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SPEED TRACKING AND VEHICLE DETECTION SYSTEM

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ABSTRACT

Traffic safety and regulation enforcement remain critical challenges in urban areas. This paper presents an advanced Speed Tracking and Vehicle Detection System leveraging computer vision techniques, specifically OpenCV and YOLO, integrated with a user-friendly Tkinter GUI and MySQL database for efficient data management. The system identifies vehicles, calculates their speed based on frame-to-frame motion, and logs instances of over speeding. A newly added feature enables automatic number plate recognition and email notifications to alert authorities of speed violations. Designed for real-time performance, the system aims to support traffic management authorities by providing an automated, scalable, and adaptable solution.

KEYWORDS *Speed Detection, Vehicle Tracking, Number Plate Recognition, Computer Vision, Opencv, YOLO, Tkinter, Traffic Management*

I.INTRODUCTION

With the rapid increase in urban traffic and the growing number of vehicles on the road, ensuring traffic safety and enforcing speed limits have become more challenging than ever before. Traditional methods, including speed guns, manual monitoring, and static cameras, often fall short due to limited coverage, resource dependency, and lack of real-time automation. This inefficiency leads to numerous cases of untracked overspeeding, contributing to rising accident rates and chaotic traffic flow.

The integration of computer vision and automation into traffic monitoring systems presents a transformative solution to these issues. This paper introduces a comprehensive, AI-powered Speed Tracking and Vehicle Detection System capable of detecting vehicles, calculating their speeds, recognizing number plates, and instantly alerting authorities via email when violations occur. Unlike conventional methods, this system operates autonomously, reducing human involvement while enhancing accuracy and response time.

The proposed system leverages YOLO (You Only Look Once) for real-time vehicle detection, OpenCV for image processing, and Tesseract OCR for number plate recognition, all connected through an intuitive Tkinter GUI. Furthermore, a MySQL database supports data storage for analysis and reporting. The newly integrated email notification feature ensures timely enforcement by directly informing authorities of any over speeding incidents, complete with vehicle details and speed records.

Additionally, the system aims to reduce manual errors, improve enforcement efficiency, and promote safer driving behaviour. The combination of speed tracking, number plate detection, and email alerts creates an all-in-one solution that addresses key challenges faced by traffic monitoring authorities. This innovation supports both pre-recorded video analysis and live detection modes, making it adaptable to various surveillance scenarios — from highways to city streets. The system aims to improve road safety by providing a cost-effective, scalable, and highly responsive solution to traffic enforcement agencies, paving the way for smarter cities and safer roads.

II.LITERATURE REVIEW

The evolution of traffic monitoring systems has been driven by advancements in computer vision, machine learning, and automation technologies. Traditional speed detection methods, such as radar guns and induction loops, face limitations in coverage, automation, and scalability. Recent research explores automated solutions leveraging deep learning models like YOLO (You Only Look Once) for real-time object detection and Optical Character Recognition (OCR) for number plate recognition.

Studies like those by Redmon et al. (2016) demonstrate the efficiency of YOLO in vehicle detection tasks, achieving rapid inference without sacrificing accuracy. Hsu & Chien (2018) further validated the feasibility of integrating speed estimation algorithms in dynamic environments, enhancing vehicle tracking reliability. Kiran et al. (2019) proposed a deep learning-based approach to combine detection with speed estimation, showing promising results in urban traffic scenarios. Additionally, integrating REST APIs for data communication has revolutionized remote monitoring, enabling real-time enforcement alerts and data logging — a concept that supports modern smart city infrastructure.

Despite these advancements, challenges like varying lighting

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conditions, occlusion, and false detections persist. Recent innovations in AI, such as YOLOv8 and enhanced OCR models, continue to push the boundaries, promising greater accuracy and adaptability to complex traffic environments.

III.METHODOLOGY

The system consists of interconnected modules that work seamlessly to detect vehicles, calculate their speed, recognize number plates, and log relevant data for later analysis. The architecture supports two operational modes: video upload and real-time number plate detection.

1.Vehicle Detection Module

- Utilizes the YOLO (You Only Look Once) object detection model to identify vehicles in live video feeds. YOLO's real-time detection capabilities ensure minimal processing delay, making it suitable for speed tracking applications.
- The model is trained on a dataset of various vehicle types to improve detection accuracy.

2.Number Plate Recognition Module:

- Integrates Optical Character Recognition (OCR) using **Tesseract** to extract number plate details from detected vehicles.
- The module applies image pre-processing techniques such as thresholding, contour detection, and perspective transformation to enhance recognition accuracy.
- If a vehicle exceeds the speed limit, its number plate is captured and logged alongside the speed data.

