Speech-Driven Smart Home Appliances: A Modular Approach to Sustainable and Inclusive Automation

Dr K V Ramprasad[1],B swetha[2], G Swarun[3],M SONY[4],N CHANDANA[5]

Kvrp1976@gmail.com1, Swethajune19@gmail.com2,swarungullapally@gmail.com3,sonymyadari12@gmail.com4,Chandanamadhureddy@gmail.com5

ASSOSCIATE PROFESSOR 1,ASSISTANT PROFESSOR 2,UG SCHOLAR3,4&5

DEPAERTMENT OF ECE, Visvesvaraya College of Engineering and Technology,6HFQ+H98, Patel Guda, Mangalpalle, Telangana 501510

***Abstract*— Over the past decade, smart schemes have significantly influenced daily human life. Modern smart home systems enhance entertaining, household control, energy monitoring, and security using advanced technologies, sensors, and processors. Services like voice-controlled alarms, personalized calendars, besides weather or news reminders are common. This paper benevolences a voice-controlled electric devices project aimed at improving accessibility and usability for household appliances. By integrating advanced speech recognition technology, users can control devices such as lights, fans, and air conditioners with simple voice commands. The system includes a microphone for voice input, a speech processing module to interpret commands, besides an Arduino microcontroller to control appliances via relays, sensors, Bluetooth modules, or smart plugs. Basic commands like "turn on/off" besides "adjust settings" offer hands-free operations, ideal for folks with mobility challenges, seniors, and those seeking efficient home management. The organisation's modular design allows seamless mixing with smart home surroundings and future scalability for features like voice-based automation, IoT compatibility, besides mobile app control. Additionally, the project incorporates sensors for weight measurement, gas detection, and temperature monitoring to enhance safety and convenience. This innovative approach aims to simplify routine tasks, promote inclusivity, besides support sustainability. Overall, the project represents a significant advancement toward next-generation smart home solutions, educating efficiency besides user experience.**

Keywords*— Voice-Controlled Smart Home, Speech Recognition Technology, Arduino Microcontroller, IoT-Based Home Automation, Smart Appliances Control, Sensor Integration and Monitoring, Accessibility and Sustainability in Smart Systems.

I. INTRODUCTION (*HEADING 1*)

Improving productivity while decreasing labour has always been technology's top priority. We have been advocating for pervasive computing across all domains since the introduction of the "Internet of Things" a decade ago. Simplifying human-technology interaction is, hence, of paramount importance. The goal of automation, for example, is to increase efficiency while also making things easier to use [1]. The purpose of a voice-controlled home automation system is to simplify life via more automation [2]. The earliest humans understood that speaking to one another was the most efficient means of communication. It would be easy to narrate concepts with little effort. The idea of being able to tell a computer what to do just by speaking to it was a thing of science fiction when the first computers appeared. Nevertheless, because to significant advancements in the field [3], we are on the verge of really being able to use voice commands to interact with electronics. We could bring technology much closer to people if we used this engrained but highly effective mode of communication [4]. The use of voice commands to operate various home automation systems is already commonplace [5].

There are several benefits of utilising voice as a means of communication. First, we would drastically cut down on, or eliminate entirely [6], the requirement for operating system training. Secondly, if services were to be simplified, more individuals would use the technology that is already available, which would be great for people with all kinds of disabilities since it would level the playing field [7]. Due to the platform's extensive usage in the mobile market and the ease with which it allows us to apply advanced technology, we have deployed an Android application as the user front end. More than 80% of the world's cellphones run on Android [8]. Figure 1 presents the sample image for smart home automation based on voice input.

Figure.1. Example image for Smart home voice-based automation.

