Sign Language Glove Teaching Device

Project Proposal

Reebbhaa Mehta – Daniel Fong – Mayapati Tiwari

TA: Igor Fedorov

ECE 445 – Senior Design

February 6, 2013

Table of Contents

1.0. Introduction

1.1. Statement of Purpose

This project was chosen because presently the gloves that are used for sign language are the ones that convert sign language gestures into vocalized speech, however there are no gloves available that can help a person to learn sign language on their own. The goal of this project is to create a glove device that detects sign language gestures for letters used in American Sign Language, and inputs them into a computer, where a computer program checks the gesture. If the character is wrong the program will indicate, with the help of LED's and haptic feedback as to what was wrong with the gesture. It can be a good learning tool for sign language and the idea can be built on in the future. Our focus is to make the device easy to handle, and user friendly.

1.2. Objectives

1.2.1. Goals

- Build a glove device to detect sign language.
- Develop a database of the gestures of sign language alphabets for the computer program to use as reference while checking input gestures.
- Develop a computer program that checks the input gestures.
- Develop a haptic feedback circuit to make the user aware of any mistake
- Bluetooth communication between computer and glove device.

1.2.2. Functions

- Flex Sensors, accelerometers and gyroscopes to detect sign language gestures.
- Bluetooth communication between device and computer.
- DSP program checks each gesture.
- Haptic feedback and LED's to help the user correct any errors.
- Glove device powered by batteries to avoid any risk of shocking users.

1.2.3. Benefits

- Haptic feedback and LED alerts help to correct any errors with gestures.
- Convenient to use as the device is wirelessly connected to the computer.
- Help users to become more adept with sign language.

1.2.4. Features

- Tri-axis accelerometer and Tri-axis gyroscope in one glove.
- Bluetooth transmission between computer and glove.
- Haptic feedback and LED response for error correction.
- One-directional flex sensors on each finger for reference.
- Mathematical Kalman filtering

