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Home Guard AI Smart Home with Gesture Control for Handicapped

Sagar Dhar Dwivedi[1], Raj Kumar Singh[2], Abhijeet Sharma[3], Srishti Shukla[4], Dr. Shailendra Tahilyani[5]

[1,2,3,4]Student, Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management
[5]Head of Department, Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management

Abstract
The fast growth of Artificial Intelligence (AI) and the Internet of Things (IoT) has played a big role in the growth of smart home systems, which make homes more convenient, automated, and secure. But a lot of the smart home solutions that are out there right now aren't fully accessible to people with physical disabilities because they mostly use manual controls, mobile apps, or voice-based interfaces. These methods might not work for people who have trouble moving or speaking, which would make it harder for them to be independent and use household devices easily.
This project introduces Home Guard AI, a smart home automation system that is specifically made for people with disabilities. It uses gesture-based control as its main way of interacting with users. The system uses a flex sensor to pick up on hand gestures, and an ESP32 microcontroller processes those gestures to figure out what the user wants. The system uses a relay module to control different household appliances based on the recognized gestures. This makes it easy to use without having to touch anything. The system has safety features that work with gesture control. For example, the MQ2 gas sensor detects gas leaks, the flame sensor detects fires, and the DHT11 sensor keeps an eye on temperature and humidity.
The proposed system focuses on being affordable, easy to use, and reliable, which makes it a good choice for use in the real world, especially in places with limited resources. It gives differently-abled people more freedom and lessens their reliance on caregivers by giving them a simple, non-verbal way to control things. Also, adding IoT features makes it possible to monitor things from a distance and make them bigger.
The system can accurately recognize predefined gestures and control appliances in real time, as shown by experimental results. The system has some problems, like being too sensitive to gestures and being dependent on the environment, but it is a strong base for future improvements using machine learning and computer vision.
In summary, the Home Guard AI system is a useful and all-inclusive way to automate smart homes that helps make life easier, safer, and better for people with disabilities.

Keywords: Smart Home Automation, Gesture Recognition, Artificial Intelligence (AI), Internet of Things (IoT), Assistive Technology, Handicapped Accessibility, ESP32 Microcontroller, Flex Sensor, Home Security System, Wireless Control Systems, Embedded Systems, Arduino Uno

1. Introduction

In the last few years, the fast growth of Artificial Intelligence (AI) and the Internet of Things (IoT) has changed the way people interact with the world around them in big ways. Smart home systems are one of the most popular uses of these technologies. They let you control your household appliances from anywhere, which makes your home more comfortable, energy-efficient, and safe. But even with these improvements, a lot of people, especially those with physical disabilities, still have trouble using regular smart home interfaces well. Most of the time, traditional home automation systems use manual switches, mobile apps, or voice commands. These methods are easy for most people to use, but they might not work for people who have trouble moving, speaking, or have other serious physical problems. For these users, even simple things like turning on a light or controlling a fan can be hard, which makes them more dependent on caregivers and less independent.

Gesture-based control systems have come up as a promising way to get around these problems. Gesture recognition lets people use simple hand movements to interact with devices, which makes communication more natural, intuitive, and touchless. Gesture-based interfaces are more reliable in some situations because they don't get messed up by speech problems or loud places like voice-controlled systems do. Gesture recognition also lets you control multiple devices in a smart home ecosystem without any problems when combined with IoT technology.

This research paper introduces Home Guard AI, an intelligent smart home system specifically designed for individuals with disabilities. The proposed system combines gesture recognition with IoT-based automation to make it easy for anyone to control home appliances. The system has sensors like flex sensors that can tell when your hands move, an ESP32 microcontroller that handles processing and connectivity, and relay modules that can turn on and off electrical devices. Gas sensors, flame sensors, and temperature sensors are also used to add safety features and make sure the living space is safe.

The proposed system is unique because it focuses on being open to everyone, affordable, and easy to use. The system gives users the power to do their daily tasks on their own by reducing the need for physical interaction and giving them a way to control things without speaking. Also, adding AI makes gesture recognition more accurate, so the system can learn to work with different people and ways of using it over time.

In short, the goal of this work is to connect advanced smart home technologies with the needs of people with disabilities. The proposed HomeGuard AI system helps make homes safer, smarter, and more welcoming by using AI, IoT, and gesture-based interaction.

