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ANALYSING HIGH SECURITY REGISTRATION PLATE (HSRP) OF VEHICLE CLASSIFICATION IN INDIAN SCENARIO

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Abstract: The implementation of **High Security Registration Plates (HSRP)** in India has significantly improved vehicle identification and security by introducing tamper-proof, standardized registration systems. This paper, titled *"*Analysing High Security Registration Plate (HSRP) of Vehicles and Vehicle Classification in Indian Scenario*,"* focuses on the development of an intelligent system that automatically detects and classifies vehicles using advanced computer vision techniques.

The proposed method employs the **YOLO (You Only Look Once)** deep learning algorithm for real-time detection and recognition of HSRPs from captured images frames. The system extracts alphanumeric data from plates and classifies vehicles into categories such as cars, bikes, trucks, and buses. The analysis is further enhanced through image preprocessing, segmentation, and machine learning-based classification.

Index Terms **- Object Detection, YOLO method, python programming , OpenCV, Real-Time Monitoring, Vehicle Detection .**

1.INTRODUCTION

The rapid growth of the automobile sector in India has created pressing challenges in vehicle identification, regulation, and security. Traditional registration plates have long been vulnerable to tampering, duplication, and misuse, leading to difficulties in law enforcement and road safety management. To address these concerns, the Government of India has mandated the use of **High Security Registration Plates (HSRP)**, designed with advanced security features such as a chromium-based hologram, laser-etched permanent identification number, and tamper-proof snap locks.

HSRPs not only enhance the authenticity of vehicle registration but also play a crucial role in **vehicle classification, traffic monitoring, and crime prevention**. Their integration with digital databases enables seamless enforcement of policies related to toll collection, pollution control, and stolen vehicle tracking. In the Indian context, where diverse vehicle categories—from two-wheelers to heavy commercial vehicles—coexist, the adoption of HSRPs represents a significant step toward modernizing transportation governance and ensuring national security

2. PROPOSE METHODOLOGY

1. Data Collection

- Primary Data : Capture images of vehicles equipped with HSRPs across different categories (two-wheelers, cars, buses, trucks). Collect samples from multiple regions to account for variations in plate placement, lighting, and environmental conditions.
- Secondary Data : Government notifications, transport department records, and existing literature on HSRP implementation. Vehicle classification datasets from traffic monitoring agencies.

2. Preprocessing

- Image Enhancement: Apply noise reduction, contrast adjustment, and normalization to improve plate visibility.
- Segmentation: Isolate the registration plate area using edge detection or deep learning-based object detection models (e.g., YOLO, CNN).
- Feature Extraction:Identify HSRP-specific security features (hologram, laser code, snap lock). Extract alphanumeric characters using Optical Character Recognition (OCR

3. Vehicle Classification

- Rule-Based Classification: Categorize vehicles based on registration number series and transport authority guidelines.
- Machine Learning Models: Train classifiers (SVM, Random Forest, CNN) to distinguish vehicle classes using plate data and physical attributes.
- Validation: Compare classification accuracy with official transport records.

4. Security Analysis

- **Tamper Detection**: Evaluate robustness of HSRP features against duplication, removal, or alteration.
- **Cross-Verification**: Match laser-etched codes with centralized databases to confirm authenticity.

5. Integration with Smart Systems

- **Traffic Monitoring**: Test methodology in real-time scenarios such as toll plazas and traffic checkpoints.
- **Policy Evaluation**: Assess how HSRPs improve enforcement of emission norms, insurance compliance, and stolen vehicle tracking.

6. Performance Metrics

- Accuracy of plate detection and OCR recognition.
- Classification precision and recall across vehicle categories.
- Security validation success rate.
- Computational efficiency in real-time applications

3. SYSTEM DESIGN

1. Input Layer

The system begins with the acquisition of vehicle data. Inputs are collected from multiple sources such as surveillance cameras at traffic junctions, toll plazas, parking facilities, and enforcement checkpoints. These cameras capture real-time images and video streams of vehicles equipped with HSRPs. Additionally, transport authority records and centralized databases provide reference information for validation. This dual input approach ensures both **visual evidence** and **official records** are available for analysis

2. Preprocessing Layer

Raw images often suffer from noise, poor lighting, or distortions due to environmental conditions. To address this, preprocessing techniques such as **contrast enhancement, noise reduction, and normalization** are applied. Plate localization algorithms (e.g., edge detection, contour analysis, or deep learning-based object detection models like YOLO) are used to isolate the registration plate from the vehicle body. Normalization ensures that plates of varying sizes and orientations are standardized, making subsequent analysis more reliable

3. Feature Extraction Layer

This layer focuses on identifying both **security features** and **registration details** embedded in HSRPs.

