PAMANTASAN NG LUNGSOD NG MAYNILA

University of the City of Manila

Intramuros, Manila

College Of Engineering

Computer Engineering Department

CPE 0411 - 1 – Embedded Systems

Empowering Homes: Innovations in Smart Automation and Safety

Group 5

Abarientos, Ramuel R.

Cazon, Iyhana Nicole A.

Reyes, John Alfred J.

Verzosa, Cristina Andrea B.

Vicente III, Honesto E.

Engr. Evelyn B. Carolino

Faculty

December 2024

Table of Contents

Executive Summary

Our smart home is designed to redefine modern living through the seamless integration of different sensors and proactive safety features. The house prioritizes security with a keypad-based locking mechanism, ensuring controlled access for the occupants. Its safety system responds immediately to critical scenarios such as high temperatures or gas leaks. Upon detection, the system activates a warning light and buzzer to alert anyone inside while simultaneously sending real-time notifications via the Telegram app. This ensures the homeowner stays informed even when outside the premises. To mitigate risks, the system automatically turns on a fan to circulate air and opens the windows to ventilate the house.

Additionally, the house offers customizable comfort features, such as bedroom lighting with adjustable colors to match the occupant's preference. The windows can also be controlled remotely, and in the event of rain, they will automatically close and notify the homeowner. Other automated features include remote control of ventilation, bathroom lighting, and live monitoring of sensor readings, accessible from anywhere.

Beyond its features, our project directly contributes to the United Nations Sustainable Development Goals (SDGs). It aligns with SDG 9: Industry, Innovation, and Infrastructure by fostering technological advancements and integrating innovative solutions to enhance household safety and convenience. Furthermore, it addresses SDG 11: Sustainable Cities and Communities by promoting safe, resilient, and sustainable living environments through smart automation.

Introduction

Design Intent

This smart home project is designed to revolutionize residential living by incorporating cutting-edge automation technologies that focus on enhancing safety, promoting sustainability, and delivering personalized convenience. The project envisions a user-centric environment where sensor-based systems proactively detect and respond to risks, optimize resource use, and enhance comfort for occupants.

A critical focus is safety, achieved through intelligent sensors that detect environmental hazards such as gas leaks and elevated temperatures. Upon detection, the system activates immediate mitigation protocols, including ventilation and real-time notifications to occupants. Energy efficiency is another pillar of design. By leveraging smart monitoring and automation, the system minimizes energy wastage while maintaining optimal environmental conditions. This feature is especially relevant in the context of global climate goals, as energy-efficient smart systems contribute to mitigating the environmental impacts of residential energy use.

Sustainability is further reinforced through alignment with the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). UNEP (2021) identifies smart automation as a transformative tool in promoting resilient and sustainable urban environments by reducing resource consumption and enhancing system adaptability.

The design also focuses on convenience and customization. Features like automated lighting, adaptive ventilation, and remote window controls cater to the evolving demands of modern urban residents.

In conclusion, this smart home project aims to create a forward-thinking residential solution that addresses critical challenges in safety, sustainability, and user satisfaction. By blending technological innovation with a commitment to global sustainability goals, the design represents a paradigm shift in residential architecture and living.

Background of Study

Smart home technologies are rapidly changing the way people live, offering new levels of convenience, safety, and energy efficiency. These systems use interconnected devices, like sensors and automation tools, to manage everything from home security to energy use. However, despite their benefits, there are several challenges and gaps in the way smart homes are designed and used today.

One of the critical challenges in smart home adoption is security and privacy. IoT-enabled devices in smart homes are often vulnerable to cyber threats such as data breaches, unauthorized access, and device manipulation. The diverse architectures and lack of standardized protocols across devices exacerbate these vulnerabilities. Research by Zhang et al. (2020) emphasizes the need for intelligent algorithms and privacy-preserving mechanisms to enhance the resilience of smart home systems. Similarly, Vardakis et al. (2024) calls for improved encryption and intrusion-detection techniques to address these persistent security gaps.

Another significant challenge is energy efficiency. Although smart homes aim to optimize energy usage, inefficiencies in sensor data processing and system coordination can lead to energy wastage. Yar et al. (2021) demonstrate that integrating edge-computing paradigms into smart home designs can reduce energy consumption by enabling local data processing, minimizing bandwidth requirements, and ensuring real-time responsiveness.

Usability and accessibility remain major barriers to broader adoption. Many systems have complex interfaces and high setup costs, making them less appealing to older adults and non-technical users. Research by Ye et al. (2020) highlights the need for intuitive designs and affordable solutions to increase smart home accessibility. Meanwhile, Vrančić et al. (2024) underscores the importance of adapting smart homes to cater to aging populations by addressing usability and cost concerns.