This project's overarching goal is to design and build a voice-activated system for controlling common household appliances. The device for capturing voice will be the Google Voice search app. It is Android Meets Robots (AMR) that will be used to build the GUI. The term "voice controlled electrical appliances" is used to label this system in this project. The goal of this project is to develop a voice-activated system that can manage various electrical devices. This method allows user to activate electrical appliances just by speaking into them [9]. Disabled people who utilise this method may find it easier to go about their everyday lives at home. Machines can understand spoken words with the help of speech recognition software. While "voice recognition" can mean either "speech recognition" or "person recognition," the latter more accurately defines efforts to identify the speaker rather than the words themselves. Modern computing has made possible to record besides save human speech in digital memory for use at a later date. The Android Meets Robots program (AMR) provides the graphical user interface (GUI) are necessary for this system. With this program, you may create a GUI and code that identify human speech. Users can command their desired electrical equipment with sound of their voice. The system is built to be easy to install, setup, run, and maintain, and it is portable as well [10].

II. Related works

Wang et al., [11] has introduces an innovative voice-controlled smart home lighting system designed to enhance user control and energy efficiency. It allows users to create custom lighting scenes and schedules, automating settings for efficient lighting based on specific needs. Voice-controlled smart lights progress energy efficiency by enabling users to control lighting with voice commands, adjust brightness, and create schedules for various activities. Timers also prevent unnecessary usage, making them a valuable calculation to energy-efficient smart homes. This approach effectively contributes to energy effectiveness in smart homes, representing a significant advancement in the field. By combining personalized lighting control with seamless automation, the system not only provides convenience but also promotes sustainable and efficient energy usage in modern smart homes.

Cherian et al., [12] has presents a novel approach of managing smart appliances with voice commands, which is referred to as Voice Assisted Smart Appliance Control (VASAP). In order to assess the efficacy besides performance of the suggested system, it is compared against the traditional GPRS Assisted Smart Appliance Control (GPRSSAC). An Android app requires the user to speak commands. Voice instructions may be recognized and transmitted to the system using this program. These commands are decoded by a receiver and decoder, which then send them over a serial connection to the Arduino controllers. The system's software and hardware are developed in accordance plan, and the system's wireless communication technique, which integrates Wi-Fi and RF (radio frequency), is also established. The systems functional needs inform the design of two sets of control schemes-one for voice control and one for button control-with the goal of making the system more compassionate. For the voice control solution to work, the user must smart terminal the control instructions that have been pre-programmed into the system's voice library. Once the recognition is confirmed, the user will be able to command their household appliances. Under the key control scheme, smart terminal keys are used to appliances. In order to collect and store audio, verify family members, and recognize voice commands, the upper computer uses an algorithm that was studied in this study. The lower computer collects environmental information in real-time and wirelessly controls home facilities. Upon startup, family members are asked to confirm their voice commands. Following this, the system uses real-time environmental information and the results of voice command recognition to formulate a control command. Through the serial port, the command to operate the associated home equipment is sent from the top computer to the lower computer. Under controlled laboratory settings, the inspected and evaluated. In addition to authenticating family members, the test findings demonstrate that the technology can operate home amenities using voice commands and instantaneous fashion data on the environment.

Selvarathi et al., [13] has design a gadget that will help people with mobility impairments by utilising the principle of this particular component of IoT. Mainly, there are two segments to the suggested device. A channel relay, an Arduino, and a smart lightbulb are included in the hardware section. The cloud and IOT platforms, along with an app created especially for this use, make up the software component. The principal purpose of this apparatus is to identify particular words in an individual's speech and subsequently trigger or deactivate the smart gadget, so establishing an intelligent living space. First, a lightbulb will be used to demonstrate this. Java programming language will be used in the app's development. The primary characteristic that sets this programme apart is its microphone, which will be used to issue commands. To increase transmission speed, Bluetooth and Wi-Fi chips will also be included in the lightbulb and the phone. Additionally, noise sensitivity and quick transmission will be given special consideration. It is also possible to add different appliances, such fans and air conditioners, to the suggested gadget. An enhanced safety feature is taken into consideration in cases where the application reacts exclusively to a specific voice.

