PBL 2 for Computer Engineering

No. 23, 26, 27, 35

SignLent User Manual

I. Introduction

SignLent is an IoT-based smart glove designed to enable deaf individuals to communicate more effectively. The system translates sign language gestures into text and speech in real time using flex sensors and a gyroscope (MPU6050) mounted on an ESP32 microcontroller. The glove captures finger and hand movements, processes them using Machine Learning, and outputs both readable text and audible communication through a connected web app.

Intended Users:

- Individuals who are deaf or hard of hearing
- Sign language interpreters
- Healthcare professionals
- Educational institutions
- Family members and caregivers

II. System Overview

II.I. System Architecture

SignLent is a comprehensive communication system consisting of three integrated components:

1. Hardware Component (Smart Glove)
    - Wearable glove equipped with five flex sensors for finger bend detection
    - MPU6050 inertial measurement unit (IMU) for hand orientation and motion tracking
    - ESP32 microcontroller for data processing and wireless communication
    - Rechargeable battery power system
    - LED status indicators and haptic feedback motor
2. Software Component (Web Application)

- Cross-platform web interface accessible via smartphone or computer
- Real-time gesture recognition display
- Text-to-Speech (TTS) output engine
- Gesture history logging and analytics

3. AI/Machine Learning Component
   - LSTM (Long Short-Term Memory) neural network for gesture recognition
   - Edge AI inference capability on ESP32 for reduced latency
   - Adaptive calibration algorithms
   - Continuous learning from user-specific gesture patterns

II.II. System Workflow

The SignLent system operates through the following sequence:

```
User Makes Gesture
↓
Sensors Detect Movement (Flex Sensors + MPU6050)
↓
ESP32 Processes Raw Sensor Data
↓
Data Transmitted via Bluetooth Low Energy (BLE)
↓
Web App Receives Data
↓
AI Model Recognizes Gesture
↓
Output Generated (Text Display + Speech Synthesis)
```

II.III. Technical Specifications

Data Transmission Protocol:

- Protocol: Bluetooth Low Energy (BLE)
- GATT Characteristic UUID: `7094fd70-4532-4d73-a118-473a0a63701a`
- Packet Size: 50 bytes per transmission
- Data Format (Big-Endian):
  - 5 × 16-bit integers (flex sensor values: little finger → thumb)
  - 4 × 32-bit floats (quaternion rotation: x, y, z, w)
  - 3 × 32-bit floats (acceleration in g-forces: x, y, z)
  - 3 × 32-bit floats (gyroscope angular velocity in deg/s: x, y, z)

Performance Metrics:

- Gesture Recognition Latency: < 200ms
- Recognition Accuracy: Up to 95% (after calibration)
- Battery Life: 4-6 hours continuous use
- Wireless Range: Up to 10 meters
- Supported Gestures: Extensible vocabulary (base model: 100+ common signs)

III. Installation / Setup

III.I. Hardware Requirements

Glove Device:

- ESP32 microcontroller (pre-installed)

- 5 × flex sensors
- 1 × MPU6050 gyroscope/accelerometer

User Device (for Web App):

- Smartphone or tablet with:
  - Operating System: iOS 12.0+ or Android 8.0+
  - Bluetooth 4.0 or higher (BLE compatible)
  - Modern web browser (Chrome, Safari, Firefox, Edge)
  - Internet connection (for initial setup and updates)
- **OR** Computer with:
  - Operating System: Windows 10+, macOS 10.14+, or Linux
  - Bluetooth 4.0 adapter
  - Modern web browser with BLE support
  - Internet connection

III.II. Software Requirements

- Web browser with JavaScript enabled
- Bluetooth permissions enabled
- Microphone/speaker access (for TTS features)

