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Voice Control IoT Home Automation using Bluetooth Module

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***Abstract*— The approach presents the design of a low-cost Android-based home automation system making use of Bluetooth technology. The user can control home appliances through voice commands on an Android app. The system is built on Arduino Uno microcontroller, Bluetooth module (HC-06), and MIT App Inventor 2. For switching operations, it employs relays and Triacs. The system enables the users to operate appliances through Bluetooth or Google Assistant voice prompts, with an added feature to schedule automatic shutdowns within 12 hours, ensuring convenience and efficiency in home automation.**

***Keywords*— Home Automation, Smartphone, Arduino UNO Controller, Hc-06 Bluetooth Module, 2 channel Relay Module, Android application (MIT App Inventor 2).**

I. INTRODUCTION

An IoT-based home automation system majorly consists of IoT Gateway, Virtual Assistant, and User Interface. Most users prefer to control the home appliances through Android devices, which are familiar and easy to operate. In the proposed work, the appliances such as lights, fans, switches, and coolers are controlled wirelessly via Bluetooth using an Arduino microcontroller. The main control unit is Arduino processes the data received from the Bluetooth module and controls the appliances through a relay module. A short-range Bluetooth technology enables wireless communication, forming a personal area network that allows all connected appliances to be monitored and controlled efficiently.

II. LITERATURE REVIEW

According to B. Dilleshwara Rao, According to B. Dilleshwara Rao, the system built around Arduino UNO, HC-05 Bluetooth module, and Android application to control the device. Compared to IR or GSM systems, Bluetooth-based systems are more efficient, by providing a 10 m communication range and data transfer rates up to 3 Mbps [1].
Rejwan Bin Sulaiman emphasized Wi-Fi–based systems using Arduino UNO or Mega 2560 microcontrollers for monitoring and controlling temperature, fire, intrusion, and lighting enhancing comfort through Android-based voice-controlled home automation [2].
An IoT-based home automation model using Google Assistant, Firebase, NodeMCU, and Node-RED Uma S. was developed by R. Eswari, Bhuvanaya R., and Gopisetty Sai Kumar developed.
It allows users to schedule and control devices through Wi-Fi–enabled ESP8266 modules, integrating Dialogflow for voice commands and real-time data exchange via Firebase [3].

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N. David, A. Chima, A. Ugochukwu, and E. Obinna proposed a low-cost, web-controlled home automation and environmental monitoring system using an Arduino Mega 2560 microcontroller as a micro web server. The setup employs DHT11 sensors for temperature and humidity monitoring and a PHP–JavaScript–Ajax-based web interface for real-time device control [4].

A low-cost, efficient, and adaptable for future IoT or voice-controlled extensions based on Bluetooth intelligent home automation system [5] was developed by A.K. Kasim and A. Raheem with Arduino UNO, HC-05 Bluetooth module, relays, and an H-bridge motor driver to control lights, fans, and motor speed through an Android smartphone.

A.K. Kasim and A. Raheem proposed the design that provides efficient solution for remote home automation to control home appliances such as lights and fans through an Android smartphone via a Bluetooth connection [6].

M. G. S. M. R. K. A. K. Kim Baraka propose the system to optimize power consumption and enhance user comfort by collecting real-time data on energy usage and environmental conditions. The users can remotely control appliances and receive alerts to improve energy efficiency [7].

In this study, Y. Zhang, C. Hu, and X. Yang presented two-level control system coordinates appliance scheduling and ESS/EV energy flow to minimize cost while maintaining user comfort under time-of-use pricing. Simulation results demonstrated significant energy savings and cost reductions compared to traditional optimization methods [8].

A. U. Khalid, S. M. Khan, and R. Ahmed proposed monitoring system using wireless sensors and intelligent algorithms. The system uses current sensors and a K-Nearest Neighbour (KNN) classifier to identify active appliances from aggregate electrical data. Experiments in multiple household setups showed that the KNN-based approach achieved 74–87% accuracy, outperforming rule-based detection methods [9].

A. Rahman, S. Hossain, S. Ahmed, and M. T. Ahmed proposes an Internet-of-Things (IoT) based system for predicting household appliance energy consumption, supporting smarter management of home devices. The authors deploy sensors interconnected via the IoT, collect high-resolution data (1-minute intervals) on appliance usage, ambient conditions, and energy prices, then apply machine learning and explainable AI (XAI) techniques to forecast consumption. Their results demonstrate that accurate short-term prediction enables better scheduling of appliances, reduces peak demand, and enhances overall home energy efficiency. The work is significant because it tackles the forecasting side of home energy management rather than just control, thereby offering a foundation for more proactive and optimized appliance use [10].

