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YOLOV5-BASED SYSTEM FOR DETECTING HELMET VIOLATIONS AND OVERLOADING IN TWO-WHEELERS

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Abstract:

The Two-Wheeler Violation Prediction System is a real-time object detection framework designed to enhance road safety by monitoring helmet usage and the number of riders on motorcycles. It employs the YOLOv5 model to detect violations, such as missing helmets and overloaded vehicles, from video feeds and webcams. Trained on a custom dataset annotated with Roboflow, the system ensures accuracy through image preprocessing and enhancement. It includes a helmet detection model to assess compliance with traffic laws. Additionally, it features license plate recognition using Roboflow's API and TesseractOCR, storing violation data in an Excel database for enforcement. The system can save frames of violations for documentation and legal use. Designed for scalability, it integrates with traffic monitoring, urban surveillance, and law enforcement checkpoints, automating violation detection to improve traffic safety and law enforcement efficiency.

Keywords **—** Real-time object detection, YOLOv5-based system, Traffic law enforcement, Automated road safety monitoring.

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1. INTRODUCTION

Road safety is an escalating issue in both urban and rural areas, driven by rising traffic violations and disregard for regulations. Two major violations, riding without a helmet and overloading motorcycles, are significant factors in severe injuries and deaths resulting from road accidents. Helmets are essential for safeguarding riders against head injuries, and making helmet usage laws strict is a key focus for traffic authorities globally. However, manually monitoring whether riders wear helmet is a process that consumes time, requires a lot of labour, and has a higher likelihood of human error. To tackle these issues, this system has been created as an automated, real-time object detection framework that identifies traffic violations related to helmet compliance and motorcycle overloading. This system employs the YOLOv5 deep learning model for the detection, which provides high levels of accuracy and effectiveness in recognizing non-compliant riders. Moreover, it incorporates number plate recognition through Roboflow's API and TesseractOCR, enabling authorities to systematically record violations and take appropriate measures. By automating the detection process, this system aims to improve road safety, reduce the need for manual monitoring, and boost the effectiveness of law enforcement. With its ability to integrate into smart city frameworks, traffic surveillance networks, and law enforcement systems, the Two-Wheeler Violation Prediction System offers a cost-effective and scalable approach to reducing traffic infractions and fostering safer roads.

2. METHODOLOGY

The Two-Wheeler Violation Prediction System is designed to detect and analyse traffic violations in real time, particularly focusing on helmet usage and overloading on motorcycles. The methodology involves multiple stages, including data collection, model training, object detection, violation verification, and result storage.

2.1 Software requirements:

- **Python 3.x** – The primary programming language for implementing the system.
- **YOLOv5 (Ultralytics)** – Pretrained and custom-trained models for object detection.
- **Torch and Torchvision** – Essential libraries for running YOLOv5.
- **OpenCV** – For image processing, ROI selection, and bounding box visualization.
- **TesseractOCR** – For extracting text from detected number plates.
- **NumPy and Pandas** – For data handling, logging violations, and frame analysis.
- **Roboflow API** – For number plate detection and model training assistance.
- **Excel/CSV Logging** – For recording detected violations with timestamps.

2.2 Data Collection and Preprocessing:

A custom dataset was created using publicly available images and manually collected images. The dataset was annotated using Roboflow, labelling key objects such as:

- Motorcycle
- Rider with Helmet
- Rider without Helmet
- Back seater
- License Plates

To enhance model robustness, various image preprocessing techniques were applied, including contrast enhancement, noise reduction, and geometric transformations like flipping, scaling, and rotation.


Fig 1. Rider without helmet


Fig 2. Riders with helmet


Fig 3. Back seater

2.3 Object Detection with YOLOv5:

The YOLOv5 object detection framework was employed to identify motorcycles, riders with helmets, riders without helmets and back seaters. The system includes:

- **Motorcycle Detection Model:** A pretrained YOLOv5s used for spotting motorcycles in traffic.
- **Helmet Detection Model:** A custom-trained YOLOv5 model designed for recognizing helmet usage and counting passengers.

Each identified object receives a bounding box along with a confidence score, allowing for the elimination of low-confidence detections to enhance accuracy.

