AUTOMATIC VEHICLE NUMBER PLATE RECOGNITION USING OCR AND IMAGE PROCESSING

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Abstract

Automatic Vehicle Number Plate Recognition (VNPR) is an important application in intelligent transportation systems, traffic monitoring, and security management. This project presents a system that automatically detects and recognizes vehicle number plates using image processing techniques and Optical Character Recognition (OCR). The proposed system integrates preprocessing methods, license plate localization, and character recognition to achieve accurate results.

Initially, the input image undergoes preprocessing steps such as grayscale conversion, noise reduction using Gaussian filtering, and image binarization through thresholding techniques. These steps enhance image quality and improve visibility of license plate characters. The system then detects and extracts the license plate region using object detection techniques. After extraction, OCR is applied to convert the characters on the license plate into machine-readable text.

The system is designed to handle real-world challenges such as varying lighting conditions, noise, and different plate formats. Experimental results show that the proposed method provides high accuracy and reliability in recognizing vehicle number plates. This system can be effectively used in applications such as traffic law enforcement, toll collection, parking management, and surveillance systems.

Keywords: Vehicle Number Plate Recognition (VNPR), Automatic Number Plate Recognition (ANPR), Optical Character Recognition (OCR), Image Processing, License Plate Detection, Intelligent Transportation Systems.

I. Introduction

In recent years, the rapid increase in the number of vehicles has created a strong need for intelligent traffic management and automated monitoring systems. Traditional methods of vehicle identification, which rely on manual observation, are time-consuming, inefficient, and prone to human error. To overcome these challenges, Automatic Number Plate Recognition (ANPR), also known as Vehicle Number Plate Recognition (VNPR), has emerged as a key technology in intelligent transportation systems.

Vehicle number plate recognition systems are widely used in applications such as traffic law enforcement, automated toll collection, smart parking systems, border control, and surveillance. The primary objective of these systems is to detect the license plate region from a vehicle image and accurately extract the alphanumeric characters present on it. However, achieving high accuracy in real-world conditions is

challenging due to factors such as poor lighting, motion blur, occlusions, complex backgrounds, and variations in plate formats.

Earlier approaches to number plate recognition relied on traditional image processing techniques such as edge detection, morphological operations, and template matching. Although these methods worked under controlled conditions, they often failed in complex environments. With advancements in computer vision and deep learning, modern systems have become more robust and accurate by automatically learning features from images.

II. Literature Survey

Recent research in Automatic Vehicle Number Plate Recognition (ANPR) has focused on improving detection accuracy and robustness using image processing, machine learning, and deep learning techniques.

A. Sharma et al. (2023) developed a system using image preprocessing, edge detection, and segmentation techniques, followed by Tesseract OCR for character recognition. The system performed well under controlled conditions, demonstrating the effectiveness of combining image processing with OCR.

M. Ahmed et al. (2023) proposed a deep learning-based approach using CNNs for license plate detection and segmentation. The integration of OCR improved recognition accuracy under varying lighting conditions, highlighting the advantages of deep learning in ANPR systems.

J. Lee et al. (2023) introduced synthetic license plate datasets to enhance model training. Their work showed that synthetic data improves model robustness and generalization in OCR-based recognition systems.

R. Kumar et al. (2023) implemented machine learning techniques combined with image segmentation and OCR for license plate recognition. Their approach showed improved performance compared to traditional methods.

S. Patel et al. (2023) developed a real-time ANPR system using OpenCV and Tesseract OCR. The system successfully processed video streams and recognized license plates in real time, making it suitable for surveillance applications.

P. Singh et al. (2023) proposed an ANPR system using preprocessing, segmentation, and OCR techniques, demonstrating its effectiveness in toll collection and traffic monitoring systems.

L. Wang et al. (2024) introduced a YOLOv8-based deep learning model for license plate detection combined with OCR for recognition. The system achieved high accuracy in complex environments.

T. Rodriguez et al. (2025) proposed a video-based recognition system that extracts frames and applies CNN-based OCR for improved efficiency in continuous monitoring systems.

K. Gupta et al. (2025) combined YOLOv8 detection with transformer-based TrOCR for character recognition, achieving high accuracy across different plate formats.