2.0. Design

2.1. Block Diagrams

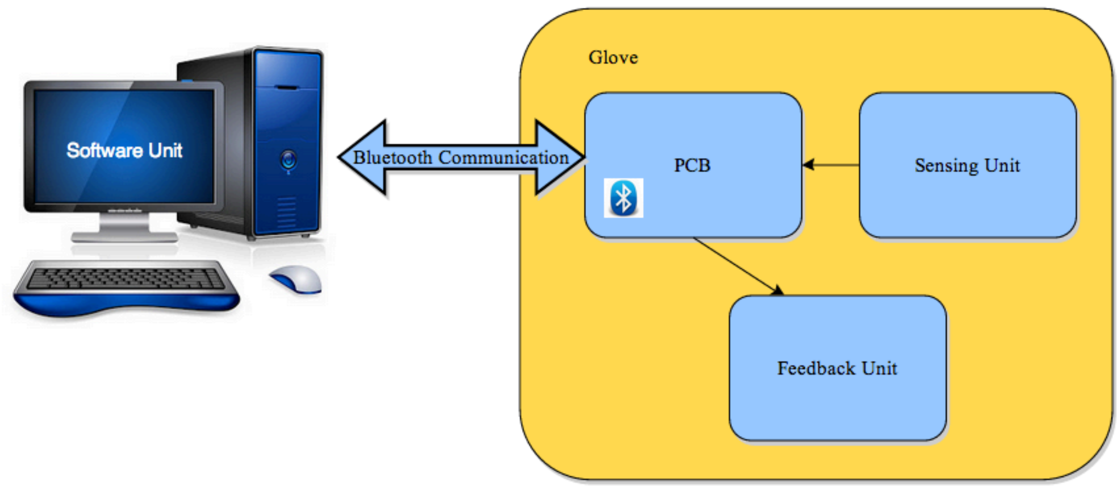

Figure 1: Top Level Block Diagram

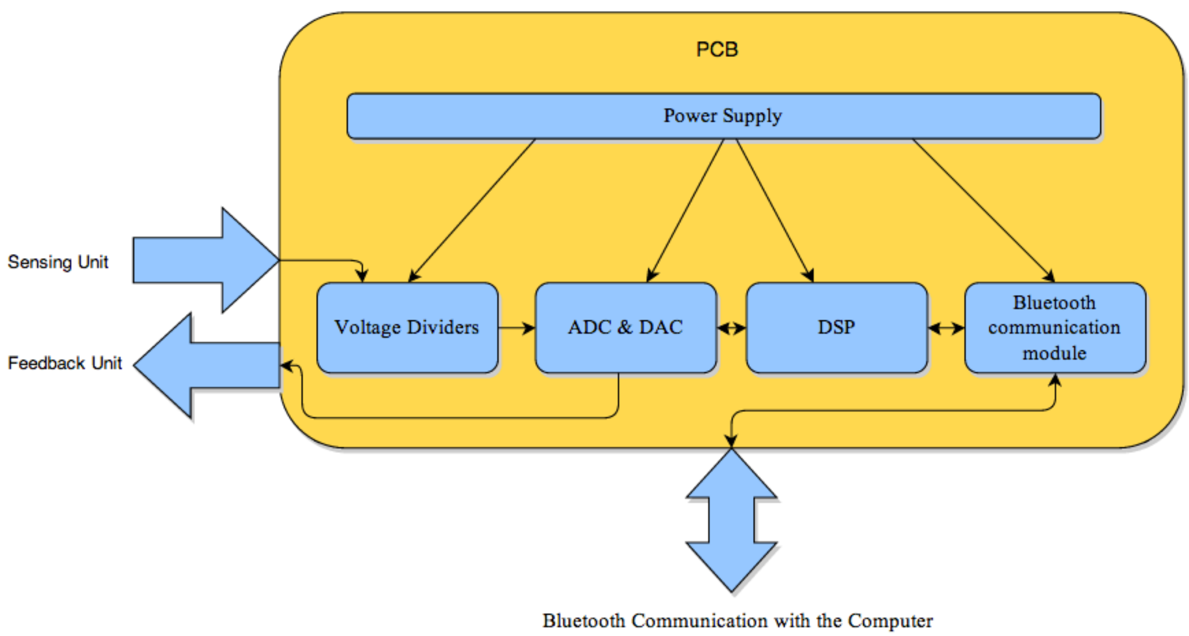

Figure 2: PCB Block Diagram

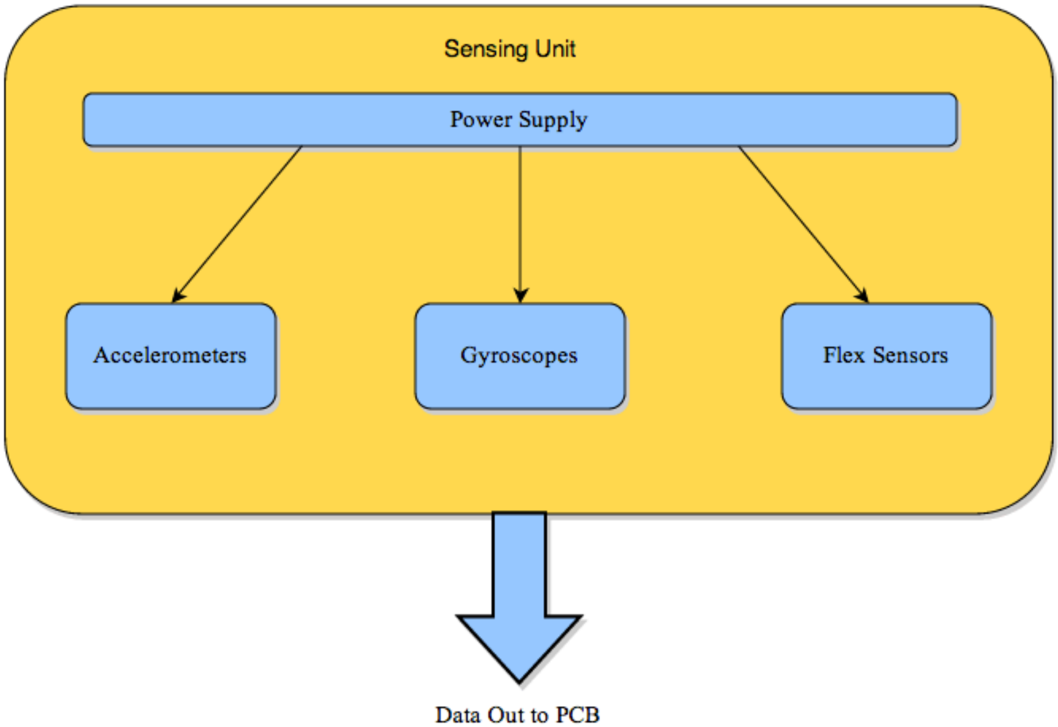

Figure 3: Sensing Unit Block Diagram

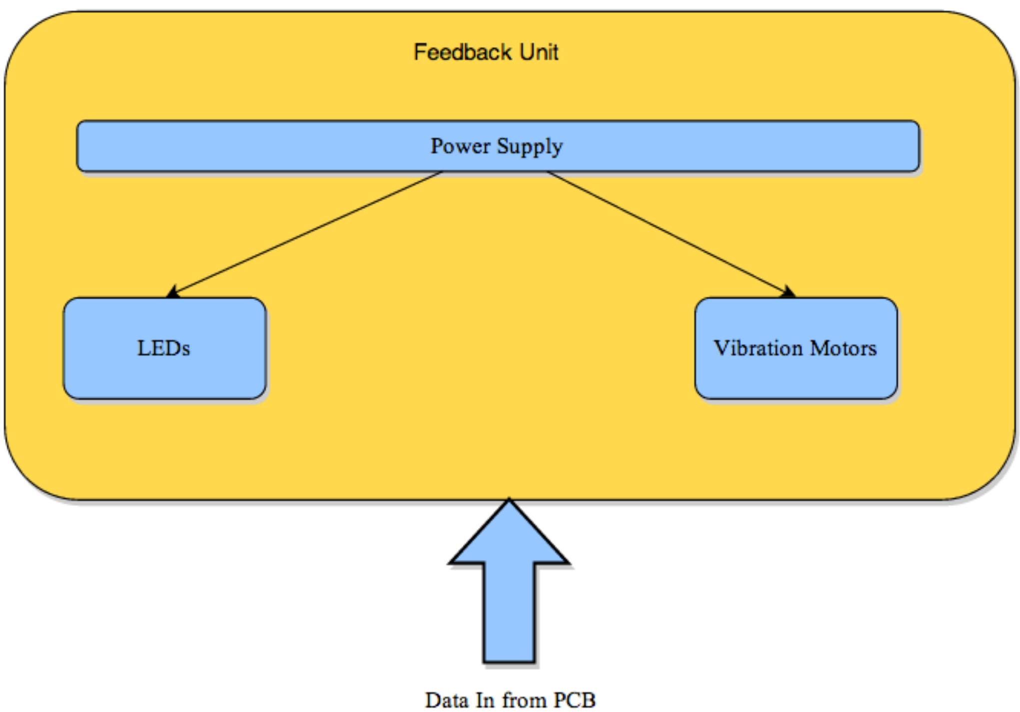

Figure 4: Feedback Unit Block Diagram

2.2. Block Diagram Description

2.2.1. Top Level Block Diagram

The glove device consists of a PCB, sensing unit and a feedback unit. The sensing unit detects the position of the hand and fingers and sends the data to the PCB where it is processed and sent to a computer via Bluetooth. After the data is checked, the PCB unit alerts the feedback unit to act and alert the user of any wrong movement or position, which may have occurred during the gesture. A detailed summary of each block and its components is given below.

2.2.2. PCB

Overall Summary:

The PCB consists of the power supply, Bluetooth module, Microcontroller DSP Chip and the Voltage Divider circuit placed upon the PCB board. The power supply powers all the other units with the appropriate voltages. The Microcontroller DSP will compare the data gathered from the sensors with the data from the computer and sends out the feedback signals. The Bluetooth Chip provides the communication between the Microcontroller DSP and the computer.