2.4 Number Plate Detection and OCR Processing:

The system integrates Roboflow API for number plate detection, followed by TesseractOCR to extract the vehicle's license plate number. To enhance OCR accuracy, image thresholding, edge detection, and adaptive binarization techniques are applied.

2.5 Violation Verification and Logging:

A violation is recorded if:

- A **rider is detected without a helmet**.
- The **number of back seater exceeds one**.

Once a violation is confirmed:

- The **detected frame is saved** as evidence.
- The **extracted license plate number is logged** in an Excel file along with **date and time stamps**.

2.6 Real-time Processing and System Deployment:

The system processes live video feeds in real time, optimizing frame selection to reduce computational load. It is designed for **scalability**, allowing deployment in **traffic surveillance networks, checkpoints, and urban monitoring systems**.

2.7 Flow Diagram:

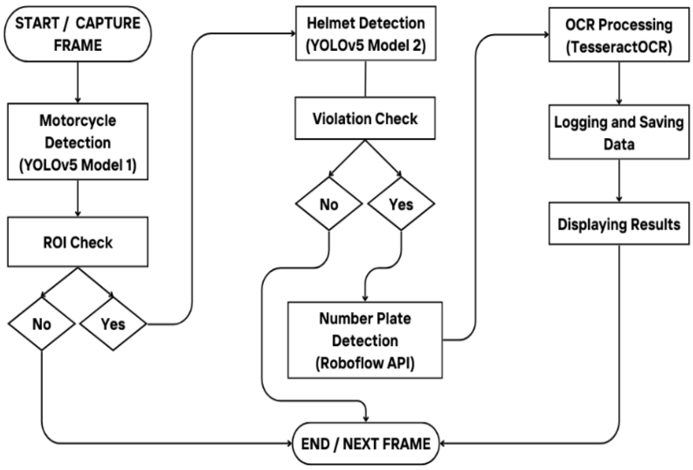

Fig 4. Flow Diagram

The Two-Wheeler Violation Prediction System is designed to efficiently detect traffic violations related to helmet usage and overloaded vehicles. The process begins with the system initializing and capturing frames from a video file or live webcam feed. Each frame is individually processed to detect potential violations, ensuring real-time monitoring and accuracy. Once a frame is captured, it is passed to the first YOLOv5 model, which is a pre-trained model which can detect motorcycles within the frame. Instead of processing the entire frame for subsequent detection, only the cropped region containing the detected motorcycle is extracted and passed to the next stage. This optimization reduces computational overhead and enhances the accuracy of subsequent detections.

Once a motorcycle is detected, the system verifies whether it is located within a predefined Region of Interest (ROI) to ensure that only relevant vehicles are analysed. If the detected motorcycle falls within the monitoring zone, the cropped image of that motorcycle is then passed to the second YOLOv5 model, which is trained to detect helmet usage and count the number of riders on the vehicle. This step helps determine if any rider is without a helmet and if the vehicle is carrying more than two riders, both of which are considered violations. The cropped motorcycle image is also saved locally for record-keeping.

If a violation is detected, the system proceeds to number plate detection using the Roboflow API. Instead of analysing the full frame, a cropped section containing the vehicle's number plate is extracted from the motorcycle's bounding box and sent to the number plate detection model. This improves accuracy and ensures that irrelevant background details do not interfere with detection. Once the number plate region is identified, TesseractOCR is applied to extract the vehicle registration number from the cropped number plate image. The extracted number plate image is also saved locally, ensuring that there is a visual record of the detected vehicle.

Finally, the detected violation is logged, and all relevant details including the date, time, extracted number plate, and associated images are stored in an Excel (CSV) file for further analysis. The system then continues processing the next frame, repeating the entire detection pipeline until the video ends or the user stops execution. This structured and optimized approach ensures that the system efficiently identifies and records traffic violations while minimizing unnecessary computations.

