return time. It identifies speeding violations by comparing measured speeds against designated limits and cooperates with an integrated camera system equipped with license plate recognition capabilities to capture images. These images are then used to provide additional evidence for the identified violations. Subsequently, real-time infraction details, including speed and license plate information, are relayed to the nearest traffic authorities for prompt action, underscoring the critical role of the LiDAR unit in bolstering road safety.

5 Simulation of TariqAmn Algeria

To validate the efficacy of TariqAmn Algeria in a real urban context, simulations utilizing SUMO (Simulation of Urban Mobility) and TraCI (Traffic Control Interface) (Anupriya et al., 2020; Carlsen et al., 2020; Jayanto et al., 2023; Srivastava and Kumar, 2020) were conducted in Annaba, Algeria. Annaba was chosen as the testbed due to its representative nature as a typical urban area in Algeria, featuring diverse traffic patterns and road infrastructure. SUMO accurately models Annaba's road network, capturing main roads, intersections, and sensitive areas such as schools. TraCI integration enables real-time data collection via LiDAR sensors, providing insights into vehicle speeds and behaviour. Adaptive traffic signs, equipped with intelligent algorithms, dynamically adjust to changing traffic conditions, weather variations, and peak-hour events.

Two operating modes are evaluated under identical conditions: one with TariqAmn Algeria fully integrated, dynamically adjusting traffic signals and enforcing speed limits, and another without it, serving as a baseline for comparison. The comparison aims to assess TariqAmn Algeria's effectiveness in enhancing road safety and optimizing traffic management efficiency in Annaba.

To clearly define the metrics used for comparison, the following specific indicators were utilized:

- *Average vehicle speed*: Monitored to gauge traffic flow efficiency, indicating potential congestion or effective speed management.
- *Accident rates*: Evaluated by recording collisions, providing insights into the system's impact on road safety.
- *Speeding violations*: Tracked to assess control over vehicle speeds, focusing on frequency and severity.
- *Compliance with speed limits*: A direct measure of how well drivers adhere to enforced speed limits under the system's regulation, indicating the effectiveness of the "TariqAmn Algeria" in promoting lawful driving behaviors.
- *Distribution of driving behaviors*: Categorized into law-abiding, moderate speeding, and severe speeding to understand driver responses and refine system parameters.

Fig. 2 offers a visualization of traffic in Annaba, utilizing the SUMO traffic simulation. On the left, the general map displays the distribution of vehicles on the roads, with particular attention to congestion points. On the right, a zoomed-in view of a specific road section reveals the moving vehicles, colour-coded according to their speed behaviour. Vehicles in orange are exceeding the speed limit by more than 10 km/h, indicating moderate speeding. Those in green are adhering to speed limits and are considered to be driving safely. Vehicles in red are marked as 'reckless drivers', significantly exceeding the speed limit and posing an immediate danger to road safety.

Fig. 2 TariqAmn Algeria Mode with SUMO

6 Results and discussion

The results from the SUMO and TraCI simulations provide clear empirical evidence of the transformative effect of TariqAmn Algeria on road safety within Annaba. By maintaining consistent conditions across both scenarios, the simulations ensured a fair and precise assessment of the system's impact on key safety metrics.

Fig. 3 presents a compelling visualization of the TariqAmn Algeria system's impact, synthesized in a graphical format. The real-time graph plotted with Matplotlib offers a vivid depiction of the traffic dynamics throughout the simulation.

Table 1 presents a comparative analysis illustrating the system's influence on key safety metrics before and after the implementation of the TariqAmn Algeria system.

