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RoadSafe AI: Helmet and License Plate Detection Using Deep Learning

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ABSTRACT

This study presents the Helmet and License Plate Detection system, which leverages deep learning techniques to enhance road safety and streamline law enforcement. The system provides an intuitive interface that allows users to upload images, where it processes the content to determine whether the motorcyclist is wearing a helmet and recognizes the vehicle's license plate. Using Convolutional Neural Networks (CNNs), the helmet detection module analyzes the uploaded image to detect the presence or absence of a helmet on the rider. If no helmet is detected, the system automatically extracts the vehicle's license plate using Optical Character Recognition (OCR) and alerts the appropriate authorities. In addition, the system triggers an email notification, providing real-time updates for law enforcement or traffic management. This dual functionality of helmet detection and license plate recognition offers a comprehensive solution for enhancing public safety, ensuring compliance with helmet laws, and assisting in the efficient tracking of vehicles. The integration of these features into one platform could improve road safety, reduce traffic violations, and enable more effective law enforcement by providing timely, actionable data. The system is designed to be scalable and can be deployed in various settings, including traffic surveillance, smart cities, and security systems.

KEYWORDS: Helmet, Labeling, Cnn, Ocr , Yolov8, Flask, Python , Deep Learning

INTRODUCTION

Road safety is a major concern, especially in regions with high motorcycle usage, where enforcing helmet laws is crucial in preventing severe injuries and fatalities. Traditional methods of monitoring helmet compliance rely on manual observation, which is time-consuming, resource-intensive, and prone to human error. To address these challenges, this project presents Helmet and License Number Plate Detection Using Deep Learning, leveraging advanced AI techniques to enhance law enforcement and traffic monitoring.

The system utilizes YOLOv8 for object detection and CNNs for helmet recognition to accurately identify motorcyclists without helmets. If a violation is detected, Optical Character Recognition (OCR) extracts the vehicle's license plate details, and real-time alerts, including notifications to the authorities, are generated for enforcement. This automated approach reduces reliance on manual surveillance, providing a scalable, efficient, and accurate solution for ensuring helmet compliance.

By integrating AI-driven technologies, the system contributes to intelligent transportation systems, improves road safety, and minimizes traffic violations. Similar to global traffic enforcement initiatives like Turkey's TEDES and ANPR technologies, this solution enhances public safety by ensuring compliance with helmet laws and supporting effective vehicle tracking and law enforcement.

Problem Statement: Non-compliance with helmet laws leads to severe road accidents and fatalities. Manual enforcement is inefficient and prone to errors, making it difficult to track violations in real time. To address this, our project introduces an AI-powered helmet detection system using YOLOv8 and EasyOCR, with a Python backend and Flask interface. The system automatically detects motorcyclists without helmets, extracts their license plate details, and sends email alerts for enforcement, ensuring efficient and automated road safety monitoring.

Objectives: To develop an AI-powered automated system using YOLOv8, EasyOCR, Python, and Flask for real-time helmet violation detection and license plate recognition. The system reduces manual monitoring, enhances enforcement efficiency, and sends automated email alerts to ensure compliance with helmet laws and improve road safety.

Motivation: The rising number of helmet law violations contributes to severe road accidents and fatalities, emphasizing the need for an automated enforcement system. AI and machine learning have proven effective in real-time monitoring and risk assessment across various industries. By leveraging YOLOv8 for object detection, EasyOCR for license plate recognition, and Flask for a web-based interface, this project enhances road safety, reduces manual enforcement efforts, and ensures timely violation alerts through automated email notifications.

METHODOLOGY

Data Collection and Preprocessing

The Traffic Violation System relies on video images as data sources. The input data consists of real-time image collected from surveillance cameras placed at traffic intersections, highways, and other critical locations. These images serve as the foundation for detecting various traffic violations like helmet less riding.

Data Sources

Our system processes static images to detect helmet violations and recognize license plates. The sources of input data include:

Traffic Surveillance Images – Captured images from CCTV cameras at traffic intersections to identify motorcyclists without helmets and extract their license plate numbers.

Manually Collected Images – Photographs taken in real-world traffic conditions to enhance dataset diversity and improve model accuracy.

Publicly Available Datasets – Open-source datasets containing images of motorcyclists with and without helmets, as well as vehicle license plates, used for model training and validation.

Data Cleaning and Preprocessing

Before feeding the data into the detection model, preprocessing is performed to enhance accuracy:

Frame Extraction - The video is split into individual frames for image-based analysis.

Image Resizing and Normalization - Frames are resized and normalized to match the input size of the deep learning model.

