

# Smart Doorbell With Face Recognition Using ESP32

Kaustubh Chavan<sup>1</sup>, Sarvesh Haldankar<sup>2</sup>, Veenita Bharde<sup>3</sup>, Nikita Harmalkar<sup>4</sup>, Cajetan Ghonsalvis<sup>5</sup>, Heenali Korgaonkar<sup>6</sup>

<sup>1,2,3,4</sup> Student, Electronics and Telecommunication Eng, MITM Sindhudurg, Maharashtra, India

<sup>5,6</sup> Asst. Professor of Electronics and Telecommunication Eng, MITM, Sindhudurg, Maharashtra, India

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## ABSTRACT

*The rapid growth of smart home technology has increased the need for intelligent security systems. This project presents a Smart Doorbell using an ESP32-CAM module with face recognition capability to enhance home security and convenience. The system captures images when the doorbell is pressed and processes them using face recognition algorithms. Authorized faces are recognized automatically, while unknown visitors are recorded and notifications can be sent to the homeowner through a connected application or server. The system uses the ESP32-CAM module, which integrates a camera and Wi-Fi capability, enabling real-time monitoring and wireless communication. This low-cost and compact solution improves traditional doorbell systems by adding automation, surveillance, and smart identification features*

**Keyword:** - ESP32-CAM, Wi-Fi capability

## 1. INTRODUCTION

A smart doorbell with face recognition is an advanced home security device that combines a video doorbell, artificial intelligence (AI), and facial recognition technology to identify people who come to the door. Unlike traditional doorbells that only alert the homeowner when someone presses the bell, smart doorbells provide real-time video, notifications, and intelligent identification of visitors. These systems use a built-in camera and AI algorithms to detect human faces, analyze facial features, and compare them with stored images of known individuals. When someone approaches the door, the system can recognize whether the person is a family member, friend, delivery person, or unknown visitor and send a notification to the homeowner's smartphone.

### 1.1 Design and Implementation of Smart Doorbell with Face Recognition

A smart doorbell with face recognition is a modern home security system that uses computer vision, artificial intelligence (AI), and IoT technology to identify visitors at the door automatically. Unlike traditional doorbells, this system captures the visitor's image through a camera, analyzes the face using a recognition algorithm, and notifies the homeowner via a smartphone or other connected device. The main purpose of this system is to improve home security, automate visitor identification, and allow remote monitoring. It can recognize known individuals such as family members and alert the user when an unknown person approaches the door.

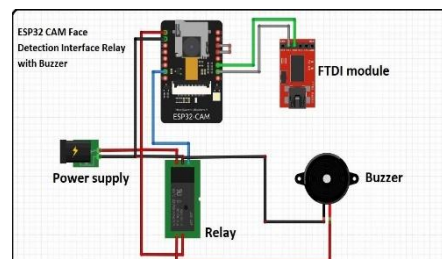
### 1.2 System Architecture

A smart doorbell with face recognition is typically built using a layered system architecture that integrates hardware, edge computing, networking, and cloud services to deliver secure and intelligent visitor identification. At the device layer, the doorbell unit contains a high-resolution camera, microphone, speaker, motion sensor (often PIR), and an embedded processor such as an ARM-based SoC or edge AI module (e.g., NVIDIA Jetson Nano or Raspberry Pi with a neural accelerator). When motion is detected or the doorbell button is pressed, the camera captures video frames and the embedded system performs pre-processing such as image resizing, noise reduction, and frame selection. A face detection model (for example based on CNN architectures like MTCNN or Haar cascades) identifies faces within the frame, after which a face recognition model (such as Face Net or Maleficent) extracts facial embeddings and compares them against a locally stored or cloud-based database of known individuals. If a match is found, the system labels the visitor (e.g., family member, delivery person), while unknown faces trigger alerts. The edge layer handles low-latency inference and basic decision-making to minimize bandwidth usage and ensure quick responses.

The device connects via Wi-Fi or Ethernet to a home router, sending encrypted data through protocols like

HTTPS or MQTT to a cloud backend. The cloud layer manages heavy processing tasks, large-scale face databases, user authentication, device management, and event storage, often implemented using microservices hosted on platforms such as AWS, Azure, or Google Cloud. A mobile or web application layer provides the user interface, allowing homeowners to receive real-time notifications, view live video streams, communicate with visitors through two-way audio, review recorded events, and manage authorized faces. Security components such as end-to-end encryption, secure boot, device authentication, and access control policies are integrated throughout the architecture to protect user data and prevent unauthorized access. Overall, the system operates as an intelligent IoT solution where edge AI handles immediate recognition tasks while the cloud supports scalability, storage, analytics, and remote user interaction.

## 2. METHODOLOGY AND EXPERIMENTAL SETUP



The implementation of the system follows these steps: Hardware Setup Connect ESP32-CAM module Connect push button for doorbell Provide stable power supply Programming Program ESP32-CAM using Arduino IDE Upload face recognition firmware Face Enrollment Capture and store authorized faces in the system database Face Detection and Recognition System detects faces using computer vision algorithms Matches detected faces with stored data Notification and Monitoring Send alerts to a mobile device or web interface

## 3. DESIGN ANALYSIS AND EXPECTED OUTCOMES

The design focuses on: Low cost implementation Compact hardware design Wireless connectivity Real-time face recognition User-friendly monitoring interface Key performance factors include: Face recognition accuracy Response time Network reliability Power efficiency Expected Outcomes The expected outcomes of the project include: Accurate identification of registered users Detection and logging of unknown visitors Real-time monitoring through Wi-Fi Enhanced home security compared to traditional doorbells Low-cost smart security solution

## 4. CONCLUSIONS

The ESP32-CAM Smart Doorbell with Face Recognition provides an innovative solution for improving home security systems. By combining IoT technology with computer vision, the system enables automatic visitor identification and remote monitoring. The ESP32-CAM module offers a cost-effective platform with built-in Wi-Fi and camera functionality, making it ideal for smart home applications. Future improvements may include: Integration with mobile applications Cloud storage for captured images Voice communication features AI-based advanced face recognition This project demonstrates how embedded systems and IoT technologies can be used to build intelligent security solutions.

## 5. REFERENCES

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