JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

IMPACT OF AI&ML IN REAL-TIME TRAFFIC VIOLATION DETECTION

[1] Nanda M B, [2]Yashaswini GS, [3]Likhitha M, [4]Tamil selvi, [5]Hrishab N

[1] Assistant Professor [2,3,4,5] UG Students
Department of Artificial Intelligence and Machine Learning
Sri Krishna Institute of Technology, Bengaluru, Karnataka, India

Abstract: The integration of Artificial Intelligence (AI) and Machine Learning (ML) in real-time traffic violation detection has revolutionized road safety, providing automated solutions for law enforcement. This study develops a system to detect motorbike riders not wearing helmets and identify their license plates using advanced ML techniques, including convolutional neural networks (CNNs) for object detection and optical character recognition (OCR) for plate identification, leveraging TensorFlow, OpenCV, and YOLOv3 for high accuracy and speed. Upon detecting a violation, the system captures the license plate and sends an automated notification via a Telegram bot to relevant authorities, including details like the license plate number and timestamp. This instant communication ensures quicker responses, enhances enforcement efficiency, reduces manual effort and human errors, and promotes road safety through consistent monitoring and effective helmet-wearing regulation enforcement.

Keywords **- Deep Learning, Convolutional Neural Network (CNN), Deep neural networks (DNNs), Optical Character Recognition (OCR), Object Detection, TensorFlow, OpenCV, YOLOv3 .**

I INTRODUCTION

Road safety has become a major concern globally, with traffic rule violations significantly contributing to accidents and fatalities. Among these violations, the failure of motorbike riders to wear helmets is particularly alarming, as it increases the risk of severe injuries during accidents. Traditional methods of detecting such violations rely heavily on manual observation and enforcement, which are inefficient, time-consuming, and prone to human errors. To overcome these challenges, Artificial Intelligence (AI) and Machine Learning (ML) are being increasingly employed in real-time traffic violation detection systems.

Artificial intelligence (AI) and machine learning (ML) are revolutionizing real-time traffic violation detection. By analyzing video footage from surveillance cameras, these technologies can accurately identify and classify various traffic offenses, such as speeding, red-light running, and illegal lane changes. This automation enhances traffic enforcement, reduces human error, and improves overall road safety.

License Plate Recognition (LPR) forms a crucial part of traffic violation systems by identifying vehicles associated with violations.

Using technologies like Optical Character Recognition (OCR), LPR systems can extract alphanumeric details from license plates even in challenging scenarios, such as poor lighting or high-speed traffic. Integrating these systems with a database allows authorities to track violators and ensure accountability. These features make LPR an indispensable tool in enforcing road safety regulation.

II LITERATURE SURVEY

To guide the focus of a literature survey, it is essential to define clear objectives and scope. For example, *Redmon et al. (2018)* proposed YOLOv3, YOLO Framework for Helmet Detection a real-time object detection model with high accuracy and speed. It has been widely adopted for identifying motorbike riders and detecting helmets, *Kumar et al. (2020)* studied the application of deep learning models for real-time helmet detection, demonstrating how convolutional neural networks (CNNs) can distinguish between riders with and without helmets for Deep Learning for Traffic Monitoring. *Patil and Yadav (2021)* reviewed existing systems and highlighted the challenges of deploying helmet detection systems under varying lighting and weather conditions. OpenCV for Image Processing OpenCV's feature extraction techniques, including edge detection and segmentation, have been pivotal in preprocessing video frames for better detection accuracy.

The notification systems for real-time violations have also evolved. Early systems by *Khan and Ahmed (2018)* relied on email or SMS notifications for violation alerts. However, these systems faced delays in high-volume traffic scenarios. Recent studies, like those by *Rao et al. (2021)*, demonstrate the effectiveness of Telegram Bot APIs for instant messaging, significantly reducing response times. The integration of these systems ensures authorities receive real-time updates, allowing quicker action against violators.

