UNIVERSITATEA DE MEDICINĂ, FARMACIE, ȘTIINȚE ȘI TEHNOLOGIE “GEORGE EMIL PALADE” DIN TÂRGU MUREȘ

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LUCRARE DE LICENȚĂ

Îmbunătățirea Automatizării Caselor prin Sisteme Inteligente

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Abstract

Introducere

Un sistem de casă inteligent este o tehnologie inovatoare care permite proprietarilor să aibă control continuu asupra unei game variate de electrocasnice și dispozitive casnice. Prin utilizarea unui centru central, a unui smartphone sau a unei aplicații web, indivizii pot gestiona eficient locuințele lor și pot îmbunătăți viața de zi cu zi. Este o combinație de senzori, dispozitive și software care lucrează împreună pentru a automatiza și optimiza gestionarea casei.

Într-un sistem de casă inteligent, utilizatorii obțin un control fără precedent asupra funcționalităților esențiale, inclusiv iluminatul, reglarea temperaturii, sistemele de securitate, dispozitivele de divertisment și multe altele. Această nivel de control și automatizare îmbunătățește semnificativ confortul, comoditatea și siguranța proprietarilor, făcându-le viața mai eficientă și mai plăcută.

Unul dintre elementele fundamentale care fac sistemele de casă inteligentă cu adevărat revoluționare este capacitatea lor de a crea o rețea de dispozitive interconectate, formând ceea ce se numește Internetul Lucrurilor (IoT). Prin integrarea IoT, sistemele de casă inteligentă stabilesc o comunicare și coordonare fără probleme între diferite dispozitive, permițându-le să lucreze împreună inteligent. De exemplu, un termostat inteligent poate ajusta temperatura în funcție de preferințele proprietarului, luând în considerare și factori precum ocuparea și condițiile meteo. Similar, sistemele de iluminare inteligentă se pot adapta prezenței și preferințelor utilizatorului, economisind energie și îmbunătățind atmosfera generală a casei.

Creșterea tehnologiei caselor inteligente a fost stimulată de avansuri rapide în diverse domenii, inclusiv inteligența artificială, comunicarea wireless și senzorii miniaturizați. Aceste progrese tehnologice, combinate cu accesibilitatea și accesibilitatea tot mai mare a dispozitivelor inteligente, au alimentat adoptarea pe scară largă a sistemelor de casă inteligentă în mediul rezidențial. Rapoartele din industrie și tendințele de pe piață indică o traiectorie constantă de creștere pentru piața caselor inteligente, cu prognoze care sugerează o creștere semnificativă a numărului de case conectate în anii următori.

Scopul Lucrării

Un sistem de casă inteligent este o soluție inovatoare pentru persoanele cu dizabilități. Oferă confort, accesibilitate și independență. Iată cum rezolvă trei probleme importante:

Mobilitate și accesibilitate: Utilizatorii pot controla casa prin comenzi vocale sau aplicații de smartphone, evitând deplasarea fizică. De exemplu, pot aprinde/stinge luminile, bloca ușile și regla termostatul.

Siguranță și securitate: Sistemele de casă inteligentă monitorizează și alertează proprietarii în cazul unor pericole, precum fumul sau monoxidul de carbon. De asemenea, oferă control și monitorizare la distanță a sistemelor de blocare.

Eficiență energetică: Sistemele de casă inteligentă automatizează gestionarea energiei, reducând consumul inutil și facturile. Pot monitoriza consumul și oferi feedback pentru îmbunătățirea obiceiurilor energetice.

Arhitectura Sistemului

Arhitectura și designul sistemului de casă inteligentă sunt esențiale pentru funcționarea sa. Sistemul este construit în jurul microcontrollerului ESP32, care coordonează componente și comunică cu dispozitivele externe. Arhitectura include componentele cheie și interacțiunile acestora. Deciziile de design sunt deosebit de importante pentru dezvoltarea sistemului.

Placa de Dezvoltare ESP32

ESP32 este un microcontroller puternic dezvoltat de Espressif Systems. Este bazat pe procesorul Xtensa LX6, care rulează la o viteză de până la 240 MHz. ESP32 este echipat cu conectivitate Wi-Fi și Bluetooth integrate, făcându-l potrivit pentru aplicații IoT.

Caracteristici: Arhitectură dual-core: ESP32 are două nuclee CPU, permițând procesare paralelă și capacități de multitasking. Wi-Fi și Bluetooth: Modulele integrate de Wi-Fi și Bluetooth de 2,4 GHz permit comunicare wireless și conectivitate la internet și alte dispozitive.

Memorie: ESP32 vine în mod obișnuit cu opțiuni variabile de memorie Flash (stocare program) și RAM (stocare date), oferind flexibilitate pentru diferite cerințe de proiect.

Convertor analogic-digital (ADC): ADC-ul incorporat permite ESP32 să măsoare semnale analogice de la senzori precum senzori de temperatură, senzori de lumină, etc.

Mediu de dezvoltare: ESP32 poate fi programat folosind Arduino IDE, PlatformIO ca extensie Visual Studio Code sau folosind framework-ul oficial de dezvoltare al Espressif, ESP-IDF (Espressif IoT Development Framework).

Avantaje: Versatilitate și putere: ESP32 oferă o gamă largă de funcționalități, fiind potrivit pentru o varietate de aplicații IoT. Conectivitate: Cu Wi-Fi și Bluetooth integrate, ESP32 simplifică procesul de conectare la rețele și alte dispozitive.

Eficiență cost-efectivă: ESP32 este o soluție rentabilă în comparație cu alte microcontroloare cu funcționalități similare. Comunitate open-source: ESP32 beneficiază de o comunitate open-source extinsă și activă, oferind documentație, biblioteci și exemple pentru dezvoltare.

Limitări: Consum de energie: ESP32, fiind un microcontroller bogat în funcții, poate consuma mai multă energie în comparație cu microcontroloare mai simple. Tehnici atente de gestionare a energiei ar trebui implementate în aplicațiile alimentate de baterii.

Senzori si Module

Sistemul de casă inteligentă include LED-uri pentru iluminarea camerei, oferind atât funcționalitate cât și confort. Aceste LED-uri sunt eficiente din punct de vedere energetic și permit controlul de la distanță. Utilizatorii le pot porni sau opri de oriunde î n casa folosind aplicația web de pe orice dispozitiv, cu doar câteva atingeri. Sistemul integrează un senzor de temperatură și umiditate care acționează ca un termostat, oferind citiri în timp real ale temperaturii și control inteligent al sistemelor de încălzire și răcire, precum și nivelul de umiditate din cameră. Senzorul de temperatură monitorizează continuu temperatura ambientală din casă, permițând sistemului să ajusteze și să mențină un mediu confortabil.

Pentru a indica vizual starea de încălzire și răcire, se folosește un LED albastru pentru a simula activarea aerului condiționat, în timp ce un LED roșu reprezintă încălzirea. Când temperatura depășește pragul dorit, LED-ul albastru se aprinde pentru a indica procesul de răcire, iar când temperatura scade sub nivelul dorit, LED-ul roșu semnalează activarea sistemului de încălzire. Acest sistem intuitiv de feedback asigură reglarea eficientă a temperaturii și oferă utilizatorilor o indicare vizuală clară a stării actuale a controlului climatic din casa lor.

Sistemul de casă inteligentă integrează un senzor de gaz pentru a îmbunătăți siguranța și securitatea în gospodărie. Senzorul de gaz este conceput pentru a detecta prezența gazelor potențial periculoase, cum ar fi monoxidul de carbon sau scurgerile de gaz natural. Cu ajutorul capacităților sale avansate de detecție, senzorul de gaz asigură identificarea timpurie a scurgerilor de gaz, permițând acțiuni rapide pentru a reduce riscurile potențiale.

În cazul în care senzorul de gaz detectează o concentrație mare de gaz, se declanșează o avertizare pentru a notifica utilizatorii, permițându-le să evacueze locația și să solicite asistență, dacă este necesar.

Incorporarea unui senzor magnetic de ușă este crucială pentru a îmbunătăți securitatea și a oferi monitorizare în timp real a punctelor de intrare în casă. Senzorul magnetic de ușă este instalat pe ușa din față și este alcătuit din două componente: un întrerupător magnetic și un magnet.

Când ușa este închisă, magnetul se aliniază cu întrerupătorul magnetic, creând un circuit închis. Cu toate acestea, dacă ușa este deschisă, alinierea este întreruptă și circuitul se întrerupe, declanșând o avertizare. Aceasta permite sistemului să detecteze intrarea neautorizată sau încercările de manipulare.