Several studies have proposed solutions to address these challenges. Zhang et al. (2020) explored integrating artificial intelligence (AI) with IoT to enhance smart home functionalities, particularly in automating tasks and maintaining security. Vrančić et al. (2024) reviewed how smart home technologies could support aging populations, recommending more intuitive user

interfaces and educational initiatives to improve adoption rates. In addition, Yar et al. (2021) successfully implemented a cost-effective smart home system using edge-computing. Their approach demonstrated improved energy efficiency and reduced operational costs compared to traditional cloud-based systems. These studies collectively emphasize the importance of user-centric designs and scalable, energy-efficient technologies for future smart home solutions.

To address these gaps, this study aims to develop a smart home system that emphasizes security, energy efficiency, and user accessibility. The proposed system will incorporate advanced sensor networks and cutting-edge technologies to detect and mitigate security risks effectively. It will leverage IoT-based solutions to optimize energy management and reduce operational costs by enabling real-time monitoring and automation. Furthermore, the system will feature intuitive interfaces and include educational programs to enhance usability and adoption across a diverse user base, ensuring a seamless and inclusive smart home experience.

Statement of the Problem

Smart home technologies have emerged as innovative solutions to enhance residential living by improving safety, sustainability, and convenience. However, the widespread adoption and optimal functioning of smart homes face significant challenges in the following areas:

1. Lack of Integrated Safety Systems
   Many existing smart home solutions lack comprehensive safety mechanisms, such as fire detection, emergency alerts, or intrusion alarms. This limitation leaves residents vulnerable to accidents and unauthorized access, undermining the fundamental purpose of enhancing home security and safety.
2. Limited Ease of Control
   Controlling smart home systems can be cumbersome for users, especially if the interface is not intuitive or the system lacks centralized control. This complexity discourages adoption and diminishes the convenience that smart homes are intended to offer.
3. Usability and Accessibility
   Many smart home solutions have complex interfaces and high setup costs, making them

inaccessible to non-technical users, older adults, and low-income households. The lack of intuitive designs and affordable options limits their potential for widespread adoption.

This study seeks to address these problems by developing a smart home system that prioritizes ease of control, and user-friendly accessibility. It also aims to align with global sustainability goals to ensure a transformative and inclusive approach to modern residential living.

Methodology

Materials

Materials Used	Quantity
Arduino Uno R3	**1**
Esp 32 WROOM Dev Module (38pins)	**1**
Breadboard	**2**
Servo Motor (180 degree)	**3**
Matrix Keypad Module (4x4)	**1**
I2C LCD Screen (16x2)	**1**
MQ2 Gas Sensor	**1**
DHT11 Sensor	**1**
DC Motor Fan (5.9V)	**1**
L298N Motor Driver	**1**
LED (Red)	**1**
LED (White)	**1**
RGB LED Module	**1**

Passive Buzzer	**1**
½ Illustration Board	**2**
Jumper Wires	**50**
Popsicle Sticks	**50**
Electrical Tape	**1**

Procedure

INPUT	PROCEDURE	OUTPUT
• Understanding emerging technologies, including the Internet of Things (IoT), is crucial. • A solid foundation in both software and hardware development, specifically about microcontrollers and the Blynk website. • Knowledge of components: ESP32, sensors (temperature, humidity, gas.), and mobile app of Blynk for control.	• Proponents designed the appropriate hardware and software modules based on the needs of the smart home. • Proponents have done prototyping for the hardware and software implementation. • Proponents conducted rigorous testing and debugging to ensure the system operates efficiently and meets the design objectives. • Proponents integrated the hardware components with the Blynk application to enable seamless communication and remote-control functionalities. • Proponents documented the entire development process for reference and future system improvements.	• Empowering Home: Innovation in Smart Automation and Safety

