Implementation of Home Automation System Using GSM Module and Arduino Microcontroller

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Abstract: Development of a home automation system is presented in this paper leveraging a GSM module interfaced with an Arduino microcontroller. The proliferation of smart technologies has propelled the demand for intelligent home management systems, fostering convenience, efficiency, and security. The proposed system integrates the versatile functionalities of an Arduino microcontroller with the ubiquitous connectivity of a GSM module to enable distant operation and monitoring of household appliances. The goal of this investigation is to create a system that can be operated remotely by any Android OS smartphone. In order to do this, the Arduino board at the receiving end is linked to a GSM module, while on the transmitting end, a mobile phone sends specific messages to the receiver to activate or deactivate various loads, such as home appliances. The loads are controlled by an Arduino board via relays. This study contributes to the advancement of smart home technologies, providing insights for future advancements in the domains of home automation and Internet of Things (IoT) applications.

Keywords: Home automation, GSM module, Arduino microcontroller, mobile phone

Introduction:

The integration of technology into everyday living spaces has brought about a period of unparalleled convenience and efficiency (Aziz *et al*., 2023; Roslan and Ahmad, 2023; Eltaleb *et al*., 2023; Bhimwal and Mishra, 2023; Ramírez and Islam, 2024). According to Madakam *et al*. (2015), there have been changes in humans' daily lives in addition to the office environments of companies since the coming of information technology (IT) and the Information Technology Evolution System (ITeS). Mankind has always looked for ways to make life easier and more time-saving, which has led to the use of many research and development technologies for different purposes.

Technologies such as home appliances have been playing significant roles in making our lives very easy, saving time, reducing cost, and thereby increasing our efficiency and productivity (Rock *et al*., 2024; Arshad *et al*., 2017). Manual or analog home appliances can be very stressful, expensive, and time-consuming in terms of management and control (Jan *et al*., 2021; Leitao *et al*., 2020; Tolio *et al*., 2017). Staying away from your home appliances poses a big challenge or risk of electrical disasters (such as fire outbreaks) for people who happen to be outside their homes and mistakenly leave their equipment on or off based on the specific circumstances. This could lead to inefficient use of energy when equipment is inadvertently kept plugged into the electrical grid for a longer duration than necessary (Wójcicki *et al*., 2022; Nižetić *et al*., 2020; Hassan *et al*., 2020; Asghari *et al*., 2019).

Over the years, home appliance control has been a big task for homes in terms of maintenance and control (Aguilar *et al*., 2021; Paredes-Valverde *et al*., 2020; Sovacool *et al*., 2020). It cannot be neglected or abandoned, but it can be improved by making it digital and automatic due to its great importance in our daily lives. The process of making home appliances work automatically is referred to as home automation. The term "home automation" describes the application of technology in homes. to remotely automate and control equipment and systems for the home (Stolojescu-Crisan *et al*., 2021; Ashraf *et al*., 2020; Al-Kuwari *et al*., 2018; Jabbar *et al*., 2018). This can include controlling lighting, heating, ventilation, air conditioning (HVAC), security cameras, locks, as well as additional gadgets through a centralized system such as a smartphone app or a voice command interface like Amazon Alexa or Google Assistant.

Through the implementation of home automation, individuals have the ability to remotely monitor and control many aspects of their residences, resulting in enhanced convenience, energy efficiency, and security. A home automation system enables users to interact with and control many devices effortlessly by displaying and updating The linked device's state through an intuitive interface (Rozita *et al*., 2019). Some of the mediums used in communicating with modern home automation systems include Bluetooth, Zigbee, the Global System for Mobile Communication (GSM), WiMAX, SMS, and Wireless LAN (Wi-Fi).

The mobile phone is the most convenient gadget for controlling most household appliances. According to reports on the world's population, which currently stands at over 8.01 billion (Alam and Siddiqui, 2023; Wei and Lo, 2021), the estimated global smartphone user base has grown to 6.93 billion individuals, accounting for 86.5 percent of the world's population (Areán *et al*., 2016). The number of users has experienced a substantial increase since 2016, when it stood at 3.668 billion, or 49.40% of the world's population at that point (Iyen *et al*., 2024; Frej *et al*., 2023; Adhikari *et al*., 2023). Moreover, the majority of individuals consistently possess their mobile phones, rendering them an excellent choice for wirelessly switching household devices (Natarajan *et al*., 2022; Apthorpe *et al*., 2017).