Cu senzorul magnetic de ușă integrat în sistemul de casă inteligentă, proprietarii pot avea liniște sufletească, știind că locuința lor este monitorizată și protejată împotriva posibilelor intruziuni.

Senzorul ultrasonic joacă un rol crucial în sistemul de casă inteligentă prin furnizarea detectării de proximitate și permite controlul automat al luminii din hol. Folosește unde sonore de frecvență înaltă pentru a măsura distanța dintre obiecte și detectează prezența persoanelor care se apropie de intrarea în casă.

Când se detectează pe cineva într-un interval specificat, senzorul declanșează activarea luminii din hol, iluminând zona și asigurând o navigare sigură. Această caracteristică îmbunătățește confortul și securitatea pentru proprietari, permițându-le să se miște în jurul casei cu ușurință, mai ales în timpul nopții sau în condiții de iluminare scăzută.

PyCharm

PyCharm a fost ales pentru dezvoltarea API-ului Flask și găzduirea paginii web în proiectul de casă inteligentă. Funcționalitățile puternice precum completarea inteligentă a codului, depanarea și suportul pentru medii virtuale îmbunătățesc productivitatea. Implementarea serverului web integrat simplifică găzduirea locală a API-ului Flask. PyCharm este o alegere excelentă pentru dezvoltarea și găzduirea API-ului Flask, contribuind la o experiență de dezvoltare eficientă.

API Flask

API-ul Flask joacă un rol crucial în sistemul de casă inteligentă, conectând microcontrollerul ESP32 cu aplicația web. Acesta servește ca un cadru web ușor și flexibil, permițând comunicare eficientă între hardware și interfața utilizatorului. Prin analizarea și schimbul de date JSON, API-ul Flask permite afișarea și interacțiunea în timp real în aplicația web. Mai mult, facilitează comunicarea bidirecțională, permițând utilizatorilor să controleze eficient dispozitivele din casa inteligentă. În ansamblu, Flask ca framework pentru API asigură o integrare fără cusur și oferă o interfață de control receptivă și intuitivă pentru gestionarea sistemului de casă inteligentă.

Aplicatia Web

Aplicația web este interfața utilizatorului pentru sistemul de casă inteligentă, oferind o modalitate convenabilă și accesibilă de interacțiune cu dispozitivele conectate. Construită cu tehnologii web moderne, oferă o interfață receptivă și intuitivă pentru monitorizarea și controlul casei inteligente. Preia datele de la API-ul Flask și le prezintă într-un format prietenos utilizatorului, oferind funcționalități precum actualizări în timp real și programare automată. Aplicația web facilitează gestionarea sistemului de casă inteligentă cu ușurință și flexibilitate, de oriunde și oricând.

Implementarea Sistemului si Fluxul de control

Sistemul prezentat utilizează un flux de date complex. Senzorii măsoară distanța, temperatura, calitatea aerului și starea ușii, transmitând datele către microcontrollerul ESP32. Acesta stochează și actualizează datele într-un fișier JSON. API-ul Flask extrage datele relevante și le afișează pe o pagină web dinamică. Astfel, utilizatorii pot monitoriza în timp real starea sistemului lor de casă inteligentă.

Fluxul de control în acest sistem implică interacțiunea între utilizator, microcontrollerul ESP32 și componentele sistemului. Utilizatorul controlează sistemul prin intermediul unei pagini web, care trimite comenzi către API-ul Flask. Acesta procesează și transmite comenzi către microcontroller, care efectuează acțiunile necesare. Microcontrollerul monitorizează, de asemenea, starea sistemului și actualizează pagina web în timp real. Această interacțiune eficientă asigură un control apt și o gestionare eficientă a sistemului.

Comportamentul sistemului în proiectul meu se caracterizează prin reactivitate, adaptabilitate și luare de decizii intr-un mod inteligent. Sistemul răspunde prompt la citirile senzorilor în timp real, ajustându-și operațiunile pentru confort și eficiență energetică. Microcontrollerul analizează datele senzorilor și ia decizii inteligente în funcție de regulile predefinite sau de setările utilizatorului. Pagina web interactivă oferă actualizări în timp real, reflectând starea curentă a sistemului. Comportamentul sistemului promovează o experiență personalizată și eficientă pentru utilizatori, asigurându-le confort și securitate în mediul casei in care acest proiect este implementat.

Sistemul funcționează prin intermediul unui microcontroller ESP32 care servește ca hub central. Acesta primește date de la diferiți senzori, cum ar fi senzorul cu ultrasunete, senzorul de temperatură, senzorul de gaze și senzorul magnetic al ușii. Funcționalitățile includ activarea luminilor, ajustarea sistemului de încălzire și aer condiționat, monitorizarea nivelurilor de gaze și furnizarea informațiilor despre starea ușii. Microcontrollerul ESP32 facilitează integrarea acestor componente și asigură functionalitatea inteligentă și eficientă al sistemului prezentat.

Rezultate

Am demonstrat cu succes rezolvarea problemelor de securitate, eficiență și ușurință în utilizare în cadrul proiectului nostru de casă inteligentă prin intermediul capitolului de Rezultate. Implementarea avertismentelor privind nivelul de gaze și monitorizarea intrării prin ușa principală îmbunătățește măsurile de securitate, în timp ce controlul automat al termostatului asigură eficiență energetică. În plus, aplicația web prietenoasă pentru utilizatori, cu o interfață interactivă, oferă o accesibilitate îmbunătățită și ușurință în utilizare, beneficiind în special persoanele cu dizabilități. În ansamblu, proiectul nostru de casă inteligentă abordează eficient aceste preocupări critice, făcând locuințele mai sigure, mai eficiente și mai prietenoase pentru utilizatori, îmbunătățind astfel calitatea generală a vieții rezidențiale.

Concluzii

Un sistem de casă inteligentă este o soluție esențială pentru a aborda preocupările legate de siguranță și ușurința utilizării întâmpinate de persoanele cu dizabilități. Prin incorporarea caracteristicilor de mobilitate, accesibilitate, siguranță și eficiență energetică, un sistem de casă inteligentă oferă confort și independență sporită persoanelor care implementeaza acest sistem.

Abstract

This thesis presents a comprehensive study on addressing key issues in smart home environments, with a focus on enhancing security, efficiency, and ease of use. The research project involved the implementation of various features and technologies to overcome these challenges. Firstly, gas level warnings and front door entry monitoring were integrated to ensure heightened security. Real-time alerts were provided for raised gas levels, while a smart door lock system facilitated secure access control.

Secondly, to improve energy efficiency, an automated thermostat control system was developed. This system autonomously adjusted temperature settings based on sensor readings, minimizing energy wastage and promoting environmentally friendly practices. Furthermore, to facilitate ease of use, particularly for disabled individuals, a user-friendly web application with an interactive UI was developed. This application enabled remote control of lights and thermostat settings, empowering users to customize their living environment through an accessible platform.

We have demonstrated the successful resolution of security, efficiency, and ease of use issues in our smart home project through the Results chapter. The implementation of gas level warnings and front door entry monitoring enhances security measures, while the automated thermostat control ensures energy efficiency. Additionally, the user-friendly web application with an interactive UI offers enhanced accessibility and ease of use, particularly benefiting disabled individuals. Overall, our smart home project effectively addresses these critical concerns, making homes safer, more efficient, and more user-friendly, enhancing the overall quality of residential living.

Chapter 1

Introduction

A smart home system is an innovative technology that empowers homeowners to have seamless control over a wide range of household appliences and devices. By leveraging a central hub, smartphone, or web application, individuals cand efficently manage their homes and enhance their daily lives. It is a combination of sensors, devices,and software that work together to automate and optimize the management of the home.This sophisticated system integrates sensors, devices, and software to automate and optimize various aspects of home management.

In a smart home system, users gain unprecedented control over essential functionalities, including lighting, temperature regulation, security systems, entertainment devices, and many others. This level of control and automation significantly enhances the comfort, convenience, and security of homeowners, making their lives more efficient and enjoyable.

One of the fundamental elements that make smart home systems truly revolutionary is their ability to create a network of interconnected devices, forming what is known as the Internet of Things (IoT). Through IoT integration, smart home systems establish seamless communication and coordination among different devices, enabling them to work together intelligently. For example, a smart thermostat can adjust the temperature based on the homeowner's preferences, while also considering factors such as occupancy and weather conditions. Similarly, smart lighting systems can adapt to the user's presence and preferences, saving energy and enhancing the overall ambiance of the home.

