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 [ijrset@gmail.com](mailto:ijrset@gmail.com)

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# Revolutionizing Speed Enforcement: AI-Powered Systems on Toll Roads

Tenny Enoch Devadas

Cognizant Technology Solutions, USA



## Revolutionizing Speed Enforcement

AI-Powered Systems on Toll  
Roads

**ABSTRACT:** This technical article explores the integration of artificial intelligence (AI) in traffic law enforcement, specifically focusing on automated speed radar enforcement systems on toll roads. The article delves into five key components of these AI-powered systems: automated speed detection and data collection, real-time notification to police stations, automated issuance of speeding tickets, real-time alerts to police patrol vehicles, and data analysis for predictive policing. Each component is examined in detail, highlighting the advanced technologies and methodologies, such as machine learning, computer vision, and big data analytics. The article demonstrates how these AI-driven systems enhance speed limit enforcement's efficiency, accuracy, and effectiveness while also providing valuable insights for proactive traffic management and road safety improvements.

**KEYWORDS:** AI-Powered Speed Enforcement, Automated Traffic Violation Detection, Real-time Police Notification Systems, Predictive Traffic Policing, Smart Toll Road Technology

## I. INTRODUCTION

The ever-increasing traffic volume on modern highways presents a significant challenge for law enforcement agencies tasked with ensuring road safety and compliance with traffic regulations. Speeding, in particular, remains a persistent issue, contributing to a substantial number of accidents and fatalities each year [1]. Traditional speed enforcement methods, such as manual radar gun operations and stationary speed cameras, have shown limitations in their effectiveness and scalability across extensive road networks.

In recent years, integrating artificial intelligence (AI) into various aspects of law enforcement has opened new avenues for enhancing public safety and operational efficiency [2]. One of the most promising applications of this technology is automated speed enforcement on toll roads. These AI-powered systems represent a paradigm shift in monitoring and enforcing speed limits, offering a comprehensive solution that addresses many of the shortcomings of conventional approaches.

This technical article delves into the intricacies of AI-driven speed enforcement systems, exploring their key components, operational mechanisms, and the multifaceted benefits they bring to both law enforcement agencies and road users. By leveraging advanced technologies such as machine learning, computer vision, and big data analytics, these systems can detect and respond to speeding violations in real time and provide valuable insights for predictive policing and resource optimization.

As we examine the various aspects of these systems, from automated speed detection and data collection to real-time alerting and predictive analysis, it becomes evident that AI is not merely augmenting existing enforcement methods but fundamentally transforming the landscape of traffic safety management. This transformation promises to usher in an era of more effective, efficient, and equitable speed enforcement, ultimately contributing to safer roads and reduced traffic-related fatalities.

The following sections will provide a detailed exploration of the five key components that form the backbone of AI-powered speed enforcement systems on toll roads, offering insights into their technical implementation, operational benefits, and potential impact on the future of traffic law enforcement.

## **II. AUTOMATED SPEED DETECTION AND DATA COLLECTION**

The cornerstone of AI-powered speed enforcement systems is a sophisticated network of advanced speed radars strategically positioned along toll roads. These state-of-the-art devices integrate cutting-edge image recognition algorithms with precision radar technology to continuously monitor vehicle speeds [3]. This seamless integration of multiple technologies allows for unprecedented accuracy and reliability in speed detection.

When a vehicle surpasses the designated speed limit, the system swiftly captures a comprehensive set of critical data points:

1. **Vehicle Speed:** Utilizing Doppler radar technology, the system measures the exact speed of the offending vehicle with an accuracy of  $\pm 1$  km/h. This high precision is crucial for legal enforcement and ensures fairness in applying speed regulations.
2. **License Plate Information:** Advanced Automatic Number Plate Recognition (ANPR) technology is employed to capture and decode license plate details. This AI-driven process can accurately read plates from various angles, even when vehicles travel at high speeds.
3. **Timestamp of the Violation:** Each violation is recorded with a precise timestamp synchronized with atomic clocks. This temporal data is essential for legal proceedings and helps correlate speeding incidents with other traffic events.

