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A Literature Survey on AI based Chatbots for Appliance Control

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Abstract: Home automation is the automated control of electrical equipment in a house, facilitated by internet connection. These devices can be remotely managed using voice assistants or apps, reducing the need for manual operation. Home automation can control lighting, air conditioning, and temperature settings, thereby reducing energy, heating, and cooling costs. Additionally, it enhances security by using Internet of Things devices like cameras, thereby reducing the risk of accidents. In current scenario ,with the advent of smart home technology, the integration of chatbots for controlling appliances has gained significant attention. This paper provides a comprehensive overview of appliance control techniques leveraging chatbot interfaces. It examines the evolution of smart homes, the role of chatbots in human-computer interaction, and various methods employed for appliance control via chatbots. Additionally, challenges and future directions in this domain are discussed, highlighting the potential for further research and innovation.

Keywords: Smart homes, Chatbots, Appliance Control, Human-Computer Interaction, Artificial Intelligence.

I. INTRODUCTION

The proliferation of Internet of Things (IoT) devices and advancements in artificial intelligence (AI) have paved the way for the concept of smart homes. Smart homes integrate various appliances and devices to provide automation, energy efficiency, and convenience to homeowners. Among the different interfaces for interacting with smart home systems, chatbots have emerged as a promising solution due to their natural language processing capabilities and ease of use. This paper aims to explore the techniques and applications of chatbots in controlling appliances within smart home environments.

This research paper also aims to provide a comprehensive overview of appliance control techniques, covering evolution of home appliance control techniques, traditional methods of home automation like central controller based (Arduino or Raspberry pi), Bluetooth-based, SMS based, ZigBee based, smart appliance integration, challenges, and future directions. Through this literature survey, researchers and practitioners can gain insights into the current state of the field and identify areas for innovation and improvement in appliance control systems.

II. EVOLUTION OF HOME APPLIANCE CONTROL TECHNIQUES

Automating homes in the early days started with labor-saving devices. With the development of electric power distribution in the 1900s, self-contained electric or gas-powered household appliances became economically feasible. This resulted in the advent of items such as washing machines (1904), water heaters (1889), freezers, clothes dryers, sewing machines, and dishwashers .The first widely used home automation system, X10, was developed in 1975. An electronic device communication protocol is called X10. It is still the most widely accessible and essentially uses electric power transmission wiring for control and flagging, with the indications consisting of short radio recurrence blasts of sophisticated information. [1]. A 16-channel charge support, a light module, and an apparatus module were all included into X10 items by 1978. The core X10 clock and the divider switch module appeared shortly afterward. According to ABI Research, there were 1.5 million home mechanization frameworks implemented in the US by 2012. [2].

There are three generations of home automation, according to Li et al. (2016)[3]:

First generation: remote innovation with intermediary server, e.g. ZigBee robotization.

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Second generation: artificial brainpower controls electrical devices, e.g. Amazon Echo;
Third generation: robot buddy who associates with human, e.g. Robot Rovio, Roomba.

A. First Generation: Proprietary Protocols(1970s-1990s):

The invention of home appliances- like refrigerators, washing machine, dishwashers, irons, toaster and garments dryers. These inventions laid the foundation for the development of home automation systems in the future. The integration of these appliances with smart technology has revolutionized the way households operate. The earliest home automation systems relied on proprietary protocols developed by individual manufacturers. These protocols were often closed and proprietary, limiting interoperability between devices from different vendors.

- Examples: Systems like X10, developed in the 1970s, utilized powerline communication for control of home devices but lacked robustness and security.

B. Second Generation: Standardized Protocols:

The early 2,000's saw a further ascent in brilliant home innovation, including local tech, home systems administration, and different devices showing up available. A combination of short-range technologies created by Zen-Sys in 2005, this wireless technology creates a mesh network at the user's home and sends signals at the 900 MHz spectrum. The Z-Wave technology is capable of connecting a variety of devices to control appliances, door locks and even flood monitors .Home automation began to gain traction in the late 20th century as consumer electronics companies started offering more accessible and affordable automation solutions. Products such as programmable thermostats, remote-controlled garage door openers, and home security systems became increasingly common.

- 1990s-2000s: The second generation of home automation protocols saw the emergence of standardized protocols aimed at improving interoperability and ease of integration.

- Zigbee (2004): Zigbee emerged as a popular wireless protocol for low-power, short-range communication, enabling connectivity among various devices in a home automation network.

