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AI-Based Automatic Vehicle Verification System for Restricted Area

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Abstract: ***This paper presents an AI-based Automatic Number Plate Recognition (ANPR) system designed for vehicle verification in restricted areas. The system utilizes deep learning and computer vision techniques to detect and recognize vehicle license plates in real time. YOLO is employed for accurate number plate detection, while PaddleOCR is used for extracting alphanumeric characters from the detected plate region. The extracted vehicle number is then processed and compared with a predefined authorized database to determine access permission.***
A user-friendly dashboard provides real-time monitoring, displaying live camera feed along with instant access status indicators such as "Access Granted" or "Access Denied." The system ensures high accuracy, fast processing, and efficient performance, making it suitable for applications such as smart parking systems, gated communities, and secure institutional environments. The proposed solution reduces manual effort and enhances security through automated decision-making.
Keywords: ANPR, YOLO, PaddleOCR, Computer Vision, Vehicle Verification, Access Control, Deep Learning;

I. INTRODUCTION

In recent years, the need for efficient and automated security systems has increased significantly due to rapid urbanization and growing vehicle usage. Restricted areas such as residential societies, parking facilities, industrial zones, and institutional campuses require reliable vehicle verification mechanisms to ensure safety and controlled access. Traditional methods of vehicle verification rely on manual inspection, which is time-consuming, labor- intensive, and prone to human error.

Automatic Number Plate Recognition (ANPR) systems have emerged as an effective solution to automate vehicle identification and monitoring.

These systems use image processing and machine learning techniques to detect and recognize vehicle license plates. However, conventional ANPR systems often face challenges such as low accuracy in varying lighting conditions, slow processing speed, and lack of real-time integration with access control systems.

To address these limitations, this paper proposes an AI-based vehicle verification system that integrates deep learning and optical character recognition (OCR) techniques for real-time performance. The system utilizes YOLO for fast and accurate number plate detection and PaddleOCR for reliable text extraction. The recognized plate number is compared with a predefined authorized database to make instant access decisions.

Additionally, the system includes a user-friendly dashboard developed using PyQt6, which displays live camera feed and access status indicators. This integration enables efficient monitoring and management of vehicle entry in restricted areas. The proposed system aims to improve accuracy, reduce manual effort, and provide a scalable solution for modern security applications.

II. LITERATURE REVIEW

Automatic Number Plate Recognition (ANPR) has been an active area of research in the field of computer vision and intelligent transportation systems. Earlier approaches for number plate detection and recognition primarily relied on traditional image processing techniques such as edge detection, thresholding, morphological operations, and character segmentation. Although these methods were simple and computationally less expensive, their performance was significantly affected by environmental factors such as lighting conditions, shadows, and image noise.

With the advancement of machine learning and deep learning technologies, modern ANPR systems have shifted towards more robust and accurate approaches. Convolutional Neural Networks (CNNs) and object detection algorithms such as YOLO (You Only Look Once) have been widely used for real-time number plate detection due to their high speed and accuracy. These models are capable of detecting objects in complex environments with varying backgrounds.

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For character recognition, Optical Character Recognition (OCR) techniques such as Tesseract OCR and PaddleOCR have been extensively used. Recent developments in deep learning-based OCR systems have improved the accuracy of text extraction from images, even under challenging conditions such as low resolution or distorted plates.

Several research works have successfully combined deep learning-based detection models with OCR techniques to develop efficient ANPR systems. However, many existing systems are limited to detection and recognition tasks only and do not incorporate real-time decision-making or user- friendly interfaces for practical applications.

The proposed system addresses these limitations by integrating YOLO for accurate plate detection and PaddleOCR for reliable text recognition, along with a real-time verification mechanism and an interactive dashboard. This combination provides an efficient, scalable, and practical solution for vehicle verification in restricted areas.

III. SYSTEM ARCHITECTURE

The proposed AI-based Automatic Number Plate Recognition (ANPR) system is designed using a modular architecture that enables efficient real-time vehicle verification. The system consists of four main components: input module, detection module, recognition module, and verification module.

The input module captures real-time video streams using a camera. The detection module utilizes the YOLO deep learning model to identify and localize the number plate region within each frame. This model ensures high-speed and accurate detection even in complex environments.

Once the number plate is detected, the cropped image is passed to the recognition module. This module employs PaddleOCR to extract alphanumeric characters from the number plate image. The extracted text is then processed and formatted to ensure consistency and accuracy.

The verification module compares the recognized number plate with a predefined database of authorized vehicles. Based on the comparison result, the system determines whether to grant or deny access.

Finally, the output is displayed through a PyQt6- based user interface, which shows the live camera feed along with the access status indicator. This modular architecture ensures scalability, flexibility, and efficient real-time performance of the system.

