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EagleEye: Smart Helmet Violation System

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Abstract: *EagleEye: Smart Helmet Violation System is an artificial intelligence system designed to automatically identify helmet-related traffic violations by two-wheeler riders. The system uses computer vision and deep neural networks to process real-time video feeds from surveillance cameras to detect whether riders are wearing helmets. When a helmetless rider is identified, the system automatically scans the vehicle number plate through Automatic Number Plate Recognition (ANPR). Violation details are stored in a database and a fine notice is sent to the registered vehicle owner via email or SMS. The project integrates Helmet Detection, ANPR, Database Management, and an Automated Notification System using AI, Image Processing, and Cloud Computing, providing a scalable solution for intelligent traffic monitoring., providing a scalable solution for intelligent traffic monitoring.*

Keywords: Computer Vision, Deep Learning, YOLOv8, ANPR, Helmet Detection, Traffic Violation, OCR, Road Safety, AI-Based Surveillance

I. INTRODUCTION

In today's fast-paced world, road safety has become one of the most critical concerns for governments globally. Every year, numerous accidents occur due to traffic rule violations, especially among two-wheeler riders. Not wearing a helmet significantly increases the risk of fatal injuries. Despite strict regulations, manual monitoring is inefficient and time-consuming.

This paper presents EagleEye: Smart Helmet Violation System — an AI-based automated system capable of identifying helmetless two-wheeler riders and capturing their vehicle number plate using ANPR technology. Once a violation is detected, details are stored in a database and a notification or fine is sent to the registered owner via email or SMS. EagleEye leverages computer vision, deep learning, and image processing on real-time video feeds, contributing to intelligent traffic management in smart cities.

II. PROBLEM STATEMENT

Road safety violations such as riding without helmets have led to a significant rise in accidents and fatalities. Manual traffic enforcement is time-consuming, error-prone, and limited in coverage. Key problems addressed:

- Manual monitoring is slow, limited in coverage, and prone to human error.
- Widespread helmet violations lead to preventable fatal injuries.
- Absence of a real-time automated system to detect and report violations.
- Difficulty in maintaining violation records manually at scale.

III. OBJECTIVES

- Automatically detect whether a rider is wearing a helmet using AI.
- Capture the vehicle number plate upon violation detection.
- Extract and recognize plate number using OCR technology.
- Send instant fine notifications to registered owner via email or SMS.

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- Minimize human intervention and improve monitoring efficiency.
- Contribute toward safer roads and better traffic rule enforcement.

IV. LITERATURE SURVEY

A comprehensive literature review was conducted to understand prevailing technologies in automated traffic violation detection.

A. Helmet Detection Systems

Research employing CNN and YOLO architectures for real-time helmet detection was analyzed. These models offer high speed and accuracy. Most existing systems lack ANPR integration and automated notification — a gap this project addresses.

B. ANPR Techniques

Various OCR and image segmentation-based plate recognition methods were studied. ANPR is widely applied in vehicle tracking and toll collection, informing the implementation strategy for precise violator identification.

C. Deep Learning Models

Models including YOLOv5, Faster R-CNN, and MobileNet were reviewed. Their ability to detect objects in dynamic environments guided selection of YOLOv8 for its superior speed-accuracy balance.

D. Smart City Systems

Smart city implementations using IoT sensors, CCTV analytics, and cloud management for traffic enforcement were explored. EagleEye combines automated detection with immediate notification in a unified platform.

E. Privacy and Ethics

Literature on data privacy, secure storage, and legal compliance for public surveillance shaped the development of EagleEye as an ethically responsible system.

V. METHODOLOGY

A. Data Collection

A large dataset of two-wheeler rider images and video frames was collected under varying lighting, weather, and traffic conditions, capturing both helmet-wearing and helmetless riders along with vehicle number plates.

B. Data Preprocessing

Images were resized, noise removed, and annotated for helmet/no-helmet classification and number plate marking. Data was split into training and test sets with augmentation applied.