The open-source Arduino microcontroller platform enables the creation of interactive electronic projects (Mukherjee and Dey, 2019; Ali *et al*., 2016; Zlatanov, 2016). It consists of a simple hardware board with an Atmega microcontroller chip and a software development environment to compose, assemble, and submit code to the board (Ismailov and Jo‘Rayev, 2022; Louis, 2016). Arduino boards come in a range of sizes and forms, providing different characteristics and capacities to accommodate various project requirements. Arduino boards can interact with various sensors, actuators, and other electronic components to control lights, motors, displays, and more (Kondaveeti *et al*., 2021; Papoutsidakis *et al*., 2018). They can also communicate with other devices via serial communication, USB, Ethernet, Wi-Fi, Bluetooth, and other protocols. The Arduino Integrated Development Environment (IDE), an easy-coding environment based on the wiring architecture and the processing language, simplifies the design of Arduino software (Marn-Marn et al., 2024; Kondaveeti et al., 2021; González and Calderón, 2019). With the IDE, users may write applications in a programming language akin to C/C++, compile it into machine code for the microcontroller, and upload it to the Arduino board via a USB cable or other interfaces (Kumar *et al*., 2022; Ismailov and Jo‘Rayev, 2022).

Arduino works well for electronic project rapid development (Chand and Khosla, 2022; Shankar *et al*., 2021; Jelen, 2021; Suraj *et al*., 2019; Blum, 2019; Al-Janabi, 2019; Ja’afaru *et al*., 2018; Akeredolu *et al*., 2017). The Arduino microcontroller has been the tool of choice for several projects. For instance, Iyen et al. (2020) built a rain detection system with a rainfall warning device using an Arduino microcontroller and a rain sensor.. Every time there is rainfall, the alarm triggers. Using an Arduino microcontroller, Iyen et al. (2024) employed Bluetooth to controll home gadgets within a radius of one hundred meters of the mobile smartphone.

Daadoo and Tarapiah (2016) also worked on developing inexpensive security home automation made with the Arduino microcontroller to implement an alarm mechanism founded on the Global System for Mobile (GSM) communication network, the owner's system can receive short message service (SMS) messages. In a study conducted by Naing and Hlaing (2019), a smart home automation system powered by Arduino was developed. This system made use of two Arduino nanocontrollers and relays to track a designated area and respond to specific factors such as outdoor temperature, light, and other variables. If the sensors identify a variation, the microcontroller will transmit a short message (SMS) to the device's owner.

In order to help the elderly live more independently and in a safe, secure environment, Ransing and Rajput (2015) introduced A smart home system that is based on wireless sensor networks. They also utilized LabVIEW to construct a graphical user interface. An intelligent home system combining a Raspberry Pi, a variety of sensors, and Bluetooth as a method of communication was presented by Davidovic et al. (2015). Additionally, a simple-to-use interface based on Android was designed.

Baraka *et al*. (2013) built a smart house that is extremely expandable, energy-efficient, and managed remotely, featuring essential characteristics that preserve the tenants' security and comfort. The system comprises an Arduino microcontroller, Android software acting as the user interface, and a home network (sensors and device transducers to gather data from and regulate the home environment, appropriately).

This study aims to implement a remotely controlled home automation system that allows users to switch gadgets in the house from any location in the globe, provided they have access to a mobile network via SMS.

Materials and Methods:

Materials:

The hardware and software materials employed in this study comprises the following: Arduino Uno Board (5 V), SIM900 GSM module, Relay module x3 (5 V), AC bulb (220 V), AC bulb holder, 12 V, 2 A power supply for GSM module, liquid crystal display 16x2 LCD (5 V), AC socket (220 V), AC fan (220 V), breadboard, jumper wire, resistors (220 Ω), Arduino IDE software, Proteus software. Figures 1, 2, and 3 show the GSM module, the relay, and the Arduino Uno Board.

Figure 1:Sim 900 GSM module

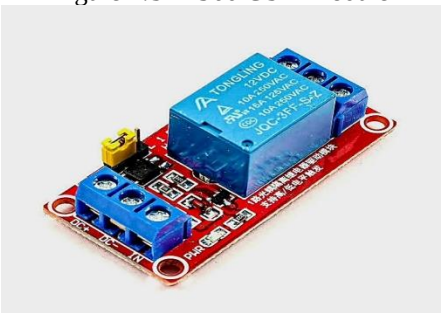

Figure 2: 5V relay

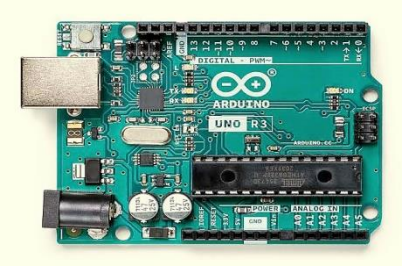

Figure 3: An arduino UNO board

Methods:

The circuit utilizes an Arduino microcontroller and a GSM module to create a home automation system. The Arduino microcontroller acts as the central processing unit, controlling various home appliances based on input received via the GSM module. The microcontroller and embedded system transmit and receive signals from the GSM module. Figure 5 shows the research work's operating method.

