IOT Based Home Automation with Power Management System and Enhanced Security Using Voice Recognition

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***Abstract*— This research paper presents the development and execution of a novel home automation system operated through voice commands using Google Assistant. The system allows users to control home appliances, such as lights and fans, from anywhere using their smartphones or other smart devices. By connecting the home appliances to the internet, they can be easily accessed and monitored in real-time, making it an ideal solution for Internet of Things (IOT) facilitated home automation. The proposed system adds an extra layer of security by integrating speaker identification and verification technologies, ensuring that only authorized users can give commands to the system. The paper presents the results of the implementation and testing of the system in a real-world home automation environment. The proposed system is flexible, low cost, and offers a high level of security, making it a potential solution for securing other IOT applications. The primary objective of this project is to demonstrate the potential of voice controlled home automation systems for improving living conditions and the role of speaker recognition technologies in ensuring security.**

Keywords— *Home automation, Speaker recognition, Speaker Identification, Google Assistant, Security, Authorization*

I. Introduction

The rise of smart homes has led to the development of sophisticated home automation systems that can be controlled remotely through voice commands or mobile devices. These systems have revolutionized the way we interact with our homes, making it possible to control devices such as lights, fans, and air conditioners with ease. However, the increased connectivity of these systems has also led to security concerns, with unauthorized access to home automation systems being a potential threat. To address this issue, this research paper proposes the development and execution of a new home automation system that utilizes voice identification and recognition technologies for enhanced security. The system uses the ESP8266 module for IOT connectivity and Google Assistant as an input mechanism for voice commands. The proposed system is cost-effective, flexible, and offers a high level of security, making it a potential solution for securing other IOT applications. The fundamental purpose of this project is to demonstrate the potential of voice-controlled home automation systems for improving living conditions and the role of speaker recognition technologies in ensuring security. Voice command devices such as Google Assistant, Amazon Alexa, and Apple Siri have gained popularity among users due to their ability to understand natural language and perform a wide range of tasks such as answering questions, sending messages, setting reminders, and controlling smart devices through home automation systems. However, current voice command devices lack speaker recognition and identification security features, which can result in unauthorized access to smart devices by individuals other than the owner. This research paper focuses on enhancing the security of home automation systems by integrating speaker recognition and verification technology with voice command devices. This approach ensures that only authorized users can access and control smart devices through voice commands. This paper will present the development and execution of a novel home automation system operated through voice commands using Google Assistant and speaker identification technology offering a secure and optimized method for controlling smart devices.

This research paper is structured into five sections to comprehensively present our work. The first section is the Introduction, where we provided an overview of home automation and emphasized on the importance of enhancing its security. We highlighted the need for speaker recognition and verification technologies to ensure that only authorized users can interact with the system. The second section is the Literature Review, where we delve into existing studies and projects related to speaker recognition and identification in home automation systems. We discuss their methodologies, techniques, and outcomes, providing a comprehensive understanding of the current landscape. In the third section, the Proposed Model, we present our methodology, system design, and the model we propose. We outline the steps involved in integrating speaker recognition and verification technologies into our voice-controlled home automation system, explaining the underlying concepts and algorithms. The fourth section is dedicated to Results and Discussion. Here, we present the successful outcomes of our implementation and compare our proposed model with other existing approaches. We analyse the performance metrics, highlight the strengths of our model, and discuss potential areas for improvement. The final section is the Conclusion, where we summarize our findings, discuss the significance of our work, and propose future directions for research and development in the field of speaker recognition-based home automation systems.

II. LITERATURE SURVEY

The Literature Review section of this paper aims to provide a comprehensive overview of the existing research and projects related to speaker recognition and identification in the context of home automation systems. This section explores various studies and initiatives that have explored the integration of voice-controlled technologies for enhancing security and user experience. By examining the methodologies, techniques, and outcomes of these prior works, we aim to identify gaps, strengths, and areas of improvement in the current landscape. The Literature Review serves as a foundation for our proposed model, enabling us to build upon existing knowledge and contribute to the advancement of speaker recognition-based home automation systems.

