

Real-Time Sign Language to Voice Conversion and Smart Light Control Using Hand Gestures with Arduino

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Abstract: *This project introduces a wearable system that translates sign language gestures into audible voice output while enabling smart light control through hand gestures. Designed for individuals with speech, hearing, or mobility impairments, it enhances both communication and independent living. A glove embedded with flex sensors and an accelerometer detects finger movements and hand orientation, processed by an Arduino Uno and transmitted via Bluetooth. Voice conversion is achieved using a DFPlayer Mini or Android's Text-to-Speech feature. In parallel, predefined gestures control appliances through a relay module, eliminating the need for physical switches. The dual functionality provides an affordable, intuitive solution that fosters autonomy, reduces caregiver dependency, and improves quality of life.*

Keywords: *Sign Language, Flex Sensors, Arduino Uno, Gesture Sensor, Bluetooth, Smart Light Control, Accessibility*

I. Introduction

Sign language is the primary mode of communication for hearing-impaired individuals, but its limited understanding among the general population creates a communication gap. Similarly, physically challenged or bedridden individuals face difficulty operating electrical appliances, depending heavily on caregivers. Existing assistive technologies are often expensive, non-portable, or lack real-time functionality.

Recent advancements in embedded systems and IoT have enabled the development of wearable and sensor-based assistive devices. This project integrates two independent modules: a smart glove for sign-language-to-voice conversion and a gesture-controlled lighting system using APDS9966 RGB sensor and relay module.

II. Material And Methods

This experimental hardware-based study was conducted in the Department of Electrical & Electronics Engineering at G. Pulla Reddy Engineering College, Kurnool, India during the academic year 2025–2026. The system was designed and tested using embedded hardware and IoT modules. It focuses on real-time gesture recognition and assistive control, combining a smart glove for sign-language-to-voice conversion with a gesture-based lighting system for appliance automation.

Study Design: Experimental hardware implementation of two independent assistive systems.

Study Location: This study was conducted in the Electrical & Electronics Engineering laboratory at G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India

Study Duration: Academic year 2025–2026

Sample size: Prototype-based system (single hardware setup for each module)

System A – Smart Glove for Sign Language Conversion

- Arduino Uno microcontroller
- Flex sensors (3–5 units)
- MPU6050 accelerometer
- HC-05 Bluetooth module
- DFPlayer Mini / Android TTS for voice output

System B – Smart Light Control Using Gesture Sensor

- APDS9966 RGB gesture sensor
- Arduino Uno
- 4-channel relay module
- AC bulbs
- 16×2 I2C LCD display
- Power supply

Procedure methodology

Flex sensors detect finger bending angles, while the accelerometer captures hand orientation and movement. These sensor signals are continuously acquired and processed by the Arduino Uno, which compares them against predefined threshold values to identify specific gestures. Once recognized, each gesture is mapped to a corresponding word or sentence stored in the program. The Arduino then transmits this data wirelessly via the HC-05 Bluetooth module to a smartphone or voice output device. On the mobile side, the received text is converted into audible speech using Text-to-Speech technology, ensuring real-time communication that is clear, fast, and accessible.

In parallel, the APDS9966 gesture sensor detects directional hand movements. Arduino Uno processes these inputs and toggles relay channels to control bulbs. The LCD provides real-time feedback of gesture detection and bulb status.



Working Model

Statistical analysis

System performance was evaluated based on accuracy, response time, and reliability. Gesture recognition accuracy was measured through repeated trials under varying conditions. Relay switching response time and voice output latency were recorded.

III. Result

The system successfully converts hand gestures into text and then into voice output. Flex sensors and the accelerometer detect finger movements and orientation effectively, while the Arduino processes these signals and identifies predefined gestures with good accuracy. Bluetooth communication ensures smooth data transfer to the mobile device, and the Android application produces clear voice output using text-to-speech. The glove operates in real time with quick response, is portable, and reduces the communication gap between users.

The gesture-controlled lighting system also performed reliably. The APDS9966 sensor consistently detected directional hand movements and mapped them to relay switching. Each gesture correctly toggled the corresponding bulb, with the LCD providing clear feedback of bulb status. The system responded instantly under repeated trials, demonstrating practical usability for contactless appliance control.



Output Display on Mobile using Arduino Bluetooth Text to Speech

IV. Discussion

The dual-module system demonstrates the effectiveness of combining embedded sensors with microcontroller-based processing for assistive applications. The smart glove provides a low-cost alternative to commercial sign-language translators, offering real-time voice output and portability. The gesture-controlled lighting system enables contactless appliance control, beneficial for physically challenged or bedridden individuals.

Flex sensors and accelerometers provided stable gesture detection, while the APDS9966 sensor offered high-accuracy directional gesture recognition. Both systems operated independently, ensuring modularity and ease of deployment. Future enhancements may include cloud integration, multilingual voice output, and expansion to control multiple appliances.

V. Conclusion

The proposed system successfully integrates real-time sign-language-to-voice conversion and gesture-based smart light control. Both modules are cost-effective, reliable, and suitable for enhancing accessibility for differently abled individuals. The system demonstrates strong potential for practical deployment in homes, hospitals, and rehabilitation centers.

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