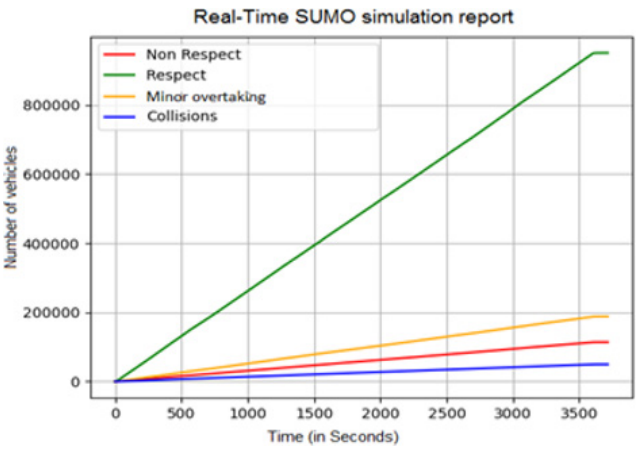

Fig. 3 Simulation results of TariqAmn Algeria in real-time

Table 1 Comparative analysis of ISA systems

Metric	Scenario 1: Before TAA	Rate (%)	Scenario 2: After TAA	Rate (%)
Total number of vehicles	1252959	100	1252959	100
Total number of pedestrians	730490	100	730490	100
Speeding violations detected by LiDAR	Not applicable	/	113737	37.69
Law abaiding	636264	50.78	951222	75.91
Moderate speed	382102	30.49	188000	15
Speeder	234593	18.72	113737	9.07
Collisions with vehicles	129310	10.33	49560	3.69

The implementation of the TariqAmn Algeria system, has led to significant improvements in key safety metrics as discussed in Section 5, crucial for understanding the system's impact on road safety and traffic management:

- *Average vehicle speed*: The system effectively manages vehicle speed, ensuring a more consistent and safer traffic flow, reducing potential congestion and improving overall efficiency.
- *Accident rates*: Collisions decreased from 10.33% to 3.69%, a 60% reduction, highlighting the system's ability to enhance road safety by deterring aggressive driving behaviors.
- *Speeding violations*: Detected at a rate of 37.69%, this new metric underscores the system's proactive approach to monitoring and enforcing speed regulations.
- *Compliance with speed limits*: Law-abiding behavior increased from 50.78% to 75.91%, a 25.13% rise, due to enhanced surveillance and real-time feedback provided by the system, which encourages drivers to adhere to speed limits.
- Distribution of driving behaviors:
  - *Moderate Speeding*: Reduced from 30.49% to 15%, this 50.79% reduction demonstrates the system's effectiveness in deterring minor infractions and promoting safer driving practices.
  - *Severe Speeding*: Dropped from 18.72% to 9.07%, a 50% reduction, driven by immediate feedback from the LiDAR radar, prompting proactive speed adjustments by drivers. The ability to significantly reduce the number of speeders reflects the system's robust enforcement capabilities.

The TariqAmn Algeria system effectively improves speed compliance, reduces speeding violations, and decreases vehicle collisions. Table 1 highlights its positive impact on driver behavior and road safety, showing potential to transform traffic management in high-risk areas.

We assessed smart signage panels and Intelligent Speed Adaptation (ISA) systems separately. Limited comprehensive studies hindered direct comparison with the integrated system, but Tables 2 to 4 summarize individual assessment results.

Table 2, highlights the advantages and disadvantages of various ISA systems, showing how TariqAmn Algeria offers improved precision and real-time responsiveness compared to other technologies.

Table 3, provides a detailed comparison of various panel systems, demonstrating TariqAmn Algeria's superior real-time capabilities and adaptability.

Table 4, compares the Polish project and the TariqAmn Algeria project, emphasizing the latter's high precision and effectiveness under various conditions.

Compared to the previous study (Ahmed Malek and Boudour, 2023), the TariqAmn Algeria project introduces

Table 2 Comparative analysis of ISA systems

Solution	Advantages	Disadvantages
GPS	It provides precise and global positioning data with wide availability of map data.	The accuracy is limited in dense urban areas, and a stable GPS signal is required.
RFID	It enables specific information retrieval from traffic signs, utilizing accurate speed limits on designated road segments.	The real-time data collection can be challenging at high speeds, requiring proximity to the transmitter.
Image processing	It is adapted to various types of traffic signs, using onboard cameras or sensors.	The effectiveness depends on visibility conditions and image quality, requiring substantial computational power.
Dead reckoning	It operates with reduced reliance on external signals.	The accuracy decreases over time without regular sensor calibration, leading to potential errors.
TariqAmn Algeria	It improves speed limit precision and real-time responsiveness, adapting to temporary speed limit changes.	It relies on reliable wireless communication for effectiveness.