- Z-Wave (2001): Z-Wave gained traction for its reliability, interoperability, and mesh networking capabilities, allowing for easy expansion and robust communication among devices.The early 2,000's saw a further ascent in brilliant home innovation, including local tech, home systems administration, and different devices showing up available. A combination of short-range technologies created by Zen-Sys in 2005, this wireless technology creates a mesh network at the user's home and sends signals at the 900 MHz spectrum. The Z-Wave technology is capable of connecting a variety of devices to control appliances, door locks and even flood monitors.Home automation began to gain traction in the late 20th century as consumer electronics companies started offering more accessible and affordable automation solutions. Products such as programmable thermostats, remote-controlled garage door openers, and home security systems became increasingly common.

C. Third Generation: IP-Based Protocols:

- Late 2000s-Present: The advent of Internet Protocol (IP)-based protocols marked the third generation of home automation standards, leveraging existing networking infrastructure for communication.

- Wi-Fi (IEEE 802.11): Wi-Fi became ubiquitous in homes, enabling high-speed, reliable communication between smart devices and the internet, leading to the proliferation of IP-based home automation solutions.

- Thread (2014): Thread, built on IPv6 and low-power IEEE 802.15.4 wireless technology, was developed to provide a secure, reliable, and scalable networking protocol for smart home devices.

D. Present and Future , Fourth Generation:

The early 21st century witnessed a surge in home automation adoption driven by advancements in wireless communication, mobile computing, and the proliferation of smart devices. In recent years the Internet of Things (IOT) have enabled shrewd innovation to the point that it is now unquestionably essential to our daily existence. Home appliances are a vital component of the Internet of Things when they can be monitored and controlled remotely over the Internet. Modern trends in home automation include computerized lighting, robotized indoor regulator adjustment, booking machines, portable/email/content alerts, remote video monitoring, and remote flexible control.

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Unified Protocols and Standards-

- Present and Future: The fourth generation of home automation protocols focuses on unification and standardization, aiming to streamline communication and enhance interoperability among diverse devices and systems.

- Project CHIP (Connected Home over IP): Led by major industry players, Project CHIP aims to create a unified standard for smart home communication based on IP, facilitating seamless interoperability among devices from different manufacturers.

- Continued Innovation: Future protocols are expected to prioritize security, scalability, and compatibility across a wide range of devices, paving the way for truly integrated and interconnected smart home ecosystems.

The below figure 2. shows the evolution of technologies in home automation systems.

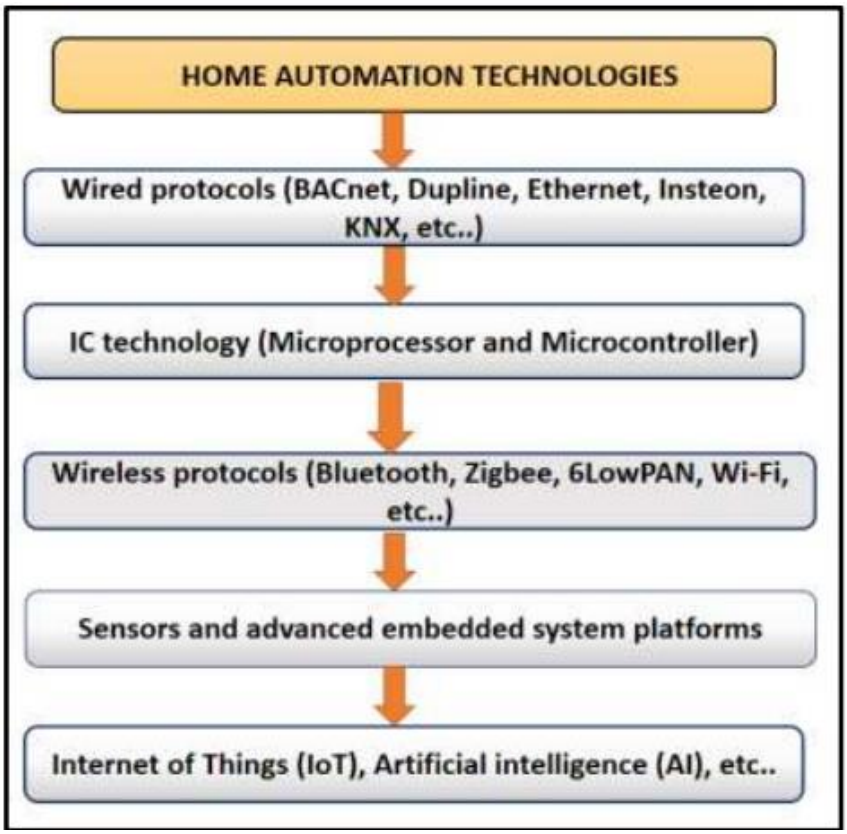

Fig. 1. Evolution of technologies in home automation [7]