III. Methodology and Implementation

A. Methodology

Home automation describes a system of networked, controllable device that work together to make your home more comfortable, customized, efficient and secure. In this device the 5 key additives are: Arduino UNO V2.0, Bluetooth module, Relay drives smartphone and android application. A Proteus 8.13 Professional was used in this project for the implementation of the design. The Arduino is a microcontroller which is a small integrated circuit that governs a certain operation and the Arduino IDE software is a specialized program in the Windows environment for writing programs for the microcontroller Arduino, therefore the C++ code for this project is written and verified(compiled) and the hex file of the compiled code is being copied and pasted in the Proteus software environment where we have made the connections of the components mentioned above.

Further to understand the communication agenda, we've first hooked up the Bluetooth app on our smartphone, which is available in the play store without any difficulty. The application is free and easy to use. This app first asks us to set up the Bluetooth module from the device of implementation of the circuit to the android device and then recognizes our Voice command through the google assistant and sends it to the Bluetooth module wirelessly. The Arduino decodes this command from the Bluetooth module.

Then the Arduino sends a command to the Relays to govern the house home equipment such as the LED light and fan used in our project. This project is relatively simple to implement in the real world and it may be controlled by anyone of any age just by uttering the orders.

B. Implementation

A Proteus 8.13 professional software development was used for the implementation of the design of this project. All the components were connected according to the design interpreted and understood. The Arduino UNO v2.0 is available in the Proteus environment. The Bluetooth module used in this project is installed from the Bluetooth libraries available in web browsers. The Bluetooth module compatible for the environment of the project was the HC-06 module. The HC-06 module of Bluetooth is more compatible as it consists of a serial interface and a

Bluetooth adapter. The module is user-friendly as it uses the slave mode of operation and does not require a setting to switch between master and slave modes. The transmitter and the receiver pins of the Bluetooth module and the Arduino UNO are connected alternatively to encourage serial communication between the two which means to transmit one bit at a time serially which uses the simple SPP (serial port protocol) module planned for the direct distant consecutive affiliation arrangement. Client module (Bluetooth HC-06) and the host controller (Arduino UNO) communicate through enabled Bluetooth in a smartphone. Next, we use the 2 channel 5V relay for the connection to the home equipment devices such as bulbs, fans, motors etc. which is used typically as a switch to turn on or off the devices when controlled from the Bluetooth based app. It has a maximum current rating of 10A at 250VAC. It works on the principle of electromagnetism where the electromagnetic switch of the relay is used to defer two circuits electrically and connect it electromagnetically. So, when the Arduino transmits the signal then the relay driver receives the signal and starts to work. After all these components are connected in the Proteus software environment then it is important to assign the appropriate values to these components and dump the hex file in the Arduino board which has been compiled in the Arduino IDE environment. The app development is usually done from the MIT app inventor where we create our own apps or simply to download the Bluetooth based voice control app from the play store. The process of connection of the Bluetooth from the device where the design is being implemented to the android device to which the app is being controlled is the next most major step. Later a properly available WI-FI connection is necessary for the working of the automation without any proxy error problems for the stability of the medium. Now the software implementation from the Proteus is ready to be run and the voice commands are given from the user which is recognized by the google assistant in the android app. So, the commands are then being obeyed after a delay of how much ever time is being mentioned in the code and also the same instructions are given by the user, which is coded in the Arduino IDE and turns on/off the lights.

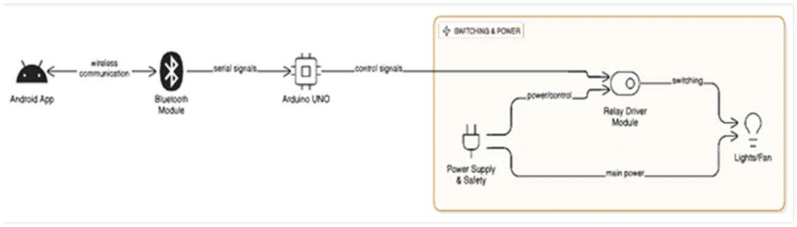

Fig. 1. System Architecture and Bluetooth Communication Flow

In the developed system as shown in Figure 1, the user gives a voice command through an Android phone, which is converted into text and passed to the home automation app. This application sends a simple instruction to the HC-06 Bluetooth module, which then transfers it to the Arduino via serial communication. The Arduino interprets the received message and drives the relay module accordingly. The relay either switches the appliance ON or OFF based on the command. This straightforward chain from voice input to relay activation makes the system easy to operate and suitable for basic home automation tasks.

