Project Submission Checklist
Embedded IOT Systems Fall 2025

Project Title: <u>Face Recognition and Door Lock System</u>

Group Name: <u>Snap and Verify</u>

Class: BSCS - 5th B   **Date:** 5th Jan - 2026

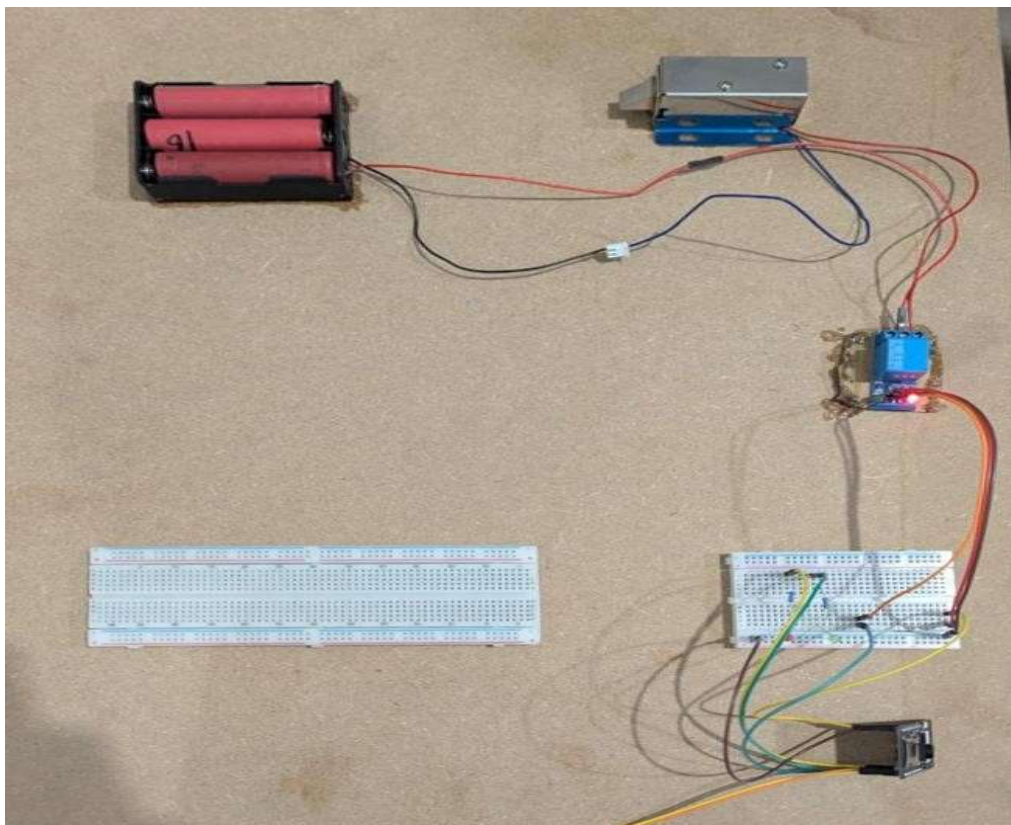| Group Member:	Registration No:
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1. Problem Statement and Objectives

Problem Statement

Traditional door locking systems such as keys, keypads, and RFID cards suffer from security risks like theft, duplication, loss, and unauthorized access. These systems also lack centralized monitoring and access logging. There is a need for a **secure, contactless, and intelligent door access system** that can authenticate users reliably while maintaining real-time records.

Objectives

- To design an IoT-based smart door lock using **facial recognition**
- To implement **contactless biometric authentication**
- To control an electronic door lock automatically using ESP32-CAM
- To provide **real-time access logs** using cloud storage
- To develop a **web-based dashboard** for monitoring and control
- To support **manual override** in emergencies