IV. Getting Started

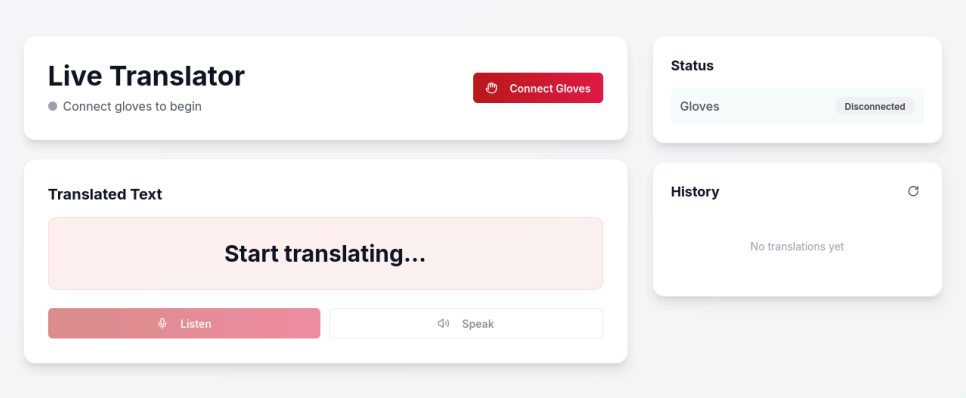

Figure 1: The SignLent Web UI.

IV.I. Step 1: Web Application Access

Method A: Smartphone Access

1. Open your device's web browser (Chrome recommended)
2. Navigate to the Web UI
3. Grant necessary permissions when prompted

Method B: Desktop/Laptop Access

1. Launch a Bluetooth-compatible browser:
   - Google Chrome (version 90+)
   - Microsoft Edge (version 90+)
   - Opera (version 76+)
2. Navigate to the Web UI
3. Grant necessary permissions when prompted

Note: Safari and Firefox have limited Bluetooth Web API support. Chrome is strongly recommended for optimal compatibility.

IV.II. Step 2: Device Pairing Configuration

1. **Prepare the glove:**
   - Plug in your gloves
   - Relax your hand and allow it to fall towards gravity, in it's natrual position flush with your torso.
   - Allow up to 15 seconds for the glove to calibrate.
2. **Initiate pairing from web app:**
   - Click **"Connect Gloves"**
   - The app will scan for available BLE devices
3. **Select your device:**
   - Identify your glove in the list: **"SignGoGlove"**
   - Click on your device name
4. **Complete pairing:**
   - Browser will request permission to connect, click **"Pair"**
   - Wait for connection confirmation (typically 5-10 seconds)
   - Web app will display: **"Device Connected Successfully"**

V. Features and Functions

Real-Time Gesture Recognition

- Continuous translation of sign language gestures into text and speech
- LSTM-based machine learning for accurate pattern recognition
- Recognition latency: <200ms
- Accuracy: 85-95% (up to 98% with adaptive learning)

Gesture History & Logging

- Chronological record of all recognized gestures

Confidence Meter

- Real-time accuracy indication (0-100%)
- Color-coded feedback (green/yellow/orange/red)
- Configurable minimum threshold

Bluetooth Connectivity

- BLE (Bluetooth Low Energy) wireless connection
- Range: Up to 10 meters
- Auto-reconnect capability
- Single-connection pairing for security

Sensors

- 5 flex sensors (one per finger)
- MPU6050 gyroscope + accelerometer (IMU)
- Real-time hand position and orientation tracking

Power

- 4-6 hours continuous use (standard mode)
- USB rechargeable battery

- 2-3 hour full charge time
- 48-hour standby time

Design
- Comfortable wearable glove
- Lightweight and ergonomic

VI. Troubleshooting & FAQ

Problem	Solutions
Device not appearing in pairing list	• Verify Bluetooth is enabled on your phone/ computer • Move closer to the device (within 1 meter during pairing) • Restart both glove and browser • Clear browser cache and refresh page
Browser doesn't support Bluetooth	• Switch to Google Chrome or Microsoft Edge • Update browser to latest version • Enable experimental web platform features (`chrome://flags`) • Use a different device if compatibility issues persist
Calibration fails or shows low quality	• Ensure glove fits • Check that flex sensors are properly aligned with fingers • Perform calibration in a stable position (standing, arm flush with torso) • Avoid excessive movement during calibration capture

VII. Support & Contact

If you need assistance with using SignLent , Please contact the appropriate team members for your issue.

General Support
- 66991026@kmitl.ac.th - Pradubfah Thanataweerat
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Software Support
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