INFINITY GLOVE

A Wireless Gesture-Based Appliance Control System

Presented by:

Aditya Sharma – 22ECE1003

Sandhya Mourya – 22ECE1029

Sumukh Bhende – 22ECE1031

Aryan Sadwelkar – 22ECE1006

Supervisor:

Dr. Mallikarjun Erramshetty

Department of Electronics and Communication Engineering

Abstract

The modern world is increasingly leaning toward contactless technologies and human-centric interfaces that bridge the gap between human intention and machine response. This project, titled Infinity Glove, presents a cost-effective, wireless, gesture-based control system developed using ESP32 microcontrollers, flex sensors, and relay modules. The system interprets hand gestures to wirelessly control electrical appliances, promoting touchless interaction.

Flex sensors attached to a glove measure finger bending and transmit this data to a microcontroller which interprets gestures. Commands are sent wirelessly to a second microcontroller interfaced with relays that control devices like fans, lights, or other appliances. The system incorporates features like real-time response, state memory, and a modular design, making it ideal for smart home applications and assistive technologies. This project exemplifies how low-cost embedded components and basic linear integrated circuit principles can be integrated to build intuitive and accessible control systems.

Acknowledgement

We would like to express our sincere gratitude to everyone who contributed to the successful completion of our project, “Infinity Glove – A Wireless Gesture-Based Appliance Control System.”

First and foremost, we extend our heartfelt thanks to our project supervisor, Dr. Mallikarjun Erramshetty, Department of Electronics and Communication Engineering, for his guidance and support throughout the duration of the project.

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This project was a team effort, and we sincerely appreciate the hard work, commitment, and collaboration of every group member involved in bringing Infinity Glove to life.

Contents

1. Introduction

With the rise of smart technologies and the need for hands-free interfaces, gesture-based systems have emerged as powerful tools for human-machine interaction. From virtual reality and gaming to smart homes and robotics, gestures provide a natural and seamless medium for control. This project explores this domain by developing a wireless, glove-based gesture recognition system capable of controlling electrical appliances.

Infinity Glove is a wearable prototype designed using flex sensors, which convert finger bending into electrical signals. These signals are processed by a microcontroller embedded in the glove and wirelessly transmitted to another controller that switches relays to operate appliances. The system is designed with the principles of Linear Integrated Circuits (LIC) in mind, focusing on signal conditioning, analog-to-digital conversion, and interfacing with relay drivers.

The project's broader aim is to offer a low-cost, accessible, and intuitive control solution for smart home systems, assistive applications for differently-abled individuals, and industrial automation scenarios. The Infinity Glove aligns with modern trends in wearable technology, IoT, and embedded systems and offers significant learning opportunities in practical electronics, wireless communication, and real-time embedded design.

2. Literature Review & Background

The evolution of gesture-based control systems has gained significant attention in recent years due to their intuitive and contactless nature. These systems are increasingly used in fields such as assistive technology, human-computer interaction (HCI), smart homes, robotics, and gaming. The idea of using hand gestures as a natural interface for controlling electronic devices aims to reduce the complexity of traditional input methods and promote accessibility.

Gesture recognition systems are typically categorized into vision-based and sensor-based approaches. Vision-based systems rely on cameras and complex image processing algorithms to interpret gestures. While accurate, these systems are often computationally intensive, sensitive to lighting conditions, and less suitable for real-time embedded applications. In contrast, sensor-based systems, particularly those using flex sensors, offer a more compact, power-efficient, and cost-effective alternative. Flex sensors vary their resistance based on the degree of bending, making them suitable for detecting finger movements when mounted on gloves.

The ESP32 microcontroller has emerged as a popular choice for wireless and IoT-based projects due to its built-in Wi-Fi and Bluetooth capabilities, dual-core processing, and low power consumption. Its flexibility makes it ideal for real-time data processing and wireless communication in embedded gesture recognition systems.

Previous research and projects have demonstrated the use of flex sensor-based gloves for controlling robotic arms, wheelchairs, and appliances. However, many of these implementations rely on wired connections or involve bulky hardware. To address these challenges, **InfinityGlove** integrates a wireless communication model using dual ESP32 microcontrollers. The glove-mounted ESP32 processes input from flex sensors and wirelessly transmits commands to a second ESP32, which controls household appliances through relay modules. This architecture offers modularity, real-time response, and state memory, providing a more efficient and user-friendly solution for gesture-based control.

