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Design and Implementation of Real-Time Kitchen Monitoring and Automation System Based on Internet of Things

Ch Anwar Ul Hassan [1], Jawaid Iqbal [2], Muhammad Sufyan Khan [3], Saddam Hussain [4,*], Adnan Akhunzada [5], Mudabbir Ali [6], Abdullah Gani [7], Mueen Uddin [5] and Syed Sajid Ullah [8,9,*]

1 Department of Creative Technologies, Air University, Islamabad 44000, Pakistan
2 Department of Software Engineering, Capital University of Science and Technology, Islamabad 44000, Pakistan
3 Department of Computer Science, COMSATS University Islamabad, Islamabad 44000, Pakistan
4 School of Digital Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei
5 College of Computing and Information Technology, University of Doha For Science and Technology, Doha 24449, Qatar
6 Department of Computer Science, Federal Urdu University of Arts, Sciences and Technology, Islamabad 44000, Pakistan
7 Faculty of Computing and Informatics, University Malaysia Sabah, Kota Kinabalu 88400, Malaysia
8 Department of Information and Communication Technology, University of Agder (UiA), N-4898 Grimstad, Norway
9 Department of Electrical and Computer Engineering, Villanova University, Villanova, PA 19085, USA
* Correspondence: saddamicup1993@gmail.com (S.H.); syed.s.ullah@uia.no (S.S.U.)

Abstract: Automation can now be found in nearly every industry. However, home automation has yet to reach Pakistan. This paper presents an Internet of Things smart kitchen project that includes automation and monitoring. In this project, a system was developed that automatically detects the kitchen temperature. It also monitors the humidity level in the kitchen. This system includes built-in gas detection sensors that detect any gas leaks in the kitchen and notify the user if the gas pressure in the kitchen exceeds a certain level. This system also allows the user to remotely control appliances such as freezers, ovens, and air conditioners using a mobile phone. The user can control gas levels using their phone with this system. In this paper, the ESP32, DHT11 Sensor, 5 V Relay X 8, and MQ-135 gas sensors create a smart kitchen by controlling the temperature, managing humidity, and detecting gas leakage. The system was built on an Arduino board that is connected to the Internet. The hardware was integrated and programmed using an Arduino, and a user Android application was developed. The project's goal is to allow any Android smartphone to remotely control devices. This method is commonly used in homes, businesses, and grocery stores. Users will be able to control all of their instruments from anywhere, including switches, fans, and lights. Furthermore, simulation was performed using Matlab2016b on multiple houses. In the simulation, not only was the kitchen considered, but also two, four, and six houses. Each house has two bedrooms, one living room, one guest room, two bathrooms, and one kitchen. The results revealed that using this system will have a scientifically significant impact on electricity consumption and cost. In the case of the houses, the cost was USD 33.32, 32.64, 22.32, and 19.54 for unscheduled, two, four, and six houses, respectively. Thus, it was observed that the cost and power are directly proportional to each other. The results reveal that the proposed solution efficiently reduces the cost as compared to that of unscheduled houses.

Keywords: Internet of Things; smart kitchen; monitoring system; automation system; home appliances

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1. Introduction

Automation is now being used in almost every type of industry. However, home automation has not yet fully penetrated homes, especially in Pakistan [1]. This paper presents a project for an IOT-based smart kitchen with an automation and monitoring system. In this project, the system automatically detects the temperature of the kitchen.

In addition, it also measures the kitchen's humidity. In the system, built-in installed gas detection sensors automatically detect the leakage of gas, if present, in the kitchen and other rooms. If the gas pressure of the room/kitchen increases and crosses a certain level, then this system will send a notification on the user's mobile. This system also enables the control of various appliances, such as the freezer and oven, by a mobile phone; for example, they can be automatically turned on/off through the mobile phone. The gas level of the house can also be controlled through the mobile phone using this system. The system was developed using an Arduino board that is connected to the Internet [2]. Its goal is to allow any smartphone running the Android operating system to operate devices remotely. This technique can be used mostly in households, industries, and general stores, among other places. While implementing this system, users will be able to manage all of their instruments, such as switches, fans, and lights, from any location. With time, innovations in a variety of fields of life are being introduced, which are substantially assisting humans in their efforts to save time. The value of time cannot be overstated, and everyone strives to conserve their time to the greatest extent possible.

As innovations and technological advancements are introduced, homes are becoming increasingly intelligent, cost effective design of house hold items [3]. Modern homes are gradually transitioning away from traditional switches and toward centralized control systems that include remote-controlled switches and other devices [4]. In a similar vein, in this study, a smart kitchen with an automation and monitoring system saves people's time while also doing something novel. This technology allows the user to operate their home appliances from their mobile phone, which is a convenient feature. With the help of the Android app, users may remotely control their household appliances, such as turning on and off the AC, refrigerators, gas stoves, etc. The applied sensor in this system will automatically detect the temperature, humidity, and leakage of gas, and inform the user on their smartphone if any abnormality is found. Similar concepts are presented and similar automation methodologies and sensors are used in the smart system for a smart kitchen [3]. The kitchen is one of a smart home's most crucial spaces for a gas stove, refrigerator, and boiler [4]. Electricity and gas are the energy resources, and these need to be managed efficiently to allow for the better usage of energy and to save energy for later use, because the world, especially underdeveloped countries, is facing an energy crisis. Management and saving of energy will allow its better utilization for other purposes or for industries; when these industries are properly operational, their trading opportunities will increase. Thus, by using the proposed system, we can manage energy usage, from a single house to a wider scale. However, by moving towards a wider scale, we need to bear the hardware cost.