2. Problem Statement

Smart home technologies that use Artificial Intelligence (AI) and the Internet of Things (IoT) are growing quickly, but they are still hard for people with physical disabilities to use and get to. Most home automation systems on the market are made for the average person and rely on interfaces like manual switches, smartphone apps, or voice commands. These interfaces are useful, but they don't always meet the needs of people with physical disabilities.

People who have trouble moving around, are paralyzed, or have limb disabilities often have a lot of trouble doing even simple household tasks. It may not always be possible to reach wall-mounted switches or mobile devices, especially for people who have trouble moving. In the same way, voice-controlled systems may not work well for people who have trouble speaking or in places with a lot of background noise, which can make them unreliable.

Another big problem is that there aren't any easy-to-use and intuitive ways to interact with the system. A lot of the systems that are already out there need technical knowledge, a constant internet connection, or complicated setups, which makes them hard for older people or people with disabilities to use. Also, advanced assistive technologies are often expensive, which makes them hard to use in homes with low or middle incomes.

Safety is also very important. People with physical disabilities may not be able to act quickly in emergencies like gas leaks, fires, or sudden changes in temperature. Traditional smart home systems may not be able to keep an eye on things in real time or send automated alerts that are specific to those users, which raises the risk of accidents.

Also, current systems don't have personalized and adaptive features that can learn how a user behaves or change based on their abilities. Gesture-based interaction has a lot of potential, but it isn't used enough yet and needs more work to make sure it works well, is reliable, and is easy to use in real life.

So, it's clear that we need a smart home solution that:

- Offers a different way to interact that doesn't involve talking
- Lessens reliance on speech and movement
- Makes sure that it is easy to use and cheap
- Makes things safer by using integrated monitoring systems
- Gives you dependable and effective control over your home appliances

This study looks at these problems and suggests Home Guard AI, a smart home system that can be controlled by gestures and is made for people with disabilities. The goal of the system is to provide an easy-to-use, affordable, and safe solution that makes users more independent and improves their quality of life.

3. Literature Survey

In recent years, there has been a lot of interest in developing smart home systems that use gesture recognition, artificial intelligence (AI), and the Internet of Things (IoT) to help older and disabled people.

Rao et al. (2025) did a thorough review that showed that gesture-controlled smart home systems offer a non-verbal and intuitive interface, which gives disabled users more freedom. The study focuses on how these systems have changed over time, from simple infrared and wearable tech to more complex AI-driven and IoT-enabled platforms. It also points out important problems, like being sensitive to the environment, having gestures that change, and not having standardized ways to evaluate things.

Previous research focused on making home automation cheaper by using microcontrollers and wireless communication. For example, Malhotra et al. (2019) suggested a gesture-controlled system that uses Arduino and Wi-Fi modules to control things like lights and fans. Their system was cheap and easy to set up, but it didn't have advanced intelligence or the ability to adapt.

Recent improvements have used machine learning and computer vision to make gesture recognition more accurate. Using deep learning and computer vision tools like Media Pipe, Devi et al. (2025) made a home automation system that could be controlled by gestures using AI. Their system was able to recognize gestures quickly and easily in real time, and it made it easier for users to interact with the system by using touchless controls.

Yang et al. (2023) also suggested an IoT-enabled system that uses hand gesture recognition along with machine learning algorithms such as Principal Component Analysis (PCA) and Random Forest classifiers. Their method made classification more accurate and showed that combining AI with IoT can work for smart home applications.

Researchers have also looked into assistive technologies that go beyond smart homes. For instance, a smart wheelchair system that uses IoT and Convolutional Neural Networks (CNN) to control gestures was suggested to help disabled people move around more easily and be more independent. The system had safety features like fall detection and emergency alerts, which showed how important it is to combine gesture control with safety features.

IoT-based assistive systems are also well-known for making life better for older and disabled people. Studies show that IoT devices can help with remote monitoring, automation, and personalized help. However, privacy, security, and energy efficiency are still major obstacles to their widespread use.

4. Hardware Components Used in the System

The suggested Home Guard AI system combines different hardware parts to make it possible to control smart home devices with gestures and keep disabled users safe. Every part is important for sensing, processing, and controlling the system.