3.Speed Calculation Module:

- Captures vehicle positions across consecutive frames to calculate speed using the formula:
- Speed (km/h) = (Distance traveled in meters / Time taken in seconds) × 3.6
- The distance is calibrated based on a predefined reference object in the frame.
- Motion tracking algorithms, such as centroid tracking, ensure accurate vehicle tracking across frames, minimizing errors.

4.Automated Email Alert Module:

- If a vehicle is detected overspeeding, the system triggers an automatic email alert.
- The email contains details including the vehicle's number plate, detected speed, date, time, and location (if integrated with GPS).
- The email is sent to a pre-configured list of authorities for immediate action.
- The email module supports SMTP-based configurations, ensuring compatibility with various email services.
- Enhancements ensure reliable email delivery with retry mechanisms and alert logging.

5. Data Logging Module:

- Uses MySQL to store vehicle details, including detected vehicle type, speed, date, time, and number plate data.
- Logs overspeeding events for further analysis, allowing traffic authorities to generate reports.
- Data can be exported as CSV files for external analysis or record-keeping.
- A search feature allows authorities to query historical data based on date, vehicle type, or number plate.

Tkinter GUI Integration:

- The system features an intuitive Tkinter-based graphical interface, allowing users to:
- Start and stop the detection system.
- Choose between video upload mode or real-time detection mode.
- View live video feed with detected vehicles highlighted.
- Access a database of recorded overspeeding events.
- Export reports for enforcement actions.
- Monitor email alert logs to ensure successful notifications.
- Configure email settings and speed thresholds directly from the interface.
- View logs and alerts for better monitoring and control.

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IV.SYSTEM ARCHITECTURAL FLOW