The proposed system is based on the creation of an IoT prototype for the control of kitchen AC appliances. In this study, the proposed system is used to remotely turn on and off appliances, such as by using a smartphone or tablet. The project also incorporates certain sensors such as light sensors, temperature sensors, and safety sensors, and automatically adjusts different parameters such as room lighting, air conditioning (kitchen/room temperature), and door locks; information is transmitted to the user's phone. Furthermore, users can connect or link to the Internet to control the home from a remote location while monitoring safety.

1.1. Contributions

Several authors have worked on smart kitchen automation and monitoring systems. Some have only focused on specific applications and some authors applied the machine learning application for analysis. In Our proposed system, the user can monitor the smart kitchen in real-time and not only control the smart appliances, but also monitor and control the other rooms of the home. We performed a simulation on two, four, and six houses. However, the main focus is to monitor and control the smart kitchen to manage the appliances, kitchen temperature, humidity, and gas leakages, and to inform the user by notification and by alarm.

In this project, a system was developed that automatically detects the kitchen temperature. It also monitors the humidity level in the kitchen. This system includes built-in gas detection sensors that detect any gas leaks in the kitchen and notify the user if the gas pressure in the kitchen exceeds a certain level. The gas levels can be controlled using a phone with this system. This system also allows the remote control of appliances, such as freezers, ovens, and air conditioners, using a smartphone. The major benefits of this project are saving the electricity cost by remotely managing the appliances, and reducing the harm that could be caused by gas leakage. The contributions of our proposed system are listed below:

- A smart kitchen automation system based on an Arduino board is used to control the kitchen/home appliances that are connected to the Internet and being operated remotely from any Android smartphone.
- The ability to remotely turn on and off appliances using a smartphone, such as:
    - User turns on/off the oven, fridge, exhaust fan, lights, etc.;
    - Using the app, the user can remotely measure the temperature, humidity, and possible gas leakages, and set the gas level using ESP32, DHT11 Sensor, 5 V Relay X 8, and MQ-135 gas sensors;
    - IR sensors are also integrated into the Arduino to detect the presence of humans in the room/kitchen.
- Simulation was performed on Matlab2016b by considering the unscheduled home appliances and appliances in two, four, and six homes to check the efficiency of the proposed system in terms of reducing the electricity cost.

1.2. Paper Organization

The rest of the paper is arranged as follows: The related work is described in Section 2. In Section 3, the proposed methodology is discussed. Results of the experiment are presented in Section 4, Finally, in Section 5, conclusions are presented.

2. Related Work

In this section, research efforts related to the Internet of Things are discussed. IoT is used for monitoring and automating the smart kitchen and smart homes.

The Internet of Things (IoT) is an extension of the current Internet that allows gadgets or physical items to communicate, interact, and use the Internet. To aid management and mitigate the dangers associated with IoT smart homes, smart homes require a dependable, simple, and autonomous network infrastructure. A previous article describes the present state of the Internet of Things and smart homes, and the trends in their growth, and closely investigates the security issues in smart homes [5]. A smart home system ensures the security and safety of the owner's house. It protects against gas leakage, detects fire, enables room temperature and humidity monitoring, and detects water overflow from roof tanks. The aim of the suggested system is to create a safe home system by making accessibility simpler for handicapped persons, especially youngsters and the elderly [6]. The dynamics enabled by the introduction of the IoT in the furniture and kitchen production industries, are discussed in [7]. In [8], the author designed an IoT-based smart kitchen wardrobe control system. The system was designed and developed using an Arduino and a mobile application. The grocery products in a kitchen must be manually monitored, and the user must make decisions [9]. Grocery shopping can now be undertaken online. However, keeping track of the goods is the primary responsibility of the person in charge of the kitchen; failure to do so will result in a lack of ingredients. The authors of [10,11] imagined an automated system using IoT technology to for home automation system and monitor kitchen groceries and cooking ingredients. The IoT is widely used for smart kitchens. In [12] author use the IoT for home grocery monitoring system as the sensors are involved to sense the behaviors associated with grocery replenishment, and to analyze the data to track and predict the grocery demand for a smart kitchen.