The Figure 2 explains about the integration of the various modules to implement the proposed system.

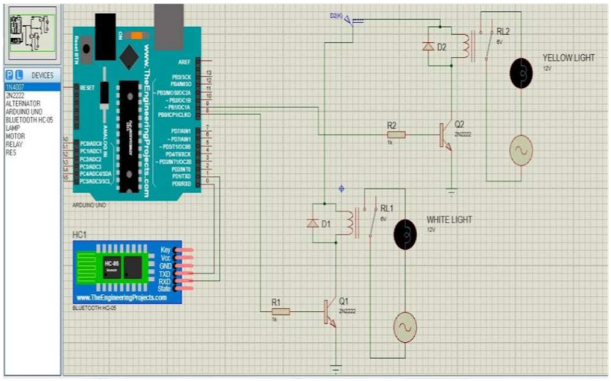

Fig. 2. Implementation of voice control home automation system using Bluetooth module.

Microcontroller: The Arduino Uno V2.0 is based on the ATmega328P microcontroller chip from Microchip

Technology. It has 32KB of flash memory for storing your program, 2KB of SRAM for variable storage, and 1KB of EEPROM for data storage. Clock Speed: The ATmega328P on the Arduino Uno V2.0 runs at a clock speed of 16 MHz.
Digital I/O Pins: It has 14 digital input/output pins, out of which 6 can be used as PWM (Pulse Width Modulation) outputs. Analog Input Pins: The board features 6 analog input pins that can also be used as digital I/O pins if needed.
USB Interface: The Arduino Uno V2.0 comes with a built-in USB interface, allowing you to connect it to your computer for programming and communication. It uses the CH340G USB-to-serial converter chip for communication with the computer.
Power Supply: The board can be powered through a USB connection or an external power supply. The recommended input voltage range is 7 to 12 volts.
Power Jack and Vin Pin: The Arduino Uno V2.0 includes a power jack that accepts a DC input, and it also has a Vin pin that can be used to supply power to the board.
Reset Button: It has a reset button that allows you to restart your program or initiate the bootloader.
ICSP Header: The Arduino Uno V2.0 features an ICSP (In-Circuit Serial Programming) header, which enables you to program the microcontroller using an external programmer.
LED Indicators: The board has built-in LEDs that indicate the power status and the status of digital pins 13, 5, 4, and 3.
Compatibility: The Arduino Uno V2.0 is compatible with the Arduino software (IDE) and can be programmed using the Arduino programming language, which is a subset of C/C++.
BLUETOOTH MODULE HC-06: Bluetooth era is an excessive velocity low powered wi-fi era hyperlink that is designed to attach telephones or different transportable gadgets. The Bluetooth module has six pins -Enable, VCC, Ground, Transmit Data (TxD), Receive Data (RxD), and State. The Enable and State pins are unused and so now no longer linked within side the circuit. The VCC and Ground pins are linked to the not-unusual place VCC and Ground. The TxD and RxD pins of the module are linked to pins 10 and 11 of the Arduino. For serial communication connect the TXD pin of Bluetooth Module HC-06 with RX (pin 0) of Arduino UNO and RXD pin with TX (pin1) of Arduino UNO. It supports the Serial Port Profile (SPP) that allows transparent serial data transmission between devices.
CHANNEL RELAY: A 2-channel relay is a device that allows you to control two separate electrical circuits using a single control signal. Each channel of the relay consists of a switch that can open or close the circuit it is connected to. Relay is an electromagnetic switch that is used to defer two circuits electrically and connect magnetically. When Arduino transmits the signal the relay driver receives the signal and starts its work. They are frequently used to interface an electronic circuit (working at low voltage) to an electrical circuit which works at extremely high voltage. When the power is transmitted the relay works as a switch due to electromagnetic effect so that we can switch ON or OFF our home appliances.

IV. RESULTS AND DISCUSSION

The proposed system effectively demonstrates the development of a smart and affordable home automation setup. This automation framework enables easy control of household appliances such as lights, fans, tube lights, air conditioners, and bulbs through a Bluetooth-connected Android application.
Figure 3 describes the Software implementation of voice control home automation system using Bluetooth module. The flowchart illustrates the working process of a Bluetooth-based voice-controlled home automation system using an Android application and an Arduino module (HC-06). The operation begins when the user opens the application on their Android smartphone and selects the HC-06 Bluetooth module for connection. If the device is not connected, the system prompts the user to reconnect; once connected, the user can either tap a button or give a voice command to control appliances such as lights or fans. The application converts the user's input either from a button press or a voice command into text, which is then transmitted via Bluetooth to the Arduino. The Arduino receives this text at its serial input and compares it with predefined commands in its code. If the received command matches, the Arduino executes the corresponding action through the relay module, turning the appliance ON or OFF. If no match is found, the system requests the user to repeat the voice command. This flow ensures smooth, wireless, and user-friendly control of home appliances through voice or app-based inputs.
Figure 4 and Figure 5 illustrates the Voice Command given to Turn on Light and to Turn off the light.
Although the system does not use advanced encryption, basic precautions can still improve safe operation.