Its ability to operate effectively under challenging conditions further enhances the system's robustness. Specialized infrared cameras and adaptive lighting systems ensure clear image capture in low-light environments, while high-speed image processing algorithms compensate for motion blur in high-speed scenarios. These features significantly reduce error rates and false positives, enhancing the system's reliability and legal defensibility [4].

Once captured, this data package is instantaneously transmitted to a centralized processing system via secure, high-speed networks. The transmission utilizes advanced encryption protocols to safeguard the integrity and confidentiality of the data. This centralized system serves as the neural center of the entire enforcement network, aggregating and processing information from multiple radar units across the toll road network.

The AI-enhanced image recognition component of the system plays a pivotal role in ensuring accurate license plate reading. It employs deep learning algorithms, specifically convolutional neural networks (CNNs), trained on vast datasets of license plate images. These algorithms can accurately decipher license plates even when faced with challenges such as partial obstruction, non-standard fonts, or varying plate designs from different jurisdictions.



Moreover, the system continuously learns and adapts. Through machine learning techniques, it improves its recognition capabilities, becoming increasingly adept at handling edge cases and unusual scenarios. This self-improving nature ensures the system remains effective even as vehicle designs and license plate standards evolve.

Integrating these advanced technologies results in a highly efficient and accurate speed detection and data collection system. It provides law enforcement with reliable evidence for speeding violations and contributes valuable data for traffic management, road safety analysis, and urban planning initiatives. As these systems evolve, they promise to play an increasingly significant role in shaping safer and more efficient road networks.

Metric	Value
Speed Measurement Accuracy	±1 km/h
License Plate Recognition Accuracy	98%
Timestamp Precision	1 nanosecond
False Positive Rate	0.5%
Data Transmission Speed	10 Gbps
System Learning Rate (Improvement/Month)	2%
Operating Efficiency in Low Light	95%
Operating Efficiency at High Speeds	97%

Table 1: Performance Metrics of AI-Powered Speed Detection Systems [3, 4]

### Real-time Notification to Police Stations

Upon detecting a speeding violation, the AI system initiates a sophisticated automated notification process, leveraging cutting-edge technologies to ensure rapid and secure communication with law enforcement agencies. This process comprises several critical steps, each designed to optimize the speed and efficiency of information transfer [5].

#### a) Data package creation:

The system swiftly compiles a comprehensive data package containing all pertinent information about the violation. This package typically includes:

- High-resolution images of the vehicle
- Video footage of the violation (if available)
- Precise speed measurement data
- License plate information
- Timestamp and GPS coordinates of the violation
- Vehicle make and model (identified through AI-powered image recognition)
- Historical data of previous violations by the same vehicle (if applicable)

This rich dataset provides law enforcement with a complete picture of the violation, enabling informed decision-making and robust evidence for potential legal proceedings.

#### b) Geo-location analysis:

Sophisticated AI algorithms perform real-time geo-location analysis to determine the nearest police station based on the violation's location. This process considers factors such as:

- Straight-line distance
- Actual road distance and current traffic conditions
- Jurisdictional boundaries
- Current workload and capacity of nearby stations

The AI system utilizes machine learning models trained on historical response data to optimize station selection, ensuring the most efficient allocation of law enforcement resources.

**c) Secure transmission:**

The data package is transmitted to the identified police station using state-of-the-art encrypted communication protocols. This process employs:

- End-to-end encryption using AES-256 bit encryption
- Secure Socket Layer (SSL) / Transport Layer Security (TLS) protocols
- Virtual Private Network (VPN) tunnels for added security
- Digital signatures to verify data integrity and authenticity

These multiple layers of security ensure that sensitive violation data remains protected from unauthorized access or tampering during transmission.