The computer software's purpose is to allow users to become adept at signing quickly by signing the necessary letters. For every letter they sign, the users data is recorded.

Power Supply:

The power supply will be 3 AA batteries of 1.5V connected in series for 4.5 V. A low-dropout regulator will step down the voltage to 3V to power the microcontroller, gyroscopes, flex sensors, accelerometers, LEDs, vibration motors. A low-dropout regulator will step down the voltage to 1.8V to power the Bluetooth module. The power supply will connect to all the other components through the PCB board and wires.

Bluetooth:

The Bluetooth transmitter and receiver will be Texas Instrument CC2560. It was chosen due to low cost, low power and specifications. The Bluetooth transmitter will receive the location and movement specifications of each sign language action through Bluetooth and transfer through the PCB to the microcontroller. It will also receive the calculation data from the microcontroller through the PCB and transfer the sensor and computational data to the computer through Bluetooth for Matlab debugging.

Microcontroller DSP:

The Microcontroller will collect the information from the accelerometers, gyroscopes, and the flex sensors/ voltage divider after the outputs from the sensing unit have gone through the Analog to Digital converter chip, and it will be programmed to implement a Kalman Filter to estimate the movements and locations of the fingers and that of the glove. Then, it will compare the result with the data sent from the computer from Bluetooth and outputs a signal, which is sent to the fingers of the glove that performed the gestures incorrectly after being converted to analog data by the DAC.

ADC & DAC:

The analog to digital and digital to analog converter is required to convert the analog data from the sensing unit to digital so that our microcontroller can process it. Similarly for the feedback mechanism, we require digital to analog data conversion drive our feedback unit.

Voltage Divider:

The voltage divider will divide the voltage using one high resistance resistor and the flex sensor acting as a variable resistor. As the flex sensor bends, the resistance will increase and the output voltage increases. The output voltage will connect with analog to digital converter in the microcontroller DSP, and it will provide a gauge for how much the fingers are bent in the glove.

2.2.3. Sensing Unit

Overall Summary:

The sensing unit consists of six gyroscopes; six flex sensors and three accelerometers to detect the position of the hand and each finger for a particular gesture. The data from the sensing components goes to the microcontroller.

Tri-axis Accelerometers:

Accelerometers will be used for tilt sensing. Along with gyroscopes, accelerometers will help us to know the orientation of the glove and help us to differentiate hand gestures.

Tri-axis Gyroscopes:

Gyroscopes will detect the angular velocity in three axis which will help us in calculating the angle of the glove in each direction which will help us to know the orientation of the glove. Different hand gestures can be differentiated this way.

Flex Sensors:

One directional flex sensors are needed to detect how much each finger is bent in order to check that each hand gesture is within the given tolerance level.

2.2.4. Feedback Unit:

Overall Summary:

The feedback unit consists of haptic feedback, using five vibration motors, and five LEDs, placed on each fingertip. The feedback unit is used to alert the user what is incorrect with the position of the fingers for a particular gesture. If for a gesture one finger is in an incorrect position then the vibration motor for that finger will vibrate and the LED will flash red to inform the user of the wrong positioning of the finger.

Vibration Motors:

Vibration motors are used at the fingertips to alert the user when a hand gesture is incorrect by vibrating only for the fingers that are incorrectly placed.

LEDs:

LEDs are used with vibration motors to show more accurately which finger is in an incorrect position for a particular gesture. If a finger is in an incorrect position the LED will be red, else it will be green.

2.3. Performance Requirements

1. Should be able to detect all alphabets in American Sign Language.
2. Glove device and computer must able to communicate at least at least to a distance of 10m.
3. Should record data only when the wrist is at or above chest height.
4. Feedback response time should be under 2 seconds.

3.0 Verification

3.1. Testing Procedures

1. One-dimensional flex sensors:
   Accuracy of location determination from flex sensors can be tested by flexing fingers at small intervals, if there is an increase in the resistance of the sensors from a nominal 10k ohms, then it works well.

