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Face Detection and Smart Bell Technology are Features of this ESP32-CAM-Powered Smart Home Door Access System

Y. Harshini[1], K. Anand[2], A. Akshitha[3], Dr. J. Narasimharao[4]
UG Scholars, Department of Computer Science & Engineering[1-3]
Associate Professor, Department of Computer Science & Engineering[4]
CMR Technical Campus, Hyderabad, India

Abstract: *A fresh look at home safety shapes this work - building a door security setup using ESP32-CAM. Instead of old methods, face spotting and a smart bell guide how it operates. One step closer happens when someone nears the entrance; that moment triggers an image capture by the camera board. Algorithms then scan those pictures, spotting who's there without delay. From the hub, data moves wirelessly out - ending up on either a personal online storage space or a phone for checking later. Built into it are pieces like a power handler, central brain unit, switch board, along with links for exchanging signals. Instead of old-style fixes, this setup brings sharper control over entry points using cleaner logic than standard setups allow*

Keywords: IoT-Based Smart Home Security, ESP32-CAM Embedded Platform, Real-Time Face Detection, Intelligent Door Access System, Wireless Image Transmission, Low-Cost Embedded Security

I. INTRODUCTION

With more people wanting smart homes, better safety features are being built - ones smarter than basic door locks. These days, owners expect more: live updates, instant access, even remote oversight when away. The front door stands out because it's where intruders first show up. That spot needs something sharp, something alert - the heart of any modern household shield. Old setups like mechanical locks, basic doorbells, or separate CCTV cameras can't do much on their own. They miss early warning signals because they lack active protection abilities.

This smart door system tackles old issues by blending face recognition with an alert function in one compact setup. Looking at the drawing, the ESP32-CAM handles most tasks - mixing camera capabilities with processing power. From there, links connect it to energy sources along with a notification trigger. A picture forms when motion is caught or the bell gets pressed. Inside that snapshot, software looks for signs of a person - specifically, a face.

Using the ESP32-CAM's built-in Wi-Fi, pictures plus warnings travel to homeowners through a phone app or online platform. Because data moves in real time, people can see who arrives while choosing how to respond. Size matters here - it fits small spaces without bulk. Power use stays low, which helps batteries last longer. Cost stays reasonable too, so more places can use it without breaking budgets.

Using IoT tools, tiny computer networks, and vision processing ideas shows a clear path forward - ways to boost household safety through smarter protection methods. These setups also open doors for easier upgrades across next-gen living spaces.

II. LITERATURE SURVEY

1. Smart Door Lock System Using Face Recognition and IoT

Kumar, [15] along with Patel and Mehta, [6] takes on this topic.

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Description:
A smart door lock system powers this project, built with IoT technology. Face detection stands as the main way to confirm who enters. When someone approaches, a camera takes their picture. That image travels through recognition tools to check if they're allowed in. A tiny processor handles local tasks while data also flows into a web-based service. From there, real-time updates and notifications become possible. This work shows stronger protection than old key-only methods yet demands more power from processors - making it hard to run well on basic, cheap devices.

2. IoT-Based Home Security System Using ESP32-CAM
M. S. Rao [9] and P. Anitha [12] wrote this work
Description:
This study looks at how the ESP32-CAM module captures images in real time, useful in home security setups. Live video flows through a web interface while motion close to the entrance triggers warnings. Even though face recognition isn't completed here, the work shows that ESP32-CAM can work well in battery-powered surveillance tasks. That feature makes it fitting for future smart door security designs.

3. Face Recognition-Based Smart Security System for Smart Homes
Li [7] and Zhang [8] wrote this work
Description:
A fresh take on home security shows up here - face scanning tied directly to smart door management. Algorithms built with OpenCV handle image analysis, spotting individuals and confirming their identity. Once recognized, the door opens without delay. Updates reach the owner instantly via phone app alerts. Even though the setup achieves good recognition results, it depends on outside hardware, making everything heavier and harder to manage.

4. Intelligent Doorbell System with Image Capture and Mobile Notification
R. Sharma and N. Verma [9] wrote this work
Description:
A visitor picture gets taken once the doorbell is triggered, showing up later on a phone. This setup makes it easier for people to connect with others at a distance. Still missing? Tools like identity spotting or entry management. Features for spotting familiar faces or locking gates aren't part of this version. This work helps link smart bells to face detection while connecting them to IoT-security tools.