Many intelligent and smart safety and security systems for kitchens have been proposed by researchers. There is now an important need to ensure the kitchen's safety and security. Systems have been designed to give users a variety of options for checking, managing, controlling, and monitoring kitchen data [13]. To monitor the kitchen, researchers have incorporated a variety of technologies, such as sensors, ZigBee, databases, embedded tools, Web applications, and mobile development used in [14]. In [15], a smart and safety monitoring system is powered by the following sensors: a DTH11 sensor monitors the humidity and temperature of the kitchen; an IR flame sensor detects the presence of fire in the kitchen's surroundings; and an MQ-3 sensor detects any gas leakage in the kitchen. Gas leakage is a major issue in kitchens and causes many problems, such as the spread of fire. Because the spread of a fire can often lead to significant loss of life and property damage, early detection of fire sources, and identifying effective remedies, have become critical challenges in fire prevention and property protection [16]. Thus, refs. [17,18] investigated kitchen gas leakage issues, and the investigators proposed an IoT-based kitchen gas leakage management and control system to manage kitchen safety. To address kitchen safety issues, the authors of [19] placed Internet protocol cameras, so that residents can monitor the gas stove from their phones, and used an alarm to alert the occupants.

In [20], the author proposed a home automation system to make it easier for handicapped people. A live monitoring system provided real-time updates on the energy usage of a room or a hall. The system was built around a few sensors and detectors that were integrated with a Raspberry Pi [21]. Authors have used a Raspberry Pi [22] and an Arduino [23], with an Android app for home automation and monitoring systems, respectively. The design challenges of home automation have become more apparent as technology has become more invasive [24]. Home automation, in addition to surveillance system security based on IoT, are important [25], because home automation, monitoring, and programming by the end user have yet to become commonplace. Artificial intelligence applications in smart kitchens' automation systems have been designed and used in everyday kitchen appliances [26]. Temperature and weight sensors are part of the automation system. A developed system continues to monitor kitchen services [27]; the smart kitchen prototype is placed in a miniature kitchen, and the layout of each indicator and sensor is adjusted to the actual system condition to control the kitchen appliance [28]. IoT-based smart kitchens with automation and monitoring systems, including for the smart home, smart city, smart grid, smart health, and smart kitchen, have been developed [29]. The IoT-based smart kitchen has been examined, including its importance for safety and security, particularly for children and adults, and the smart kitchen's various roles [30]. The Nuvoton smart kitchen system was designed. The smart kitchen system includes subsystems such as a gas leak detection system and a fire extinguishing system [31]. The smart kitchen has the capability of significantly improving one's lifestyle. Another study [32] proposed the implementation of an interactive kitchen monitoring system and an automation system in the kitchen. The trend is to build smart kitchen systems using the hardware system framework of a future home smart kitchen, terminal, kitchen central processor, and service robot [33].

Our project aims to create a new smart kitchen that can be controlled remotely. Another system controls and operates the entire grocery system [34]. Similarly, the smart HAC system for the smart kitchen presents a similar type of idea and uses similar methodologies and automation sensors [35]. The kitchen is one of the most important rooms in a smart home, and can include a smart boiler, smart refrigerator, gas stove, and smart table [36]. Another author [37] presented a system idea based on the development of an IoT prototype for controlling the AC appliances in the kitchen. To access a smart kitchen, [38] created a Web platform for smart kitchens. The created Web platform includes a user interface through which the user can inspect the monitored sensors and control the smart kitchen appliances. In [39]. The author mounted a camera permanently in the smart kitchen cabinet to monitor and control the smart kitchen appliances. A Decision Tree-based approach was used in [40] for the Human Health Index and to monitor the kitchen effectively. A DeepSafe system was proposed by an author using the Internet of Things-based Hybrid Kitchen

Safety Protecting System with Stove Fire Recognition in [41]. Researchers have undertaken work to make human life easier and more efficient by automating tasks [42]. In this regard, our proposed home automation system based on IoT was designed and employed in the kitchen to automate and monitor smart kitchen appliances.

3. Problem Scenario

The field of automation has evolved significantly in the industrial sector, as evidenced by the fact that most vehicle manufacturing plants and bottling plants have automated assembly lines [43]. However, automation has not yet made its way into most homes, particularly in Pakistan. Automation may be utilized in houses, which would make everyday living slightly easier [44]. Additionally, people are becoming more familiar with the usage of smartphones and tablets, which can perform a large portion of the work that can be done by a computer [45].

As a result, a low-cost home automation system was developed that would allow cell phones to be used to assist in automating the entire house. The user will be able to access and operate all of the subsystems in the house using this system, which will be accessible via the Internet. While considering the kitchen appliances, the problem scenario faced by the user is the need to turn on/off the fan, exhaust fan, fridge, lights, and other appliances. Another major issue that people deal with regularly in their homes is the occurrence of gas leaks and the collapse of appliances such as refrigerators, air conditioners, and other similar items. There is no way to stop the increase in these types of situations, which are occurring daily.