The rise of smart home technology has been driven by rapid advancements in various fields, including artificial intelligence, wireless communication, and miniaturized sensors. These technological breakthroughs, combined with the increasing affordability and accessibility of smart devices, have fueled the widespread adoption of smart home systems in residential settings. Industry reports and market trends indicate a steady growth trajectory for the smart home market, with projections suggesting a significant increase in the number of connected homes in the coming years.

1.1 Introduction in Thesis's Theme

For disabled people, a smart home system can be a game-changer. It provides an unprecedented level of convenience, accessibility, and independence that was previously impossible. Here are three problems that a smart home system solves regarding safety and ease of use for disabled people:

Mobility and accessibility: One of the significant challenges faced by disabled people is mobility. Smart home systems can help solve this problem by enabling users to control their home environment through voice commands or smartphone applications, without having to physically move around the home. For example, a wheelchair-bound person can turn on/off lights, lock doors, adjust the thermostat, and control other appliances using voice commands or their smartphone, eliminating the need to physically reach out and interact with switches or buttons.

Safety and security: Smart home systems can also help address safety and security concerns for disabled people. Smart locks, for example, can be remotely controlled and monitored, providing an added layer of security to the home. Additionally, smart home systems can detect and alert homeowners to potential hazards such as smoke or carbon monoxide, ensuring a quick response and preventing potential accidents.

Energy efficiency: Smart home systems can help disabled people reduce their energy bills and environmental impact. By automating the management of heating, cooling, and lighting, smart home systems can optimize energy consumption, reducing unnecessary energy use and costs. Additionally, smart home systems can monitor energy use and provide feedback to homeowners, encouraging them to adopt more energy-efficient habits.

In summary, a smart home system is an innovative technology that solves several problems faced by disabled people regarding safety and ease of use. By providing mobility, accessibility, safety, security, and energy efficiency, a smart home system empowers disabled people to live more independent and fulfilling lives.

1.2 Personal Contributions

In the development of my smart home system, I placed significant emphasis on addressing the crucial aspects of security and energy efficiency. Recognizing the importance of ensuring a secure living environment, I integrated a gas sensor and a safety door sensor into the system.

The inclusion of a gas sensor is of utmost importance in any modern smart home system. Gas leaks can have severe consequences, posing risks to both life and property. By incorporating a gas sensor, my smart home system can detect the presence of harmful gases, such as carbon monoxide, and promptly alert the homeowners. This early detection mechanism enables swift action to mitigate potential hazards, ensuring the safety of the occupants.

Furthermore, I integrated a safety door sensor that enhances the overall security of the smart home system. By monitoring the status of entry doors, the sensor provides an additional layer of protection against unauthorized access. The homeowner receives instant notifications through the central hub or smartphone application in the event of any suspicious door activity, enabling them to take appropriate measures to safeguard their home.

In addition to prioritizing security measures, my smart home system also focuses on energy-saving capabilities. I understand the significance of energy efficiency in today's environmentally conscious world. Therefore, I incorporated a thermostat and an entrance hall light, both controlled automatically through advanced sensor technology.

The thermostat plays a vital role in regulating the temperature within the smart home. By analyzing factors such as occupancy, external weather conditions, and user preferences, the thermostat optimizes energy consumption while maintaining a comfortable living environment. It intelligently adjusts the heating or cooling systems, reducing unnecessary energy usage and contributing to long-term energy savings.

Furthermore, I installed an entrance hall light that operates in tandem with an ultrasonic sensor. This intelligent lighting solution ensures that energy is conserved by activating the light only when it detects movement in the vicinity. Upon detecting the presence of individuals, the ultrasonic sensor triggers the hall light to illuminate the area, providing sufficient visibility for safe navigation. Once the area becomes unoccupied, the light automatically turns off, minimizing unnecessary energy wastage.

To ensure versatile access to the smart home system, I implemented a web application accessible from any device. This web application allows homeowners to control and monitor their smart home appliances and devices remotely. Whether they are using a smartphone, tablet, or computer, they can securely access the system's features and make adjustments according to their preferences and needs.

By integrating these security and energy-saving features into my smart home system, I aim to provide homeowners with a comprehensive solution that enhances their quality of life. The gas sensor and safety door sensor promote a secure living environment, offering peace of mind to the occupants. Simultaneously, the thermostat and entrance hall light contribute to energy conservation, reducing environmental impact and promoting sustainable practices.

Chapter 2

System Architecture and Design

The architecture and design of the smart home system are crucial for its successful implementation and functionality. This section provides an overview of the system architecture, highlighting the key components and their interactions. Additionally, the design considerations and decisions made during the development process will be discussed.

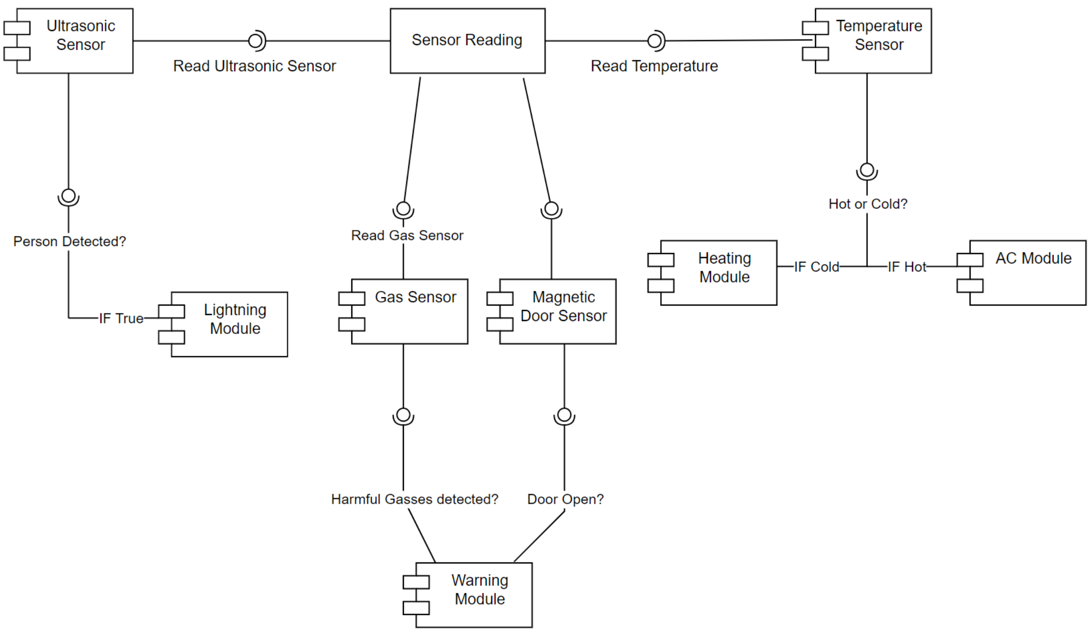


Figure 2.1 Component Diagram

The smart home system is built around the ESP32 microcontroller, which serves as the central processing unit for controlling and coordinating the various components and modules of the system. The ESP32 is responsible for gathering data from sensors, processing it, and communicating with the external devices and the web application. The architecture consists of the following major components:

2.1 Hardware Components

2.1.1 ESP32 Microcontroller

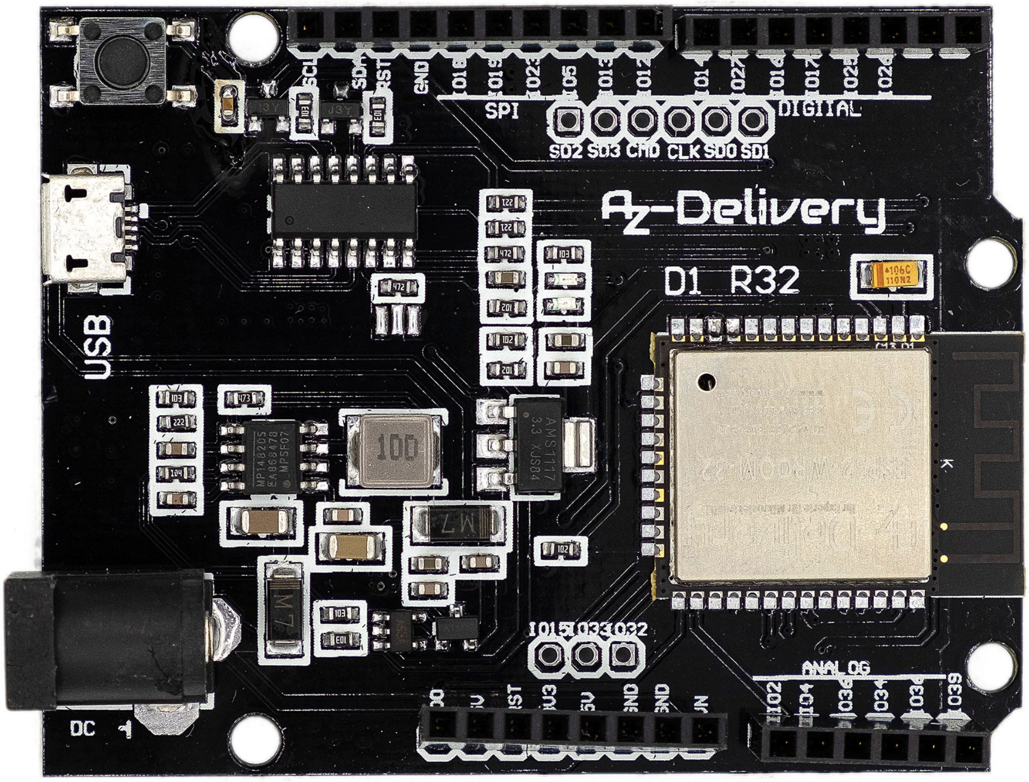


Figure 2.2 ESP32 Microcontroller

[1]