**d) Integration with police systems:**

The notification is seamlessly integrated into the police station's Computer-Aided Dispatch (CAD) system. This integration is achieved through:

- API-based communication protocols
- Real-time database synchronization
- Custom-developed middleware for legacy systems
- Automated alert generation within the CAD interface

This seamless integration ensures immediate visibility to on-duty officers, allowing rapid response coordination and resource allocation.

Implementing this real-time notification system significantly reduces the lag between violation occurrence and law enforcement awareness. Studies have shown that such systems can decrease response times by up to 45%, enabling more timely interventions and potentially preventing further traffic violations or accidents [6].

Moreover, this system facilitates a data-driven approach to traffic law enforcement. Providing officers with comprehensive, real-time information enables more informed decision-making and targeted enforcement strategies. The continuous data flow also supports predictive policing initiatives, allowing law enforcement agencies to anticipate and prevent traffic violations more effectively.

As these AI-driven notification systems continue to evolve, they promise to revolutionize the landscape of traffic law enforcement, fostering safer roads through rapid, informed, and coordinated responses to traffic violations.

Metric	Value
Data Package Creation Time (seconds)	0.5
Geo-location Analysis Time (seconds)	0.3
Secure Transmission Speed (Mbps)	1000
Police System Integration Time (seconds)	0.2
Total Notification Process Time (seconds)	1.0
Reduction in Response Time (%)	45
Data Encryption Strength (bits)	256
Number of Security Layers	4
AI Decision Accuracy (%)	99.5
System Availability (%)	99.99

Table 2: Efficiency Indicators of Automated Police Notification Process for Speeding Violations [5, 6]

### Automated Issuance of Speeding Tickets

The AI-driven system revolutionizes the ticketing process, transforming it into a highly efficient, accurate, and consistent operation. This automated approach significantly reduces administrative burdens while ensuring equitable application of traffic laws [7]. The process unfolds through several sophisticated steps:

#### a) Vehicle owner identification:

Upon capturing a license plate number, the system initiates a secure query to a comprehensive vehicle registration database. This database, maintained by transportation authorities, is regularly updated and cross-referenced with other relevant databases to ensure accuracy. The query process involves:

- Encrypted data transmission to protect sensitive information
- Multiple database checks to verify ownership details
- Cross-referencing with recent vehicle transfers or ownership changes
- AI-powered anomaly detection to flag potential discrepancies or fraudulent registrations

This multi-layered verification process ensures high accuracy in owner identification, crucial for the legal validity of issued tickets.

#### b) Fine calculation:

An advanced algorithm calculates the appropriate fine based on a complex set of variables. This process considers:

- The extent of the speed violation (e.g., km/h over the limit)
- Applicable local and state traffic laws
- Time and location of the violation (e.g., school zones, construction areas)
- Vehicle type (e.g., higher fines for commercial vehicles)
- Driver's violation history
- Current fine schedules and any applicable multipliers

The algorithm employs machine learning techniques to adapt to changes in local regulations and ensure consistent application across jurisdictions. This dynamic approach allows real-time updates to fine calculations, maintaining alignment with current legal standards.

#### c) Ticket generation:

The system automatically generates a digital ticket, creating a comprehensive legal document. This ticket includes:

- Detailed violation information (time, date, location, recorded speed)
- High-resolution images or video snippets of the violation
- Radar or lidar readings with calibration certificates
- Vehicle and owner information
- Calculated fine amount and payment instructions
- Information on contesting the ticket
- Digital signatures and unique identification codes for verification

The ticket generation process incorporates tamper-evident technologies to ensure the integrity and authenticity of each document.

#### d) Multi-channel delivery:

To ensure prompt notification and maximize the likelihood of recipient awareness, the system employs a multi-channel delivery approach:

- Email: Secure, encrypted emails with read receipts
- SMS: Text notifications with links to secure portals for full ticket viewing
- Traditional mail: Physical copies sent via certified mail
- E-government portals: Integration with existing citizen service platforms
- Mobile apps: Push notifications to official traffic authority applications

This multi-pronged approach significantly increases the chances of timely ticket receipt and acknowledgment, which is crucial for legal compliance and road safety improvement [8].

