Machine Learning Based Traffic Rules Violation Detection System

Sushma V[1] Rakshitha Kumar H K[2] Sanmitha V[3] Shreya G[4] Suchithra R[5]

[1,2,3,4,5]Department of Computer science and Engineering

[1,2,3,4,5]ATME college of Engineering, Mysuru, India

Abstract—Video grounded vehicle recognition is a performing disquisition region in wise Transportation system. Real time identification systems are veritably important and needful for safety rule following and illiberalism and also for own safety enterprises. The point is to liberate the necessary information from enormous productively measure of recordings caught by surveillance cameras by distinguishing, following feting objects of interest and examine their exercises. currently two- wheeler is the most popular modes of transport. still, because of lower protection there's a high threat involved. As a result to this, it's largely desirable for bike riders to use helmet. Observing the utility of helmet, Government have made it punishable offence to ride a bike without helmet and have espoused homemade strategies to catch the violators which has limitations of speed. Using videotape surveillance of the road, the proposed approach detects if the bike rider is wearing a helmet automatically without homemade help.However, license plate of the vehicle read and noted, grading violations consequently and issuing the forfeiture which will help increase the effectiveness of business rule enforcement, If a bike rider is detected not wearing the helmet.

Key words: Optical Character Recognition (OCR), Real time identification systems, Instant Challan generation, PyTorch, Pillow, Helmet detection, YOLO v5 ML-Based Rules violation detection.

I. INTRODUCTION

The Traffic Rule Violation Detection System is an advanced, ML-based solution to automate the identification, recording, and enforcement of traffic law violations for better road safety and operational efficiency. Traditional methods of traffic monitoring rely more on human intervention, making them labour-intensive, error-prone, and inefficient. The system uses computer vision, machine learning to provide an automated, real-time mechanism for the detection of violations for better compliance with traffic regulations.

The helmet detection is one of the key features of this system, which is detecting motorcyclists riding without helmets, thus a major concern for safety. It also uses vehicle number plate recognition, OCR, which automatically extracts vehicle registration details from the images and feeds from video sources. The incorporation of YOLO v5, the best object detection algorithm, helps recognize vehicles, riders, and violation with accuracy at high speed. The detected infringement may thus establish an automatic procedure that would immediately generate a challan (fine) subsequently forwarded to the violator with licence plate data.
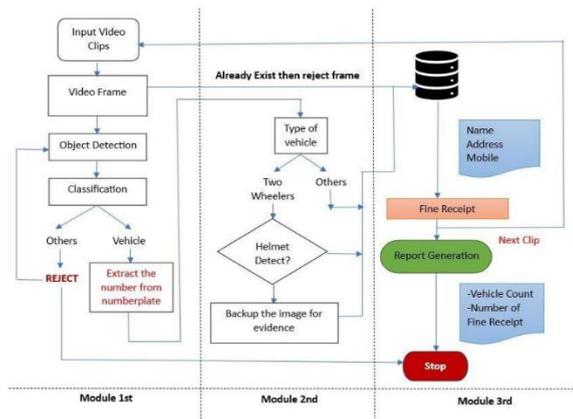
Figure 1: Functional Flow of Helmet Detection, Number Plate Extraction and Instant Challan Generation Application.
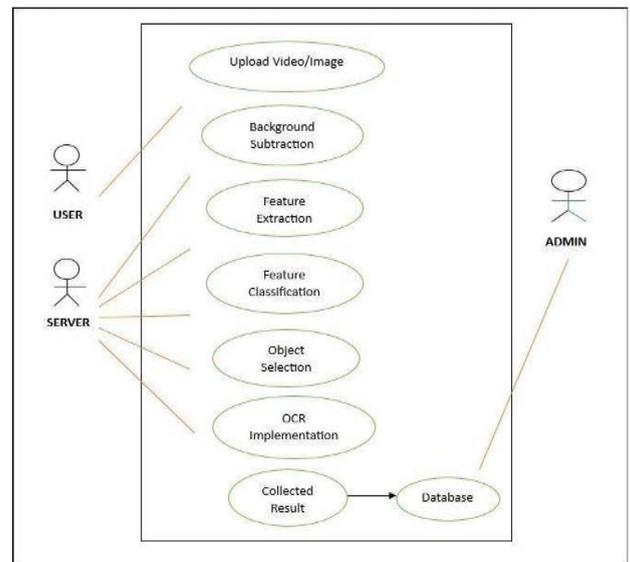

Figure 2: System Methodology

This real-time violation detection system minimizes human efforts and thereby reduces errors, provides transparency, accountability, and a quicker response from traffic authorities. It enables detection of signals, over speeding, lane discipline violations, and parking despite signs, making it a comprehensive traffic management solution for today's roads.