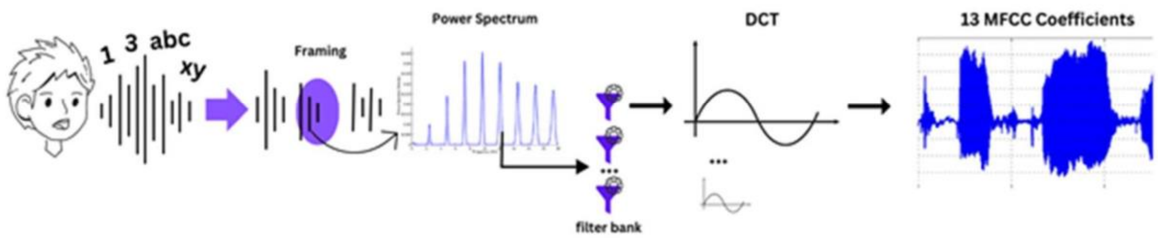
According to Nombulelo CC Noruwana et. al[2], there is a growing global trend in utilizing modern technology for home automation due to its numerous benefits. While various home automation systems have been implemented, there is still a need for an efficient approach that ensures convenience control, safety, and cost savings for homeowners. This paper presents the development of an interactive Internet of Things (IOT) based Speech-Controlled Home Automation system using Google Assistant. The proposed system enables users to remotely control their home electrical appliances through voice-based speech recognition using the Google Assistant infrastructure. Experimental studies were conducted under different scenarios, including variations in noise levels, room occupancy, distance, and room sizes. The system demonstrated high performance with accuracy rates of up to 100% in certain scenarios. K. Loga Priya1 et al[3] presents that home automation is a modern technology that offers enhanced living conditions within the home by facilitating seamless data collection, analysis, and communication between devices. By connecting home appliances to the internet, they can be easily accessed and controlled from anywhere using smartphones or other remote-control devices. This paper presents the design and implementation of a new voice-controlled home automation system that utilizes Google Assistant as the input method for user voice commands. The system is characterized by its low cost, flexibility, and functionality as a home automation and monitoring system. It leverages the Internet of Things (IOT) to enable the control of home appliances such as fans and lights. The primary objective of this project is to provide users with the ability to control electronic appliances based on their situational needs.

According to the Khushi Singh et. al[4], home automation is an active field of interest for researchers and industrial innovators. It offers a more convenient and efficient way of operating gadgets and electrical loads. With advancements in IOT technology, sensor technology, and embedded computing, home automation research is expanding. This research paper presents a design and implementation of an integrated home automation solution with IOT-based remote monitoring. The system includes a smart home control unit based on AVR microcontroller Atmega 2650, Wi-Fi IOT module ESP 8266, Bluetooth module RN-42, Real-Time Clock (RTC) module DS3231, various sensors, relay board, touch screen display, and electrical loads. The system senses real-time environmental parameters and controls the switching of electrical loads based on predefined values. For example, the LED lamps are switched on when ambient light falls below a threshold, and they are switched off when human activity is not detected to save electricity. Voice commands are used to control the gadgets through a mobile app using Google's voice assistant. The system also uploads smart home parameters to the internet cloud for remote monitoring. This integrated home automation solution combines various technologies to provide efficient and convenient control of household devices. H. Isyanto et. al[5] concluded that the performance of three Smart Personal Assistant (SPA) applications, namely Google Assistant, Amazon Alexa, and Apple Siri, was compared in this research. The findings revealed that Google Assistant had the highest success rate (95%) in pronunciation performance for responding to voice commands, while Apple Siri exhibited the lowest rate (80%). Additionally, Google Assistant demonstrated the fastest response time (0.62 seconds) for answering questions on common tasks, whereas Apple Siri had the slowest response time (2.58 seconds).