4. Proposed Methodology

In this section, the proposed methodology for monitoring and automating the smart kitchen is discussed. Because automation has not yet made its way into most kitchens, particularly in Pakistan, our primary goal was to design a smart kitchen automation system based on an Arduino board connected to the Internet, and which is capable of being operated remotely from any Android OS smartphone. At the moment, standard wall switches are dispersed throughout the house or in a kitchen, making it difficult for the user to get close to them to activate them. It is even more difficult for persons who are elderly or physically challenged to do so in this environment. With the use of smartphones, a remote-controlled home automation system yields the most modern solution. To accomplish this, the Arduino board placed at the receiver end communicates with the Internet, while a GUI program on the mobile phone running on the transmitter end delivers on/off orders to the receiver where the loads are connected, and vice versa. Through the use of this technology, the loads can be turned on and off remotely by simply tapping the designated location on the GUI. The Arduino board manages the loads by controlling them with relays. The project is an Internet of Things (IoT)-based smart kitchen with an automation and monitoring system. Using this system, the user can manage numerous appliances, such as freezers, ovens, air conditioners, and other similar devices, with their cell phone. The user can also regulate the gas level in their home from their smartphone or tablet. The ultimate goal is to make it possible for any smartphone running the Android operating system to control devices from a distance. Figure 1 illustrates the proposed solution.

Figure 1. Proposed automation and monitoring system.

4.1. System Analysis

Problem analysis serves as the foundation for the design and development phases of software development. The problem is studied in order to provide enough information to develop a new solution. Large problems are broken into smaller ones to make them more intelligible and easier to solve. Similarly, in this project, all duties were subdivided and categorized. Table 1 shows the capabilities or services that the system is expected to provide.

Table 1. System functionality.

Functionality	Services
Human Detected	User can check people in the kitchen
Temperature	The user measures the temperature of the kitchen
Humidity	User checks humidity
Lights On/Off	User check lights and turn on or off lights in the kitchen
Fan On/Off	User turns on/off exhaust fan
Gas Leakage	User can check gas leakage and set gas level
Oven On/Off	User turns on/off the oven
Fridge On/Off	User can turn on/off fridge

4.2. System Requirements

Specific hardware and software are employed to meet system requirements. A computer, for example, may require a specific I/O port to interact with a peripheral device. A smartphone may require a specific operating system to run a specific app. The system requirements can be verified before purchasing a software application or hardware device to ensure that the product is compatible with the system. The following are typical system requirements:

I. Hardware Required
   a. ESP32
   b. DHT11 Sensor
   c. 5 V Relay X 8
   d. MQ-135 Gas sensor
   e. Prototyping board (Breadboard)
   f. Connecting wires

g. 5 V power supply
h. Smartphone or tablet:
   i. Minimum 2.4 GHz processor
   ii. Minimum 4 GB RAM
   iii. Minimum 16 GB hard disk

II. Software Required
   a. Arduino IDE
   b. Android application.

4.3. Appliance Flow Design

The process of transforming what was discovered during domain analysis into a workable implementation is known as system design. This design implementation will carry out the system charter and lead to system reuse across several systems. In design mode, components such as sensors are placed to control the controllers through the Wi-Fi using the developed Android applications. The working flow is shown in Figure 2.

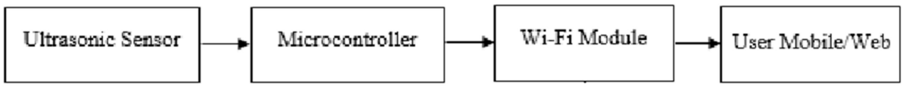


Figure 2. Working flow of the designed system.

The illustration of software object interactions via messages is emphasized in interactive modeling. The activity diagram is included. This is another crucial diagram in the UML for describing the dynamic characteristics of the system. An activity diagram is a flow chart that depicts the transition from one activity to another. The action can be described as a system operation. Thus, the control flow is drawn from one operation to another, as the gas leakage operations status is presented in Figure 3.

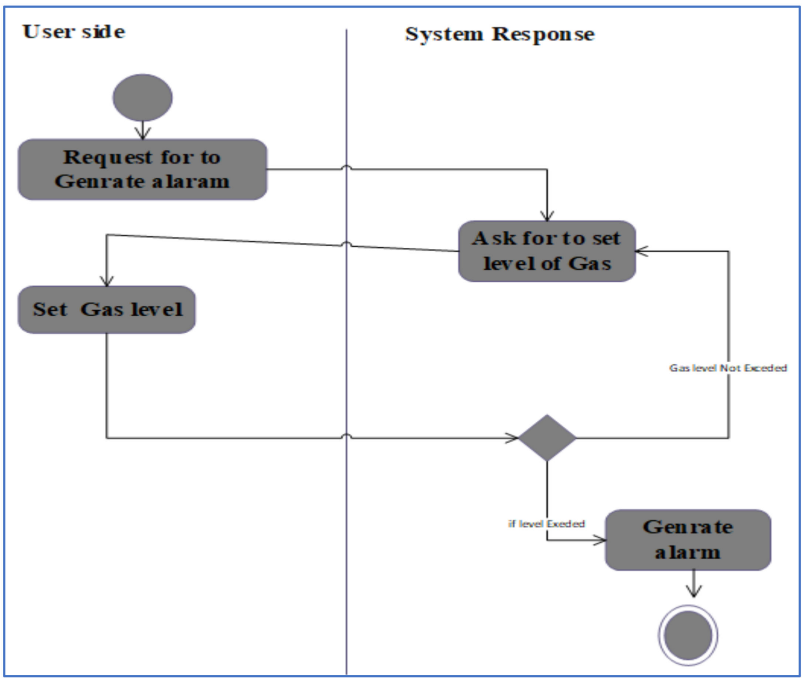


Figure 3. Gas leakage on/off status.