IPO Design of the Project

Program Logic

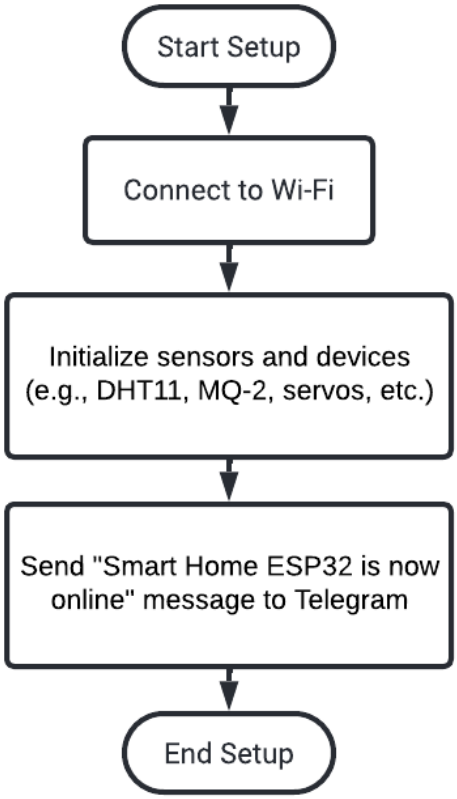

Diagram 1. Smart Home ESP32 Initialization Flowchart

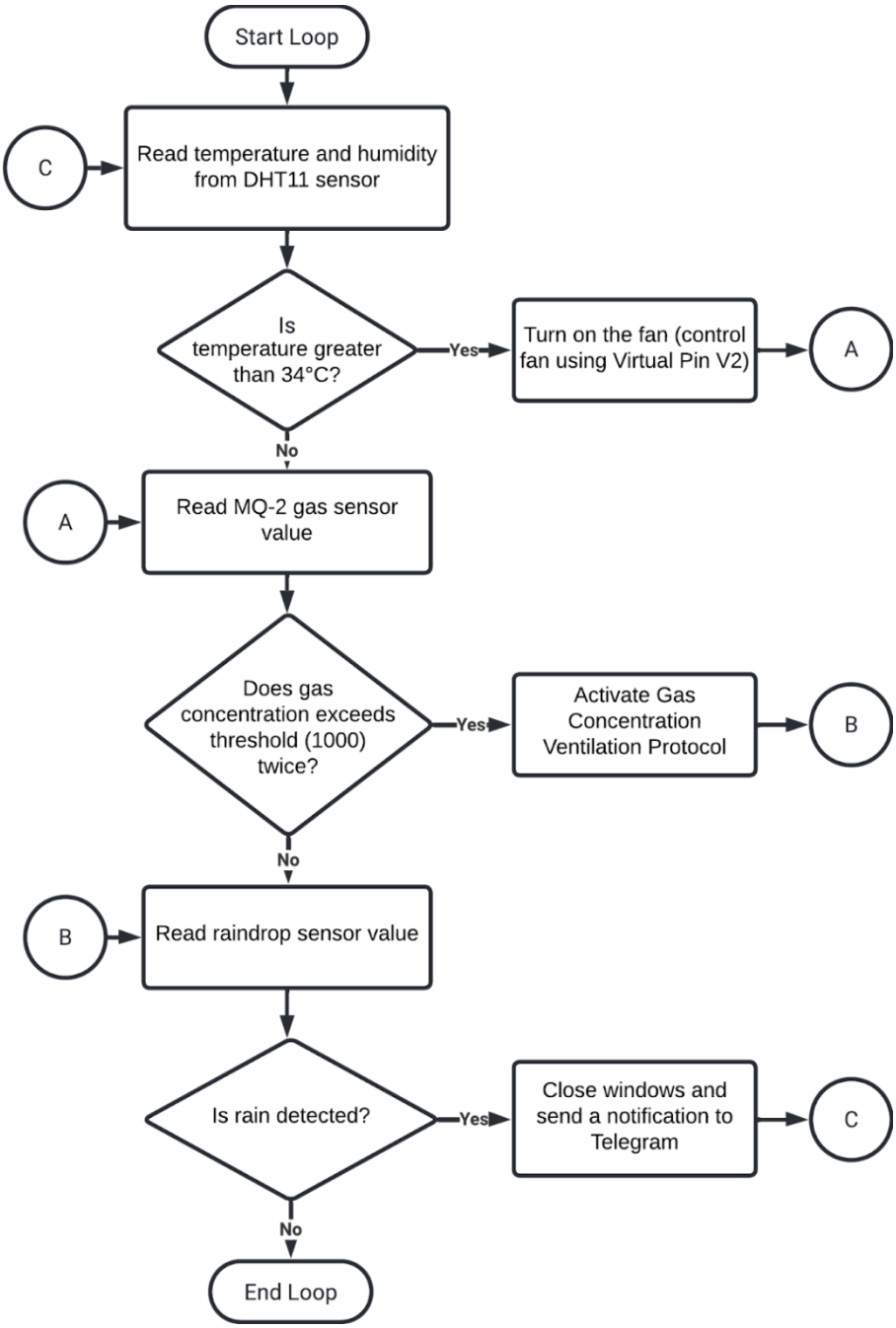

Diagram 2. HomeESP32: Automated Safety and Control System Flowchart

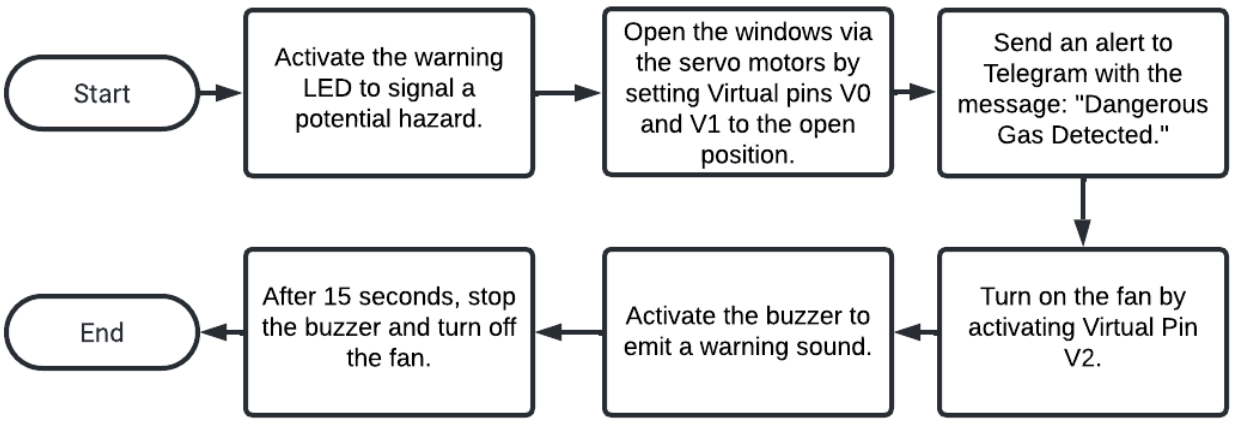

Diagram 3. Gas Detection and Ventilation Automation

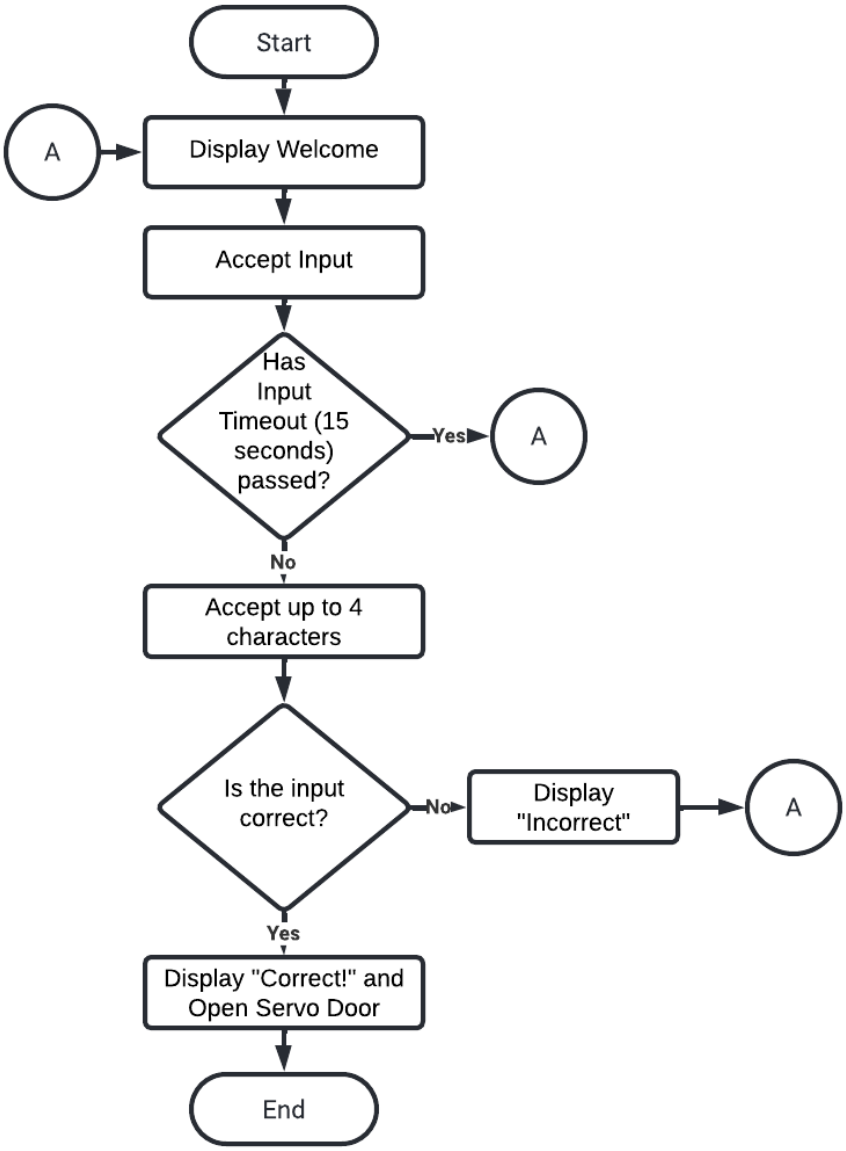

Diagram 4. Keypad Door Unlocking System Flowchart

Results

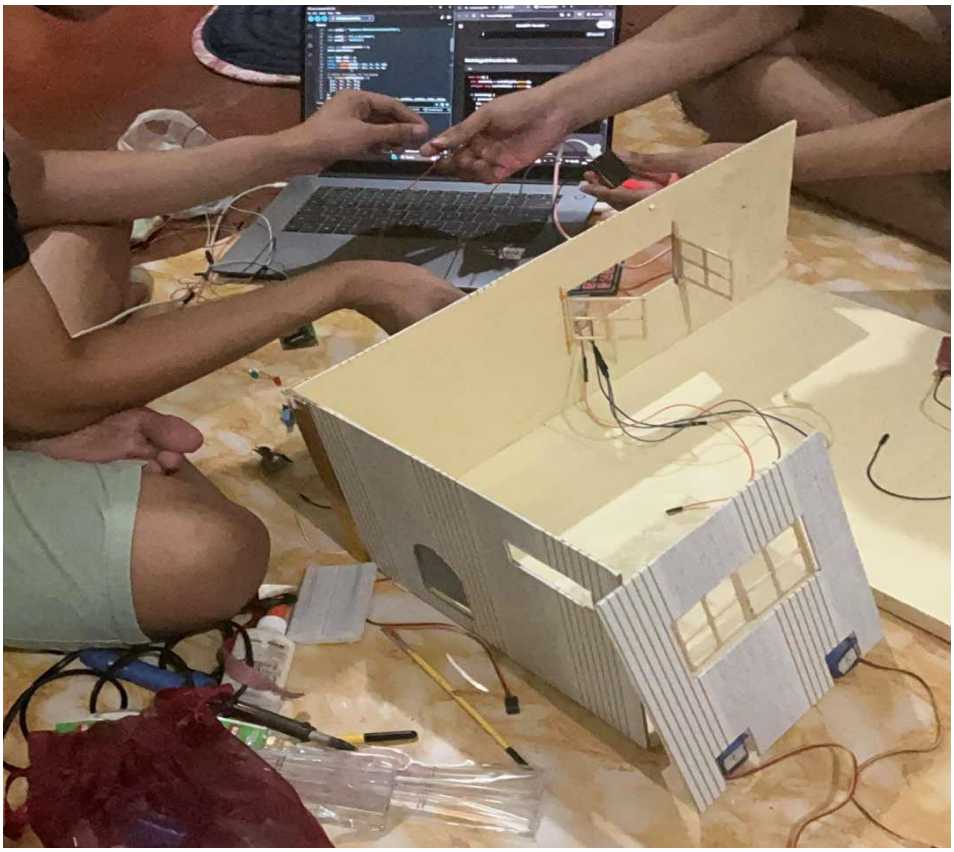

Figure 1. Assembly Process of the Smart Home System

Figure 2. Interior View of the Smart Home System

Hardware

Figure 3. Internal View of the Smart Home Sensor System