5. Embedded Face Detection System Using ESP32-CAM for Access Control
K. Lee [11] worked on the simulation tests. H. Park handled data logging during trials. S. Kim [14] contributed analysis methods used in the study
Description:
This study looks at using face detection software right on the ESP32-CAM board, especially for security entry systems. Because the chip has small memory and processing ability, simpler detection networks need adjustments to function well. After recognizing individuals, the setup can perform tasks like opening doors automatically. Results show the method works as expected under real conditions. The research demonstrates that ESP32-CAM is a cost-effective solution for smart door security with real-time face detection.

III. PROPOSED METHODOLOGY

Here comes the part where I explain how the smart door security system was put together using an ESP32-CAM board. The smart door security system can spot faces away and it also works as a basic doorbell with some extra features. The smart door security system checks visitors in time without any delays thanks to the internet-connected technology that powers it. Home owners get alerts away even when they are not at home because the linked systems do all the work.

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A. System Overview

The smart door security system has a camera at its heart. It uses an ESP32-CAM chip to handle tasks like seeing and talking. The ESP32-CAM chip has ways to find faces connect to Wi-Fi and take pictures near entry points built into it. When someone appears the camera takes a picture of that moment. Sends it to the home owner through the airwaves. Watching from a distance becomes easier because the information moves quickly without any delay. The smart door security system feels more secure when updates arrive away instead of waiting for days.

B. Operational Workflow

The smart door security system leads through a series of steps each moving forward into the next.

1) System Initialization

The ESP32-CAM board starts up. Sets up the camera, GPIO pins and Wi-Fi settings right away. Once it is connected it links into the network so live data can move through without any delay.

2) Visitor Detection and Trigger Mechanism

When someone presses the doorbell button by the entrance that move kicks things off. The ESP32-CAM board picks up the signal. Then starts capturing what is being recorded.

3) Image Acquisition

When the camera is turned on it takes a picture of someone at the entrance. The picture sits inside the ESP32-CAM boards memory until things move ahead from there.

4) Face Detection Processing

When the ESP32-CAM board takes a picture it runs a simple face detection method. Of guessing what is there the smart door security system checks if a persons face appears in the frame. Because of how it works things like shadows or moving objects do not trigger alarms. Only human faces do.

5) Wireless Data Transmission

Once a face shows up the ESP32-CAM board sends pictures and a notice to the home owner through Wi-Fi. The information travels to a phone or gets stored in an online system so people can check later.

6) User Notification

A message arrives away showing who was spotted and when. The picture appears so you can actually see who is there. There is no need to rush to the entrance since the proof sits in your hands.

7) System Reset and Standby Mode

Once the alert stage ends, the smart door security system shifts back into waiting status. Prepared to react whenever someone approaches again like, after a chime or detection. The smart door security system is always ready to work.

C. System Architecture

A setup exists within the structure. Built into the system, the ESP32-CAM handles tasks. It captures images, analyzes data, then shares results online. Over there sits the smart doorbell switch, tied into power by a little supply unit. From a phone or laptop, users tap in - voice connections form without fuss.

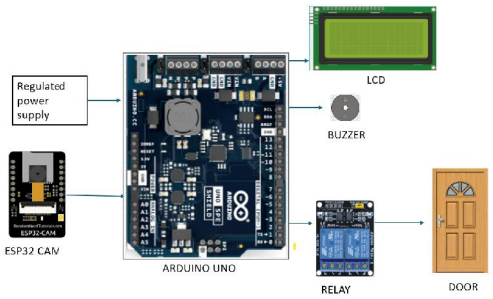

FIG:1 System Architecture

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Architecture Description:
A click on the doorbell triggers a message reaching the ESP32-CAM. That camera snaps a photo of whoever is there. Face recognition kicks in, matching the image to a known person. When a person shows up, the system checks them out. If it sees a face, the image goes straight to the homeowner's phone or laptop along with a notification.

D. Advantages of the Proposed Methodology
Away from home, folks can see who's standing at their door thanks to this setup.
The system uses face detection to keep people safe
This setup costs little while staying compact
Watches on arms aren't always necessary
The Power Supply Unit gives the system the voltage it needs. This is really important for the Power Supply Unit to work properly and keep the system running with the right amount of voltage, from the Power Supply Unit.