C. Helmet Detection

YOLOv8 detects the rider head region and classifies helmet presence in real time. Frames without helmets are flagged as violations and coordinates are passed to the ANPR module.

D. Number Plate Recognition

The ANPR module extracts the plate region and applies OCR via the Plate Recognizer API to read the alphanumeric plate number accurately for database storage.

E. Database Management

Violation records including image, date, time, plate number, and location are stored in Firebase Firestore. Firebase Realtime Database manages user account information.

F. Notification System

PDF fine notices generated by ReportLab are dispatched via smtplib email. Each notice carries a unique notice ID and timestamp for full traceability.for full traceability.

G. Integration and Testing

All modules are integrated into a single pipeline and tested under real-time conditions for high detection accuracy, processing speed, and reliable inter-module communication.

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VI. SYSTEM WORKFLOW

- Step 1: Surveillance camera captures continuous real-time traffic footage.
- Step 2: YOLOv8 analyzes each video frame for helmet violations.
- Step 3: ANPR module triggered to extract number plate on violation.
- Step 4: Violation details stored in Firebase (image, plate, date, time, location).
- Step 5: System emails PDF fine notice to registered vehicle owner.
- Step 6: Admin Dashboard allows authorized personnel to view all records.

VII. TECHNOLOGIES USED

A. GUI — PyQt5

PyQt5 provides all windows and widgets. QThread handles background processing, QStackedWidget enables multi-tab navigation (Home, Reports, Upload, Profile, Processing), and QTableWidget displays the violation records in the Reports tab, while a custom DatabaseStatusWidget renders live violation cards in the Processing tab..

B. AI/ML — YOLOv8 and OpenCV

Two YOLOv8 instances handle motorbike detection and helmet/plate detection respectively. OpenCV manages video capture and preprocessing. NumPy handles image array operations.

C. OCR — Plate Recognizer API

The Plate Recognizer cloud REST API reads Indian license plates from cropped images with high accuracy via HTTP POST requests.

D. Backend — Firebase

Firebase Firestore stores confirmed violations with embedded PDF fine notices. Firebase Realtime Database manages user accounts including name, email, username, and phone.

E. Reporting — ReportLab and smtplib

ReportLab generates PDF fine notices with violation images. smtplib sends these notices via email. A custom notice ID generator combining date, plate reference and a random suffix produces unique traceable identifiers in the format MH-TRF-YYYYMMDD-XXXXXX

VIII. RESULTS AND OUTPUT SCREENSHOTS

The EagleEye system was implemented and tested with real traffic video footage. All seven output screenshots are shown below:

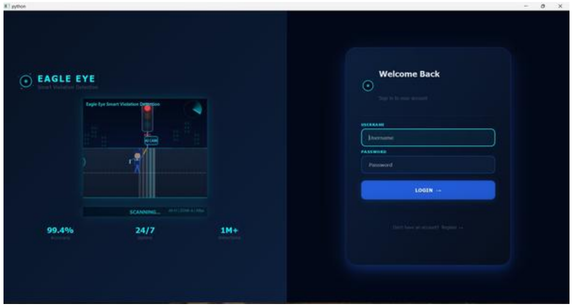
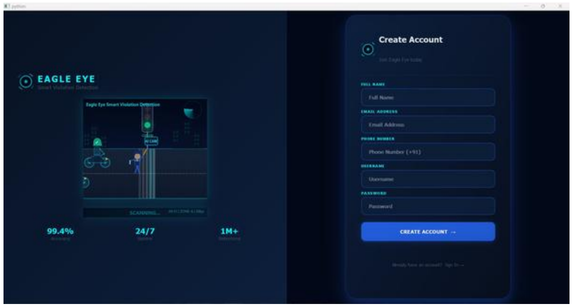


Fig. 1.*Fig. 1. Login Screen — secure authentication with animated AI surveillance scene*


EAGLE EYE
Smart Violation Detection
Eagle Eye Smart Violation Detection
SCANNING...
99.4%
24/7
1M+

