Development of IoT Multilingual Voice Controlled Home Automation System

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Abstract. The concept aims to overcome a common issue with voice-controlled smart home automation systems: language barriers. Existing solutions mostly support English, highlighting the necessity for a multilingual solution. The proposed Internet of Things (IoT) home automation system includes voice commands in languages such as Hindi. Home automation's growing popularity, driven by its ease of use and improved quality of life, emphasizes the significance of accessible and inclusive language assistance. The concept revolves around an IoT based home automation system that communicates via Wi-Fi, with a Node MCU acting as the core server. Users can use voice commands to manage household appliances by talking with a web-based interface over the internet. The solution reduces the need for human involvement by developing control firmware and automating it with the Node MCU IoT platform. Various components communicate in a number of ways, improving user control through the Node MCU interface and enabling remote access via smart phones. Cloud-based server connectivity eliminates the need for physical distance. This low-cost system is straightforward to set up and features an easy-to-use Android UI. It meets the demands of the elderly and disabled while also improving overall living circumstances by incorporating smart home concepts. The project "Development of an IoT Multilingual Voice-Controlled Home Automation System" combines IoT technology with multilingual voice recognition to deliver a more efficient and inclusive home automation experience. Voice commands in a variety of languages can be used to control lighting, heating, security, and entertainment systems, providing a customizable and user-friendly solution.

Keywords: Node MCU · ESP8266 · Home Automation · Multilingual · Internet of Things (IoT) · Wi-Fi module

1 Introduction

The investigation at hand delves deeply into the multifaceted realm of home automation, aiming to unravel its myriad challenges and boundless prospects. In the contemporary milieu, the insatiable quest for heightened home security looms large, propelling

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the demand for fortified systems. Yet, the complexity transcends mere fortification; a nuanced symbiosis of security and seamless control is imperative. Nestled within the heart of every smart home, the orchestration of house automation orchestrates a symphony encompassing appliance security, notably during absences, culminating in the discernible reduction of electricity consumption [1].

The pervasive tentacles of the Internet of Things (IoT) unfurl, espousing a fervent crusade to extol the virtues of interconnected technologies, a panacea for the constraints tethered to this sprawling web [2]. Automation, a dynamic force, perpetually burgeons amidst the frenetic cadence of our surroundings. Its essence lies in the orchestration of temporal or stimuli-driven protocols, choreographing a ballet of events for tethered devices within the labyrinth of local networks or the vast expanse of the cyber realm. This orchestrated choreography, be it in sprawling corporate landscapes or diminutive entrepreneurial ventures, begets a streamlined panorama, relegating human intervention while bestowing the mantle of efficiency upon the machinery, particularly in the realm of energy conservation.

The domicile metamorphoses into a sanctuary of automation, christened as domestics, wherein the tapestry of technology weaves its intricate design, ensnaring myriad household contrivances within the embrace of smartness [3]. Automation unfurls its wings, unfettered by temporal constraints, configuring events and scheduling tasks for devices ensconced within the labyrinth of local networks or the vast reaches of the cyber expanse, an eternal flux mirrored in the ceaseless evolution of our epoch [4].

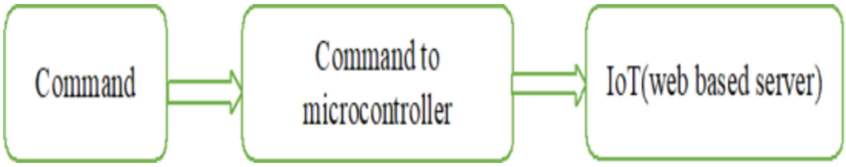

Fig. 1. Working Principle

Embedded within the intricate tapestry of home automation lies its quintessential feature as shown in Fig. 1, the unparalleled bestowal of convenience upon consumers. Its prowess extends beyond mere energy conservation, embracing ease of use amidst a plethora of solutions. However, the landscape burgeons with myriad options, diverse in reliability, affordability, and the pivotal test of longevity in this ever-evolving epoch.

User Command: A user command epitomises the desired action for the system to execute a personalised directive. From the humble task of illuminating the home to orchestrating the cooling system's rhythms and parting the main gate, an array of possibilities awaits at the beck and call of the user's whim.

Command to the Microcontroller: In the intricate ballet of microcontroller commands, an ethereal directive traverses the silicon pathway, weaving through circuits with algorithmic finesse. Venturing into the IoT's nebulous realms, we sculpt a domicile automaton, a sentient entity pulsating with interconnected intelligence. This paradigm shift transfigures the commonplace, choreographing a cosmic dance where equipment

lights pirouette, cooling systems waltz, and refrigerators become kinetic sculptures. Bursting with complexity, our automated tableau defies uniformity, embracing a sublime narrative of domestic functionality redefined by the enigmatic cadence of digital existence.

IOT Based Server: In the labyrinthine landscape of the Internet of Things (IoT) architecture, the user's command embarks on a serpentine journey, traversing the digital synapses to reach the microcontroller. Here, the microcontroller, akin to a cybernetic sentinel, establishes a wireless connection through a Wi-Fi module, extending its tendrils to a remote computer via a local area network (LAN). The command, akin to a digital siren's call, meanders through this LAN-based server, a conduit for the orchestration of electronic command and response [5].

