Automatic Number Plate Recognition System

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Abstract

Automatic Number Plate Recognition (ANPR) is an intelligent vehicle access control system that identifies vehicle registration numbers using image processing and Optical Character Recognition (OCR). The proposed system uses an ESP32-CAM module to capture vehicle images and OpenCV with EasyOCR to extract number plate information. The extracted number is verified with a MySQL database of authorized vehicles. Based on the verification result, access is granted or denied automatically. An ESP32 development board controls an OLED display and a servo motor for gate operation. The system provides a low-cost, reliable, and efficient solution for automated vehicle monitoring and access control in parking areas, residential societies, and educational institutions.

Keywords— ESP32-CAM, OpenCV, EasyOCR, MySQL Database, OLED Display, Servo Motor, Automatic Number Plate Recognition (ANPR)

Introduction

Vehicle security and access control have become important in residential societies, educational institutions, and parking areas. Traditional vehicle entry systems rely on manual verification, which is time-consuming and prone to errors. With advancements in image processing and artificial intelligence, Automatic Number Plate Recognition (ANPR) technology enables automatic vehicle identification and access control.This project aims to develop a smart ANPR system using ESP32-CAM, OpenCV, and EasyOCR to recognize vehicle number plates. The extracted number is verified with a MySQL database of authorized vehicles. Based on the verification result, the system automatically grants or denies access while displaying the status on an OLED display.

Literature Survey

Vehicle identification and access control systems have evolved significantly over the years. Traditional security systems relied on manual verification of vehicle details, which was time-consuming and prone to human errors. With the advancement of image processing, computer vision, and artificial intelligence, Automatic Number Plate Recognition (ANPR) systems have become an effective solution for automated vehicle monitoring and access control. Modern ANPR systems utilize cameras, OCR techniques, and database management systems to recognize vehicle registration numbers accurately and provide real-time access decisions.

S. Du et al. (2013) presented a comprehensive review of Automatic Number Plate Recognition systems. The study discussed various image processing and character recognition techniques used in ANPR applications. The authors highlighted challenges such as varying lighting conditions, image quality, and plate orientation, which affect recognition accuracy.

R. Silva and K. Jung (2018) developed a vehicle identification system using computer vision and OCR techniques. Their work demonstrated that integrating

image preprocessing methods with OCR algorithms significantly improves the accuracy of license plate recognition in real-time applications.

M. Laroca et al. (2021) proposed a deep learning-based license plate recognition framework capable of detecting and recognizing vehicle plates under challenging environmental conditions. The system achieved high accuracy and demonstrated the effectiveness of AI-based approaches in intelligent transportation systems.

P. Singh and R. Kumar (2023) proposed an ANPR-based vehicle access management system using OCR and database verification techniques for automated vehicle authentication and access control. **Problem Statement**

Traditional vehicle access control systems rely on manual verification of vehicle details, which is time-consuming, labor-intensive, and prone to human errors. Existing security systems often lack the capability to automatically identify authorized and unauthorized vehicles in real time. This can lead to delays in vehicle entry, inefficient monitoring, and reduced security. Therefore, there is a need for an automated system that can accurately recognize vehicle number plates, verify them with a database, and control vehicle access without human intervention. The proposed ANPR system addresses these challenges by providing a smart, efficient, and secure vehicle access control solution.

Aim and Objectives

To develop an Automatic Number Plate Recognition (ANPR) system that automatically identifies vehicle registration numbers, verifies them with a database, and controls vehicle access using embedded hardware and image processing techniques.

Objectives:

- To capture vehicle images using the ESP32-CAM module.
- To extract vehicle registration numbers using OpenCV and EasyOCR.
- To verify recognized vehicle numbers with a MySQL database.
- To display access status on an OLED display.
- To control gate operation automatically using a servo motor.
- To reduce manual intervention and improve vehicle security.

Diagram

A) Block Diagram

The proposed ANPR system consists of an ESP32-CAM module, image processing software, a MySQL database, an OLED display, and a servo motor. The ESP32-CAM captures the image of the vehicle number plate. The captured image is processed using OpenCV and EasyOCR to extract the vehicle registration number. The extracted number is compared with the authorized vehicle records stored in the MySQL database. Based on the verification result, the system displays the access status on the OLED display and controls the servo motor to open or keep the gate closed.

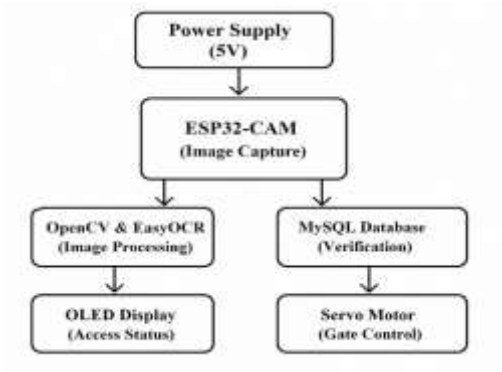


Fig. 1. System Block Diagram.

