MJSAT

Malaysian Journal of Science and Advanced Technology

journal homepage: https://mjsat.com.my/

Constructing An Integrated IoT-based Smart Home with An Automated Fire and Smoke Security Alert System

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KEYWORDS

IoT Smart Automation
Easy Access Control
Cost-Effective
GSM Module
Smart Security Alert

ARTICLE HISTORY

Received 6 December 2022
Received in revised form 14 January 2023
Accepted 17 January 2023
Available online 22 January 2023

ABSTRACT

The Internet of Things is quickly becoming one of the most important developments in this century's automation technology field. The Internet of Things (IoT) establishes a new approach to resolving issues that may arise in the foreseeable future by establishing an interface between the many devices that are now in use and integrating the functionalities of these devices. This study's primary objective is to develop methods that will cleverly simplify living arrangements and increase their convenience. The majority of things are now automated and computerized. This work aims to provide a system for integrating sensors and other data sources for different home automation. A home with intelligence on par with humans is called a smart home. This study proposes an IoT-based smart home automation system that operates in different modules to automate the complete home. If there is a problem, it will immediately identify and attempt to resolve it. In that case, it will send a notification to the homeowner. The suggested prototype included an automated door lock system, an automated gas detection system, and a smart smoke and fire alert system that sends an alert message to the owner and remotely controls the inside fan light. The system will immediately notify the users if a fire is detected in the user's residence. A smartphone application known as the Blynk App controls things remotely. As a result of being transformed into a smart home, it can offer security, energy efficiency, and the capability to control all of the current appliances in the house remotely or from a central place. Due to the exponential growth of technology, day-to-day activities are becoming less complicated, which has contributed to the popularity of home automation systems in recent years.

1. INTRODUCTION

Due to its numerous advantages, including comfort, convenience, centralized control of appliances, cost reduction, energy savings, protection, and safety, automation systems are becoming increasingly popular daily. Users gain from a home automation system, notably the elderly and those with impairments. Human negligence or disinterest frequently results in home appliances being left ON.

Homeowners frequently need to remember to turn off air conditioners, fans, or lighting when they leave a room. Without a person's help, smart home automation systems can turn off equipment. Around 90% of all energy use is accounted for by lighting, air conditioners, fans, air coolers, refrigerators, televisions, and water heaters, according to NITI. (National Institution for Transforming India) May 2016 and World Bank 2008 [1]. The report also demonstrates that households continue to consume power primarily for illumination. Lighting makes up about 30% of the space, followed by ventilation at 16% and climate control at 16%. Internet of Things and the rapid development of sensor technology, communication with the rest of the world is now straightforward [2]. The first smart home technology was developed in 1975 by a Scottish company called X10 [3]. On the other hand, early smart homes have

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inadequate administration and maintenance, high initial expenses, low efficiency, a difficult setup process, and a difficult user interface. The optimum choice can also be demonstrated as the smart house with a cloud-based strategy that enables secure real-time monitoring and control of the home from a distance. This design does not need much hardware or memory for storing system data. The Internet of Things (IoT) focuses on networking capabilities and data-driven decision-making, which means that by connecting to other devices, a computer may perform more effectively. The Internet of Things, a complex fusion of the virtual and real worlds, facilitates communication between machines and people. A wired or wireless network connecting a collection of computers and sensors does not constitute it. The method for a home automation system that integrates many duties in our living areas is presented in this article. Fig. 1 combines [4] them with remotely controlled gadgets like smartphones, iPods, laptops, fans, lights, etc., into a single action point.

The remaining eight sections had arranged in chronological order. Section 2. provides the overall literature review of the study, which describes the approach, and Section 3. represents the methodology and the modelling of the constructed prototype. Section 4 discusses the theoretical analysis of the designed prototype. Section 5 presents the working procedure. Section 6 offers the implementation of the prototype. Section 7 defines the research simulated result & data analysis. Section 8 explains future research developments. Finally, Section 9 describes the conclusion of the study.

Fig. 1: Smart Home System

2. LITERATURE REVIEW

Architectures for the Internet of Things (IoT)-enabled home security systems have been presented in the past [5]. Developing the prototype with a focus on utilizing open-source software and low-cost hardware components has been used. According to the smoke and gas sensor, a significant number of gas-particle emissions are produced whenever there is a fire. Power is turned on when the sensor detects them. It can be utilized to find environmental carbon monoxide gas (CO). The same reasoning holds for gas and smoke alarms. A fire produces a lot of gas particles, which activates the gas sensor and sets off the fire alarm. The central heating system may leak carbon monoxide due to a problem with the gas pipe or boiler problem. The alert is set off when the sensor detects the gas. Flame detector, when a fire or flame is present, a flame sensor is a particular kind of detector used to alert the user and take appropriate action. The installation of the flame detector may have an impact on how it responds. A fire suppression system, a propane line, a natural gas line, and an alarm system are included. In order to stop the spread of the coronavirus during the COVID-19 pandemic, Sayeduzzaman M. et al. [6] published a research paper at Smartcom 2021 in Las Vegas, United States, titled "A Design of an IoT-Based Smart Home with Auto-sanitization System" They did this by implementing a fog machine that sanitizes the inside of the house. Cristina Stolojescu-Crisan et al. [7] published a paper named "An IoT-based smart home automation system."

