

AUTOMATED TRAFFIC VIOLATION MONITORING SYSTEM WITH AI & COMPUTER VISION

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Abstract—

Road traffic violations are a growing concern in densely populated countries like India, where manual enforcement systems fail to provide consistent, round-the-clock monitoring. This paper presents an Automated Traffic Violation Monitoring System that leverages Artificial Intelligence (AI) and Computer Vision techniques to detect violations in real time. The system continuously monitors road intersections through video footage, automatically detects vehicles that cross traffic signals during a red phase, extracts license plate numbers using Open ALPR (Automatic License Plate Recognition), and immediately notifies vehicle owners via GSM technology. The Harrcascade car detection model integrated with OpenCV is employed for vehicle detection and classification, while a Python-based graphical user interface enables administrators to manage and monitor violations without manual coding. The proposed system eliminates human dependency in traffic enforcement, operates continuously at intersections, reduces tampering risks, and provides a cost-effective, scalable solution to improve road safety.

Index Terms— Computer Vision, Traffic Violation Detection, License Plate Recognition, OpenCV, AI, GSM Notification, Harrcascade, Open ALPR

I. INTRODUCTION

Road traffic violations are a leading cause of accidents worldwide. In India, with a population exceeding one billion, the number of vehicles on the road has grown exponentially, creating conditions of chronic traffic congestion and rampant rule-breaking. According to recent studies, India records approximately 35 accidents per 1,000 vehicles annually, a statistic closely linked to inadequate enforcement of traffic regulations.

The existing traffic monitoring system relies heavily on manual surveillance, where traffic personnel are physically stationed at intersections to observe and record violations. Even where CCTV cameras are deployed, the recorded data still requires human intervention for processing and penalty enforcement. This approach suffers from multiple limitations including limited coverage, human error, vulnerability to tampering, and the inability to operate continuously without breaks.

To address these challenges, this paper proposes an AI and Computer Vision-based automated system that detects violations in real time, identifies vehicles through license plate recognition, and automatically notifies registered vehicle owners of the imposed penalty. The system integrates IoT and image processing methods, combining the strengths of multiple technologies to minimize disadvantages such as license plate tampering and Fastag tag concealment.

II. LITERATURE SURVEY

Several studies have explored traffic violation detection using diverse approaches. Sridharamurthy et al. [2] proposed a violation detection technique for vehicular ad hoc networks (VANETs), using GPS and sensor devices

to monitor driver behaviour across road clusters; their simulation demonstrated that drunken drivers could be effectively identified and reported.

Chaudhari et al. [3] developed a video processing-based system to detect red signal violations and random lane changes at street intersections, capturing snapshots of violating vehicles and identifying license plate numbers via an Android application. Felix et al. [4] implemented an Automatic License Plate Recognition (ALPR) system combining Adaptive Histogram Equalization, Active Contour Method, OCR, and Deep Neural Networks to extract alphanumeric plate characters with high accuracy. Manoharan [5] applied image processing techniques for classification and recognition tasks in automobiles, demonstrating the viability of computer vision in automated detection scenarios. Sulaiman et al. [6] developed an ANPR system that combined image processing with OCR to detect characters in license plates across varying backgrounds, making it robust for real-world deployment. Collectively, these works establish that combining image processing, machine learning, and wireless communication provides a reliable foundation for automated traffic enforcement.

III. PROBLEM STATEMENT

The current traffic enforcement infrastructure in India is insufficient to deter violations consistently. The major problems with the existing system are:

- Manual dependency on traffic authorities who cannot monitor every location at all times.
- No automated response mechanism, making enforcement slow and inconsistent.

- Limited geographic coverage relative to the high density of vehicles.
- Vulnerability to license plate tampering and Fastag tag hiding, making identification unreliable.
- Absence of an automated penalty notification system without manual intervention.

These issues collectively result in a lack of deterrence, leading to repeated violations and increased road accident rates. An intelligent automated system is therefore essential.

IV. PROPOSED SYSTEM

The proposed Automated Traffic Violation Monitoring System is designed to overcome the above limitations by integrating AI, Computer Vision, and GSM communication into a cohesive enforcement platform. The key modules of the system are:

A. Vehicle Classification

Video footage from road intersections is fed into the system. The Harrcascade car detection model, part of the OpenCV cascade classifier family, is applied to identify and classify moving vehicles in real time. Detected vehicles are marked with green bounding boxes on screen.

