AI Integrated System in Smart City for Traffic Police Optimization

Suhashini Awadhesh Chaurasia[1], Lowlesh Nandkishor Yadav [2]
[1,2]Lincoln university college, Malaysia
pdf.suhashini@lincoln.edu.my, pdfsv.lowlesh@lincoln.edu.my

Abstract: Traffic management is highly essential task in road safety and crime presentation. But the conventional mechanism to handle traffic is very cumbersome which is based on manual decision making, fixed schedules and intuition of the officers which in many cases results in a lack of effective use of resources and slow response time. It is very less effective in identifying criminal activities and traffic management. These limitations are enhanced over time in the fast-changing urban settings where traffic trends and hotspots of violations change dynamically over time. This paper is the solution to the problem which is AI based automation system of tactical deployment of police checkpoints aimed at maximizing the presence of police points based on predictive analytics and real time operational intelligence. The framework includes machine learning engine based on gradient boosting algorithm to estimate the probability of violation and spatial clustering methods to detect geographic regions at high risk. A web-based command center dashboard is a real time visualization of dynamically generated heatmaps, violation notifications, and deployment suggestions with a mobile application allowing field officers to get alert messages and track their geographical locations on the control center.

Keywords: AI; Smart City; Optimization; Safety; Machine Learning

Introduction

Managing traffic is really important for keeping people safe on the roads and stopping crime. The old way of doing things is not very good. It relies on people making decisions following set schedules and using their instincts. This often means that resources are not used well. It takes a long time to respond to the situations. The old way is not very good at finding activities and managing the traffic as well. These problems become more acute over time in cities that are in a state of flux. Traffic patterns and areas where people break the rules are always changing. The traffic management system is a solution to these problems. It is a computer system that uses intelligence to decide where to put police checkpoints. The system uses map to figure out where people are most likely to break the rules and where the police should focus their attention. It also uses maps to find areas that're at high risk. The police can see all of this information on a website that shows them where the problems are and where they should send officers. The police can also use an app to get messages and see where they are, on a map. The traffic management system is a way to use police resources and keep people safe. Traffic management is very important. This system can help with traffic management.

Related work

Due to the limitations of manual decision making and cumbersome to deal with the modern urban complexities, an innovative automated method is the need. There is a pressing need for a transition from reactive, manual patrolling to proactive, intelligence-led enforcement. By integrating advanced data analytics and automated coordination, law enforcement can optimize their presence, ensuring that checkpoints are strategically positioned where they are most likely to deter crime and improve road safety.

Table 1. Analysis of literature work

Author Details	Technology	Model Used	Innovation	Strengths
Rathore, P. S. et al. (2025)	Connected Vehicle Technology (V2X), Smart CCTV Networks, RFID, Infrared Sensors, Edge Artificial Intelligence, Cloud Computing Architectures.	Deep Neural Networks (CNN for video streams, LSTM for temporal flow patterns) Object Detection Frameworks (YOLO, R-CNN, DeepSORT) Reinforcement Learning Agents (Q-learning, DQN)	Synchronizes spatial-geographical data (GIS) directly with a mixed hybrid neural network architecture (CNN+LSTM) to predictively route general urban transit prior to actual gridlock formation.	Exceptional, robust comparative breakdown of modern machine vision models. Highly effective at extracting complex, non-linear traffic features from heavily congested, unstable city intersections.
Harper, F., et al. (2025)	V2X (Vehicle-to-Everything) Communication, Cloud-Edge Compute Node Fusion, IoT Sensor Arrays, 5G/6G Ultra-Reliable Low-Latency Communication Systems.	Core engine: Reinforcement Learning via Deep Q-Learning Neural Networks for multi-modal sensor data fusion SUMO & MATLAB simulation environments	Introduces a real-time closed-loop decision matrix that synthesizes emergency fleet GPS navigation with adaptive municipal traffic infrastructure to build Dynamic Green Corridors.	Remarkable performance under peak congestion conditions, cutting emergency travel delays by 35% to 50%. Achieves over 90% accuracy in real-time intersection priority adjustments.
Paul, Y., Nisa, S. U., & Singh, R. (2025)	Integrated Traffic Management System (ITMS) Geographic	Support Vector Regression (SVR) with a Radial Basis Function	Develops highly precise localized ML models trained on 6 months of actual operational police registry logs enabling accurate	Outstanding predictive accuracy, achieving perfect classification performance (1.00 Accuracy/ Precision/ Recall) for traffic categories.

