Smart Door System

Documentation

Author

Jirayu Khunrak 6633036921

Pattaradanai Thanomsittikul 6633185721

Phavarisa Pitavaratorn 6633181121

2110356 Embedded System

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Department of Computer Engineering Faculty of Engineering,

Chulalongkorn University

Preface

In an age where convenience, security, and energy efficiency are essential to modern living, the need for intelligent home solutions is growing. The Smart Door System project introduces an innovative and cost-effective approach to enhancing the functionality of traditional doors. By integrating a range of IoT technologies, including motion detection, adaptive lighting, and real-time notifications, this system addresses common challenges faced by homeowners today.

This system is designed to improve the security, accessibility, and energy efficiency of doors, providing a seamless user experience through technologies like the ESP32 and ESP32-CAM. Users can monitor and control their doors remotely via an intuitive dashboard, enhancing both the safety and convenience of their homes.

This document outlines the design, components, testing, and challenges encountered during the development of the Smart Door System. The insights and findings presented here offer valuable lessons for future improvements, with plans to incorporate advanced features such as facial recognition, voice command integration, geofencing, and solar-powered operations. We are committed to continuing our innovation in smart home technologies to meet the ever-evolving needs of modern households.

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1. Introduction and Problem Statement

Introduction

In today's smart home era, traditional doors lag in functionality, offering little beyond basic manual operation. As homes demand greater convenience, security, and efficiency, the need for intelligent systems has become essential. This project introduces a **Smart Door System** equipped with advanced features like motion detection, adaptive lighting, and real-time notifications. By integrating IoT technologies, the system enhances safety, usability, and energy efficiency, setting a new standard for modern homes.

Problem Statement

Traditional doors fail to meet the evolving demands of modern households. Key issues include:

- **Manual Operation**: Inconvenient and outdated mechanisms for opening and closing.
- **Limited Security**: Absence of features like motion detection and facial recognition.
- **No Real-Time Monitoring**: Lack of alerts or feedback.
- **Energy Inefficiency**: Inability to adapt lighting based on ambient conditions.

This project addresses these challenges by developing a cost-effective **Smart Door System** that improves safety, functionality, and efficiency through IoT integration.

2. Related Work and Similar Solutions

Related Work

Research in IoT and smart home systems has demonstrated advancements in automation, remote monitoring, and energy management. Existing solutions have explored motion detection, and environmental monitoring individually. However, few have combined these features into a unified, cost-effective system tailored specifically for door automation. Challenges such as reliance on cloud services, limited customization, and high costs persist in existing implementations.

Similar Solution

- **Ring Systems**: Focused on motion detection and remote control, but limited by high costs and dependence on cloud services.
- **Chamberlain MyQ**: Provides app-based door control but lacks advanced safety features like facial recognition.

This project differentiates itself by offering a low-cost, open-source Smart Door System with comprehensive integration of motion detection, adaptive lighting, real-time video streaming and real-time notifications using ESP32 and ESP32-CAM technologies.

3. System Design

The Smart Door System is designed to provide a seamless integration of multiple technologies, including IoT sensors, microcontrollers and cloud services. The system is divided into several components that interact with each other to deliver a highly functional and secure solution for modern homes.

3.1 Overall Architecture

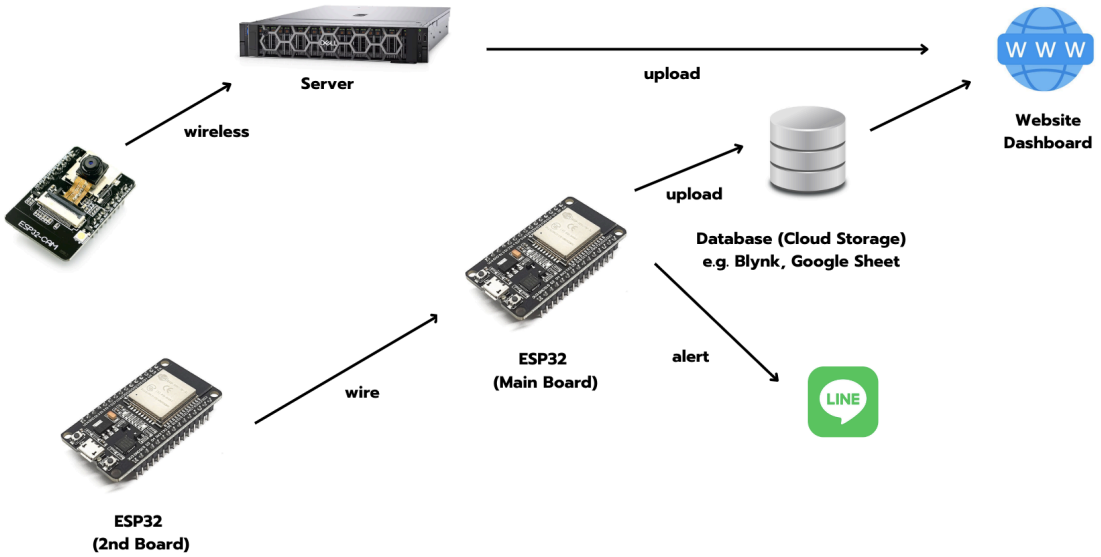
The system architecture is divided into four key components:

1. **Sensor Node**: This is the first layer of the system, consisting of sensors that monitor the home environment. The sensor node gathers data like input from numpads sending the information to the gateway for processing.
2. **Gateway**: The gateway is responsible for processing data from the sensor node and performing actions based on the sensor input. The ESP32 microcontroller handles the sensor data, controls the servo motor for door operation, and communicates with the cloud services for real-time data storage and notifications. The ESP32-CAM, integrated with the gateway, handles real-time video streaming that provides additional security through biometric access control.
3. **Cloud / Storage**: Cloud services like Blynk and Google Sheet are used to store sensor data, send notifications, and interface with the user dashboard. The cloud acts as a centralized hub for all the system data, enabling real-time monitoring and remote control of the door.
4. **Dashboard**: The user interface is built to display real-time sensor data (light, motion, temperature) and event logs (e.g., timestamps for motion or temperature alerts). The dashboard provides a convenient and accessible way for users to interact with the system and monitor the home's status.