The ESP32 is a powerful microcontroller developed by Espressif Systems. It is based on the Xtensa LX6 CPU, running at up to 240 MHz clock speed. The ESP32 is equipped with built-in Wi-Fi and Bluetooth connectivity, making it suitable for IoT applications.

Features: Dual-core architecture: The ESP32 features two CPU cores, allowing for parallel processing and multitasking capabilities. Wi-Fi and Bluetooth: Built-in 2.4 GHz Wi-Fi and Bluetooth modules enable wireless communication and connectivity to the internet and other devices.

Memory: The ESP32 typically comes with varying amounts of Flash memory (program storage) and RAM (data storage) options, providing flexibility for different project requirements.

Analog-to-Digital Converter (ADC): The built-in ADC enables the ESP32 to measure analog signals from sensors such as temperature sensors, light sensors, etc.

Development Environment: The ESP32 can be programmed using the Arduino IDE, Platform io as a Visual Studio Code extension, or using Espressif's official development framework, ESP-IDF (Espressif IoT Development Framework).

Advantages: Versatile and Powerful: The ESP32 offers a wide range of features and capabilities, making it suitable for a variety of IoT applications. Connectivity: With built-in Wi-Fi and Bluetooth, the ESP32 simplifies the process of connecting to networks and other devices.

Cost-Effective: The ESP32 is a cost-effective solution compared to other microcontrollers with similar capabilities. Open-Source Community: The ESP32 has a large and active open-source community, providing extensive documentation, libraries, and examples for development.

Limitations: Power Consumption: The ESP32, being a feature-rich microcontroller, may consume more power compared to simpler microcontrollers. Careful power management techniques should be implemented in battery-powered applications.

[2]

2.1.2 LED Lights

The smart home system incorporates LED lights for room lighting, providing both functionality and convenience. These LED lights are not only energy-efficient but also offer the flexibility of remote control.

Users can turn them on or off from anywhere within the home using the web application from any device all with just a few taps on their device.

2.1.3 Temperature and Humidity Sensor

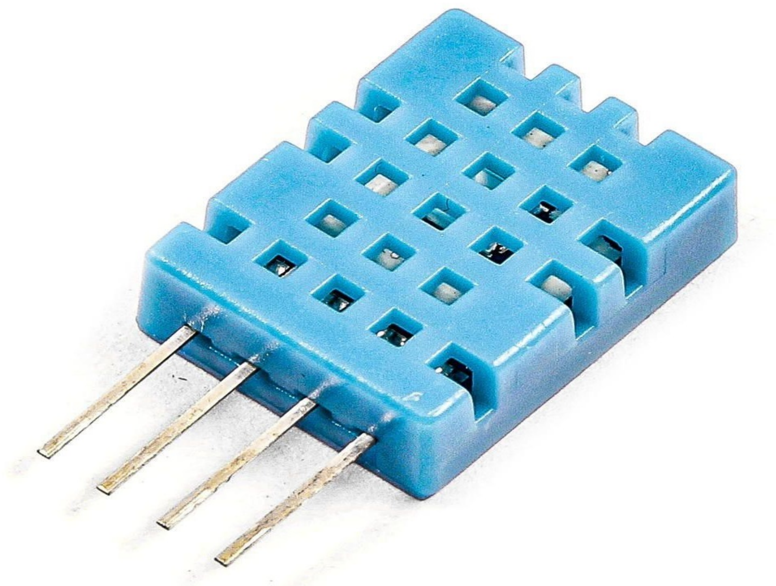


Figure 2.3 Temperature And Humidity Sensor

[3]

At the same time, a temperature sensor that serves as a thermostat, offering real-time temperature readings and intelligent control of heating and cooling systems besides the level of humidity in the room that it resides. The temperature sensor continuously monitors the ambient temperature within the home, allowing the system to adjust and maintain a comfortable environment.

To visually indicate the heating and cooling status, a blue LED is employed to simulate the activation of the air conditioning, while a red LED represents heating. When the temperature rises above the desired threshold, the blue LED turns on to indicate the cooling process, and conversely, when the temperature drops below the desired level, the red LED signals the activation of the heating system. This intuitive feedback system ensures that the temperature is regulated efficiently and provides users with a clear visual indication of the current climate control status in their home.

2.1.4 Gas Sensor

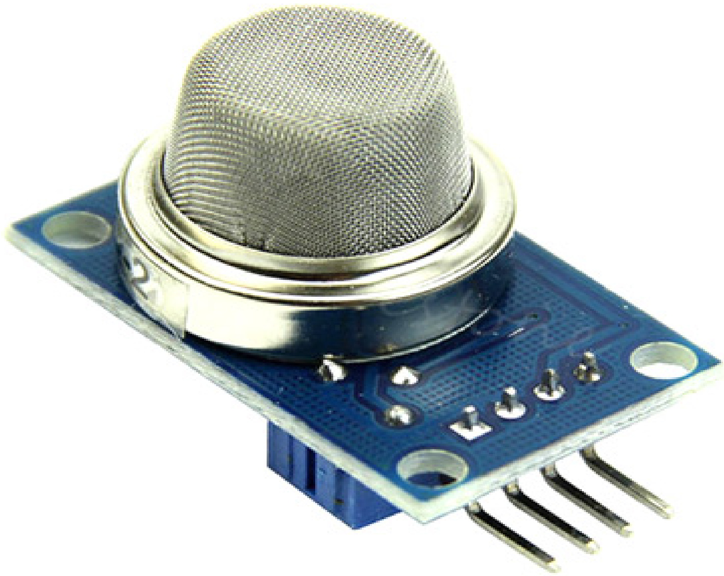


Figure 2.4 Gas Sensor

[4]

The smart home system integrates a gas sensor to enhance safety and security within the household. The gas sensor is designed to detect the presence of potentially hazardous gases, such as carbon monoxide or natural gas leaks. With its advanced detection capabilities, the gas sensor ensures the early identification of gas leaks, enabling swift action to mitigate potential risks.

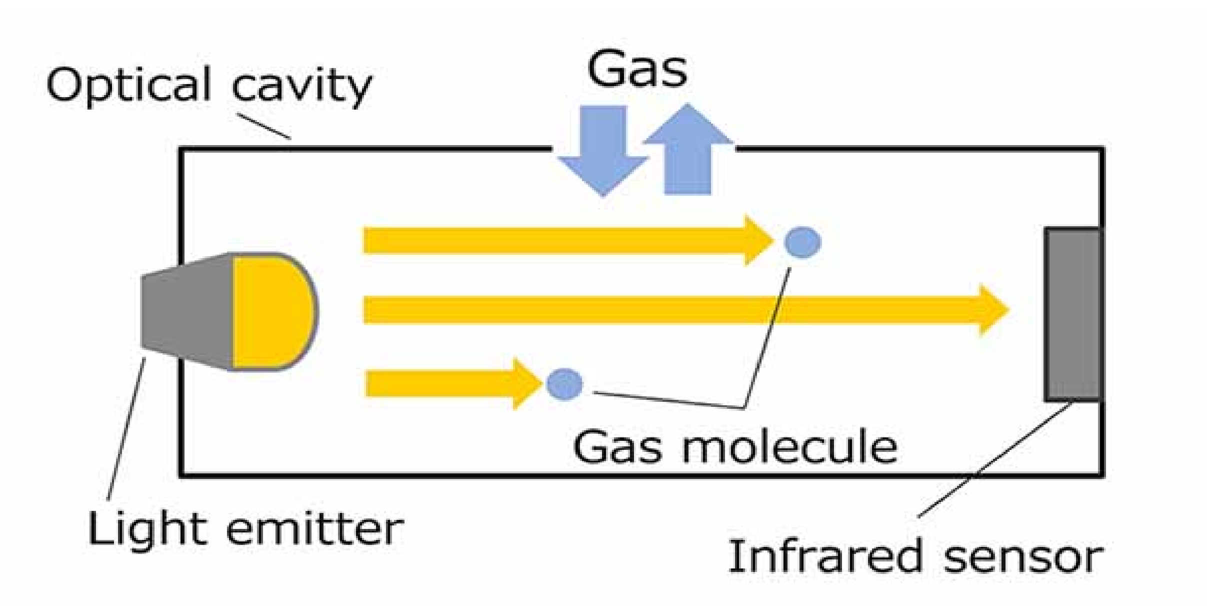


Figure 2.5 Gas Senor Working Principle

[5]

In the event that the gas sensor detects a high concentration of gas, a warning is triggered to notify the users, allowing them to evacuate the premises and seek assistance if necessary.