This paper uses interconnecting sensors and actuators using a qToggle system based on ESP8285/ESP8285 chips. Kodali et al. [8] described a cost-effective wireless home security and automation system, The TI-CC3200 Launch Pad, a battery-powered Micro-controller Unit (MCU) with built-in Wi-Fi connectivity. PIR motion sensors are installed at a building's entrances and connect to an MCU's digital input-output pin. The MCU is Wi-Fi enabled and programmed using the Energia Integrated Development Environment (IDE. Tanwar et al. [9] describe a low-cost home security system with an email alert system that works in real-time. A PIR module with a Raspberry Pi is used in the system. The Raspberry Pi is connected to security cameras and PIR sensors via USB ports and general-purpose input/output pins. The system assumes that homes should have Internet access and s the Internet to send real-time emails to residents. Waheb A. Jabbar et al. [10] published a paper titled "Design and Implementation of IoT-Based Automation System for Smart Home." They analyzed a low-cost WI-FI based automation system and used an Android-based Application and monitoring the temperature, humidity, and motion. Gupta and Chhabra [11] offer a low-cost Ethernet-based smart home system for monitoring energy use, detecting trespassing, and monitoring Smoke and temperature levels.

This system makes use of an Intel Galileo 2nd generation microcontroller board that is certified by Arduino. Four 220 V devices are wired through a relay module, while temperature, smoke, and PIR sensors are wired directly to the microcontroller. Abhay Kumar Ray et al. [12] designed a paper named "IoT-based Smart home: Security Aspects and security architecture." They built a safe architecture for smart homes that included the cloud, a secure fog protected by a firewall, and a security analysis engine. Mohammad Asadul Hoque et al. [13] published a paper titled "Design and Implementation of an IoT-Based Smart Home Security System." They used cost-effective smart door sensors, infrared sensors, motion sensors, temperature sensors, smoke sensors, and web cameras. Sudha Kousaalya et al. [14] published a paper named "IoT Based Smart Security and Smart Home Automation." They used Wi-Fi for the communication protocol. ZigBee, Bluetooth, GSM, and Node MCU are helpful for the Handicapped. Piyare et al.

[15] describe a Bluetooth-based home automation system in which a Python script on Android phone talks with an Arduino BT board with digital and analog input/output ports to which sensors and appliances are connected.

Each gadget includes a toggle on and off feature on the smartphone app. However, within a concrete building, the Bluetooth range needed to make contact between the smartphone and Arduino BT board has to be 50 meters or fewer. Praveen Kumar et al. [16] titled "IoT-based monitoring and control of appliances for the smart home. "They discuss the low-cost design, user-friendly interface, easy installation, and reduced electrical power waste. Sayeduzzaman M. et al. [17] published a research paper at IJISRT in 2021 titled "A Facile Method to Construct an IoT-Based Smart Home," where they designed and constructed a cost-effective way to build a Smart Home for all. Behera et al. [18] used an Arduino Uno board, an Arduino Wi-Fi Shield, and a PC home server to build and implement a real-time smart home automation system. Data was collected using a PIR or motion sensor, a light-dependent resistor, and an LM35 temperature sensor, then made available on the computer.

A MATLAB-GUI platform was used to control a PC server's temperature, lights, and fans. Uma Pujari et al. [19] titled "Internet of Things based Integrated Smart Home Automation System." This paper presents a multifunctional, flexible, and low-cost for smart home monitoring and control. They used various sensors like temperature, humidity, light, LPG, and motion sensors with prototypes. Punit Gupta et al. [20] titled "IoT based Smart home design using power and security management." They discuss Ethernet-based smart homes, monitoring, voice control, remote control, and monitoring security. They focused on multiple benefits of saving electricity bills and voice or simple toggle touch on their smartphone. V. Jyothi et al. [21] titled "IoT Based smart home system Technologies." They are present in this paper as cost-effective, improved efficiency, accuracy, and economic benefit. Dimitris Geneiatakis et al. [22] in 2017 titled "Security and privacy issues for an IoT-based smart home." They described in this paper mobile devices, privacy, and data collection. Faisal Saeed et al. [23] named "IoT Based Intelligent modelling of the smart home environment for fire prevention and safety." They present their paper on fire detection systems using Wireless sensor networks (WSN), cheap, and low-power sensors This system they used for global systems for mobile communications (GSM). Howedi et al. [24] presented the Arduino Uno board, PIR sensors, DHT11 temperature sensors, and INA219 are used in a low-cost smart home system, high-side DC sensors, and servo motors to operate doors and windows.

3. METHODOLOGY AND MODELLING

Methodology in research refers to the specific procedures or strategies utilized to locate, select, process, and analyse information about a subject [25]. Sayeduzzaman M. et al. [26] designed a disinfection fog machine that evaporates disinfection liquids as fog to alleviate the Covid-19 problem and published their findings in a research paper that is also included in the World Health Organization database. They had a substantial impact on reducing COVID-19 and rose in social standing as a result. It inspires the authors to build and develop a prototype that will significantly impact social life and also play a crucial role in advancing automation technology through an IoT-based smart home that notifies prototype owners of fire and gas leaks. The Arduino IDE builds the system's control and monitoring module [27]. Additionally, this prototype incorporates an automated door lock system that requires a manual keypad entry and pin code to access the house. Rishika Yadav et al. [28] paper named "Sensor Based Smart Fire Detection and Fire Alarm System." presents this paper on the fire alarm, fire control, gas sensor, and GSM module and improve safety. In summary, it can be said that this prototype can be extremely useful in the surveillance system since it can warn the user when someone knocks on the door by recording it on the front door's camera. As a result, the owner can open the door manually or automatically by viewing it on the device after receiving a camera image. It can regulate electricity usage, decrease gas or fire occurrences, decrease house theft, boost security, and make the lives of the elderly, youngsters, and those with disabilities more comfortable and simpler. The designed model is implemented in Fig. 2.