Create Account

FULL NAME
Full Name

EMAIL ADDRESS
Email Address

PHONE NUMBER
Phone Number (+91)

USERNAME
Username

PASSWORD
Password

CREATE ACCOUNT →

Fig. 2.*Fig. 2. Registration Screen — user account creation with full details form*

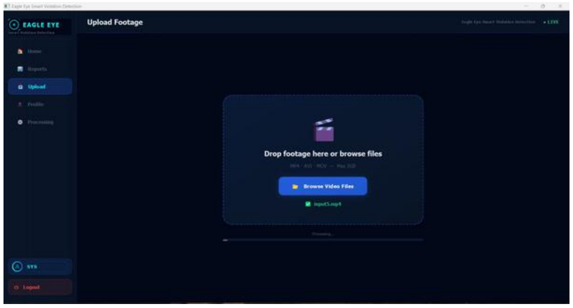


Fig. 3.*Fig. 3. Upload Footage Screen — supports MP4/AVI/MOV files up to 2 GB*

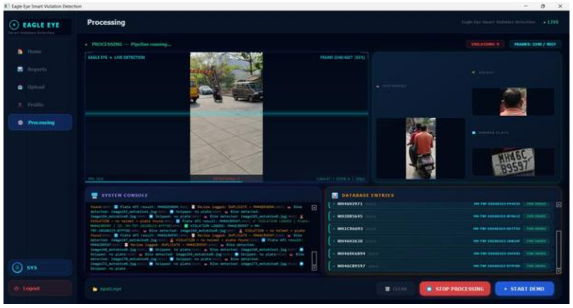
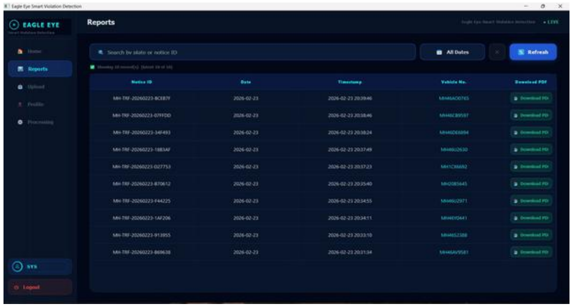


Fig. 4.*Fig. 4. Live Processing — 9 violations detected, plate MH46CB9597 recognized at 29.9 FPS*



Notice ID	Date	Timestamp	Vehicle No.	Download PDF
MH-TRF-20260223-8CEB7F	2026-02-23	2026-02-23 20:39:46	MH46AD0765	Download PDF
MH-TRF-20260223-07FFDD	2026-02-23	2026-02-23 20:38:46	MH46CB9597	Download PDF
MH-TRF-20260223-34F493	2026-02-23	2026-02-23 20:38:24	MH46DE6894	Download PDF
MH-TRF-20260223-1883AF	2026-02-23	2026-02-23 20:37:49	MH46U2630	Download PDF
MH-TRF-20260223-027753	2026-02-23	2026-02-23 20:37:23	MH1CX6692	Download PDF
MH-TRF-20260223-870612	2026-02-23	2026-02-23 20:35:40	MH20BS645	Download PDF
MH-TRF-20260223-F44225	2026-02-23	2026-02-23 20:34:55	MH46U2971	Download PDF
MH-TRF-20260223-1AF206	2026-02-23	2026-02-23 20:34:11	MH46Y0441	Download PDF
MH-TRF-20260223-913955	2026-02-23	2026-02-23 20:33:10	MH46S2388	Download PDF
MH-TRF-20260223-869638	2026-02-23	2026-02-23 20:31:34	MH46AV9581	Download PDF

Fig. 5.*Fig. 5. Reports Dashboard — 18 violation records with Notice ID, Timestamp and PDF download*