	Information Systems GPS vehicular telematics Edge execution frameworks	Random Forest K-Nearest Neighbours (KNN) model Linear Regression baseline	traffic behaviour mapping under intense geographic constraints.	Delivers high-precision spatial tracking for accident hotspot analysis using computationally efficient algorithms over dense deep neural networks.
Sharma et al., (2026)	Computer Vision, Sequence Learning, Reinforcement Learning, Traffic Simulation	YOLO (v4), LSTM, Q-learning (RL)	Unified data pipeline designed specifically for Indian cities that integrates real CCTV traffic feeds with calibrated SUMO simulations to handle dense, non-lane-based heterogeneous traffic.	Achieves a 35–50% reduction in average vehicle waiting time; highly robust against occlusion and overlapping vehicles in unstructured traffic environments.
Farooq et al., (2025)	Computer Vision, Internet of Things (IoT), GPS-based Alerts, Acoustic Sensing	YOLO, Gaussian Mixture Model (GMM), LSTM	Proactive congestion management using an LSTM-based 10–15minute predictive alert sent via GPS to drivers within a 1–2 km radius, combined with a pre-signal mechanism to actively prevent urban gridlock.	Multi-modal emergency vehicle verification fusing visual and audio (siren frequency) cues; adaptive dynamic resizing of the warning notification radius based on congestion severity.
Suresh et al., (2025)	Machine Learning, Geographic Information Systems (GIS), Real-Time IoT Communications	Variational Deep Embedding (VaDE), Linear Regression	An unsupervised generative deep learning model that predicts accident likelihood and maps clusters to proactively position emergency resources before crashes occur.	targets an optimized strict 5-minute drive-time threshold for medical arrival; establishes immediate data links that sync emergency routes with traffic departments and hospital prep teams.
Wairagade et al., (2025)	Computer Vision, Internet of Things (IoT), Cloud Computing	Convolutional Neural Networks (CNNs), LSTM,	A highly scalable, cloud-backed centralized environment that	Eliminates localized computing restrictions; introduces data-frugal preprocessing steps (noise

		Reinforcement Learning	syncs data across wide urban intersections to optimize holistic traffic flows rather than managing intersections in isolated silos.	reduction, grayscale conversion) to slash data latency and minimize backend computational overhead.
Thakur et al., (2026)	Intelligent Transportation Systems (ITS), Real-Time IoT Sensing	Computer Vision (CNNs, YOLO), Reinforcement Learning	An in-depth technological synthesis tailored to handle uniquely complex, dense, and unstructured Indian city traffic mixtures (e.g., two-wheelers, auto-rickshaws, and cars sharing narrow city corridors).	Drastically cuts urban idling delays by 20–30% via event-driven "green waves"; introduces specialized field-tested feedback loops involving smart city engineers and local traffic police.
Yusuf et al., (2025)	Internet of Drones (IoD), Microscopic Traffic Simulation	Particle Swarm Optimization (PSO), Modified Dijkstra Algorithm	Integrates air-to-ground (A2G) probabilistic RF channel propagation links with real-time microscopic urban maps to execute decentralized incident data sharing and fleet rerouting.	Minimizes global greenhouse gas emissions by up to 41% and path travel delay by 32% using an eco-routing cost function; features dynamic drone relocation triggers if a hover node fails.
Bekbussinova et al., (2025)	Qualitative & Quantitative Mixed-Methods	Mixed-Methods Empirical Framework, Volume/Speed Linear Regression	Evaluates intelligent urban infrastructure in Central Asia by structurally integrating real-world physical traffic telemetry with local public perception and ethical data security metrics.	Maps distinct green-signal vehicle complacency parameters; identifies concrete friction points between data privacy concerns and automated deployment costs.