These interconnected systems herald a pantheon of advantages, bestowing upon the user the boons of energy thrift, streamlined utility, temporal economy, and an elevated quality of life. In the evolving landscape of IoT, the architects of home automation systems find themselves increasingly drawn to the ethereal embrace of cloud-based systems. The voguish allure of home automation systems infused with voice assistance burgeons among the denizens of technology. Artefacts like Amazon Echo, Google Home, and Apple Home Pod ascend to the status of indispensable custodians of the smart home experience, embodying a polyphony of functionalities.

In the harmonious convergence of speech and technology, the significance of speech recognition resonates as a crucial element within the symphony of home automation. The voices of Wit.ai, IBM Watson, Google Cloud Speech, Microsoft Cognitive Services, and others echo through the corridors of existing automation systems, providing a chorus of recognition. Yet, the capricious winds of unstable internet connections threaten to play a discordant note, jeopardizing the reliability of cloud-dependent voice recognition features. The perpetual tether to the home Wi-Fi, a cybernetic umbilical cord, poses vulnerabilities amidst the rising tide of cybersecurity threats, casting shadows of danger upon users.

In this complex ballet of interconnected intelligence, allegations emerge as ominous specters, suggesting that behemoths like Google and Amazon may harvest private information through the prism of home automation systems, casting a pall of concern over the sanctity of privacy [6]. Virtual assistants, donned in the attire of voice, ascend in popularity, offering developers a canvas upon which to paint bespoke applications. End users, participants in this grandiloquent technological opera, engage with these applications through the sonorous interplay of a Voice User Interface (VUI), translating natural language commands into actionable operas [7].

The orchestration extends beyond the ephemeral realms of voice and ventures into the tangible landscape of home security. An Ethernet-based system, a tapestry woven with real-time monitoring and voice command threads, materializes [8]. Devices and switches pirouette to the silent command of an Android-based app, establishing a symphony of remote control. The surging tide of Internet of Things (IoT) applications begets a burgeoning multitude of devices and applications that, like sentinels at the edge of a digital precipice, produce, collect, and analyse data [9].

The tapestry extends further, intertwining with the avenues of telephone lines and internet interfaces, providing a portal for management and observation through smart

phones, personal computers, and the all-seeing eye of smart watches. The expansive canvas of the internet, a cosmic palette, allows users to transcend spatial boundaries, monitoring home gates, regulating appliances, and wielding dominion over the luminosity of television screens, all with a mere whisper of digital command [10].

Yet, amidst the cornucopia of advantages, home automation stands as both a paragon of technological marvel and a labyrinth of complexity [11]. The acme of ease materialises in the form of management and control via an eclectic array of devices, from smart phones to smart watches, laptops to desktops. The apotheosis of smart home technology rests in the crucible of home automation systems, heralding a realm where convenience and comfort intertwine in a dance of digital elegance.

One unique crescendo in this technological symphony lies in a smart home that not only comprehends the dulcet tones of English but also embraces the cadence of Hindi [12]. This IoT driven marvel metamorphoses mundane home items lights and fans into sentient entities that converse with each other through the linguistic dance facilitated by the Node MCU. This cybernetic brain, an omniscient overseer, links the home to the vast expanse of the internet, allowing remote control with the deftness of a digital puppeteer. The accessibility of this technological marvel extends to all, especially catering to the needs of the elderly and those with disabilities, embodying the ethos of technological egalitarianism [13].

2 Literature Review

Here, we reviewed some methods from recent publications which are relevant to our work i.e., voice controlled IoT based home automation.

In the annals of 2023, Ivan Froiz-Miguez et al. [14] unfurled an avant-garde tapestry, proposing a revolutionary modality for IoT home automation entwined with the ethereal tendrils of a voice assistant. Their innovative paradigm pivots on the orchestration of local speech inference, an intricate ballet that harmonises with IoT devices in a Bluetooth mesh, an ephemeral dance transpiring in the crucible of real-time without the tether of an internet umbilical cord. The proposal, a chameleon of adaptability, seamlessly extends its embrace to languages with scant linguistic resources, flaunting a zenith of 92% success in detecting enigmatic commands. However, amidst this crescendo of innovation, the drawback reverberates: the confinement within the realm of Wi-Fi and the proximity constraints of a Bluetooth-only system pose constraints on the symphony of this paper's conceptual brilliance.

Amidst the intricate landscape of 2023, Vivek Kalyan et al. unveiled a groundbreaking IoT driven home automation system at Mart [15]. This symphony of sensors, actuators, and cyber connectivity orchestrates a realm where devices harmonize in automated unison, augmenting convenience, energy efficiency, security, and overall domestic comfort. Yet, a conspicuous absence echoes—the lack of refuge for voice-controlled commands within this otherwise efficacious ecosystem.

