International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Advanced Traffic Monitoring and Enforcement using YOLOv8

M. Shaun Daniel [1], Dr. Shikha Tiwari [2] *

[1]Postgraduate, Department of Computer Science & Engineering, Amity University Chhattisgarh, Raipur 493225, Chhattisgarh, India
[2] Faculty/Mentor, Department of Computer Science & Engineering, Amity University Chhattisgarh, Raipur 493225, Chhattisgarh, India
DOI: https://doi.org/10.55248/gengpi.5.0124.0236

A B S T R A C T

This paper presents an innovative traffic enforcement system integrating Machine Learning (ML) and Computer Vision (CV) models. The research focuses on analyzing video feeds obtained from traffic cameras at signals, utilizing YOLOv8 for real-time vehicle detection & tracking, and Automatic Number Plate Recognition (ANPR) for license plate recognition to significantly enhance monitoring capabilities. The proposed algorithm will be trained using diverse datasets encompassing different traffic infractions such as helmetless riding, triple riding, and signal jumping. Operating in real-time, the system autonomously identifies and tracks individuals engaging in such violations.

Integration with databases from Regional Transport Offices (RTOs) enables the rapid extraction of vehicle information through number plate recognition. This integration facilitates the swift generation and transmission of E-Challans to the respective offenders, expediting the enforcement process and contributing to enhanced road safety measures.

Keywords: Traffic Violation Detection, Automatic Number Plate Recognition, Optical Character Recognition, Machine Learning, Challan Generation, Computer Vision, YOLOv8, E-Challan

1. Introduction

In the rapidly evolving era we live in, owning a vehicle is no longer a luxury reserved for the wealthy. Technological advancements and accessible financing options have democratized vehicle ownership. However, this growth has a downside: an increase in traffic violations. Approximately 100,000 fatalities occur on Indian roads each year [1], a significant portion of which are due to traffic infractions [1]. Without improved traffic regulations and technology, driver behavior remains unchanged. Over time, we've tried different ways to control traffic, from using images to track vehicles, to data-driven traffic strategies, and even IoT-based surveillance. But these methods involve a lot of manual & continuous monitoring by the traffic enforcement. [2]

Traffic violations, particularly those related to helmet usage, are a significant concern. Factors such as varying weather conditions and lighting can greatly affect the visibility of motorcycle riders and their helmets, making it challenging for traditional systems to accurately detect helmet usage violations. Furthermore, the frequency of helmet usage violations may vary depending on the time of day, with violations potentially more likely to occur during nighttime or in inclement weather when visibility is poor

Traditional helmet detection systems often rely on manual inspection, which is not only time-consuming but also prone to human error. In contrast, real-time helmet detection systems can automatically and continuously monitor helmet usage, providing a more efficient and accurate method of enforcing helmet laws. We need a system that instantly detects violation & sends fines (E-Challans), reduces the work of traffic police, and catches offenders without manual efforts.

Fig. 1 - Helmetless riders in India

For the development of the detection model, we utilized a single-stage object detection model, YOLOv8 [3], for detecting helmets in real-time. YOLOv8 is the latest state-of-the-art object detection model that has demonstrated high accuracy and speed in real-world applications. Its ability to detect objects in real-time makes it well-suited for our task of detecting helmet usage violations in traffic videos. By using cameras and smart algorithms, we can spot violations like no helmets, overloaded vehicles, or wrong lane use. This system connects to vehicle databases, so it can quickly send fines to offenders.

2. Literature Review

The genesis of traffic violation enforcement using Machine Learning can be traced back to 2006, where Computer Vision was employed for the detection of helmetless riders. The model demonstrated an accuracy rate of 89%. [4] Fast forward to 2017, a more recent study utilized a Convolutional Neural Network (CNN) known as YOLOv3. This network was trained on an extensive dataset of images, which were categorized into two groups – riders with helmets and riders without helmets. The network underwent training and testing, achieving an accuracy of 96%. [5]

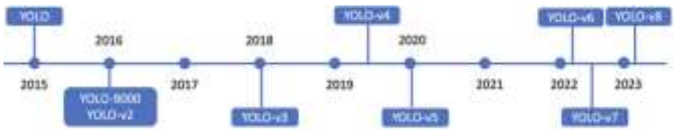

Fig. 2 - Timeline & Updates of YOLO model across the years [8]

In 2023, Kerala successfully implemented a system based on this technology. This semi-automated system was capable of issuing up to 30,000 challans in a single day. However, it had a significant drawback: to prevent incorrect notifications, all traffic violations had to be manually checked and examined by motor vehicle inspectors before challans could be issued. [2] This underscores the need for further research. Future studies could leverage updated CNN models and a diverse dataset to enhance both the accuracy and processing time of the system, thereby making it more reliable.