Sahu [14] has explores the implementation of a home automation system using the Blynk app and IFTTT (If This Then That) platform. The system is designed to control the on/off status of two bulbs using a two-channel relay module, NodeMCU ESP32 microcontroller, and physical push buttons. The hardware components include a two-channel relay module, two bulbs, NodeMCU ESP32 microcontroller, too physical push buttons. The physical push buttons are connected between the ESP32 and the relay module, as well as between the power supply and the ESP32. The ESP32 serves as the central hub for the automation system, controlling the relays based on physical push buttons and commands received via the Blynk app. Software development for this project is done using the Arduino IDE, which provides a user-friendly interface for programming the ESP32 microcontroller. The Blynk platform is utilized to create a virtual dashboard for monitoring besides controlling the status of the relays remotely through the Blynk mobile app. Users can easily toggle the on/off status of the bulbs using the virtual buttons on the Blynk app, providing convenient control from internet connection. Furthermore, the system is integrated with the IFTTT platform to enable automation based on predefined triggers and actions. This allows users to create custom automation rules, such as turning on the lights at sunset or sending a notification when lights are turned on/off. By leveraging the capabilities of both Blynk and IFTTT, the home automation system becomes more versatile and adaptable to the user's preferences and needs

Laha et al., [15] has proposed design also facilitates the utilization of the said device under different human capabilities, such as those who are normal, deaf, dumb or completely disabled. The inbuilt Wi-Fi module used with Raspberry Pi, thus eliminating the use of personal computers (PCs). The designed system includes a variety including lights, fans, and motors, to showcase how the suggested smart home system is feasible, reliable, and capable of quick operation. After leading testing, it was found that the entire designed system is capable of running successfully and performing desired operations, such as switching functionalities, controlling the speed of a DC motor, and regulating light intensity.

III. Proposed model

The proposed methodology taught about controlling of electric devices at home. An innovative voice-controlled system used to perform extensive range of actions, including power devices on or off, locking and unlocking mechanisms, opening and closing elements, adjusting temperature by increasing or decreasing, monitoring conditions of fruits and vegetables with weight checking and gas sensing. This system leverages advanced integration of sensors and motors to activate seamless interaction through voice commands, providing an efficient and automated solution for home automation and produce monitoring. At its core, the system arranges a voice recognition module to interpret voice commands such as “turn on”, “turn off”, “lock”, “unlock”, “open”, “close”, temperature”. Once command is recognized, it is processed by Arduino microcontroller, which orchestrates the corresponding actions. The relay module manages power supply to connected appliances, enabling tasks such as turning lights or devices on and off. A motor facilitates mechanical actions like locking/unlocking doors opening/closing compartments. the temperature sensor ensures precise adjustments and continuous monitoring of temperature levels, while gas sensor detects the presence of ethylene or other gas indicative of fruit ripening or spoilage.

To enhance user interaction and system feedback, real time data is displayed on LCD screen, providing insights into the operational status and monitoring conditions. LED indicator visually represents system states, while a temperature deviation or detected spoilage of stored produce. These features ensure users are promptly informed of critical conditions, enhancing reliability and safety. The proposed designs offer practical benefits such as reduced manual effort, improved produced quality monitoring, and enhanced accessibility for users with mobility challenges. Its modular and scalable architecture further allows customization and expansion, making it a forward-looking contribution to the field of smart systems and IOT enabled devices. By following steps architecture will be given below.