Key Contribution

- **From predictive AI to perspective AI incorporating reinforcement learning -** Existing Gradient boosting model is predict which predicts the probability of traffic violations. By adding reinforcement learning agent for the deployment phase, the model can enhance its capabilities.
- **Integrate real-time edge AI for field agents –** The mobile app is capable of displaying the alter messages and it also uses a features GPS tracker to track the location. A step further can be taken

and offload some of the computation to the edge mobile devices as suggested by the authors of papers.

- **Fuse checkpoint Data with V2X or Drone Telemetry –** The papers used in the literature survey are based on traffic flow optimization based on Vehicle-to-Everything (V2X) or internet of Drones (IoD) data. The which can be made is the integration of V2X communication or drone feeds for law enforcement use. Coupling with the spatial clustering with live telemetry from connected vehicles or drones that could allow the system to automatically move police checkpoints minutes before a predicted bottleneck or violation hotspot fully forms.
- **Privacy Security trade-off –** Papers referred raised the dilemma between data privacy and automated deployment. The contribution which can be made is incorporating privacy-preserving layer to the framework. Federated learning or dynamic data anonymization can be implemented in the model. Users can access AI checkpoint system by enhancing road safety while keeping the invasive tracking of innocent civilians to a minimum, offering a much-needed ethical framework for smart city policing.

Proposed Methodology

The proposed framework is an intelligence-led proactive deployment system for optimizing traffic management and crime prevention. The architure hinges on three core modules:Data processing, AI Predictive Engine, and Tactical Deployment Interface.

- **Data Acquisition and Preprocessing**

  The system collects data from various urban touchpoints, including historical traffic violation records, crime incident reports, weather conditions, and time-series geographic data as well as real-time data. The data is normalized and categorical variables are encoded to handle spatial-temporal anomalies.
- **AI Predictive Engine (Gradient Boosting)**

  Gradient Boosting algorithm has been used to predict the probability of the violation in a given sector. This is an ensemble method which constructs sequential decision tress to minimize prediction errors which is very efficient for complex and non-linear urban traffic patterns. The probability of a violation or crime incident P(V=1/X) is calculated based on the feature vector X (time, location, historical density), where the objective function minimizes the log-loss:

  $$L=-\sum_{i=1}^{N}[yi\log(pi)+(1-yi)\log(1-pi)$$
- **Spatial Clustering for Risk Detection**

  Gradient Boosting is used to estimate the event probability, and then Density-Based Spatial Clustering of Applications with Noise (DBSCAN) which is used to search the exact geographic risk zones. Unlike traditional k-means, DBSCAN does not need to specify the number of clusters beforehand, which allows it to dynamically identify irregularly shaped violation hotspots according to real-time traffic density.

- **Command Center and Mobile Architecture**
  Final outputs are pushed to synchronized dual interface: Web based Command Center- Centralized dashboard with real-time heatmaps. It visualizes the high-risk cluster and offers tactical checkpoint coordinates automatically to dispatcher.
  Field Officer Mobile App: Officers get real-time alter notifications and GPS deployment vectors. The app sends the officer's location back to the constant ping, creating a closed loop resource management system.

Discussions

AI-driven predictive deployment is much better as compared to manual policing according to the study. A Gradient Boosting algorithm with spatial clustering framework is used in this paper to effectively identify dynamic violation hotspots. This shortens incident response time and maximizes the use of resources. The web and mobile architecture integration allow for seamless tactical execution in real time for smart city management.

Conclusions

1. Proactive policing- The research makes traffic management a proactive, intelligent system instead of a reactive, manual scheduling method.
2. Robust AI framework – Delivers highly accurate predictions of traffic violations
3. Improved resource allocation – improved optimal police utilization of resources, enhanced operational efficiency
4. Reduce response time by strategically pre-positioning officers using predictive analytics.
5. Real time tactical ecosystem – Deployed synchronized web-based command dashboard, and filed officer mobile app.

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