Commands Used for the Operation of GSM module.

The arduino program flowchart is shown in Figure 4

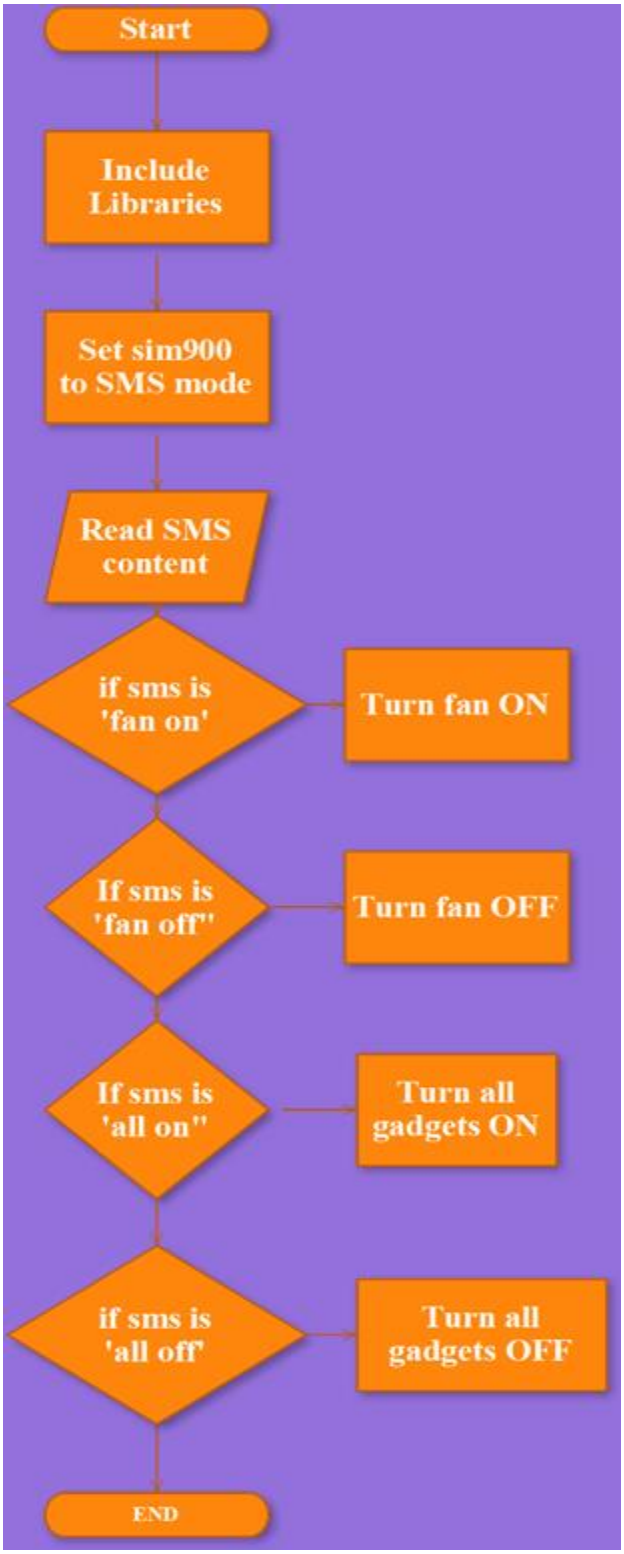

Figure 4: The flowchart used in writing the arduino code6

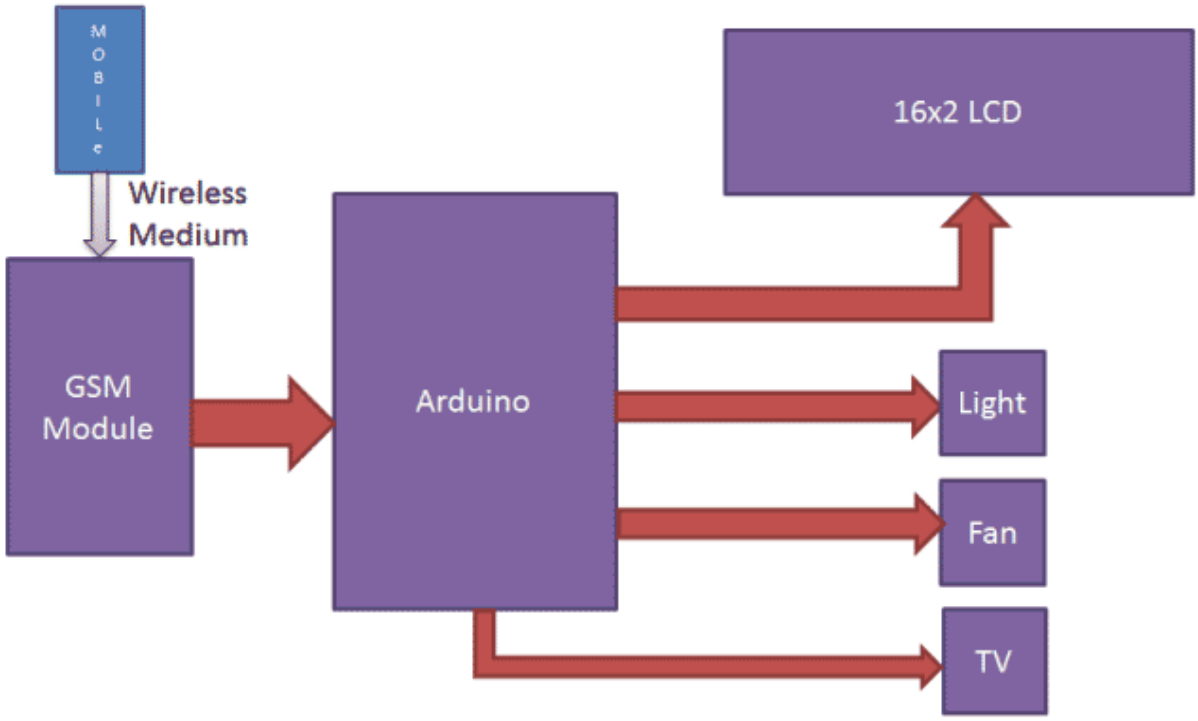

Figure 5: Block diagram of the project

Results and Discussion:

The circuit diagram, the testing of the subcircuit on a breadboard, and the soldered components on a Vero board are shown in Figures 6, 7, and 8, respectively.

