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A Deep Learning based System to Detect Triple Riding and Helmet Violations

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ABSTRACT: Real-time monitoring systems use surveillance videos to automatically detect motorcycle helmet requirements and triple-riding violations, which protect road safety. Deep learning methods currently show practical worth for addressing surveillance system constraints because they have developed superior capabilities in object detection and classification. The models deliver poor results repeatedly because they are limited by low-resolution video, together with adverse weather conditions, as well as problems from occlusions and deficient illumination conditions. The issue of recognizing multiple individuals riding together on one motorcycle requires better solution methods because it remains unresolved. YOLOv8 operates in real-time to detect both helmet violations and multiple riders on vehicles using CCTV video and webcam feeds. The detection system reaches a 95% accuracy level, thereby establishing itself as an effective monitoring method in automated traffic control. A YOLOv8 detection model serves for detecting triple riders, along with YOLOv8-based detection of helmet violations. The model has tailored detection skills since its training with helmet-specific data enables it to monitor properly non-helmeted riders. The system supplies capabilities for processing video and image data, which helps it create visual violation marks for practical realworld applications. Quality evaluation of the system happens through precision and recall metrics, which measure its reliable operation functions. The method utilizes publicly available data and self-collected information to solve illumination conditions and issues that affect detection systems. The evolution of traffic rule enforcement systems has improved thanks to the resolution of implementation problems. The research application proves how deep learning transforms surveillance systems, which advances road safety through system improvements. Better traffic management possibilities, combined with improved efficiency and innovation, enable wider expansion of safety programs in urban areas.

KEYWORDS: Machine Learning, You Only Look Once, Convolutional Neural Network, Accuracy, Prediction, Pneumonia, Detection, Deep Learning,

I. INTRODUCTION

The number of road traffic offenses stands as a leading cause of accidents and fatalities worldwide and is most prevalent in densely trafficked urban zones. Motorcyclists who fail to use helmets and engage in triple riding represent two primary traffic violations among others. The combination of limited human resources, inadequate surveillance infrastructure, and high road traffic volumes makes traffic enforcement difficult, despite existing traffic regulations. The requirement for automatically scalable solutions has become essential because manual monitoring shows limited effectiveness in achieving uniform compliance. New technology based on deep learning and computer vision enables traffic enforcement teams to create automated enforcement systems. Real-time detection applications utilize YOLO (You Only Look Once) object detection models because these models demonstrate outstanding performance and speed in detection operations.

Information systems powered by such models enable precise traffic infraction detection in challenging circumstances, including situations with occlusion, varying illumination, and reduced video quality levels. Object detection algorithms from deep learning integrate with video monitoring systems to track both helmet compliance and





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instances of riding with three individuals on a single vehicle. The systems employ CCTV or webcam video stream scanning capabilities to process violations through intelligent algorithms before sending alerts or reports to authorities. An automated system performs this task, simultaneously improving traffic enforcement processes and enhancing road safety compliance, thereby reducing traffic accidents and fatalities. This research demonstrates a YOLOv8 network implementation for the real-time detection of both helmet violations and triple riding infractions. The system acts as a supplementary tool for traffic enforcement through its dependable, accurate, and efficient mechanism to monitor motorcyclists. The system delivers outstanding results in traffic surveillance operations by relying on publicly available data, as well as specialized models specifically designed for the task.

II. OBJECTIVE

Our goal is to enhance road safety in urban areas by tackling the persistent challenges of motorcycle-related traffic violations, such as riding without helmets and triple riding, which contribute significantly to accidents and fatalities worldwide. We aim to develop an innovative, automated solution that eases the burden on overstretched traffic enforcement teams and overcomes the limitations of manual monitoring—like limited manpower and poor surveillance infrastructure. By harnessing the power of deep learning and computer vision, specifically through the YOLOv8 model, we seek to create a real-time monitoring system that detects these violations with precision and efficiency. This system will analyse live video feeds from CCTV and webcams, identifying helmetless riders and triple-riding offenses even in tough conditions like low light, occlusions, or low-resolution footage. Our hope is to deliver a reliable tool that not only alerts authorities to violations but also promotes consistent compliance with traffic laws, ultimately reducing road accidents and saving lives. Using publicly available data and custom-trained models, we strive to build a scalable, practical solution that transforms traffic surveillance, supports enforcement agencies, and paves the way for safer, smarter cities through technology-driven innovation.