Noise Reduction - Techniques such as gaussian blurring and contrast enhancement are applied to improve image clarity. Feature Engineering

Feature engineering enhances the accuracy of the Traffic Violation Detection System by extracting meaningful information. Key transformations include:Key transformations to enhance system performance:

Helmet Detection – Identifies if a rider is wearing a helmet.

License Plate Recognition – Extracts alphanumeric text from number plates using OCR (Optical Character Recognition).

Multi-Class Object Detection – Simultaneously detects motorcycles, helmets, and number plates.

Model Selection

YOLOv8 (You Only Look Once v8) – Used for object detection due to its high speed and accuracy.

OpenCV – Applied for image processing and OCR-based number plate extraction.

Tesseract OCR – Converts detected license plate images into text.

Model Training & Evaluation

Pretrained YOLOv8 is fine-tuned on our dataset.

The detection system is built using:

Real-Time Prediction & Deployment

Once a traffic violation is detected, the system generates an automated warning message and sends it via email. The Flask-based web application allows users to upload images for real-time analysis.

Real-Time Data Integration

The system processes images dynamically, extracting vehicle numbers and violations instantly. Results are directly used to trigger warning messages without storing in a database.

Web-Based Deployment

To make the system **accessible to Traffic authorities**, a **web-based dashboard** was implemented using Flask.

User Interface: Allows users to upload traffic images/videos for violation detection.

Image Analysis: The uploaded image will be analyzed to bring the accurate result.

Violation Alerts: Generates and sends automated warning emails to a predefined address when a traffic violation is detected

Testing and Validation

The implemented system underwent **multiple testing phases** to ensure reliability and accuracy.

Unit Testing

Individual components, such as **data preprocessing, model detection , and UI interactions**, were tested separately.

Integration Testing

The system's **data pipeline, machine learning models, and real-time processing** were tested together to check for inconsistencies.

Performance Evaluation

The system was tested on **real-time traffic images** to evaluate accuracy and responsiveness.

False Positive & False Negative rates were analyzed to fine-tune the risk prediction model.

Challenges and Solutions:

During the implementation, several challenges were encountered, which were resolved using different strategies. Low quality images: applied image enhancement and noise reduction techniques.

Difficulty in detecting multiple violations: Used advanced object detection models like YOLO for multi-class recognition.

False positives in violation detection: Fine-tuned model thresholds and applied ensemble learning techniques. Data privacy concerns: Implemented secure data handling and anonymization protocols

A. MODEL ARCHITECTURE

The system follows a multi-layered architecture designed for helmet violation detection and license plate recognition using static images:

1. Input Layer

Accepts uploaded images for processing.

2. Processing & Analysis Layer

Uses YOLOv8 for helmet violation detection.

Employs EasyOCR for license plate extraction.

3. Data Management Layer

Stores processed data for record-keeping and enforcement. Provides a Flask-based web interface for traffic authorities to access results.

4. User Layer

Sends automated email alerts to violators with details of the offense.

b. System Modules

1. Model Management Module

Loads the YOLOv8 model for helmet detection.

2. Preprocessing Module

Reads and enhances input images to improve detection accuracy.

3. Object Detection Module

Uses YOLOv8 to identify motorcycles and riders.

B. RELATED WORK

Several automated traffic violation detection systems have been developed to improve road safety and law enforcement. Traditional methods rely on CCTV surveillance and manual monitoring, which are inefficient due to their lack of real-time processing and automation. These systems require human intervention to review footage and issue penalties, making large-scale enforcement challenging.

Recent advancements integrate computer vision and deep learning for automatic violation detection. Studies have explored the use of YOLO (You Only Look Once) models for vehicle and helmet detection, improving accuracy in traffic surveillance. However, many existing models struggle with real-time performance, accuracy in varying lighting conditions, and integration with enforcement databases.

Our approach enhances these existing methods by using YOLOv8 for helmet detection, ensuring high precision and efficiency. Additionally, Easy OCR is employed for accurate license plate recognition, and an automated email notification system is integrated to instantly inform violators. This AI-driven solution improves scalability, reduces the need for manual intervention, and enables real-time enforcement of helmet laws.

C. MODEL SELECTION

The system is designed to detect helmet violations and recognize license plates using a single deep learning model, YOLOv8.

1. Object Detection Model

YOLOv8 – Used for detecting motorcycles, riders, and helmet violations in uploaded images.

2. Model Training & Evaluation

Pretrained YOLOv8 is used to ensure high accuracy in helmet detection.

The system processes images and applies object detection to classify helmet violations.

Model Evaluation Metrics:

Mean Average Precision (**mAP**): Evaluates how accurately YOLOv8 detects helmet violations.

Intersection over Union (**IoU**): Measures the overlap between predicted and actual violation areas.