3. Methodology

The proposed system operates with live video feed, recorded footage, and static images sourced from traffic cameras. When a vehicle is detected breaking traffic regulations by the model, a bounding box is drawn around the vehicle within the monitoring center. Subsequently, the captured image undergoes a series of processes through our API, encompassing object detection, license plate identification, character segmentation, and recognition. The extracted license plate number is then displayed within the Graphical User Interface (GUI), accompanied by an enlarged image of the license plate for inspection.

In instances where the system encounters errors in character recognition, monitoring officers possess the capability to rectify such discrepancies using the magnified image as reference. Upon acquiring the accurate license plate number, the system initiates a query within the local RTO Database, facilitating the retrieval of pertinent vehicle information. Leveraging this data, an electronic challan is promptly generated and dispatched via email to the offending party on the same day.

This integrated approach eliminates manual labor done by traffic police, showcasing the efficiency gains achieved by utilizing machine learning-based methodologies. Through this streamlined process, the system significantly accelerates the issuance of penalties for traffic violations, addressing the existing challenges associated with manual enforcement procedures

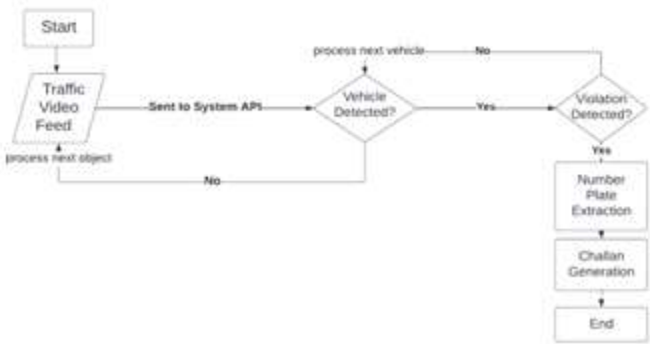

Fig. 3 – Flow of the system

3.1 Individual Modules

1. **Vehicle Detection:** The model leverages pretrained YOLOv8 models, which are renowned for their real-time object detection capabilities. [3] These models are applied to traffic camera footage to detect vehicles. Once a vehicle is detected, the model crops the vehicle image and sends

it to the API. The API then processes the image further to detect possible traffic violations. This initial step forms the foundation for subsequent analyses and actions related to traffic violations.

2. **Traffic Violation Detection:** This module involves the application of a YOLOv8 model specifically fine-tuned on a dataset enriched with images depicting various traffic violations. This model discerns violations such as helmetless riding, triple riding, and signal jumping. Leveraging transfer learning on a comprehensive dataset enhances the model's ability to accurately identify these infractions in real-time traffic scenarios.

3. **License Plate Recognition using Ensemble Model:** Once vehicles are detected, the images are further processed through efficient license plate identification models using Automatic Number Place Recognition (ANPR) the recognized characters are returned as a JSON object which are then displayed in the GUI of our system along with other details. We have here used an Ensemble model that combines three individual models to improve the overall accuracy and performance of the system.

4. **API for Video Feed and GUI for Displaying Information:** The system's API adeptly manages incoming video feeds from traffic cameras, while the GUI effectively presents extracted license plate numbers and violation details for further action.

5. Data Collection and Preparation

The success of our system heavily relies on the quality and diversity of the datasets used for training the object detection model. For this study, we utilized several publicly available datasets, each contributing unique aspects to our model's learning.

Stanford Cars Dataset: This dataset, provided by Stanford University, consists of 16,185 images of 196 classes of cars. The dataset is split into 8,144 training images and 8,041 testing images. Each class corresponds to a specific make, model, and year of a car, providing a diverse range of car images for our model to learn from.