Security Features: The hologram, laser-etched permanent identification number, and snap lock are detected using image recognition techniques

These features are critical for verifying authenticity and preventing tampering.

Alphanumeric Extraction: Optical Character Recognition (OCR) is applied to extract the registration number. Advanced OCR models are trained to handle variations in font, alignment, and plate conditions

4. Classification Layer

Vehicle classification is performed using a hybrid approach:

Rule-Based Logic: Registration series and Regional Transport Office (RTO) guidelines are used to categorize vehicles into two-wheelers, light motor vehicles (LMV), and heavy motor vehicles (HMV).

Machine Learning Models: Convolutional Neural Networks (CNN) and Support Vector Machines (SVM) are trained on labeled datasets to classify vehicles based on plate data and physical attributes (e.g., size, shape, and dimensions). This ensures higher accuracy in diverse real-world conditions

5. Security Validation Layer

The extracted laser-etched code is cross-verified with centralized transport databases maintained by state and national authorities. This step ensures that the plate belongs to the registered vehicle and has not been duplicated or tampered with. Anomaly detection algorithms are employed to flag suspicious cases such as mismatched codes, missing holograms, or altered snap locks. This layer strengthens the **anti-counterfeit capability** of HSRPs

6. Output Layer

The final stage generates a comprehensive report containing:

Vehicle category (two-wheeler, LMV, HMV).

Registration details extracted from the plate.

7. Integration with Smart Systems

The system is designed to integrate seamlessly with India's evolving **Intelligent Transport Systems (ITS)**. By linking HSRP analysis with smart city infrastructure, toll automation, and pollution monitoring, the design supports broader policy objectives such as reducing manual enforcement, enhancing transparency, and improving compliance with road safety regulations