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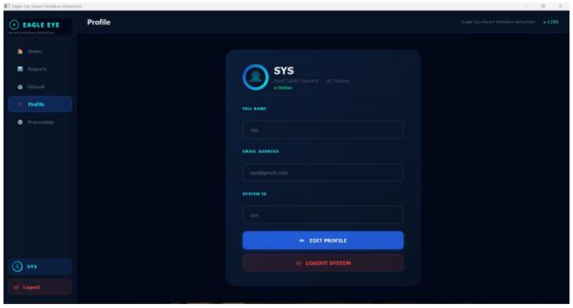
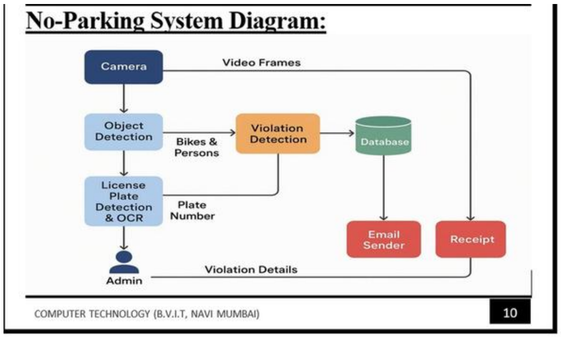


FULL NAME: sys

EMAIL ADDRESS: sys@gmail.com

SYSTEM ID: sys

Fig. 6.*Fig. 6. User Profile Screen — Road Safety Operator account management*


No-Parking System Diagram:

COMPUTER TECHNOLOGY (B.V.I.T, NAVI MUMBAI) 10

Fig. 7.*Fig. 7. System Block Diagram — Camera to Database to Email/Receipt pipeline*

IX. SYSTEM REQUIREMENTS

A. Hardware

- Laptop/PC — Minimum 8 GB RAM, Intel i5 or higher processor
- Camera/CCTV — for live traffic video input at monitored zones
- Internet Connection — for API calls and email notification delivery

B. Software

- Python 3.x — Primary programming language
- Libraries: OpenCV, NumPy, TensorFlow/PyTorch, Ultralytics YOLOv8, PyQt5
- Firebase Admin SDK and Pyrebase for database management
- IDE: VS Code; ReportLab for PDF fine notice generation

X. ADVANTAGES AND DISADVANTAGES

A. Advantages

- Fully automated detection eliminates need for continuous manual surveillance.
- Real-time processing at 29.9 FPS ensures no violation is missed.
- Instant e-challan PDF generation and automated email dispatch to violators.
- Centralized searchable database with 18+ records and PDF download support.
- Scalable modular architecture suitable for smart city-wide deployment.

B. Disadvantages

- High initial cost for camera infrastructure installation and maintenance.
- Requires stable internet for API calls and email notification delivery.
- Public camera surveillance raises data privacy and ethical concerns.
- Detection accuracy may reduce in poor lighting or adverse weather.

- Coverage limited to areas where cameras are installed only.

XI. FUTURE SCOPE

- Extension to detect triple riding, signal jumping, and seatbelt violations.
- Integration of Edge AI and 5G for lower-latency real-time processing.
- Cloud-based analytics for city-wide violation pattern analysis.
- Mobile app for citizen violation history and online fine payment.
- Direct integration with RTO database for automated owner lookup.
- Deployment in smart city traffic control infrastructure nationwide.

XII. CONCLUSION

This paper presented EagleEye: Smart Helmet Violation System, an AI-driven automated system that addresses the inefficiency of manual traffic enforcement. The system successfully detects helmetless two-wheeler riders using YOLOv8, extracts vehicle number plates via ANPR and OCR, stores records in Firebase, and dispatches automated PDF fine notices by email. Testing demonstrated reliable detection at 29.9 FPS with 9 violations detected in a single session and 18 total records maintained.

EagleEye significantly reduces the workload on traffic authorities while improving accuracy and transparency. The modular design allows future extension to additional violations. By integrating AI, IoT, and cloud data management, EagleEye is an efficient, scalable, and future-ready solution for smart city traffic management and improved road safety.

ACKNOWLEDGMENT

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