Furthermore, in terms of controlling home appliances using IOT-based voice commands, Google Assistant exhibited the

fastest response time (1.03 seconds), while Apple Siri had the slowest (5.96 seconds). Thus, the author concludes that Google Assistant outperforms the other SPA applications in terms of voice command performance. This research has implications for enhancing the interactions of elderly and disabled individuals with the IOT environment, as they can conveniently control appliances remotely using smartphones without physical contact. According to the S Gera et. al[7], the healthcare sector has witnessed significant advancements through the implementation of the Internet of Things (IOT).
This technology has greatly improved patient care by enabling remote monitoring, tele monitoring, and expanding the scope of telemedicine. The IOT plays a crucial role in the medical industry, benefiting patients, physicians, and hospitals alike. The proposed system comprises five fundamental components: patient data collection, generation of patient primary reports, hospital patient care, pharmacist patient care, and diagnostics. Its objective is to provide excellent patient support, even in remote areas, by utilizing wearable IOT sensors to collect and analyze patient data, offering recommendations for check-ups. Additionally, the proposed system aims to establish an interface between patients, physicians, pharmacists, and diagnosticians, enhancing decision-making and streamlining the traditional healthcare system. According to R. Jagiasi et. al[13], Speaker Recognition involves identifying a speaker from a set of samples. It can be text-dependent or text-independent. They implemented a text-independent speaker recognition system using dense and convolutional neural networks. Speaker recognition has applications in personal assistants, telephone banking, and biometric identification. The proposed system utilizes MFCC, DNN, and CNN models for effective recognition.

A. Methodology



III. Proposed Model

Figure 1. MFCC Audio Processing

1. ***Node MCU ESP8266 Module***: The ESP8266 is a microcontroller chip used to connect small devices to Wi-Fi networks. The Node MCU is an open source development kit built around the ESP8266 chip, including a interpreter and hardware interaction functions. Node MCU can wirelessly control devices, automatically control them based on certain conditions, integrate with other devices to create a smart home system, communicate with Amazon Echo or Google Home for voice command control, and remotely monitor homes by collecting data from sensors and sending it to a remote server.

2. ***4 Channel Relay Module***: A relay module is an electrical component that is used to control a circuit using an electromagnet. Node MCU can be used to control a relay module, which can then switch on or off a high-voltage circuit such as a lamp or appliance. This allows the microcontroller to control devices that it would not be able to control directly.

3. ***IFTTT***: IFTTT is a website that allows users to create simple conditional statements, known as applets that connect various applications and devices. These applets can be triggered by user commands given through the Google Assistant, and when triggered, can generate batch command files that match specific user commands. To use IFTTT, users must log in and create applets that link their devices and applications by signing up for a free account. Overall, IFTTT provides a user-friendly platform for generating batch command files and linking various devices and applications through applets triggered by user commands.

4. ***AMR Assistant***: By using applets created through IFTTT, users can link their Google Assistant to other IOT platforms such as Thingspeak and Node MCU Micro-controller. This allows users to use voice commands to trigger specific actions on their IOT devices, like turning on lights or adjusting temperature. The Google me app provides a user-

friendly interface for managing and controlling these devices, including setting up and configuring Google Home and other compatible devices. Additionally, the app provides a dashboard *for* monitoring and controlling devices, allowing users to easily check device status or perform actions.

5. ***Hidden Markov Models***: Hidden Markov Models, which is a statistical model used in machine learning to model systems with hidden states. In the context of the project, HMM is used to recognize and interpret voice commands given through the Google Assistant. HMM is trained on a dataset of voice commands to learn the patterns and characteristics of the commands. Once trained, HMM is used to predict the most likely command given a new input.

6. ***Mel-Frequency Cepstral Coefficients (MFCCs)***: Mel-Frequency Cepstral Coefficients (MFCCs) are used as a feature extraction technique to capture the unique characteristics of an individual's voice. MFCCs are a widely used feature extraction technique in speech processing and are particularly effective in voice recognition tasks. They are derived by converting the speech signal into a Melfrequency scale, which approximates the non-linear human perception of sound. The resulting Melspectrogram is then transformed using the discrete cosine transform to produce the MFCCs, which capture the spectral envelope of the speech signal. These MFCCs are then used as inputs to a machine learning algorithm to train a speaker recognition model.