Changing the default Bluetooth PIN, keeping the HC-06 module within the home, pairing the device only once, and allowing the Arduino to accept only valid commands help reduce accidental access and ensure reliable performance. These simple measures are suitable for small indoor home automation setups and match the practical features of the HC-06 module. The HC-06 operates within ~10 m. Placing it inside the house minimizes external access. After initial pairing, the device remains connected only to the paired smartphone, reducing the chance of other devices attempting to connect. Arduino checks only pre-defined commands and ignores all other strings, preventing accidental or malformed command execution.

V. CONCLUSION

Voice-controlled home automation marks a significant advancement in IoT technology, utilizing a completely wireless medium for seamless connectivity. Numerous Android-based applications have been developed in this domain, including systems like voice-controlled wheelchairs. Building on previous research and experiments, this work efficiently applies the same concept to control home appliances through simple voice commands, making daily tasks more convenient.

If implemented on a larger scale, this technology has the potential to greatly transform everyday living, especially for the elderly and physically challenged. Controlling appliances such as fans, lights, and heaters wirelessly represents a remarkable step forward in modern automation. While security and vulnerability issues remain areas of ongoing improvement, this innovation offers a strong foundation for future development and a smarter, more accessible lifestyle.

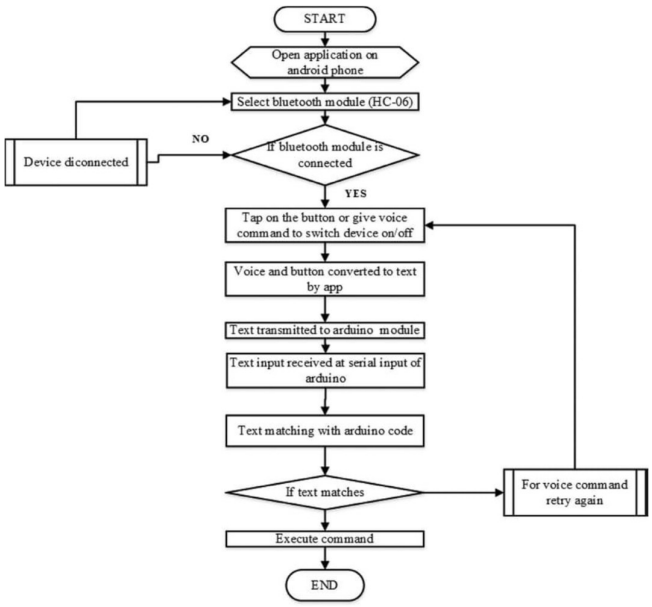

Fig. 3. Software implementation of voice control home automation system using Bluetooth module

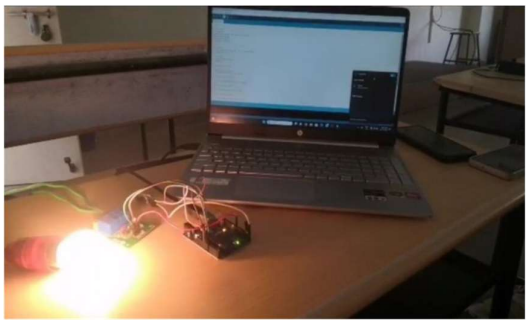

Fig. 4. Voice Command given to Turn on Light

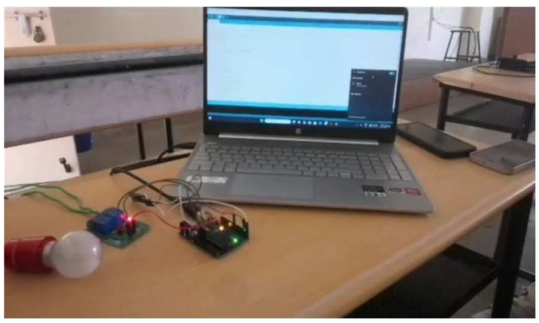

Fig. 5. Voice Command given to Turn off Light

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