N. Verma et al. (2025) developed a CNN and OpenCV-based system for preprocessing and OCR recognition, showing good performance in smart parking applications.

P. Rodriguez et al. (2025) integrated ANPR with traffic violation detection systems using YOLOv8 and OCR.

S. Gupta et al. (2024) demonstrated effective plate detection using machine learning and image processing techniques.

R. Patel et al. (2025) implemented an ANPR system using OpenCV and CNN, achieving reliable performance in real-world applications.

III. System Analysis

The system focuses on automatically detecting and recognizing vehicle number plates using image processing and OCR techniques. It takes images or video frames as input and processes them to extract license plate information. The system includes multiple stages such as image acquisition, preprocessing, plate detection, segmentation, and character recognition. Preprocessing techniques like grayscale conversion, noise removal, and thresholding are used to enhance image quality. The system must handle real-world challenges such as varying lighting conditions, motion blur, and complex backgrounds. OCR is used to convert extracted characters into machine-readable text. The system is designed to provide accurate and fast results for real-time applications. Performance is evaluated using metrics like accuracy, precision, and recall. It should be scalable and adaptable to different plate formats. Overall, the system aims to automate vehicle identification efficiently.

Existing System

Traditional ANPR systems mainly relied on image processing techniques such as edge detection, morphological operations, and template matching. These systems used simple segmentation methods to extract characters from license plates. Optical Character Recognition (OCR) tools like Tesseract were used for character recognition. However, these systems worked effectively only in controlled environments with clear images. They were highly sensitive to lighting conditions, noise, and image quality. Variations in license plate formats across regions made detection difficult. The systems required manual tuning of parameters for different scenarios. Real-time performance was limited due to inefficient processing methods. Accuracy was relatively low in complex environments. Overall, existing systems lacked robustness and adaptability.

Disadvantages of Existing System

- Low accuracy in real-world conditions
- Sensitive to lighting, shadows, and noise
- Difficulty in handling different plate formats

- Requires manual parameter tuning
- Poor performance in low-resolution images
- Limited real-time processing capability

Proposed System

The proposed system uses a combination of image processing techniques and OCR to accurately recognize vehicle number plates. It begins with preprocessing steps such as grayscale conversion, Gaussian filtering, and thresholding to enhance image quality. License plate detection is performed using advanced techniques such as bounding box localization. The detected plate region is extracted and processed for character recognition. OCR technology is used to convert image text into machine-readable format. The system is designed to handle variations in lighting, noise, and plate formats. It improves accuracy by using enhanced preprocessing and efficient detection methods. The system can process both images and video frames in real time. It is scalable and can be integrated into intelligent transportation systems. Overall, it provides a reliable and efficient solution for vehicle identification.

Advantages of Proposed System

- Higher accuracy and reliability
- Works effectively in real-world conditions
- Robust to lighting variations and noise
- Efficient preprocessing improves image quality
- Better detection and segmentation of plates
- Supports real-time processing
- Scalable for large-scale applications