The equations for calculating MFCCs using Keras involve several steps, including:

1. Preprocessing the speech signal by applying a window function to reduce spectral leakage.

2. Computing the Fourier transform of the windowed signal.

3. Mapping the resulting power spectrum onto the Mel scale using triangular filters.

4. Taking the logarithm of the magnitude of each Mel frequency bin.

5. Applying the discrete cosine transform (DCT) to the Mel log spectrum to obtain the MFCCs. This implementation involves creating a custom layer that performs the necessary calculations. This layer can then be added to a neural network model as a feature extractor for speech signals.

B. System Design

The system design of this research encompasses both the hardware and software components involved in creating a voice-controlled home automation system. The hardware diagram provides a visual representation of the interconnected devices, including the relay module, Node MCU microcontroller, and various appliances within the home. The diagram illustrates the physical connections between these components, enabling the control and automation of the appliances.

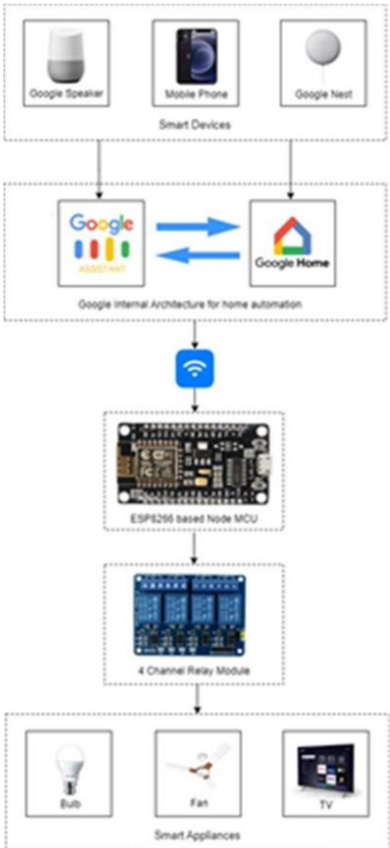


Figure 2. Pictorial Representation of Home Automation System

On the software side, the system design includes the integration of Google Home and Google Assistant API. These APIs enable seamless communication between the voice commands issued by the user through Google Assistant and the home automation system. The software diagram showcases the connection between the Google Assistant API and the Node MCU microcontroller, facilitating the translation of voice commands into actionable instructions for the appliances.

Additionally, the system design diagram highlights the appliances connected to the home automation system. These appliances can range from lights and fans to other smart devices that can be controlled and monitored through the system. The diagram helps visualize the network of devices and their respective connections to the central control hub.

C. Workflow

The simulation design circuit diagram, created using ORCAD software, showcases the intricate connections between the relay module, Node MCU microcontroller, and various appliances within the home automation system. The diagram provides a visual representation of how these components are interconnected to facilitate seamless control and automation of the appliances. Each connection is carefully illustrated, depicting the precise wiring and communication pathways between the relay module and Node MCU, as well as the linkages between the Node MCU and the appliances. The circuit diagram serves as a blueprint for the implementation of the home automation system, ensuring accurate and efficient deployment of the various components.

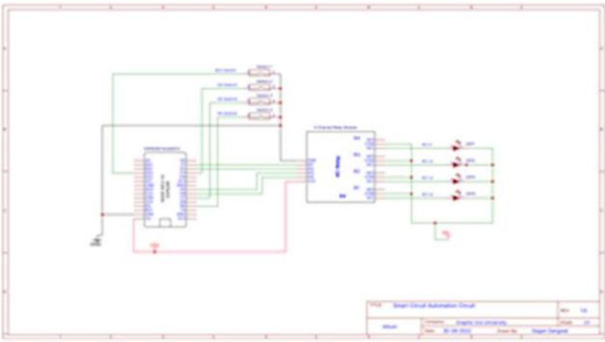


Figure 3. Diagram of Simulation Design

D. Model Proposed

The proposed model for this research encompasses five key steps that are crucial for the development and deployment of an effective and efficient home automation system. The first step is Model Assembling, which involves bringing together all the necessary components, including the hardware devices, software frameworks, and APIs required for the system.