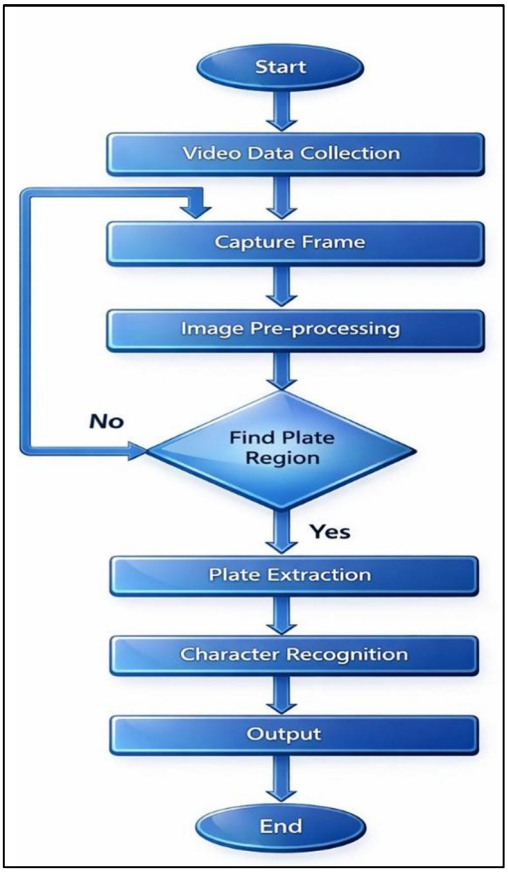


Fig. 1: System Architecture

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IV. METHODOLOGY

The proposed system follows a systematic approach for real-time vehicle number plate detection and verification. The complete workflow is divided into multiple stages, ensuring accurate and efficient processing.



Fig. 2: Workflow of Proposed System

Initially, the system captures real-time video input using a camera. The video stream is processed frame by frame to detect vehicles entering the monitored area. Each frame is passed to the detection stage, where the YOLO model is used to identify and localize the number plate region. The model generates bounding boxes around detected number plates with high precision.

After detection, the identified number plate region is cropped from the original frame and preprocessed to improve image clarity. Preprocessing steps may include resizing, noise reduction, and contrast enhancement to improve OCR accuracy.

The processed image is then passed to the text recognition stage, where PaddleOCR is used to extract alphanumeric characters from the number plate. The extracted text is further cleaned and formatted to remove unwanted characters and ensure consistency with standard vehicle number formats.

In the next stage, the recognized number plate is compared with a predefined database of authorized vehicles. This comparison is performed in real time to determine whether the detected vehicle is allowed or restricted.

Based on the verification result, the system generates an output decision. If the vehicle number is found in the authorized database, access is granted; otherwise, access is denied. The final result is displayed on a graphical user interface developed using PyQt6, which includes live video feed and visual indicators for system status.

This methodology ensures accurate detection, reliable recognition, and efficient decision-making in real-time environments.

V. IMPLEMENTATION

The proposed AI-based ANPR system is implemented using Python, integrating multiple libraries and frameworks to achieve real-time performance and accuracy. The system is designed as a modular application, where each component performs a specific function in the overall pipeline.

OpenCV is used for capturing and processing real- time video streams from the camera. It handles frame extraction, image preprocessing, and basic image manipulation tasks. The YOLO model is implemented for detecting number plates within each frame. The model is capable of identifying the plate region accurately and efficiently, even in dynamic environments.

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Once the number plate is detected, the cropped image is passed to PaddleOCR, which is used for extracting the text from the plate. PaddleOCR provides high accuracy in recognizing alphanumeric characters under different lighting and orientation conditions.
The extracted text is further processed using Python- based string handling techniques to remove noise and standardize the format. The cleaned number plate is then compared with a predefined database of authorized vehicles stored locally within the system.
A graphical user interface (GUI) is developed using PyQt6 to provide real-time interaction and monitoring. The interface displays the live camera feed, detected number plates, and system status messages such as “Access Granted” or “Access Denied.” It also includes features such as adding or removing vehicle numbers and searching within the database.
The system is designed to operate in real time with minimal latency, ensuring smooth performance and quick decision-making. The modular implementation allows easy scalability and integration with additional components such as automated gate control systems.

VI. RESULTS

The proposed AI-based ANPR system was tested under real-time conditions using a live camera feed. The system demonstrated effective performance in detecting and recognizing vehicle number plates with high accuracy and minimal delay.
The YOLO model successfully detected number plates from video frames with precise bounding box localization, even in scenarios with moderate background complexity. The detection process was fast enough to support real-time operation.
PaddleOCR effectively extracted alphanumeric characters from the detected number plates. The OCR module performed reliably under normal lighting conditions and provided accurate text outputs with minimal preprocessing.
The extracted number plate was compared with the authorized database, and the system generated instant access decisions. The results were displayed on the PyQt6-based dashboard, which showed live video feed along with status indicators such as “Access Granted” and “Access Denied.”



Fig. 3: Sample Output (Blur due to privacy)

Overall, the system achieved high performance in terms of speed, accuracy, and usability. The integration of detection, recognition, and verification modules ensured smooth and efficient operation suitable for real-world applications.

VII. FUTURE SCOPE

The proposed AI-based ANPR system can be further enhanced with several improvements to increase its efficiency, scalability, and real-world applicability.

