



Gesture and Voice Controlled Smart Home Using IoT

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Abstract: Smart home technologies are increasingly shaping modern living, with devices like voice activated speakers, automated lighting, and connected appliances offering convenience and comfort. However, these systems often assume that users can speak clearly, leaving out groups such as the elderly and people with speech disabilities who may find voice commands difficult or impossible to use.

This paper introduces a gesture-based smart home control system designed to fill this gap, allowing users to interact with their home environment in a natural, intuitive, and accessible way. Leveraging the Internet of Things (IoT), the system links everyday appliances into a network that responds seamlessly to hand gestures. At its core, sensors and a central control panel interpret gestures and convert them into commands for various devices. With a simple wave or swipe of the hand, users can open or close doors and windows, adjust curtains, turn on or off air conditioners, dehumidifiers, and air purifiers, and fine-tune settings such as temperature or fan speed—without touching buttons or juggling multiple remotes.

The system emphasizes simplicity, safety, and inclusivity, ensuring that even users with limited mobility or speaking difficulties can manage their home environment with ease. By integrating gesture recognition with IoT-enabled appliances, it reduces both physical and cognitive effort, offering a centralized interface that supports independence and convenience. Unlike many prototypes that are limited to single-device control, this system can operate multiple appliances simultaneously, making it scalable and adaptable to various home setups. The research highlights the potential for gesture-based smart homes to create safer, smarter, and more inclusive living spaces, addressing the needs of individuals often overlooked by conventional voice-controlled technologies.

Key Words: Gesture-Based Control, Smart Home System, Internet of Things (IoT), Arduino MEGA 2560, APDS-9960 Sensor, Non-Touch Interface, Accessibility, Elderly Assistance, Speech-Disabled Users, Home Automation.

I. INTRODUCTION

The study, "Development of Smart Home Gesture- based Control System," presents a novel approach to assist elderly individuals and people with speech disabilities in operating smart home devices [1]. Authors Rong-Jing Wang, Shu-Chen Lai, Ji-Yun Jhuang, Ming-Chin Ho, and Yan-Chyuan Shiau focus on providing an alternative to conventional voice-activated smart speakers [7],[10], which are inaccessible to users who cannot rely on verbal commands [1].

1.1 Research Background

The research is driven by Taiwan's aging population. As of January 2021, the elderly population reached 3.804 million, representing 16.2% of the total population, with an aging index of 128.7 (elderly per 100 young people). Many seniors prefer to live independently at home, highlighting the need for smart solutions that can assist in daily tasks. The proposed gesture-based system provides a practical method for managing doors, windows, air conditioners, and curtains with simple hand movements, ensuring independence and convenience for elderly users.

1.2 Research Aim

The primary goal of this research is to create a barrier-free smart home environment that enables elderly individuals and people with speech disabilities to enjoy the benefits of modern AI and IoT technologies. Specific objectives include:

- Investigating the current living conditions and challenges of elderly people in Taiwan.
- Examining existing smart home solutions to identify areas for improvement.
- Developing a prototype gesture-based control system using IoT sensors for devices such as air conditioners, air purifiers, dehumidifiers, windows, and curtains.

II. LITERATURE REVIEW

Smart home care technologies can be grouped into three main categories: health care, safe living environment, and living support [8]. These solutions allow family members and professionals to remotely monitor and assist older adults [8], [10]. Hasan et al. provide a detailed analysis of various smart home automation systems [5].

2.1.1 Health Care

This category focuses on collecting physiological data to help users monitor their health [8], [10]. Information can be shared with medical professionals or stored in the cloud for long-term analysis [5], [8]. Examples include smart pill boxes, gait analysis software, and two-way video communication for rehabilitation [8].

2.1.2 Safe Environment

Sensors monitor activities, detect falls, track movement, and control access [7], [10]. Systems can automatically issue emergency alerts in case of accidents or environmental hazards such as flooding [8], [10].

2.1.3 Living Support

Living support covers assistance with daily routines, such as diet, transportation, and social interaction [8]. Smart devices can track user preferences to provide personalized services, while virtual reality and social media platforms help users with limited mobility maintain social connections [8], [10].

2.2 IoT for Smart Appliance Control

IoT has become a standard in automation, enabling remote monitoring and control of embedded devices [2], [5]. Kolanur et al. describe strategies that empower users to operate multiple appliances without being restricted to a single remote system [3].

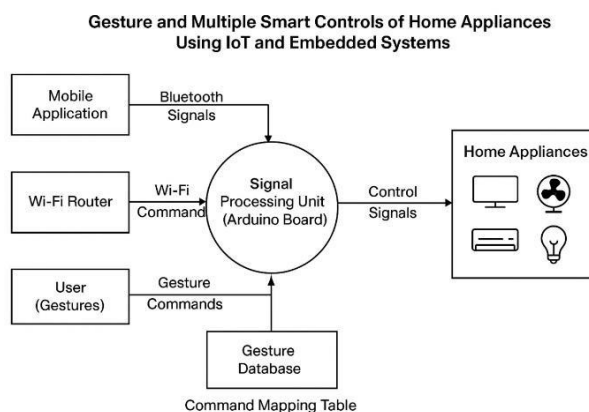
2.3 Gesture-Based Operation

Gesture-based systems provide an intuitive means of interacting with electric devices without the need for voice command, physical contact [1], [4]. Han et al. created a gesture recognition system that recognizes 9 unique hand movements [6], enabling users to control assorted appliances connected to their home network, including home entertainment equipment, smart picture frames, lights, and alarms. Current technologies include freehand gesture recognition via time-of-flight cameras, stereo vision, and structured light [6]; Rahman et al. proposed a gesture-based approach to managing IoT devices in health care settings geared towards elderly individuals and those with disabilities [7].

