Sign Language Interpreter Glove

Group 24

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Electrical Engineering
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leidos
Motivation

● The Survey of Income and Program Participation (SIPP) – estimates that about 1,000,000 are functionally deaf in the United States.

● The World Health Organization estimates that over 5% of the world’s population – 360 million people – has disabling hearing loss (328 million adults and 32 million children).

● The original motivation to pursue this project comes from one of our team members who has experienced the difficulty of communicating with his speech-impaired sister.
Goals and Objectives

- Our objective is to establish communication between a sign language speaker and a non-sign language speaker. Any letter the user signs will be displayed through a user interface where the non ASL-speaker can read the letter. We also want to implement a learning mode, where the user has the option to learn the American Sign Language letters.

**Hardware**
- Flex sensors
- Contact sensors
- Accelerometer
- Gyroscope
- MCU: ATMega328
- Bluetooth Low Energy

**Software**
- Android Mobile Application
Specifications

- Lightweight
- Portable
- Energy Efficient

Glove Weight < 1.5 lb.
Lithium Ion Battery 3.7 V 2000mAh
Battery Life 13 hours

Specifications Table
Related Standards

- IEEE Standards 802.15.1™-2005 (Revision of IEEE Std 802.15.1-2002)
  - Establishes a communication standard optimized to serve a variety of medical and non-medical applications.

- Safety standards for Lithium-ion batteries (International Electrotechnical Commission (IEC) and International Organization for Standardization (ISO)).
  - IEC 62133-2: safety requirement for portable battery cells
  - IEC 62660: batteries for EV/HEV applications
  - IEC 61427: secondary cells and batteries for renewable energy storage

- Google’s Android developers have set up a multitude of standards and qualification on the different aspects of an android application.
  - UX-B1: App uses common user interface patterns and conventional use of icons
## Significant Hardware Decisions - Wireless Communication

<table>
<thead>
<tr>
<th>Pros:</th>
<th>Pros:</th>
<th>Pros:</th>
</tr>
</thead>
</table>
| - Security (WPA2)  
- Range 150-300 feet | - Range 20-120 feet  
- Consumes less power than Wi-Fi | - Consumes less power than Bluetooth Low Energy |

<table>
<thead>
<tr>
<th>Cons:</th>
<th>Cons:</th>
<th>Cons:</th>
</tr>
</thead>
</table>
| - Needs Router  
- Consumes lots of Power  
- Not portable friendly | - No cons for SLIG 😊 | - Limited Range (about 0-4 inches) |
Significant Hardware Decisions - Battery & Regulators

- Polymer Lithium Ion Battery - 2000mAh
  - 3.7V at 2000mAh
  - Built-in protection against over voltage and over current
  - Self-discharge rate <8% per month

- Regulators - TI LP2985
  - The purpose of voltage regulators is to keep a constant voltage level
  - Dropout Voltage: 0.4 V
  - Output Voltage: 3.3 V
Significant Hardware Decisions - Charging

- **Charger input:**
  - Micro-USB
  - Charge current 500mA

- **Charger output:**
  - Single-Cell batteries Only
  - Lithium-Polymer or Lithium-Ion Only
  - Max Voltage: 4.2 V

**Top challenges were:**

- Learning how to solder small electronics
Significant Hardware Decisions – Flex Sensors

- Flex sensors will be the primary sensors employed in this project.
- Flex sensors will be used to detect the degree to which each finger is bent on the hand performing the sign language gesture.
- Each letter will have a specific configuration based on expected outputs of the five flex sensors.
**Significant Hardware Decisions – Flex Sensors**

<table>
<thead>
<tr>
<th>SpectraSymbol Long Flex Sensor</th>
<th>Images Two-Directional Bi-Flex Sensor</th>
<th>Tactilus Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pros:</strong></td>
<td><strong>Pros:</strong></td>
<td><strong>Pros:</strong></td>
</tr>
<tr>
<td>- widely available</td>
<td>- built in pressure sensors</td>
<td>- claims high durability (&gt;35 million cycles)</td>
</tr>
<tr>
<td>- accurate output</td>
<td></td>
<td>- high quality leads</td>
</tr>
<tr>
<td><strong>Cons:</strong></td>
<td><strong>Cons:</strong></td>
<td><strong>Cons:</strong></td>
</tr>
<tr>
<td>- fragile leads</td>
<td>- irregular shape</td>
<td>- increased cost</td>
</tr>
<tr>
<td></td>
<td>- sold exclusively by manufacturer</td>
<td>- sold exclusively by manufacturer</td>
</tr>
</tbody>
</table>
Significant Hardware Decisions – Gyroscope and Accelerometer

● Accelerometers and gyroscopes can be used to measure these type of parameters, which are crucial in identifying certain sign language letters.

● Examples include "j" and "z" or distinguishing between “g” and “q”.

● The group is using the SparkFun 9 Degrees of Freedom IMU Breakout - LSM9DS1.
Significant Hardware Decisions – Contact Sensors

- Contact sensors were crucial in telling apart the following pairs of sign language: R, U, and V, S and T and M and N.

