RESEARCH ARTICLE OPEN ACCESS

# AI- Powered Smart Automated Traffic System with Accident Detection &Violation Detection with E-Challan

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## Abstract:

An AI-based smart traffic management system that can improve road safety, reduce traffic congestion, and automate traffic law enforcement. The system uses computer vision techniques such as OpenCV and YOLO- based models and analyse the traffic using captured lane-wise frames. A Django-based backend entails integration of modules such as adaptive traffic signal control, violation detection and accident detection. Traffic signals are dynamically adjusted based on a weighted vehicle density approach so as to optimize traffic flow. The system detects violations such as red light jumping, helmetless riding, triple riding and license plate recognition (using OCR) for vehicle identification. It also consists of an accident detection module for faster emergency response. Automated e-challan system for generating digital penalties with evidence images and send notification. A caching mechanism is implemented so that duplicate challans never occur. The system is a complete end-to-end solution with less human intervention and efficiency in traffic management.

*Keywords* — **Smart Traffic System, YOLO, Computer Vision, Accident Detection, E-Challan, OpenCV, Deep Learning.**

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## I. INTRODUCTION

Traffic congestion, road accidents, traffic rule violation etc. are some of the most prevalent issues in the cities today especially the countries like India. Most of the current traffic systems still rely on fixed timer signals and manual monitoring by traffic police. These methods are not efficient with changing traffic conditions which causes unnecessary delays, congestion, and higher chances of accidents.

With the expanding technologies such as Artificial Intelligence (AI) and Computer Vision, it is now possible to develop smarter systems that can be used to manage traffic more effectively. Such systems are able to analyze real-time data, make quick decisions and reduce the need for human intervention [4].

In this project, we have developed an AI-based Automated Traffic Control System which merges various features into one platform. The system detects vehicles using deep learning models such as YOLO [1] and OpenCV [2] processes video frames in real time. Django based backend is used for data and system operations. The overall system of traffic signals adjusts the timing in a dynamic way according to the number and type of vehicles present on each lane. It also identifies traffic violations like jumping the red light, riding helmetless, and triple riding. In such cases, the system will automatically create an e- challan and send it to the owner of the vehicle. Additionally, there is an accident detection module to detect possible accidents and provide alerts for rapid emergency response [9].

Overall, the proposed system seeks to make traffic management more efficient, with less human effort, safer on the roads, and contribute to the development of smart city infrastructure.

## II. LITERATURE SURVEY

With the growing urbanization today's cities are facing issues like severe traffic congestion, frequent accidents, inefficient signal systems. Traditional traffic signals are highly dependent on fixed signal timers and manual monitoring, which means they are not very efficient at managing real-time traffic conditions. These systems are often do not adapt to the actual traffic density, which results in longer waiting times, and increases risks of accidents. To overcome these limitations, many researchers have proposed various intelligent traffic management systems using technologies like computer vision, artificial intelligence and IoT. These systems aim to Automate the traffic control system, improve road safety, and enforcement mechanisms through real-time data analysis.

In this purpose of understanding the existing approaches and technologies in this domain, a detailed review of the previous research work has been done.

This paper proposes the intelligent traffic signal system based on real-time vehicle density using image processing technique. The system adjusts signal timings dynamically based on how many vehicles pass through an intersection dynamically and therefore reduces congestion and waiting time. However, it does not deal with traffic violations and accident detection [5].

Another study shows a computer vision-based traffic monitoring system based on deep learning model for vehicle detection and classification. The system utilizes convolution neural networks (CNNs) to enhance the ability to detect the different lighting conditions for accurate detection. While the system works perfectly good in detection, there is a lack of integration with enforcement mechanism, like challan generation [2]. A research work, the implementation of a smart traffic management system based on IoT using sensors and cameras to capture the real time traffic data. The system helps to optimize the timing of signals and provides traffic updates. However, reliance on physical sensors adds to the system cost and complexity of maintenance [7].