III. RELATED WORK

A. Central Controller based Home Automation System

The key component of a smart home setup is this system. It consists of a single hub that controls and interacts with all of the home's smart appliances, sensors, and gadgets. Through a centralized interface, such as a smartphone app or online dashboard, users may automate and control a variety of services, including lighting, temperature, and security. Convenience, remote access, and the opportunity to design personalized automation routines are some of the benefits of this system; nevertheless, there are also drawbacks, such as the need to guarantee device compatibility, maintain dependable connectivity, and handle security issues throughout the network of linked devices.

B. Bluetooth Based Home Automation System

N. Sriskanthan [4] described a Bluetooth-enabled home automation system that used a host controller connected to sensor and device controllers based on microcontrollers.

Their Home Automation Protocol (HAP) makes it easier for different device controllers to communicate with one another and with the host controller. H. Kanma [5] also suggested a Bluetooth-based system that could be accessed remotely

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using GPRS. This system would allow for device control, updates, fault detection, diagnostics, and even the provision of an electronic user manual that could be accessed via Bluetooth and the Internet. Home automation with Bluetooth connectivity enhances home security, allows for remote control of appliances, and gives management insights. However, some significant negatives include its narrow range, weaker security, and possible connection problems.

C. GSM or Mobile-Based Home Automation System

Due to the increasing use of mobile phones and GSM technology, researchers are lured to mobile-based home automation systems. Three GSM communication channels are the main focus of the study: automation based on GPRS, Dual Tone Multi Frequency (DTMF), and SMS. A few published resources describe how the mechanical, electrical, and sensor equipment in a house function together seamlessly as a network. A Subscriber Identity Module (SIM) is used by a GSM module to enable communication. Transducers enable a microcontroller to process sensor data by converting machine operations into electrical signals. These signals are analyzed and converted into commands that the GSM module can comprehend. Based on the commands it receives, the module chooses amongst the SMS, GPRS, and DTMF communication methods.

D. Wi-Fi based Home Automation System

WiFi-based solutions are becoming more common as a result of smart home systems' obstacles, which include expensive and complicated cabling. The Smart Home Automation system by Chentao et al. [6] uses WiFi to handle internal networks and Zigbee to manage terminal nodes. It describes how wireless solutions control devices within a smart home by establishing local networks using WiFi, which works well and is reasonably priced.

IV. INTEGRATING CHATBOT TECHNOLOGY IN HOME AUTOMATION SYSTEMS

Home Automation systems have been implemented earlier using different technologies like GSM, Bluetooth and Internet. Having a higher rate of power consumption, Bluetooth based system requires each component to have a Bluetooth adapter for communication, but its limitation lies in the minimum range of 100 meters. GSM based system involves transducers to take inputs (mostly physical quantities) via sensors and convert them into understandable commands using microcontrollers. By integrating chatbot technology into automation systems, users can easily control their home devices and appliances through natural language commands, making the system more user-friendly and efficient. This modern approach not only enhances the overall user experience but also reduces the need for additional hardware components, ultimately leading to a more cost-effective solution. This approach has been implemented using various ways of integrating chatbot into automation systems , such as voice recognition technology or text-based interfaces. The seamless integration of chatbots into automation systems has revolutionized the way users interact with their smart devices, creating a more intuitive and convenient user experience.

In [8], the authors have used Machine Learning approach to build a chatbot. The system offers two communication modes: text and voice, with input via a Chatbot Application and voice assistant. Natural Language Processing is used to determine user actions, while the Raspberry Pi IoT component controls lighting and fan settings. The figure 2. shows the general block diagram of how the approach has been implemented using NLP module.