IV. RESULTS

1) System Initialization
When the ESP32 is powered ON:
Camera module is initialized
A face detection system sits in the computer's RAM
GPIO pins - bell, buzzer, relay/servo - are set up
Wi-Fi is initialized for alerts or logging
This sign means the system is prepared to run
2) Face Capture
Frames keep being recorded by the camera nonstop
Now imagine adjusting frame sizes - resizing them while turning inputs gray or keeping color layers separate during early processing steps
Data is prepared for the face detection model
This is where the model gets its input, marking the start of running the system
3) Face Detection Model Execution (Inference)
On every image, the face detection system operates directly within the device.
It looks at face parts like eyes, nose, together with the outline of the face
This place runs nothing but guesses. Inference lives here, that is all
This sits at the heart of "model execution"
A face gets recognized through the ESP32 running an already trained detection system
4) Decision Logic
Based on model output:
Face found. Access allowed. System recognized person. Clearance granted. Event recorded.
A switch activates - either motor or electronic - when door unlocks
A smart bell could remain silent sometimes
Optional message: "Access Granted"
Case 2: Face Detected & Not Authorized
Smart bell is on
Buzzer or LED alert turns on
Optional notification sent to owner
This happens when choices are made using information from artificial intelligence systems
5) Smart Bell Execution
It runs whenever someone shows up. That is its main condition

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Prevents unnecessary ringing (no person = no bell)
Turns machines into thinking tools, not just moving parts
Shows context-aware execution
6) Loop Continuation
Back in monitoring mode, the system pauses its active tasks.
Continuous real-time execution
This shows AI running on live embedded systems in operation

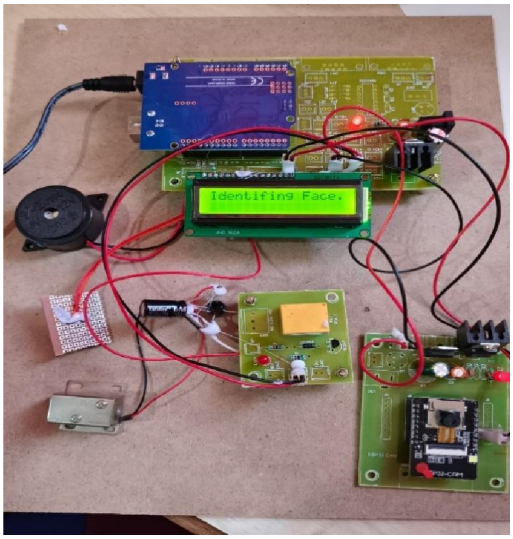

FIG:2 System Initialization and connect to "iotserver" network

FIG:3 Connect to the specified IP Address from "Network Scanner" app

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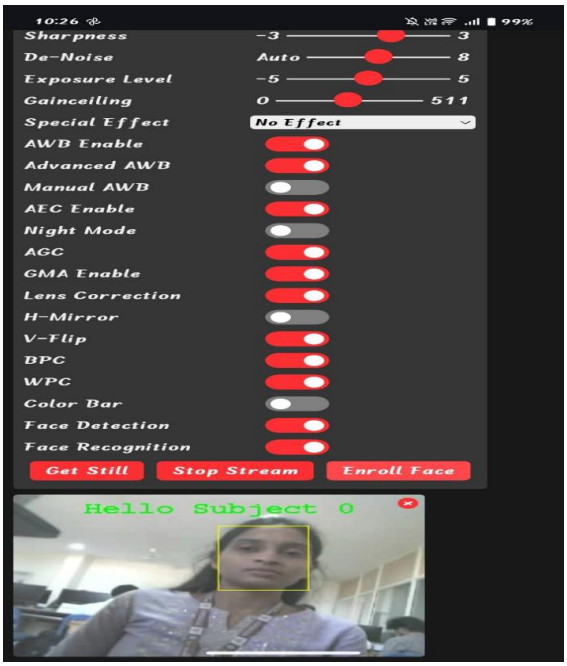

FIG:4 Identifying and Enrolling face

V. CONCLUSION

This project is a fresh take on keeping your front door safe comes alive here - through a clever build powered by an ESP32-CAM. Instead of just repeating old ways, this setup bundles face spotting, an alert system, and wireless links into one tidy package. When someone nears, their photo is grabbed and checked instantly, cutting down on endless watching by hand. All of it fits neatly where it matters most: at the entry point.

With cameras tied into internet-of-things links, people at home can see who visits right away through phones or online accounts, making things safer and easier. Using just basic gear like an ESP32-CAM, a manager for electricity, and switches that handle operation keeps expenses low while keeping setup clean for houses.

This effort shows what can happen when home safety gets support from embedded tech and internet-connected devices. Instead of basic locking methods, the new setup uses sharper decision-making built right into the system. Room for growth exists too - features like identity scanning or keyless entries might join later on. Because parts of it can adjust over time, staying effective across different living spaces. So it becomes useful where old flaws often appear in modern smart living setups.

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