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Traffic Eye: A Literature Survey on AI-Powered Traffic Rules Violation Detection System

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Abstract: *The growing number of vehicles on urban roads has turned traffic management and road safety into a pressing challenge. Manual methods of spotting violations are still common, but they tend to be slow, inconsistent, and unable to keep pace with heavy traffic conditions. Recent advances in Artificial Intelligence (AI), Machine Learning (ML), and computer vision provide an opportunity to design smarter, automated solutions for this problem. This work introduces a system that uses the YOLO object detection model to identify traffic rule violations such as speeding, running red lights, and triple riding. To track offenders, Easy OCR is applied for reading vehicle license plates directly from video frames. By bringing together object detection and OCR, the system cuts down on human involvement, lowers the chance of mistakes, and allows for quicker enforcement actions. The approach is intended not only to support authorities in monitoring but also to encourage disciplined driving, making roads safer and traffic management more reliable.*

Keywords: *Traffic Management, Artificial Intelligence (AI), Object Detection, License Plate Recognition (OCR), Road Safety.*

I. INTRODUCTION

The rapid growth of urban environments has led to a dramatic increase in the number of vehicles on the road, raising important concerns about road safety and efficient traffic management. Common infractions such as speeding, running red lights, and improper lane usage disrupt traffic flow and are major contributors to road accidents and congestion. Conventional traffic monitoring methods still depend largely on manual observation, which is not only labour-intensive but also susceptible to human error and increasingly infeasible as traffic volumes escalate.

Recent advances in Artificial Intelligence (AI), Machine Learning (ML), and smart surveillance technologies are driving a transition toward automated traffic rule enforcement. Modern computer vision algorithms now make it possible to analyse video streams in real time, enabling accurate identification of traffic violations without direct human involvement.

Notably, the YOLO (You Only Look Once) object detection framework has demonstrated the ability to rapidly and reliably detect vehicles and various infractions within traffic scenes. Furthermore, Easy OCR technology enhances these systems by automating license plate recognition, which is critical for identifying and penalizing offenders with speed and precision.

This project introduces an integrated approach to real-time traffic violation monitoring using object detection, optical character recognition, and live video analysis. The goal is to empower traffic authorities to supervise road conditions more effectively, alleviate the workload of manual enforcement, and facilitate prompt action against rule-breakers. By merging automated intelligence with detailed video analytics, the proposed system promotes safer driving habits, decreases accident risks, and plays a vital role in developing secure and efficient urban roads.

II. LITERATURE SURVEY

The literature reviewed spans a diverse set of methodologies and technologies applied in the field of emotion recognition. In [1] Malik et al. proposed a computer vision-based framework for automatic detection of traffic violations using deep learning to monitor vehicles in real time. The system integrates YOLOv3 with Darknet-53 for vehicle detection and classification, while OpenCV and a custom GUI facilitate video processing and user interaction. It is capable of identifying violations like red-light jumping, speeding, and lane changing by tracking vehicle movement through bounding boxes that change color when infractions occur. The model further estimates vehicle speed using frame analysis and monitors in/out traffic flow across city limits, providing both violation records and video evidence to support enforcement. Implemented in TensorFlow and Python, the framework demonstrated reliable detection performance but requires GPU acceleration for real-time scalability. Its main contribution lies in extending traffic monitoring beyond single-rule detection to multi-violation tracking, though future integration of license plate recognition is suggested to enhance robustness in real-world deployment

In [2] Irani et al. proposed a machine learning-based traffic violation detection system aimed at automating law enforcement in urban settings. The framework applies Convolutional Neural Networks (CNNs) in TensorFlow to detect vehicles, identify helmet usage, and recognize license plates through Tesseract OCR. A Turner-based interface enables traffic officers to monitor live CCTV footage and record violations in real time. The system achieved around 93% accuracy in motorcycle classification, 85% in helmet detection, and 51% in license plate recognition, yielding an overall performance of about 75%. By reducing reliance on manual monitoring, the model enhances efficiency in identifying signal and helmet violations. However, its accuracy is limited by poor image quality and OCR performance, indicating the need for larger datasets and advanced vision methods. The work contributes a practical, real-time computer vision solution for urban traffic management.