2.1.5 Magnetic Door Sensor

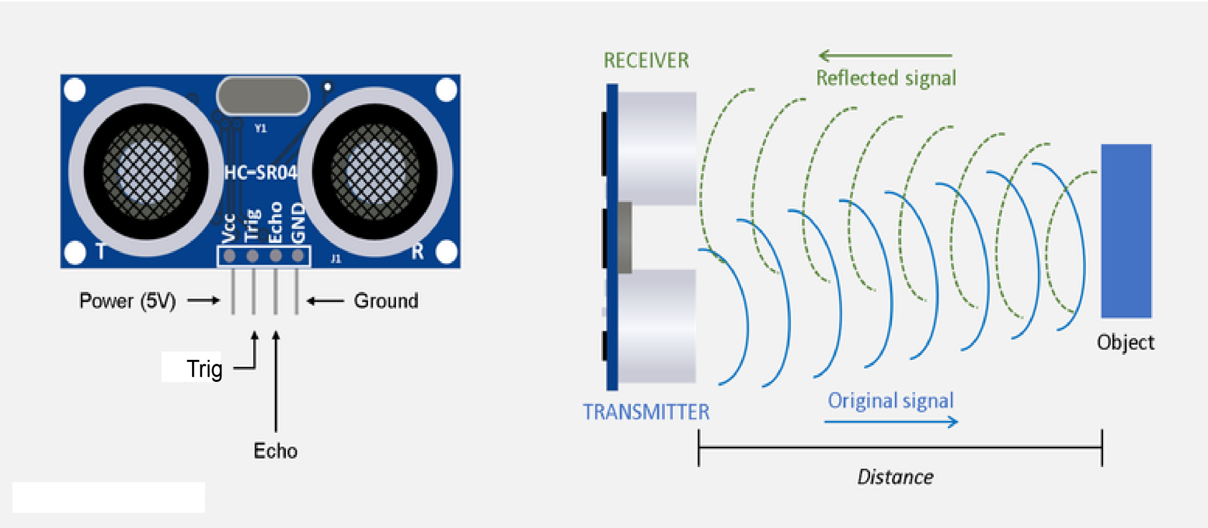
Figure 2.6 Magnetic Door Sensor

[3]

The incorporation of a magnetic door sensor is critical to enhance security and provide real-time monitoring of the home's entry points. The magnetic door sensor is installed on the front door and consists of two components: a magnetic switch and a magnet.

When the door is closed, the magnet aligns with the magnetic switch, creating a closed circuit. However, if the door is opened, the alignment is disrupted, and the circuit is broken, triggering a warning. This allows the system to detect unauthorized entry or tampering attempts. With the magnetic door sensor integrated into the smart home system, homeowners can have peace of mind, knowing that their home is effectively monitored and protected against potential intrusions.

2.1.6 Ultrasonic Sensor



[6]

Figure 2.7 Ultrasonic Sensor and Working Principle

The ultrasonic sensor plays a crucial role in the smart home system by providing proximity detection and enabling automatic control of the hall light. It uses high-frequency sound waves to measure the distance between objects and detects the presence of individuals approaching the entrance of the home.

When someone is detected within a specified range, the sensor triggers the activation of the hall light, illuminating the area and ensuring safe navigation. This feature enhances convenience and security for homeowners, allowing them to move around their home with ease, especially during nighttime or low-light conditions.

2.2 Software Components

2.2.1 PyCharm

PyCharm was selected as the integrated development environment (IDE) for developing the Flask API and hosting the web page for this smart home project. PyCharm offers a range of powerful features and benefits that greatly enhance productivity and streamline the development process.

It's comprehensive code editor provides intelligent code completion, error highlighting, and code navigation, enabling efficient and error-free coding. PyCharm's robust debugging capabilities facilitate quick identification and resolution of issues during development. Additionally, PyCharm's support for virtual environments simplifies package management and dependency handling.

The built-in web server deployment feature of PyCharm further simplifies hosting the Flask API and web page locally for testing and development purposes. Overall, PyCharm's rich feature set and user-friendly interface make it an excellent choice for developing and hosting the Flask API, contributing to enhanced productivity and a seamless development experience.

[7]

2.2.2 Visual Studio Code with PlatformIO Extension

Visual Studio Code (VS Code) with the PlatformIO extension was chosen as the IDE for developing the ESP32 code in our smart home project. The combination of VS Code and PlatformIO offers a versatile and efficient development environment for embedded systems.

The PlatformIO extension provides excellent support for managing ESP32 projects, including easy setup, library management, and firmware uploading. It offers a rich set of features, such as code completion, syntax highlighting, and integrated debugging, which significantly enhance the coding experience.

The seamless integration of VS Code and the functionality of the PlatformIO extension make it a powerful IDE for ESP32 development, enabling efficient coding and debugging.

2.2.3 ESP32 Firmware

The ESP32 Firmware is the essential software component that runs on the ESP32 microcontroller, forming the core of the smart home system. It is responsible for managing the communication with various sensors and actuators, collecting real-time data, and controlling the devices based on predefined rules and user inputs. The firmware incorporates programming logic to read sensor data from the temperature sensor, gas sensor, and magnetic door sensor, and processes it to make informed decisions.

It also implements control algorithms to regulate the LED lights, simulating AC or heating functionality with the blue and red LEDs respectively, based on the temperature readings. Additionally, the firmware interacts with the ultrasonic sensor to detect motion and trigger the hall light accordingly. With its ability to interpret sensor data, execute programmed actions, and facilitate communication with other software components, the ESP32 Firmware forms the backbone of the smart home system, enabling intelligent automation and efficient management of the connected devices.

[2]

2.2.4 JSON Data Management

JSON data management plays a crucial role in the smart home system, facilitating the exchange and storage of information between the ESP32 microcontroller and the Flask API. JSON, or JavaScript Object Notation, is a lightweight and widely-used data interchange format.

In the context of the system, the ESP32 microcontroller generates and updates a JSON file, which contains relevant sensor data and device statuses. This JSON file serves as a structured representation of the current state of the smart home system. The Flask API, hosted on a web server, is responsible for receiving the JSON file from the ESP32, parsing its contents, and extracting the necessary data. It then utilizes this data to update the web page, displaying real-time information to the user.

The JSON data management ensures seamless communication between the hardware and software components, enabling efficient data transfer, synchronization, and visualization in the smart home system.

2.2.5 Flask API

The Flask API is a critical component of the smart home system, responsible for handling the communication between the ESP32 microcontroller and the web application. Flask is a lightweight and versatile web framework written in Python, making it an ideal choice for building APIs. The Flask API acts as the intermediary between the hardware and the user interface, facilitating the exchange of data and commands.

It receives the JSON data generated by the ESP32, parses it, and extracts the relevant information. Through the Flask routes and endpoints, it exposes this data to the web application, making it accessible for real-time display and interaction.

Additionally, the Flask API enables bidirectional communication by accepting user inputs from the web application and relaying them to the ESP32 for appropriate actions. By utilizing Flask as the API framework, the smart home system achieves seamless integration between the hardware and the user interface, providing users with a responsive and intuitive control interface for managing their smart home devices.

[8]

2.2.6 Web Application

The web application serves as the user interface for the smart home system, providing a convenient and accessible way for users to interact with their connected devices. Built using modern web technologies such as HTML, CSS, and JavaScript, the web application offers a responsive and intuitive interface that can be accessed from any device with a web browser.

Through the web application, users can monitor and control various aspects of their smart home, such as adjusting the room lighting, setting the desired temperature, checking the gas levels, and monitoring the status of the magnetic door sensor. The web application fetches the data from the Flask API, which acts as the bridge between the hardware components and the user interface. It then presents the data in a user-friendly format, allowing users to easily understand and interact with their smart home system.