4. THEORETICAL STUDY

4.1 Wireless Sensor Network (WSN)

Wireless Sensor Network (WSN) is a non-infrastructure wireless network technology used in an ad-hoc way to monitor the system, physical or environmental status of huge numbers of wireless sensors. Sensor nodes with inbuilt processors which control and monitor the environment in a specific field are used in WSN. They are connected as a processor in the WSN system to the Base Station. The WSN system base station is connected to data sharing through the Internet.

4.2 The Internet of Things (IoT)

The "Internet of Things" (IoT) refers to the assortment of commonplace objects that have been outfitted with digital connections to the Internet [29]. Internet connections, sensors, and other web-based communication and control technology are included in these devices. The Internet of Things (IoT) enables "dumb" gadgets to communicate with people and other IoT-enabled devices as well as to transport data over the Internet, so transforming them into "smart" devices. The connected "smart house" is an excellent example of how the Internet of Things may be used. Data is shared between physical devices in a connected hub formed by internet-connected thermostats, doorbells, smoke detectors, and security alarm systems. Through a smartphone app or website, users can remotely control the "things" in that hub (such as adjusting the temperature settings, unlocking doors, and so on)

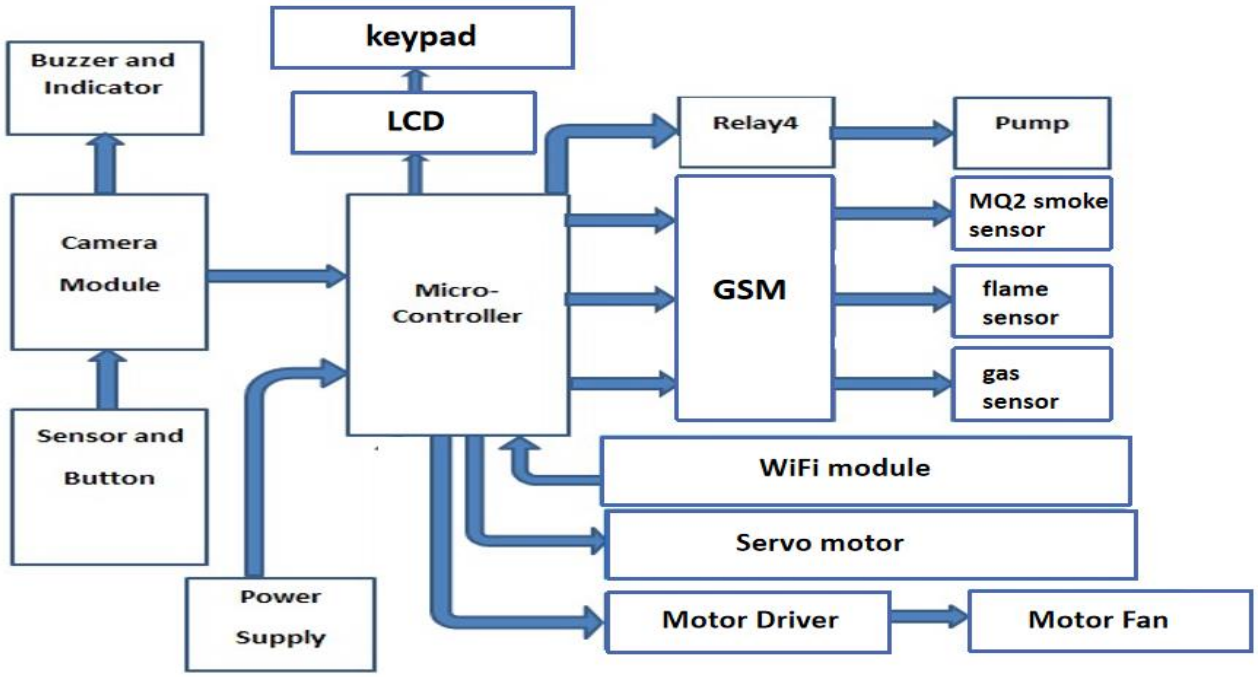

Fig. 2: Integrated Smart Home System

The Internet of Things (IoT) operates as follows:

- Sensors are part of the hardware that collects information or data from the devices.
- The data that the sensors have gathered and subsequently shared processes by software over the Internet via the cloud.
- After that, the program analyses the data and sends it to clients via an app or a website.

4.3 Equipment Used

1) *Equipment for Automated Door lock System - ESP32 Cam, IR Sensor, Relay Module, 7805 Regulator, 16V-100uf Capacitor, Keypad, LCD, Servo motor.*
2) *Equipment for Smock, Gas, Fire & Humidity Detection - DHT11 temperature and humidity sensor, Thermistor, DC motor, GSM, Smoke and Gas Sensor, Flame Sensor*
3) *Equipment for Common Parts - Arduino NANO, ESP8266, Resistor, 12V Power Battery, LED Light, Holder, Jumper and Electric wire, Vero board.*

5. WORKING PROCEDURE

Smart home means will detect and solve the problem by themselves. A smart home has to be able to detect any fire, gas, or Smoke and send an alert to the owner; it can open the door without any physical interaction, owner of the home can control the fan light outside of the home.

