Face Recognition Door Lock using ESP32-CAM

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Abstract

This project developed a low-cost, secure door lock system using the ESP32-CAM module, which utilizes advanced face recognition technology to enhance authentication accuracy and reliability.

The system addresses the limitations inherent in traditional mechanical locks and keypad-based systems, such as vulnerability to unauthorized access, key loss, and forgotten passwords, by providing a convenient and robust solution that relies on biometric verification.

Prototype testing demonstrated over 95% accuracy in face authentication under various lighting conditions and angles, showcasing the system's effectiveness and resilience.

By integrating accessible and dependable technology, this project aims to significantly improve home and office security, offering an innovative approach to secure door access that combines convenience, safety, and modern smart home capabilities.

Furthermore, the design emphasizes affordability and ease of installation, making advanced security technology available to a wider range of users without compromising performance.

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Introduction

Traditional lock systems have been the cornerstone of residential security for many years; however, they exhibit significant vulnerabilities such as susceptibility to lock picking, lost keys, and unauthorized duplication. These drawbacks have driven the increasing demand for enhanced security solutions that can provide more reliable and tamper-resistant protection. Biometric authentication systems, which leverage unique physical characteristics such as facial features, fingerprints, or iris patterns, offer a highly secure alternative by ensuring that access is granted only to authorized individuals.

The ESP32-CAM module presents an affordable and compact platform for implementing real-time face recognition technology, making advanced biometric security accessible for home and office environments. By integrating face detection with automated door control mechanisms, the system facilitates seamless and convenient access management without compromising safety. This approach not only mitigates the risks associated with conventional locking methods but also introduces smart home capabilities that enhance overall user experience. The following sections will detail the objectives, existing technologies, system design, and future enhancements related to this project.

Objectives

- Design reliable face recognition door lock

- Use ESP32-CAM for capturing and processing images

- Ensure high accuracy and low response time

- Develop secure, user-friendly access management

- Keep system cost below $50 USD

- Implement robust door control mechanism

Literature Survey

1

Algorithms

Viola-Jones, Eigenfaces, CNN adapted for embedded systems

2

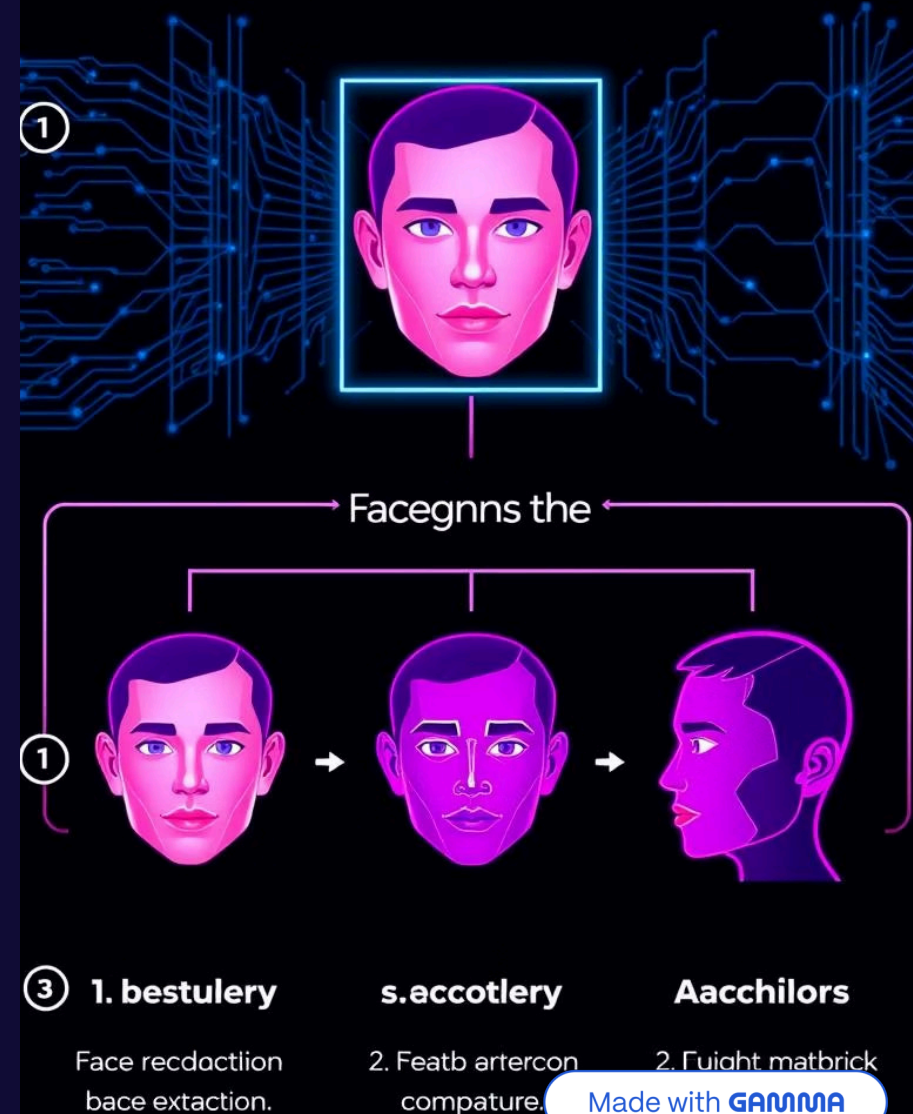### ESP32-CAM Performance

Balancing speed and memory constraints

3

Commercial Systems

Face lock prices typically range $200-$500

4

Security Issues

Threats from spoofing and data breaches

Existing Systems

- Keypad locks risk code sharing

- Fingerprint locks vulnerable to fake prints

- Traditional locks prone to picking

- Smartphone locks depend on network connectivity

- Face recognition systems are costly and less accessible

Proposed System

Local secure face database for authorized users	Real-time face detection and recognition using LBPH algorithm
Relay control for activating door lock mechanism	User enrollment interface and physical key backup

Modules: Face Recognition & Enrollment

Face detection via Haar cascades for speed

LBPH algorithm used for reliable recognition

Enrollment stores unique ID and face images locally

Uses OpenCV libraries for processing and database management

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Modules: Door Control & Security

- Relay module controls physical locking device
- 5V power supply supports camera and relay
- Encrypted storage protects face data

- Alert system notifies unauthorized access attempts
- Tamper detection disables system on forced entry

Future Enhancements

☁ **Cloud Integration**
Use cloud for better recognition and updates

🔒 **Liveness Detection**
Prevent spoofing with real-time verification

📱 **Mobile App**
Remote control and monitoring via smartphone

🎤 **Voice Control**
Hands-free system operation for convenience

Adding multi-factor authentication for enhanced security is planned.