4.1 ESP32 Microcontroller

The system's main processing unit is the ESP32. It is a cheap, high-performance microcontroller with built-in Wi-Fi and Bluetooth, which makes it perfect for IoT use. The ESP32 in this system takes input from sensors, runs gesture recognition logic, and controls output devices through relay modules. It has two cores and uses very little power, which makes it good for real-time use.

4.2 Flex Sensor

The flex sensor is used to detect gestures. It works by changing its resistance when it is bent. The ESP32 reads the different electrical signals that the sensor sends when the user makes hand gestures. Next, these signals are analysed to find certain gestures and the commands that go with them.

4.3 Relay Module (3-Channel)

The relay module connects low-power control signals to high-power electrical devices. It lets the ESP32 safely control things like lights, fans, and other appliances in the home. Each relay channel can turn an appliance on or off on its own, depending on the command it gets.

4.4 MQ2 Gas Sensor

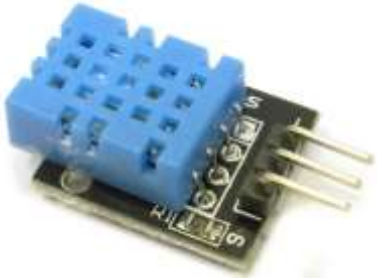
It is possible to use the MQ2 sensor to find dangerous gases like LPG, methane, and smoke. It keeps an eye on the air quality all the time and sends signals to the ESP32 when the amount of gas goes above a certain level. This feature makes the system safer by letting people find gas leaks early.

4.5 Flame Sensor

The flame sensor finds fire or flames. It can quickly find fire hazards because it is sensitive to infrared light from flames. The system can send out alerts or take steps to stop a fire from happening when it sees one. This lowers the risk of accidents.

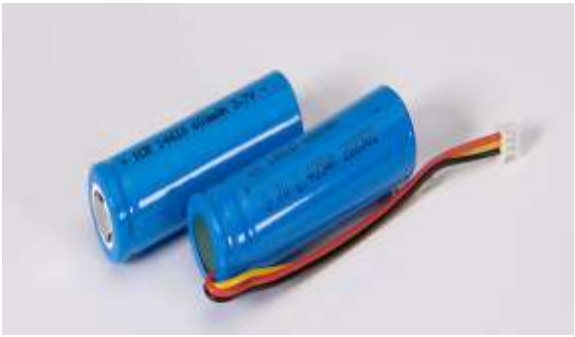
4.6 DHT11 Temperature and Humidity Sensor

The DHT11 sensor tells you the temperature and humidity in the air. It helps keep an eye on the weather inside the house. You can also use the data to automate things, like turning on fans or sending alerts when the temperature goes outside of normal ranges.



4.7 Lithium Ion Battery

A lithium-ion battery project usually means putting together cells (like 18650) to make a high-capacity power source for electronics or electric cars. These cells have cathode (lithium metal oxide) and anode (graphite) materials. Key steps are grading cells, spot welding them in series or parallel, adding a Battery Management System (BMS), and testing the capacity**.**



4.8 Jumper Wires

Jumper wires, also called DuPont cables, are important solderless wires with pin connectors that are great for prototyping with Arduino, Raspberry Pi, and breadboards. There are three main types: male-to-male (M-M), male-to-female (M-F), and female-to-female (F-F). They come in lengths of 10 cm to 30 cm. The connectors on these cables have a pitch of 2.54mm, which makes them great for breadboards.

4.9 LCD Display (16x2)

The LCD (Liquid Crystal Display) is a type of output device that shows information in a visual way. The proposed Home Guard AI system uses the LCD to give the user real-time feedback by showing them the status of the system, detected gestures, and alerts. Liquid crystals are what make an LCD work. When an electric field is applied, they can change the way light behaves. There are layers of liquid crystal molecules between two polarizing filters. When voltage is applied, these molecules change their alignment, which lets light through or blocks it, making characters visible on the screen.

4.10 Voltage Regulators

An important electronic part is a voltage regulator, which keeps the output voltage steady even when the input voltage or load conditions change. Voltage regulators in the Home Guard AI system make sure that sensitive parts like the ESP32, sensors, relay module, and LCD display get a stable and reliable power supply. By changing the flow of current, a voltage regulator controls the output voltage. The regulator keeps the output voltage steady even when the input voltage changes or the load changes. This keeps electronic parts from getting damaged and makes sure the system works right.

