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# AI Enhanced Hybrid Vehicle Authentication System with Robust Number Plate Recognition

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**ABSTRACT:** Restricted areas such as colleges, apartments, and industrial campuses require secure and efficient vehicle entry management systems. Traditional manual verification methods are time-consuming, error-prone, and inefficient under heavy traffic conditions. This paper proposes an AI-based real-time vehicle detection and automatic number plate recognition (ANPR) system for smart access control. The system integrates YOLO-based deep learning for vehicle detection with image processing techniques, including frame selection, histogram equalisation, morphological operations, and template matching for plate recognition. Recognised vehicle numbers are verified against a MySQL database to determine authorisation status, and all entries are logged through a real-time dashboard interface. The proposed system improves operational efficiency, reduces human intervention, and enhances scalability compared to existing manual and RFID-based systems.

**KEYWORDS:** Artificial Intelligence, Computer Vision, Deep Learning, YOLO, Number Plate Recognition, Smart Security Systems, Access Control, Image Processing, IoT Gate Automation

## I. INTRODUCTION

With the rapid development of smart cities and intelligent infrastructure, secure and automated access control systems have become essential. Conventional vehicle entry systems rely on manual verification by security personnel or hardware-based solutions such as RFID and barcode systems. These methods suffer from human errors, limited scalability, and inefficiency during peak hours. Recent advancements in Artificial Intelligence and Computer Vision enable automated vehicle detection and number plate recognition systems to operate in real time. This research presents a practical AI-driven system designed to detect vehicles, extract and recognise number plates, verify authorisation from a database, and maintain digital logs for monitoring and analysis.

## II. PROJECT DOMAIN

The proposed system belongs to the following domains: Artificial Intelligence, Computer Vision, Deep Learning, Smart Security Systems, IoT-ready Gate Automation.

## III. PROBLEM STATEMENT

Restricted areas require secure vehicle entry control. Manual verification processes are slow, prone to errors, and inefficient under heavy traffic. Existing RFID and barcode systems require additional hardware and are not scalable. There is a need for an automated system that can detect vehicles, recognise number plates in real time, verify authorisation from a database, and log entries accurately under varying environmental conditions.

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#### IV. OBJECTIVES OF THE PROJECT

The objectives of the proposed system are to automatically detect vehicles in live video or images, accurately recognise number plates, and verify vehicle authorisation using a MySQL database. Additionally, the system will identify vehicle types (such as cars, bikes, or trucks), log both authorised and unauthorised entries, and improve reliability through frame selection and enhancements, all while ensuring real-time operation in low- light conditions.

#### V. EXISTING SYSTEM

Current vehicle entry control methods include: Manual checking at security gates Entry register maintained by guards RFID tag- based systems Barcode- based access systems

#### VI. DRAWBACKS OF EXISTING SYSTEMS

The limitations of current systems include: Human error in recording vehicle numbers Slow verification process and poor scalability No automatic fake plate detection Requirement of additional hardware (RFID cards) Inefficiency under heavy traffic.

#### VII. PROPOSED SYSTEM

The proposed system utilises AI- based vehicle detection and number plate recognition to automatically authenticate vehicles entering restricted premises.

**The system integrates:** YOLO deep learning algorithm for vehicle detection Morphological operations and template matching for plate recognition Frame quality selection Histogram equalisation for low- light enhancement MySQL database verification Real- time dashboard logging.

#### VIII. SYSTEM ARCHITECTURE AND WORKFLOW

To implement the system, a structured methodology is followed, beginning with the capture of an image or video frame. The process then proceeds to filter low- quality frames to ensure data integrity, followed by an image enhancement phase to improve clarity. Once the image is prepared, the system will detect the vehicle and subsequently detect the number plate within the frame. The next phase involves the extraction of characters and the use of recognition algorithms to recognise the plate number. For the final operational stages, the system will verify the number with the database, log the result for administrative records, and ultimately display the authorisation decision



## IX. METHODOLOGY

### 9.1. Frame Selection Module

Blurred or dark frames are removed using Laplacian variance for blur detection and brightness threshold checks.

### 9.2 Image Enhancement Module

Histogram equalisation is applied to improve contrast under low- light conditions.

### 9.3 Vehicle Detection Module

YOLO (You Only Look Once) deep learning algorithm is used to detect vehicles and generate bounding boxes.

### 9.4 Plate Detection Module

Morphological operations or YOLO- based detection are used to isolate the number plate region.

### 9.5 Character Segmentation Module

Characters are separated using contour detection techniques.

### 9.6 Template Matching Recognition Module

Extracted characters are compared with stored templates (A–Z, 0–9) using normalised cross- correlation.

### 9.7 Database Verification Module

Recognised plate numbers are verified against records stored in a MySQL database.