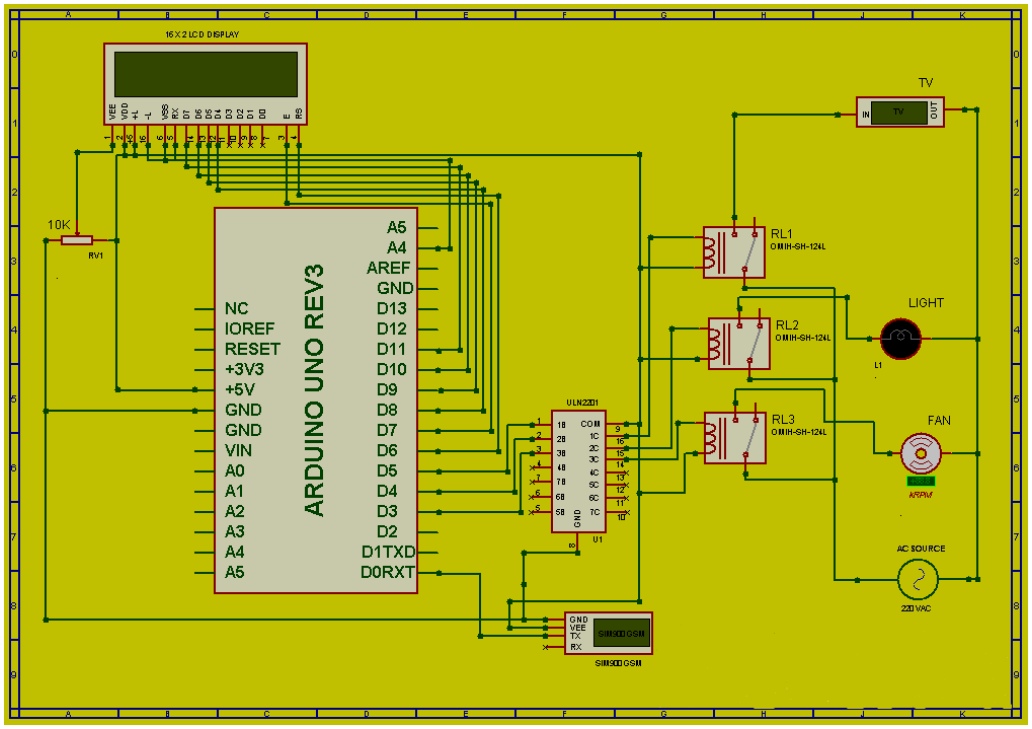

Figure 6: The complete circuit diagram

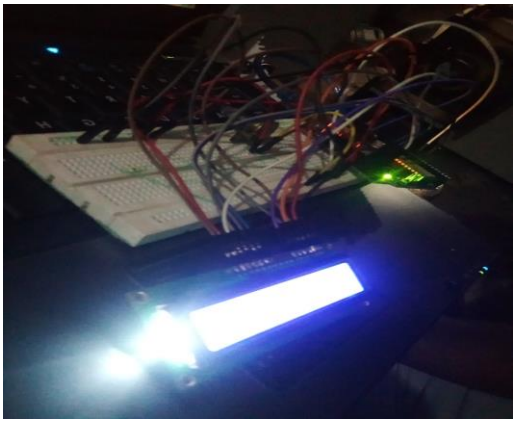

Figure 7: Testing the Subcircuit on a Breadboard

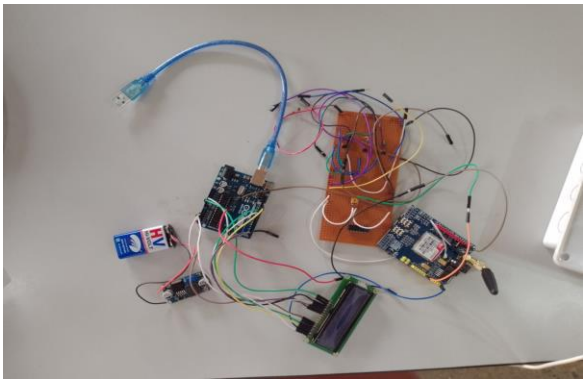

Figure 8: Soldered components on a Vero board.

In this research, the hardware was first tested on a breadboard and then soldered on a veroboad before a prototype was deployed to operate household appliances. The system performed as expected. The home automation system using GSM technology utilizes an Arduino Uno as its central controller, with the SIM900 serving as the SMS gateway, a 3-channel relay for output, and a smartphone for input. The system operates by sending instructions or messages from the smartphone through the SMS gateway to the Arduino Uno microcontroller. Subsequently, the Arduino Uno interprets, extracts, and processes these user-defined instructions encoded as data strings, enabling control of household appliances and devices by toggling them on or off through the relay switching unit.

The mobile phone communicates with the GSM module via the mobile network provided by the SIM card that was inserted into the GSM module. The GSM module transmits the information to the Arduino microcontroller, which processes and interprets the message and sends an electrical signal to the LCD for the display of the result and a 5 volt signal to the relay. The relay uses the 5V electrical signal to control the bulb, the light, and the switch. Every other component in the circuit, except the one mentioned above, is used to supply, control, and regulate voltage and current. Similar research was conducted, which agreed with the result (Ajagbe *et al*., 2024; Gupta *et al*., 2023; Okubanjo *et al*., 2021).

Conclusion and Recommendation:

As the name "Home automation" suggests, the technology increases flexibility and offers a more appealing user interface than existing home automation systems. We incorporate mobile devices and home automation systems together in this solution. We propose a unique design with relatively recent communication technologies for a home automation system.

Three primary parts make up the system: relay circuits, an Arduino microcontroller, and a GSM module. To communicate with the Arduino microcontroller and Android phone, a mobile network is utilized. This research offers a remotely operated, widely accessible, low-cost, secure, and long-range solution. The technique outlined in the article has succeeded in linking system components and satisfying user requests by providing remote control of home appliances via GSM module technology. It has been proven that a solution with GSM capabilities can be controlled remotely and is cheaper than previously installed systems. Thus, we can state that the home automation system's required purposes and objectives have been reached. The system's architecture and design were handled, and a prototype that demonstrates the foundations of remotely operating home appliances was created. In conclusion, the recommended system displays higher scalability and flexibility compared to home automation systems that are currently marketed.

Conflict of Interest:

The authors declare that there is no conflict of interest related to this work.

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