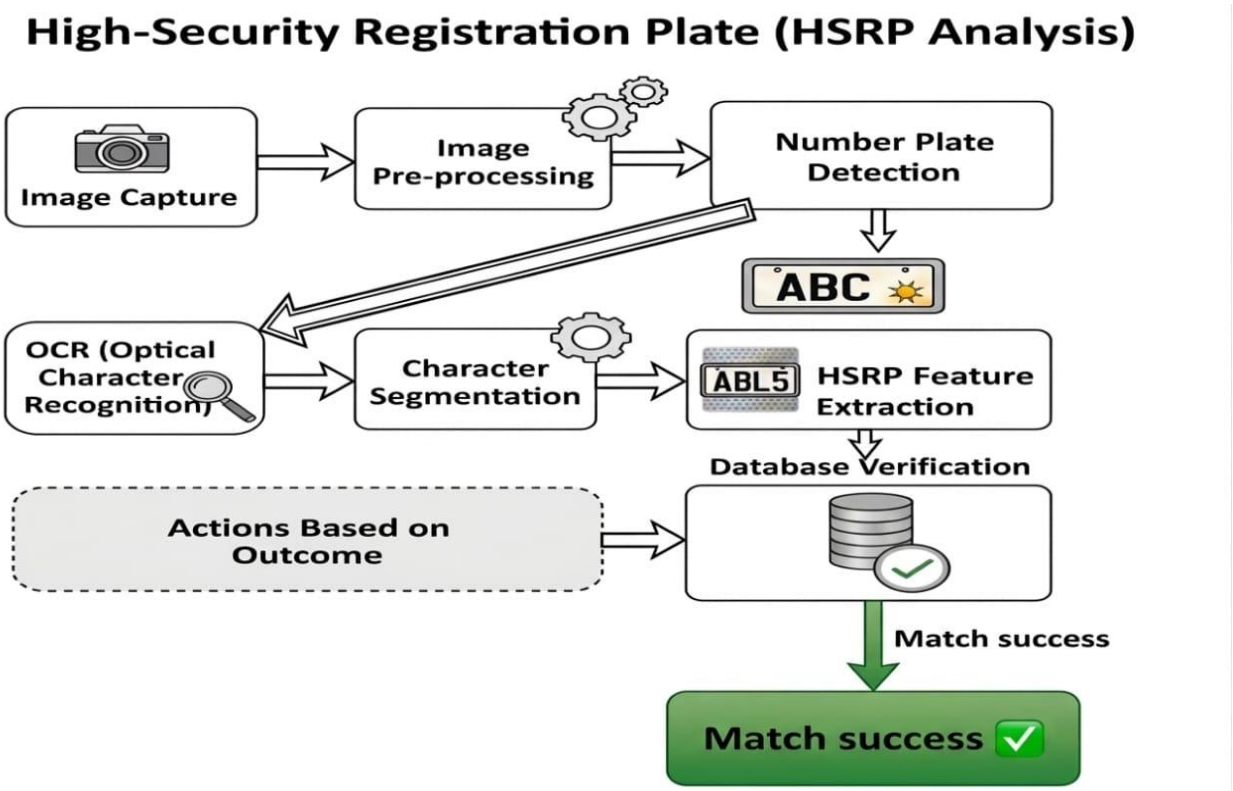


Figure: block diagram

4. IMPLEMENTATION

The proposed HSRP Detection and Vehicle Classification System is designed to detect High Security Registration Plates (HSRP) from vehicle images and videos in the Indian scenario. The main objective of this system is to identify Indian HSRP plates, extract important information such as the vehicle registration number and HSRP-specific features including the IND hologram, chromium-based font, laser code, and blue IND band. The extracted details are verified with databases such as VAHAN, local RTO databases, or enterprise databases to ensure authenticity. The system also classifies vehicles into categories such as two-wheelers, four-wheelers, and trucks. Based on the verification results, the system can perform actions such as access control, generating alerts, and maintaining logs.

The implementation faces several challenges due to Indian road conditions. These challenges include non-uniform lighting conditions, dust, rain, damaged or unclear number plates, different fonts, regional language text near plates, and varying camera angles from traffic cameras or toll booths. Another major challenge is detecting fake or tampered number plates and distinguishing them from original HSRP plates.

The system architecture consists of multiple processing stages. First, the camera or video feed captures vehicle images. The captured images are passed through image preprocessing techniques to improve quality. After preprocessing, the system performs vehicle detection and classification, followed by HSRP-specific number plate detection. The detected plate region is processed for character segmentation, and Optical Character Recognition (OCR) is applied to extract the registration number. After OCR, the system validates HSRP features and compares the extracted information with the database. Finally, the decision engine generates the output such as allowing access, denying access, or generating an alert.

The image and video capture module uses hardware such as IP cameras with 1080p or higher resolution for better image quality and IR cameras for night-time detection. A frame rate of 15–30 FPS is considered suitable for real-time vehicle monitoring. The captured images are processed using image preprocessing techniques such as resizing, noise removal, contrast enhancement, and motion blur reduction to improve detection accuracy

Summary:
The **High Security Registration Plate (HSRP) Project Flowchart** illustrates the systematic procedure followed during verification, authentication, and installation of HSRP for vehicles in India. The process begins with verifying the authenticity of the plate as per government standards, including checks for secure alphanumeric fonts, chromium hologram, laser-etched serial number, and tamper-proof snap locks. If authentication fails, the plate is **rejected or flagged for inspection**. If it succeeds, the system identifies the **type of vehicle**—whether a two-wheeler, three-wheeler, or four-wheeler—and issues the corresponding HSRP size. After issuing the appropriate plate, all details such as vehicle number, chassis number, and laser code are recorded in a **centralized database** to ensure security and traceability.

FLOW CHART:

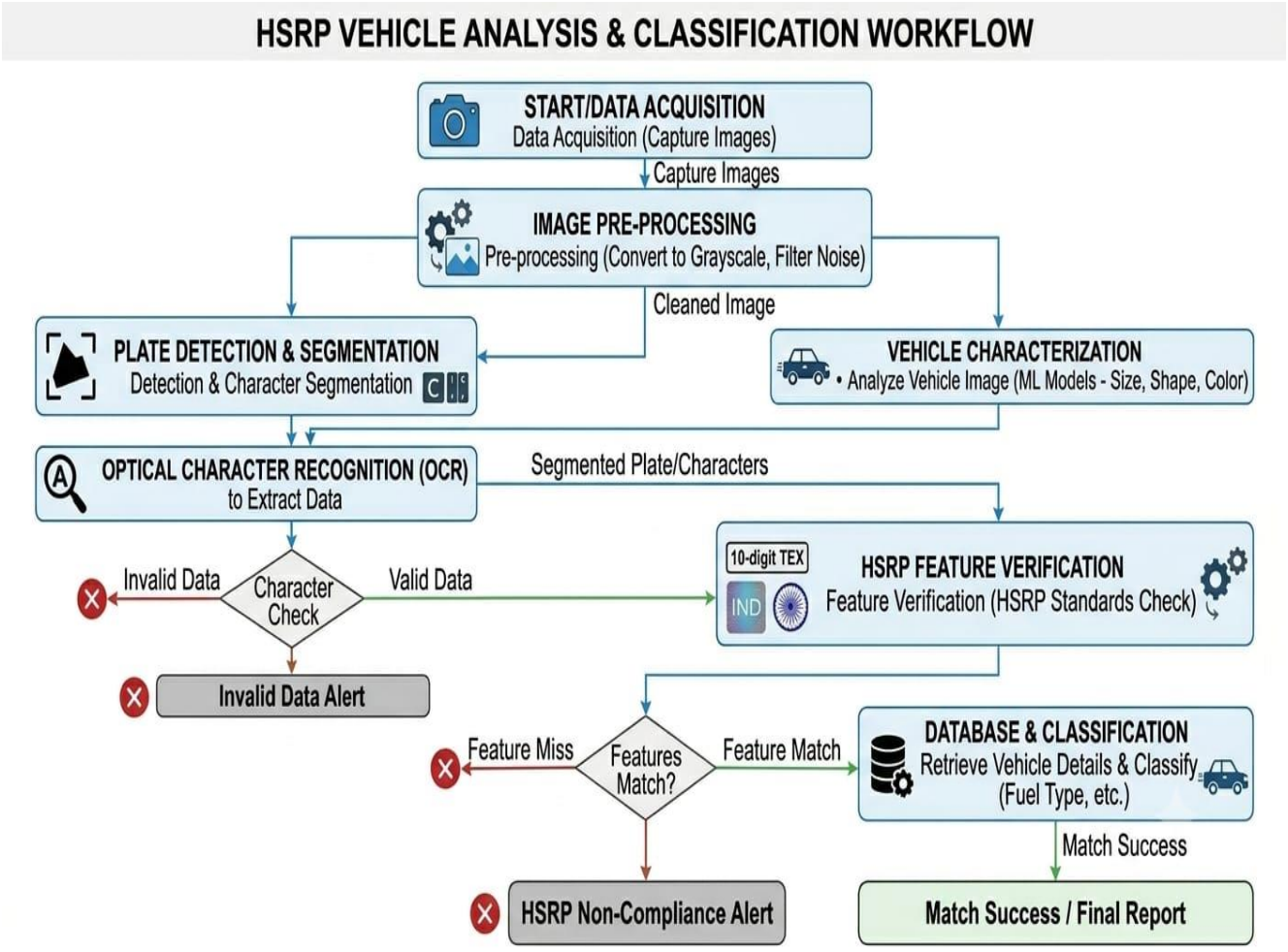


Figure: Flow chart

5. TECHNOLOGIES USED

The proposed system for High Security Registration Plate (HSRP) analysis and vehicle classification in the Indian scenario integrates advanced computer vision, machine learning, and database technologies to ensure accurate recognition, verification, and decision-making under diverse environmental conditions B] Development and Testing Tools:
Thonny / VS Code: IDEs used for coding and debugging Python scripts.
GitHub: For accessing pre-trained models and open-source resources.
PuTTY / VNC Viewer: Used for remote access and control of the Raspberry Pi during testing and monitoring.

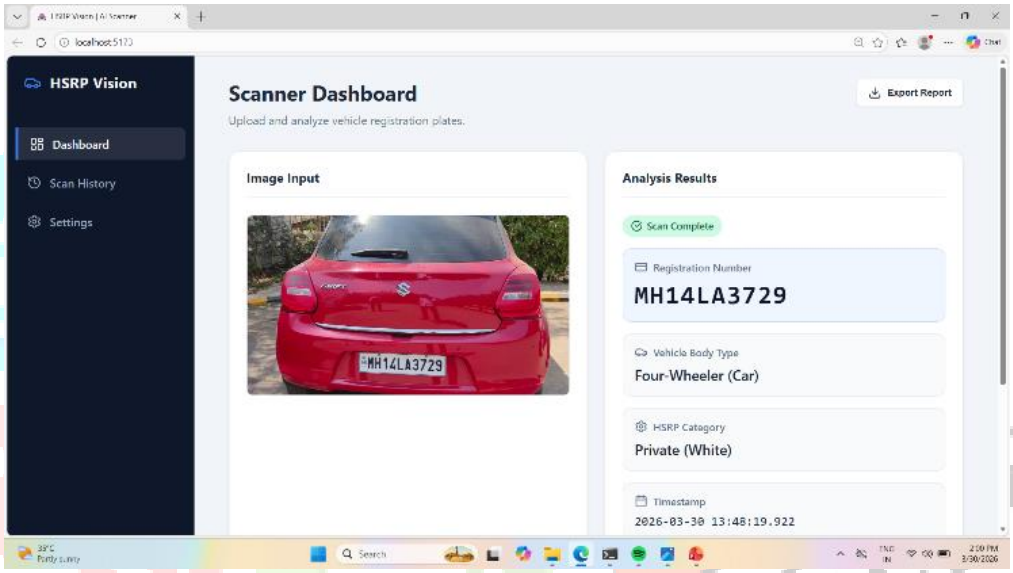
6. RESULT ANALYSIS

Proposed system should be able to achieve the following as results:
The trained YOLO model successfully detected HSRP regions from images and live video streams with high accuracy.
The average detection accuracy achieved was approximately 95% for HSRP recognition under normal lighting conditions.