5.1 Automated Door Lock System

The main theme of this feature is to open the door without any physical activity. If someone arrives at the door, there will be a sound to alert the owner. Then the mobile app owner can take a picture of that person standing outside the door with the camera placed in front of the door. Then if the owner wants to open the door, press the ON button in the mobile app. Also, the owner can click multiple images of that person to verify. Users can use the automated door lock, a flowchart of the operation of the door has shown in Fig. 3.

5.2 Automated Smoke and Fire Detection Alert System with location Sending

Automated Smoke and Fire Detection means if the sensors placed in different places of the house detect any smoke or fire, they will automatically send an alert message to the owner. With this feature, our system will detect any smoke leakage or fire and alert the owner. It will also send the location of the occurrence. SMS sending procedure is shown in Fig. 4.

6. IMPLEMENTATION OF THE PROTOTYPE

6.1 Hardware Implementation

Working Progress on Automated Door Lock

If the owner wants, he can capture new pictures through the app. The photo will be taken automatically when someone stands in front of the camera. Also, the door can be opened with a password input.

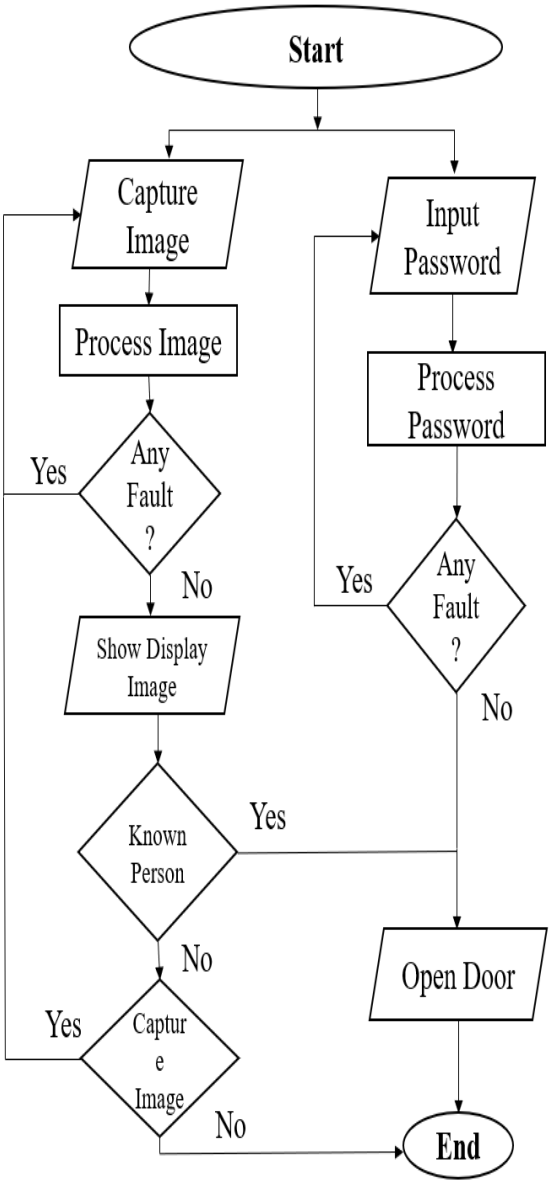

Fig.3: Flowchart of the Automated Door Lock System

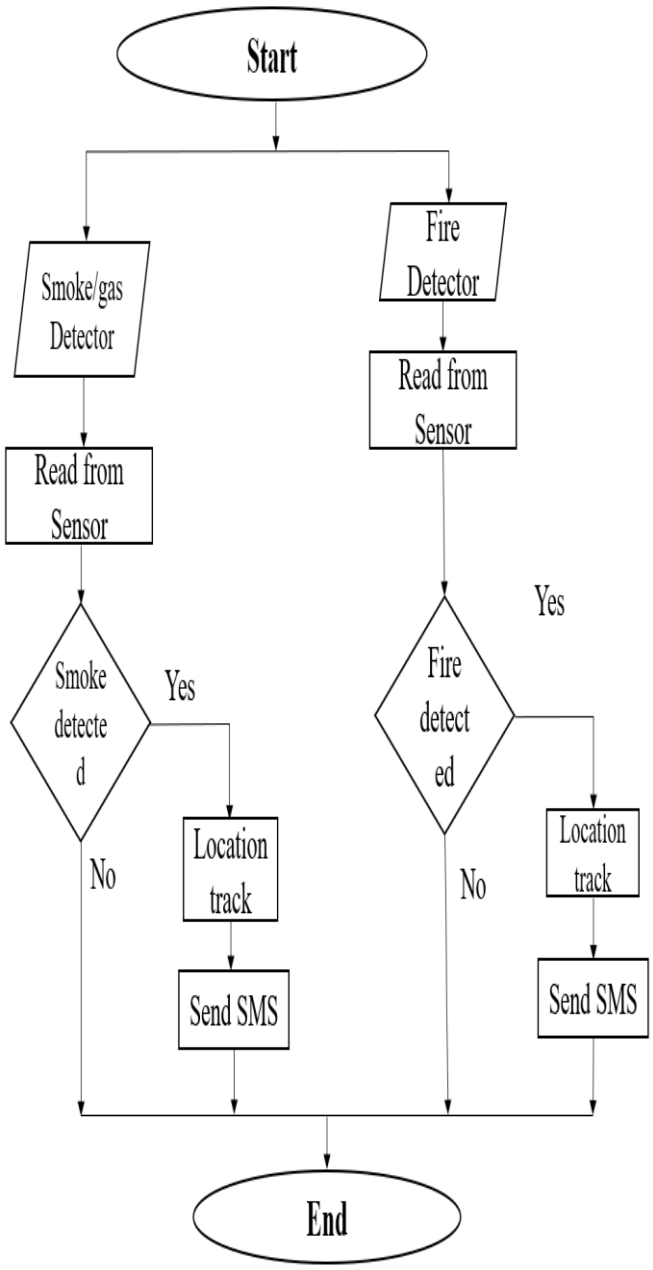

Fig. 4: Smoke and Fire Detection

6.2 Working Progress of Smoke / Fire Sensor with location message

When Smoke or fire occurs within two feet of distance, the sensor's readings will increase. When the sensor's readings increase, the GSM module will send an SMS to the owner in Fig. 6.

6.3 Software Implementation

Working Progress of Automated Fan-Light with Adafruit Server. The user interface was done using the Blynk application in Fig. 7.

6.4 Circuit diagram of the Integrated System

Programming was done using the Arduino UNO. and Node MCU IDE. The schematic Diagram in Fig. 8 and Fig. 9 was generated using Proteus 8 application.

7. RESULTS AND DATA ANALYSIS

The primary object of the proposed research was to develop and measure the price premium that a group of new home buyers would pay for smart technology. The goal was to see if the value of smart technology is represented in the price of new homes on the market. Additionally, the traits of that group must be determined to be compared to the entire population of Bangladeshi homebuyers. The web server page will permit us to screen and control the framework. This web worker page will show up by entering the assigned IP address