Despite these advancements, existing systems still have limitations. *Choudhary et al. (2023)* discussed the lack of unified frameworks combining helmet detection, LPR, and real-time notifications. They emphasized the need for scalable, adaptable solutions capable of handling urban and rural traffic conditions. Addressing these gaps, modern systems aim to integrate advanced AI models, robust OCR techniques, and efficient notification platforms to enhance enforcement and road safety. Research highlighted challenges like varying lighting conditions, occlusions, and dirty plates, which require robust preprocessing methods for optimal performance.

In real-time traffic violation detection systems has significantly enhanced traffic management and road safety. AI-driven systems leverage advanced algorithms to analyze live video feeds and sensor data, enabling accurate and swift detection of violations such as red light jumping, speeding, and helmet non-compliance.

III EXISTING SYSTEMS

AI and ML have revolutionized real-time traffic violation detection systems, significantly enhancing their accuracy and efficiency. By employing deep learning algorithms, these systems can accurately detect helmetless riders and recognize vehicle number plates with remarkable precision, even under challenging conditions such as low light or heavy traffic. This real-time analysis empowers authorities to issue instant challans and send automated notifications to violators via Telegram bots, ensuring swift and efficient enforcement.

Existing systems for traffic violation detection primarily focus on individual functionalities like helmet detection or license plate recognition, rather than an integrated solution. These systems leverage deep learning models such as YOLO and SSD for object detection and Tesseract OCR for license plate recognition. Helmet detection modules analyze live traffic footage to identify riders without helmets, while license plate recognition modules extract alphanumeric details for tracking violators.

AI and ML have had a profound impact on real-time traffic violation detection systems. By automating processes, improving accuracy, and delivering actionable insights, these technologies are revolutionizing traffic rule enforcement. As AI and ML continue to advance, they promise to enable even more sophisticated and effective solutions, further enhancing road safety and minimizing traffic violations.

IV PROPOSED SYSTEM

Artificial Intelligence (AI) and Machine Learning (ML) have revolutionized real-time traffic violation detection systems, this system captures live video footage, detects non-helmeted riders using computer vision techniques, and extracts their vehicle's license plate details. By integrating a Telegram bot, the system automates notifications to violators and traffic authorities, ensuring timely intervention and minimizing manual enforcement efforts.

This section outlines a proposed system for real-time traffic violation detection, focusing on helmet detection and number plate recognition with automated notifications through a Telegram bot.

1. Feature Extraction: Proposed AI and ML models for real-time traffic violation detection focus on feature extraction from live video feeds to identify and classify violations accurately and a text extraction.
2. Deep Learning Models: deep learning models(YOLOv3) are used for object detection, enabling precise identification of helmets and motorbikes in real-time.
3. Training and Evaluation: These models are trained on a diverse dataset of helmeted and non-helmeted riders, as well as license plates, to improve accuracy across varying lighting, angles, and environmental conditions.

4. The performance of these models is evaluated based on metrics like precision, recall, and F1-score, ensuring reliable detection. The system adapts to new data through periodic retraining, ensuring robust performance in dynamic traffic scenarios.