This web application also provides features like real-time updates, warnings, and the ability to schedule automated tasks, enhancing the overall convenience and flexibility of managing the smart home. With its intuitive design and seamless integration with the underlying technologies, the web application empowers users to effortlessly control and monitor their smart home system from anywhere, at any time.

Chapter 3

System Implementation

3.1 Overview

This chapter focuses on providing an overview of the system flow and implementation, detailing the interactions and data flow between different components. It explores the process of collecting sensor data, processing and storing it in a JSON file within the ESP32 microcontroller, and establishing communication with a Flask API for further data extraction.

Furthermore, it highlights how the sensor data is dynamically displayed on a hosted web page, providing real-time insights into the smart home system's status. By understanding the system flow, readers can gain a comprehensive understanding of the underlying mechanisms that enable efficient data management and visualization in a smart home environment.

3.2 Data Flow

The data flow within the smart home system begins with the collection of sensor data from various components. The ultrasonic sensor measures the distance between objects, enabling the activation of the hall light. Simultaneously, the temperature sensor acts as a thermostat, continuously monitoring the room temperature. Based on the readings, it triggers the corresponding red or blue LED to simulate heating or air conditioning for energy efficiency.

```
  if (distance < 30)
    {
    digitalWrite(ledPinHall, HIGH);
    Serial.print("Hall Light is ON");
    ledSensorValue = true;
    delay(5000);
  }
else
  {
    digitalWrite(ledPinHall, LOW);
    ledSensorValue = false;
    Serial.print("Hall Light is OFF\n");
  }
```

Figure 3.1 Automated Hall Light Sensor Functionality

Additionally, the gas sensor monitors the air quality, detecting the presence of harmful gases, while the magnetic door sensor contributes to security by providing door status information. These sensors collectively feed their data to the ESP32 microcontroller, serving as the central processing unit. The microcontroller retrieves the sensor data and stores it in a structured JSON file in its memory, ensuring continuous updates as new readings are obtained.

```
// Create JSON object
DynamicJsonDocument jsonDoc(1024);
jsonDoc["Sensor1"] = "Hall Light";
jsonDoc["Value1"] = ledSensorValue;

// Convert JSON object to string
String jsonString;
serializeJson(jsonDoc, jsonString);

// Open file in write mode
File fileToWrite = SPIFFS.open("/spiffs/sensors.json", "w");
if (!fileToWrite) {
  Serial.println("Failed to open file for writing");
} else {
  // Write JSON string to file
  fileToWrite.println(jsonString);
  fileToWrite.close();
}
```

Figure 3.2 Saving Data From Sensors as JSON file in ESP32 Memory

Subsequently, a Flask API extracts the relevant data from the JSON file, saving it to variables within the API. These variables hold the latest sensor readings and are constantly updated. The API then integrates the live sensor data into a dynamically generated web page, allowing users to monitor the smart home system in real-time. Through this seamless process of data extraction, variable storage, and live updates, users can stay informed about the current status and performance of their smart home system.

```python
@app.route('/receive-data', methods=['GET', 'POST'])
def receive_data():
    global data

    if request.method == 'POST':
        data = request.get_json()  # Get the JSON data from the request

        # Save the JSON data to a file
        with open('data.json', 'w') as file:
            json.dump(data, file)

        return jsonify(message='Data received and saved successfully')
```

Figure 3.3 Saving Data Recieved From ESP32

3.3 Control Flow

The control flow within the smart home system involves the interaction between the user, the ESP32 microcontroller, and the various components of the system. The user initiates control actions through the hosted web page, which provides an intuitive interface for managing the smart home features. Upon receiving user inputs, the web page sends control commands to the Flask API, which acts as the intermediary between the user interface and the ESP32 microcontroller.

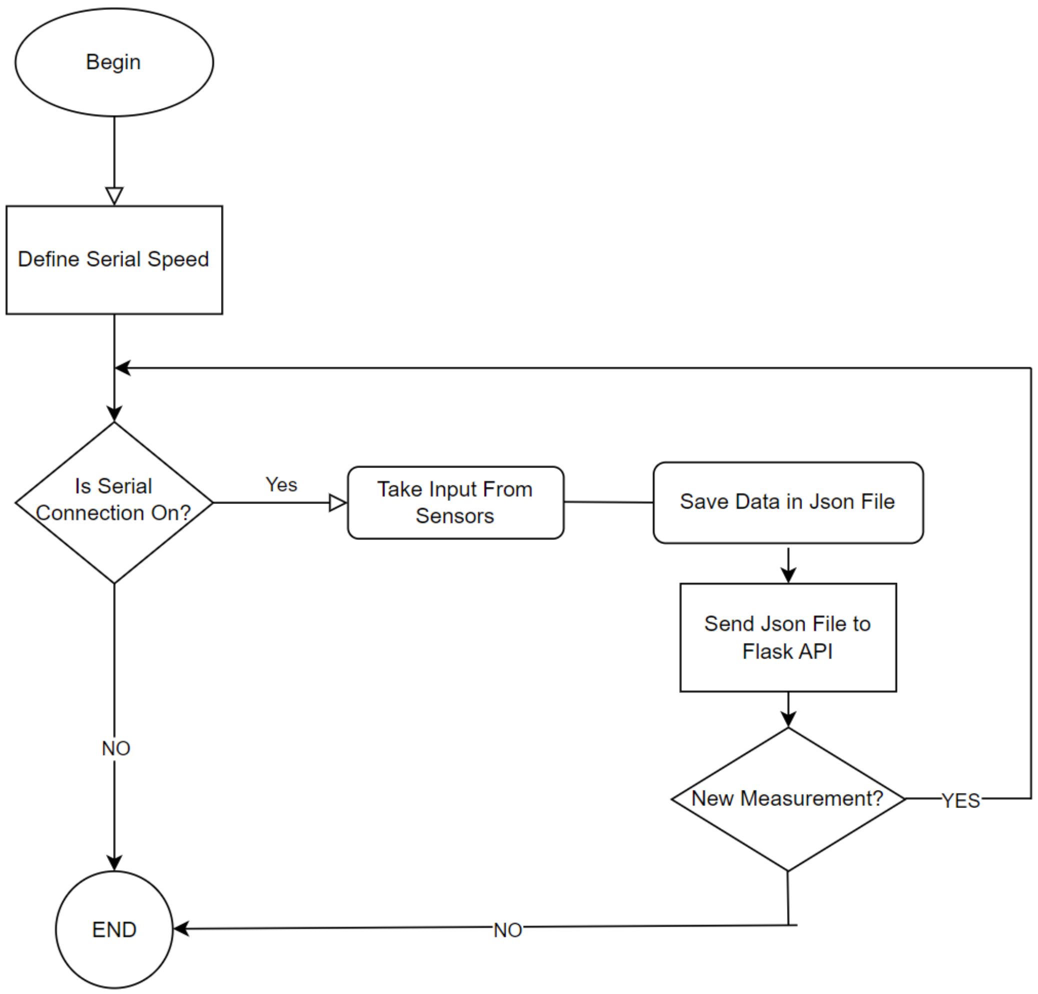


Figure 3.4 Control Flow Diagram

The Flask API receives the control commands and processes them accordingly. For example, if the user adjusts the desired temperature on the web page, the API translates this input into a command to activate the heating or air conditioning system. Similarly, if the user wants to turn on or off the lights throughout the house, the API generates the corresponding command for the ESP32 microcontroller.

The ESP32 microcontroller receives the control commands from the Flask API and performs the necessary actions. It interacts with the relevant components, such as the lights, heating and air conditioning system, and other connected devices, to execute the user's desired commands.

To ensure the smooth execution of control actions, the microcontroller constantly monitors the status of the smart home system. It retrieves the sensor data from the various sensors and performs any required adjustments based on predefined rules or user settings. For instance, if the gas sensor detects a dangerous level of gas, the microcontroller will automatically trigger an warning.

```
const int triggerPin = GPIO_NUM_13;   // Ultrasonic Sensor trigger pin
const int echoPin = GPIO_NUM_12;      // Ultrasonic Sensor echo pin
const int ledPinHall = GPIO_NUM_14;   // Hallway LED
```

Figure 3.5 Mapping Sensors for the Automated Hall Light

The microcontroller also updates the JSON file in its memory to reflect the changes in the system status resulting from the control actions. This updated information is then sent back to the Flask API, which further updates the web page to provide real-time feedback to the user.