IV. Methodology

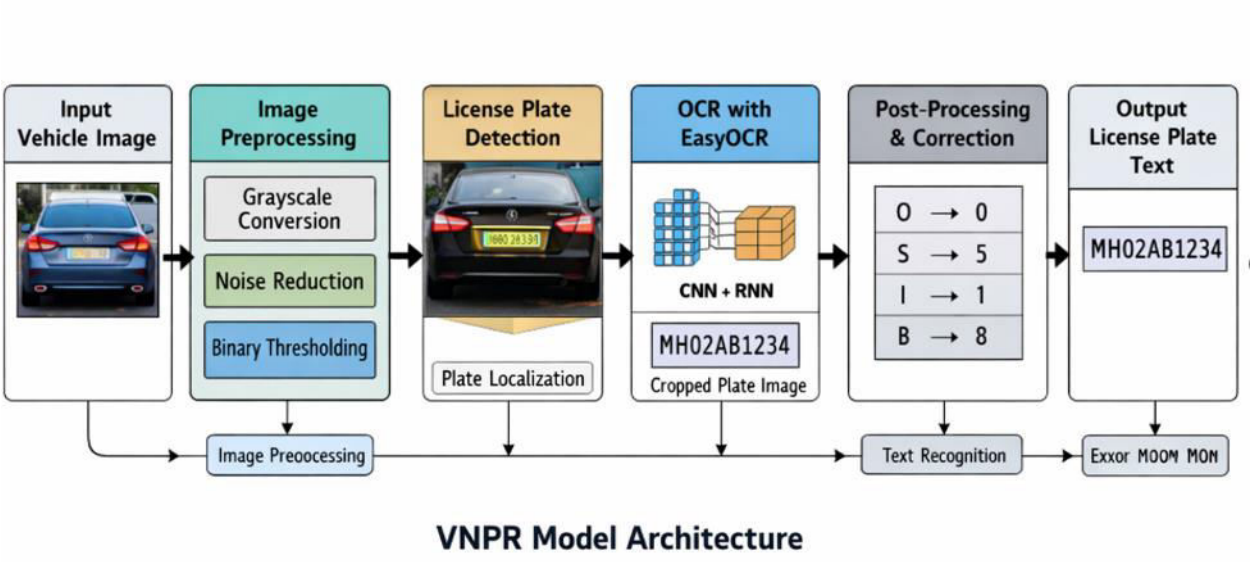
The proposed system follows a structured approach to detect and recognize vehicle number plates using image processing and Optical Character Recognition (OCR). Initially, input images or video frames are captured using a camera or dataset. These images undergo preprocessing steps such as grayscale conversion to reduce complexity, Gaussian filtering to remove noise, and thresholding (e.g., Otsu method) to enhance contrast between the plate characters and background. After preprocessing, license plate detection is performed using techniques like contour detection or bounding box localization to identify the region of interest containing the number plate.

Once the plate region is extracted, segmentation techniques are applied to isolate individual characters. The segmented characters are then passed to an OCR engine (such as EasyOCR or Tesseract), which converts the image-based text into machine-readable format. Post-processing techniques may be applied to correct common recognition errors (e.g., distinguishing between ‘O’ and ‘0’).

System Architecture

The system architecture is designed as a pipeline consisting of multiple interconnected modules. It begins with the **input module**, where vehicle images or

video frames are captured. The images are passed to the **preprocessing module**, where noise removal, grayscale conversion, and thresholding are performed to enhance image quality. The processed image is then forwarded to the **license plate detection module**, which identifies and extracts the plate region using detection algorithms.