III. RELATED WORKS

In study [1], Rahul Sharma and Priya Mehta propose a YOLOv5-based real-time detection system for traffic violations such as red light jumping and helmet usage, utilizing CCTV footage. The approach demonstrates high detection speed and accuracy, making it a viable solution for integration into urban traffic surveillance systems aimed at real-time enforcement.

The research [2] by Ali Khan and Riya Das presents a deep learning-based helmet detection framework that leverages CNN architectures like YOLOv4 to analyze live video feeds. The system is specifically optimized for low-light and occluded environments, enhancing its reliability in varied real-world conditions. It achieves notable performance in differentiating between helmeted and non-helmeted motorcyclists.

Study [3] introduces an image processing and machine learning-based approach to detecting triple riding violations. Sunil Patel and Kavita Sharma employ frame-wise video analysis to accurately identify the number of riders on a motorcycle. Their system generates real-time alerts, aiming to support law enforcement through non-intrusive monitoring techniques.

Ananya Rao and Vishal Gupta's study [4] propose an integrated system utilizing YOLOv8 for detecting helmet violations and triple riding. Their model is combined with OpenCV-based preprocessing for video enhancement, addressing challenges such as poor lighting and occlusion. The study evaluates the system using precision-recall metrics, showing its effectiveness in urban traffic enforcement contexts.

In [5], Manoj Verma and Sneha Roy develop a deep learning-based surveillance system that leverages YOLO models to identify multiple types of traffic violations, including two-wheeler overloading. The model is trained and tested on large public datasets and emphasizes real-time alert mechanisms to support proactive enforcement.

Multiple studies have highlighted the potential of deep learning and computer vision-based systems for automated traffic violation detection, focusing on common infractions like helmet non-compliance and triple riding. The synergy between high-resolution surveillance infrastructure and OpenCV-driven preprocessing enables efficient frame extraction and noise reduction, laying the groundwork for reliable object detection.





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Recent advancements have seen the application of YOLOv8, both pre-trained and custom-trained, for real-time detection in complex traffic environments. These systems adapt to variable lighting, low-resolution footage, and partial occlusions. The integration of bounding box annotation and real-time alert generation enhances system responsiveness. Evaluation metrics such as precision and recall are employed to quantify detection effectiveness across diverse datasets. Despite the promising results, several studies note the scalability challenges in deploying AI-based traffic enforcement in high-density urban zones. However, deep learning-powered surveillance systems exhibit improved consistency and scalability over manual monitoring, offering real-time feedback mechanisms that bolster public compliance. The growing body of research supports the adoption of AI-driven traffic monitoring solutions as an effective means to improve road safety and reduce traffic-related fatalities.

IV. METHODOLOGY

A systematic approach directs the proposed live system, which detects helmet violations and multiple passenger violations with accuracy and scalability for real-world traffic situations. Image and video data from various traffic locations serve as the initial step through CCTV cameras and webcams. A specific dataset for detecting helmet violations incorporates various images showing riders with and without helmets to provide extensive coverage under different traffic conditions, weather, and light variations. During data preparation, the information collection is marked by bounding boxes for both helmets and riders to establish precise detection.

Data normalization functions enhance the data's consistency by applying different techniques, and the model benefits from enhancement through methods like rotation, scaling adjustments, and brightness modifications. A pre-trained YOLOv8 model serves as the basis for detecting triple-riding violations during the training process. The YOLOv8 model obtains improved performance for helmet detection by receiving training with the helmet dataset labels. The pre-trained model's knowledge benefits the training process through transfer learning, which provides both better performance and shorter training schedules on custom datasets. A model evaluation process requires the evaluation of trained model accuracy through precision, recall, and F1-score metrics.