V System Architecture

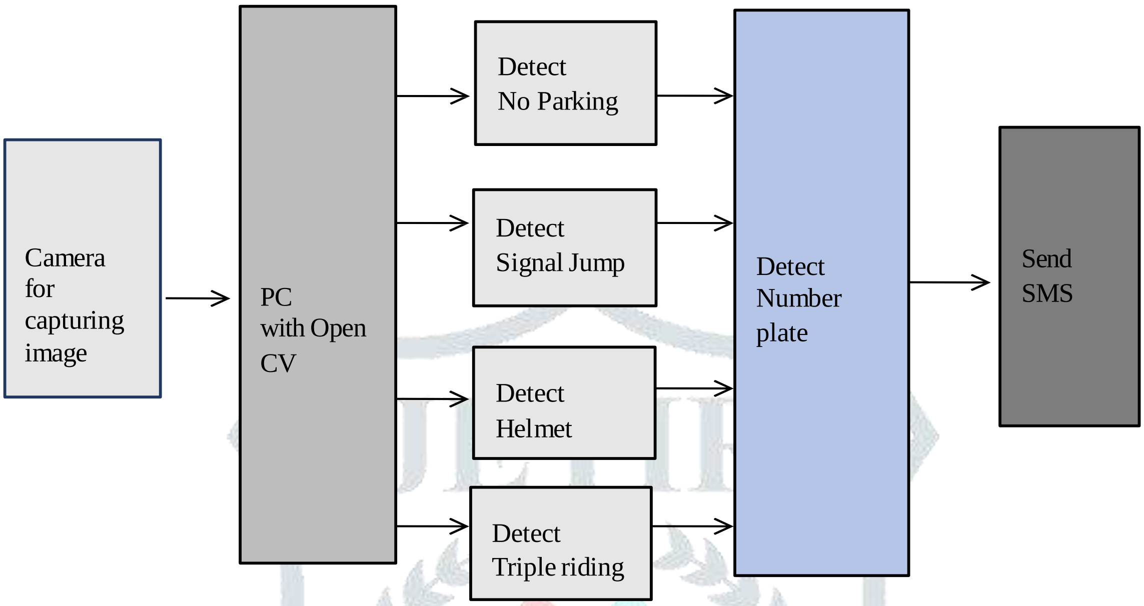

Fig 1. Architecture of virtual traffic police

IMPLEMENTATION

5.1 System Requirements:

1) Operating System: Linux (e.g., Ubuntu) or Windows
2) Programming Language: Python 3.x.
3) YOLOv3: For helmet and license plate detection.
4) OpenCV: For video processing.
5) Tesseract OCR: For license plate character recognition.
6) Database: MySQL or MongoDB for storing violation records.
7) IDE: PyCharm, Jupyter Notebook, or VS Code.

5.2 Hardware Requirements:

powerful GPU-enabled system or an edge device (e.g., NVIDIA Jetson Nano or Raspberry Pi) for running deep learning models such as YOLOv3. Cameras with high resolution and low latency are critical for capturing clear images and videos. Additional components include OCR modules for number plate recognition and a reliable internet connection to integrate with Telegram bots for instant messaging. The system also benefits from storage devices for data logging and real-time processing capabilities to minimize delay in detecting violations and sending notifications.

METHODOLOGY

Video Acquisition and Preprocessing

- Video Capture:
  - High-resolution cameras strategically placed at intersections or along roadways capture continuous video streams.
- Preprocessing:
  - Video Stabilization: Stabilize the video footage to compensate for camera shake or vehicle movement.
  - Image Enhancement: Improve image quality by adjusting brightness, contrast, and sharpness.
  - Region of Interest (ROI) Extraction: Define specific areas within the video frames (e.g., road surface, vehicle lanes) for focused analysis.

Object Detection and Tracking

- Vehicle Detection: Employ object detection models (e.g., YOLO, Faster R-CNN) to identify and localize vehicles within the video frames.
- Two-Wheeler Detection: Further refine the detection process to specifically identify two-wheelers (motorcycles, scooters).
- Object Tracking: Track the movement and trajectories of detected vehicles across multiple frames using techniques like Kalman filtering or deep sort.

Helmet Detection

- Helmet Localization: Utilize object detection models to detect and localize helmets on the heads of two-wheeler riders.
- Helmet Classification: Employ image classification models (e.g., CNNs) to classify whether a rider is wearing a helmet or not .

Number Plate Recognition

- Number Plate Localization: Detect and isolate the number plate region within the vehicle images.
- Character Recognition: Employ OCR techniques (e.g., Tesseract, custom-trained CNNs) to extract and recognize individual characters from the number plate.

