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USING MOBILE PHONE TO CONTROL REMOTELY ELECTRONIC DEVICES IN SMART HOME SYSTEM

Introduction. *Smart Home technology encompasses a range of intelligent devices designed for residential use. These devices present numerous opportunities to transform our lifestyles in the future. Smart Home technology has made significant contributions to enhancing safety and reliability while potentially altering our daily habits. In contemporary society, mobile phones serve purposes beyond mere communication. As technology evolves, the functionality of mobile phones expands, allowing them to be utilized for various applications. Currently, a wide array of applications and hardware is available in the market that can be integrated without necessitating further advancements in existing smartphones. Through network connectivity, mobile phones can facilitate the management of smart home systems, enabling users to control devices and receive alerts regarding potential theft or unauthorized access.*

The purpose of the paper *is to establish a smart home system that allows for remote control of electronic devices and provides notifications of intrusions or movements in restricted areas. The devices are managed via mobile phones using the Short Message Service (SMS), with alerts also sent as SMS messages detailing activities occurring within the vicinity.*

Results. *A smart home system was developed that allows remote control of household electronic devices using a mobile phone. Control of the devices was facilitated through the transmission of instructions via SMS, with alerts also being delivered in the same manner. A Hall Effect proximity sensor was employed to detect unauthorized entry, while a passive infrared sensor was utilized to monitor movement in restricted zones. Additionally, a temperature sensor functioned as a heat detector, and an LED light was incorporated to demonstrate the management of electronic devices. The Arduino Uno Board served as the microcontroller, and the SIM900 GPRS/GSM module was utilized for communication between the microcontroller and the mobile device. Notably, the mobile phone did not require any specialized applications or hardware; any mobile phone capable of sending and receiving SMS could function as a mobile station.*

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Conclusion. *Thus, the developed Smart Home system demonstrated its effectiveness. The microcontroller unit effectively responds to commands issued by the mobile phone, adapting to the application's requirements and activating an alarm in critical situations. Additionally, the application successfully facilitates the remote management of electronic devices.*

Keywords: *Smart Home, mobile phone, remote control, electronic devices.*

Introduction

Smart Home (SH) refers to a residence equipped with a home controller that integrates various home automation systems. The most widely used home controllers are those programmed via a Windows-based PC, after which they operate independently to manage home control functions. This integration allows different home systems to communicate through the home controller, facilitating simultaneous control of multiple systems via a single button or voice commands, whether in pre-set scenarios or operational modes. The home automation sector is experiencing rapid growth as electronic technologies converge. The home network includes systems for communication, entertainment, security, convenience, and information. Power Line Carrier Systems (PCS) utilize existing electrical wiring in a home to transmit coded signals to programmable switches or outlets. These signals carry commands linked to specific device «addresses,» dictating their operation times and methods. For example, a PCS transmitter can send a signal through the home's wiring, which a receiver connected to any electrical outlet can pick up to control the attached appliance. X10 is a prevalent protocol for PCS, serving as a signaling method for the remote control of devices connected to the electrical power line. X10 signals consist of brief radio frequency (RF) bursts that encode digital information, enabling communication between transmitters and receivers [1].

The European Installation Bus, commonly referred to as Instabus, is a specialized embedded control protocol designed for digital communication among smart devices. This system utilizes a two-wire bus line that is integrated with standard electrical wiring. The Instabus line connects all devices to a decentralized communication network, functioning similarly to a telephone line that allows for the control of appliances. The European Installation Bus Association is affiliated with Konnex, an organization dedicated to the standardization of home and building networks across Europe [2].

In this setup, all appliances and devices act as receivers, while the control mechanisms, such as remote controls or keypads, serve as transmitters. For instance, if one wishes to turn off a lamp located in a different room, the transmitter sends a numerical code that encompasses the following elements [3]:

1. A notification to the system indicating that a command is being issued.
2. A unique identification number for the device intended to receive the command.