2. System Architecture / Block Diagram
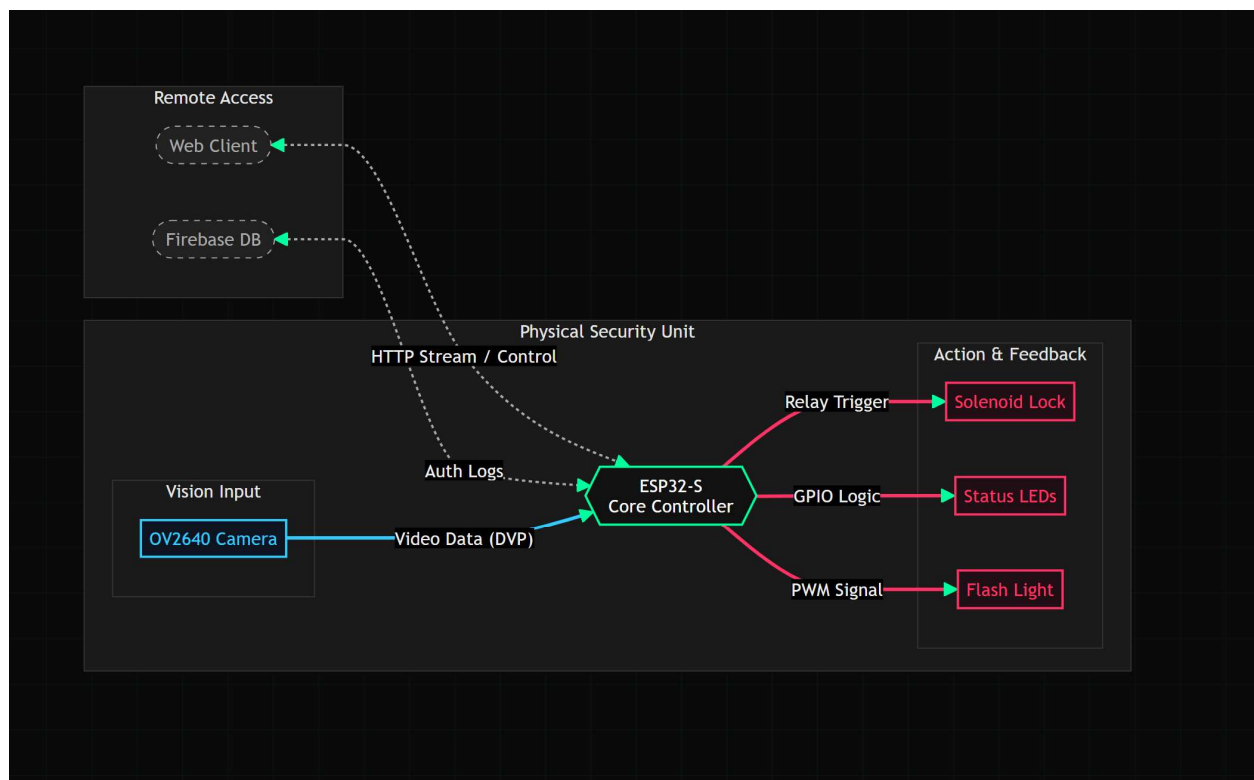
System Architecture Description

The Secure Access Terminal (E-Lock) is centered around the **ESP32-CAM** microcontroller. The camera captures facial images and processes them locally using embedded AI models. Based on recognition results, the ESP32 controls a relay module that locks or unlocks the door.

The system also hosts a **web server and WebSocket server** to stream live video and receive commands from a browser-based dashboard. All access events are logged to **Firebase Realtime Database** for cloud-based monitoring.

Main Blocks:

- ESP32-CAM (Controller + Camera)
- Facial Recognition Engine
- Relay-based Door Lock
- Web Interface (Dashboard)
- Firebase Realtime Database
- LEDs for status indication
- Power Supply Unit

Block Diagram

3. Hardware and Software Description

Hardware Description

Component List

- **Microcontroller:** ESP32-CAM (AI-Thinker)
    - Dual-core 240 MHz processor
    - 4 MB PSRAM for image buffering and face embeddings
- **Camera Module:** OV2640
    - 2 MP image sensor
    - Configured for optimized resolution and frame rate
- **Actuator:** 5V Relay Module
    - Electrically isolates ESP32 from door lock circuit
- **Indicators:**
    - Green LED → Access Granted
    - Red LED → Access Denied
- **Power Supply:**
    - 5V DC (minimum 2A) for stable operation

Software Description

Dependencies

- **Arduino Framework**
- **ESP32 Board Support Package**
- **ArduinoWebsockets** (low-latency video streaming)
- **Firebase ESP Client** (cloud communication)
- **esp_camera** (camera driver)
- **fd_forward / fr_forward** (face detection & recognition models)

Pin Configuration

Component	ESP32 GPIO Pin	Function & Notes
Relay (Lock)	GPIO 2	Digital Output. Sends a signal to trigger the relay coil. Active State (High/Low) depends on relay board logic.
Flash LED	GPIO 4	PWM Output. Controls the brightness of the intense on-board LED. *Warning: Shared with SD Card Data Line 1.*
Green LED	GPIO 12	Digital Output. Active High. Illuminates when recognition is successful.
Red LED	GPIO 14	Digital Output. Active High. Blinks or stays lit when an unknown face is detected.
Camera D0-D7	Y2-Y9	Parallel Data Interface. High-speed bus for transferring image data from sensor to MCU.
Camera Control	XCLK, PCLK, VSYNC	Clock and Sync lines. XCLK is generated by the ESP32 to drive the camera sensor logic.