In [3] Patil et al. designed a smart system to detect traffic rule violations by leveraging advanced computer vision and machine learning methods aimed at improving road safety. The system uses YOLOv5 for real-time detection of objects, Easy OCR for recognizing license plates, and OpenCV for processing images. This combination enables the system to accurately identify common infractions such as riding without a helmet or not wearing seat belts. Detected violations are automatically recorded on an administrative dashboard, and offenders receive timely email notifications via the SMTP protocol. Experimental evaluations showed that the system effectively detects violations and extracts vehicle information with high accuracy. This approach stands out by integrating detection, reporting, and notification into a seamless workflow, making it scalable for practical use. However, the system's performance under varying traffic and environmental conditions requires further enhancement to support widespread adoption.

In [4] Revadala et al. developed an Intelligent Traffic Management System featuring multiple AI-powered modules for improved urban traffic control. This system detects helmet use, monitors traffic signal breaches, recognizes license plates, tracks mobile phone use, and sends GPS alerts to nearby police stations. By leveraging machine learning and computer vision, it performs real-time violation monitoring and communicates results instantly to authorities. The ITMS demonstrated impressive reliability, with its accuracy, precision, and recall exceeding 93% in various tests. Its holistic approach solves several road safety issues in one integrated application. The unified pipeline design enables seamless detection, tracking, and reporting, boosting utility for smart cities. Despite strong results, the system's widespread adoption faces challenges relating to cost, infrastructure, and scalability. Addressing these limitations remains vital for successful, large-scale deployment of ITMS.

In [5] Maduri et al. proposed a deep learning-based framework for automatic detection of helmet and seat belt violations to improve road safety compliance. The system utilizes YOLO object detection integrated with OpenCV and Raspberry Pi hardware, enabling real-time surveillance at highway checkpoints. Convolutional Neural Networks (CNNs) were trained on locally collected datasets to enhance robustness under varying traffic conditions, achieving more than 90% detection accuracy. The model automatically captures images of violators and stores them in a secure database accessible only to authorized officials, ensuring transparency in enforcement. Unlike traditional manual policing, the system minimizes human error and negligence while providing continuous monitoring for high-speed vehicles. Its key contribution lies in offering a cost-effective and unbiased method for large-scale safety rule enforcement. However, the need for larger datasets and further scalability improvements highlights directions for future research.

In [6] Charran and Dubey proposed an AI-driven framework for automated detection and ticketing of two-wheeler traffic violations in Indian road conditions. The system employs YOLOv4 with Deep SORT for detecting and tracking violations such as helmet absence, phone usage, triple riding, wheeling, and illegal parking, while YOLOv4 with Tesseract OCR is used for license plate recognition. A custom dataset was developed and tested, achieving a mean average precision of 98.09% for violation detection and 99.41% for license plate recognition. Real-world experiments across live video feeds validated its robustness, successfully capturing 83 of 93 violations with zero false positives. Unlike earlier works that focused on isolated tasks, this study delivers an end-to-end pipeline integrating both detection and automated ticketing. Its key contribution lies in offering high precision and real-time scalability, making it suitable for dense urban environments. Overall, the work represents a significant step toward AI-enabled smart traffic enforcement and road safety.

In [7] Jain et al. proposed a machine learning-based real-time traffic control system designed to mitigate urban congestion through computer vision and intelligent monitoring. The framework employs YOLOv4 for detecting and classifying vehicles such as cars, bikes, and trucks, while Easy OCR is utilized for license plate recognition. A dataset of over 500 labelled images was trained using transfer learning on Google Collab, enhancing detection accuracy. Beyond vehicle identification, the system also counts vehicles by category and analyses traffic density to provide insights into congestion patterns at different locations. Experimental results demonstrated effective real-time monitoring, enabling authorities to assess and redirect traffic flow. Its novelty lies in combining detection, classification, and density analysis within a single system for traffic control.