D. Future Enhancements

1. Real-Time Video Processing

Extend the system to process live traffic camera feeds instead of just static images.

2. Violation History Tracking

Develop a database to store past violations and track repeat offenders.

3. Automated Fine Generation

Integrate with traffic enforcement systems to issue fines directly to violators.

4. Mobile App for Traffic Authorities

Develop a mobile interface where traffic officers can view violations in real time.

5. Improved Helmet Detection

Fine-tune the YOLOv8 model with more diverse datasets to reduce false positives and improve detection accuracy.

6. Improved OCR Recognition on Number Plates: Enhance the OCR model to accurately extract text from number plates under various conditions, including tilted or blurred images.

SYSTEM ARCHITECTURE

Our system is designed for helmet and license plate detection using deep learning. It takes input images and videos from traffic surveillance cameras and processes them using a YOLOv8-based convolutional neural network. The system first detects motorcyclists and determines whether they are wearing a helmet. If a violation is detected, the next step involves automatic license plate detection using Optical Character Recognition (OCR) to extract vehicle details. The system ensures accurate identification of violators and generates automated alerts, making traffic law enforcement more efficient and scalable.

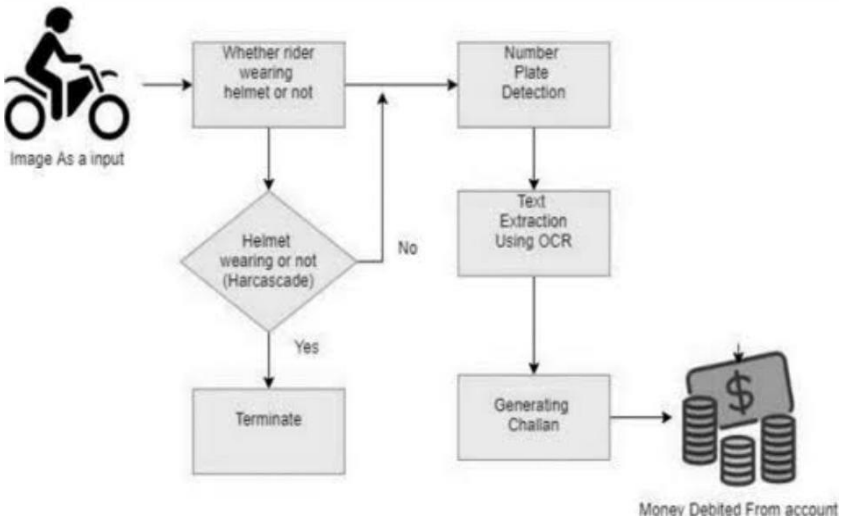


FIG: SYSTEM ARCHITECTURE

Implementation Suggestions:
YOLOv8: Detects motorcyclists, helmets, and license plates.
OCR: Extracts license plate numbers for identification.
Deep SORT: Tracks violators across multiple frames.
Automated Reporting: Sends violation details via email/SMS.

RESULTS AND DISCUSSION

The Helmet and License Plate Detection System successfully identifies helmet violations and extracts license plate numbers using a pre-trained YOLOv8 model. The system processes images in real-time, accurately detecting motorcyclists without helmets and recognizing license plates with Easy OCR. The detection efficiency remains high, enabling automated monitoring without manual intervention. YOLOv8 ensures reliable classification, with strong Mean Average Precision (mAP) for accurate identification.The system is optimized to run efficiently on standard CPU-based systems, eliminating the need for high-end GPUs. Additionally, the automated email notification system enhances enforcement by instantly alerting authorities with violation details.However, some challenges remain. In crowded traffic conditions, overlapping objects may lead to false positives. Detection accuracy can also be affected by low-resolution images, requiring further image enhancement techniques. Features like real-time video processing and multi-camera integration are potential future enhacements.Overall, this AI-powered solution significantly improves helmet law enforcement by reducing manual effort, ensuring real-time violation detection and automated reporting.