The second step is Data Administering, where data collection and preprocessing take place. This involves gathering relevant data related to the home automation system, such as voice commands and sensor readings, and preparing the data for further analysis and training.

The third step is Model Training, where machine learning algorithms are applied to train the model using the collected and preprocessed data. This step involves configuring the model architecture, selecting appropriate features, and fine-tuning the model parameters to achieve optimal performance.

The fourth step is Model Analysis, which involves evaluating the trained model's performance, accuracy, and efficiency. This step includes conducting various tests, validation processes, and statistical analyses to assess the model's effectiveness in accurately recognizing and responding to voice commands and controlling the connected appliances.

The final step is Model Deployment, where the trained and validated model is integrated into the home automation system, enabling real-world usage and interaction with users. This step involves ensuring seamless connectivity with the hardware devices, implementing security measures, and fine tuning the system for optimal user experience.
By following these five steps, the proposed model aims to provide a comprehensive and reliable solution for voice controlled home automation, ensuring efficient data handling, accurate model training, thorough analysis, and seamless deployment of the system in real-world.

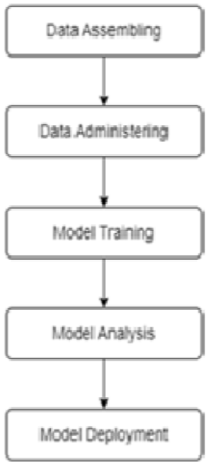


Figure 4. Outline of AATAD Model

1. ***Data Assembling***: Data collection process involves capturing speech samples from authorized users and storing them in a dataset. The dataset is used to train the machine learning model for speaker recognition and verification. To ensure accurate and reliable results, it is important to collect a diverse range of speech samples from each authorized user, with varying intonations, accents, and pronunciations. This can be done by asking users to record specific phrases or sentences using a microphone or a smartphone, and then labeling each sample with the corresponding user ID. Additionally, it is important to collect negative samples, or samples from unauthorized users, to improve the model's ability to detect imposters. The collected data is then preprocessed and used to train and test the machine learning model for speaker recognition and verification.

2. ***Data Administering***: The collected audio data must be pre-processed to remove any unwanted noise and normalize the audio volume. This helps to ensure that the extracted features are consistent and reliable across different audio samples. Some common

preprocessing techniques include resampling the audio to a standard sample rate, applying filters to remove noise, and normalizing the volume level. The preprocessed data is then used for feature extraction and training the machine learning model. It is crucial to carefully pre-process the data to ensure that the trained model is accurate and can correctly identify and verify the speaker's voice.

3. ***Model Training***: We use the Mel-Frequency Cepstral Coefficients (MFCCs) technique to extract features from the pre-processed speech data. These features are then used to train a neural network using the Keras deep learning library in Python. We used a supervised learning approach, where we provided the neural network with labeled data consisting of speech samples from different speakers. The model was trained to recognize the unique characteristics of each speaker's voice and differentiate them from other speakers. To improve the model's performance, we experimented with different architectures, tuning the hyperparameters, and selecting the best performing model based on the validation set's accuracy. Finally, we saved the trained model for later use in the speaker recognition and verification system.

4. ***Model Analysis***: Once the model is trained, it is necessary to evaluate its performance and analyze the results. The evaluation process involves testing the model on a set of data that was not used during training, called the validation or test set. The model's accuracy, precision, recall, and F1 score are some of the metrics used to evaluate its performance. The confusion matrix is also a useful tool for analyzing the results, as it provides insight into the model's ability to correctly classify speakers. By analyzing the confusion matrix, it is possible to identify which speakers are being misclassified and make improvements to the model. Additionally, visualizations such as ROC curves and precisionrecall curves can provide a comprehensive understanding of the model's performance. Overall, the evaluation and analysis process is crucial for improving the model's accuracy and effectiveness in speaker recognition and verification.