3. A specific code that conveys the actual command, such as "turn off".

This entire process is designed to occur in less than a second; however, X10 technology does have certain limitations. Communication over electrical lines can be unreliable due to interference from other devices, which can create "noise". Consequently, an X10 device may misinterpret electronic interference as a command or fail to receive the command altogether. Although X10 devices remain in use, newer technologies have emerged to vie for market share in home networking. Some systems now utilize radio waves for communication, akin to the operation of Wi-Fi and cellular signals. Nevertheless, home automation networks do not require the extensive bandwidth of a Wi-Fi network, as automation commands are typically brief messages. The two leading radio networks in home automation are ZigBee and Z-Wave, both of which operate as mesh networks, allowing for multiple pathways for messages to reach their intended destinations [4].

Design of Smart Home System

The system is fundamentally divided into two components: the mobile station and the microcontroller unit. The mobile station serves as the command center, issuing control instructions to various devices and sensors while also receiving their responses. It functions solely as a user interface and does not exert direct control over the devices. In contrast, the microcontroller unit is tasked with managing the devices and processing the information collected from both the devices and the mobile station. This unit acts as the system's central processing unit, overseeing the flow of information to and from all other components.

As illustrated in Fig. 1, the system consists of these two primary units. The microcontroller unit is equipped with four sensors and a light, in addition to the SIM900 module.

The LM35 sensor detects temperature, the digital output proximity sensor serves as an intrusion detector, and the Panasonic passive infrared sensor functions as the motion detector within the system. The microcontroller continuously processes data from these sensors and will alert the mobile station if any anomalies are detected or if the temperature exceeds a predefined threshold. In addition to receiving alerts, users can inquire about the current temperature in their home by sending a command to the microcontroller. These three components collectively enhance home security. Furthermore, the microcontroller unit includes a lighting system that can be controlled remotely via the mobile station. For demonstration purposes, a simple Light Emitting Diode (LED) showcases the remote lighting management capabilities. Users can monitor the light's status — whether it is ON or OFF — through the mobile station and can adjust the light's state remotely. Additionally, a heat sensor is integrated into the system, which is programmed to send an SMS alert in the event of a fire.

The Sim900 GPRS/GSM module serves as the intermediary between the microcontroller unit and the mobile station, facilitating communica-

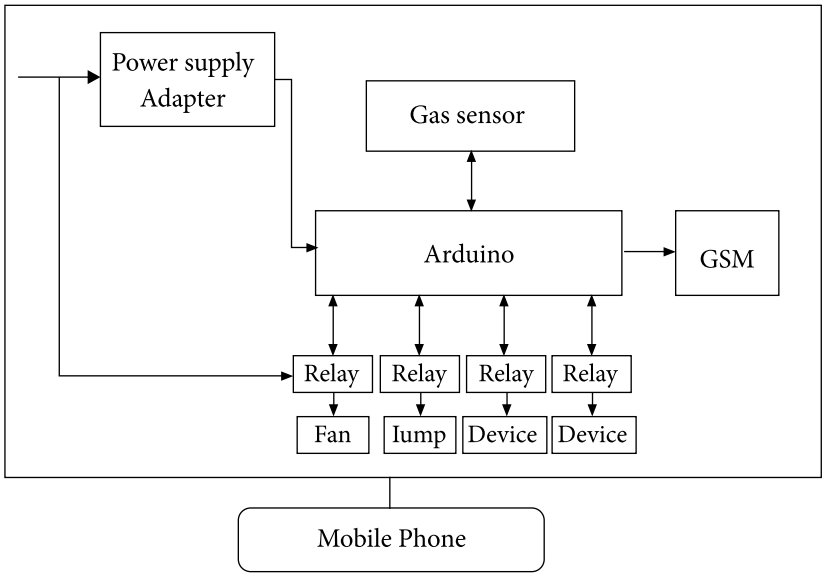

Fig. 1. System block diagram

tion between the two. This module is tasked with transmitting data from the microcontroller to the mobile station and relaying instructions from the mobile station back to the microcontroller. The microcontroller executes the commands issued by the user via the mobile station. The second component of the system is the mobile station, which is essentially a mobile phone. There are no specific requirements or applications needed for the mobile phone to integrate into the system; any mobile phone that supports messaging functionality is adequate. Instructions to the microcontroller are conveyed through text messages, and alerts from the microcontroller are also received in text format. This system functions as a smart home solution, enhancing home security and enabling remote management of household devces.

