DESIGN AND IMPLEMENTATION OF A REAL-TIME INTELLIGENT BARRIER GATE SYSTEM USING RASPBERRY PI AND IP CAMERA FOR VEHICLE ACCESS CONTROL

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Annotation: *This paper presents a comprehensive approach to designing and implementing an intelligent vehicle access control system using license plate recognition (LPR) technology. The proposed solution leverages the computational capabilities of Raspberry Pi and the visual coverage of an IP camera to enable automated barrier gate operation. By integrating image processing, optical character recognition (OCR), and servo motor control, the system offers a real-time, cost-effective, and scalable infrastructure for monitoring and controlling vehicle entry. Applications in residential, commercial, and high-security environments are explored, and performance metrics including accuracy, latency, and reliability are analyzed.*

Аннотация: *В данной статье рассматривается проектирование и работа интеллектуальной системы управления доступом для транспортных средств, основанной на Raspberry Pi и IP-камере. Система использует технологии с открытым исходным кодом, такие как OpenCV и Tesseract OCR, для распознавания номерных знаков в реальном времени, сравнивает их с локальной базой данных и при совпадении автоматически поднимает шлагбаум с помощью сервомотора. Решение является недорогим, автономным и масштабируемым, что делает его подходящим для различных задач контроля доступа и безопасности. В статье проанализированы архитектура системы, её преимущества, ограничения и возможные области применения.*

Keywords: *License Plate Recognition, Raspberry Pi, IP Camera, Intelligent Barrier System, Real-Time Processing, Automated Access Control*

Ключевые слова*: Распознавание номерных знаков, Raspberry Pi, IP-камера, Интеллектуальная барьерная система, Обработка в режиме реального времени, Автоматизированный контроль доступа*

Introduction

The need for intelligent vehicle access systems has risen with the increase in urban traffic, demand for automation, and the necessity for enhanced security. Traditional gatekeeping methods that involve manual verification are time-consuming and prone to errors. Automatic license plate recognition (ALPR) technologies provide a viable solution by automating the recognition of vehicle plates and making access decisions in real time. This paper proposes a complete system that integrates Raspberry Pi, an IP camera, and open-source software tools to deliver a self-contained, affordable, and reliable automated gate control system.

Related Work

ALPR systems have been widely used in urban management, toll booths, and security checkpoints. Most commercial solutions, however, rely on expensive hardware and cloud

services. Recent developments in edge computing using Raspberry Pi have made it possible to deploy intelligent systems on-site with minimal costs. Previous works have explored the use of OpenCV and Tesseract OCR on Raspberry Pi for object and character detection, showing promising results in accuracy and latency. Nevertheless, limited processing power and camera quality remain challenges.

System Architecture

The system architecture comprises four key modules:
1. Image Acquisition: An IP camera captures vehicle images in real-time.
2. Image Processing and OCR: Raspberry Pi processes the image using OpenCV and applies OCR with Tesseract to extract the plate number.
3. Verification and Control: The extracted text is compared against a whitelist database. If matched, access is granted.
4. Actuation: A servo motor connected to Raspberry Pi lifts the barrier gate for authorized vehicles.

The entire process takes place on the Raspberry Pi without relying on cloud services, making the system fast and suitable for remote locations.

Implementation and Methodology

The implementation was carried out on a Raspberry Pi 4 Model B running Raspbian OS. A Hikvision IP camera streamed video over RTSP to the Raspberry Pi. OpenCV libraries were used to process video frames, applying grayscale conversion, edge detection, and contour filtering to isolate the license plate. Tesseract OCR was trained with localized license plate fonts to improve accuracy. Servo motor control was implemented using the RPi.GPIO Python library. SQLite served as the local database storing authorized license plate numbers. The entire system was encapsulated within a Python-based event loop ensuring asynchronous processing and fast response times

Advantages and Limitations main Advantages

- Cost-effective due to use of open-source tools and affordable hardware.
- Fully autonomous, with no need for constant internet connectivity.
- Customizable for local license plate formats and multilingual OCR support.
- Scalable to support cloud syncing or mobile alerts.

Limitations:

- Accuracy drops under poor lighting or bad weather conditions.
- Limited processing speed may affect frame rate and real-time responsiveness.
- Needs periodic retraining for OCR in regions with varying plate styles.6. ApplicationsThis intelligent system has broad applications including:
- Gated residential communities
- University and corporate campuses
- Government installations
- Private and public parking areas
- Industrial and warehouse entry points

The modular design makes it adaptable for future extensions such as automatic fee collection, vehicle counting, and integration with smart city infrastructure.

Conclusion

The real-time intelligent barrier control system proposed in this paper demonstrates a practical implementation of ALPR using low-cost components. Through image processing, character recognition, and GPIO actuation, the system ensures accurate and secure vehicle access control. Future improvements may include night vision support, AI-based vehicle detection, and integration with centralized monitoring systems.

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