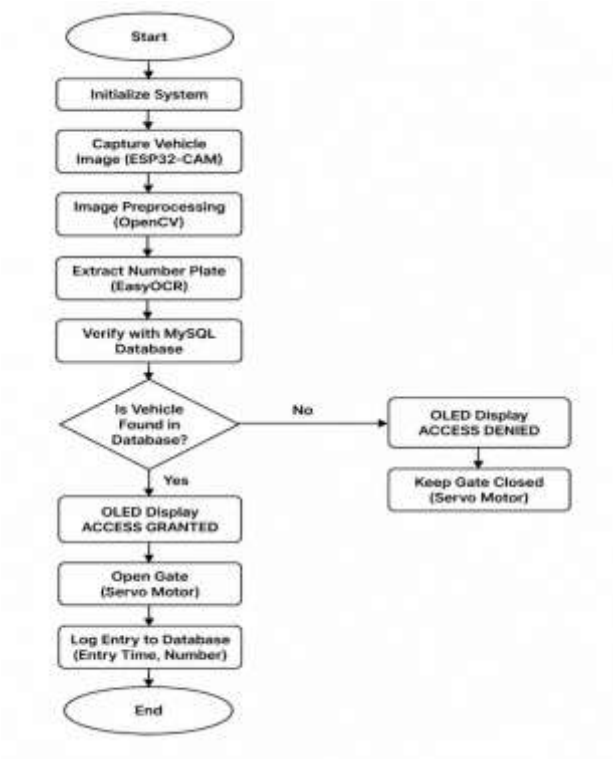
B) Flow Chart

The process begins with the initialization of the ANPR system. The ESP32-CAM captures the image of the approaching vehicle. The captured image is processed using OpenCV and EasyOCR to extract the vehicle registration number. The extracted number is compared with the records stored in the MySQL database.

If the vehicle number is found in the database, access is granted. The OLED display shows the access status and the servo motor opens the gate. If the vehicle number is not found, access is denied and the OLED display indicates the denial status. After the action is completed,

the system returns to the monitoring state for the next vehicle.

Fig. 2. Flow Chart.



Working

The system is built around the ESP32-CAM module, which is powered using a 5V supply and acts as the image acquisition unit. When a vehicle approaches the entry point, the ESP32-CAM captures an image of the vehicle and its registration plate. The captured image is then transferred to the processing system for further analysis and recognition.

For image processing, the system utilizes OpenCV and EasyOCR technologies. OpenCV is used to preprocess the captured image by improving image quality and preparing it for character extraction. EasyOCR then analyzes the processed image and extracts the vehicle registration number from the number plate. The extracted text is converted into a readable format for verification.

After the vehicle number is recognized, the system compares it with the records stored in the MySQL database containing authorized vehicle information. If the detected vehicle number matches an existing record in the database, the vehicle is considered authorized and access permission is granted. If no matching record is found, the vehicle is treated as unauthorized and access is denied.

When access is granted, the system displays "ACCESS GRANTED" on the OLED display and activates the servo motor to open the gate automatically. If the vehicle is unauthorized, the OLED display shows "ACCESS DENIED" and the gate remains closed. Additionally, the system can store vehicle entry information such as the vehicle number, access status, and timestamp in the database for future monitoring and record management.

The developed ANPR system was successfully implemented and tested. The system accurately recognized vehicle registration numbers, verified them against the database, and controlled gate operation based on the verification result. The results demonstrate that the proposed system provides an efficient, reliable, and low-cost solution for automated vehicle access control and security management.

Advantages & Applications

ADVANTAGES

- Automatically identifies and verifies vehicle registration numbers without manual intervention.
- Prevents unauthorized vehicle entry by verifying vehicle details against a database.
- Provides instant decision-making for granting or denying vehicle access.
- Utilizes ESP32-CAM, OLED display, and servo motor, making the system economical and easy to deploy.
- Eliminates the need for manual vehicle verification and gate operation.
- Maintains vehicle entry records for monitoring, analysis, and future reference.

APPLICATIONS

- **Residential Societies:** Automates vehicle entry and exit management for residents and visitors.
- **Parking Management Systems:** Controls access to parking areas and maintains vehicle records automatically.
- **Educational Institutions:** Enhances campus security by allowing entry only to authorized vehicles.
- **Industrial Premises:** Restricts unauthorized vehicle access to factories and industrial zones.
- **Toll Collection Systems:** Supports automatic

vehicle identification for efficient toll management.

- **Government and Private Organizations:** Improves security at offices, military areas, and restricted locations.
- **Smart City Infrastructure:** Can be integrated into intelligent transportation and urban monitoring systems.

Future Scope

- **Cloud-Based Database Integration:** The system can be enhanced by storing vehicle records and entry logs on cloud platforms for remote access and centralized management.
- **Mobile Application Support:** A dedicated mobile application can be developed to provide real-time notifications and remote monitoring of vehicle entries.
- **Advanced AI-Based Recognition:** Deep learning models can be incorporated to improve number plate recognition accuracy under varying lighting and weather conditions.
- **Multi-Camera Support:** The system can be expanded to support multiple cameras for monitoring several entry and exit points simultaneously.
- **Smart Parking Management:** Integration with parking systems can enable automatic slot allocation, vehicle tracking, and parking fee management.

Conclusion

This project presents an Automatic Number Plate Recognition (ANPR) System for automated vehicle access control and monitoring. The system uses the ESP32-CAM module to capture vehicle images and applies OpenCV and EasyOCR techniques to extract vehicle registration numbers. The extracted number is verified against a MySQL database of authorized vehicles.Based on the verification result, the system displays the access status on an OLED display and controls gate operation using a servo motor. The proposed solution reduces manual intervention, improves security, and provides an efficient and low-cost vehicle authentication mechanism suitable for residential societies, parking areas, educational institutions, and industrial premises.

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