This paper is concerned with automatic number plate recognition (ANPR) systems based on OCR techniques. It highlights the problems in plate detection under a low-light and occlusion condition and suggests preprocessing methods to improve the accuracy. However, the penalty detection is not integrated with automated penalty systems [6]. Another study suggests a red light violation detection system based on image processing and vehicle tracking technique. For instance, the system is used to detect vehicles crossing the stop line during red signals and capture evidence images. However, it is not automated in real time and integrated with traffic databases. This research proposes a helmet detection system based on deep learning algorithms for detecting riders without helmets. The system enhances the road safety enforcement but lacks the features of automatic challan generation and multi-violation detection [8].

A study on accident detection systems that utilizes machine learning models to detect patterns of collisions from video feeds. It produces alerts for emergency response but they need to be manually verified, which makes response time slower [9]. Another paper discusses the application of object detection models based on the YOLO algorithm for real-time traffic analysis. The system has high detection speed and accuracy and is limited to vehicle counting and lacks traffic control logic [1]. This research proposes an integrated smart traffic system with combination of vehicle detection, violation detection and automated reporting. While the system demonstrates promising results, it does not incorporate optimization techniques that deal with the issue of minimizing overlaps of alert and making the system more efficient [10]. A recent study deals with the implementation of AI-based traffic enforcement systems (automatic generation of e-challans for violations). It goes to the importance of automation in combating corruption and enhancing transparency. However, it does not involve accident detection and adaptive signal control [9].

From the above study it can be seen that most existent systems focus on individual components like traffic density control, violation detector or accident detector. There are very rare systems that have all these functionalities into a single unified

framework.

Therefore, the proposed system has an aim of solving these limitations with making an AI-powered smart traffic control system that involves:

- Dynamic traffic signal control
- Red light violation detection
- Helmet and three riding checking
- License plate recognition
- Automated generation of e-challans
- Detecting accidents and alarming system

This integrated approach can help ensure proper traffic management, improve road safety and facilitate efficient enforcement in one grouped system.

## III. PROBLEM STATEMENT

The rapid increase in the number of vehicles in urban cities has led to traffic jams, road accidents and frequent violations. Traditional traffic signals work on fixed signal timings and manual traffic monitoring, which is inefficient in managing dynamic traffic conditions. These systems do not adapt to the real-time density of the traffic which leads to unnecessary delays and poor traffic flow. In addition, current systems for violation detection and enforcement involve considerable human involvement, resulting in delays, errors and lack of transparency. Accident detection and emergency response is also not immediate, which can increase the severity of the incidents. However, continuous processing of a video requires high computational resources and it is not always cost- effective.

Therefore, there is a need for an intelligent, automated and efficient traffic management system that can dynamically control the traffic signals and can accurately detect violations and vehicles as well as respond to accidents in real-time while reducing the computational load and human-intervention.

## IV. PROPOSED SYSTEM

Our proposed system is an **AI-Powered Smart Traffic Management System with Accident Detection and Violation Detection with E-Challan**, in which various functionalities are included in a single integrated platform. It works on frame-based traffic analysis rather than streaming video for computation to decrease computation costs and attempt to increase efficiency. The system takes images of the lanes at important intervals of time and processes them with deep learning models such as YOLO [1],[3].

Key features include:

- Weighted Vehicle Density Based Adaptive Traffic Signal Control
- Accident detection using alert system
- Traffic violation detection (Red light, Helmet, Triple riding)
- Automatic Number Plate Recognition (ANPR)
- Automated generation of e-challan
- Centralized Control Center with Django backend and database