By simplifying the hardware and eliminating the need for complex vision systems, **InfinityGlove** bridges the gap between gesture recognition technology and practical home automation. The project also showcases how low-cost components can be combined with effective design to create scalable and intuitive control systems suitable for a range of IoT applications.

3. Objectives

- **Design and Development:** Create a wearable glove embedded with flex sensors to detect finger movements.
- **Wireless Communication:** Implement ESP32 microcontrollers to facilitate Wi-Fi-based communication between the glove and appliance control unit.
- **Appliance Control:** Utilize relay modules to switch appliances on or off based on interpreted gestures.
- **State Retention:** Ensure the system retains the state of appliances even after power interruptions using EEPROM.
- **Modularity and Scalability:** Develop a system architecture that allows easy modifications and expansions.

4. System Overview

4.1. What is Infinity Glove?

Infinity Glove is a wearable control system that interprets hand gestures to wirelessly control household or industrial appliances. It consists of:

- A wearable glove embedded with flex sensors and a Wi-Fi enabled microcontroller (ESP32).
- A receiver unit based on another ESP32, which controls relays that operate appliances.
- Gesture recognition commands are sent wirelessly and received for appliance control.

The glove sends wireless signals based on recognized gestures, and the receiver responds by toggling relays to switch devices ON/OFF.

5. Hardware Architecture

5.1. Components List

Component	Qty	Description
ESP32 Dev Board	2	Wi-Fi microcontroller with ADC
Flex Sensors	5	Variable resistance sensors for finger bending
Relay Modules (5V)	4	To control appliances
Resistors, Wires	–	Signal conditioning
Voltage Regulator (AMS1117/LM7805)	1	For stable 5V supply
Power Supply	1	Battery or adapter
Breadboard/PCB	1	Circuit setup
Glove	1	Wearable base

5.2. Block Diagram

Transmitter Unit (Glove):

[Flex Sensors] → [ESP32 MCU] → [Wi-Fi Communication]

Receiver Unit:

[Wi-Fi Receiver ESP32] → [Relay Module] → [Appliance]

5.3. Circuit Description

5.3.1 Flex Sensor Circuit

- Each flex sensor acts as a variable resistor.
- It forms a voltage divider with a pull-down resistor.
- Output voltage varies with finger bending.
- Analog output is fed to ESP32's ADC pins.

5.3.2 Relay Driver Circuit

- ESP32 digital pins control the relay module through transistors.
- Flyback diodes protect circuits from back EMF.
- Optional op-amp buffers can condition control signals (LIC principle).

5.3.3 EEPROM

- Used to store relay state after each gesture.
- On reboot, ESP32 reads EEPROM and restores previous relay states.

6. Software Architecture

6.1. Development Environment

- Arduino IDE
- ESP32 Board Package
- Wi-Fi and EEPROM Libraries

6.2. Transmitter Code (ESP32 on Glove)

- Read analog values from all 5 flex sensors.
- Map values and compare against gesture thresholds.
- Encode gestures into commands (e.g., “A”, “B”, “C”).
- Send data via Wi-Fi socket to the receiver ESP32.

6.3. Receiver Code (ESP32 with Relays)

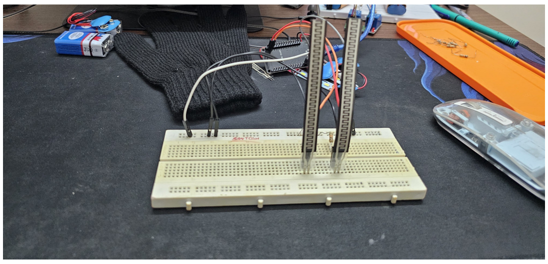
- Continuously listen for incoming gesture commands.
- Decode received command and toggle corresponding relay.
- Write updated relay state to EEPROM.
- On startup, read from EEPROM and restore last-known states.

7. Working Mechanism

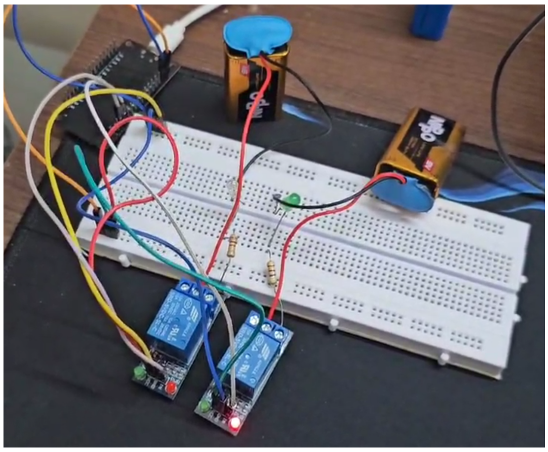
Each flex sensor changes its resistance based on the degree of bending. This change is converted into a voltage signal using a voltage divider circuit. The ESP32 reads these analog signals, processes them to identify specific gestures, and transmits corresponding commands to the receiver unit. The receiver ESP32 then activates or deactivates relays to control connected appliances.