In the evolving tapestry of 2022, Muhammad Abbas Khan et al. [16] unveiled a novel smart Android-based home automation system harnessing the prowess of the Internet of Things (IoT). This pioneering study delved into a myriad of interconnection techniques, tapping into an array of data sources like sensors and actuators, fostering diverse home automation applications. The system operates through a robust API (application programming interface), serving as the linchpin for a seamless and versatile communication avenue. However, a notable lacuna emerges the absence of multilingual voice control technology, a shortfall in this otherwise pioneering technological narrative.

In the mosaic of 2022, Md. Sajjad Hossain Shawon et al. [17] pioneered the voice-controlled smart home automation system utilising Bluetooth technology. This paper unfurls an Android application-driven, Bluetooth-enabled smart home automation paradigm. At its nucleus lies a programmable Arduino Uno, meticulously executing programmed commands as the epicentre of control. However, a caveat emerges—its efficacy remains confined within the confines of its local precincts, an inherent limitation nestled within this otherwise groundbreaking technological framework.

Amidst 2022's landscape, Priyanka Maharana et al. [18] unveiled a voice-controlled home automation method merging Blynk, IFTTT for appliance settings, and Arduino IDE for device configuration, yet faltering in multilanguage support—a conspicuous limitation in this technological stride.

In the 2021 tapestry, Shaik Fareed Ahmed et al. [19] unveiled an ingenious smart energy-efficient home automation system driven by IoT. This system grants control over home appliances via an Internet-linked module fused into the primary supply unit. Leveraging a static IP for wireless connectivity, it operates through a versatile application, heeding voice directives from Google Assistant or a web app. Yet, a constraint looms—its absence of multilingual functionality. Amidst the 2021 horizon, Olutosin Taiwo et al. [20] unveiled a pioneering vista with their Internet of Things-Based Intelligent Smart Home Control System. This groundbreaking convergence of IoT, cloud computing, and machine learning orchestrates intelligent home automation. Accessible via an Android-based mobile app, it bestows both local and remote control. Yet, a shortfall persists voice commands find no dominion within this otherwise intricate and sophisticated system.

In the epoch of 2020, Shaam Garg et al. [21] unfolded a fresh approach to home automation rooted in the IoT. Their article delineated hands-free electronic equipment control through the Internet of Things (IoT), harmonising seamlessly within the home milieu. Connected appliances, tethered to an internet-accessible cloud database, seamlessly undergo remote monitoring and operation. However, a lamentable absence persists—voice control in multiple languages remains beyond the realm of feasibility within this innovative framework.

In the epoch of 2020, Nombulelo CC Noruwana et al. [22] unveiled a visionary system enabling remote control of home electrical systems via voice-based speech recognition, leveraging Google Assistant. Their experimental pursuits traversed varied terrains, exploring outcomes amid fluctuating noise levels, room occupancy, distances, and room dimensions. Yet, the system stumbles on the path of multilingual responsiveness, unveiling a palpable limitation within this otherwise pioneering and innovative endeavour.

In 2020, Habila [23] unveiled a pioneering smart home system, a versatile, remotely controlled marvel. Operable through phone dialling and interfaced with a microcontroller and relay module, it deftly manages electrical appliances, signalling states via Short Message Service. A caveat arises—the system lacks adaptability to voice commands. Amid the technological panorama embracing apps and voice control, the void of multilingual inclusivity remains. Addressing these limitations, a novel proposition emerges: a home automation system leveraging IoT. This system transcends barriers, empowering users to voice-control and monitor electrical appliances, infusing the digital landscape with a harmonious convergence of innovation, and offering a glimpse into the future of interconnected living.

3 Methodology

A novel model is designed on development of IoT multilingual voice-controlled home automation. The block diagram as shown in Fig. 2.

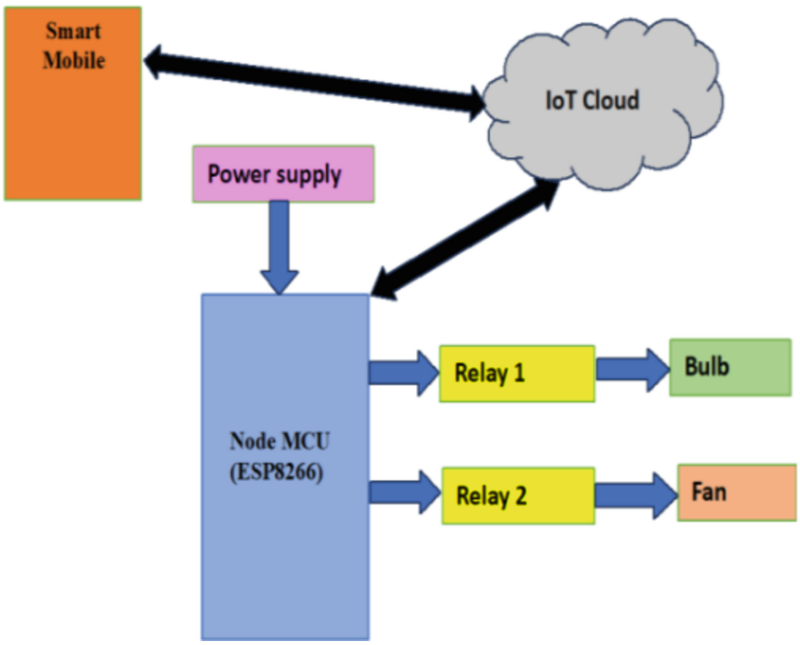

Fig. 2. Proposed Block Diagram

3.1 Power Supply

Here lies the schematic of a +4 V regulated power supply, a stalwart for average current demands around 1 amp. Anchored by the LM7812 integrated circuit, a three-terminal voltage regulator, this circuit safeguards against thermal overload and short circuits, as shown in Fig. 3.