By establishing an efficient control flow, the smart home system enables seamless interaction between the user, the ESP32 microcontroller, and the various components, ensuring responsive control and effective management of the smart home features.

[9]

3.4 Interaction Between Components

The smart home system encompasses a harmonious interaction between its various components, enabling the seamless operation of the entire ecosystem. The ESP32 microcontroller serves as the central hub, orchestrating the communication and coordination among the different hardware components.

It receives data from sensors such as the ultrasonic sensor, temperature sensor, gas sensor, and magnetic door sensor, facilitating the monitoring and control of the smart home environment. The microcontroller processes the sensor data and triggers appropriate actions based on predefined rules or user inputs. For instance, when the ultrasonic sensor detects nearby movement, it signals the activation of the hall light.

Similarly, the temperature sensor's readings inform the microcontroller to adjust the heating or air conditioning system accordingly, providing optimal comfort and energy efficiency. The gas sensor and magnetic door sensor contribute to the system's security by providing real-time information about gas levels and door status, respectively.

The ESP32 microcontroller facilitates the integration of these components, ensuring a cohesive and intelligent functioning of the smart home system.

[10]

3.5 System Behaviour

The system behavior of the smart home project is characterized by its responsiveness, adaptability, and intelligent decision-making capabilities.

Furthermore, the smart home system exhibits adaptability by dynamically adjusting its operations based on real-time sensor readings. The temperature sensor constantly monitors room temperature and triggers the appropriate response from the heating or air conditioning system. This adaptive behavior ensures that the desired comfort levels are maintained while optimizing energy consumption.

Intelligent decision-making is another key aspect of the system behavior. The microcontroller analyzes the sensor data and applies predefined rules or user-defined settings to make informed decisions. For example, if the gas sensor detects a hazardous gas level, the system sends a warning on the user's web page.

Moreover, the system behavior is reflected in the interactive web page, which provides real-time updates to users. As the sensor data is constantly updated and transmitted to the Flask API, the web page dynamically reflects the current status of the smart home system.

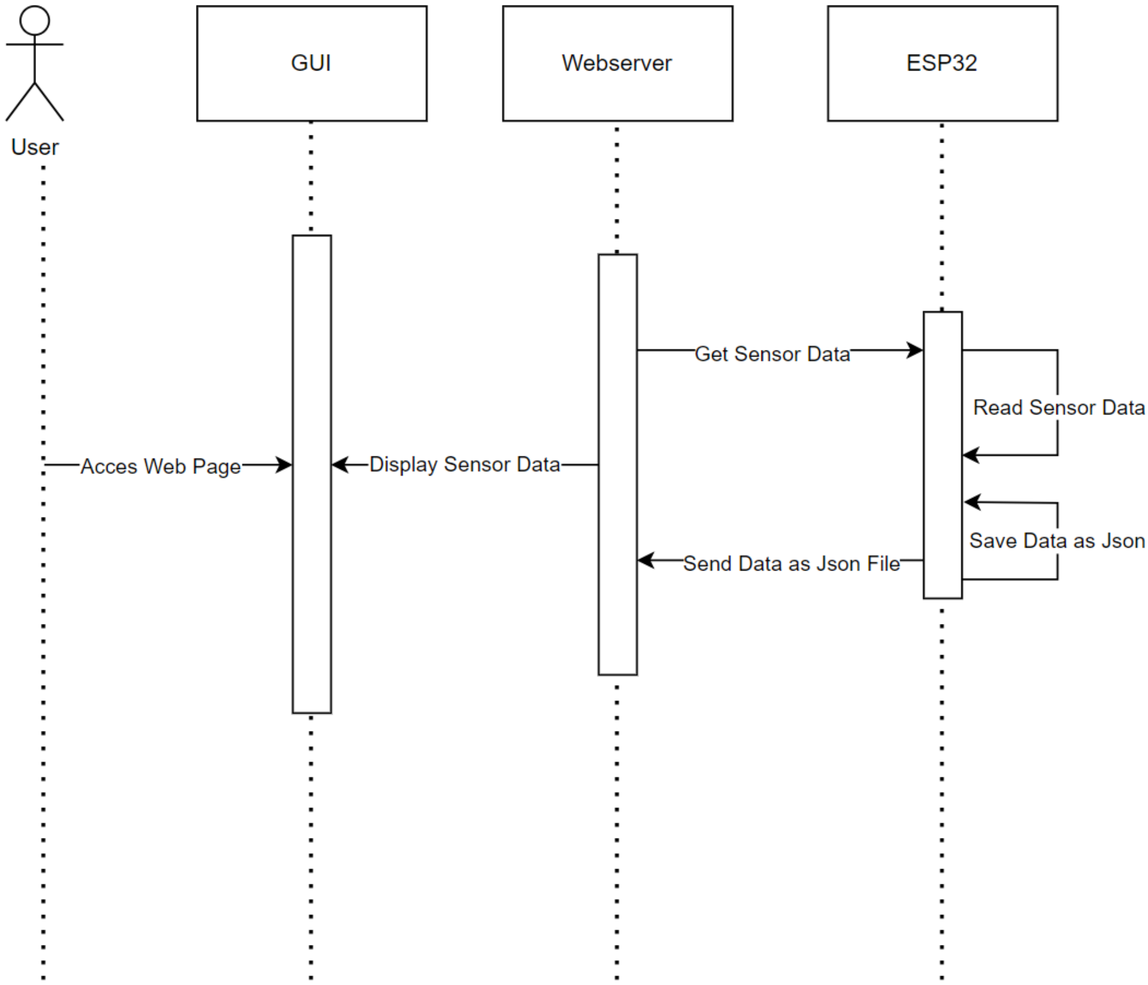


Figure 3.6 Control Flow Diagram

Overall, the system behavior of the smart home project showcases its ability to respond promptly, adapt to changing conditions, and make intelligent decisions based on sensor data. This behavior ensures an enhanced and personalized experience for users, while also promoting energy efficiency and security within the smart home environment.

Chapter 4

Information Exchange

The effective communication between different components is vital for the smooth operation of a smart home system. This chapter focuses on the ways in wich I have employed data exchange in this smart home project, to facilitate seamless data exchange, control commands, and real-time updates.

4.1 Data Transmission

In my smart home project, the POST HTTP method is utilized to transmit sensor data from the ESP32 microcontroller to the Flask API. The ESP32 continuously updates a JSON file stored in its memory with the latest sensor readings. When sensor data needs to be sent, the ESP32 establishes a connection with the Flask API and sends the JSON file as the payload using the POST method.

This enables the reliable and efficient transmission of real-time sensor data, allowing the Flask API to process and analyze the received information effectively.

[11]

4.2 Control Commands

Furthermore, user control commands are established through the GET HTTP method. The Flask API listens for GET requests and retrieves the user inputs or commands from the API endpoint. By utilizing the GET method, users can interact with the smart home system, providing inputs for controlling devices, adjusting settings, or querying information. The Flask

API processes these GET requests to perform the desired actions and respond accordingly, enhancing the user's ability to interact with and control the smart home system.

[11]

Chapter 5

Results

In this chapter, we present the results of our smart home project, focusing on the successful resolution of key issues related to security, efficiency, and ease of use. We discuss the implementation and outcomes of various features designed to address these concerns.

5.1 Practical Measures and Utility of the Smart Home System

To demonstrate the practical measures and utility of the smart home system, we will consider three scenarios where the system's sensors play a significant role.

But before that, a table chart detailing the practical data the system measures.

Sensor/Device	Data Type	Range/Values	Description
Door Sensor	Status	Open/Closed	Indicates the status of the front door (open or closed)
Gas Sensor	Gas Concentration	0-100%	Measures the concentration of gas in the air
LEDs	Status	On/Off	Indicates the status of the LED lights
Ultrasonic Sensor	Distance	0-500 cm	Measures the distance of an object from the sensor
Temperature Sensor	Temperature	-100 to +100 °C	Measures the ambient temperature
AC System	Cooling Status	On/Off	Indicates whether the air conditioning is on or off
Heating System	Heating Status	On/Off	Indicates whether the heating system is on or off

Table 5.1 Data Table Chart

5.1.1 Gas Level Monitoring

Sensor: Gas Sensor

Practical Measure: The gas sensor continuously monitors gas levels in different areas of the house. When it detects an unusually high gas concentration, it triggers a warning and notifies the residents through the web application.

Utility: This feature ensures the safety of the residents by providing timely alerts in the event of a gas leak. It allows them to take immediate action to prevent potential hazards.