3.2 System Workflow

1. When a user approaches the door, the PIR sensor detects motion.
2. When motion is detected,it will send an alert via Line to the user.
3. Users can use numpads to open the door.

4. The system adjusts the lighting based on the LDR sensor.
5. The users can monitor the system status through the dashboard, receiving real-time updates and notifications. and also control the door.



4. Component

4.1) Sensor Node

- LDR (Light Dependent Resistor): Detects ambient light to control the light.
- Motion Sensor (PIR): Triggers the camera when motion is detected.
- Temperature & Humidity Sensor: Monitors temperature and humidity

4.2) Gateway

- ESP32 Microcontroller: Handles sensor data, controls the servo motor, and communicates with the cloud.
- ESP32-CAM: Real-time video streaming.

4.3) Cloud / Storage

- Blynk/Firebase/Google sheet: Stores data logs and interfaces with the dashboard.

4.4)Alert

- Line : Microcontroller sends an alert to Line on conditions.

4.4) Dashboard

- Displays real-time sensor data (e.g., light, motion detection, and temperature).
- Controls data.

5. Test Results

Test Scenario	Scenario	Expected Result	Outcome
Motion Detection	Simulate motion in front of the sensor	Motion detected, sends alert	Successfully detected motion
Light Control	Simulate different light levels	LED toggles based on ambient light	Successfully toggled the LED based on light levels
Manual Keypad Input	Enter a matching passcode	Opens door and logs the activity	Successfully verified passcode and opened door
	Enter an incorrect passcode	Sends an alert after 3 attempts	Successfully alerted after incorrect attempts
Data logging	Receive data from sensors.	Sends data to Cloud Storage.	Successfully upload.

6. Discussion and Conclusion

Discussion

The Smart Door System successfully integrates multiple IoT technologies to enhance convenience and security. However, several challenges were encountered during the development and testing process, providing opportunities for further improvement.

Challenges

- ESP32 camera: The ESP32-CAM is a microcontroller with limited processing power, memory, and bandwidth. Streaming video requires significant resources, and handling two streams simultaneously can quickly overwhelm the device.
- Network Dependence: The system relies heavily on a stable internet connection for real-time notifications and data logging. Network instability can result in delayed responses or missed alerts.
- Sensor Sensitivity: The motion and temperature sensors require regular calibration to ensure consistent performance, as environmental factors can affect their accuracy over time.

Improvements

- Implement Facial Recognition: Implementing AI-based facial recognition algorithms capable of performing accurately in low-light conditions or under varying angles can significantly enhance reliability.
- Offline Functionality: Introducing local data storage and processing capabilities will ensure that the system can function seamlessly even during network outages. Alerts and logs can be synchronized once the network is restored.
- Robust Sensor Configuration: Incorporating automatic calibration mechanisms or more advanced sensors can mitigate the need for frequent manual adjustments, ensuring stable and accurate performance over extended periods.

Conclusion

The **Smart Door System** now features motion detection,real-time video streaming and real-time logging, offering improved security and functionality. Future developments may include facial recognition, voice command integration, geofencing, and solar-powered operations.

7. Responsiblity

Jirayu Khunrak 6633036921 :

- **Write Arduino Code for Sensors**: Develop code for the ESP32 to interface with various sensors (e.g., temperature, humidity, light level sensors).

- **Connect ESP32 to Blynk**: Use the Blynk platform to send sensor data from ESP32 to the Blynk app or web dashboard.
- **Send Data to Google Sheets**: Write code to send sensor data to Google Sheets, using the Google Sheets API
- **Create a Blynk Dashboard**: Use the Blynk app or website to design a dashboard that displays data from sensors connected to the ESP32.
- **Configure and Connect with ESP32**: Connect the Blynk Dashboard to the ESP32 using Virtual Pins via the Blynk Token.

Pattaradanai Thanomsittikul 6633185721 :

- **ESP32-CAM Video**: Configured and performs real-time video streaming.
- **Website Dashboard Script**: Developed scripts to display real-time sensor data and control the door.
- **LINE Notifications**: Implemented a notification system to alert users about key events.
- **Documentation**: Responsible for documenting the system design, testing, and challenges faced during development

Phavarisa Pitavaratorn 6633181121 :

- **Documentation**: Responsible for documenting the Introduction and Problem Statememt, Related Work and Similar Solution, Test Result, and Discussion and Conclusion
- **Connect Esp32 to firebase :** Connected the ESP32 to Firebase for data storage and retrieval.
- **UX/UI :** Test and improve the UI/UX to ensure users can easily understand the information
- **UX/UI Improvement :** Tested and refined the user interface and experience to ensure the information is easily understandable.
- **Authentication System :** Develop code for the ESP32 to secure the door