*TABLE I*
*Comparison Between Existing System and Proposed System*

| **Feature** | **Existing Systems** | **Proposed System** |
|---|---|---|
| Cost | High installation cost (₹15L – ₹2Cr+) | Cost-effective (uses optimized processing) |
| Processing Method | Continuous video processing | Frame-based processing (low load) |
| Traffic Control | Basic / limited adaptive control | Fully dynamic signal timing |
| Violation Detection | Separate modules | Integrated system |
| Accident Detection | Limited or not included | Included with alert system |
| E-Challan System | Available but separate | Fully automated and integrated |

| | | |
|---|---|---|
| Hardware Requirement | High-end infrastructure | Reduced hardware dependency |
| Scalability | Complex | Easily scalable |

*Advantages of Proposed System Over Existing System*

1. Reduces the computational load using frame based approach
2. Integrates many characteristics into a single system
3. Improves traffic flow with the use of adaptive signals control
4. Improves road safety using accident detection
5. Reduces human efforts by traffic police

## V. METHODOLOGY

The proposed system is based on a structured approach for the real-time traffic monitoring, violation detection and accident detection using computer vision [2] and deep learning techniques. The system is implemented using client-server system using frontend, backend & Artificial Intelligence Model.

### A. System Design

Following are the major parts contained in the system:

1. Frontend (User Interface):
- Web-based Dashboard developed using Django Templates
- Displays live camera feed, violations, accidents and status of system

2. Backend (Server):
- Developed using Python and Django framework
- Handles API requests, processing and database operation

3. AI Models:
- YOLOv8 model for vehicle detection [1]
- Custom helmet and triple riding detection model [8]
- Roboflow model for detecting accident [10]

4. Database:
- Stores the data of the vehicles, violations, accident events, and users
- Managed using Django ORM

### B. Workflow Implementation

The Smart Traffic Control System (STCS) has a workflow that is developed to offer an efficient, automated, and intelligent traffic management. The process focuses on the real-time data processing of traffic, the detection of a violation, and processing of adaptive signal management.

1. Frame-Based Traffic Analysis Workflow

a) Frame Capture:
The system records individual frames of every lane, at a regular time interval, particularly during the final 3-5 seconds of a green signal. This eliminates the processing latency and computation of continuous video streaming.

b) Vehicle Detection and Classification:
The model used to process captured frames is the YOLOv8 deep learning [3]. Vehicles such as cars, motorcycles, trucks, buses and bicycles are identified. The system is used to determine the count of each type of vehicle in order to analyze traffic.

c) Calculation of the Weighted Traffic Load:
The weight of each type of vehicle is given depending on the road space, speed and the effect on the traffic. Effective traffic load is calculated as:
Effective Load = (Number of vehicles × Vehicle weight)/ Passage Capacity
This guarantees that lanes that have high traffic get more priority in signal timing.

Assigned Weights:

| Vehicle Type | Weight |
|---|---|
| Car | 1 |
| Motorcycle | 0.5 |
| Truck | 2 |
| Bus | 2 |
| Bicycle | 0.3 |

d) Dynamic Signal Allocation:
The green signal is dynamically set in the range of 5 to 40 seconds by scaling formula based on the load traffic. This allows the traffic flow to be adapt efficiently.

Minimum time = 5 seconds Maximum time = 40 seconds Formula:
Green Time = MIN + (MAX − MIN) × Scaling Factor
Where:
Scaling factor is derived from normalized traffic load

2. Violation Detection Workflow

a) Red-Light Violation:
Stop-line coordinates and vehicle tracking are predefined to detect whether a vehicle crosses the stop line when on red signal.

b) Safety Violations:
The helmet detectors and three rider detectors recognize helmetless riders and/or vehicles with more than two riders.

c) Evidence Capture and Storage:
Screenshots and annotated images are stored as an evidence and for faster emergency response.

d) License Plate Recognition and E-Challan Generation:
Detection is done by means of YOLO-based detection and OCR [6]. Fuzzy matching is used to detect text and correct it. Confirmed violations leads to e-challan creation that is stored in the database and e-mail is sent to the owner of that vehicle. Redis cache system prevents duplicate challans.