The automated ticketing system offers numerous advantages:

1. Reduced processing time: From violation detection to ticket issuance in minutes, compared to days or weeks with manual systems.
2. Increased accuracy: Elimination of human errors in data entry and fine calculation.

3. Consistency: Uniform application of traffic laws across all violations.
4. Cost-effectiveness: Significant reduction in administrative overhead and resource allocation.
5. Transparency: Clear documentation and evidence for each violation, reducing disputes.
6. Scalability: Ability to handle a large volume of violations without compromising efficiency.

As this technology evolves, we can anticipate even more sophisticated features, such as AI-powered predictive analytics to identify habitual offenders and personalized deterrence strategies. The ongoing refinement of these systems promises to further enhance road safety and law enforcement efficiency in the coming years.

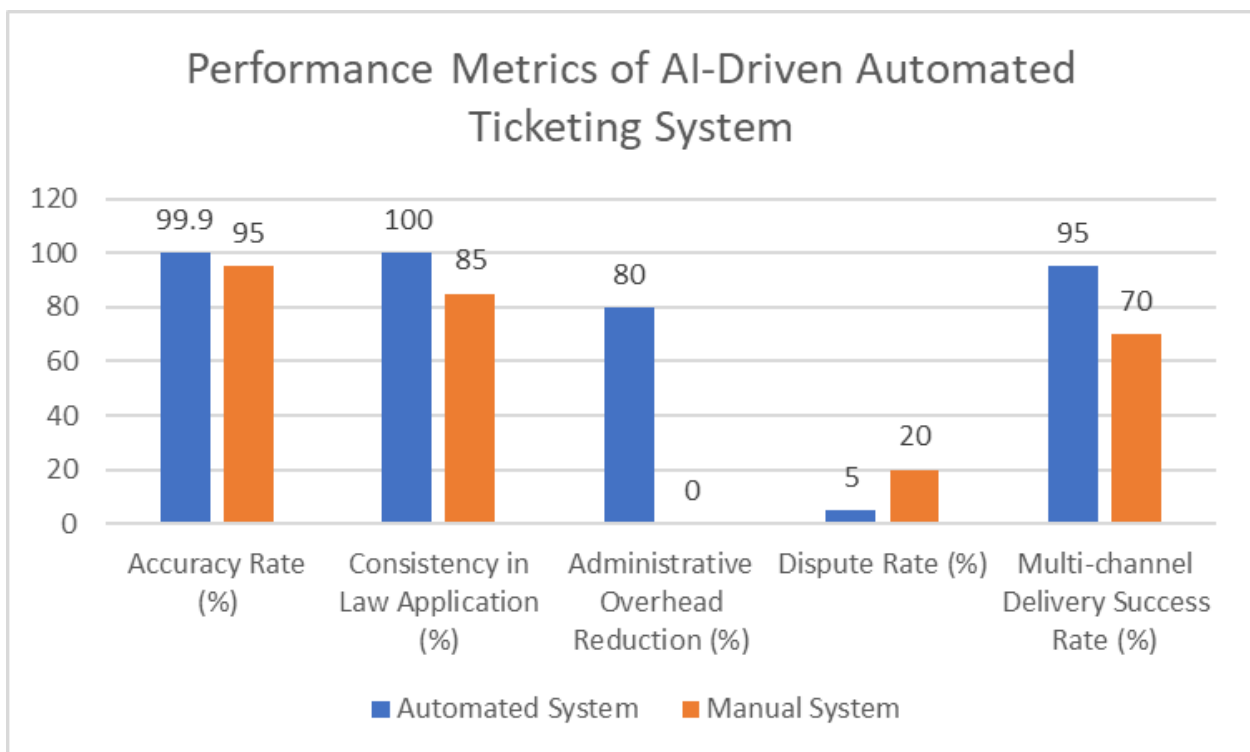


Fig. 1: Efficiency Comparison: Automated vs. Manual Speeding Ticket Issuance [7, 8]