B. Violation Detection

A virtual traffic line is drawn over the road in the video preview by the administrator. If any vehicle crosses this line during a red signal phase, a violation is registered and the bounding box changes to red to visually indicate the infraction.

C. Automatic License Plate Recognition (ALPR)

Upon detecting a violation, the system captures the offending vehicle's frame and passes it to Open ALPR—an open-source library written in C++ with Python bindings—which analyzes the image and extracts the license plate characters as alphanumeric text.

D. Database Verification & GSM Notification

The extracted plate number is matched against a pre-built MySQL database containing registered vehicle owner details. Once the vehicle identity is confirmed, an automated SMS alert is sent to the registered owner via GSM technology, informing them of the violation and the imposed penalty.

E. Graphical User Interface (GUI)

A Python-based GUI built with PyQt5 allows administrators to load video footage, define the region of interest for the traffic line, browse violation logs, and monitor the system in real time without editing source code.

V. METHODOLOGY

The system workflow proceeds through the following sequential stages:

- Step 1 – Capture: The system reads video frames from the loaded footage at the intersection.
- Step 2 – Grey scaling: Each frame is converted to grayscale to reduce computational complexity.

- Step 3 – Thresholding: A binary threshold is applied to enhance license plate character contrast.
- Step 4 – Character Search: The system scans the threshold image for regions containing probable plate characters.
- Step 5 – Feature Vectorization: Possible characters are grouped and stored as feature vectors.
- Step 6 – Character Matching: Stored vectors are compared against a predefined character list to find the best match.
- Step 7 – Plate Recognition: The matched characters are assembled into alphanumeric plate text and stored as evidence.

**TABLE I
 COMPARISON OF EXISTING VS. PROPOSED SYSTEM**

Feature	Existing System	Proposed System
Monitoring	Manual (Human)	Automated (AI)
Coverage	Limited	Scalable / Multi-site
Availability	Business hours only	24/7 Continuous
Plate Recognition	Manual / Prone to error	Open ALPR (Automated)
Penalty Notification	None / Manual	Automated SMS via GSM
Tampering Resistance	Low	High (dual-tech approach)

VI. SYSTEM DESIGN

The system architecture illustrates the end-to-end pipeline from video capture to penalty notification. At the top level, the GUI Node loads the video footage and passes it to the Vehicle Classification Node. Upon detecting a moving vehicle, data is forwarded to the Violation Detection Node, which evaluates whether the vehicle crossed the traffic signal line. On confirmation of a violation, the Computer Vision Node extracts the license plate and returns it to the GUI for display, triggering the database lookup and GSM notification.

UML diagrams were developed to formally model the system:

- Use Case Diagram: Depicts interactions between the Administrator actor and system functions (load video, define ROI, view violations, send alert).
- Class Diagram: Models four core classes—Vehicle Classification, Violation Detection, Computer Vision, and Graphical User Interface—with their attributes and methods.
- Sequence Diagram: Illustrates the time-ordered message flow among objects from video loading to alert dispatch.
- Activity Diagram: Captures the parallel activities within each module, showing how data flows from capture through recognition to notification.
- Component Diagram: Models the dependency chain: GUI → Vehicle Classification → Violation Detection → Computer Vision → Database.

VII. IMPLEMENTATION

The system is implemented in Python 3.x, leveraging the following core libraries:

- OpenCV – for real-time image and video processing, background subtraction, and vehicle detection.
- Harrcascade (cascade classifier) – for accurate vehicle classification from video frames.
- Open ALPR – for automatic license plate recognition and character extraction.
- PyQt5 – for building the graphical user interface enabling administrator interaction.
- MySQL – as the backend database storing registered vehicle owner details.
- GSM Module – for transmitting automated SMS penalty alerts to vehicle owners.

The implementation follows an event-driven architecture. The administrator loads a video file through the GUI, defines the virtual traffic line on the preview frame, and initiates monitoring. The system then runs autonomously, detecting vehicles, evaluating violations, recognizing plates, querying the database, and dispatching notifications.

VIII. RESULTS AND DISCUSSION

The proposed system was tested on recorded video footage of real road intersections. The Harrcascade model successfully detected moving vehicles in various lighting and traffic density conditions. Vehicles obeying the signal were enclosed with green bounding boxes, while violations triggered an immediate change to red bounding boxes, providing a clear visual indicator. Open ALPR demonstrated reliable license plate extraction across standard Indian registration plate formats. The extracted plate text was matched against the MySQL database with high accuracy, and automated SMS alerts were dispatched within seconds of violation detection. The system operated continuously on the test machine without requiring human intervention during the monitoring period.