Nonetheless, challenges such as blurred license plates and short-range detection limit its robustness. Future extensions include integration with advanced congestion management strategies and adaptive traffic signal optimization for smart city applications.

In [8] Yadav et al. proposed an anomaly detection framework for traffic scene surveillance that leverages unsupervised learning to identify irregular driving behaviours. The system applies trajectory-based spatial-temporal analysis in combination with K-means clustering, PCA, linear regression, Z-score analysis, and Hierarchical Temporal Memory (HTM) to distinguish between normal and abnormal traffic patterns. Anomalies are categorized into point, sequential, and co-occurrence types, allowing detection of violations such as wrong-side driving, illegal turns, and abrupt lane changes. Feature extraction from video surveillance data enables clustering of object trajectories, thereby separating routine from anomalous behaviours. While linear regression and Z-score approaches aided initial analysis, they proved less effective for high-dimensional traffic data. The study's key contribution lies in demonstrating the scalability of clustering-based unsupervised learning for real-time anomaly detection, though improvements are needed to address complex urban traffic scenarios.

In [9] Abishek et al. presented an intelligent framework for traffic violation detection and vehicle number plate recognition using computer vision techniques. The system employs YOLO-based object detection models with SORT tracking to monitor vehicle behaviour and identify violations such as red-light jumping and triple riding. Optical Character Recognition (OCR) is integrated for license plate extraction, enabling offender identification and supporting enforcement actions. A large, labelled dataset of traffic scenarios was used for training and validation, ensuring robust performance across varied conditions. Experimental evaluation reported low training and testing loss, demonstrating efficient and reliable detection in real time. The system also generates violation reports, thereby assisting law enforcement in enhancing road safety monitoring. Its main contribution lies in combining violation detection with license plate recognition into a unified framework.

In [10] Avupati et al. (2023) proposed a traffic violation detection system that leverages YOLOv5 and Haar Cascade to automate the identification of common infractions such as riding without helmets, triple riding, phone usage while driving, and over-speeding. The framework employs YOLOv5 for object detection and integrates Haar Cascade with dib for vehicle tracking and speed estimation, supported by a custom dataset labelled using MakeSense.ai. Experimental evaluation demonstrated strong results, with precision-recall and mAP scores indicating high accuracy, including 0.995 for triple riding detection. Violations are visualized in real time using bounding boxes and speed indicators, enabling efficient monitoring across both image and video inputs. The system's contribution lies in its scalability and effectiveness in handling multiple types of violations simultaneously. However, challenges remain in distinguishing helmets from visually similar objects and addressing varied camera perspectives. Future extensions include license plate recognition and enhanced multi-violation tracking to strengthen real-world applicability.

A. Summary of Literature Survey

From the reviewed studies, it is clear that research on traffic violation detection has gone through several stages of development. Early attempts were mostly based on anomaly detection methods, such as clustering vehicle movements or analysing driving trajectories. While useful at the time, these techniques did not always deliver reliable accuracy. With the rise of deep learning, especially CNNs and the YOLO family of models, detection became far more effective. Researchers began targeting specific violations like riding without helmets, ignoring seat belts, speeding, or crossing signals. More recent work has focused on combining detection with supporting technologies. More recent work has focused on combining detection with supporting technologies. For instance, OCR has been applied to read number plates automatically, while tracking algorithms such as SORT or Deep SORT make it possible to follow vehicles across video feeds. Some studies even went further, linking detection directly with automated ticketing and real-time notifications.