The model's reliability under diverse conditions becomes apparent through precision-recall curve analysis conducted at different detection threshold settings. YOLOv8 models that undergo training integrate into real-time detection pipelines during system deployment. The video processing system utilizes CCTV and webcam streams, which reveal detected violations by drawing bounding boxes on the output feed. Continuous performance monitoring and system optimization run as a permanent procedure to keep accuracy norms stable in changing operational conditions. Traffic regulation enforcement becomes more efficient through model updates with new data, since the system adapts to changing traffic patterns.

V. PROPOSED SYSTEM

The proposed traffic management system represents a significant leap forward in the automation of traffic law enforcement by leveraging the latest advances in deep learning and computer vision. At the heart of this system lies the YOLOv8 (You Only Look Once version 8) model, a state-of-the-art object detection framework renowned for its high accuracy, real-time processing capabilities, and adaptability to varied detection tasks. YOLOv8 functions as the central analytical engine of the system, effectively enabling the identification of two major road safety violations: triple riding and helmet non-compliance.

This AI-powered detection mechanism processes inputs in the form of real-time video streams and still images captured through CCTV and webcam systems deployed at key traffic intersections and checkpoints. As the data flows into the system, YOLOv8 processes each frame to identify motorcyclists, check for the presence or absence of helmets, and count the number of riders on a two-wheeler. Violations such as riding without helmets or with more than two individuals on a motorcycle are detected and marked clearly using bounding boxes, labels, and confidence scores.

The system not only automates the detection process but also generates visual and statistical outputs in the form of annotated images, violation logs, and performance reports. These outputs help traffic authorities track the frequency and locations of violations, thus providing actionable insights for better enforcement strategies. Additionally, performance evaluation metrics such as precision, recall, and F1-score ensure that the system maintains a high standard





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of accuracy and reliability across varying environmental conditions, including low lighting, occlusion, and low-resolution footage.

One of the standout benefits of this system is its ability to reduce the dependency on manual monitoring and enforcement. Traditionally, law enforcement officers are required to observe road conditions continuously, identify violations manually, and take appropriate action. This approach is both time-consuming and prone to human error. The implementation of the proposed automated system significantly reduces the workload on human resources, allowing agencies to redirect their personnel to more critical tasks while maintaining or even improving the effectiveness of law enforcement efforts.

The broader implications of this system extend to enhancing road safety and reducing traffic-related injuries and fatalities. By deterring riders from violating safety norms, especially the critical use of helmets and limiting the number of passengers, the system plays a crucial role in cultivating responsible driving behaviour. The deterrence is further strengthened when violators receive prompt feedback or penalties based on real-time detection.



Fig 5.1 Architecture Diagram





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Fig 5.2 Work Flow

VI. MODULES

6.1 Data collection module

The system establishes its foundation through the collection of authentic traffic information to represent real-world urban chaotic conditions. We obtain image and video footage from CCTV webcam installations located at various traffic areas to monitor motorcycle vehicles under different lighting and weather conditions throughout day and night. Extensive image data collection involves organizing specific data for helmet violation detection through an assortment of helmeted and no helmeted rider images. The system gathers information through various viewpoints of different helmet types and rider positions in diverse settings to understand different traffic conditions effectively. Creating such a database serves as the foundation for the model's learning process and guarantees its preparedness when confronting anything during street travels.

6.2 Data pre-processing module

Training requires refined raw data before it becomes usable. Standardized bounding boxes label frames in every image and video sequence for training purposes that direct the system to identify helmets and riders. Next we normalize the data through procedures that eliminate inconsistencies while implementing methods including data rotation and scaling along with brightness modification. The annotation process duplicates natural riding situations such as when riders are partially concealed by trucks or traveling at night. With adequate dataset augmentation we strengthen the model to become more resistant and precise regardless of environmental conditions.





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6.3 Training the YOLO model

YOLOv8 model takes center stage at this moment. The model starts with pre-trained expertise in detecting triple riding because this saves us time and effort at its inception. A customized helmet dataset helps fine-tune YOLOv8 to identify helmet use from no helmet use accurately. Transfer learning enters as a lifesaver because it enables the model to access learned information from pre-training for rapid adaptation to precise requirements. Providing a veteran detective with a new case file offers them familiar detection capabilities alongside fresh eyeglasses for the task. Combined detection with YOLOv8 enables swift and accurate processing of helmet violations together with other rule violations in the traffic system.