2. Accelerometers and gyroscopes:
   Accelerometers and gyroscopes can be checked by simple movements and plotting them on Oscilloscopes. When accelerometer is moved up/down a plus/minus gravity change occurs around 0V. Gyroscope is zero when there is no movement. It can be calibrated to perform when not stationary.

3. Bluetooth communication:
   The communication network between the glove and computer can be checked by programming the microcontroller to send a particular data to the computer and then cross examining the data received with the data sent to make sure it is the same.

4. LEDs and Vibration motors:
   Once everything else is working, then we can check if the right LEDs and vibration motors go on when an incorrect gesture is made for a particular gesture.

5. Kalman Filter:
   The output of the circuit will be approximated using the Kalman Filter, which will be compared to the output of the circuit without Kalman Filter to see the difference in outputs. The output of the circuit with Kalman Filter should be a lot more stable.

3.2. Tolerance Analysis

The sensing unit is the most important feature of the project. The design project is heavily dependent on the data it receives from the sensing unit (accelerometers, gyroscopes and flex sensors), thus, to detect gestures properly it is very important that the sensing unit works efficiently to provide accurate data to know the hand position in space as accurately as possible.

4.0. Safety Analysis

Safety is one of the highest priorities for the glove device. The device should be carefully made to not expose the user to any current from the circuit.

During the development process safety precautions must be taken while soldering and using the hot glue gun.

5.0. Cost Analysis and Schedule

5.1. Cost Analysis

5.1.1. Labor

Name	Hourly Rate	Time Invested (Hours)	Total = Hourly Rate x 2.5 x Time invested
Reebbhaa Mehta	$35.00	180	$15,750
Daniel Fong	$35.00	180	$15,750
Mayapati Tiwari	$35.00	180	$15,750
Total		540	**$47,250**

5.1.2. Parts

Item	Quantity	Cost ($)
Glove	1	5.00
Flex Sensors (FLX-03)	5	50.00
Accelerometers (ADXL335)	3	45.00
Gyroscopes (L3G4200D)	6	120.00
Vibrating Motors (Pico Vibe 308-100)	5	33.00
LEDs	5	2.00
Microcontroller (TMS320C6701-150)	1	37.00
Analog to Digital Converter (LMP92001)	2	14.00
Bluetooth (CC2560)	1	15.00
Battery	1	5.00
Resistors, Capacitors, Inductors		20.00
PCB	1	30.00
Total		**376.00**

5.1.3. Grand Total

Section	Total
Labor	$47,250
Parts	$376
Grand Total	**$47,626**

5.2. Schedule

Week	Task	Responsibility
2/4	Proposal	Mayapati
	Design Sensor Unit Circuit	Mayapati
	Prepare Mock Design Review	Daniel
	Design PCB	Reebbhaa
	Order Parts	Reebbhaa
2/11	Assemble Inventory	Mayapati
	Work on DSP software	Daniel
	Create the computer software	Reebbhaa
2/18	Prepare Design Review	Mayapati
	Configure gyroscopes and accelerometers	Daniel
	Test Sensor Unit Circuit	Daniel
	Solder PCB	Reebbhaa
2/25	Enable Bluetooth communication	Daniel
	Implement Kalman Filter on DSP	Reebbhaa
	Create ASL database	Mayapati
3/4	Test Kalman Filter	Reebbhaa
	Connect PCB to Sensor Unit	Daniel
	Test glove without feedback	Mayapati
3/11	Debug glove without feedback Unit	Reebbhaa
	Assemble Feedback Mechanism	Mayapati
	Implement real time control loop	Daniel
3/25	Prepare Mock-up Presentation	Mayapati
	Test & debug Feedback Mechanism	Reebbhaa
4/1	Tolerance Analysis	Reebbhaa
	Test entire device	Daniel
	Verification of Specifications	Mayapati
4/8	Testing and Debugging	Mayapati
4/15	Complete Project	Daniel
4/22	Prepare Demo	Daniel
	Prepare Presentation	Reebbhaa
	Prepare Final Paper	Mayapati
4/29	Demo	Daniel
	Presentation	Reebbhaa
	Final Paper	Mayapati
	Check Supplies	Daniel