Interfacing of Sim900 Gprs/Gsm Module

The Sim900 module plays a crucial role in facilitating communication between the microcontroller and the mobile phone. To interface and configure the module, ATtention (AT) commands are employed. These commands are incorporated in C-language as a string of characters, which are transmitted to the module via a terminal program.

To activate the SIM card, the SIM pin code is necessary. As illustrated in listing 1 on Fig. 2, the instructions are articulated within a program as C-language code that can be executed at a designated time. Subsequently, the code is compiled and uploaded to the Arduino/GPRS shield unit.

Listing 2 presents on Fig. 3 the AT commands required to identify the index of an SMS and to access the content of the SMS message. It is essential to retrieve the SMS index each time a new SMS is received, as the

```
mySerial.println("AT+CPIN=4510"); //the pin code for the sim
delay(5000); mySerial.println("AT+CMGF=1"); //sets the text mode
```

Fig. 2. Listing 1 — AT command syntax to set the text mode

```
pos = msg.indexOf(",");
 String index = msg.substring(pos+1); //the index of SMS
myS When exposed to the fire of an ignited lighter:
erial.print("AT+CMGR = ");
        mySerial.println(index);        //read the incoming SMS
```

Fig. 3. Listing 2 — AT commands to read the SMS message defined within a program

index continues to increment. Failing to do so may result in the program repeatedly reading the same SMS, despite the presence of new messages. Given the limited storage capacity of the SIM card, SMS messages are deleted after they have been read and the corresponding instruction has been executed. The microcontroller acts according to the instructions conveyed through the SMS message from the mobile phone.

Interfacing and Implementation of Sensor

There are various areas that require regular monitoring, as well as devices that need to be inspected both inside and outside the residence. It is essential to keep an eye on doors and windows to prevent unauthorized access, as well as to observe the movements of unfamiliar individuals in the vicinity of the property. Additionally, a household member may wish to check the status of electronic devices after leaving the home and may need to deactivate them if they have been inadvertently left on. Furthermore, monitoring the home's temperature is crucial to activate an alarm when it reaches a critical threshold. The oversight of temperature, the movement of strangers, and the operation of doors and windows is facilitated by specific sensors. These sensors can be designed as various types of detectors based on the requirements of the application and user preferences. The functionality of these sensors is governed by software. Given the diversity of sensor types, they are connected according to their output characteristics and specifications. The external circuitry required for interfacing the sensor with the application varies depending on the sensor type; however, it is not always necessary, as some sensors can provide direct output for immediate use in the application.

Heat Sensor

The heat (flame) sensor depicted in Fig. 4 exhibits a high sensitivity to standard light, which is why it is commonly employed for flame detection purposes.

This module is capable of identifying flames or light sources within the wavelength range of 760 nm to 1100 nm. The output interface of the small plate can be directly connected to the microcomputer's IO port. It is

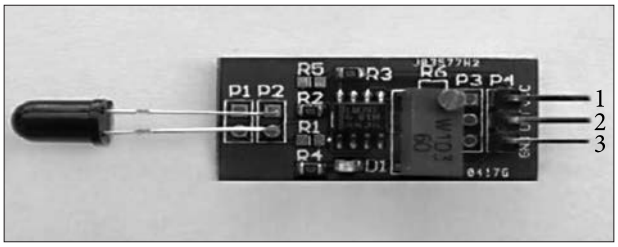

Fig. 4. Heat sensor

```
void setup() { Serial.begin(9600);
} void loop()
{ if (analogRead(A0) < 250) Serial.println("No
Fire"); else Serial.println("There's a Fire!");
 delay(100); }
```

Fig. 5. Listing 3 — C code used to read the temperature

essential to maintain a specific distance between the sensor and the flame to prevent damage from excessive heat. The minimum testing distance is 80 cm; for larger flames, a greater distance should be used. The sensor has a detection angle of 60 degrees, making it particularly responsive to the flame spectrum.