It will further integrate it into a central database for empowering the authorities in maintaining an online record of infractions thus allowing them to track repeated violators while monitoring the flow of traffic to help in analyzing them for decisions. The process thereby implementing this technology diminishes the accident caused due to non-compliance and simultaneously makes the fine collection smooth without having to do everything manually.

II. METHODOLOGY

The project integrates computer vision and machine learning technologies to detect traffic violations, specifically focusing on helmet detection and **automatic number plate recognition (ANPR)** for two-wheelers. It utilizes **YOLOv5** for object detection and **Optical Character Recognition (OCR)** for licence plate extraction, enabling automated enforcement of traffic rules.

Step 1: Admin Login, and Authentication

- **Admin Login**
  - Admin will enter their username and password.
  - The system validates unique email addresses to prevent duplication.
  - Passwords are encrypted and securely stored.

Step 2: Vehicle and Helmet Detection (Input)

- **Video input**
  - Upload **real-time** data.

- **Vehicle and Helmet Identification:**
  - YOLOv5 and OpenCV detects two-wheelers and their riders.
  - The system classifies whether the rider is wearing a helmet or not.

Step 3: Number Plate Detection (OCR and ANPR)

  - If a violation (rider without a helmet) is detected:
  - The system captures the number plate and extracts the text using OCR and ANPR techniques.

- **Image Preprocessing**

  - Before text recognition, the image undergoes the following preprocessing steps:

  - **Grayscale Conversion** – Converts color images to grayscale for better contrast.

  - **Thresholding (Binarization)** – Converts images to black and white for improved text detection.

  - **Noise Reduction** – Removes irrelevant artifacts to enhance clarity.

  - **Resizing** – Adjusts the image dimensions to meet **OCR input requirements**.

Step 4: Instant Challan Generation

- If a traffic violation is confirmed, the system:

- Generates a challan with violation details and fine amount.

- Sends the challan to the violator via email.

- **Email Sending Using SMTP Protocol:** The system utilizes the **Simple Mail Transfer Protocol (SMTP)** for sending emails.

- SMTP is a widely used communication protocol that handles the transmission of emails between mail servers.

- **Integration with Yagmail:** Yagmail automatically **connects to Gmail's SMTP server** (smtp.gmail.com) over a secure **SSL connection.**

- It requires the sender's Gmail credentials, which can be securely stored using keyrings to avoid hardcoding passwords.

- The challan, either as **text or an attachment** is sent to the violator's **registered email address.**

Step 5: Frontend-Backend Communication:

- Users interact through a web-based interface for monitoring and data access.

- The backend processes video frames, extracts required details, and manages challan issuance.

- **Backend-ML Model Interaction:**

- **YOLOv5** and **OpenCV** handle vehicle and helmet detection.

- **OCR** extracts licence plate numbers for legal enforcement.

Step 6: Challenges and Solutions

- **Handling Low-Quality Video Inputs:**

  - **Poor lighting** and **motion blur affect** detection accuracy.

  - **Solution:** Applied preprocessing techniques like frame enhancement and noise reduction.

- **Scalability and Real-Time Processing:**

  - Processing **large volumes of traffic data** in real-time is computationally intensive.

  - **Solution:** Optimized model performance using **efficient frame extraction** and **cloud-based deployment.**
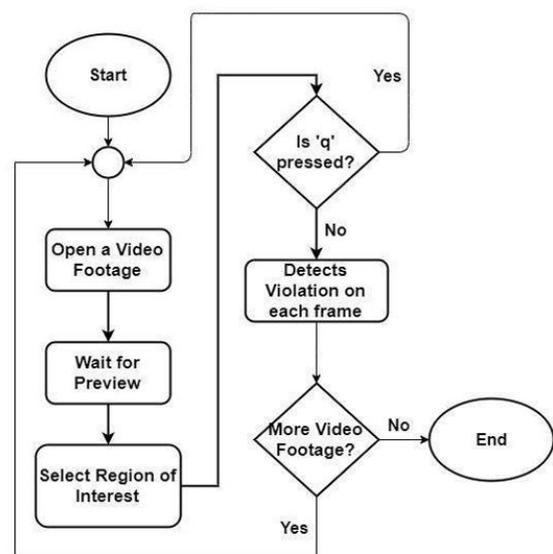
Figure 3: System Implementation