B. Table of Summary

Paper No.	Title	Authors	Techniques Used	Focus Area	Remarks	Limitations
[1]	Framework for Automatic Detection of Traffic Violations	Malik et al. (2021)	YOLOv3, Darknet-53, OpenCV, TensorFlow, Python	Multi-rule violation detection (red-light, speeding, lane changing)	Extends monitoring beyond single rule; provides video evidence	Requires GPU acceleration; lacks license plate recognition

[2]	Machine Learning Based Traffic Violation Detection System	Rani et al. (2023)	CNNs (TensorFlow), Tesseract OCR, Tkinter GUI	Helmet detection, vehicle classification, license plate recognition	Real-time monitoring with officer interface	Limited by image quality; OCR accuracy only 51%
[3]	Traffic Rule Violation Detection System	Patil et al. (2024)	YOLOv5, Easy OCR, OpenCV, SMTP	Helmet/seat belt detection, automatic notification	Unified pipeline with detection + reporting	Needs optimization for diverse traffic conditions
[4]	Efficient Intelligent-Based Compliance, Detection, Tracking, and Proximity Model	Revadala et al. (2024)	ML, CV, OCR, GPS integration	Multi-rule compliance (helmet, signals, phone usage, proximity alerts)	Holistic design covering multiple safety challenges	High cost, infrastructure, and scalability issues
[5]	Seat Belt and Helmet Detection Using Deep Learning	Maduri et al. (2021)	YOLO, CNNs, OpenCV, Raspberry Pi	Real-time helmet/seat belt detection	Cost-effective and unbiased enforcement	Needs larger datasets; limited scalability
[6]	Two-Wheeler Vehicle Violations Detection & Automated Ticketing	Charran & Dubey (2022)	YOLOv4, Deep SORT, Tesseract OCR	Helmet absence, triple riding, illegal parking, automated ticketing	High accuracy (mAP ~98%); robust in real-world	Dataset and deployment limited to Indian conditions
[7]	ML-Based Real-Time Traffic Control System	Jain et al. (2021)	YOLOv4, Easy OCR, Transfer Learning	Vehicle classification, density analysis	Combines detection+ congestion analysis	Struggles with blurred plates, short-range detection
[8]	Detection of Anomalies in Traffic Scene Surveillance	Yadav et al. (2018)	K-means, PCA, Regression, Z-score, HTM	Anomaly detection (illegal turns, wrong-side driving)	Uses unsupervised clustering for traffic anomalies	~80% accuracy; less effective for high-dimensional data
[9]	Detection of Traffic Violation & Vehicle No. Plate	Abishek et al. (2024)	YOLO+SORT tracking, OCR	Identifies violations and extracts license plate data	Streamlined system for detection and documentation	Weather and low image quality hinder accuracy
[10]	Traffic Violation Detection via YOLO & Haar Cascade	Avupati et al. (2023)	YOLOv5, Haar Cascade, dlib, MakeSense.ai	Helmet use, triple riding, phone usage, speeding High precision	easily adaptable	Difficulty with helmet recognition and varied viewing angles

III. CONCLUSIONS

In today's experience-driven market, simply offering quality products is no longer enough understanding how customers truly feel has become just as important. This paper explored various research efforts that use artificial intelligence and facial expression recognition to decode human emotions in retail settings. From analysing subtle facial muscle movements to interpreting textual feedback, these systems provide a deeper, more natural understanding of customer satisfaction.

Through our study and literature review, it is evident that real-time emotion recognition powered by Convolutional Neural Networks (CNNs), Viola-Jones face detection, and other machine learning methods offers a powerful alternative to traditional feedback systems.

These technologies are capable of capturing honest, unbiased emotional responses without requiring verbal input from the customer. They reduce the reliance on manual surveys and help businesses gain faster, data-driven insights into customer preferences and reactions. Ultimately, this paper supports the growing shift toward affective computing—where machines don't just process data, but understand feelings. By integrating such emotion-aware systems into customer experience strategies, businesses can not only improve satisfaction but also build stronger, more empathetic relationships with their users.

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