

SMART GATEWAYS: AUTOMATED NUMBER PLATE RECOGNITION FOR SAFER AND SMARTER COMMUNITIES

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Abstract: This project proposes an Automated Vehicle Access Control System that leverages Number Plate Recognition (NPR) technology to identify and authorize vehicles entering a restricted area, such as a university campus or corporate facility. The system captures the vehicle's number plate image using a high-resolution camera positioned at the entry gate. The captured image undergoes grayscale conversion to simplify data processing and reduce computational complexity. Using image processing techniques such as noise removal, edge detection (e.g., Canny or Sobel operators), and segmentation, the number plate region is isolated. Once extracted, the Optical Character Recognition (OCR) module converts the plate's characters into a machine-readable text format. This alphanumeric string is then cross-referenced with a predefined database containing authorized vehicle numbers. If a match is found, the system retrieves and displays the stored image of the corresponding vehicle, and the gate control mechanism permits entry. In case of a mismatch, the system displays a "No Access" message and denies entry to the premises.

Keywords: Number Plate Recognition, OCR, Edge Detection, Grayscale Conversion, Access Control System.

I. INTRODUCTION

Automated access control systems are revolutionizing the way secure zones manage vehicle entry, offering a seamless blend of safety, efficiency, and technological sophistication. This project centers on designing a robust solution that leverages advanced image processing and recognition techniques to identify vehicles through their number plates. By capturing and analyzing plate images in real time, the system eliminates the need for manual verification, thereby reducing human error and enhancing throughput at entry points. Integration with a gate control mechanism ensures that only authorized vehicles are granted access, creating a contactless and scalable framework suitable for environments like university campuses, corporate facilities, and residential complexes. The approach not only streamlines operations but also strengthens perimeter security by maintaining a digital log of vehicle movements, making it a forward-thinking solution for modern infrastructure.

II. PROBLEM STATEMENT

In high-security environments such as university campuses, corporate offices, and residential complexes, traditional manual vehicle access control methods are increasingly proving to be inefficient, error-prone, and difficult to scale. These systems often rely on human personnel for verification, which introduces delays, inconsistency, and potential security lapses. As the demand for secure, contactless, and scalable entry solutions grows, there is a critical need for an automated system capable of reliably identifying and authorizing vehicles using Number Plate Recognition (NPR) technology. Such a system would not only enhance perimeter security but also reduce human dependency and streamline the entry process. However, implementing a robust NPR-based access control system presents several challenges:

- **Variable Lighting Conditions:** Fluctuating lighting environments—such as low visibility at night, glare from headlights, or intense sunlight—can significantly impact image clarity and reduce the accuracy of plate detection and character recognition.
- **Plate Format Diversity:** Number plates vary widely in design, font, size, and layout across different regions and jurisdictions, complicating the development of a universal recognition algorithm.
- **Environmental Interference:** External factors like rain, fog, dust, or dirt accumulation on plates can obscure visibility, leading to misreads or failed recognition attempts.
- **Real-Time Processing Constraints:** Ensuring fast and accurate recognition without causing delays at entry points requires efficient algorithms and optimized hardware-software integration.