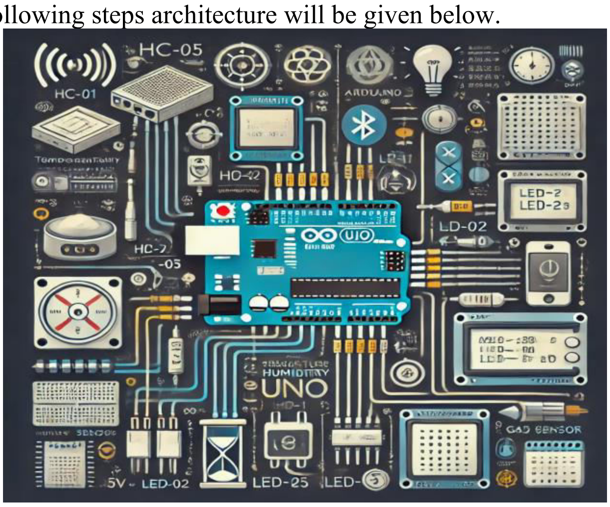

Figure.2 architecture model

In this concepts Figure.2 shows the project starting with collecting of all devices. Then connect each component with Arduino uno.

The first step involves identifying the primary challenges combining with existing IOT systems, such as integration between home automation and real time produce monitoring, limited accessibility for users with mobility things, based on these challenges, the objective is to design a modular and scalable voice controlled with IOT system capable of automating household tasks and monitoring produce conditions in real time while ensure enhanced accessibility and adaptability.

This system architecture was developed by integrating hardware and software components to enable voice-controlled automation and environmental monitoring. The architecture centers on an Arduino microcontroller that will take commands from the speech recognition module, with the HC05 Bluetooth module ensure wireless transmission. The hardware setup incorporates DHT11 sensors for temperature and humidity monitoring, gas sensor for detecting ethylene levels, weight sensors for measuring produce weight, and an IR sensor for proximity detection.5V DC motor perform mechanical tasks, while an CLD 12C display, LED indicators provide real time feedback.

Voice recognition module is configured to interpret actual language commands such as “turn on the fan”, “increase temperature”, or “unlock the door”. These commands transmitted via HC05 Bluetooth module to the Arduino microcontroller, which translate them into real time actionable signals. These signals are then routed with respective sensors to execute the corresponding tasks, ensuring efficient and reliable command processing.

The integration of sensors with microcontroller is a critical step in real time environmental monitoring. The DHT11 sensor monitors temperature and humidity, we can adjust based on requirements for climate control. The gas sensor detects the presence of ethylene or other gases emitted by ripening spoiling produce, triggering alerts when threshold levels are exceeded. The weight sensor tracks the quantity of fruits or vegetables, helping identify changes indicative of spoilage or usage. The IR sensor detects user proximity to enable automation, further enhancing the system interactivity.

To increase the human interaction, the system incorporates multiple feedback mechanisms. Real time sensor data and operational status are displayed on an LCD I2C screen, providing users with detailed insights LED indicators visually present active system states, and temperature increase or decrease states here. These mechanisms ensure that users all were informed and able to respond promptly in critical situations.

The motor activity used to do the on and off condition statements also to perform different mechanical actions based on user commands. Motors utilized for perform task to increase or decrease temperature. 5V DC motor handle large scale operations like controlling movable components. The relay module integrated to manage power supply appliances, enabling tasks turning lights on/off.

The system optimization performance tested and optimized for efficiency and accuracy. Voice command recognition fined tuned to minimize the response time and improve integration accuracy. Sensor calibration ensures reliable environmental monitoring, motors will give operations. The system's modular design allows for scalability and the sensors in future iterations.

The integration and testing is the final process, series of integration tests, ensures that hardware components are functioning harmoniously. Voice commands are tested for accuracy and latency, while sensor data is verified for consistency and responsiveness. The system ability controls home appliances and monitor produce condition tested in a variety scenario, including required conditions.

Performance evaluation: the system performance is evaluated based on ability to accurately execute voice commands, monitor environmental conditions, and provide feedback through the LCD, and LEDS. Key metrics include response error rates in voice recognition and sensor accuracy.

By integrating voice control with real time monitoring and automation, this system offers a practical solution for managing house hold tasks and ensuring the produce, all while providing use and capability.