The LM7806, a stalwart in the LM78XX lineage, reigns as a positive voltage regulator catering to diverse voltage needs. Variants like the LM7806 serve at a steadfast 6 V. Its counterpart, the LM79XX family, tackles negative voltages. To metamorphose 230 V mains to 4 V, a transformer (Tx = Primary 230 V, Secondary 4 V, 1 Amp step-down converter) steps in. Enter the bridge rectifier, comprising four 1N4007 or 1N4003 diodes, translating AC to DC. Enter the 1000 uF, 25 V filtering capacitor, adept at ripple eradication, yielding pristine DC output. The Node MCU board ordinarily works in the range of 3.3 V to 5 V. The bulb has a working voltage of 230 V, which demonstrates the electrical potential required for it to function as expected. The working voltage of the fan is 6 V.

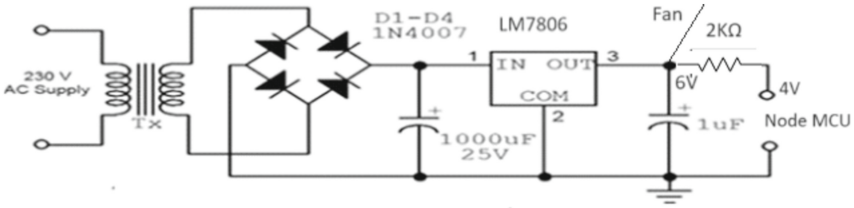

Fig. 3. Power supply

A relatively straightforward assembly ensures circuit construction ease. For peak performance, IC LM7806 pin-1 mandates an input voltage exceeding 4 V. To safeguard the LM7806, a heat sink becomes imperative, fortifying its operational integrity.

3.2 Node MCU

Enter the realm of Node MCU, as shown in Fig. 4, a microcontroller luminary poised for an Internet rendezvous in the enchanting landscape of the Internet of Things (IoT). This open-source marvel, the Node MCU development board, unfurls with an embedded Wi-Fi transmitter, anchored by the Esp8266 microcontroller's prowess. A synergy of hardware and software, it breathes life into an IoT ecosystem, seamlessly relaying data to ethereal cloud realms through the xtos operating system. The ESP8266, a digital virtuoso, orchestrates an electronic symphony with programmable 2.4 GHz Wi-Fi. It metamorphoses into an application development haven, merging open-source code with a chip system (SoC), embodying CPU, RAM, Wi-Fi, and a modern operating system and SDK [24].

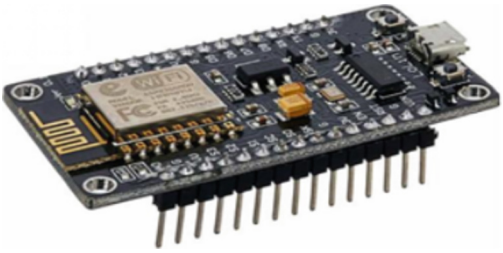

Fig. 4. Node MCU

Explore the intricate world of electro mechanical relays, adaptable actuating entities in electrical circuits that come in a variety of shapes, sizes, and configurations. These miracles, which are critical in switching huge currents or voltages "on" or "off" for low-power circuits, necessitate the use of relay switch circuits. When infused with a modest input voltage, a coil orchestrates a magnetic symphony. Three contactors beckon inside the domain of this relay: a normally closed (NC), a normally open (NO), and a common (COM). The alchemy of exact contactor combinations becomes the talent for orchestrating the electrical ballet, switching appliances with elegance [25]. The pin diagram of the node MCU is shown in Fig. 5.

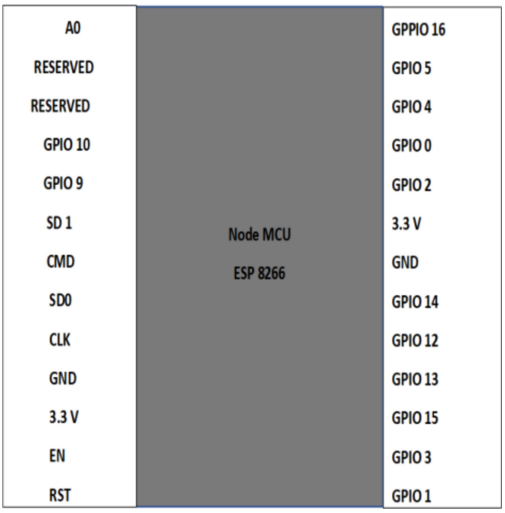

Fig. 5. Pin Diagram of Node MCU ESP8266

Specifications of Node MCU

- Wi-Fi protocol: −802.11 b / g / n
- VDC Range frequency: −2.4 Ghz–2.5 Ghz

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3–5 V
- Input Voltage: 7–12 V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs, SPIs, I2Cs: 1
- Flash Memory: 4 MB, SRAM: 64 KB
- Clock Speed: 80 MHz