III.LITERATURE REVIEW

SL NO.	YEAR	TITLE	DESCRIPTION
1	2024	Automatic Number Plate Recognition System using Machine Learning Techniques.	The reviewed ANPR system combines YOLOv8 for real-time license plate detection with EasyOCR for text recognition, enabling accurate identification from video streams. It preprocesses plate images to enhance clarity before extracting alphanumeric data, which is stored for analysis. This setup offers high accuracy and flexible deployment across surveillance and access control scenarios. However, performance may degrade under poor lighting, adverse weather, or with non-standard plates, and the need for powerful hardware and secure data storage raises cost and privacy concerns.
2	2024	Vehicle Number Plate Detection and Encryption in Digital Images Using YOLOv8 and Chaotic-Based Encryption Scheme.	The proposed system integrates YOLOv8 for accurate real-time number plate detection with Chaotic Logistic Map encryption to safeguard sensitive vehicle data. After detection, plate information is encrypted before storage or transmission, combining deep learning with chaos-based cryptography to enhance privacy and security. This approach offers high detection accuracy, real-time performance, and making it suitable for surveillance and access control. However, it faces challenges such as high computational requirements, and increased costs due to hardware and secure data management needs.
3	2024	Intelligent Vehicle Number Plate Recognition System Using Yolo For Enhanced Security In Smart Buildings	With growing urban infrastructure, the need for advanced security has made automated surveillance essential in places like universities, hospitals, and commercial zones. This project proposes an end-to-end ANPR system that captures high-speed images, isolates license plate characters, and converts them into machine-readable text. Using CNNs and YOLO for real-time detection on embedded systems, it leverages edge computing to deliver high performance and low latency, enabling efficient vehicle monitoring, data logging, and enhanced building security.
4	2024	Utilizing Automatic Number Plate Recognition for an Intelligent Campus Gate Security System	CLSU, a 658-hectare campus with heavy daily vehicle traffic, requires efficient gate monitoring for safety. Manual methods are slow and error-prone, prompting the development of an ANPR system using OCR and image processing for real-time plate detection. A web-based app manages cameras, alerts, and data, achieving 92% accuracy for 2- and 4-wheeled vehicles (excluding those outside camera range). The system improves security, enables traffic analysis, and integrates with CCTV and alarms for enhanced campus safety.
5	2023	Automatic vehicle access control into the residential areas using Face Detection and ANPR technologies.	This research presents a multi-layered Automated Vehicle Access Control System designed for residential complexes, combining license plate and facial recognition to ensure secure and reliable entry. The system initiates upon vehicle detection via infrared sensors, capturing the license plate and processing it through OCR using KNN and CNN for accurate identification. A second layer of verification uses LBPH-based facial recognition to authenticate the driver, granting access only when both credentials match the authorized database.

6	2023	Automatic License Plate Detection and Recognition System for Security Purposes.	Detection of vehicle license plates have many important applications including identification of traffic rules breaking vehicles, entry-exit restriction in secured places to many more. This paper presents a simple yet effective architecture for automatic license plate detection and recognition for secured places. The proposed architecture has three main parts - a) license plate detection, b) license plate segmentation where we segment the characters of the License Plate into constituents digits and letters, and c) character recognition, which uses Convolution Neural Network (CNN) classifier to recognize the segmented digits.
7	2022	License plate recognition system based on image recognition.	The proposed system utilizes OpenCV with Python and Convolutional Neural Networks (CNN) to perform accurate license plate recognition. It begins with digital image correlation for plate localization, followed by edge analysis for character segmentation and quantity estimation. CNN then handles character recognition and classification, enabling precise extraction of alphanumeric data. It reduces manual intervention and enhances efficiency. However, performance may degrade under poor lighting, complex backgrounds, or motion blur. Additionally, CNN's computational demands can limit deployment on low-resource devices.
8	2022	Real Time Car Model and Plate Detection System by Using Deep Learning Architectures.	This system integrates Vehicle Make and Model Recognition (VMMR) with Automatic Number Plate Recognition (ANPR), achieving 97.5% accuracy using deep learning. It uses MobileNet-V2 and YOLOx for vehicle classification, and YOLOv4-tiny, Paddle OCR, and SVTR-tiny for plate recognition, performing well even in fog, rain, and low light. Tested on over a thousand images, it includes GradCam analysis to improve interpretability and reduce misclassification.
9	2021	License Plate Recognition System.	This system adopts a two-phase license plate recognition strategy—first detecting plates from images, even with multiple vehicles, and then segmenting and recognizing characters to extract alphanumeric data. It supports applications like vehicle identification, smart parking, and e-challan generation. Key advantages include cost-effectiveness, wide applicability, and multi-plate recognition, which boosts automation and reduces manual workload. However, its accuracy depends heavily on image quality, lighting, and plate consistency, making it vulnerable to issues like blur, non-standard formats, and varied plate sizes.
10	2021	Vehicle Number Plate Detection Using Python and Open CV.	This system uses Python with OpenCV and PyTesseract to perform license plate recognition through a simple, open-source pipeline involving grayscale conversion, noise reduction, edge detection, and OCR. It's efficient and cost-effective for small-scale setups, delivering reasonable accuracy in controlled environments. However, its performance is sensitive to lighting, image quality, and plate variations, with Tesseract struggling on non-standard fonts or regional scripts. Compared to deep learning-based methods, it may underperform in complex or large-scale scenarios.

IV. CONCLUSION

The proposed Automated Vehicle Access Control System offers a reliable, contactless solution for managing vehicle entry in secure zones like campuses and corporate facilities. By integrating high-resolution imaging, advanced image processing, and OCR-based number plate recognition, the system ensures accurate identification and real-time authorization.

Its ability to cross-reference vehicle data with a secure database enhances security while reducing manual errors. The scalable design supports seamless gate control and digital logging, making it a practical and forward-looking approach to modern access management and perimeter safety.

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