RESULTS

Overview: The results demonstrate the successful implementation and functionality of the ML-Based Traffic Rules Violation Detection System. Snapshots are provided to illustrate the working of the system, highlighting its efficiency, accuracy, and automation in detecting helmet violations, extracting licence plate numbers, and generating instant challans for violators. The system enhances road safety by ensuring compliance with traffic laws while reducing manual enforcement efforts.
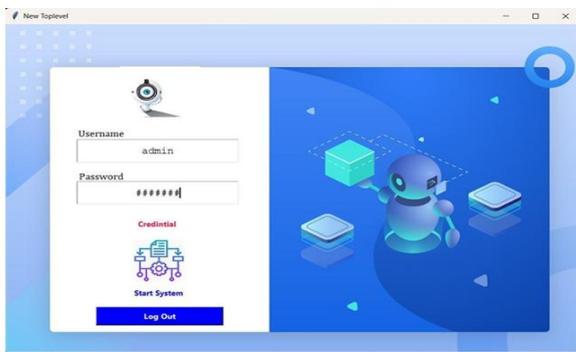
Login Page

Figure 4: The login page allows admin to authenticate using their registered credentials.

Input Page

Figure 5: The input page is where the system receives video footage or image data for processing.

Dataset Selection Page

Figure 6: The Dataset Selection Page allows users to choose the source of input data, either from a pre-recorded dataset or a live video feed.

Dataset Processing Page

Figure 7: The Data Processing Page extracts frames from the selected video or images and applies YOLOv5 and OpenCV for object detection.

Number Plate Detection with Helmet

Figure 8: This Page displays the results of the detection process, highlighting whether a helmet violation has occurred.
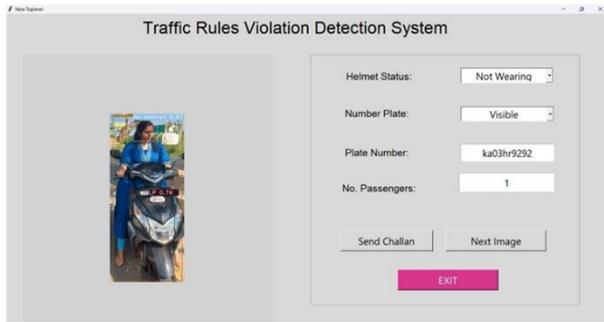
Number Plate Detection without Helmet

Figure 9: This Page provides a detailed summary of detected violations, including the extracted licence plate number of the offender.

Challan Generation

Figure 10: The Challan Generation Page is where the system automatically issues a fine for detected traffic violations.
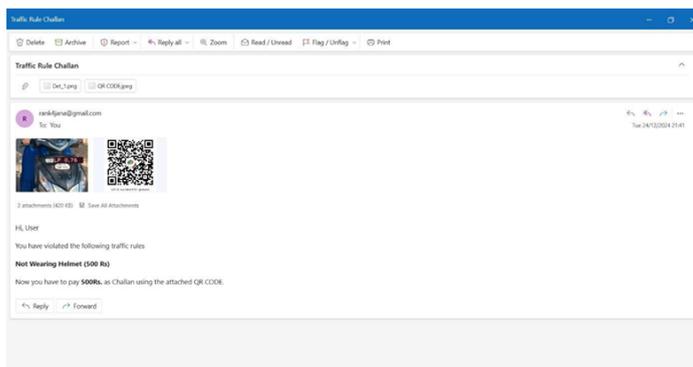
Challan Received Page

Figure 11: The Challan Received Page confirms the successful delivery of the generated challan to the violator.

CONCLUSION

The access of the database which is generated by the system is given to appropriate authorities will result increasing awareness of wearing helmet and authorities may take required action. Implementation of system could result into increase in bike rider wearing helmets.

The traffic monitoring system of the street is improved. At the end reducing fatality in accidents. Data gathered while monitoring traffic can be used for further analysis. The proposed system is developed for the detecting the violators not following the traffic law by catching the non-helmet and traffic signal jumping Two-wheelers detection using YOLOv5 algorithm and extracting the details of Two-wheeler riders.

If the present manual detecting system is replaced by automatic detection more violators can be fined and due to the fear of fine people would definitely start to follow the traffic rules and to wear the helmet.

FUTURE SCOPE

- **E-Wallet Linking**

o If the License number of the registered vehicle is linked to rider's bank account, auto deduction of the fine and SMS delivery system can be implemented. This will make the system completely automatic hence there will be no scope of corruption or unfair fine collection. But, for this to be implemented it is important that helmet and license number detection is 100% accurate.

- **A Complete traffic check system**

o This helmet check system can be expanded to check if other rules are followed. Modules can be designed for speed tracking, zebra crossing, traffic signal check etc. Also, using video surveillance it can be checked if vehicle drivers are using cellphones while driving.

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