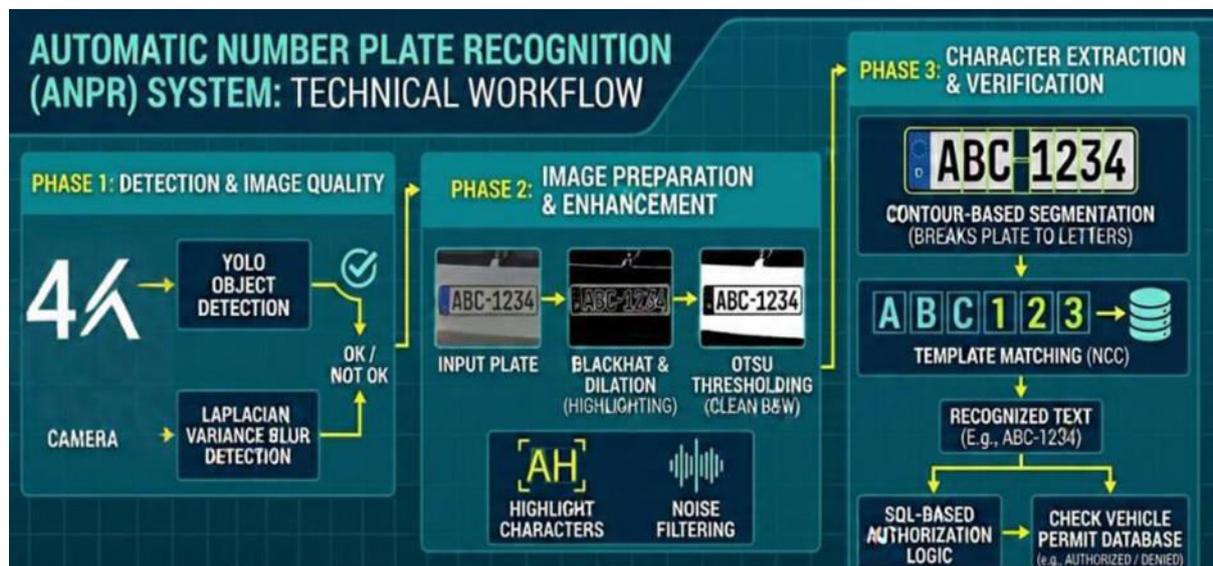
### 9.8 Logging and Dashboard Module

Entry details, including plate number, vehicle type, timestamp, and authorisation status, are stored in a vehicle\_logs table and displayed via a Flask- based dashboard.

## X. IMPLEMENTATION DETAILS

Hardware Requirements: Intel i5 / Ryzen 5 processor, 8GB RAM (minimum), Webcam / IP Camera, 20GB free storage.

Software Requirements: Python 3.8+, OpenCV, YOLO (Ultralytics), MySQL Server, Flask, HTML, Windows or Linux OS



## XI. ALGORITHMS USED

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**Detection and Image Quality:** The process begins with YOLO Object Detection to find the license plate within the frame. Simultaneously, Laplacian Variance is used for Blur Detection to ensure the image is clear enough for the next steps. Image Preparation and Enhancement: Once the plate is located, Morphological Operations (Blackhat and Dilation) are used to highlight the characters and filter out noise. Otsu Thresholding then converts the image into a clean black- and- white format, creating a sharp contrast between the letters and the background. Character Extraction and Verification: Contour- based Character Segmentation breaks the plate down into individual letters and numbers. These are identified using Template Matching (Normalised Cross-Correlation). Finally, the recognised text is passed through SQL- based Authorization Logic to check if the vehicle is permitted in the database.

## **XII. RESULTS AND DISCUSSION**

The implementation demonstrates effective real- time vehicle detection and number plate recognition. The system successfully identifies vehicle types and verifies authorisation through database matching. Frame selection and histogram equalisation improve reliability under low- light conditions. The system reduces manual workload and improves entry processing speed. However, recognition accuracy may vary depending on camera resolution and plate clarity.

## **XIII. ADVANTAGES OF THE PROPOSED SYSTEM**

It significantly reduces human error and facilitates real- time operation. A notable feature is its independence from RFID hardware, which contributes to a low- cost implementation and a scalable architecture. Furthermore, the system is well- suited for various smart campus applications.

## **XIV. LIMITATIONS**

The primary challenge is that the template matching mechanism may fail when encountering damaged or non- standard license plates. Additionally, the overall performance of the system is contingent upon the quality of the camera utilised, and extreme weather conditions may potentially impact detection accuracy.

## **XV. FUTURE ENHANCEMENTS**

Replacing template matching with CNN- based OCR models, Implement fake plate detection using anomaly detection, deploying on edge computing devices, and Integrate IoT- based automatic gate control.

## **XVI. CONCLUSION**

This paper presents a real- time AI- based vehicle detection and number plate recognition system for smart access control. By integrating deep learning with image processing techniques and database verification, the system improves efficiency, accuracy, and scalability compared to traditional manual and RFID- based methods. The proposed architecture demonstrates practical feasibility for deployment in smart campuses, residential complexes, and industrial zones.

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