



# AI-Powered Traffic Analysis for Indian Cities

Leveraging video analytics for smarter urban traffic management and rule enforcement.

# The Challenge: Urban Traffic Congestion in India

India's urban centers grapple with severe traffic issues: congestion, frequent rule violations, and unsafe driving behaviors. Existing traffic management relies on fixed-time signals and manual monitoring, lacking adaptability to real-time conditions.

This leads to:

- Long queues & inefficient road use
- Delayed emergency responses
- Increased fuel consumption & pollution
- Higher accident risks



# Unlocking Insights from Existing Infrastructure

Widespread CCTV deployment offers a unique opportunity to revolutionize traffic monitoring.



## Leveraging Existing CCTV

Transforming passive surveillance into active, data-driven traffic intelligence.



## Real-time Data Extraction

Automated analysis of vehicle count, queue length, traffic density, and rule violations directly from video footage.

The core challenge is building a vision-based perception and analytics system robust enough for complex Indian road conditions.



# Our AI-Powered Traffic Video Analytics System

A modular and explainable approach to processing pre-recorded traffic camera footage for actionable intelligence.



**Video Input**

**Vehicle Detection**

**Multi-Object Tracking**

**Analytics & Dashboard**

Each module operates independently, ensuring clarity, ease of debugging, and future extensibility.

# Precision Detection & Tracking

## Vehicle Detection

Frame-wise detection using a deep learning model (YOLO-based concept) identifies various vehicle types common in India:

- Cars, Bikes, Buses, Trucks, Autos
- Other common entities

Outputs include bounding boxes, class labels, and confidence scores for each detected object.

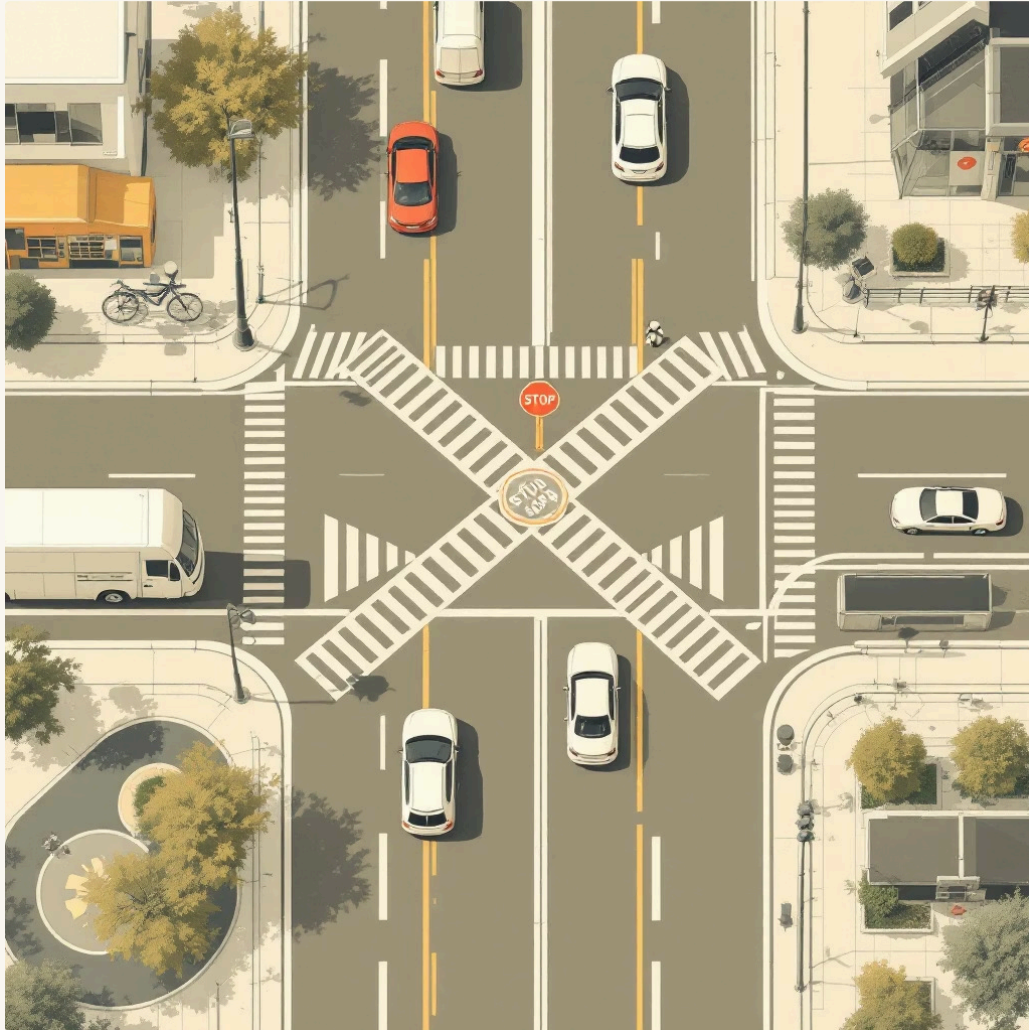
## Multi-Object Tracking

To maintain temporal consistency, a multi-object tracking mechanism (e.g., SORT/DeepSORT concept) is employed. This is crucial for:

- Consistent ID assignment across frames
- Accurate vehicle trajectory estimation
- Robust handling of short-term occlusions

Tracking distinguishes individual vehicle behavior over time, moving beyond isolated frame detections.

# Quantifying Congestion: Queue Analytics



## Queue Length Estimation

A virtual Region of Interest (ROI) is defined before the traffic signal stop line. When the signal is red, vehicles within this ROI are counted to estimate queue length.

## Queue Density Estimation

Calculated as the **Number of vehicles in queue** / **Area of queue region**, this provides a normalized measure of congestion, adapting across different intersection sizes.

- This approach is explainable and avoids black-box inference, offering clear insights into traffic flow.

# Automated Traffic Violation Detection

Our system automatically flags rule infractions, enhancing enforcement and road safety.



## Red-Light Jump Detection

Identifies vehicles crossing the stop line during a red signal phase by monitoring their trajectories.



## Rash Driving Detection

Uses motion-based heuristics (sudden acceleration/deceleration, abrupt lane changes, irregular trajectories) derived from vehicle history.



## Evidence Capture

Provides annotated frames and video segments as concrete evidence for each detected violation.

# Visualization & Reporting Dashboard

## Real-Time Metrics

A web-based dashboard (Streamlit-based prototype) provides key traffic metrics for authorities:

- Total vehicle count
- Live queue length and density
- Detected rule violations

Annotated video frames with bounding boxes, IDs, and violation markers improve interpretability.





# Current Status: Prototype & Limitations

## Implemented Components

Our proof-of-concept prototype demonstrates feasibility:

- Functional web-based dashboard
- Simulated traffic analytics metrics
- Modular system design aligned with pipeline
- Conceptual integration of detection, tracking, and analytics

## Current Limitations

- Currently uses pre-recorded video only
- Detection and tracking models are conceptual/partially implemented
- Signal state is assumed or simulated
- Edge cases (heavy occlusion, extreme weather) not fully addressed



# Conclusion & Future Outlook

This system transforms conventional traffic monitoring into an intelligent, data-driven process. By focusing on accuracy, consistency, and explainable analytics, it directly addresses real-world traffic challenges in India.

The current prototype establishes a strong foundation for future enhancements and scaled deployment, paving the way for smarter, safer urban mobility.