III. METHODOLOGY AND SYSTEM ARCHITECTURE

The proposed project involves developing a model for a gesture control system that uses technology through Internet-of-Things (IoT) to create alternative ways of interfacing with the user for persons with disabilities (e.g., older adults, non-verbal individuals).

System Architecture



The system has been designed as a star topology (distributed architecture), with an Arduino MEGA 2560 microcontroller at the centre of the various connected components and devices.

Project Components

The project components consist of:

- Arduino MEGA 2560, a microcontroller that will detect gestures and transmit commands to the associated devices.
- APDS-9960 RGB Gesture Sensor, which can detect gestures with a hand in close proximity (between 10 and 20 cm), along with ambient light, colour, and distance to any nearby objects.

- Relay, to control the function of high- power devices, including automatic window openers and window shades/curtains.
- Infrared (IR) Device, which sends signals to devices that have traditional remote control inputs (e.g., air conditioners).
- LCD Display, which shows the current system status and which control modules are currently activated.
- Control devices, including electric windows, dehumidifiers, air conditioning systems and automated curtain systems.

The continuous cycle of sensing, processing, and acting without requiring the use of physical buttons or multiple remotes makes this an easy-to-use system for individuals with disabilities.

IV.SYSTEM IMPLEMENTATION AND RESULTS

4.1 Implementation

All components are connected to the Arduino MEGA 2560. The gesture sensor detects commands, which the Arduino interprets and sends to the relay or IR emitter to operate the appliances. The LCD display provides real-time feedback on the current operation.

4.2 Operation

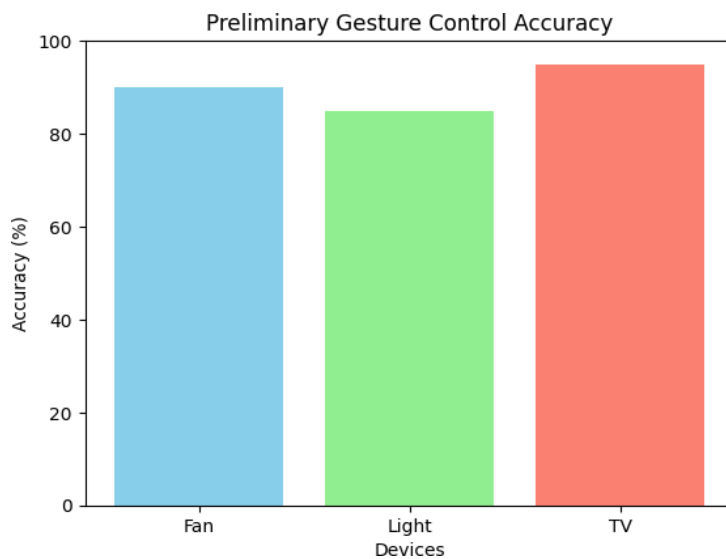
The system interprets different hand gestures to navigate and control various home automation modules displayed on the LCD screen. Upward and downward gestures are used to scroll through the available device options, such as window control, inner curtain, outer curtain, all curtains, air conditioner, and AC temperature adjustment.

Once a specific module is selected, a left-hand gesture is used to activate or turn on the chosen device. Similarly, a right-hand gesture is used to deactivate or switch off the selected appliance. This gesture-based navigation enables intuitive and contactless control of household devices within the smart home environment.

4.3 Results

The prototype successfully controlled multiple appliances:

- **Window and Curtain Control:** Relay modules opened and closed windows and curtains.
- **Air Conditioner Control:** IR emitters managed AC functions using predefined codes.



V.NOVELTY OF THE STUDY

There are five innovations that we want to highlight:

1. The "Real-World" Solution: Instead of a theoretical model, this is a real solution with actual devices.
2. Scalable Control of Devices: As many devices as you want can be controlled with any simple gesture.
3. Appliance Versatility: All types of electrical appliances (AC-powered, Infrared controlled).
4. Easy to use: Non-touch gestures allow for use by seniors and Disabled users.
5. A Solution that's good for cost and accessibility: Low-cost barrier-free option for maintaining independence and convenience in the home..

VI.CONCLUSION

An accessible method to provide access to smart home technology for older adults or those that have a speech or hearing impairment was created through the development of a gesture based smart home control system that operates with the aid of an IoT Network. The component parts of the system consist of Sensors (to detect user Gestures), a Central Control Board and (optional) Smart Device, which provide a means of control for the various electronic devices found in a typical smart home environment through the use of Gestures. It is anticipated that additional enhancements will be made by integrating existing Smart Devices with Smart Speakers for added functionality, including Voice Control.

In the future, this gesture-based smart home system may be improved in many ways to make it more practical for everyday use. One possible improvement is adding AI and machine learning so that the system slowly understands how different users perform gestures. Since everyone's hand movements are slightly different, this will help the system respond more accurately over time. Along with the hand gestures and voice control can be added so users will have more than one way to control their home appliances.

Using Wi-Fi or Bluetooth, users might control home appliances using mobile phones, even when they are away from home. They can also see whether devices are ON or OFF at any time. For better safety, future versions can include features like gesture-based door locks and emergency alert systems.

Another useful improvement is saving energy. The system can watch how home appliances used and it automatically reduce power when it's not needed. With personal settings, support for different languages, and smart customization, the system may become easy for everyone to use. It is mainly helpful for elderly people and People with physical problems, because it makes everyday life more comfortable and independent.

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