3. Detection of Accident Workflow

a) Frame Analysis:
The systems uses AI models to process frames and detect accident patterns and generates a confidence score.

b) Alert Mechanism:
If the confidence is above the threshold, the alerts are sent to hospitals nearby; otherwise, it is sent to the controller module for verification.

c) Evidence Storage:
Images and screenshots are also saved as evidence to provide quicker response to emergencies.

### C. *Backend Processing*

The backend manages all logic behind traffic load computation, violation detection and accident detection as well as signal control. It provides safe, effective and scalable functionality of the system modules.

### *D. Optimization Techniques*

The system works on frame-based processing, minimal YOLOv8n models, and caching techniques to minimize redundancy, which makes it low in terms of latency and high in terms of efficiency, allowing it for real-time deployment.

### E. *Integration and Monitoring*

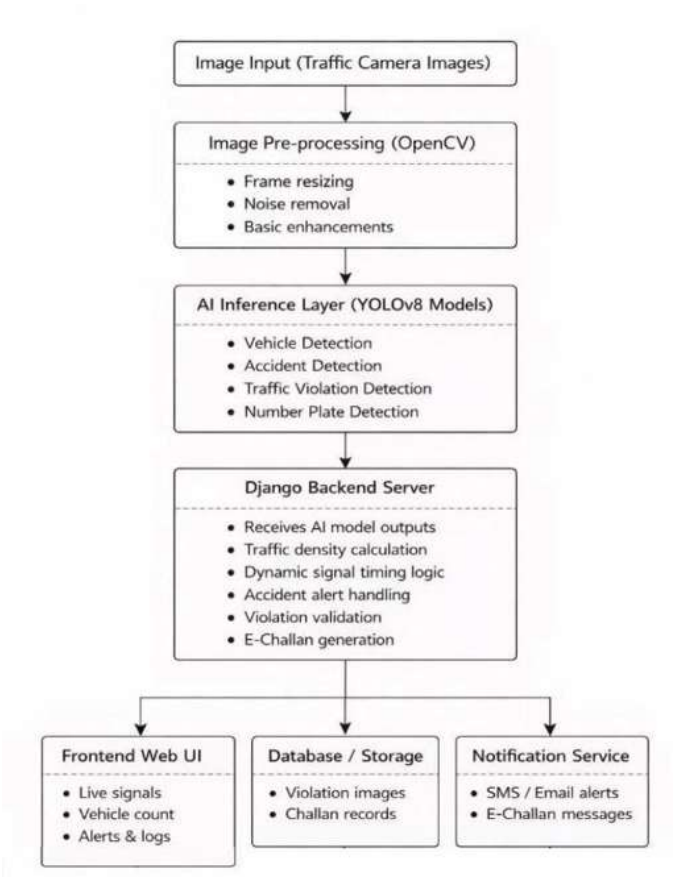
The modules such as AI models, backend logic, database, and frontend dashboard have been combined into one unified system. The frontend displays view of traffic information, violations and accidents to facilitate an automated traffic control flow that is

constantly smooth.

Fig.1 System Architecture diagram of AI – Powered Smart Automated Traffic Signal System

## VI. FUTURE SCOPE




- Integrate with real traffic signal hardware for deployment in the real world.
- Upgrade to hybrid (frame + live video) system.
- Creation of accident prediction system using advanced AI models.
- Direct connection with the ambulance and hospital systems to respond immediately.
- Scalability on cloud on a city-wide basis.
- Development of a dashboard mobile application to the traffic authorities.
- Apply edge computing to reduce the latency and enhance performance.