The microcontroller monitors the sensor's output voltage at one-second intervals through the analog Read function. Since temperature is a function of output voltage, it can be computed mathematically. The temperature is derived from the output voltage using the formula provided in listing 3 in Fig. 5. If the calculated temperature surpasses the threshold set within the software, an SMS will be automatically dispatched to the designated mobile phone. This temperature threshold can be adjusted based on the specific environment where the sensor is installed and the intended application. For instance, if the sensor is situated in a cold room to regulate its temperature, a lower threshold is appropriate, whereas a higher threshold is necessary for a sensor placed in a fire detection scenario. Furthermore, the current temperature at the sensor's location can be obtained by sending an SMS to the GPRS module.

Numerous electronic devices within a household may have an uncertain operational status (either ON or OFF), and it is possible for them to be inadvertently left ON. It is essential for the owner to ascertain the status of these devices, and if any are found to be ON, they must be turned OFF. However, returning home to switch off these devices is not always feasible. This situation highlights the necessity for remote management of electronic devices to mitigate the risk of accidents and reduce electricity consumption. Various methods exist for implementing remote management of elec-

tronic devices, including Ethernet management, wireless device management, and GPRS/GSM module management. This paper focuses on the remote management of lighting systems using the GPRS/GSM module, particularly through SMS communication. In this context, the lighting system serves as a representative example of electronic devices in general. Given that the lighting operates on a 220V AC current while the Arduino provides only a 5V DC current, a relay is employed to interface between the Arduino and the lighting system. The relay is controlled via the I/O pins of the Arduino, which ultimately regulates the lighting. The circuit diagram illustrating the control of electronic devices through the I/O pins of the Arduino Board via the relay shield is presented in Fig. 6.

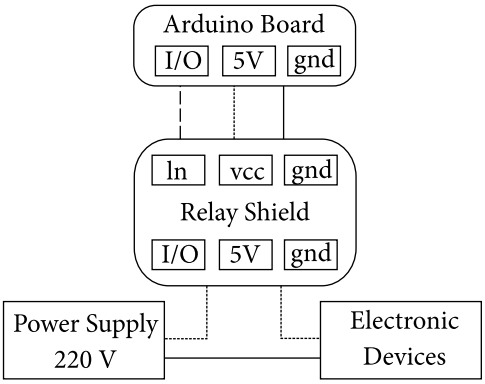

Fig. 6. Circuit diagram for the control of electronic devices

The electronic device is operated through the I/O pin of the Arduino, which is linked to a relay. When the I/O pin is in a low state, the common (com) terminal connects to the normally closed (NC) terminal, while in a high state, the common connects to the normally open (NO) terminal. This configuration indicates that the electronic device is activated when the I/O pin is high and deactivated when it is low. Essentially, the electronic device can be controlled remotely by manipulating the I/O pin of the Arduino board. For demonstration purposes, a LED is utilized to represent the remotely controlled light, functioning in place of a traditional light bulb. The operational principle for controlling the light remains consistent with that of the LED; the light is managed through the Arduino's I/O pins via relays, while the LED is directly controlled by the I/O pins.

Listing 4 presents in Fig. 7 the C-code necessary for the remote management of the light using a mobile phone. The code begins by monitoring incoming SMS messages and executes actions based on their content. The light can be turned ON or OFF in accordance with the commands received from the mobile phone. The fifth bit of port B indicates the light's status (specifically, the status of I/O pin 13), which is accessed using the bitRead function. When the status of the light is requested, an SMS is sent back to the mobile phone, providing the current status. This method allows for remote awareness of the light's status and enables the light to be turned ON or OFF via mobile phone commands.

The SH system is designed by incorporating sensors and a remotely controlled lighting system as detailed in this paper. For demonstration purposes, a single lighting system is utilized alongside three types of detectors: an LM35 temperature sensor for heat detection, a Panasonic passive infrared sensor for motion detection, and a Hall Effect proximity

```
int led = 13;
pinMode(led,OUTPUT);
 if(msg.indexOf("Turn light on") >= 0){ digitalWrite(led,HIGH);
} if (msg.indexOf("Turn light OFF") >= 0){
digitalWrite(led,LOW);
} if(msg.indexOf("State of light") >= 0){ val =
bitRead(PORTB,5);
 switch(val){ case 0: send_SMS();
break;
 case 1: send_SMS();
 break; } }
```

▲ ***Fig. 7.*** Listing 4 — C-code compilation for the management of light remotely