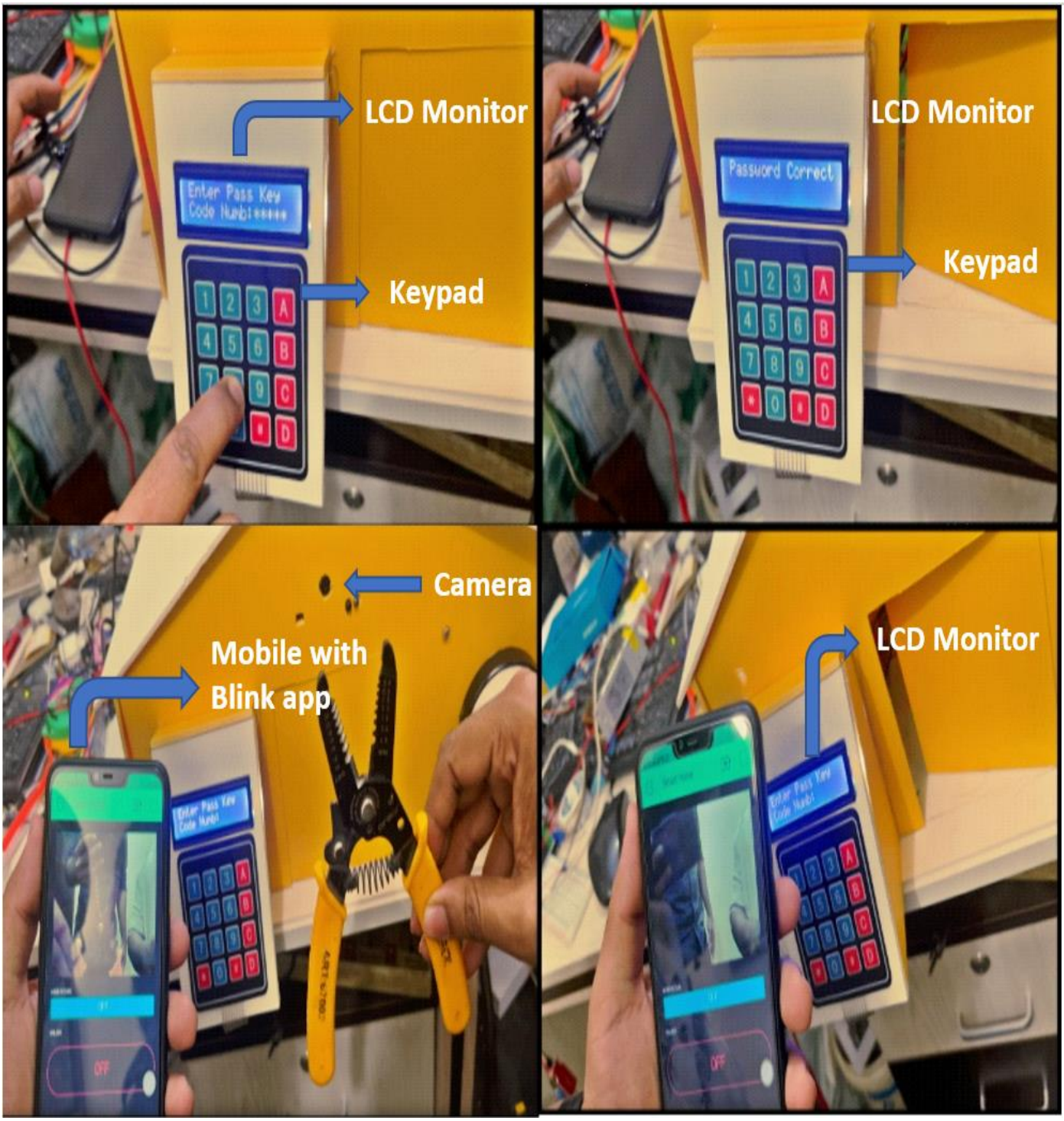

Fig. 5: Procedure of Automated Door Lock

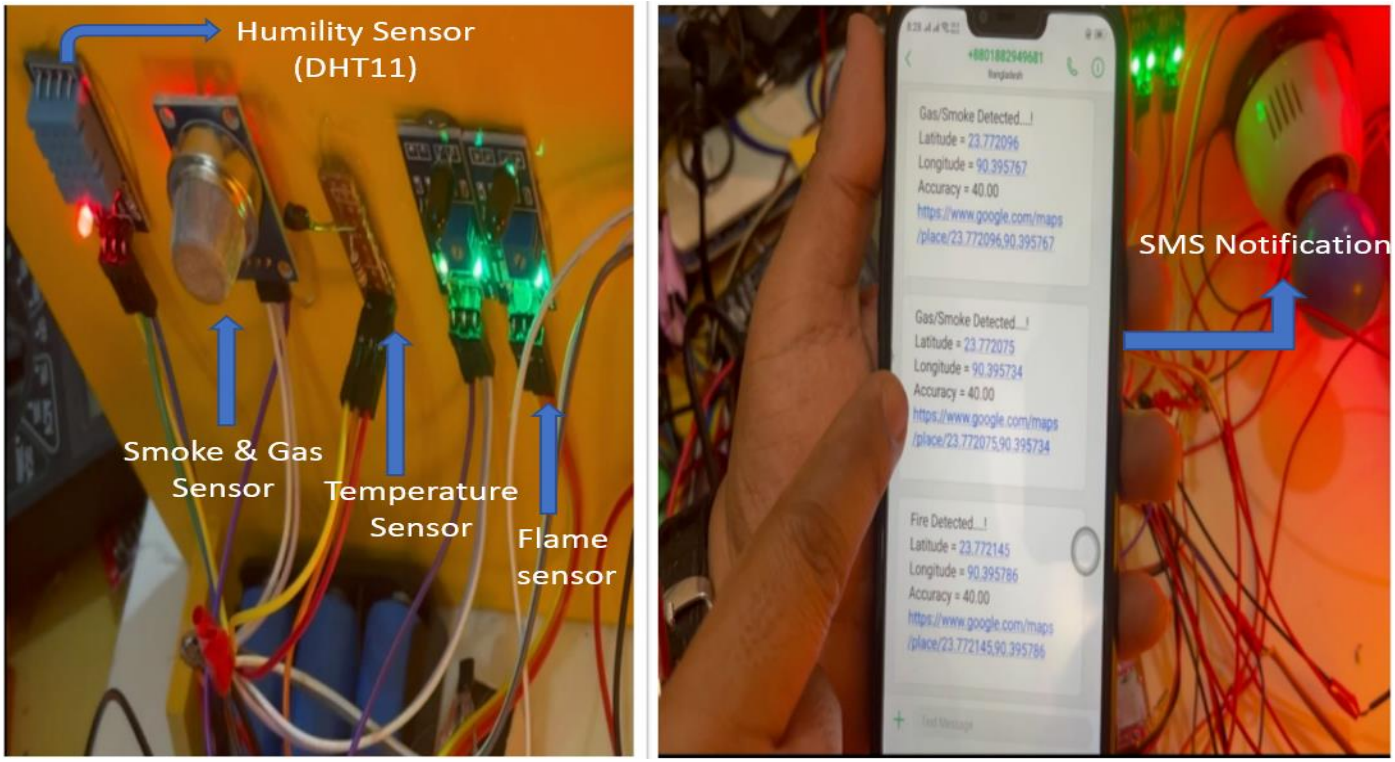

Fig. 6: Smoke and Fire Sensors and Smart alert Message system

Fig. 7: The Interface of The Adafruit Dashboard

in the internet browser. The web server gives data about the temperature in better places of the house and the movement state in the house. It likewise gives the situation with the different electrical apparatuses like door lock, light, fan and so forth, which we can handle distantly. All of the relevant data is saved on the cloud. The information that has been saved is accessible at any time and from any place. It displays the time and the state of the movement locator. This information is stored in the cloud and is accessible to the customer anytime they are away from home. We created an incredibly speedy picture preparation process. The built prototype also used improved fire, gas, and smoke sensors. Our mugginess sensor also provides an accurate result, and the alarm message is delivered in an unreasonably short amount of time.

Table 1. shows the range at which the device's load status is changing. The automatic door opens each time the sensor detects a person or moving item within a range of 300 cm to 500 cm.

Table 2. shows that when the temperature increases above 70°C, the Arduino will signal the owner and create an alarm to notify home users.

Table 3. shows that there are five observations taken from the sensor. When the density of Smoke is 250-400, the alarm sensor will be ON.

Table 4. demonstrates that when an object or person is near 8–12 cm, it automatically takes a picture. The sensor's range determines this distance. The captured power grows along with the range.