3.3 Relay

As illustrated in Fig. 6, the relay is just an electromagnetic switch. When two circuits are physically separated, a relay allows one to switch to the other. In low-voltage circuits, relays are utilized to turn on and off components that require high voltage to function. A 5 V supply attached to the relay, for example, is adequate to power a 230 V AC mains-powered bulb. Relays come in a variety of voltage levels, including 6 V, 9 V, 12 V, and 24 V. The relay is usually separated into two sections: input and output. These ON/OFF relay circuits are utilized in a variety of applications, including LED and light circuits as well as lamp flasher circuits, which are made up of simple two-transistor lamp flasher circuits. The LM3909 is an LED flasher IC that operates on 1.5 V DC and produces a bright, high-current LED Dark Detecting Circuit that will trigger the relay in the circuit when there is no light on the outermost layer of the photo-resistor [26].

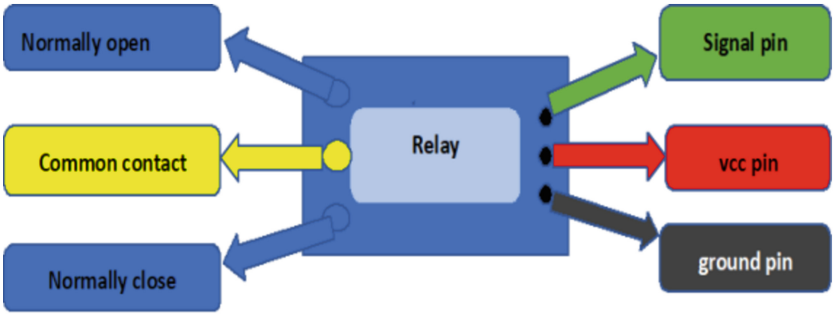

Fig. 6. Relay

Journey into the labyrinthine domain of electro mechanical relays, veritable titans within electronic circuits, boasting diverse forms, sizes, and designs. These stalwarts, commanding the ON/OFF toggling of high currents or voltages for low-power circuits, rely on relay switch circuits for their orchestration. Enter the magnetic ballet at the input side—a coil animated by a low input voltage. Herein reside three titans: the normally closed (NC), the normally open (NO), and the common (COM) contactors. The wizardry lies in precision the alchemical fusion of contactors sculpting an electrical ballet, gracefully toggling appliances [27]. This nuanced dance, an artistry, forms the crux of relay mechanics, harmonising circuits with finesse and precision, as shown in Fig. 7.

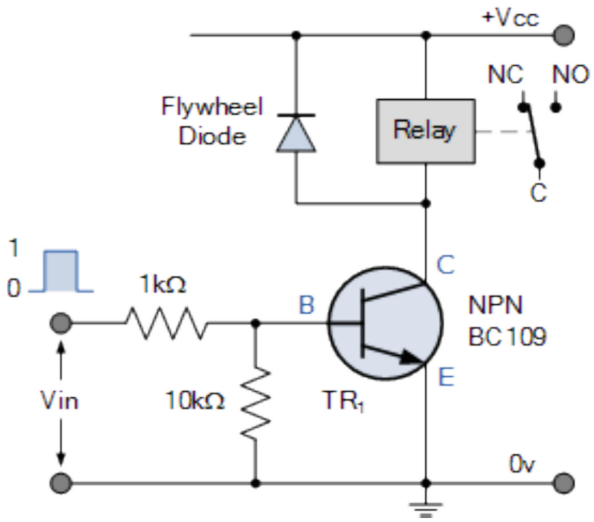

Fig. 7. Relay switch circuit

Specifications

- Normal voltage: 5 V DC
- Normal current: 70 mA
- Maximum load current: 10 A/250 V AC, 10 A/30 V DC
- Maximum switch voltage: 250 V AC, 30 V DC
- Operate time: ≤10 ms
- Release time: ≤5 ms

4 Results and Discussion

Home automation is a means of controlling household equipment such as bulbs and fans so that they can be controlled automatically for user convenience. This technology simplifies the user's life while also saving energy by utilising gadgets that meet stringent specifications. Controls can be as simple as household appliances with a remote or as complex as building up a network of items in the home that can be programmed using a main controller or even a mobile phone from anywhere in the world. They can be controlled via voice assistants like Google Assistant. Home automation kits provide convenience, energy efficiency, and enhanced security for homeowners.

For working of smart home automation, initially once the power supply is connected to the kit. Then the kit starts initializing as shown in Fig. 8.

Once kit is on, in order to control the home appliances like bulb and fan. The voice command as given like "TURN ON BULB" or " बल्ब` पर करो(BULB PER KARO)" through Google Assistant with peripherals. When a voice command is given, the bulb automatically turns on as shown in Fig. 9.