5.1.2 Automated Thermostat Control

Sensor: Environmental Temperature Sensor

Practical Measure: The environmental temperature sensor constantly monitors the indoor temperature. Based on the sensor readings, the automated thermostat system adjusts the temperature settings to maintain a comfortable and energy-efficient environment.

Utility: The automated thermostat system optimizes energy usage by automatically adjusting heating or cooling based on the temperature changes, resulting in cost savings and a greener living space.

5.1.3 Ultrasonic Sensor for Entrance Light Automation

Sensor: Ultrasonic Sensor

Practical Measure: The ultrasonic sensor placed near the entrance detects the presence of individuals. When someone approaches the front door, the sensor triggers the entrance light to turn on automatically. After a specified period of inactivity, the sensor turns off the light.

Utility: This automation feature enhances convenience for residents by providing hands-free control of the entrance light. It also contributes to energy efficiency by ensuring the light is only active when needed.

5.2 Smart Decision Scenario

In the given scenario, the smart home system utilizes an automated light at the entrance, a door sensor, and an automated thermostat with a temperature sensor. The system makes intelligent decisions based on the data received from these sensors:

5.2.1 Entrance Light Automation

When the door sensor detects the opening of the front door, it sends a signal to the web page, triggering a warning notification. Simultaneously, the automated light at the entrance turns on automatically to provide illumination for the incoming individual(s). This decision enhances convenience and safety by ensuring adequate lighting in the entrance area when the door is opened.

5.2.2 Automated Thermostat Control

The automated thermostat continuously measures the temperature using the temperature sensor. Based on the readings, the system intelligently adjusts the heating or cooling settings to maintain a desired temperature range.

If the temperature rises above a certain threshold, the system activates the air conditioning, whereas if the temperature drops below a specified level, the heating is turned on. This decision ensures optimal comfort and energy efficiency by regulating the indoor temperature based on real-time sensor data.

5.3 Security Enhancements

One of the primary goals of this smart home project was to enhance security measures. To accomplish this, I have implemented the following features:

5.3.1 Gas Level Warnings

By incorporating a gas sensor in the kitchen, our system is capable of detecting elevated gas levels. In the event of a dangerous gas concentration, my smart home system sends immediate alerts to the residents, allowing them to take necessary actions to prevent potential hazards. This feature ensures a safer living environment by providing timely warnings related to gas leaks.

5.3.2 Front Door Entry Monitoring

I have integrated a smart door system equipped with sensors to notify the homeowner of any activity related to the front door. This setup allows for real-time monitoring and notifications when someone enters or exits the premises. By providing comprehensive visibility into door activities, our smart home project effectively enhances security, enabling residents to have better control over access to their homes.

5.4 Efficiency Improvements

Another objective of our smart home project was to maximize energy efficiency within the house. The following feature played a crucial role in achieving this goal:

5.4.1 Automated Thermostat Control

To optimize temperature control, I employed a smart thermostat equipped with environmental sensors. The system continuously monitors temperature variations and adjusts settings accordingly. By leveraging this automation, our smart home project reduces energy wastage and promotes energy-efficient practices, ultimately leading to cost savings and a greener lifestyle.

5.4.2 Automated Entrance Light

In addition to the thermostat control, we implemented an automated system for the entrance light. An ultrasonic sensor was installed near the entrance to detect the presence of individuals.

When someone approaches the front door, the sensor triggers the light to turn on automatically. After a specified period of inactivity, the sensor detects the absence of individuals and subsequently turns off the entrance light. This feature not only enhances convenience for residents but also contributes to energy efficiency by ensuring that the light is only active when needed.

5.5 Ease of Use for Disabled Individuals

To ensure inclusivity and facilitate ease of use, I focused on creating a user-friendly interface accessible to disabled individuals. The following features showcase our efforts in this regard:

This smart home project includes a web application that offers a comprehensive and intuitive user interface. This application allows users, including disabled individuals, to remotely control various aspects of their homes, such as lights and thermostat settings, through a simple and accessible platform. By leveraging this interactive UI, disabled individuals gain more independence and control over their living environment, enhancing their overall quality of life.

Scenario	Triggered by	Smart Decision
Security	Door Sensor detects the front door is opened	Sends a warning notification to the web application, alerting the user about the potential unauthorized entry
Efficiency	Temperature Sensor detects a rise in temperature	Activates the AC system to cool down the room and maintain a comfortable temperature
Efficiency	Temperature Sensor detects a drop in temperature	Activates the Heating system to warm up the room and maintain a comfortable temperature
Convenience	Ultrasonic Sensor detects a person approaching	Automatically turns on the entrance LED lights, providing illumination for a safe entry
Convenience	Ultrasonic Sensor detects no motion for a while	Automatically turns off the entrance LED lights when no one is around, conserving energy
Accessibility for Disabled People	Web application receives command to adjust temperature settings	Adjusts the thermostat remotely based on the user's input, allowing disabled individuals to control the temperature without effort

Table 5.2 Simulated Cases Table

Chapter 6

Future Enhancements

This chapter explores potential future developments to further enhance security, efficiency, and ease of use in the smart home project. Building upon the successful implementation of gas level warnings, front door entry monitoring, and an automated thermostat system, this chapter outlines additional features that can be incorporated to improve the overall functionality and user experience. The proposed enhancements include the addition of a login form for safety, a user database, extra sensors for safety and efficiency, email notifications for warnings, and the integration of Z-Wave for enhanced connectivity.

6.0.1 Safety Measures

6.0.1.1 Login Form

To enhance the security of the smart home system, the integration of a login form is recommended. This feature ensures that only authorized individuals can access and control the smart home functions. Users will be required to enter their credentials, such as a username and password, before accessing the system. This login form adds an extra layer of protection against unauthorized access and safeguards sensitive user data.

6.0.1.2 User Database

Implementing a user database will provide a centralized repository for user information and preferences. This database can store user profiles, including individual settings and access permissions. By maintaining a user database, the system can personalize the smart home experience for each resident and enable easier management of user accounts.

6.0.2 Additional Sensors

6.0.2.1 Safety Sensors

To further enhance safety measures, additional sensors can be incorporated into the smart home system. For example, smoke detectors and carbon monoxide sensors can be integrated to detect and promptly alert residents in the event of a fire or gas leak. These sensors can be connected to the smart home system to trigger appropriate actions, such as sounding alarms, sending notifications, or activating emergency protocols.

6.0.2.2 Efficiency Sensors

Additional sensors can also be employed to optimize energy efficiency. For instance, occupancy sensors can detect human presence in different areas of the house and adjust lighting and temperature settings accordingly. Ambient light sensors can measure the natural light levels in a room and automatically adjust artificial lighting, minimizing energy consumption. These sensors contribute to a more energy-efficient and environmentally friendly smart home environment.

6.1 Email Notifications for Warnings

Integrating email notifications can enhance the timely communication of warnings and alerts to the residents. For example, in the case of gas level warnings or security breaches, the system can send email notifications to registered users, providing immediate awareness even if they are not actively using the web application. This feature ensures that critical information reaches residents promptly, enabling them to take necessary actions.

6.2 Z-Wave Integration for Enhanced Connectivity

Z-Wave is a wireless communication protocol widely used in smart home systems. Integrating Z-Wave technology into the smart home project enables seamless connectivity between devices, allowing for centralized control and coordination. This integration expands the range of compatible devices, such as smart plugs, door locks, and security cameras, offering a more comprehensive and interconnected smart home ecosystem.

Chapter 7

Conclusions

To conclude, the implementation of a smart home system is an essential solution for addressing the safety and ease of use concerns that disabled people face daily. Smart homes are designed to make daily life more convenient, comfortable, and secure for all individuals, regardless of their physical capabilities.

By incorporating mobility and accessibility features, smart home systems enable disabled people to control various home appliances and devices without having to physically move around the home. These features eliminate the need for a caregiver's assistance and empower individuals to live more independently and confidently in their homes.

The safety and security features of a smart home system provide a greater level of safety for disabled individuals. Real-time alerts and notifications of potential hazards, such as smoke or carbon monoxide, offer peace of mind and allow for prompt response to any threats. Additionally, remote monitoring of the home's security offers an extra layer of protection, reducing the likelihood of burglary or break-ins.

Finally, the energy efficiency features of a smart home system offer a significant benefit for disabled individuals by reducing energy costs and promoting environmental sustainability. These features help disabled individuals to live in a more energy-efficient and eco-friendly home, promoting a more sustainable future.

Overall, smart home systems have revolutionized the way we live and interact with our homes. With their unique features and capabilities, they have the power to significantly enhance the lives of disabled individuals. A smart home system enables disabled individuals to live more independently, comfortably, and securely in their homes, improving their quality of life and overall well-being.

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