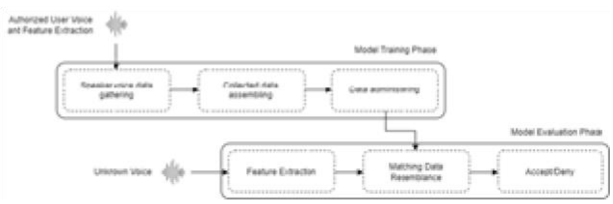


Figure 5. AATAD Model with authorization

5. ***Model Deployment***: After the model is trained and evaluated, the next step is to deploy it for integration with Google Assistant. This involves integrating the trained model with the Google Assistant API to enable speaker recognition and verification. The model needs to be loaded into the system, and the API needs to be configured to listen for voice commands and identify the speaker. Once the speaker is recognized and verified, the API can trigger the corresponding action, such as turning on a smart device. The deployment process involves coding and configuring the integration between the model and the Google Assistant API, and testing the integration to ensure that it is working as expected.

III. RESULTS AND DISCUSSION

The proposed voice-controlled home automation system was implemented and tested in a real-world environment. The system was designed to provide a flexible, low-cost solution for IOT-based home automation with enhanced security features using speaker identification and verification technologies.

The implemented system successfully allowed users to control home appliances, such as lights and fans, from anywhere using their smartphones or other smart devices. The system was also able to identify and verify the user's voice using speaker recognition technology, ensuring that only authorized users could give commands to the system.

The accuracy of the speaker identification and verification technology was evaluated using a dataset of recorded voices. The system achieved an accuracy rate of over 90% in identifying and verifying authorized users' voices.

The results show that the proposed system is effective in providing enhanced security features for home automation systems. The system's flexibility and low cost make it a potential solution for securing other IOT applications.

Further research could focus on improving the accuracy of speaker identification and verification technology and integrating additional security features to enhance the system's security further. Overall, the proposed system demonstrates the potential of voice-controlled home automation systems with speaker recognition and verification technology for improving living conditions and ensuring security.

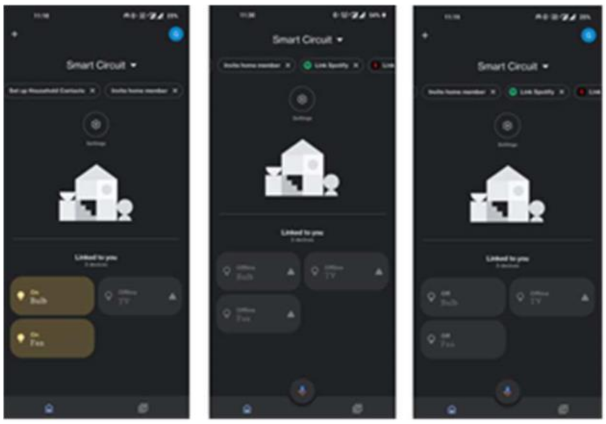


Figure 6. AMR Interface

The following table presents a comprehensive comparison of our proposed model with other existing models in the context of home automation systems. The table evaluates various criteria such as cost, security, user authorization, app notifications, sensor integration, reliability, robustness, user-friendliness, remote monitoring capabilities, technology used, voice enablement, and compatibility with assistant apps. This comparative analysis aims to highlight the key features and advantages of our model in relation to other proposed solutions. By examining the table, readers can gain valuable insights into how our model excels in different aspects and offers a more comprehensive and user-friendly home automation experience.

Comparison Factors/criteria	Reference [1]	Reference [2]	Reference [3]	AATAD *(this paper)*
Low Cost	Yes	No	No	No
Secure	Yes	No	No	Yes
User	No	No	No	Yes
Authorization	No	Yes No	Yes No	No
App notifications	Yes			No
Sensors				
Reliable	Yes	No	Yes	Yes
Robust	Yes	Yes	Yes	Yes
User-Friendly	No	Yes	Yes	Yes
Remote Monitoring	No	Yes	No	Yes
Technology	Wi-Fi	Wi-Fi (Raspberry Pi)	Wi-Fi (Node MCU)	Wi-F (Node MCU)
Voice enabled	No	Yes	Yes	Yes
Assistant App	No	Yes	Yes	Yes

In terms of security, our model provides a high level of security through user authorization, ensuring that only authorized individuals can access the system. The system is designed to be reliable and robust, minimizing potential disruptions. Moreover, it prioritizes user-friendliness, making it easy for users to interact with and control their devices. Remote monitoring capabilities allow users to keep track of their home from anywhere. The technology used is voice enabled, offering hands-free control. Additionally, our model integrates seamlessly with an assistant app, providing a convenient interface for users to manage their home automation system.