4.4. Implementation Details

Implementation refers to the process of ensuring that the system is operational, and then allowing customers to gain control over its operation for use and evaluation. The implementation stage of this project began after the design phase. During this step, a design is turned into usable software. The program is designed in such a way that it can meet the needs and expectations of the users. The tool used in the project implementation and the component that is used to implement the system are converted in the implementation of any system. In the existing system [46], functionality was upgraded to meet our needs, and simulated because there is always an opportunity for improvement in the system. The code for our proposed system is attached in the Appendix A.

4.5. Working on Our Proposed System

In this section, the working prototype of our proposed system and the screenshots of the mobile application are presented. Figure 4 illustrates the working mechanism using the mobile application. This shows how the user uses the mobile application to turn on the sensors, and the sensors operate using the application; the user can also control the application using the mobile application. Then, users check the status of the planned sensors on certain applications and, by monitoring the status, can turn them on or off; for example, in the case of humidity and gas leakage, the measurement actions can be used.

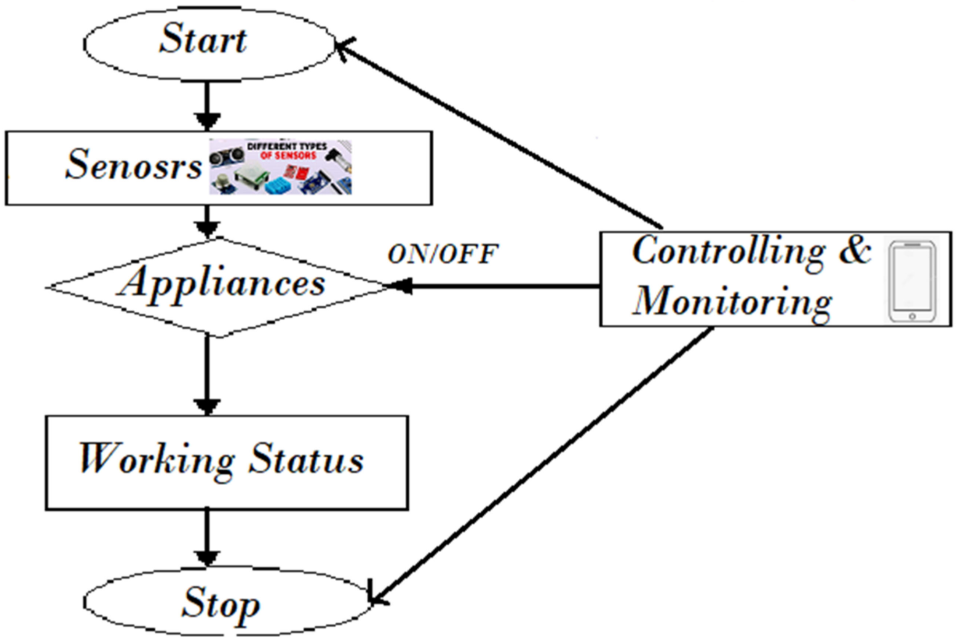


Figure 4. Working system controlled through a mobile app.

As discussed in the implementation section, after updating the existing system [29] according to the system requirements, the hardware and software listed in Section 4.2 were integrated. The working of our proposed system was then tested, as shown in Figure 5. The simulation was performed on Matlab2016b to observe the number of successful results attained from this proposed smart kitchen monitoring and automation system.

The working Android mobile application screenshots of the proposed system are shown in Figure 6a–d of the fridge, shared access, human detection, and temperature and humidity, respectively.