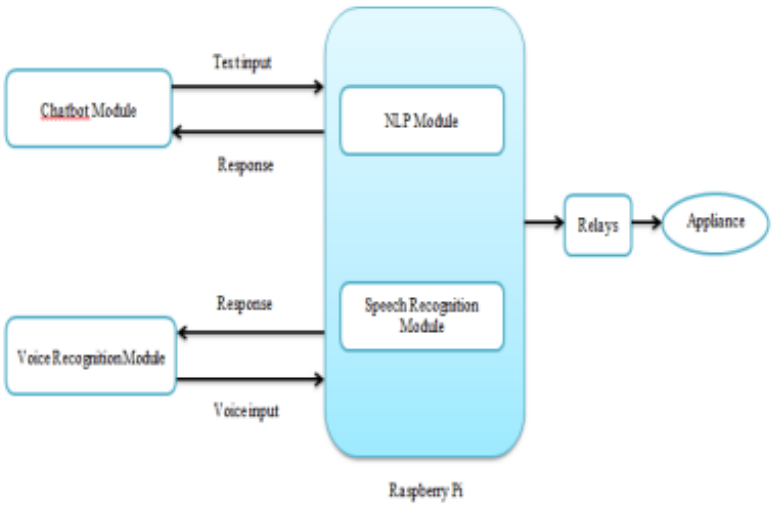

Fig. 2. Block Diagram of proposed system in [8]

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A similar approach has been proposed in [9],the Telegram Bot processes the input text request using the NLP module in the Node MCU and then the response is given back in the form of text through the Telegram Bot. A power supply is connected with the Node MCU which provides energy for the running of the system. When the process is accomplished successfully then the led bulb connected, will turn on leaving a message through the Bot stating that the bulb is ON else, it provides a response stating that the Bulb is in OFF state. The ON/OFF state of the Bulb is regarded or considered as the output. The below figure 3 shows a demonstration of the architecture proposed in [9].

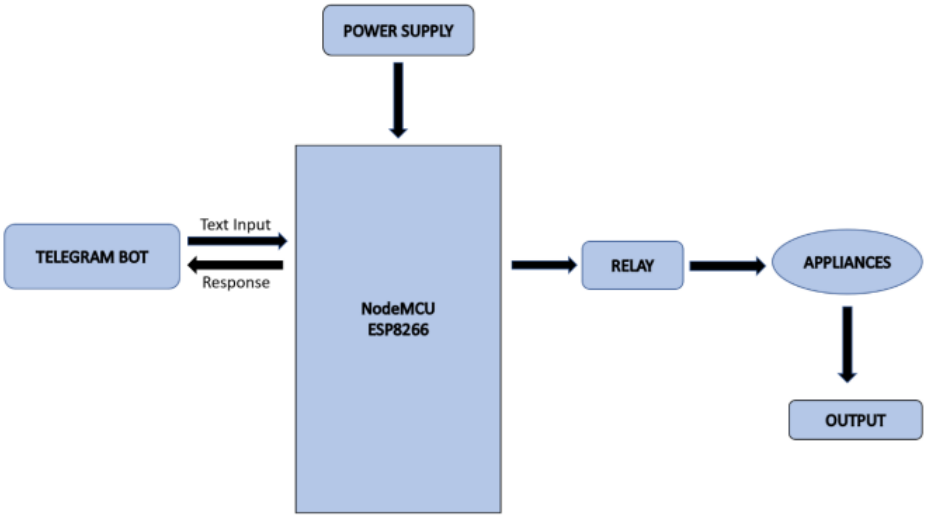

Fig. 3 Block Diagram of telegram based chatbot in [9]

The research in [10] explores the use of Intelligent Conversational Software Agents (Chatbots) using machine learning. The model comprises four parts: Natural Language Processing (NLP), mobile application conversation, device name extraction using Jaro-Winkler string matching, Naive Bayes text classification, and Firebase-based system for user interaction and hardware control. The recommended approaches will be applied to the text when the user provides the chatbot a command. The process of controlling home appliances by chatbot begins with input text in the mobile application. Figure 4 illustrates the proposed system for chatbot.