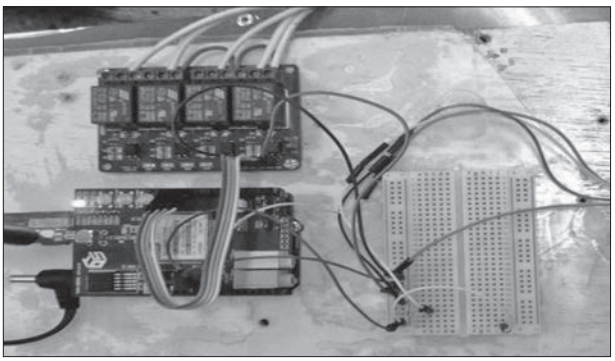

Fig. 8. Final system

sensor for intrusion detection. The quantity of sensors and remotely managed electronic devices can be adjusted based on the specific requirements of the application.

This system activates alarms in response to unauthorized entry through doors and windows, as well as detecting human movement within the premises and restricted zones. Additionally, it monitors temperature levels and triggers an alarm when critical thresholds are reached or exceeded. The entire system integrates the sensor implementation and lighting control, which is executed on the Arduino platform using the Arduino Uno Board, as illustrated in Fig. 8.

Fig. 8 illustrates the microcontroller unit, which comprises the Arduino board, GPRS shield, light, and sensors. The unit can receive power either from an external source or through the USB port of a computer. In this study, power is supplied via the USB port, while the sensors and GPRS shield draw power from the unit itself. The entire system is developed using C-code on the Arduino platform. The software created on this platform can be uploaded to the microcontroller (i.e., the Arduino board) utilizing the Arduino IDE.

The Arduino integrated development environment (IDE) is a cross-platform application developed in Java, allowing programs to be written in C or C++. This platform includes a software library and a code editor equipped with features such as syntax highlighting brace matching, and automatic indentation. The complete program is authored in C language code, which can be easily uploaded to the board with a single click of the upload button. Essentially, this work involves integrating the soft-

Unit	Instruction send by mobile	Response to the mobile	Output/Alarm triggerring condition		
Light	State of light	The light is ON/OFF			
	Turn light ON		Light is turned ON		
	Turn light OFF		Light is turned OFF		
Heat sensor	What is the flam sensor?	The flam is x °C			
		The flam is too high	If the flam is > y °C		
Switches	Turn Devise ON	The Devise is ON/OFF			
	Turn Devise OFF				

Fig. 9. Results of the instructions and the response to and from the mobile station

ware (C language code) that interfaces with and implements the sensors, GPRS module, and remote light management. Furthermore, the program includes additional code to facilitate coordination among these components, along with supplementary C-code beyond the individual codes previously mentioned.

Results

The objective of this paper is to implement a smart home (SH) system, and this goal has been successfully achieved. The microcontroller unit effectively responds to commands issued by the mobile phone, adapting to the application's requirements and activating an alarm in critical situations. Additionally, the application successfully facilitates the remote management of electronic devices.

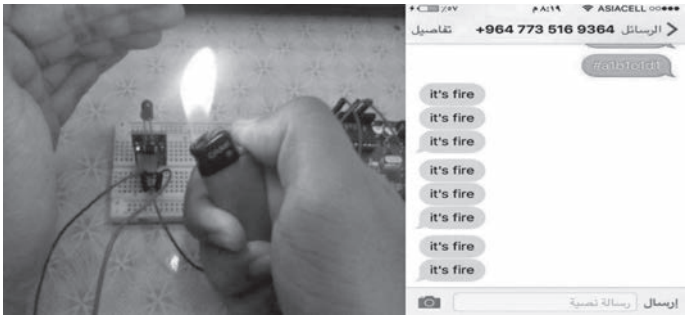

Fig. 10. Screenshot of the mobile station managing the light remotely

Table shown in Fig. 9 presents the commands transmitted to the microcontroller from the mobile device, along with the corresponding outputs and responses from the microcontroller back to the mobile device. It is evident from the Table that the commands are directed solely to the lighting system and the temperature sensor, which operate in accordance with the instructions received from the mobile phone.

Fig. 10 illustrates a screenshot depicting the management of electronic devices, specifically the lighting system, via the mobile device.