3. RESULT

The Two-Wheeler Violation Prediction System effectively detects helmet violations and overloaded vehicles using a real-time object detection framework. The results demonstrate the system's capability to accurately identify motorcycles, determine helmet usage, count riders, and extract number plate information for traffic law enforcement. The evaluation was conducted on a dataset comprising images and videos captured in real-world traffic scenarios. The system successfully identifies motorcycles in each frame and crops the detected vehicle for further analysis. The helmet detection model accurately classifies whether the rider is wearing a helmet and counts the number of riders on the motorcycle. If a violation is detected, the system extracts the number plate and applies OCR to retrieve the vehicle registration number. The detected violations, along with their corresponding images and extracted data, are logged for record-keeping.

Fig 5. Frame from video

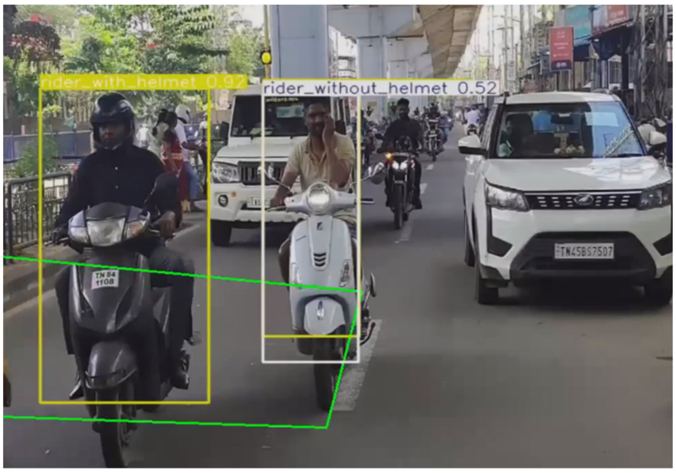

Fig 6. Frame with detection

This System utilizes an intelligent Region of Interest (ROI) to focus detection on relevant areas, ensuring accurate identification of traffic violations. In the given images, the first frame represents an unprocessed traffic scene, while the second showcases the system's detection capabilities. The green box represents the defined ROI, within which the model performs its analysis. Instead of processing the entire frame, the system isolates motorcycles detected within this region to optimize computational efficiency and improve detection accuracy. The YOLOv5-based object detection model first identifies motorcycles and subsequently crops out the detected region before passing it to the helmet detection model. This targeted approach prevents unnecessary computations on unrelated objects, such as cars or pedestrians. Within the ROI, different classifications are applied. The system correctly labels the rider on the left as "rider_with_helmet" (highlighted in yellow) and the one in the middle as "rider_without_helmet" (highlighted in white). This classification is crucial for enforcing helmet laws.


Fig 7. Frame from video


Fig 8. Cropped Vehicle


Fig 9. Detected Number Plate

In fig 7, a busy street with multiple vehicles, including motorcycles and cars, is shown. The system continuously scans the road using a surveillance camera or video feed and detects motorcycles using an object detection model. It then checks whether the rider is wearing a helmet. If the system identifies a rider without a helmet, it flags the frame as a violation instance for further processing. Once the violation is detected, the system focuses on isolating the violator, as seen in fig 8. The detected rider and their motorcycle are cropped from the original image to enhance clarity. The close-up view allows better analysis and ensures accurate identification of the violation. The final step involves extracting the number plate from the motorcycle, as demonstrated in fig 9. After isolating the vehicle, the system applies a license plate detection algorithm to locate the number plate. The plate is then cropped and processed using Optical Character Recognition (OCR) to extract the alphanumeric characters (e.g., "TN-59CS-3468"). The extracted data is stored in a database and can be used for generating fines, issuing notices, or taking further legal actions against the violator.

4. CONCLUSION

In summary, the developed Helmet Violation Detection system presents a reliable and efficient solution for enforcing road safety regulations. By leveraging advanced computer vision techniques, the system effectively detects helmet violations, isolates the violator, and extracts the vehicle's number plate for further processing. This automation minimizes the need for manual monitoring, enhances enforcement accuracy, and enables timely action against rule violators. Future advancements in this system could include integrating it with intelligent traffic management systems, enhancing detection accuracy with AI-driven models, utilizing high-resolution cameras for improved number plate recognition, implementing real-time violation alerts, and leveraging vehicle-to-infrastructure (V2I) communication for seamless law enforcement. These developments aim to further improve road safety, ensure higher compliance with traffic regulations, and contribute to a more secure and efficient urban transportation system.

5. REFERENCES

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