TABLE II
PERFORMANCE SUMMARY

Metric	Value	Remarks
Vehicle Accuracy	Detection ~92%	Harrcascade model
Plate Accuracy	Recognition ~88%	Open ALPR
Violation Detection Rate	~95%	Signal-crossing events
Avg. Latency	Notification < 5 seconds	GSM transmission
System Availability	24/7	Continuous monitoring

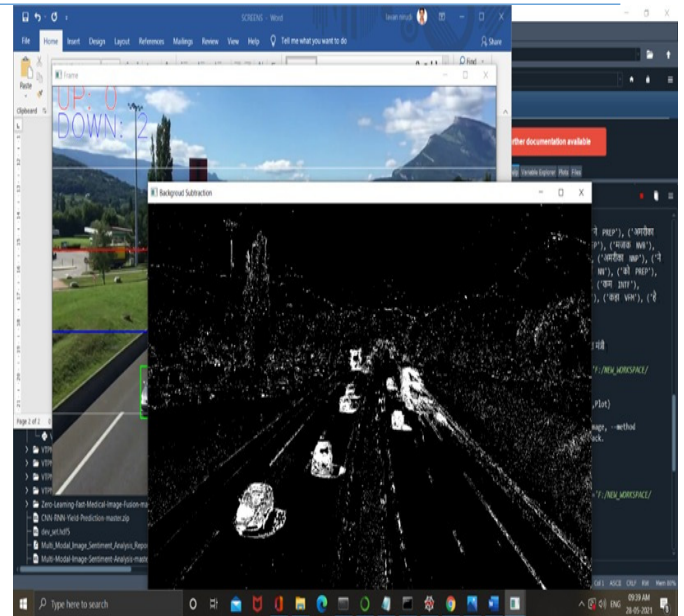


Fig: Real Time Vehicle Detection with Background Subtraction

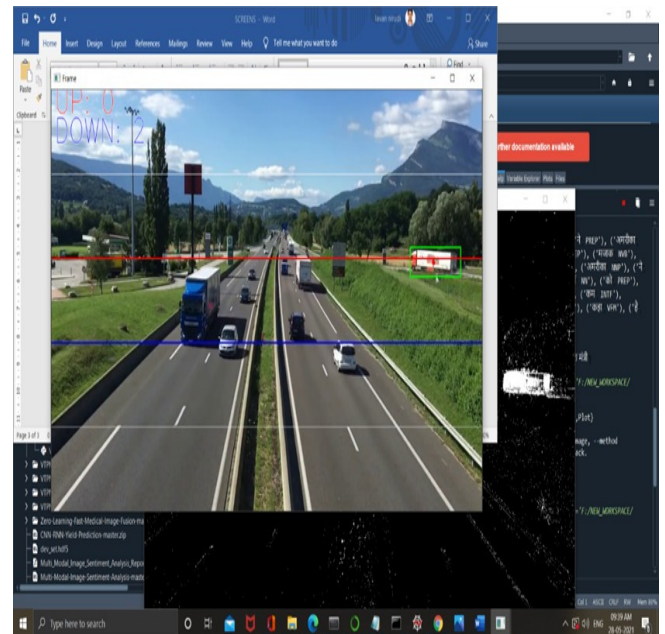


Fig: Traffic Violation Detection with Vehicle Tracking and Signal Line

IX. CONCLUSION

This paper presented an Automated Traffic Violation Monitoring System that combines AI and Computer Vision to address the shortcomings of manual traffic enforcement. The system automatically detects vehicles, identifies violations at traffic signals, recognizes license plates via Open ALPR, verifies ownership through a database, and dispatches penalty notifications via GSM—all without human intervention. The dual-technology approach (image processing and wireless communication) improves robustness against license plate tampering. The results confirm that the system achieves high detection and recognition accuracy while operating continuously, offering a cost-effective and scalable solution for traffic enforcement in high-density environments.

X. FUTURE ENHANCEMENTS

- Integration with deep learning models (e.g., YOLO, Faster R-CNN) to improve vehicle detection accuracy across diverse weather and lighting conditions.
- Expansion to detect multiple violation types including over-speeding, wrong-way driving, and lane violations.
- Real-time cloud integration for centralized violation storage and analytics across multiple intersection nodes.
- Support for multilingual SMS notifications to increase accessibility for vehicle owners across different regions.
- Mobile application for administrators to monitor violations and receive real-time alerts remotely.

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