IV. Results and Discussion

In the above figure we have used Arduino UNO microcontroller. Digital temperature and humidity sensor module with a humidity range 20-95% RH and temperature measurement range 0–50-degree C. Infrared IR LM393 module, the detection range between 10cm and 80cm. SEN0160 weight sensor module capacity with an 1kg approximately. MQ-2 Gas sensor which has high sensitivity to C3H8.ST7920 or equivalent collector LCD 16X2. For an indication LED's will use.

A. Circuit diagram for proposed model

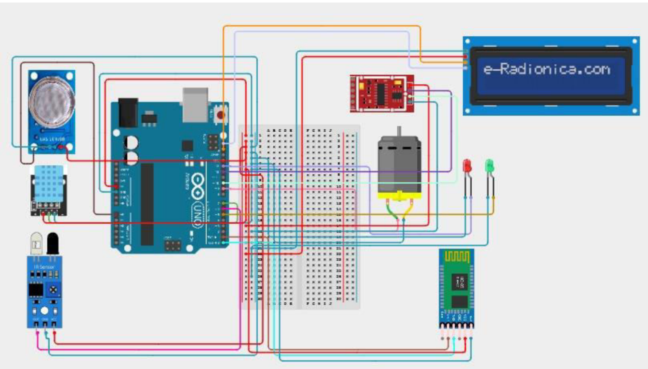

Fig.3. Proposed Circuit diagram.

In above figure 3 represent that the proposed circuit diagram of model, in these circuit diagram implemented the Arduino board with sensor module, the confections are properly assigned to build the model to get the proper results.

B. Hardware implementation of the proposed model

Figure.4. Hardware implementation of the proposed model.

In above Figure.4 signifies that the Hardware implementation of the proposed model, in this setup we used different module to inbuilt the proposed model, there are LCD displays and different sensors are attained to build the proposed model.

C. Software implementation details

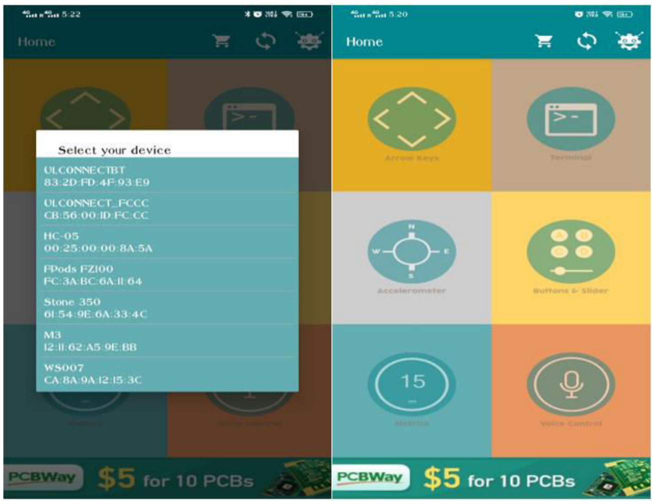

Fig.5. Proposed model software working.

In above Fig.5 represent that the Proposed model software working. The number of unique devices used in the trials is 14. Such as Light 1 on, Light 1 off, Light 2 on, Light 2 off, Night lamp on, Night lamp off, Fan on, Fan off, AC on, AC off, TV on, TV off, Fish tank motor on, Fish tank motor off.

Table 1: Number of trails with their components results

No of trial	Component	Result
1	Fish tank motor on	Success
2	Night lamp off	Success
3	Light 2 on	Success
4	TV off	Success
5	AC off	Success
6	Light 2 on	Failure
7	Light 2 off	Success
8	Fan on	Success
9	TV off	Success
10	AC off	Success
11	Light 1 on	Success
12	AC off	Success
13	Light 2 off	Failure
14	Fish tank motor off	Success
15	Night lamp on	Success
16	Light 2 off	Failure
17	Fish tank motor on	Success
18	Light 1 on	Success
19	Night lamp on	Success
20	Light 1 on	Success
21	Fish tank motor on	Success
22	AC on	Success
23	Fish tank motor off	Success