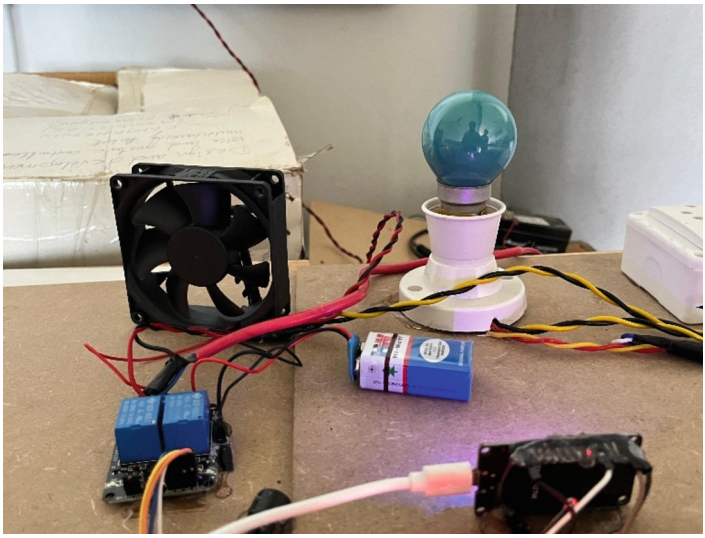

Fig. 8. Experimental setup

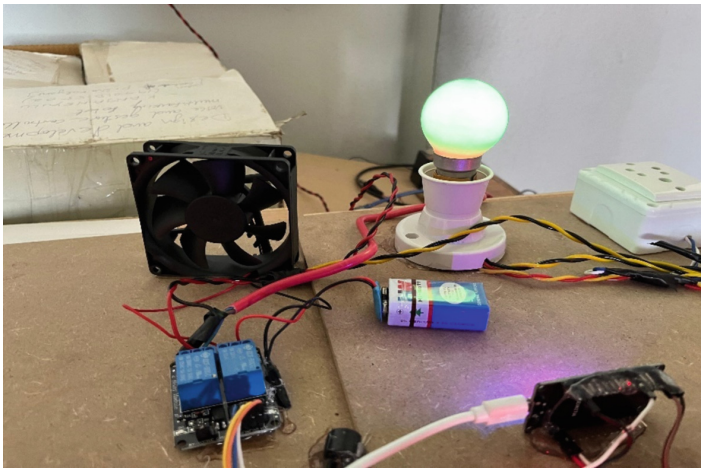

Fig. 9. Bulb is ON state through voice command

The voice command as given like “TURN OFF BULB” or “ बल्ब बंद करो(BULB BANDH KARO)” through Google Assistant with peripherals. When a voice command is given, the bulb automatically turns off as shown in Fig. 10 and its notification of Bulb ON and OFF condition is shown in Fig. 11.

The voice command as given like “TURN ON FAN” or “ पंखा पर करो(PAMKA PER KARO)” through Google Assistant with peripherals. When a voice command is given, the fan automatically turns on as shown in Fig. 12.

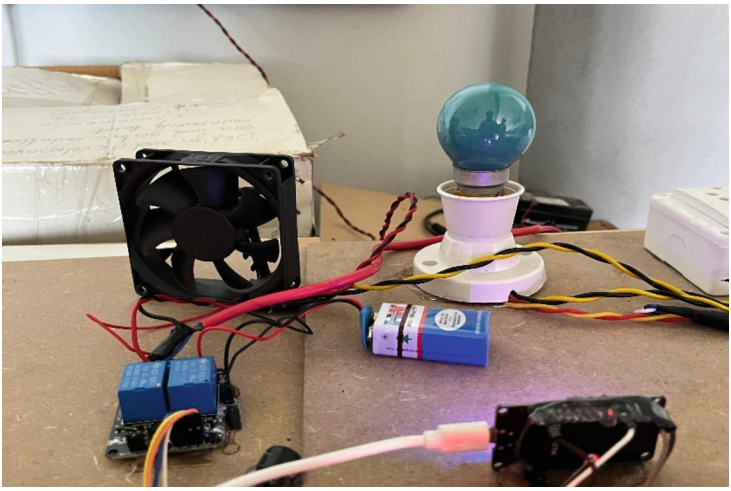

Fig. 10. Bulb is OFF state through voice command

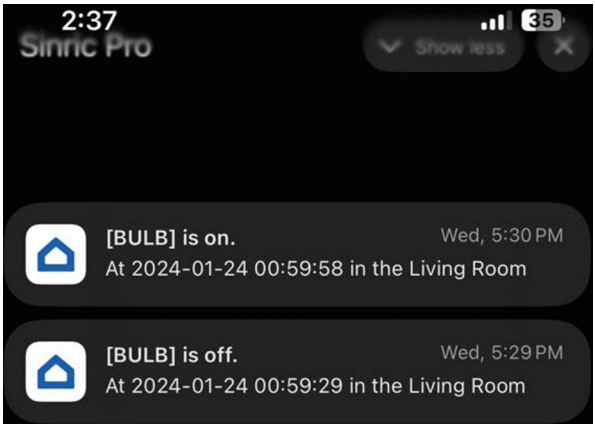

Fig. 11. Notifications for Bulb ON and OFF

The voice command as given like “TURN OFF FAN” or “ पंखा बंद करो(PAMKA BANDH KARO)” through Google Assistant with peripherals. When a voice command is given, the fan automatically turns off as shown in Fig. 13 and its notification of Fan ON and OFF condition is shown in Fig. 14.