Violation Detection and Classification

- Rule-Based System: Define rules to identify violations based on detected objects and their behavior (e.g., no helmet, obscured number plate).
- Machine Learning Models: Train machine learning models (e.g., decision trees, support vector machines) to classify violations based on historical data and expert knowledge.

Notification and Alerting

- Telegram Bot Integration: Integrate a Telegram bot to receive violation alerts from the system.
- Alert Generation: Trigger alerts for detected violations, including:
- Timestamp of the violation
- Location of the violation
- Type of violation (e.g., no helmet, obscured number plate)
- Vehicle information (e.g., number plate, vehicle type)
- Image or video evidence of the violation
- Alert Delivery: Send automated messages to designated recipients (e.g., traffic police, enforcement agencies) via the Telegram bot.

System Monitoring and Evaluation

- Performance Monitoring: Continuously monitor system performance, including accuracy, latency, and resource utilization.
- Model Retraining: Regularly retrain AI/ML models with new data to improve accuracy and adapt to changing conditions.
- System Maintenance: Perform regular system maintenance, including software updates, hardware upgrades, and data backups.

VI SCREENSHOTS

Fig 1 Detection

Fig 2. Recognition

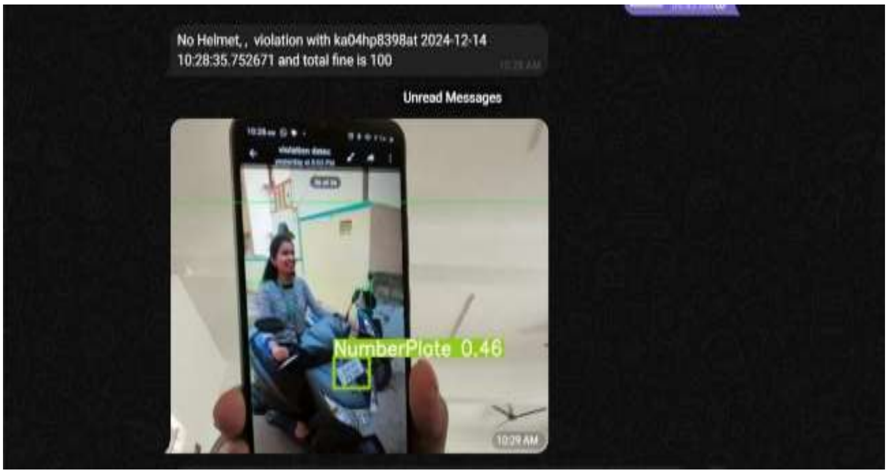

Fig 2 Message in bot

Fig 3 real-time input

Fig 4 real-time detection output

CONCLUSION

The integration of AI and ML has revolutionized real-time traffic violation detection systems, particularly in the realm of helmet and number plate detection. These advanced technologies empower systems to accurately identify and track violations with unprecedented precision, even under challenging conditions such as low light or dense traffic. This has resulted in a significant increase in the effectiveness of traffic enforcement, leading to a noticeable decline in traffic violations and a consequent improvement in road safety.

Furthermore, the implementation of Telegram bots for automated challan issuance and notification has streamlined the entire process, making it more efficient and transparent. Violators receive instant notifications, ensuring timely action and reducing the likelihood of repeat offenses. This automation also minimizes human intervention, reducing the potential for bias and ensuring consistent enforcement across the board.

The analysis of vast amounts of traffic data by AI-powered systems has enabled the identification of patterns and trends, such as high-risk areas and peak violation times. This valuable information empowers authorities to proactively allocate resources and implement targeted interventions, optimizing traffic management and further enhancing road safety.

The impact of AI and ML on real-time traffic violation detection systems has been profound. By automating tasks, enhancing accuracy, and providing valuable insights, these technologies have transformed the way traffic rules are enforced. The integration of Telegram bots for automated notifications has further streamlined the process, making it more efficient and transparent. As AI and ML continue to evolve, we can anticipate the emergence of even more sophisticated and effective solutions, leading to a further reduction in traffic violations.