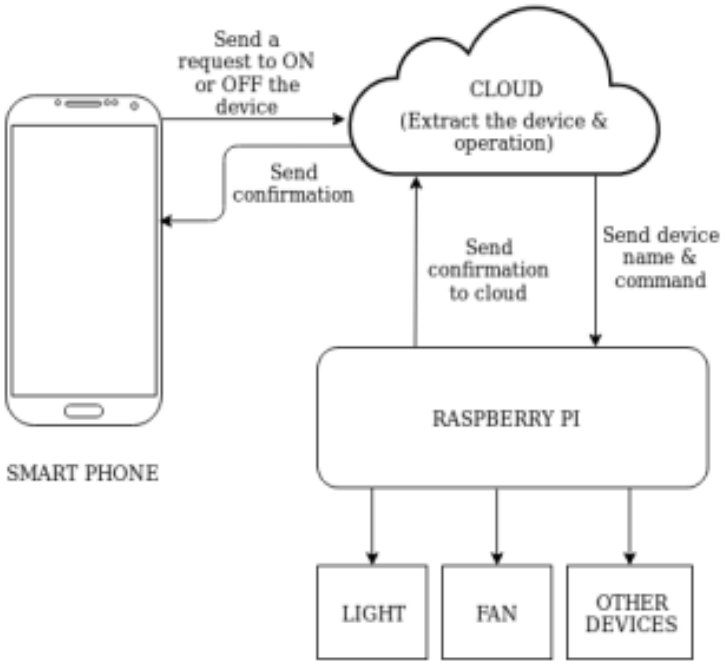

Fig. 4 Block Diagram of system proposed in [10]

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[11]This work demonstrates an experimental implementation of smart home automation using Raspberry Pi, Facebook chatbot and Google Maps APIs. The development process was shortened and additional functionalities like estimated time of arrival, interactive chat and secure communications were incorporated. More importantly, this home automation system is extendable and scalable without needing an architectural redesign and other complications.

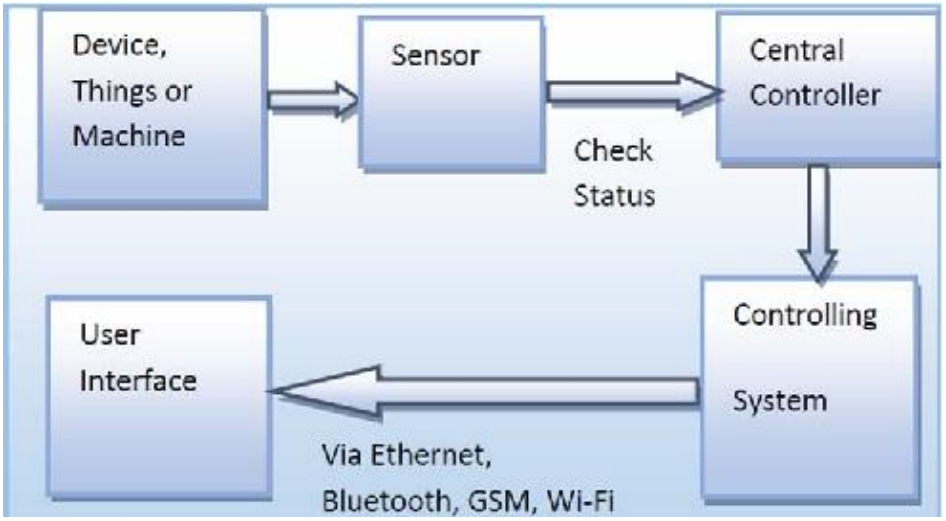

Fig. 5 Block Diagram of system proposed in [11]

V. FUTURE SCOPE

AI chatbots for appliance control have already been gaining traction, enabling users to interact with their devices in natural language. This integration of AI chatbots with home automation systems opens up possibilities for further advancements in smart home technology. s. In the future, different sensor-based control can be added with Chatbot. Self-automation will make such systems more user-friendly. Besides home appliances, the integration of chatbots can be used for other gadgets controlling like vehicles. Home security like access control, alarm, etc. can be an extension of such technologies.

The combination of chatbots and sensor-based control systems could lead to even more seamless and intuitive interactions with smart home devices. This could potentially revolutionize the way we interact with technology in our everyday lives, making tasks simpler and more efficient. The systems can be further made inclusive of extensions such as attaching of email services as an alternate form of message delivery, in situations of utmost importance. The number of devices that can be connected to the system can be expanded to a larger range.

The use of other input languages besides English language, could further be expanded to accommodate several other regional languages as well. With the continuous development in artificial intelligence and IoT, the future of home automation via chatbots is promising and likely to revolutionize the way we interact with our homes.

VI. CONCLUSION

This paper provides a comprehensive review of existing research on various home appliance control technologies as well as the integration of chatbots into home automation. We examine various approaches to integrating chatbots into home automation systems, including natural language processing techniques, user interface design, and integration with smart devices. In conclusion, the development and implementation of an AI chatbot for appliance control represent a significant advancement in home automation technology.

Through its intuitive interface and natural language processing capabilities, such a chatbot offers users a seamless and convenient way to manage their appliances remotely. By harnessing the power of artificial intelligence, this technology streamlines daily tasks, enhances efficiency, and contributes to a more interconnected and intelligent home environment. In summary, an AI chatbot for appliance control represents a promising technological innovation that can revolutionize how we interact with our homes.

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