6.4 System Development module

We integrate the trained YOLOv8 models into a real-time detection pipeline, hooking them up to live CCTV and webcam feeds. As video streams in, the system scans every frame, spotting triple riders or helmetless offenders, and highlights them with bounding boxes on the output. These marked-up images and videos are ready for traffic officials to review—no delay, no fuss. It's like having an extra set of eyes that never blink, tirelessly watching the roads. This step turns our tech into action, bridging the gap between lab experiments and real-world enforcement with seamless, automated vigilance.

6.5 System Performance Monitoring and Optimization

The system's live, but the work doesn't stop. We keep a close eye on its performance as it runs in real-world conditions—tracking how it handles rush hour chaos or a rainy day. Continuous monitoring spots any dips in accuracy, and when they happen, we feed the model fresh training data to keep it sharp. Think of it as a car needing regular tuneups; new traffic patterns or tricky weather might throw it off, but updates get it back on track. This ongoing optimization ensures the system stays reliable and adaptable, evolving with the roads it's meant to protect.

The methodology lays out a structured approach to construct a practical YOLOv8-based traffic violation detection system which will be intelligent. The process begins with gathering both real-world traffic video footage and specialized helmet dataset before it continues to the next stage. Data preprocessing prepares raw material through annotation and augmentation techniques makes the model resilient against the unpredictability of urban roads in a way similar to how a coach prepares his team for any play. The pre-trained skills in YOLOv8 serve model training for triple riding and helmet detection through transfer learning which accelerates the process by teaching advanced knowledge efficiently. The system goes through model evaluation to make sure it can properly detect violations through precision, recall, and F1-score measurements since this test determines whether the system has genuine detection capabilities before going public on streets. After completion the system deployment process activates real-time violation detection through its connection to live cameras just like an automated traffic officer. Performance monitoring and optimization ensure system sharpness by continuously updating it with new data which makes the system smarter for use both today and future developments.

VII. RESULT ANALYSIS

To wrap it up, The YOLOv8 model system yielded remarkable performance, with 95% accuracy in identifying helmet violations and triple riding in live CCTV and webcam streams. Precision and recall, as well as F1-score evaluation, validated its accuracy, even in extreme situations such as low-light and occlusion. Precision-recall curves showed uniform performance at different thresholds, indicating its flexibility to handle a range of traffic conditions. Real-time bounding box highlighting efficiently caught infractions, decreasing human supervision and increasing enforcement effectiveness. Ongoing surveillance and dataset refreshment additionally reinforced its strength, compatible with changing traffic flows. This system greatly enhances road safety, providing a scalable, reliable solution for managing urban traffic.





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Fig 7.1 Accuracy graphs





VIII. CONCLUSION

A YOLOv8-based traffic rule violation detection system represents an advanced development that advances roadway safety through better practices. Through deep learning combined with real-time video analysis, this system implements effective solutions for both helmetless riding and triple-riding behavior, which lead to numerous urban accident-related deaths. Thanks to its advanced object detection abilities, YOLOv8 allows automated surveillance of CCTV and webcam feeds at high precision accuracy rates of 95%. Real-time bounding box highlighting through the system enables traffic agencies to autonomously manage their critical priorities without supervision, thus enhancing overall enforcement effectiveness. The system's main strength is its ability to adapt through custom-dataset training and transfer learning techniques because it optimizes performance under challenging conditions of low-quality footage, adverse weather conditions, view obstructions, and reduced light sources. The reliability of the system is confirmed by precision, recall, and F1-score metrics, as well as regular updates with new datasets, which enable the system to adapt





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to changing traffic patterns. Through its implementation, the system creates an environment where people comply, making it less likely for dangerous situations to become lethal. Because of its ability to scale and function in real traffic settings, this technology resets traditional traffic management standards, which results in secured urban roads with fewer accidents. Cities experiencing overwhelming traffic problems now possess a rescue measure that combines technological progress with basic operational needs. Printed AI systems within enforcement operations today lead to better protection on the roads, which will enable us to develop predictive safety programs for the future. Through YOLOv8, deep learning achieved a significant breakthrough in surveillance that fights road dangers while building a template to protect human life through intelligent systems.

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