4.11 Buzzer

A buzzer or beeper is a device that makes sound to signal something. It can be mechanical, electromechanical, or piezoelectric. Buzzers and beepers are often used as alarms, timers, and to confirm user input, like a mouse click or keystroke.

4.12 Arduino Uno

The Arduino Uno is one of the most popular microcontroller boards for IoT and embedded systems projects. It is based on the ATmega328P and is easy to prototype, which makes it great for both beginners and more advanced projects.

Part of the Home Guard AI System

Your project mostly uses ESP32, but you can also use Arduino Uno for:

- Reading data from sensors like the flex sensor and the gas sensor
- Managing relay modules
- Testing and making prototypes of the system
- Acting as a backup controller in basic versions

5. Software Component Used in the System

5.1 Adafruit .io

Adafruit Industries made Adafruit.io, a cloud-based platform that lets people connect, monitor, and control IoT devices over the internet. It has a simple interface for visualizing data, controlling devices, and talking to the cloud in real time.

What the Home Guard AI System Does

Adafruit IO can be used in the Home Guard AI project to:

- Check sensor data from a distance (like temperature, gas, etc.)
- You can control your home appliances from anywhere
- Get alerts (for gas leaks or fires)
- Keep system data for later analysis

5.2 How Adafruit.io works with Voice Control

Adafruit.io doesn't recognize voices on its own. It doesn't work as a bridge between your hardware and voice assistants.

- The user tells Google Assistant or Amazon Alexa what to do.
- Voice assistant turns speech into a command (the AI part)
- The command is sent to Adafruit IO through IFTTT/API.
- Adafruit IO makes changes to a data feed
- The ESP32 reads the feed and uses a relay to control appliances

6. Working of the System

The suggested Home Guard AI system uses a structured method to let disabled users control their smart home with gestures.

Working Step by Step

Input through gestures

- the user uses a flex sensor to make hand gestures.
- the sensor bends and sends out different analog signals.

Getting the signal

- The ESP32 microcontroller reads the analog signals from the flex sensor.
- The ADC (Analog-to-Digital Converter) changes these signals into digital values.

Processing Gestures

- The ESP32 takes care of the sensor data.
- AI-based logic or predefined threshold values are used to find certain gestures.

Mapping Commands

- Each recognized gesture is linked to a certain command, like turning the light on or off or controlling the fan.

Control of Appliances

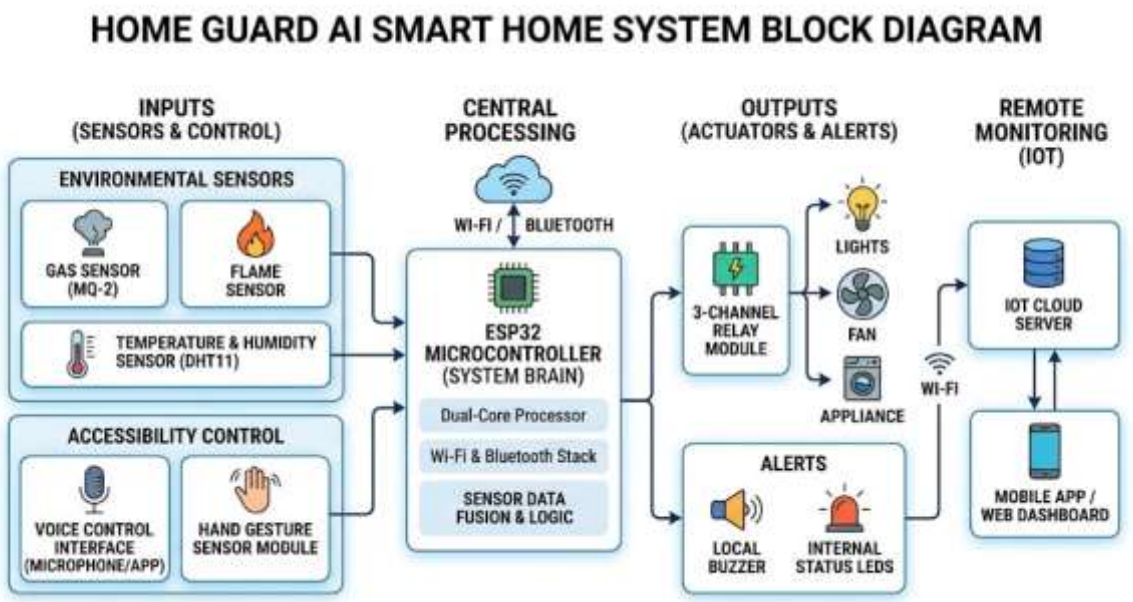
- the relay module gets signals from the ESP32.
- the relay turns on and off the appliances that are connected to it.