24	AC off	Success
25	Fan off	Success
26	Fan off	Success
27	Light 2 on	Success
28	Fish tank motor off	Success
28	Night lamp off	Success
30	Night lamp on	Success
31	Light 1 off	Success
32	AC off	Success
33	Light 1 off	Success
34	Fan off	Failure
35	AC on	Success
36	Fan off	Success
37	Light 1 off	Success
38	Fish tank motor on	Failure
39	TV on	Success
40	Light 1 off	Success
41	Light 1 on	Success
42	Light 1 on	Success
43	TV on	Success
44	Light 2 on	Success
45	TV off	Success
46	Fish tank motor off	Success
47	Night lamp on	Success
48	Night lamp off	Failure
49	Light 2 off	Success
50	Fish tank motor on	Success

In above table 1 represent the total of 50 trials were conducted to test various components, completing a 88% success rate with 44 successful operations and 6 failures (12%). Failures occurred in Trial 6 ("Light 2 on"), Trial 13 besides Trial 16 ("Light 2 off"), Trial 34 ("Fan off"), and Trial 38 ("Fish tank motor on"). Among the components, "Light 2" experienced the highest failure rate with three unsuccessful attempts, indicating a need for optimization. "TV," "AC," "Fan," and "Night Lamp" showed consistent presentation, while the "Fish Tank Motor" had one failure despite being operated multiple times. Overall, the organization demonstrated strong stability, with isolated issues in specific operations that require improvement. Number of Success: 44, Number of Unsuccess: 6, Success Rate: 88.0% generate a bar graph and it is shown in Figure 6.

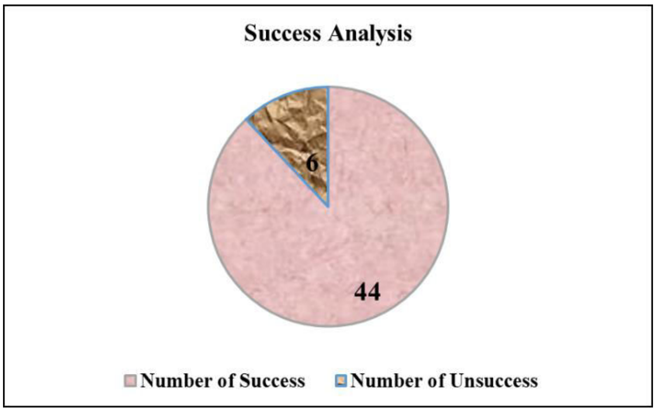

Figure 6: Success Rate analysis.

V. CONCLUSION

The proposed voice-controlled smart home automation system demonstrates significant advancements in accessibility, efficiency, and convenience for modern living. By integrating an Arduino microcontroller, speech recognition technology, and various sensors, the system enables users to manage household appliances such as lights, fans, air conditioners, and more using simple voice commands. This approach is particularly beneficial for individuals with mobility challenges and senior citizens, promoting inclusivity and hands-free operation. The experimental trials, comprising 50 tests across multiple devices, yielded a high success rate of 88%, with 44 successful operations and only 6 failures. This outcome highlights the reliability and effectiveness of the system in real-time usage scenarios. The modular design ensures scalability, allowing for future enhancements, including IoT device compatibility and remote control via mobile applications, further improving user experience. Additional safety features, such as gas detection and temperature monitoring, enhance the system's overall utility. In conclusion, the voice-controlled smart home system effectively simplifies daily routines, improves safety, and enhances energy management. It represents a significant step toward next-generation smart home solutions that prioritize user convenience and sustainability. Future work could focus on integrating more advanced artificial intelligence for personalized automation and broader device support to further enhance functionality.