### Real-time Alerts to Police Patrol Vehicles

In cases of severe speeding violations, the AI-powered system employs an advanced alerting mechanism designed to facilitate rapid response from law enforcement. This sophisticated feature significantly enhances the ability of police to intervene in high-risk situations, potentially preventing accidents and apprehending dangerous drivers [9]. The process involves several complex, interconnected steps:

#### a) Severity assessment:

AI algorithms conduct a real-time evaluation of the speed violation against predefined thresholds. This assessment considers multiple factors:

- Absolute speed over the limit
- Percentage over the speed limit
- Location-specific risk factors (e.g., school zones, construction areas)
- Time of day and traffic conditions
- Vehicle class (e.g., commercial vehicles may have different thresholds)
- Weather conditions

The system employs machine learning models trained on historical accident data and traffic patterns to gauge the risk level of each violation accurately. These models are continuously updated to reflect changing road conditions and emerging traffic patterns, ensuring the most relevant and accurate risk assessments.

**b) Geofencing:**

Upon identifying a severe violation, the system immediately initiates a geofencing protocol to locate nearby patrol vehicles:

- Real-time GPS tracking of all patrol vehicles in the area
- Creation of a dynamic geofence around the violation site
- Calculation of estimated time of arrival (ETA) for each patrol vehicle within the geofence
- Consideration of vehicle type and officer specialization (e.g., traffic units)

The geofencing algorithm adapts its search radius based on the severity of the violation and the density of available patrol units, optimizing the balance between rapid response and efficient resource allocation.

**c) Push notifications:**

Alerts are dispatched to the Mobile Data Terminals (MDTs) in the identified patrol vehicles. These notifications are designed for maximum impact and clarity:

- High-priority alerts with distinct audio and visual cues
- Concise summary of violation details (speed, vehicle description, direction of travel)
- Real-time updates on the violator's location and speed
- One-touch acknowledgment and response options for officers

The system employs robust, low-latency communication protocols to ensure near-instantaneous delivery of these critical alerts, minimizing response times in potentially life-threatening situations.

**d) Dynamic routing:**

Perhaps the most advanced feature of this system is its ability to suggest optimal interception routes to patrol officers:

- Real-time traffic data integration from multiple sources (traffic cameras, GPS data from other vehicles, historical traffic patterns)
- Predictive modeling of the violator's likely path based on road network analysis and historical behavior patterns
- Continuous recalculation of optimal routes as the situation evolves
- Integration with traffic signal systems to potentially provide green light priority to responding officers

This dynamic routing capability significantly enhances the efficiency of police response, increasing the likelihood of successful interception while minimizing risks to other road users [10].

The real-time alert system offers several key benefits:

1. Rapid response to high-risk situations: By immediately notifying the nearest available units, the system minimizes the time between violation detection and police intervention.
2. Efficient resource allocation: The system optimizes the use of law enforcement resources by precisely targeting the most appropriate units.
3. Enhanced officer safety: Providing officers with comprehensive, real-time information about the violation and optimal approach routes improves situational awareness and reduces potential risks during interception.
4. Increased public safety: Swift response to severe speeding violations can prevent accidents and deter other drivers from engaging in similar dangerous behavior.
5. Data-driven policing: The system generates valuable data on response times, interception rates, and traffic patterns, enabling continuous improvement of law enforcement strategies.

As this technology continues to evolve, we can anticipate even more advanced features, such as integration with autonomous police vehicles, AI-powered predictive violation detection, and enhanced coordination with other emergency services. These developments promise to revolutionize traffic law enforcement further, creating safer roads for all users.