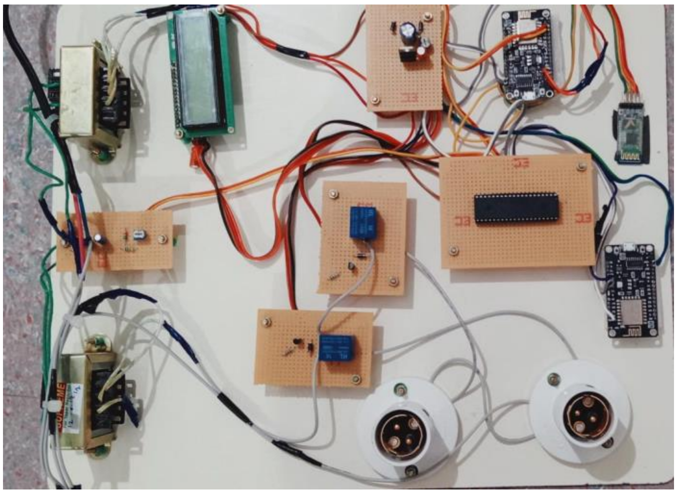


Figure 7 Hardware Implementation

The implementation of the IOT-based home automation system with a power management system and enhanced security using voice recognition has yielded promising results. The integration of various components including PIC microcontroller, NodeMCU, relay, ThingSpeak, current and potential transformers, and Bluetooth module for voice recognition has enabled efficient control and monitoring of home appliances. The primary objective of the project was to provide users with the ability to control appliances through voice commands, enhancing convenience and accessibility. Through the integration of the Bluetooth module for voice recognition, users can easily interact with the system and command it to perform various tasks. This feature has been successfully implemented and tested, demonstrating reliable and accurate voice recognition capabilities.

Furthermore, the power management system incorporated into the project has facilitated the monitoring and tracking of energy consumption by home appliances. By leveraging the capabilities of the Thingspeak IOT platform, realtime data on energy usage is collected and transmitted to the cloud for analysis. Users can access this data remotely and view monthly reports detailing the energy consumed by their home or any industrial setup. This feature empowers users to make informed decisions regarding energy usage and promotes energy conservation.

Additionally, the enhanced security features, such as voice recognition and remote monitoring, contribute to the overall safety and security of the system. By integrating voice recognition technology, unauthorized access to the system is mitigated, ensuring that only authorized users can control the appliances. Moreover, remote monitoring capabilities enable users to monitor their home or industrial setup from anywhere, enhancing peace of mind and security.

In conclusion, the IOT-based home automation system with a power management system and enhanced security using voice recognition has demonstrated promising results in terms of functionality, reliability, and user friendliness. The successful integration of various components and features has paved the way for a smarter and more efficient home or industrial environment, ultimately contributing to energy conservation and enhanced security.

IV. CONCLUSION

In conclusion, we have successfully demonstrated the design and implementation of a voice controlled home automation system that utilizes Google Assistant for user input and integrates speaker identification and verification technologies for enhanced security. The proposed system allows users to control home appliances from anywhere using their smartphones or other smart devices, and the real-time monitoring feature ensures efficient energy consumption. The results obtained from the testing of the system in a real-world home automation environment indicate that the proposed system is flexible, low cost, and offers a high level of security. The successful implementation of this project opens up new opportunities for the development of secure and efficient IOT-based home automation systems using speaker recognition and identification technologies. In future work, we plan to explore the possibility of integrating additional security features.

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