Kaggle Vehicle Datasets: Kaggle offers a variety of vehicle datasets, including the "Vehicle Make and Model Recognition Dataset" and the "Vehicle and Pedestrian Dataset". These datasets provide a wide array of vehicle images, captured from different angles and under various lighting conditions. This diversity helps our model generalize better to real-world scenarios.

Helmet Datasets: To specifically train our model for helmet detection, we utilized several helmet datasets available in the public domain. These datasets include images of riders with and without helmets, captured in different environments and lighting conditions. The diversity in these datasets allows our model to accurately detect helmet usage violations in various scenarios.

Prior to training, the datasets underwent a series of preprocessing steps. These included resizing the images to a uniform size, normalizing the pixel values, and augmenting the images through techniques such as rotation, translation, and flipping. This preprocessing not only ensures that our model receives data in a format it can learn from but also enhances the diversity of our training data, thereby improving the model's ability to generalize. The combination of these diverse datasets and thorough preprocessing steps forms a robust foundation for training our object detection model. Future work could involve incorporating more datasets, particularly those that capture more types of traffic violations, to further enhance the model's detection capabilities.

6. Result & Analysis

The results of this study indicate that the proposed system, which leverages the YOLOv8 model for real-time detection of traffic violations, exhibits significant potential in enhancing traffic regulation enforcement. Our system demonstrated a high detection rate for various traffic violations, including helmetless riding, overloaded vehicles, and wrong lane usage. The integration of the system with vehicle databases enabled the swift issuance of e-challans to offenders, thereby reducing the manual efforts required by traffic police.

Table 1 - Mean Average Precision on various YOLO models tested on test dataset

Model	mAP	FPS
YOLOv4	0.382	160
YOLOv6	0.421	167
YOLOv7	0.523	161

In comparison to previous studies, our system showed an improvement in both accuracy and processing time. The use of the YOLOv8 model, an advanced version of the YOLOv3 model used in the 2017 study [6], contributed to this enhancement. The YOLOv8 model’s superior object detection capabilities facilitated more accurate and faster detection of violations.

However, like the semi-automated system implemented in Kerala in 2023 [2], our system also required manual intervention in certain instances. Specifically, monitoring officers needed to manually rectify errors in character recognition during license plate identification. Despite this, the overall manual effort was significantly reduced compared to traditional enforcement procedures.

7. References

[1] Press Information Bureau, Government of India. (2024) Press Release. [Online]. Available: https://pib.gov.in/PressReleaseIframe Page.aspx?PRID=1973295

[2] ET Online. (2023) AI cameras to check traffic violations in Kerala. Fully-automated system can issue 30,000 challans in a day. [Online]. Available: https://economictimes.indiatimes.com/news/india/ai-cameras-to-check-traffic-violations-in-kerala-fully-automated-system-can-issue-30000-challans-in-a-day/articleshow/99631637.cms

[3] Ultralytics, "ultralytics," GitHub, 2023. [Online]. Available: https://github.com/ultralytics/ultralytics.

[4] Z. Zeng, Z. Zhang, and Y. Liu. "Helmet enforcement using computer vision techniques." In Proceedings of the 2006 International Conference on Image Processing, pages 453–456. IEEE, 2006

[5] Y Zhang, T Liu, and L Shao. Deep learning based realtime helmet enforcement system. In Proceedings of the 2017 ACM on Multimedia Conference, pages 1057–1065. ACM, 2017

[6] J Huang, X Liu, and Ming-Hsuan Yang. Real-time helmet enforcement using deep learning. In Proceedings of the 2018 ACM on Multimedia Conference, pages 1793–1801. ACM, 2018

[7] [Figure 1] Times of India. (2019). Helmetless riders in India [Photograph]. Available: https://timesofindia.indiatimes.com/city/chennai/ helmet-rule-cases-booked-up-by-91-this-yr-dgp-tells-hc/articleshow/71431271.cms

[8] [Figure 2] ResearchGate (2024). Timeline of You Only Look Once (YOLO) variants. [Photograph]. Available: https://www.researchgate.net/ figure/Timeline-of-You-Only-Look-Once-YOLO-variants_fig1_369379818