- The contact sensors were made with strips of copper braids that were connected to the power supply through wire leads.

- The glove detects when two contact sensors come in contact creating a closed circuit.
Significant Hardware Decisions – PCB

- The PCB was designed using Eagle CAD software and fabricated by Bay Area Circuits and most parts were sourced from Digikey.com
- It was designed as two layer board measuring 2.5” by 3.5” and is meant to be worn on the forearm.
- Designing and building the PCB board was the biggest challenge with the hardware.
- Top challenges were:
  - Learning Eagle CAD
  - Correctly Wiring Components
  - Ordering the write components
Significant Hardware Decisions – PCB
Significant Hardware Decisions – Microcontroller

- The unit that is chosen will have to employ at least 6 analog input pins (with included ADC units), have digital i/o pins, and also be able to establish a line of serial communication.

- When considering the microcontroller unit, it is also important to note that the two units come with their own native programming environments.

<table>
<thead>
<tr>
<th>Feature</th>
<th>MSP430</th>
<th>ATMega32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input Pins</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Digital Input Pins</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>Random Access Memory</td>
<td>512 Bytes</td>
<td>2.5 Kilobytes</td>
</tr>
<tr>
<td>Data Bus</td>
<td>16 bits</td>
<td>8 bits</td>
</tr>
<tr>
<td>Speed</td>
<td>16 MHz</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Cost/Vendor</td>
<td>$9.99 → mouser.com</td>
<td>$24.95 → ebay.com</td>
</tr>
</tbody>
</table>

Table 3.2: MSP430 vs. ATMega32 comparison
The gesture recognition system will use thresholds to determine what hand gesture is being performed.

The ranges of values that are included in every type of hand gesture determine the minimum and maximum limits to the conditional statements.
Calibration Process

- The calibration process occurs during the ‘setup’ process of the program, before the infinite loop begins.
- Calibration will capture the minimum and maximum input values from each sensor, and apply the mapping function.
- Calibration is needed because analog flex sensors provide volatile data that needs to be normalized.
Gesture Recognition Software

- Program scans sensors for data at one second intervals
- Arduino “map” function is used to apply calibration
- Normalized sensor values and motion data are used in conditional statements that determine gesture being performed
Gesture Recognition Set-Backs

- Contact sensors needed to have internal pull-up resistors enabled due to floating i/o pins.
- Had to use SPI as opposed to I2C for the motion unit due to a lack of enough analog input pins.
- Many distinct gestures unexpectedly produced similar flex sensor data and required methods of distinction.
Software Components: Mobile Application
Mobile Application: Overview

- The mobile application is an important feature of this project that will serve as the user interface for the sign language glove.

- The mobile application is responsible for wirelessly displaying hand gestures performed by the glove onto a mobile phone screen as text.

- In order for the mobile application to be successful, the design of the app should consider the user, be simple and elegant, and meet all design requirements.
Potential Mobile Platforms

- **Android**
  - Programming language: Java
  - IDE: Android Studio
  - Open source and cross-platform compatible
  - BLE compatible
  - Everyone in our group owns one!

- **iOS**
  - Programming languages: Swift or Objective-C
  - IDE: Xcode
  - Only Mac OS compatible
  - BLE compatible

- **Windows**
  - Programming Languages: C++, C#, and Visual Basic
  - IDE: Visual Studio
  - BLE compatible
### Minimum Requirements

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Device Type</strong></td>
<td>Android</td>
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<tr>
<td><strong>Mobile Platform</strong></td>
<td>Smartphone</td>
</tr>
<tr>
<td><strong>Bluetooth Version</strong></td>
<td>Bluetooth Low Energy v4.0</td>
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<tr>
<td><strong>Platform Version</strong></td>
<td>Android 4.3</td>
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<tr>
<td><strong>Codename</strong></td>
<td>Jelly Bean-MR2</td>
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<td><strong>Android API Level</strong></td>
<td>18</td>
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</table>
Mobile App Flowchart

1. Run Application
   - Compatible? (Yes/No)
     - Yes: Bluetooth Setup
       - Connection Successful? (Yes/No)
         - Yes: Return to Main Screen
         - No: Fix Connection
     - No: Display Error Message
       - Close Application
   - No: Display Error Message
     - Close Application
User Interface

Perform the gesture shown below to move onto the next one.
User Interface

BLE Device Scan

SLIG
00:15:83:00:6B:1A
Unknown device
00:03:4B:23:44:F9
Unknown device
7F:41:69:0D:60:4A

SLIG
Device Address: 00:15:83:00:6B:1A
State: Connected
Data: A
41
## Budget And Financing

- **Sponsored by:** Boeing and Leidos
- **Initial Budget Estimate:** $550
- **Final Project Cost:** $825

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Price per Unit ($)</th>
<th>Quantity</th>
<th>Cost ($)</th>
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<tbody>
<tr>
<td>Flex sensors 4.5&quot;</td>
<td>$12.95</td>
<td>15</td>
<td>$194.25</td>
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<td>Flex sensors 2.2&quot;</td>
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<td>ATmega328P</td>
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<td>Bluetooth Module</td>
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