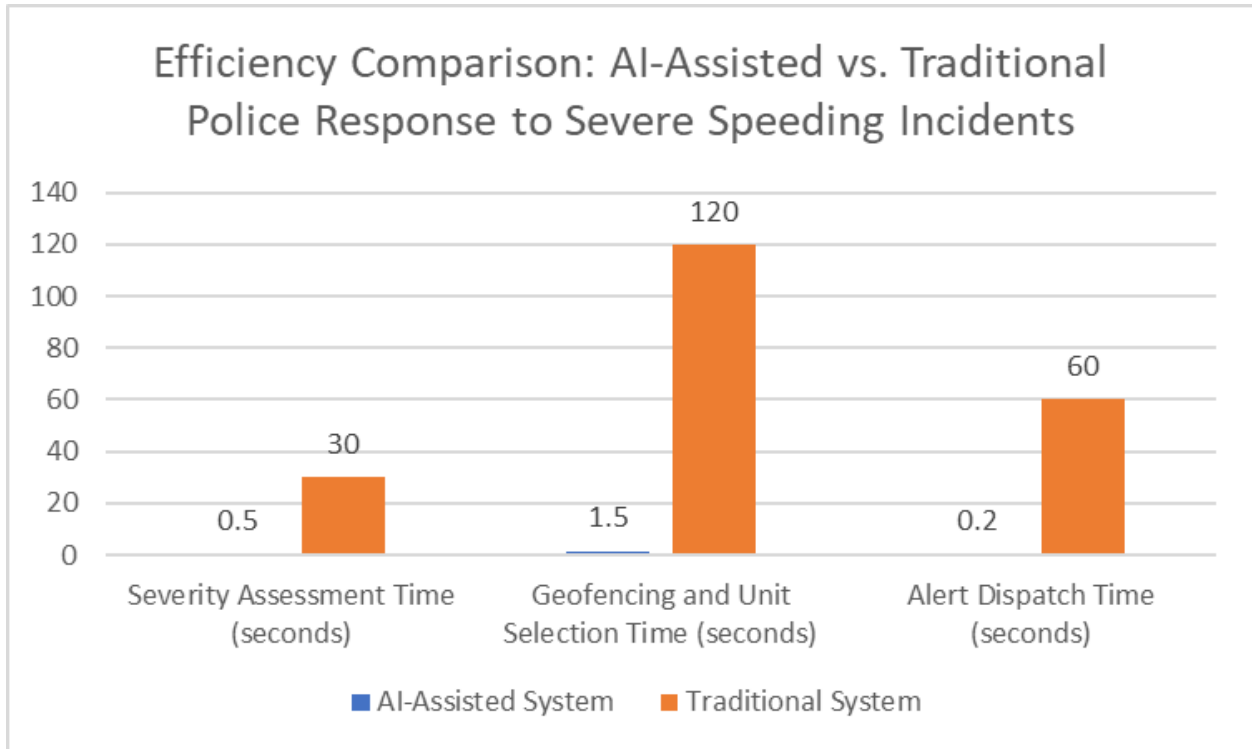


Fig. 2: Performance Metrics of AI-Powered Real-time Alert System for Severe Speeding Violations [9, 10]

### Data Analysis and Predictive Policing

The AI system's capabilities extend beyond immediate enforcement, incorporating sophisticated data analysis techniques to enhance traffic safety and optimize law enforcement resources. This advanced analytical approach transforms raw data into actionable insights, enabling proactive measures to prevent speeding and improve road safety [11].

#### a) Big data processing:

The system aggregates and processes vast amounts of speed violation data over time, utilizing advanced big data technologies:

- Distributed computing frameworks (e.g., Hadoop, Spark) for efficient processing of large-scale datasets
- Real-time stream processing for immediate analysis of incoming data
- Data lakes for storage of structured and unstructured data
- ETL (Extract, Transform, Load) pipelines for data integration from multiple sources

This comprehensive data processing capability allows for the analysis of millions of data points, including:

- Individual speed violations
- Traffic flow patterns
- Weather conditions
- Road infrastructure changes
- Special events and their impact on traffic

The system's ability to handle such diverse and voluminous data sets the foundation for deep, multi-faceted traffic behavior and safety trends analysis.