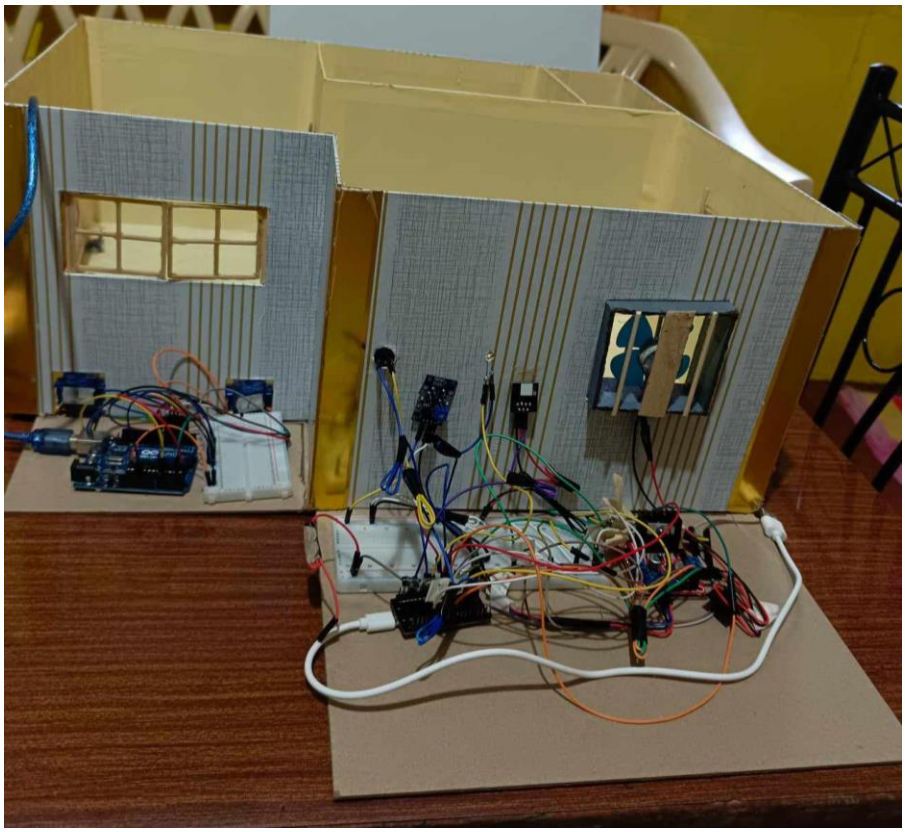

Figure 4. External Wiring of Connected Sensors in the Smart Home

Figure 5. Front View of the Smart Home

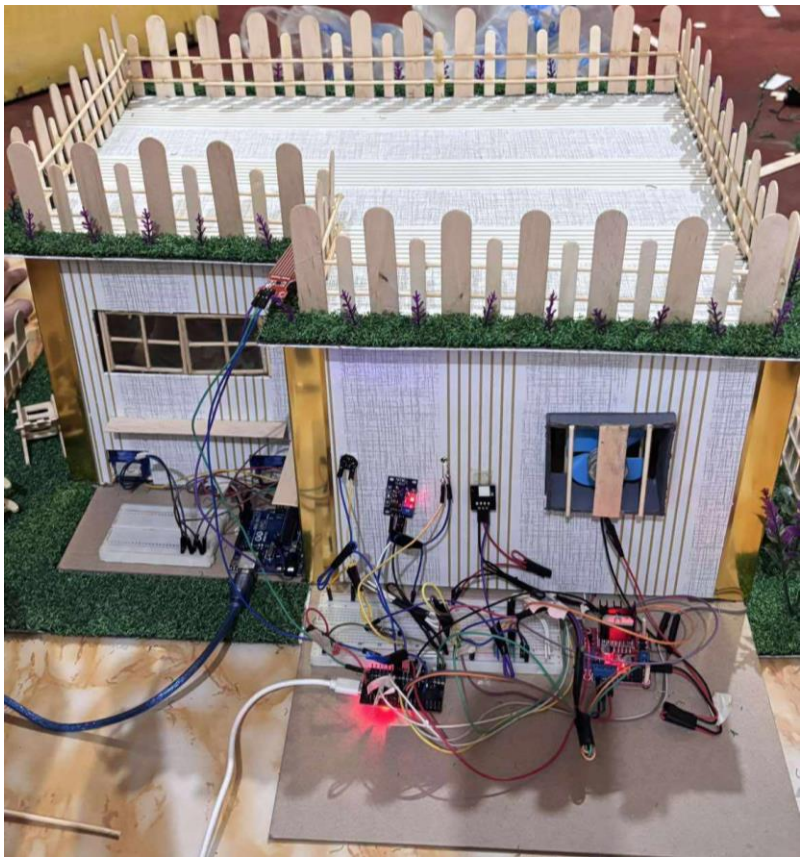

Figure 6. Side View of the Smart Home

Software

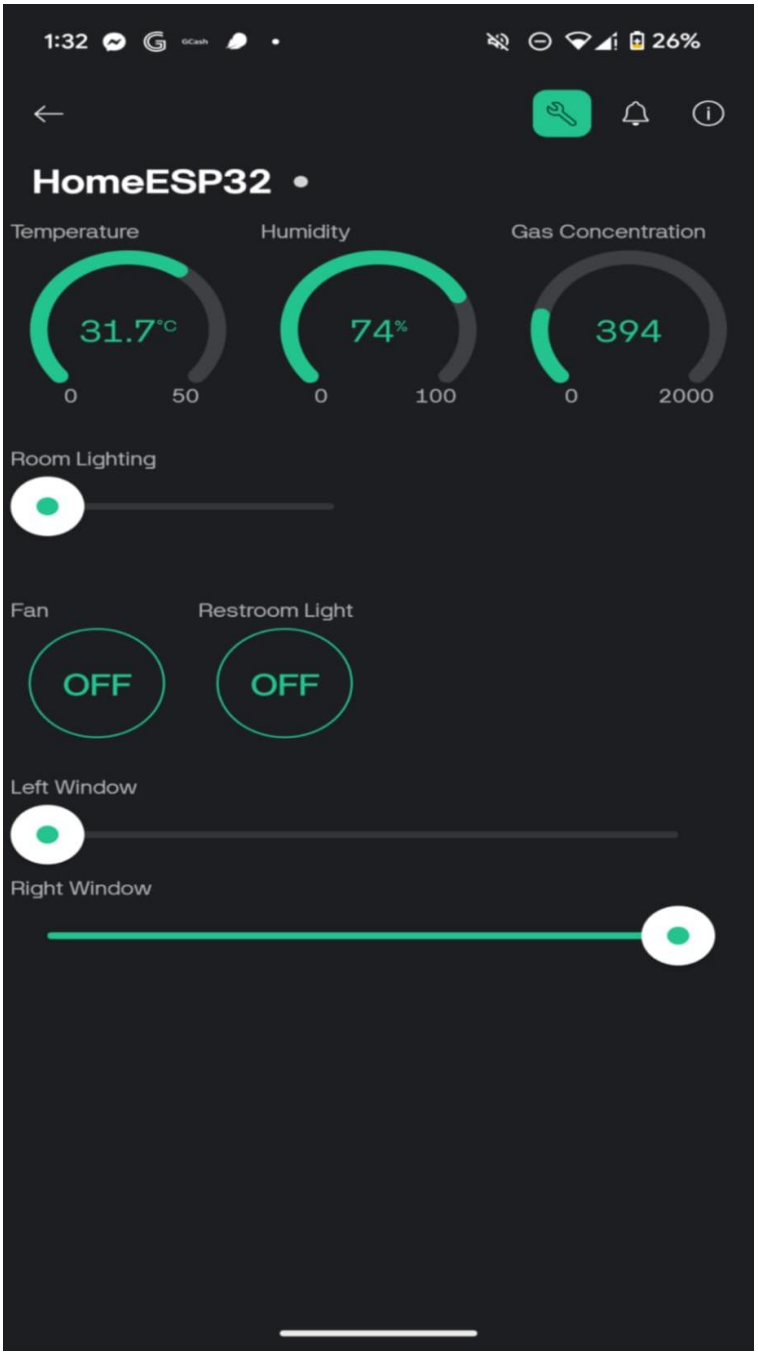

Figure 7: Mobile Application Interface for Smart Home Control

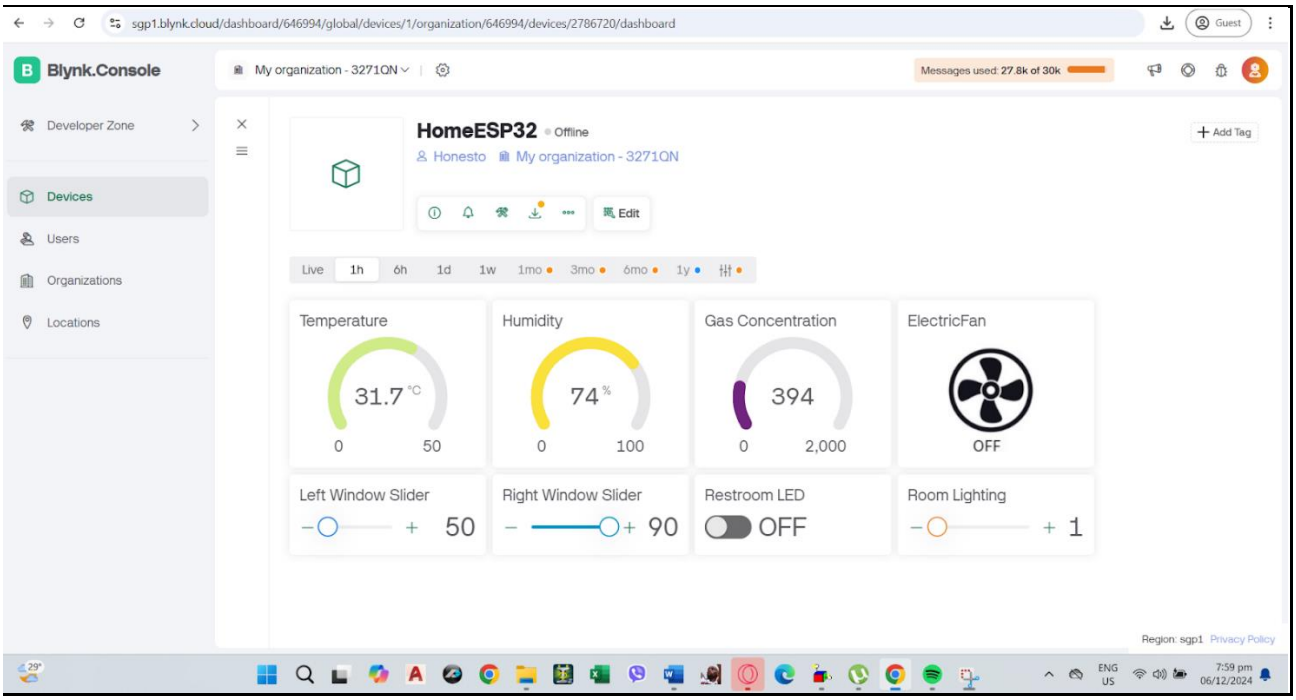

Figure 8: Web Application User Interface for Smart Home Control

Conclusion

The smart home system offers a fresh perspective on modern living by tackling critical challenges in sustainability, safety, and ease of use. With advanced IoT technologies and high-quality sensors, it provides a