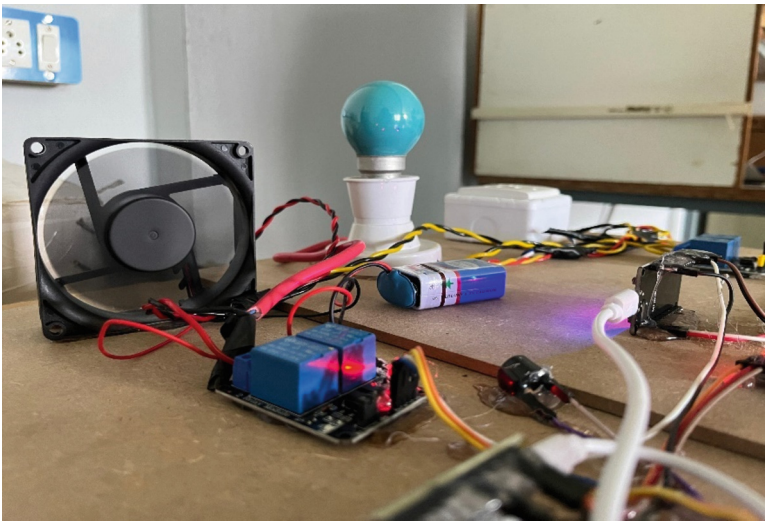

Fig. 12. Fan is ON state through voice command

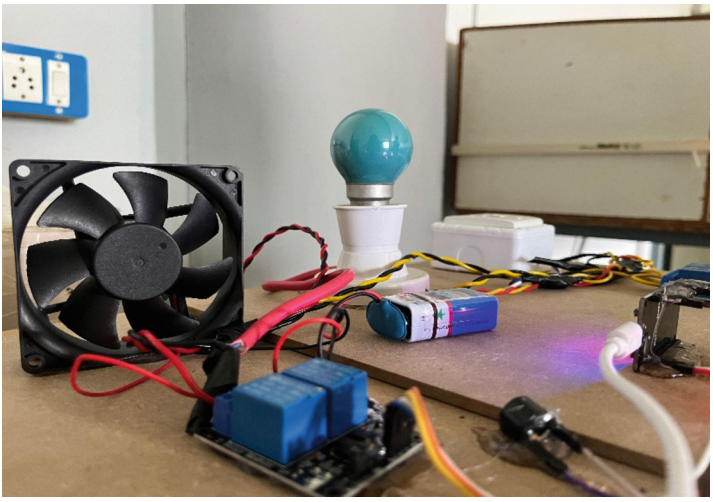

Fig. 13. Fan is OFF state through voice command

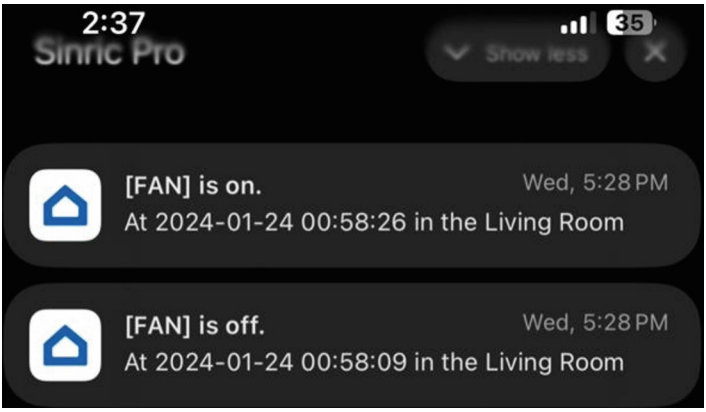

Fig. 14. Notifications for Fan ON and OFF

5 Conclusion

The research focuses on integrating multilingual voice recognition, specifically through Google Assistant, into an IoT smart home system. This upgrade aims to eliminate language obstacles, which will mostly benefit people who struggle with English. The smart home system streamlines domestic duties and provides extensive control over equipment, which may be accessed via remote controls or voice commands. Access to present IoT home automation systems is limited because they largely function in English. The suggested upgrade includes Google Assistant for multilingual voice recognition. Sinric Pro was chosen because it is dependable and compatible with newer systems. Furthermore, Node MCU ESP8266 and open-source software allow for modification to meet the individual needs of consumers. The system's scalability, adaptability, and security are superior to conventional smart home options. Language refinement, interaction with health care appliances, and other additions are possible in the future. This holistic strategy not only solves language obstacles but also lays the groundwork for ongoing innovation and diversity in the smart home sector.