Monitoring for safety

- Sensors (MQ2, flame, DHT11) keep an eye on the environment all the time.
- Alerts or actions happen when something goes wrong, like a gas leak, fire, or high temperature.

- **How the system reacts**
- the command is carried out by the system in real time, which makes it run quickly and efficiently.

7. Block Diagram



8. Result

The proposed Home Guard AI system was successfully put into use and tested to see how well it worked for real-time smart home automation using voice and gesture control. The flex sensor and ESP32 microcontroller worked together to accurately recognize set hand gestures during testing. The recognized gestures were correctly linked to the right commands, which made it easy to control lights, fans, and other household appliances through the relay module. The system responded quickly, making it possible to work in almost real time without any noticeable delay.

9. Future Scope

The suggested Home Guard AI system shows a good way to use gesture-based smart home automation for people with disabilities. But as technology gets better, the system can be made more useful, accurate, and functional by adding new features and improvements.

Adding more advanced Artificial Intelligence and Machine Learning algorithms is a big step forward. Right now, the system only works with predefined gestures. In the future, deep learning models will be able to recognize a wider range of gestures with more accuracy and flexibility. You can also teach the system to recognize specific gesture patterns for each user, which makes it more personalized and useful.

Using cameras to recognize gestures based on computer vision is another promising improvement. This would make wearables like flex sensors unnecessary and make the whole system work without any contact. Real-time image processing and hand tracking are two technologies that can make things much easier for users.

Adding voice control to gesture control can also make the system more powerful by creating a hybrid interaction model. This multimodal approach would give users the freedom to choose the best way to interact based on their skills and the situation.

Mobile and cloud integration are two more ways to make things better. With a dedicated mobile app, you can control and monitor appliances from anywhere. With cloud connectivity, you can store data, get alerts in real time, and do analytics. This would make it easier to use and let caregivers check on the system from afar.

For safety, the system can be improved with more advanced monitoring tools like real-time alerts, emergency alerts, and automatic response systems (for example, turning off the gas supply when there is a leak or sounding alarms when there is a fire). Connecting to IoT-based emergency services can make response times even faster in emergencies.

Another important part of future development is energy efficiency. By looking at how users use electricity and automatically controlling appliances, the system can use smart energy management techniques to make the most of electricity use.

The system can also be made bigger to include smart healthcare features like monitoring vital signs, detecting falls, and providing emergency help. This makes it better for older and disabled people.

Lastly, future work can focus on making the system easier to use and more affordable so that it can be easily used in real-world settings, especially in rural and low-income areas.

10. Conclusion

Home Guard AI is a gesture-controlled smart home system that was shown in this paper. It is meant to make homes more accessible and give disabled people more freedom. The system successfully combines gesture recognition with Internet of Things (IoT) technology to make it easy and quick to control household appliances without having to use physical switches or voice commands.

The setup with the ESP32 microcontroller, flex sensor, and relay module worked well in recognizing set gestures and carrying out the right actions in real time. Adding safety sensors like the MQ2 gas sensor, flame sensor, and DHT11 temperature sensor makes the system even safer by letting you find potential dangers early.

The system that has been suggested has a number of benefits, such as being easy to use, inexpensive, less reliant on caregivers, and safer. It works well for people who have trouble moving or speaking because it lets them interact without using their hands or voice.

But there were some problems, like gesture recognition accuracy, environmental sensitivity, and a small number of gesture sets. These problems show that we need to make more progress using better AI tools and more reliable ways to sense things.

In conclusion, the Home Guard AI system is a useful and scalable way to make smart home automation more accessible to everyone. It shows how gesture recognition, AI, and the Internet of Things (IoT) can work together to make smart and helpful spaces. With more improvements in the future, the system can become a more flexible, accurate, and widely usable way to improve the quality of life for people with disabilities.

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