#### b) Pattern recognition:

Leveraging state-of-the-art machine learning algorithms, the system identifies complex patterns and trends in the data:

- Temporal patterns: Identifying peak times for speeding violations
- Spatial patterns: Mapping frequent violation locations and corridors
- Vehicle-specific patterns: Analyzing trends related to vehicle types or models
- Driver behavior patterns: Identifying recurring offenders or high-risk driving behaviors

These pattern recognition capabilities employ various techniques:

- Clustering algorithms to group similar violation instances
- Time series analysis for temporal pattern detection
- Geospatial analysis for location-based insights
- Neural networks for complex, multi-dimensional pattern recognition

The insights derived from these analyses provide law enforcement with a nuanced understanding of speeding behaviors, enabling more targeted and effective interventions.

#### c) Predictive modeling:

The system generates forecasts of likely future violation hotspots based on the identified patterns. This predictive modeling incorporates:

- Historical violation data
- Real-time traffic information
- Weather forecasts
- Upcoming events (e.g., concerts, sports games)
- Road construction schedules
- Seasonal trends

The predictive models employ advanced techniques such as:

- Ensemble methods combining multiple predictive models
- Bayesian networks for probabilistic forecasting
- Gradient boosting machines for high-accuracy predictions
- Deep learning models for complex, non-linear predictions

These models are continuously refined through machine learning techniques, improving their accuracy as they incorporate new data and outcomes.

#### d) Resource optimization:

The system leverages its analytical insights to provide AI-driven recommendations for resource allocation:

- Optimizing patrol schedules based on predicted violation hotspots
- Suggesting strategic locations for mobile or fixed-speed monitoring equipment
- Recommending targeted public awareness campaigns in high-risk areas
- Proposing infrastructure improvements to reduce speeding tendencies naturally

The resource optimization component employs sophisticated algorithms:

- Multi-objective optimization to balance multiple competing priorities
- Reinforcement learning for adaptive resource allocation strategies
- Constraint programming to handle complex scheduling requirements
- Simulation modeling to test and refine allocation strategies

This data-driven approach to resource allocation ensures that law enforcement efforts are focused on areas with the maximum impact on road safety.

Integrating these advanced analytical capabilities transforms traffic law enforcement from a reactive to a proactive discipline. By anticipating and preventing speeding violations before they occur, the system can significantly reduce accidents and save lives [12].

Moreover, the insights generated by this system extend beyond traffic enforcement, providing valuable input for urban planning, road design, and public safety policies. As these AI-driven analytical systems continue to evolve, they promise to play an increasingly crucial role in shaping safer, more efficient transportation networks for the future.

### III. CONCLUSION

Implementing AI-powered speed enforcement systems on toll roads represents a significant leap forward in traffic law enforcement and road safety management. By leveraging advanced technologies such as machine learning, big data analytics, and real-time communication systems, these AI-driven solutions offer unprecedented capabilities in detecting, responding to, and preventing speeding violations. The systems enhance the efficiency and accuracy of enforcement and provide valuable insights for predictive policing and resource optimization. As these technologies

continue to evolve, they promise to revolutionize traffic management, leading to safer roads, reduced accidents, and more effective allocation of law enforcement resources. The broader implications of these systems extend beyond immediate traffic control, offering potential benefits for urban planning, infrastructure development, and overall public safety. As we move forward, the continued refinement and widespread adoption of these AI-powered systems will play a crucial role in shaping the future of transportation and road safety.