References

1. Zaidi, S.F.N., Shukla, V.K., Mishra, V.P., Singh, B.: Redefining home automation through voice recognition system. In: Hassanien, A.E., Bhattacharyya, S., Chakrabati, S., Bhattacharya, A., Dutta, S. (eds.) Emerging Technologies in Data Mining and Information Security. Advances in Intelligent Systems and Computing, vol. 1300, pp. 155–165. Springer, Singapore (2021). https://doi.org/10.1007/978-981-33-4367-2_16
2. Kelly, S.D.T., Suryadevara,N.K., Chandra Mukhopadhyay, S.: Towards the implementation of IoT for environmental condition monitoring in homes. IEEE Sens. J. **13**(10), 3846–3853 (2013)
3. Bing, k., Fu, L., Zhuo, Y., Yanlei, L.: Design of an internet of things-based smart home system. In: Proceedings of the 2nd International Conference on Intelligent Control and Information Processing, vol. 2, pp. 921–924. IEEE Xplore, China (2011)

4. Pavithra, D.: IoT based monitoring and control system for home automation. In: Proceedings of 2015 Global Conference on Communication Technologies , pp.169–173. IEEE Xplore, Chennai (2015)
5. Reddy, V., Vinay, N., Pokharna, T., Shiva Kumar, S.: Internet of things enabled smart switch. In: Proceedings of the Thirteenth International Conference on Wireless and Optical Communications Networks, Hyderabad, pp. 1–4 (2016)
6. Waheb, A.: Design and fabrication of smart home with internet of things enabled automation system. IEEE Access **7**, 144059–144074 (2019)
7. Emanuela, G., Giovanni, R., Simone, S., Gabriele, B., Rocco, O.: Sorry, i don't understand: improving voice user interface testing. In: Proceedings of the 37th IEEE/ACM International Conference on Automated Software Engineering, pp. 1–12. ACM digital library, Newyork (2023)
8. Ravi Kishore, K., Jain, V., Bose, S., Boppana, L.: IoT based smart security and home automation system. In: Proceedings of the 2016 International Conference on Computing, Communication and Automation, pp. 1286–1289. IEEE Xplore, India (2016)
9. Punit Gupta, J.C.: IoT based smart home design using power and security management. In: Proceedings of the 2016 International Conference on Innovation and Challenges in Cyber Security, pp. 6–10. IEEE Xplore, India (2016)
10. Sipola, T., Alatalo, J., Kokkonen, T., Rantonen, M.: Artificial intelligence in the IoT era: a review of edge AI hardware and software. In: Proceedings of the 2022 31st Conference of Open Innovations Association, vol. 31, pp. 320–331. IEEE Xplore, Finland (2022)
11. Abdul-Rahman: Java-based home automation system, consumer electronics. IEEE Trans. Consum. Electron. **50**(20), 498–504 (2004)
12. Stolojescu-Crisan, C.: An IoT-based smart home automation system. Sensors **21**(11), 1–23 (2021)
13. Lee, K.-M.: An intelligent universal remote-control system for home appliances. IEEE Trans. Autom. Sci. Eng. **13**(3), 1308–1317 (2016)
14. Froiz-Miguez: Design, implementation and practical evaluation of a voice recognition. IEEE Access **11**, 63623–63649 (2023)
15. Singh, M.: Smart home automation system based on IoT. IJSREM **07**(5), 1–8 (2023)
16. Khan, M.A.: Smart android based home automation system using IoT. Sustainability **14**, 1–18 (2022)
17. Hossain Shawon, M.S.: Voice controlled smart home automation system using bluetooth technology. In: Proceedings of the 4th International Conference on Recent Trends in Computer Science and Technology, pp. 67–72. IEEE Xplore, India (2021)
18. Maharana, P.: A voice controlled home automation system. Int. J. Smart Sens. Ad hoc Netw. **3**, 18–29 (2022)
19. Ahmed, S.F.: Smart energy efficient home automation system using IOT. Int. J. Sci. Res. Eng. Trends**7**, 1189–1193 (2021)
20. Taiwo, O.: Internet of things-based intelligent smart home control system. Secur. Commun. Netw., 1–17 (2021). Hindawi
21. Garg, S., Yadav, A., Jamloki, S., Sadana, A., Tharani, K.: IoT based home automation. J. Inf. Optim. Sci., 261–271 (2020)
22. Noruwana, N.C.C.: Interactive IoT-based speech-controlled home automation system. In: Proceedings of the 2020 2nd International Multidisciplinary Information Technology and Engineering Conference, pp. 1–8. IEEE Xplore, South Africa (2020)
23. Augustine Habila, A.: Construction and implementation of smart home system. Int. J. Comput. Appl. **176**(12), 0975–8887 (2020)
24. Tuyen, N., Ngoc, H.: On an application of node MCU Esp8266 in opening and closing the laboratory door - online practice. Glob. J. Eng. Technol. Adv. **9**, 86–91 (2021)

25. Wirawan: Implementation of distributed consensus algorithms for wireless sensor network using node MCU ESP8266. In: Proceedings of the 2018 Electrical Power, Electronics, Communications, Controls and Informatics Seminar, pp. 192–196. IEEE Xplore, Indonesia (2018)
26. Deepa, N.: IoT based home automation using - Node MCU. Int. J. Creative Res. Thoughts **10**, 324–335 (2022)
27. Saha, S., : IoT based smart home automation and monitoring system. In: International Conference on STEM and the Fourth Industrial Revolution, pp.133–143. Academia, Bangladesh (2022)