REFERENCE

[1] L.Jiao,F.Zhang,F.Liu,S.Yang,L.Liet al., “A survey of deep learning-based object detection,” *IEEE Access*, vol. 7, pp. 128837–128868, 2019 This paper provides a comprehensive overview of various object detection methods, including one-stage and two-stage detectors. The survey also analyzes benchmark datasets commonly used in object detection research.

[2] C A Rohith , Shilpa A Nair (2019). "An Efficient Deep Learning Model for Real-Time Helmet Detection " *Proceedings of the IEEE 3rd International Conference on Trends in Electronics and Informatics(ICOEI)* ", 2019: 10.1109. This paper focuses on developing an efficient deep learning model for real-time helmet detection. The model is designed to be lightweight and fast, making it suitable for deployment on resource-constrained devices..

[3] Muhammad Murtaza Khan, Muhammad U. Ilyas, Istiaq Rasool Khan ,Salem M. Alshormrani , Susanto

Rahardja (2023). "Making Deep fakes Look Authentic." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2023, 1-34. The paper discusses the challenges and future directions of this research area, including the potential for integration with helmet detection systems.

[4]Y. Wang, Z. Bian, Y. Zhou, and L. Chau, ‘‘Rethinking and designing a high-performing automatic license plate recognition approach,*’’ IEEE Trans. Intell. Transp. Syst.,* vol. 23, no. 7, pp. 8868–8880, Jul 2022 focuses on improving the accuracy and efficiency of Automatic License Plate Recognition (ALPR) systems.

[5] X. Jin, R. Tang, L. Liu, and J. Wu, ‘‘Vehicle license plate recognition for fog-haze environments,’’ *IET Image Process*., vol. 15, no. 6, 2021 This research paper focuses on developing a robust vehicle license plate recognition (LPR) system specifically designed to function effectively in challenging fog and haze conditions.

[6] S. Alshomrani, and S. Rahardja, ‘‘Automatic license plate recognition in real-world traffic videos captured in unconstrained environment by a mobile camera,’’ *Electronics, vol*. 11, no. 9, p. 1408, Apr. 2022. pp. 1273–1284, May 2021. This research paper focuses on developing an Automatic License Plate Recognition (ALPR) system that can effectively function in real-world traffic scenarios where videos are captured by a moving camera in unconstrained environments.

[7] Z.Li,W.Xie,L.Zhang,S.Lu,L.Xieet al., “Toward efficient safety helmet detection based on YoloV5 with hierarchical positive sample selection and box density filtering,”*IEEE Transactions on Instrumentation and Measurement*, vol. 71, pp. 1–14, 2022. the research focuses on using YoloV5 for safety helmet detection in a more efficient way by selecting better training data and reducing unnecessary computations.

[8]T. tsai, Z. lu, and C. huang, ‘‘license plate recognition system based on deep learning,*’’ in proc. IEEE int. conf. consum. electron.*, may 2019, 1–2. This paper likely employs convolutional neural networks (CNNs) to accurately detect and recognize license plates in real-time, even under challenging conditions such as varying lighting, occlusion, and plate variations.

[9] Wang, X., Liu, J., Qiu, T., Mu, C., Chen, C., & Zhou, P. (2020). ‘‘ A real-time collision prediction mechanism with deep learning for intelligent transportation system”. *IEEE transactions on vehicular technology*, 69(9), 9497-9508. This research paper presents a real-time collision prediction mechanism for Intelligent Transportation Systems (ITS).

[10] L. Zhang, P. Wang, H. Li, Z. Li, C. Shen, and Y. Zhang, ‘‘A robust attentional framework for license plate recognition in the wild,’’ *IEEE Trans. Intell. Transp. Syst*., vol. 22, no. 11, pp. 6967–6976, Nov. 2021, doi: 10.1109/TITS.2020.3000072. This research paper focuses on developing a robust and accurate license plate recognition (LPR) system that can effectively handle challenging real-world scenarios.