As shown in Fig. 10, the microcontroller communicates with the mobile phone through SMS, indicating whether the light is ON or OFF based on the command (light state) sent from the mobile device. The light can be toggled ON and OFF through SMS, and the responses to these commands vary depending on the light's status, as demonstrated in Fig. 10.

Conclusion

The objective of this paper was to develop a smart home system that enables remote control of household electronic devices via a mobile phone, as well as to receive notifications regarding unauthorized access and movement in restricted areas. This objective was successfully accomplished. Control of the devices was facilitated through the transmission of instructions via SMS, with alerts also being delivered in the same manner. A Hall Effect proximity sensor was employed to detect unauthorized entry, while a passive infrared sensor was utilized to monitor movement in restricted zones. Additionally, a temperature sensor functioned as a heat detector, and an LED light was incorporated to demonstrate the management of electronic devices. The Arduino Uno Board served as the microcontroller, and the SIM900 GPRS/GSM module was utilized for communication between the microcontroller and the mobile device. Notably, the mobile phone did not require any specialized applications or hardware; any mobile phone capable of sending and receiving SMS could function as a mobile station.

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ВИКОРИСТАННЯ МОБІЛЬНОГО ТЕЛЕФОНУ ДЛЯ ДИСТАНЦІЙНОГО КЕРУВАННЯ ЕЛЕКТРОННИМИ ПРИСТРОЯМИ В СИСТЕМІ РОЗУМНОГО ДОМУ

Вступ. Технологія «розумний дім» охоплює низку інтелектуальних пристроїв, призначених для використання в домах. Ці пристрої пропонують численні можливості змінити наш спосіб життя в майбутньому. Технологія «розумний дім» зробила значний внесок у підвищення безпеки та надійності, а також потенційно змінила наші щоденні звички. У сучасному суспільстві мобільні телефони служать не лише для спілкування. З розвитком технологій функційні можливості мобільних телефонів розширюються, що уможливлює їх використання для різних задач з застосуванням відповідних програм. Зараз на ринку доступний широкий спектр програм і апаратного забезпечення, які можна інтегрувати без необхідності подальшого вдосконалення наявних смартфонів. Завдяки підключенню до мережі мобільні телефони можуть полегшити керування системами розумного дому, даючи змогу користувачам контролювати пристрої та отримувати сповіщення про можливу крадіжку або несанкціонований доступ.

Метою цієї статті є створення системи «розумного дому», яка дає змогу дистанційно керувати електронними пристроями та надає сповіщення про вторгнення або переміщення в зонах обмеженого доступу. Управління пристроями здійснюється через мобільні телефони з допомогою служби коротких повідомлень (*SMS*), причому сповіщення також надсилаються як *SMS*-повідомлення з детальною інформацією про дії, що відбуваються поблизу.

Результати. Розроблено систему «розумний дім», яка дає змогу дистанційно керувати побутовими електронними пристроями з допомогою мобільного телефону. Управління пристроями спрощено завдяки передачі інструкцій через *SMS*, як і передача зворотних сповіщень. Датчик наближення на ефекті Холла використовувався для виявлення несанкціонованого проникнення в приміщення, а пасивний інфрачервоний датчик використовувався для моніторингу руху в заборонених зонах. Крім того, датчик температури функціонував як детектор тепла, а світлодіодний індикатор було вбудовано для демонстрації керування електронними пристроями. Плата *Arduino Uno* слугувала мікроконтролером, а модуль *SIM900 GPRS/GSM* використовувався для зв'язку між мікроконтролером і мобільним пристроєм. Зауважимо, що мобільний телефон не вимагав жодних спеціалізованих програм або апаратного забезпечення; будь-який мобільний телефон, здатний надсилати та отримувати *SMS*, може функціонувати як мобільна станція.

Висновки. Розроблена система «розумний дім» продемонструвала свою ефективність. Було показано, що блок мікроконтролера ефективно реагує на команди мобільного телефону, підлаштовуючись під вимоги програми та активуючи сигналізацію в критичних ситуаціях. Крім того, програма забезпечує дистанційне керування електронними пристроями.

Ключові слова: *розумний дім, мобільний телефон, дистанційне керування, електронні пристрої.*