REFERENCES

[1] McKechnie J, Ahmed B, Gutierrez-Osuna R, Monroe P, McCabe P, Ballard KJ. Automated speech analysis tools for children's speech production: A systematic literature review. International journal of speech-language pathol- ogy. 2018 Oct 16;20(6):583-98.

[2] Aruna TM, Kumar P, Naresh E, Divyaraj GN, Asha K, Thirumalraj A, Srinidhi NN, Yadav A. Geospatial data for peer-to-peer communication among autonomous vehicles using optimized machine learning algorithm. Scientific Reports. 2024 Aug 30;14(1):20245.

[3] Basak S, Agrawal H, Jena S, Gite S, Bachute M, Pradhan B, Assiri M. Challenges and Limitations in Speech Recognition Technology: A Critical Review of Speech Signal Processing Algorithms, Tools and Systems. CMES-Computer Modeling in Engineering & Sciences. 2023 May 1;135(2).

[4] Stephe S, Revathi V, Gunapriya B, Thirumalraj A. Blockchain-Based Private AI Model with RPOA Based Sampling Method for Credit Card Fraud Detection. InSustainable Development Using Private AI 2025 (pp. 261-277). CRC Press.

[5] Alshahrani MH, Maashi MS. A Systematic Literature Review: Facial Expression and Lip Movement Synchro- nization of an Audio Track. IEEE Access. 2024 May 22.

[6] Subasi A, Qaisar SM, Nisar H, editors. Artificial Intel- ligence and Multimodal Signal Processing in Human- Machine Interaction. Elsevier; 2024 Sep 18.

[7] Peri R, Somandepalli K, Narayanan S. A study of bias mitigation strategies for speaker recognition. Computer Speech & Language. 2023 Apr 1;79:101481.

[8] Thirumalraj A, Chandrashekar R, Gunapriya B, kavin Balasubramanian P. NMRA-Facilitated Optimized Deep Learning Framework: A Case Study on IoT-Enabled Waste Management in Smart Cities. InDevelopments Towards Next Generation Intelligent Systems for Sus- tainable Development 2024 (pp. 247-268). IGI Global.

[9] Peri, R., Somandepalli, K. and Narayanan, S., 2022. To train or not to train adversarially: A study of bias miti- gation strategies for speaker recognition. arXiv preprint arXiv:2203.09122.

[10] Verdonck MC. The meaning of environmental control systems (ECS) for people with spinal cord injury: An occupational therapist explores an intervention.

[11] Wang, H. H., Wang, Y. C., Wee, B. L., Chong, W. Y., & Hu, M. (2024). Voice Controlled Smart Home Lighting for User Centric Control and Energy Efficiency. Journal of Advanced Research in Applied Sciences and Engineering Technology, 134-146.

[12] Cherian, A. K., Mercy, H., Reshma, R., Sivakami, K., Krishnamoorthy, R., & Thiagarajan, R. (2024, August). An IoT based Voice Assisted Smart Residential Appli- ance Control Mechanism using Intelligent Node MCU Controller. In 2024 5th International Conference on Electronics and Sustainable Communication Systems (ICESC) (pp. 381-387). IEEE.

[13] Selvarathi, C., Nagul, J. G., Naveen, M., & Sutharsan,V. (2024, January). IoT based Voice Controlled Home Computerization Utilizing NodeMcu and Android Ap- plication. In 2024 5th International Conference on Mo- bile Computing and Sustainable Informatics (ICMCSI) (pp. 690-695). IEEE.

[14] Sahu, K. K. (2024). IoT Based Voice Controlled Home Automation System using Google Assistant. i-Manager's Journal on IoT and Smart Automation, 2(1), 27.

[15] Laha, S. R., Pattnaik, S., Mahapatra, S. K., & Pat- tanayak, B. K. (2025). A Novel Hybrid Smart Ap- pliances Control Framework for Specially Challenged Persons. Smart Sensors for Industry 4.0: Fundamentals, Fabrication and IIoT Applications, 57-69.