1) The system can be integrated with automated gate control mechanisms to enable fully autonomous entry and exit management without human intervention.
2) Cloud-based database integration can be implemented to allow centralized monitoring and remote access across multiple locations.
3) The system can be extended to support multiple cameras, enabling coverage of large areas such as highways, parking complexes, and smart city infrastructures.
4) Performance can be improved under challenging conditions such as low lighting, rain, or motion blur by incorporating advanced image enhancement techniques and training on diverse datasets.
5) A mobile application can be developed to allow administrators to monitor vehicle activity and control the system remotely.
6) Additional security features such as blacklist alerts, suspicious vehicle tracking, and real-time notifications can be incorporated.

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7) Integration with Internet of Things (IoT) devices can further enhance automation and connectivity within smart environments.
8) The system can be optimized for deployment on edge devices such as embedded systems for faster and more efficient processing.

VIII. CONCLUSION

This paper presents an AI-based Automatic Number Plate Recognition (ANPR) system for efficient vehicle verification in restricted areas. The system integrates YOLOv8 for number plate detection and PaddleOCR for text recognition, enabling accurate and real-time performance.

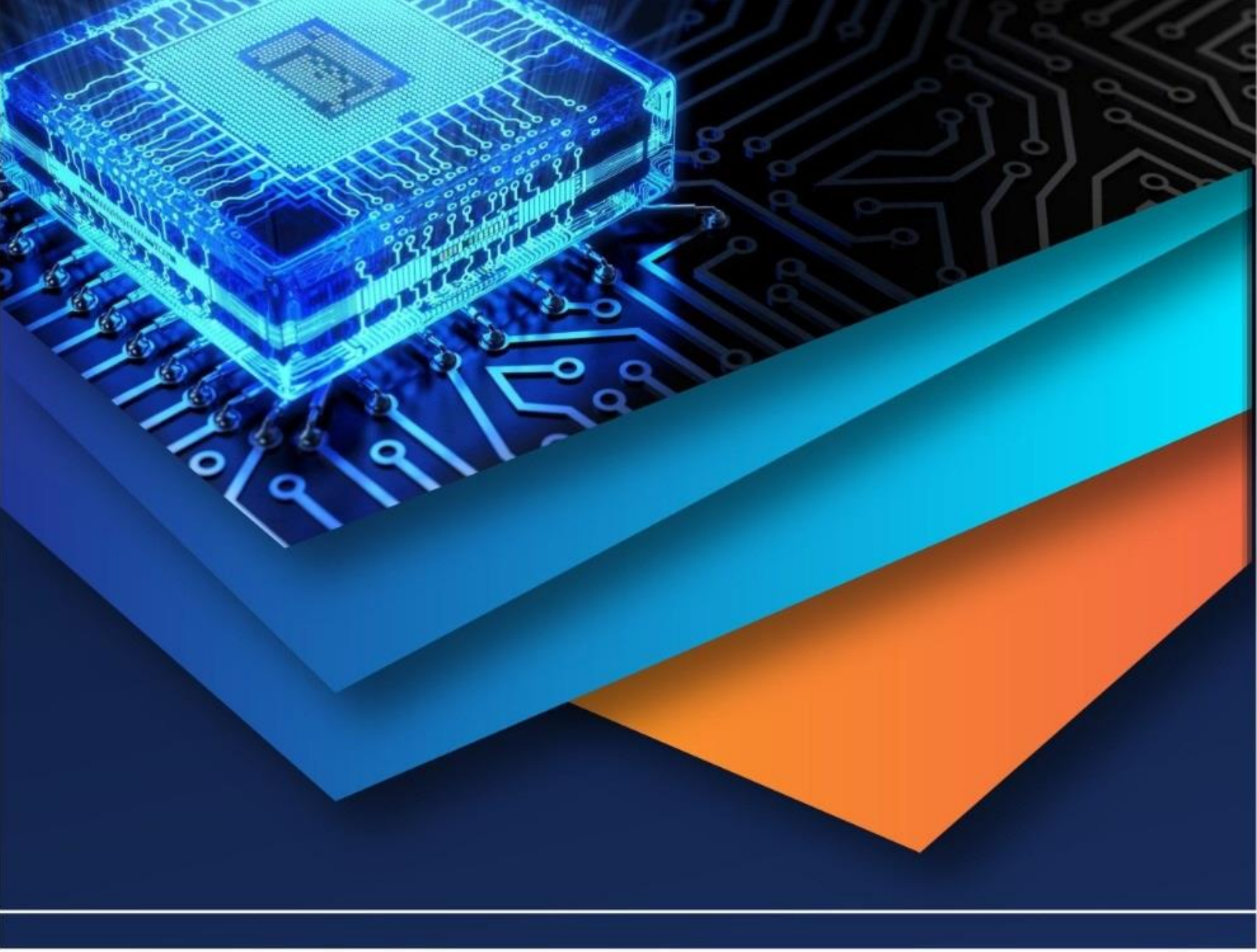
The extracted number plate is verified against an authorized database to automate access control decisions. The inclusion of a PyQt6-based interface enhances usability by providing real-time monitoring and status updates.

The proposed system successfully reduces manual effort, improves accuracy, and ensures efficient vehicle verification. It provides a practical and scalable solution for modern security applications.

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