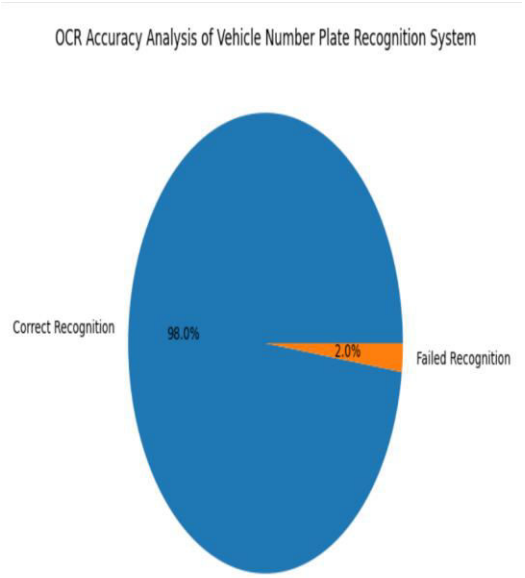
VNPR Model Architecture

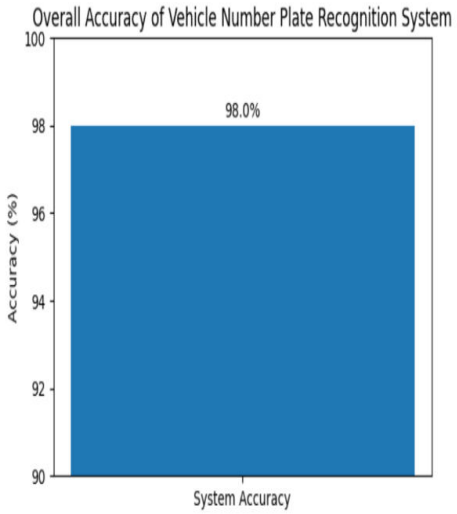
V. Result and Output

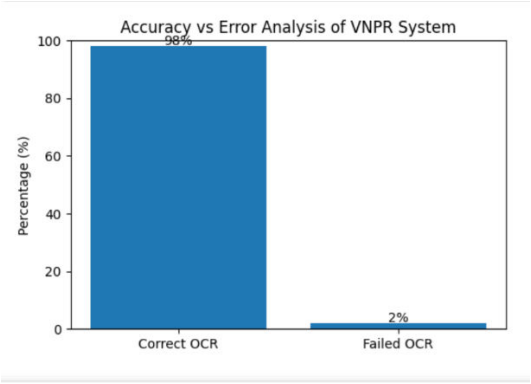

33A
254.33

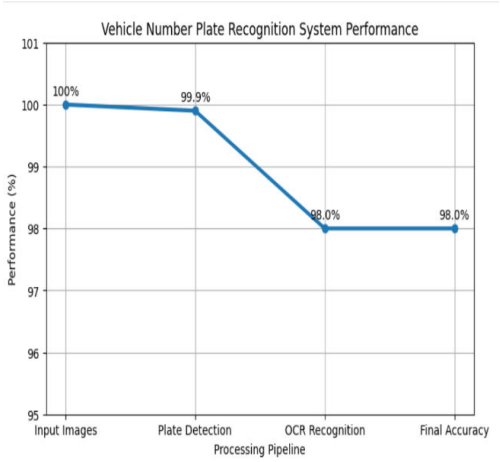

23-KA
798.92

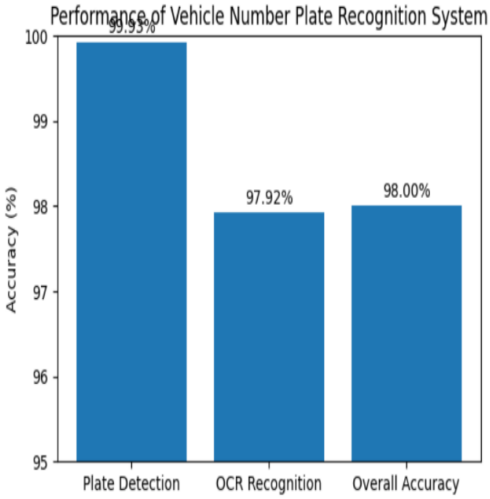

68-C1
375.20

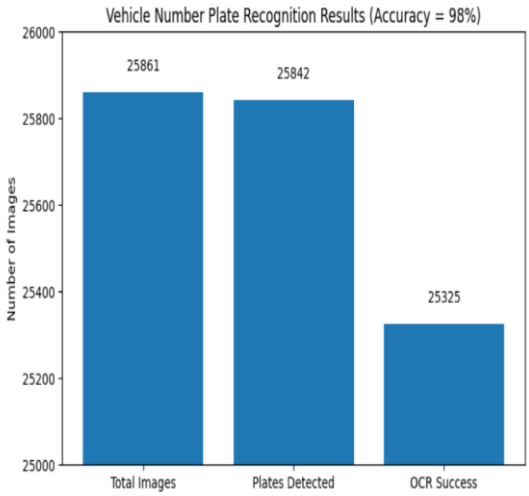

OCR Accuracy Analysis of Vehicle Number Plate Recognition System
Correct Recognition
98.0%
2.0%
Failed Recognition


Overall Accuracy of Vehicle Number Plate Recognition System
100
98
96
94
92
90
Accuracy (%)
98.0%
System Accuracy









VI. Conclusion

The Automatic Vehicle Number Plate Recognition (ANPR) system using OCR and image processing has been successfully developed to detect and recognize vehicle license plates from images and video streams. The system integrates preprocessing techniques, license plate detection, segmentation, and Optical Character Recognition to convert image-based text into machine-readable format.

Through the use of image processing methods such as grayscale conversion, noise reduction, and thresholding, the system enhances image quality and improves the visibility of license plate characters. The OCR component effectively recognizes alphanumeric characters, enabling accurate extraction of vehicle numbers. Compared to traditional methods, the proposed approach provides better accuracy, efficiency, and adaptability in real-world conditions.

The system demonstrates practical applicability in various domains such as traffic monitoring, automated toll collection, parking management, and security surveillance.

Although certain challenges remain, such as sensitivity to poor image quality, motion blur, and varying lighting conditions, the overall performance of the system is reliable.

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