4. Methodology and Flowchart

Methodology

1. ESP32-CAM captures live video frames
2. Face detection is performed on each frame
3. Detected faces are matched with stored embeddings
4. If matched → door unlocks via relay
5. Entry is logged to Firebase
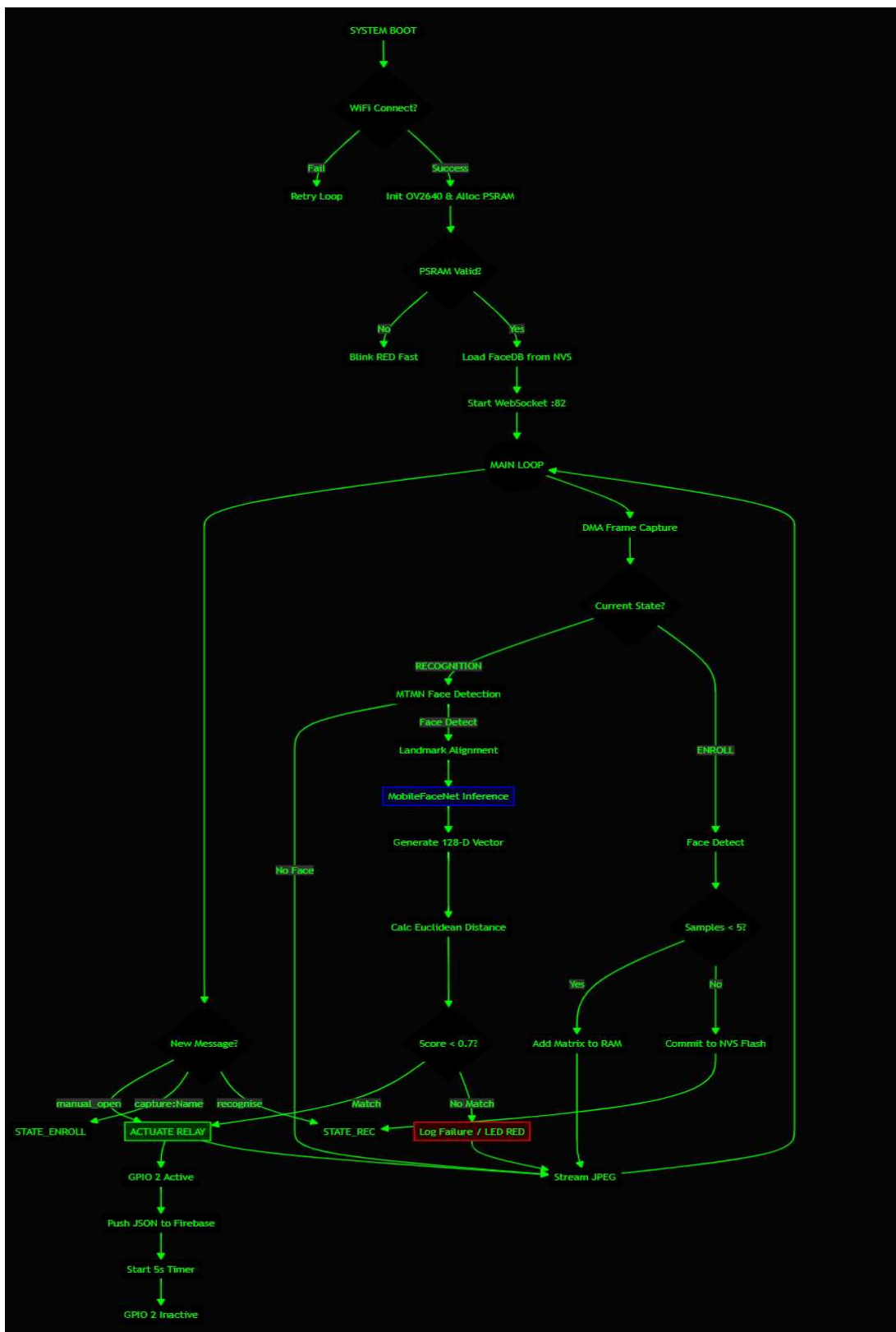6. Door locks again after a fixed delay

State Machine Logic

The system uses a **Finite State Machine (FSM)**:

- `START_STREAM` – Live video streaming only
- `START_DETECT` – Detect faces without recognition
- `START_RECOGNITION` – Match face with database
- `START_ENROLL` – Capture 5 samples for new user
- `DELETE_ALL` – Clear face database
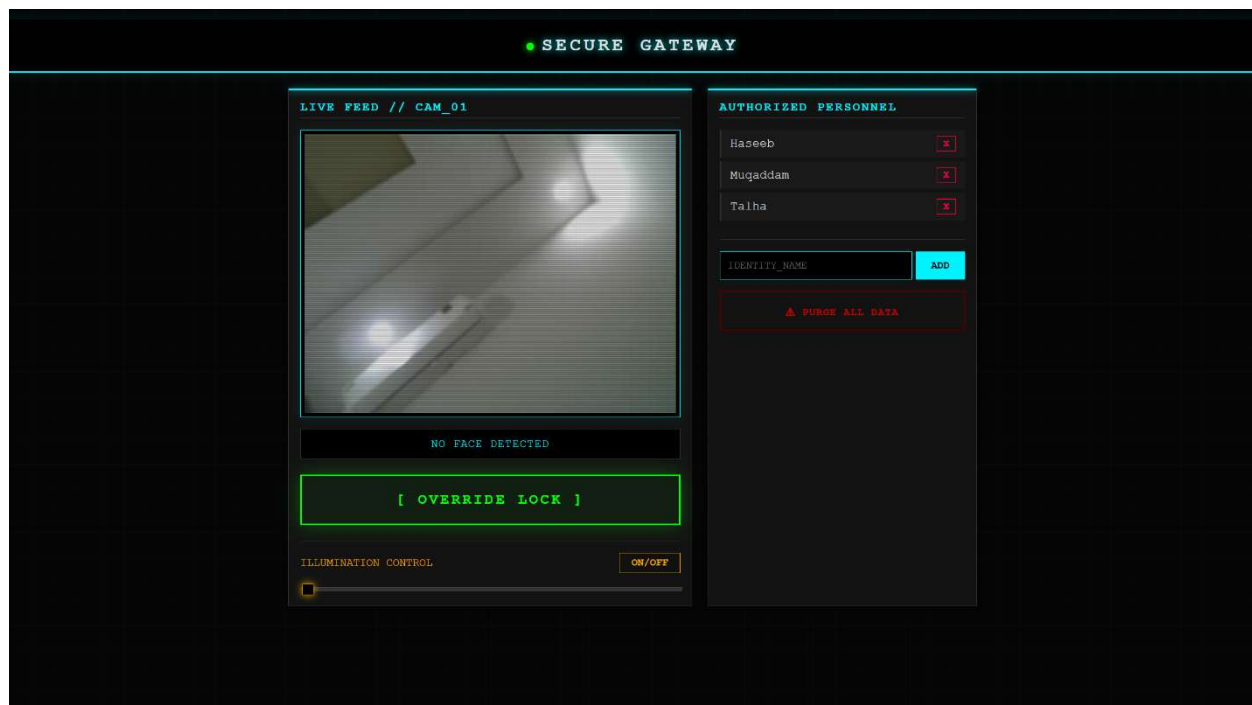
Lock Control Logic

- Unlock triggered by face recognition or manual override
- Relay activated for **5 seconds** using non-blocking `millis()`
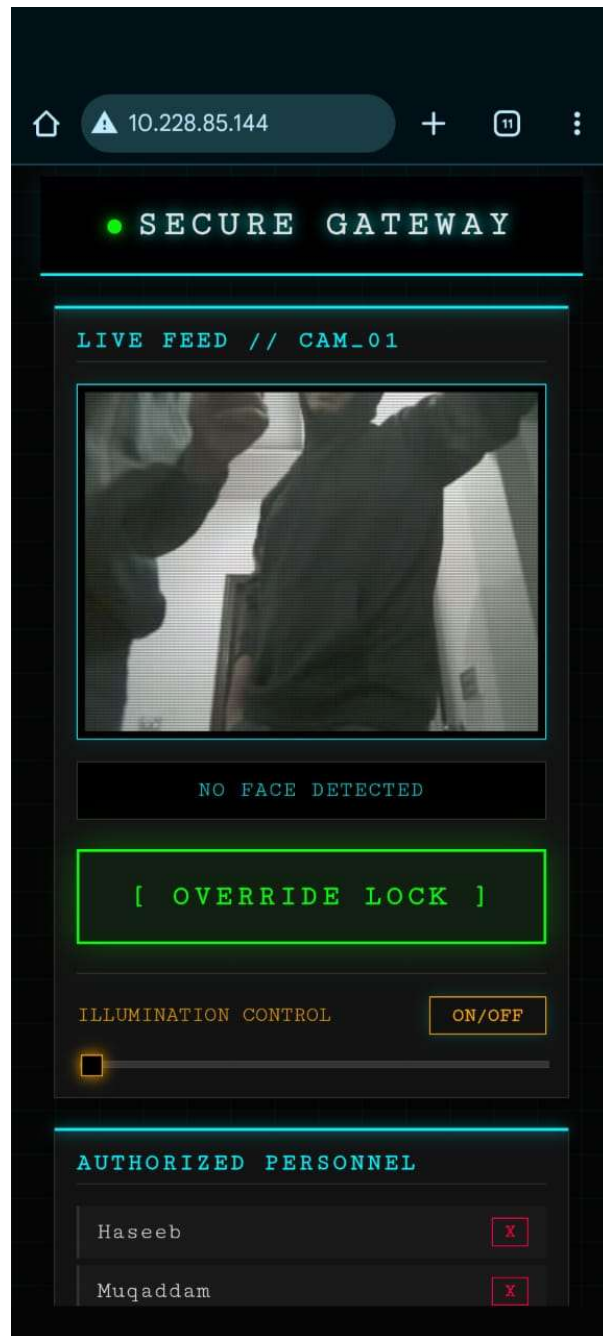- Door automatically re-locks after timeout