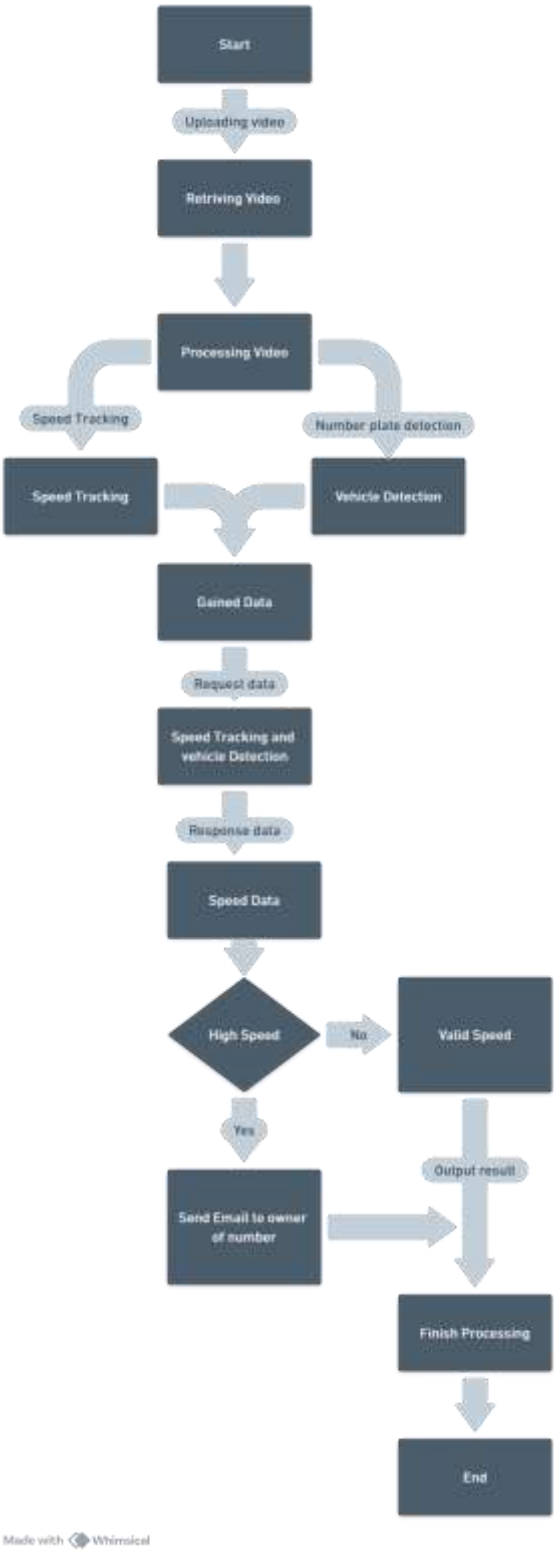

Fig 1. System Workflow

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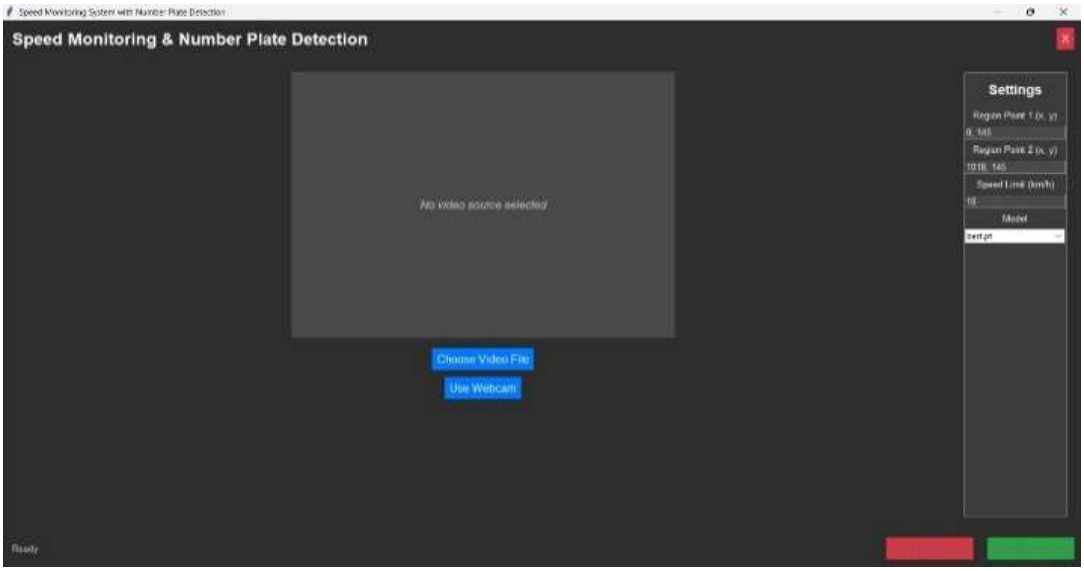
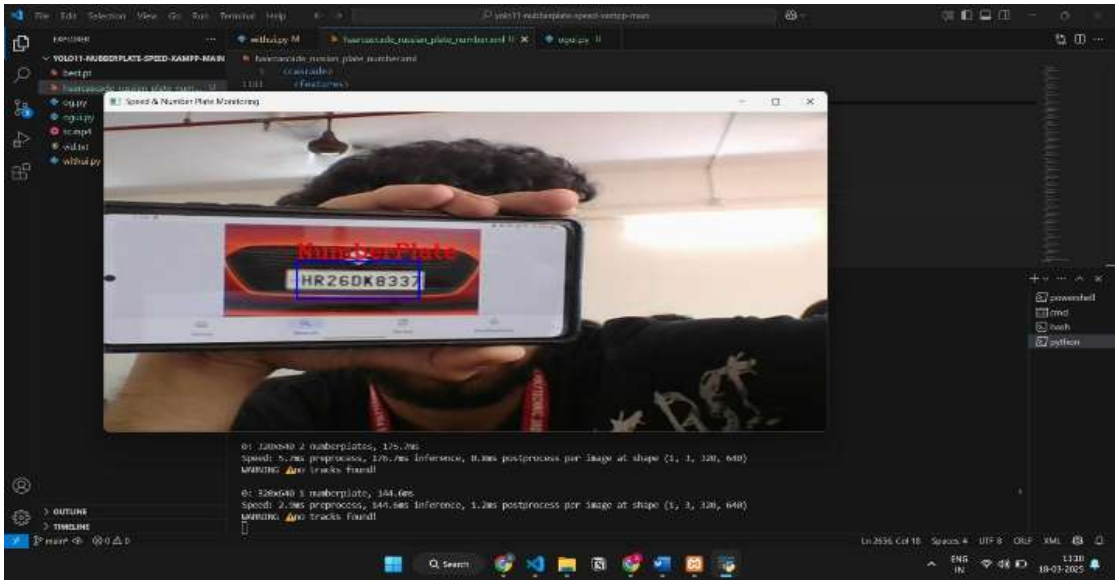
This workflow diagram represents the Speed Tracking and Vehicle Detection System with Number Plate Recognition and Automated Email Alerts. Let's break it down step by step:

1. **Uploading Video** – A video is uploaded, likely containing footage of moving vehicles.
2. **Retrieving Video** – The system retrieves the uploaded video for processing.
3. **Processing Video** – The video is analyzed, splitting into two key tasks: speed tracking and number plate detection.
4. **Speed Tracking** – The system tracks vehicle speed from the video data.
5. **Vehicle Detection** – The system detects vehicles and extracts their number plates for identification.
6. **Gained Data** – Data from both tracking and detection is collected.
7. **Request Data** – The system requests further processing of the gathered data to correlate speed and vehicle details.
8. **Speed Tracking and Vehicle Detection** – The system ensures both speed and vehicle details are aligned and validated.
9. **Response Data** – The processed data is returned, focusing on vehicle speed.
10. **Speed Data** – The final speed data of the vehicle is acquired for evaluation.
11. **High Speed?** – A decision point checks if the vehicle exceeds the speed limit.
    - **No** → If the vehicle's speed is within the limit, it moves to the "Valid Speed" step.
    - **Yes** → If the vehicle is speeding, the system proceeds to alert the owner.
12. **Send Email to Owner** – An email is sent to the registered vehicle owner, notifying them of the speeding incident.
13. **Valid Speed** – If the vehicle was within the speed limit, it's marked as valid, and results are output.
14. **Output Result** – The system outputs the final result, whether valid or a speeding alert.
15. **Finish Processing** – The system wraps up all tasks.

V.RESULT





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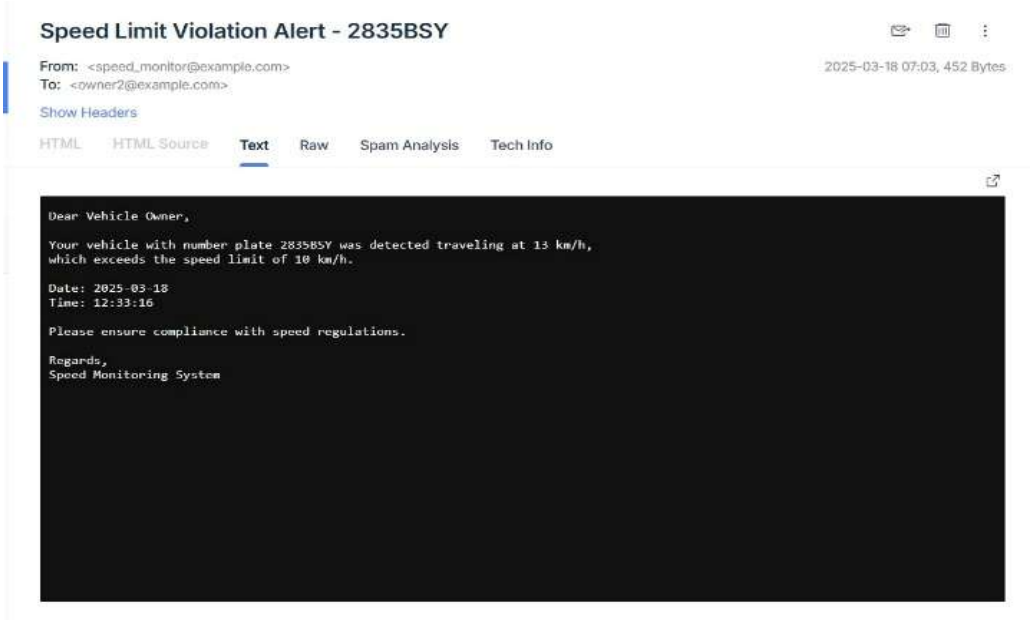

VI.FUTURE SCOPE

The proposed Speed Tracking and Vehicle Detection System can be enhanced and expanded in multiple directions:

1. Enhanced Accuracy with AI/ML Integration: Future versions can incorporate advanced deep learning models such as YOLOv8 or Efficient for improved object detection accuracy under various weather and lighting conditions.
2. Real-time Data Transmission: The system can be upgraded to stream data directly to cloud servers for centralized monitoring and instant alerts, making it ideal for smart city integration.
3. Predictive Analytics: Incorporating data analytics can help forecast traffic patterns, detect anomalies, and predict accident-prone zones based on historical data.
4. Multi-camera Integration: Future development can enable synchronized multi-camera inputs for wider area coverage and seamless vehicle tracking across intersections and highways.

VII.CONCLUSION

This research paper presents an advanced trafficmonitoring system using computer vision, machine learning, and automation to enhance accuracy and efficiency. It integrates real-time detection, number plate recognition, and automated email alerts, supported by MySQL for data management. The system manual intervention, speeds up reporting, and improves enforcement. Overall, it demonstrates a smarter, more effective approach to traffic management and road safety.

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