reliable way to detect and resolve risks like gas leaks and abnormal temperature levels quickly. The system aims to improve energy management while meeting global sustainability standards, including the United Nations Sustainable Development Goals. This approach highlights its potential to transform urban living, making homes more adaptable and resilient.

The project also recognizes the importance of inclusivity, focusing on solutions that can be used by everyone, regardless of technical expertise or economic background. By simplifying the system interface and offering educational resources, it ensures accessibility for older adults and non-technical users. This helps bridge the gap between cutting-edge technology and its practical application, allowing all residents of the smart home to feel comfortable and confident using the system.

In summary, this project shifts the traditional view of smart home technology by combining advanced features with the needs of everyday people. It addresses security risks, enhances energy efficiency, and prioritizes inclusivity, setting a new standard for future residential solutions. This innovation not only raises the bar for urban living but also contributes to a safer, more sustainable, and accessible future for everyone.

References

Arian Vrančić, Zadravec, H., & Tihomir Orehovački. (2024). The Role of Smart Homes in Providing Care for Older Adults: A Systematic Literature Review from 2010 to 2023. *Smart Cities*, *7*(4), 1502–1550. https://doi.org/10.3390/smartcities7040062

Vardakis, G., Hatzivasilis, G., Eleftheria Koutsaki, & Papadakis, N. (2024). Review of Smart-Home Security Using the Internet of Things. *Electronics*, *13*(16), 3343–3343. https://doi.org/10.3390/electronics13163343

Yar, H., Imran, A. S., Khan, Z. A., Sajjad, M., & Kastrati, Z. (2021). Towards Smart Home Automation Using IoT-Enabled Edge-Computing Paradigm. *Sensors*, *21*(14), 4932. https://doi.org/10.3390/s21144932

Ye, J., O'Grady, M., & Banos, O. (2020). Sensor Technology for Smart Homes. *Sensors*, *20*(24), 7046. https://doi.org/10.3390/s20247046

Zhang, D., & Wei, B. (2020). Smart Sensors and Devices in Artificial Intelligence. *Sensors*, *20*(20), 5945. https://doi.org/10.3390/s20205945

Appendices

Appendix A: Exhibit Presentation

Appendix B: Major Material Costs

Materials	Prices
Arduino Uno R3	₱239
Esp 32 WROOM Dev Module (38pins)	₱350
Breadboard	₱149
Servo Motor (180 degree)	₱170
Matrix Keypad Module (4x4)	₱56
I2C LCD Screen (16x2)	₱60
MQ2 Gas Sensor	₱75
DHT11 Sensor	₱125
DC Motor Fan (5.9V)	₱75
L298N Motor Driver	₱130

Appendix C: Process of Development

Appendix D: Notifications via Telegram App