5. Screenshots of Output and Dashboards

- Live camera feed on dashboard
- Face recognition status messages
- Firebase access logs
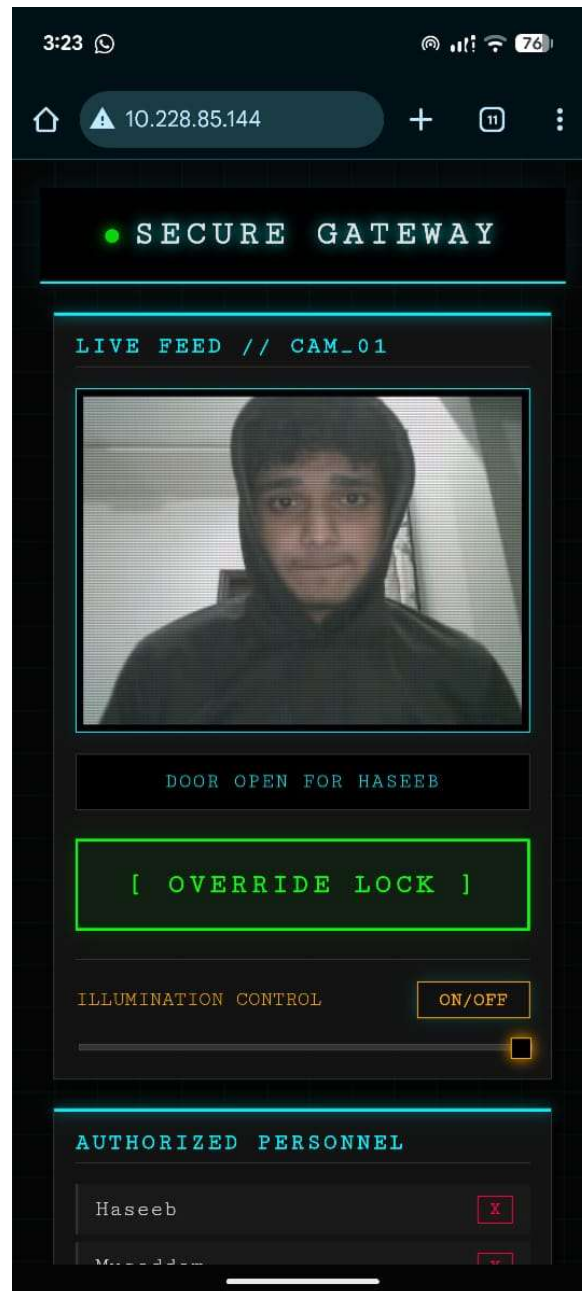- Manual override button
- Enrollment interface

On Desktop

On Mobile

6. Results, Conclusion, and Future Scope

Results

- Accurate real-time face recognition
- Reliable door lock control
- Smooth live video streaming
- Successful cloud-based access logging

Conclusion

The Secure Access Terminal (E-Lock) successfully demonstrates a **standalone smart security system** using ESP32-CAM and facial recognition. It eliminates physical keys, enhances security, and provides centralized monitoring through a modern web interface and cloud integration.

Future Scope

- Mobile application integration
- Multi-camera support
- Secure Firebase authentication rules
- Night-vision or IR camera support
- Integration with alarms and sensors