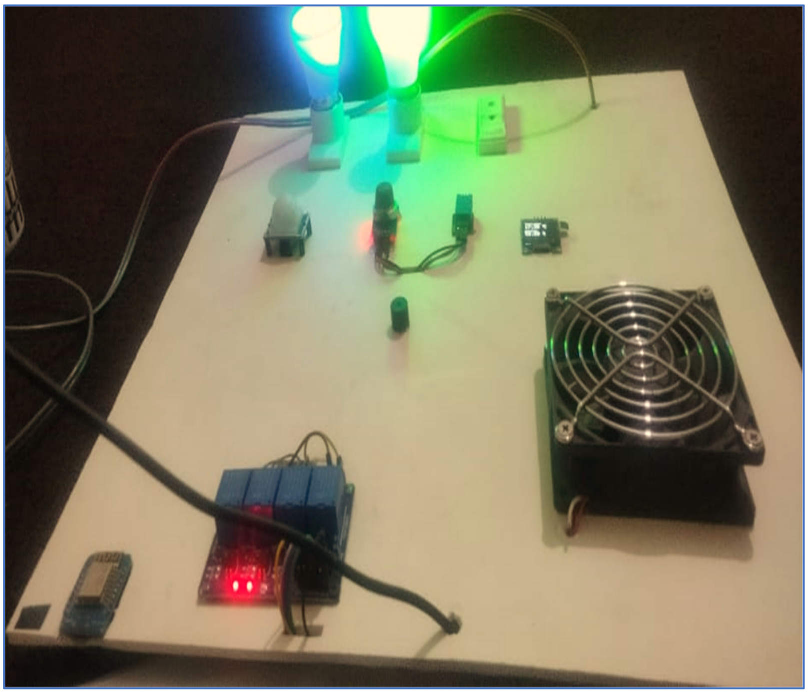
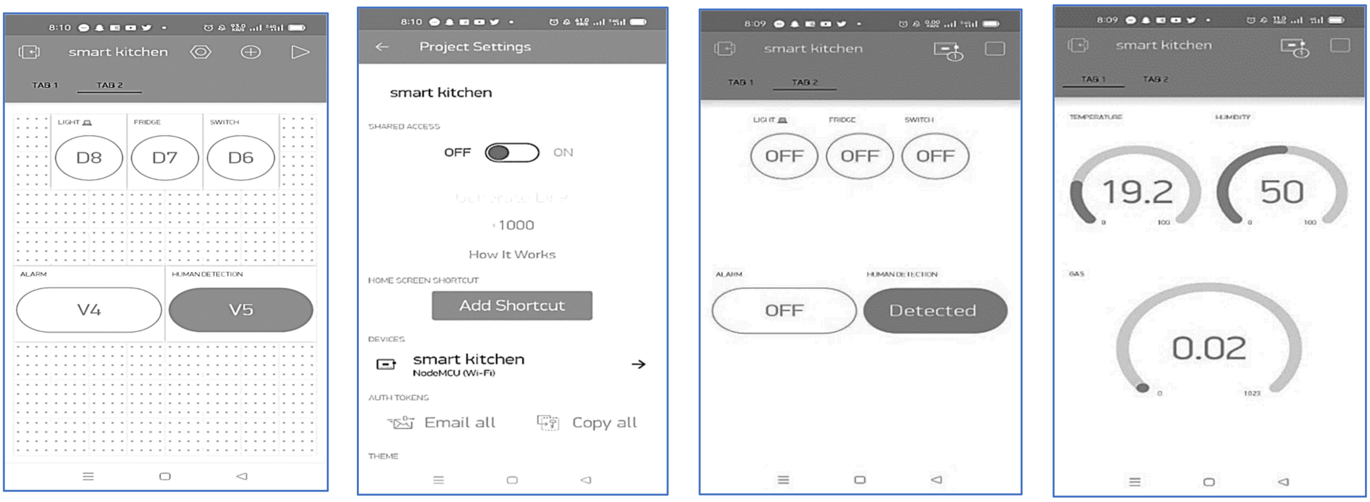


Figure 5. Working prototype of proposed system.



(**a**) Fridge on/off status. (**b**) Shared access. (**c**) Human detected. (**d**) Temperature and humidity.

Figure 6. Monitoring and Automation through Integrated Android Application.

5. Simulation Results and Discussions

In this section, simulation results are presented. The developed system was installed in multiple houses to control and monitor their appliances and check the effectiveness of the system. Users gained control by installing the smart home Android application, which controls the controllers that were programmed through an Arduino. In this way, the designed home automation system is operated. To check the effectiveness of this system, a low-level simulation was performed by providing some data input as observed in several houses.

We can implement this system on a larger scale, but the hardware implementation cost will be increased as we need to adjust the hardware for each electronic or appliance. The Android applications work smoothly because, from an Android, only the devices are controlled. Furthermore, the Internet is the basic requirement to operate this system smoothly. Thus, for a wider scale, a stable connection and the related hardware are needed.

The simulation was performed using Matlab2016b on multiple houses. To perform the simulation of the proposed system, the system was not only implemented in the kitchen; rather, the whole home was considered. However, the focus was on the kitchen appliances. The simulation considered two, four, and six houses. On average each house has two bedrooms, one living room, one guest room, two baths, and one kitchen. The averages in each house were considered, as follows. It was assumed each house uses eight lights of 60 watts, that are used daily for 4/12 (4 lights are on 12 h a day, or 2 lights are on 24 h a day), for 60 × 2 = 120 watts, and two fans are used daily for 2/24 (which means 3 fans are used daily for approx. 24 h per day), for 2 × 120 = 240 watts. Thus, the lights and fans use 360 watts of energy daily. In addition, the other items such as fridges, ovens, and irons, use around 340 watts. Thus, the daily usage of every house is approximately 800 watts.

$$Daily\ Units = \frac{Wattage\ \times\ Usage\ hours\ per\ day}{1000} \tag{1}$$

Placing the values in Equation (1) gives:

$$Daily\ Units = \frac{700 \times 24}{1000} = 16.8$$

If 1000 watts or 1 Kilowatt of power is used for 1 h then it consumes 1 unit [47]. This means that it consumes approximately 16.8 units daily, and the price of 1 unit is USD 0.045 [48].

$$Monthly\ Units = \frac{Units\ \times\ 30\ (days\ of\ month)}{1000} \tag{2}$$

Placing the values in Equation (2) gives:

$$Monthly\ Units = 16.8\ \times\ 30 = 504$$

Now the total cost is obtained using Equation (3). The per unit cost of electricity is = USD 0.045.

$$Total\ Cost = Monthly\ Units\ \times\ Per\ Unit\ cost \tag{3}$$

$$Total\ Cost = 504\ \times\ 0.045 = 22.68\$$$

So, the total cost of an average house for a month is approximately USD 22.68.