Table 3 Comparative assessment of panel systems

Solution metric	Deep learning	Google street map	Multi-agent system	TariqAmn Algeria project
Real-time capabilities	Limited	Limited	Limited	Strong
Speed of processing	Fast	Fast	Fast	Fast
Adaptability	Moderate	Moderate	Moderate	High
Accuracy	High	High	Moderate	High
Robustness	Moderate	High	High	High

Table 4 Comparative analysis of traffic monitoring technologies

Criterion	Polish project	TariqAmn Algeria project
Technologies employed	Utilizes Doppler radar, video, acoustic radar, and weather stations.	Employs LiDAR for speed detection and traffic management.
Precision	High, benefiting from a mix of technologies to offset individual limitations.	Extremely high precision in measuring distances and speeds.
Effectiveness under various conditions	Effective with a blend of technologies for comprehensive coverage.	Efficient, and less prone to meteorological interferences than radar alone.
Detection capability	Traffic volume, weather conditions, and real-time hazard alerts.	High accuracy in vehicle detection for road safety.
Adaptability	Dynamically updates recommended speeds on signs.	Adapts to speed limit changes through programming.
Integration in intelligent traffic management systems	Uses V2X technology for vehicle-to-everything communication.	High potential for integration into intelligent traffic management systems.
Advantages	Comprehensive assessment through multiple sensors; extended detection capability with weather integration.	Superior precision in speed detection; reduced interferences and high reliability under various conditions.
Disadvantage	Potential high complexity and cost due to multiple technologies; susceptible to electromagnetic interferences.	Dependent on clear visual conditions for maximum efficiency; initial installation and maintenance costs.

significant enhancements in intelligent signage panel scenarios. These upgrades include incorporating sensitive areas and addressing overlooked situations like ongoing roadworks. Moreover, the integration of LiDAR radar functionality, especially in high-risk zones, aims to bolster compliance with regulations, thereby fortifying traffic management efficacy and enhancing road safety across diverse urban landscapes.

The comparative analysis presented in the tables underscores the innovative strides made by the TariqAmn Algeria project in traffic monitoring and speed control. It accentuates the project's potential to transform road safety measures by seamlessly integrating LiDAR with real-time data processing, thereby enhancing precision, adaptability, and setting a new benchmark for traffic management systems. Its capacity to adapt to temporary speed limit changes and provide instantaneous updates places it at the forefront of technological innovation in the field.

This assessment indicates that "TariqAmn Algeria" holds promise as a more effective solution to address speeding on roads, leveraging technology to reinforce control measures and cultivate safer driving behaviors.

7 Conclusion and perspectives

In conclusion, Algeria confronts persistent road safety challenges that demand innovative interventions. Positioned as a trailblazer, "TariqAmn Algeria" stands out as a pioneering initiative, integrating cutting-edge intelligent traffic signs with advanced radar speed enforcement mechanisms and a proactive speed control system. This upgraded framework showcases proactive adaptability to real-time traffic dynamics, mandates speed compliance through authorities' alerts, and actively engages with vehicles to suggest or enforce speed modifications.

Rigorously evaluated through simulations, "TariqAmn Algeria" offers a novel pathway for enhancing road safety, characterized by unmatched accuracy, responsiveness to changing conditions, and reduced reliance on conventional infrastructure. This initiative represents a significant leap forward in addressing Algeria's road safety predicament through technological innovation.

Looking ahead, the successful implementation and testing of the system across Algeria's high-risk areas hinge upon the engagement of relevant authorities and administrations in the country. Before widespread deployment,

thorough testing and field evaluations are crucial to ensure the system's effectiveness and reliability in real-world conditions. This step is essential to identify and resolve any potential issues, ensuring that "TariqAmn Algeria" can genuinely contribute to improving road safety nationwide.

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