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Real-Time Traffic Violation Detection and Analysis Using YOLO-Based Computer Vision Models

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This study presents an advanced automated multi-violation traffic monitoring system developed using state-of-the-art computer vision and deep learning techniques to address modern traffic enforcement challenges. The system detects and analyzes critical violations, including triple riding, helmet violations, illegal parking, red-light violations, speed limit violations, and vehicle number plate recognition using optical character recognition (OCR). A unified pipeline integrates YOLOv8 (You Only Look Once version 8) object detection models with region-specific rule modeling and OCR, enabling real-time, end-to-end violation detection. The novelty of this work lies in combining multiple specialized detection modules with automated evidence generation, region-adaptive rule logic, and robustness under varying traffic conditions. Each module is optimized for specific tasks: the helmet detection module identifies riders without helmets, the triple-riding module counts multiple riders on a single motorcycle, illegal parking is detected using predefined Regions of Interest (ROIs) and temporal occupancy analysis, red-light violations are flagged by combining traffic signal state recognition with vehicle movement tracking, and speed violations are estimated using pixel-distance calibration. Number plates are localized using YOLOv8 and recognized through OCR to link violations directly to vehicle records. Experimental evaluation used six hours of video footage from Sri Lankan roads under both bright and gloomy weather conditions. The system achieved detection accuracies of 92% for helmet violations, 89% for triple riding, 94% for red-light violations, 96% for illegal parking, and 93% for number plate recognition. These results demonstrate improved precision and recall compared to traditional rule-based and earlier CNN-based approaches, particularly under occlusion, variable lighting, and dynamic traffic scenarios. Overall, this AI-driven traffic monitoring framework provides a scalable, reliable, and efficient solution for intelligent traffic management, enhanced law enforcement, and improved road safety, with potential for future expansion to additional violation types and analytical modules.

Keywords: Computer vision, Deep learning, Intelligent traffic monitoring, Optical character recognition (OCR), Traffic violation detection, YOLOv8