It is observed that the proposed solution can efficiently reduce the cost as compared to that of unscheduled houses. In addition, by increasing the number of houses, the overall usage of power is reduced. In turn, this reduces the cost, as shown in Figure 7, which is USD 33.32 in the case of unscheduled houses, and USD 23.64, 22.32, and 19.54 for two, four, and six houses, respectively. Cost and power are directly proportional to each other, as shown in Figure 8. The simulation results reveal that by controlling and monitoring the smart kitchen, the user not only controls the cost but also saves energy/electricity.

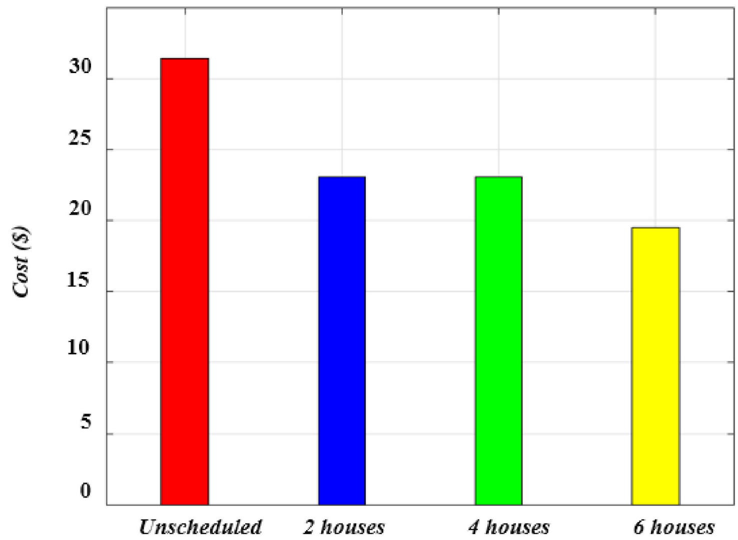


Figure 7. Electricity cost.

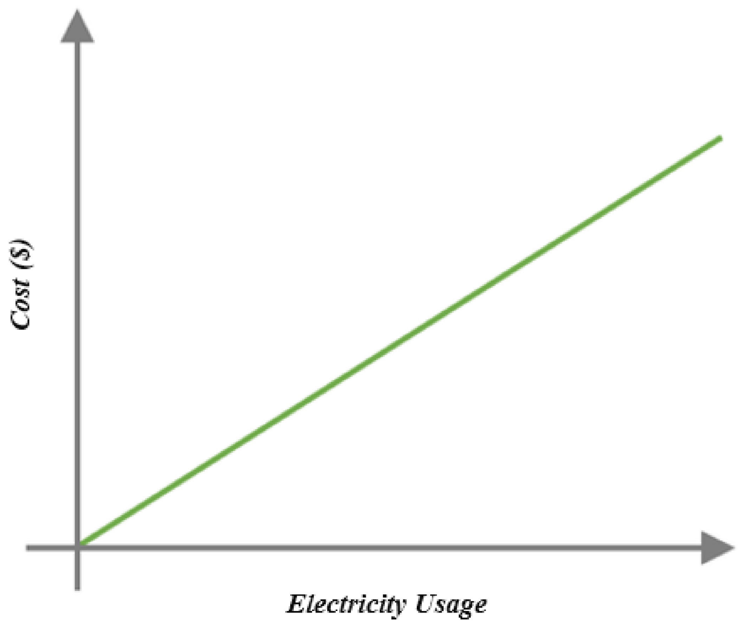


Figure 8. Electricity cost vs power usage.

6. Conclusions

This paper presents a smart kitchen with automation and monitoring system project that is currently in development. The technology enables the user to control their home appliances from their mobile phone, which is a desirable function. Users are able to turn on and off their air conditioning and other domestic equipment such as refrigerators, gas stoves, freezers, and ovens, and manage the gas level in their homes. An Internet of Things (IoT)-based smart kitchen with an automation and monitoring system is the focus of this project. The ultimate goal is to make it feasible for any smartphone running the Android operating system to operate devices from a distance using the Android remote control application. With this technology, the user can control the amount of gas that is released into the home directly from their smartphone. Furthermore, a simulation was performed in Matlab2016b; the cost achieved for unscheduled houses was USD 33.32, and that for two, four, and six houses was USD 23.64, 22.32, and 19.54, respectively, indicating that cost and power are directly proportional. The results show that the proposed solution is more cost effective than unscheduled houses. The results showed that using this system has a scientifically significant effect on electricity usage and cost. In the future, we will integrate machine learning techniques to further optimize this system and provide the predicted pattern to the user for operating their home devices.