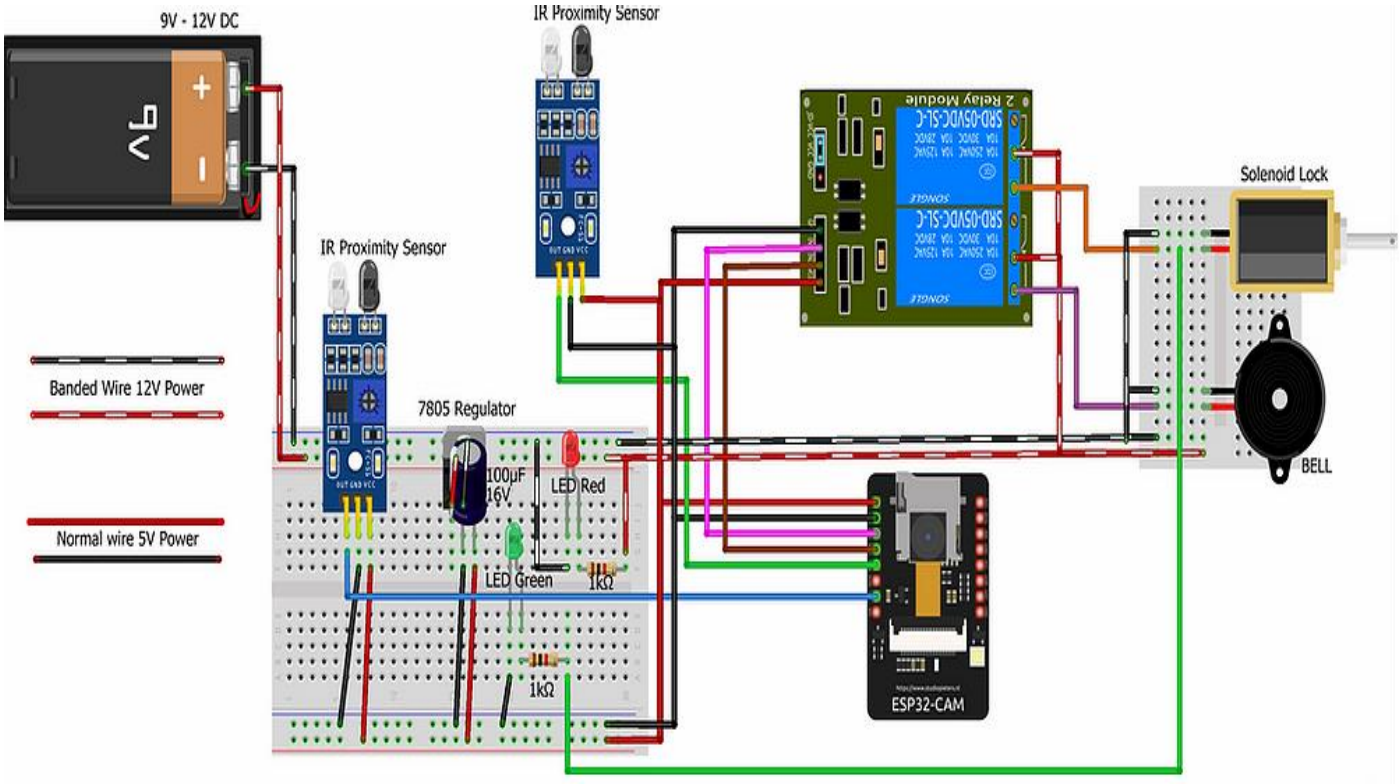

Fig. 8: Automated Door Lock System

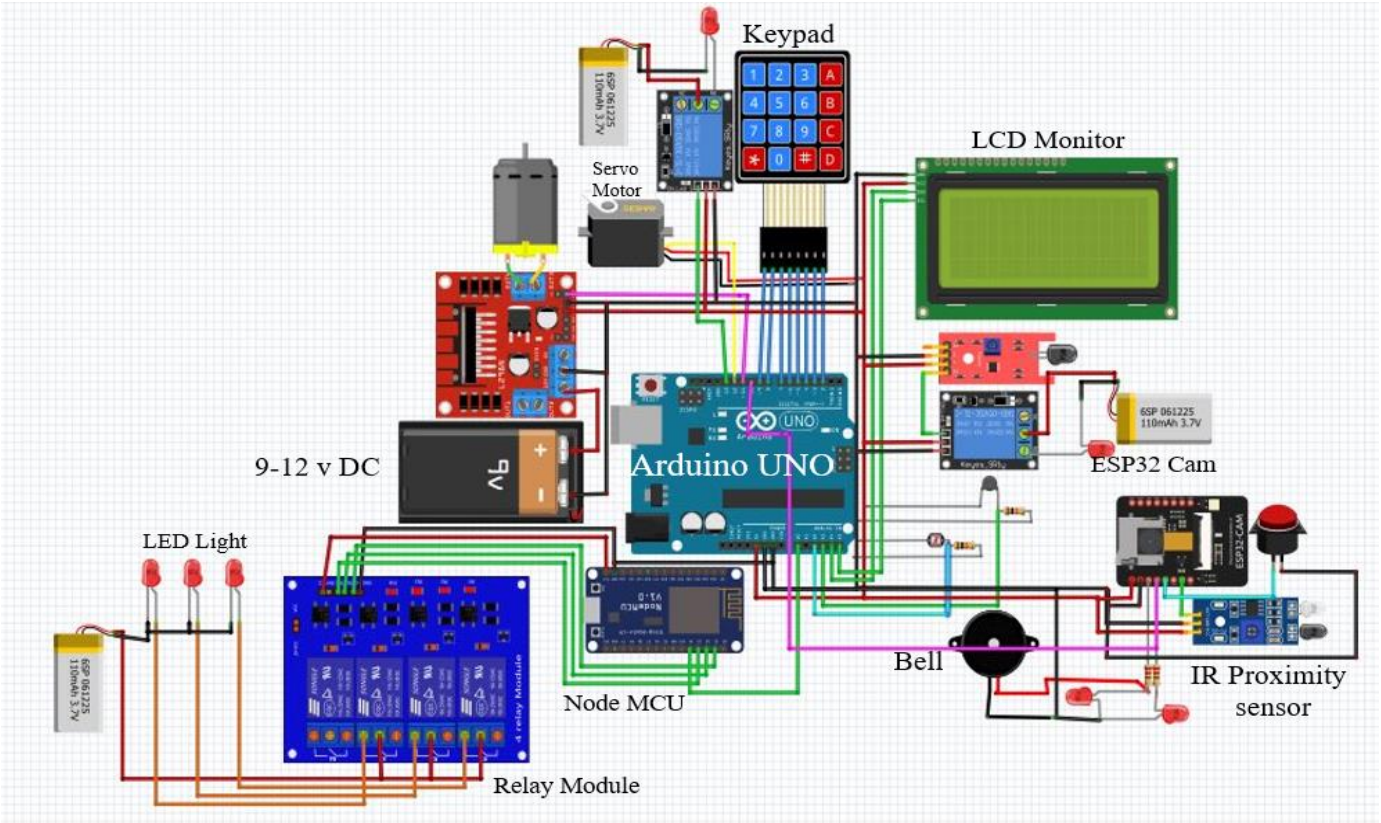

Fig. 9: Integrated IoT-Based Smart Home System

Table 1. Door Sensor Data

Observation	Distance(cm)	Load State
1.	300-400	On
2.	400-500	On
3.	500-600	Off
4.	600-700	Off
5.	700-800	Off
6.	800-900	Off
7.	900-1000	Off

Table 2. Temperature Sensor Data

Observation	Temperature (°C)	Time	Alarm
1.	100	1.0 min	On
2.	90	0.8 min	On
3.	80	0.5 min	On
4.	70	0.0 min	Off
5.	60	0.0 min	Off
6.	50	0.0 min	Off

Table 3. Gas Sensor Data

Observation	Smoke(cm^3)	Time	Alarm
1	400	1.0 min	On
2	280	0.5 min	On
3	250	0.0 min	Off
4	220	0.0 min	Off
5	0-200	0.0 min	Off

Table 4. Picture Capture Time

Observation	Distance (cm)	Action
1.	8 cm	Captured
2.	10 cm	Captured
3.	12 cm	Captured
4.	15 cm	No Captured

8. FUTURE DEVELOPMENTS

Every day, technology advances. When a system is created today, it may be changed tomorrow. Many features will be added to that system in the future.

8.1 Existing Features:

Changes can be applied to the project's existing features in the next phase. There is no auto door lock or open door; users need to click the button in the Blynk app or can control the web browser need to browse to the address io.adafruit.com, and always Internet is required when they want to run the system. If the electronic equipment does not work, an engineer will be needed to fix it. The equipment used in the project is not waterproof; if any water can seep into the device, the system will likely be damaged. Power backup is needed for GSM. The system must always have a SIM connected, and there must be a sufficient balance between the SIM; only then will the location SMS from the SIM go. If there is a lack of power consumption in the project, the system may fall. However, it can be fixed at any time.

8.2 Applicable Improvements:

Attached is a CC TV that can be extra work in IoT based automatic home system using a fingerprint instead of a password. Automatically weather reports also can be added to this system. When an occurrence occurs, a voice alarm help to will help to know or hear; adding a voice control system can help to control this home. This can be an extra feature; using an anti-theft security system can also extra work, and this feature will help to be more secure. Adding time base routing can help and make it easy to everyday li replacing the general door-to-actuator door lock and adding a single or dual-axis solar panel can also be an extra feature work to this project.

9. CONCLUSION

A smart method to automate the home is presented in this paper. This solution has the potential to generate a smart environment and can be carried out automatically. This system will activate the security system and welcome the guest. This paper provides an architecture that discusses low-cost intelligent home security systems. This paper uses an IR sensor to identify the human presence in the environment. It is a significant advantage in this project, and a camera-connected microcontroller can help the user make decisions. Use the flame sensor to identify any fires and flames in this area. The system will alert the homeowner if it detects smoke, fire, or gas leaks. The security of a home cannot be guaranteed in the absence of automation. The proposed solution will create a secure atmosphere and may be used to fully satisfy all requirements for monitoring a home's many characteristics. The suggested method is simple to use, affordable, and capable of quick responses and real-time notifications. By employing this strategy, we will be able to create adaptive, inexpensive, and low-cost smart homes capable of resolving difficulties while conserving energy.

ACKNOWLEDGMENT

The creators of this work wished, first and foremost, to convey their thanks to the Almighty and their parents. The writers would like to express their profound gratitude to Vice-Chancellor Dr. Carmen Z. Lamagna and the computer science and engineering department at American International University-Bangladesh. Both of these departments deserve credit for their contributions. The authors also like to thank Mr. Md. Sayeduzzaman and Mr. Siyamul Islam Sir for their encouragement and direction in finding the best way to finish the research work.

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