Output 1

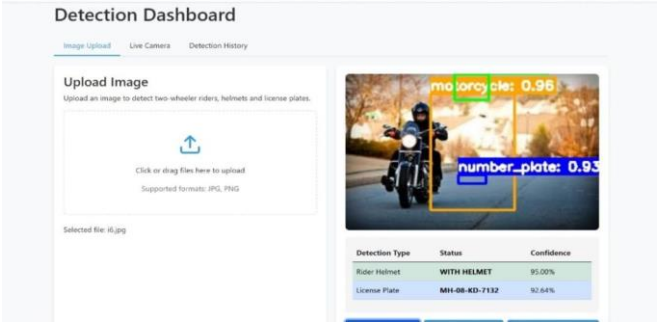


Fig1: WITH HELMET

Output 2

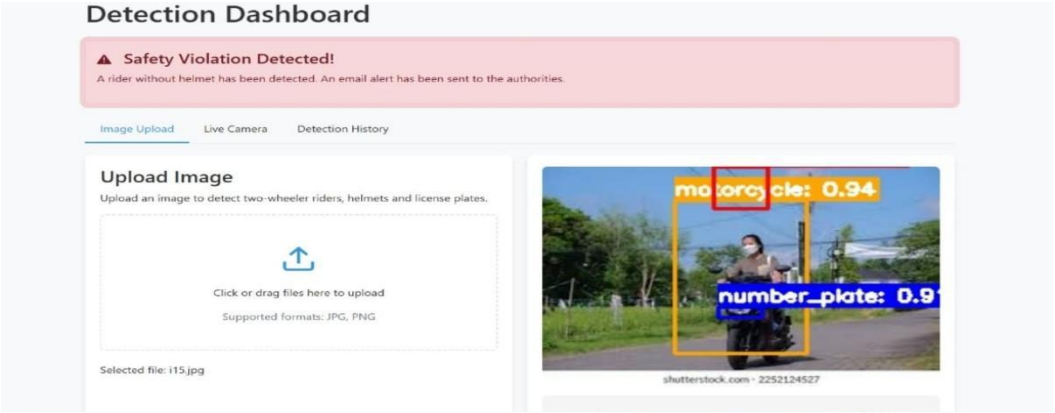
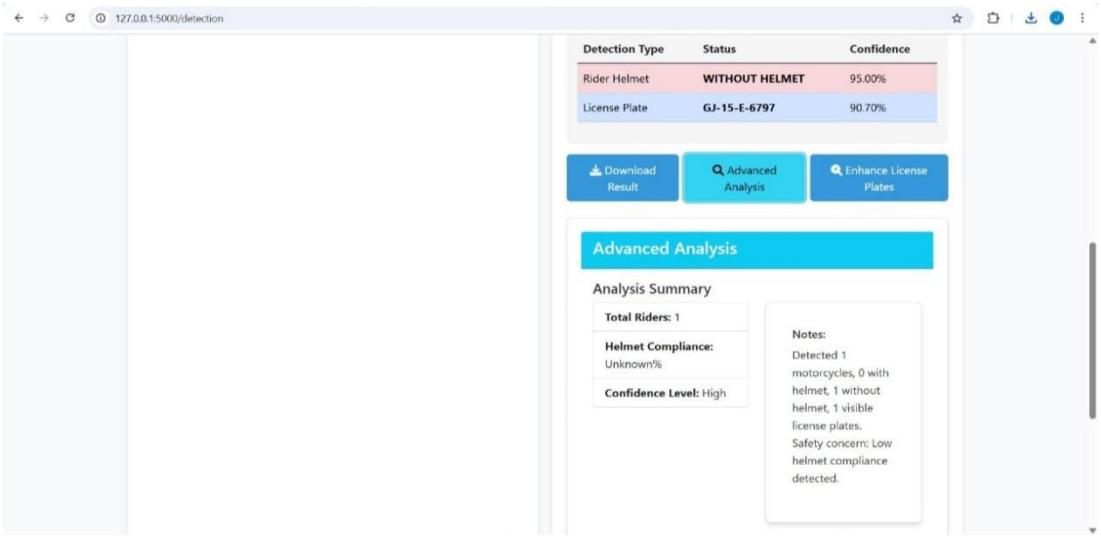


Fig2: WITHOUT HELMET



. **Fig2.1 DETECTION RESULTS**

Fig2.2 EMAIL NOTIFICATION

ETHICAL CONSIDERATIONS

Data Privacy & Security in Helmet & License Plate Detection

Secure Data Handling

The system captures images and videos for detecting helmet violations and license plates while ensuring that personally identifiable information (PII) is securely processed. All data is used strictly for traffic law enforcement and not for any unauthorized purposes.

Minimal Data Retention

To maintain privacy, the system does not store violation records long-term. Once a violation is detected, the extracted license plate number is processed, and an automated notification is sent to authorities without retaining unnecessary personal data.

Protection Against Unauthorized Access

If future enhancements involve storing license plate data, strong encryption techniques such as AES-256 and TLS/SSL will be implemented to prevent unauthorized access. Data anonymization techniques can also be applied to enhance.

CONCLUSION:

We have successfully implemented the Automatic Helmet Detection and Number Plate Recognition project using YOLOv8 and Convolutional Neural Networks (CNN). Our system accurately detects helmet violations and extracts license plate details using Optical Character Recognition (OCR), ensuring efficient and automated enforcement of traffic rules.

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