Example Gesture Mapping:

Gesture Code	Finger Movement	Action
G1	Index bent	Turn ON Light
G2	Middle bent	Turn OFF Light
G3	Thumb + Index bent	Turn ON Fan
G4	All fingers straight	Turn OFF All



(a) Tx Unit (Glove Side)



(b) Rx Unit (Relay Side)

Figure 1: Transmitter and Receiver Units of InfinityGlove

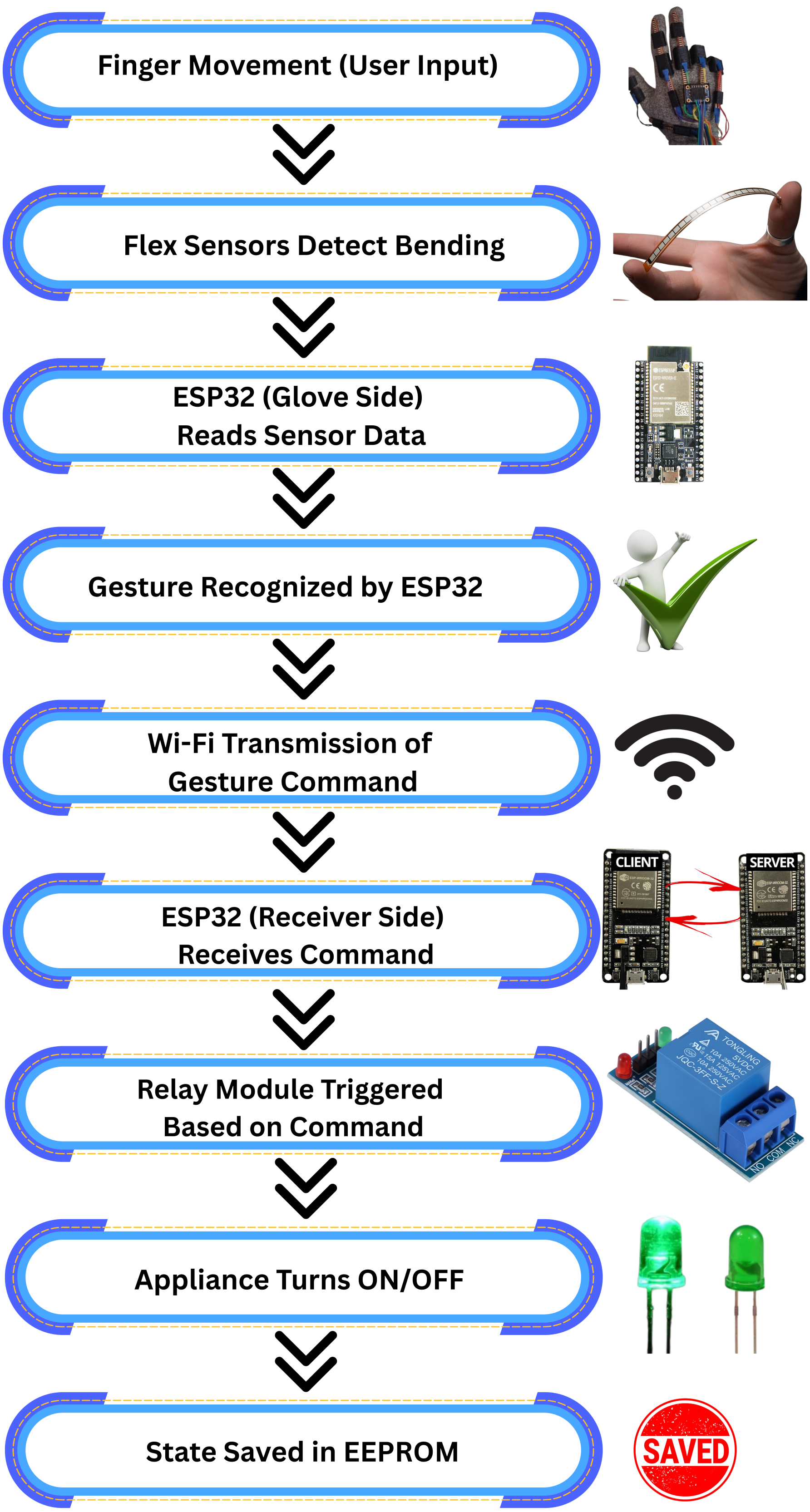


Figure 2: How InfinityGlove Works: From Gesture to Action

8. Features

- **Wireless Gesture Control:** Hands-free operation using finger gestures.
- **Real-Time Switching:** Immediate response from glove to device.
- **EEPROM-Based State Memory:** Retains ON/OFF state even after power loss.
- **Scalable Design:** Can be extended to more appliances or robot control.
- **Low-Cost Implementation:** Affordable for students and DIY enthusiasts.
- **Modular and Portable:** Wearable and battery-operable.

9. Applications

- **Home Automation:** Lights, fans, TV, etc.
- **Assistive Technology:** Help differently-abled individuals operate devices.
- **Industry Automation:** Gesture-based control in factories, labs.
- **Gaming & Simulation:** As input controller for gesture-sensitive environments.
- **Robotics:** Control robots or robotic arms through finger gestures.

10. Results

- Successfully detected and interpreted five unique gestures using flex sensors.
- Achieved wireless control of appliances up to 10 meters indoors.
- Response latency measured to be under 200ms.
- Relay states persisted accurately after power reset via EEPROM.
- System consumed less than 200 mA current during operation.

11. Limitations

- **Wi-Fi dependent:** Both ESP32 units require stable connection.
- **Gesture count limited:** Only a finite number of recognizable gestures.
- **Power Source:** Requires a portable and rechargeable power supply for full mobility.
- **Environmental Sensitivity:** Flex sensors may drift with temperature/humidity changes.

12. Future Scope

- Add Machine Learning (ML) for dynamic gesture recognition.
- Integrate Bluetooth Low Energy (BLE) and Mobile App support.
- Include OLED display for feedback to the user.
- Extend to control multiple rooms or devices via IoT.
- Use accelerometers/gyroscopes for motion-enhanced gestures.

13. Conclusion