The vehicle classification module categorized vehicles into predefined classes such as Car, Bike, Bus, Truck, and Auto-rickshaw with an overall classification accuracy of around 92%.

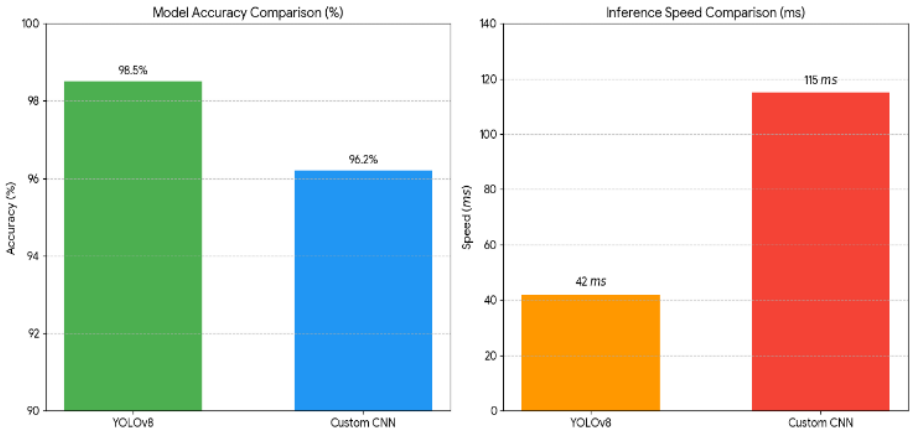
The system performed effectively in real-time, processing up to 25–30 frames per second (FPS).

The OCR (Optical Character Recognition) component extracted registration numbers with a character recognition accuracy of about 93%.



7. DATASETS

The performance of the proposed High Security Registration Plate (HSRP) analysis and vehicle classification system was evaluated using a combination of publicly available datasets and a (custom private database) Indian vehicle dataset. This hybrid approach ensures robustness and generalization across real-world traffic scenarios prevalent in India



1. Model Accuracy Comparison (%)

- The first graph compares the detection accuracy of both models.
- **YOLOv8 achieved 98.5% accuracy**, while the **Custom CNN achieved 96.2% accuracy**.
- This shows that YOLOv8 performs better in detecting vehicles/HSRP plates because it uses advanced deep learning architecture with better feature extraction capabilities.
- The higher accuracy of YOLOv8 means it can correctly identify more number plates and vehicles with fewer detection errors.

2. Inference Speed Comparison (ms)

- The second graph compares the processing time taken by each model to analyze an image.
- **YOLOv8 takes around 42 milliseconds**, whereas the **Custom CNN takes 115 milliseconds**.
- Lower inference time means faster processing.
- YOLOv8 is much faster than Custom CNN, making it more suitable for **real-time applications** like traffic monitoring, toll plaza automation, and smart parking systems.

Overall Analysis

From the comparison, **YOLOv8 provides better performance than Custom CNN** because it has:

- Higher accuracy (98.5%)
- Faster detection speed (42 ms)
- Better suitability for real-time HSRP plate detection systems

8. CONCLUSION

The project **"Analysing High Security Registration Plate (HSRP) of Vehicles and Vehicle Classification in Indian Scenario"** successfully demonstrates the use of advanced computer vision and deep learning techniques for automatic vehicle detection and classification. By implementing the **YOLO (You Only Look Once)** methodology, the system efficiently detects High Security Registration Plates and classifies vehicles in real-time with high accuracy.

The integration of **Python**, **OpenCV**, and **MX415 camera module** enables effective image acquisition, preprocessing, and recognition under varied Indian road conditions. This automated system reduces manual effort, improves traffic monitoring, and enhances vehicle authentication and security. It also supports applications such as **law enforcement, toll collection, parking management, and criminal investigation**. Overall, the project highlights how AI-based solutions can contribute to **smart transportation systems**, ensuring safer, faster, and more reliable vehicle identification in India.

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