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Appendix A

The code for our suggested system is provided below:

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>    // library for esp8266 wemos d1
#include <BlynkSimpleEsp8266.h> // library used for blynk server
#include <SPI.h>  // for Serial Peripheral Interface
#include <Wire.h> // library for connection wires
#include "MQ135.h" // for gas sensor
#include <Adafruit_Sensor.h> //for dht11 sensor temperature
#include <DHT.h> //for dht11 sensor for Humidity
#include <Adafruit_GFX.h> //for display graphics
#include <Adafruit_SSD1306.h>// for display
 // here we put the auth keys, wifi name and password
char auth[] = "2_8j5tDDh--zGKB-hnzYRyuXuB_aCdyP";    // You should get Auth Token in the Blynk App.
char ssid[] = "Automation";                           // Your WiFi credentials.
char pass[] = "pakistan";                             // wifi password
 // here we specify the pin no for the sensor
#define SCREEN_WIDTH 128    // OLED display width, in pixels
#define SCREEN_HEIGHT 64    // OLED display height, in pixels
#define OLED_RESET -1       // Reset pin # (or -1 if sharing Arduino reset pin)
#define DHTTYPE DHT11     // DHT 11
#define DHTPIN D4
#define relay_fan D5
#define relay_light D6
#define relay_fridge D7
#define relay_oven D8
#define buzzer_alarm D0
#define pir_human D3

int alarm_status;
int pir_status = 0;

DHT dht(DHTPIN, DHTTYPE);
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
void setup()
{
  Serial.begin(115200);
  dht.begin();
```

```
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C); //initialize with the I2C addr 0x3C (128x64)
  Blynk.begin(auth, ssid, pass);

  pinMode(pir_human, INPUT);
  pinMode(buzzer_alarm, OUTPUT);

  //code for relay ON and OFF
  pinMode(relay_fan, OUTPUT);
  pinMode(relay_light, OUTPUT);
  pinMode(relay_fridge, OUTPUT);
  pinMode(relay_oven, OUTPUT);
  digitalWrite(buzzer_alarm, LOW);
  digitalWrite(relay_fan, HIGH);
  digitalWrite(relay_light, HIGH);
  digitalWrite(relay_fridge, HIGH);
  digitalWrite(relay_oven, HIGH);
  delay(100);
}
void loop()
{
  Blynk.run();
  MQ135 gasSensor = MQ135(A0);
  float air_quality = gasSensor.getPPM();

  float t = dht.readTemperature();
  float h = dht.readHumidity();
  pir_status = digitalRead(pir_human);
  alarm_status = digitalRead(buzzer_alarm);

 // code for motion sensor "pir sensor"
  if (pir_status == 1)
  {
    Serial.println("Person Detected");
  }
  else if (pir_status == 0)
  {
    Serial.println("No One in Room");
  }
 // code for MQ135 sensor
  if (air_quality > 150)
  {
    digitalWrite(buzzer_alarm, HIGH);
    digitalWrite(relay_fan, LOW);
    Serial.println("Buzzer Status: ON");
    Serial.println("Exhaust Fan: ON");
  }
  else
  {
    digitalWrite(buzzer_alarm, LOW);
    digitalWrite(relay_fan, HIGH);
    Serial.println("Buzzer Status: OFF");
    Serial.println("Exhaust Fan: OFF");
  }
  Serial.print("Air Quality: ");
  Serial.print(air_quality);
  Serial.println(" PPM");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.println(" *C");
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.println(" %");
  Serial.println();
  Serial.println("****************************");
  Serial.println();
 // sending data to Blynk server via virtual pin
  Blynk.virtualWrite(V1, t);             // For Temperature
  Blynk.virtualWrite(V2, h);             // For Humidity
```

```
  Blynk.virtualWrite(V3, air_quality);   // For Gas
  Blynk.virtualWrite(V4, alarm_status);  // For Alarm & Exhaust Fan
  Blynk.virtualWrite(V5, pir_status);    // For Human Detection

 // code for display
  display.clearDisplay();
  display.setCursor(0, 0); //oled display
  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.println("Air Quality Index");
  display.setCursor(0, 20); //oled display
  display.setTextSize(2);
  display.setTextColor(WHITE);
  display.print(air_quality);
  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.println(" PPM");
  display.display();
  delay(1500);
  display.clearDisplay();
  // display temperature
  display.setTextSize(1);
  display.setCursor(0, 0);
  display.print("Temperature: ");
  display.setTextSize(2);
  display.setCursor(0, 10);
  display.print(t);
  display.print(" ");
  display.setTextSize(1);
  display.cp437(true);
  display.write(167);
  display.setTextSize(2);
  display.print("C");

  // display humidity
  display.setTextSize(1);
  display.setCursor(0, 35);
  display.print("Humidity: ");
  display.setTextSize(2);
  display.setCursor(0, 45);
  display.print(h);
  display.print(" %");

  display.display();
  delay(1500);
}
```

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