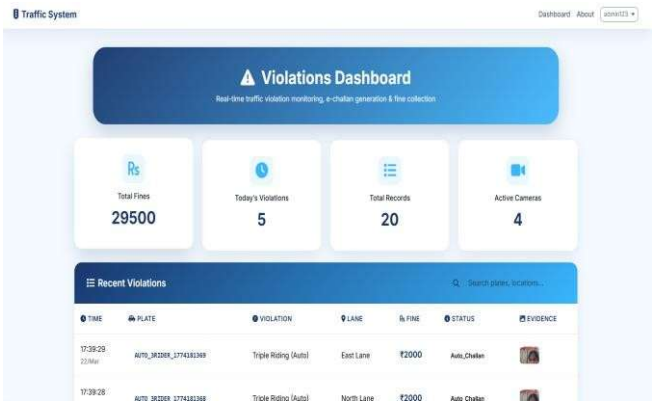
## VII. RESULTS & DISCUSSION

### *A. Key Findings*

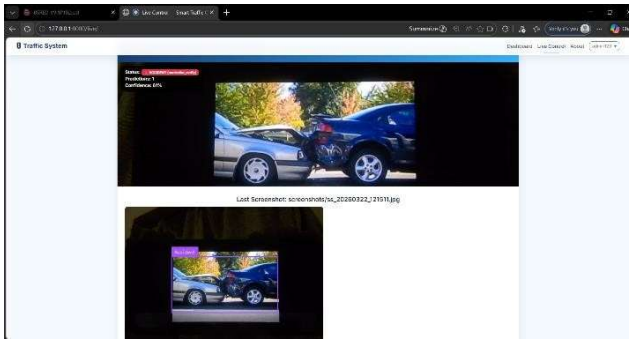
- The system manages to conduct frame-based processing of traffic to obtain real time analysis.
- Adaptive signal control facilitates in slowing down traffic congestion and waiting time.
- Proper identification of violations like red-light jumping, helmetless riding, triple riding and others.
- LPR makes possible identification and automatic enforcement of vehicles.
- E-challan system is automated to generate penalties which are quick and transparent.
- Accident detection module assists in emergency response and generation of alerts faster.
- Frame-based method consumes less computation and gives better performance.
- Caching mechanism is quite effective in stopping redundant challans.
- The combined system is more efficient than the conventional traffic systems.


1.1 Live Traffic Control Center

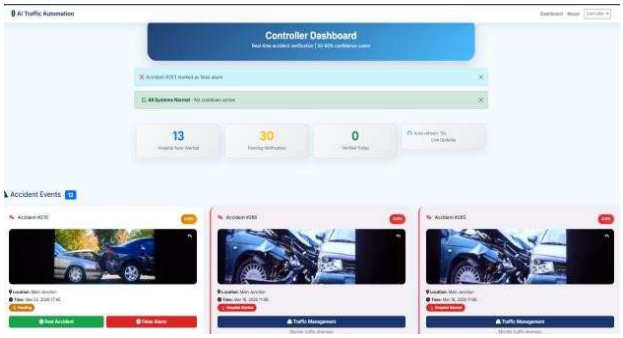
  




1.2 Violation Dashboard




1.3 Accident Monitoring Center




1.4 Controller Dashboard

### *B. Limitations and Challenges*

- The performance can be influenced during the poor weather conditions (rain, fog) or during the low light conditions.
- The quality of the camera and its position relies on accuracy.
- OCR can have a problem with blurred or illegible number plates.
- Frame-based analysis is currently being used in system and therefore very fast events can be missed.
- Needs adequate internet/network connectivity to do real time processing.
- Cameras and stop lines should be well set and calibrated.
- The detection of the accidents may require manual verification in the cases of uncertainty.

## VIII. CONCLUSION

The proposed AI-Powered Smart Traffic Management System gives a good solution to the modern traffic issues. It combines vehicle detection, dynamic signal control, violation detection and accident monitoring into one integrated system. The system improves the road safety as well as traffic flow and the automated functioning of the law enforcement by automatically generates e-challan. The feature of accident detection enhances the ability for faster emergency response.Even with the limitations associated with them, the system shows high potential for future implementation in the real world and can play a major role in the development of smart and intelligent transportation systems.

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