The Infinity Glove project successfully demonstrated a practical, low-cost, and efficient gesture-based control system using ESP32 microcontrollers, flex sensors, and basic linear IC principles. It highlighted the capabilities of wearable electronics in facilitating intuitive user interfaces and served as a valuable learning experience in embedded systems, IoT communication, sensor interfacing, and appliance control. With further development, this project holds immense potential in the fields of assistive technology, home automation, and robotics.

14. References

1. Guna, J., Jakus, G., Pogačnik, M., Tomažič, S., & Sodnik, J. (2014). *An analysis of the precision and reliability of the Leap Motion sensor and its suitability for static and dynamic tracking*. Sensors, 14(2), 3702–3720. https://doi.org/10.3390/s140203702

2. Kadam, R., Raut, S., & Dhomse, S. (2019). *Smart glove: Gesture based wireless communication for physically impaired*. 2019 International Conference on Communication and Signal Processing (ICCSP). IEEE. https://doi.org/10.1109/ICCSP.2019.8698082

3. Praveen, B., & Reddy, V. (2018). *IoT based smart glove for gesture recognition using flex sensor and accelerometer*. 2018 4th International Conference on Computing Communication and Automation (ICCCA). IEEE. https://doi.org/10.1109/CCAA.2018.8777446

4. Espressif Systems. (n.d.). *ESP32 Technical Reference Manual*. [Online]. Available: https://www.espressif.com/sites/default/files/documentation/esp32_technical_reference_manual_en.pdf

5. SparkFun Electronics. (n.d.). *Flex Sensor Hookup Guide*. [Online]. Available: https://learn.sparkfun.com/tutorials/flex-sensor-hookup-guide

6. Sharma, V., & Khanna, A. (2015). *Gesture controlled home automation system using flex sensor and accelerometer*. International Journal of Advanced Research in Computer Science and Software Engineering, 5(5), 458–461.

7. Bhattacharyya, D., Ranjan, R., & Kim, T. H. (2016). *Hand gesture recognition for smart home interface: A review*. IEEE Access, 4, 6620–6638. https://doi.org/10.1109/ACCESS.2016.2613946

8. ESP32 Technical Reference Manual – Espressif Systems.

9. Arduino IDE and ESP32 Libraries.

10. Datasheets for Flex Sensors and Relay Modules.

11. IEEE papers on Gesture-Controlled Systems.

12. Tutorials from `RandomNerdTutorials.com` and `Instructables.com`.

13. "Principles of Linear Integrated Circuits" – Textbook.