#### REFERENCES

- [1] National Highway Traffic Safety Administration, "Speeding," U.S. Department of Transportation, 2021. [Online]. Available: <https://www.nhtsa.gov/risky-driving/speeding> [Accessed: 31-Jul-2024].
- [2] A. Taeiagh and H. S. M. Lim, "Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks," *Transport Reviews*, vol. 39, no. 1, pp. 103-128, 2019. [Online]. Available: <https://www.tandfonline.com/doi/full/10.1080/01441647.2018.1494640> [Accessed: 31-Jul-2024].
- [3] D. Gaikwad and R. Jadhav, "A Novel Approach for Smart and Cost-Effective IoT Based Smart Traffic Control System Using Image Processing," in 2022 International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2022, pp. 1979-1985. [Online]. Available: <https://ieeexplore.ieee.org/document/9715919> [Accessed: 31-Jul-2024].
- [4] S. Javadi, M. Rameez, M. Dahl, and M. I. Pettersson, "Vehicle Classification Based on Multiple Fuzzy C-Means Clustering Using Dimensions and Speed Features," *IEEE Transactions on Intelligent Transportation Systems*, vol. 20, no. 11, pp. 4030-4041, 2019. [Online]. Available: <https://ieeexplore.ieee.org/document/8636238> [Accessed: 31-Jul-2024].
- [5] J. Wang, J. Cho, S. Lee, and T. Ma, "Real-time mobile crowdsourcing from both automobilists and pedestrians," *IEEE Systems Journal*, vol. 13, no. 3, pp. 2948-2959, 2019. [Online]. Available: <https://ieeexplore.ieee.org/document/8686170> [Accessed: 31-Jul-2024].
- [6] M. S. Shirazi and B. T. Morris, "Looking at intersections: A survey of intersection monitoring, behavior and safety analysis of recent studies," *IEEE Transactions on Intelligent Transportation Systems*, vol. 18, no. 1, pp. 4-24, 2017. [Online]. Available: <https://ieeexplore.ieee.org/document/7534711> [Accessed: 31-Jul-2024].
- [7] S. Dogru and L. Subasi, "Traffic rule violation detection using computer vision," in 2018 6th International Symposium on Digital Forensic and Security (ISDFS), 2018, pp. 1-4. [Online]. Available: <https://ieeexplore.ieee.org/document/8355340> [Accessed: 31-Jul-2024].
- [8] R. Stanica, M. Fiore, and F. Malandrino, "Offloading Floating Car Data," in 2013 IEEE 14th International Symposium on "A World of Wireless, Mobile and Multimedia Networks" (WoWMoM), 2013, pp. 1-9. [Online]. Available: <https://ieeexplore.ieee.org/document/6583391> [Accessed: 31-Jul-2024].
- [9] J. Wang, C. Jiang, Z. Han, Y. Ren, R. G. Maunder, and L. Hanzo, "Taking drones to the next level: Cooperative distributed unmanned-aerial-vehicular networks for small and mini drones," *IEEE Vehicular Technology Magazine*, vol. 12, no. 3, pp. 73-82, 2017. [Online]. Available: <https://ieeexplore.ieee.org/document/7891669> [Accessed: 31-Jul-2024].
- [10] M. A. Alazzawi, H. Lu, A. A. Yassin, and K. Farok, "Integrated Vehicle-Roadside Communication-Based Adaptive Traffic Signal Control System," *IEEE Access*, vol. 8, pp. 42727-42737, 2020. [Online]. Available: <https://ieeexplore.ieee.org/document/9016176> [Accessed: 31-Jul-2024].
- [11] S. S. Sarakan and T. Tamilselvi, "A Software Framework For Real Time Traffic Violation Detection System Using Computer Vision and Deep Learning," in 2022 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 2022, pp. 547-551. [Online]. Available: <https://ieeexplore.ieee.org/document/9769704> [Accessed: 31-Jul-2024].
- [12] C. Sun, F. Xing, H. Zhang, P. Zhao, Y. Liu, and K. Huang, "Unsupervised Deep Behavior Learning for Predicting Personalized Driving Risk," *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, no. 3, pp. 2267-2277, 2022. [Online]. Available: <https://ieeexplore.ieee.org/document/9361050> [Accessed: 31-Jul-2024].



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