

*Initial Project and Group Identification Document  
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# Sense Glove

*Now you really do have the power in your hands!*



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*Senior Design I*

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## INTRODUCTION:

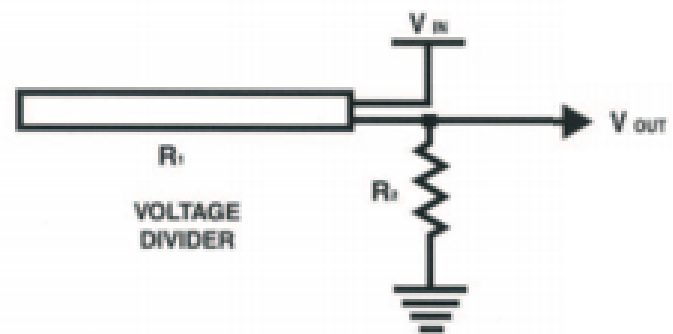
The sense glove is a lightweight, thin, Bluetooth-enabled glove that allows the user to translate the American Sign Language (ASL) sign of the letters of the alphabet to an external display. This glove is equipped with a series of flex sensors, an accelerometer, an embedded processor on a printed circuit board and Bluetooth technology that combine to give the user the ability to accurately communicate to any individual who doesn't understand sign language. 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. This project got us thinking along the lines of wearable technology and opened the door for our extensive research in the area.

Our objective is to establish communication between a sign language speaker and a non sign language speaker. Through the use of flex sensors and an accelerometer, any letter the user signs will be displayed through a user interface where the non ASL-speaker can read the letter.

## DESIGN SPECIFICATIONS:

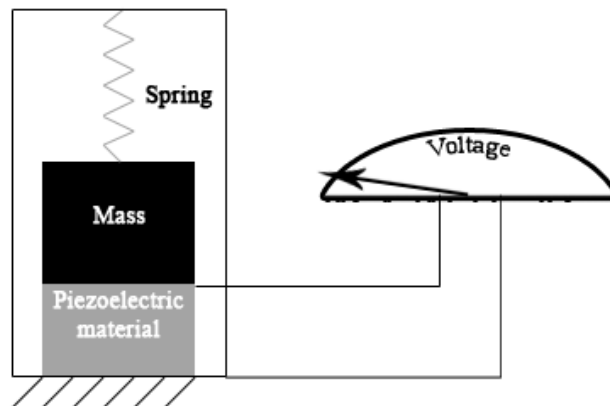
### A: Flex Sensors

The sense glove employs many forms of technology which are used to capture data from the dynamic states of the user's hand and provide the processor with a numerical representation of the data. The most prevalent type of technology present in the glove is the flex sensors. A flex sensor is a variable resistor whose resistance varies with the amount of bend present on the sensor. There is a direct relationship between the amount of bend present on the flex sensor, and the impedance across its resistive material. The way that these variable resistors can be used as sensors to report the amount of bending is by creating a voltage-divider circuit (two resistors in series). One resistor,  $R_1$  has a constant resistance, while the other resistor  $R_2$  is the actual flex sensor which experiences a varying degree of resistance. The circuit is equipped with a constant, low-amplitude voltage source  $V_i$  which is to be divided between the two resistors. The voltage drop across the flex sensor's variable resistor is clearly varying with the changing resistance of  $R_2$  due to Ohm's Law. The voltage across the constant resistor is the output, measured at the flex sensor's analog output pin. At this point, the output voltage from the flex sensor needs to be converted into a digital signal so that it can be fed to the processor through one of its input/output pins. The basic working circuit of a flex sensor is shown on the right. In practice, most flex sensors also have an impedance buffer in series with the voltage divider made with an operational-amplifier which is there to help reduce error. For the purposes of describing the flex sensors' functionality, that part of the circuit has been omitted.



## B: Accelerometer

Though flex sensors are a great way to capture many useful pieces of information from the physical state of the user's hand, they are limited in the range of motions that they are capable of sensing. The flex sensors can only detect how much bending they are experiencing, as described above. This makes the flex sensors very useful but they neglect motions that do not include the bending of fingers like tilting the hand back and forth at different angles. To capture this range of motions that are left out by the flex sensors, the sense glove employs an accelerometer. At its core, an accelerometer is a device that can measure acceleration and deceleration. The internal workings of an accelerometer are a lot more complex than that of a flex sensor. There is a multitude of methods used in industry to determine acceleration and build an accelerometer. One popular method is the use of the piezoelectric accelerometer. The piezoelectric accelerometer is an accelerometer that takes advantage of the phenomenon known as piezoelectricity. Piezoelectricity is created whenever a piezoelectric material is physically stressed. The word piezoelectricity literally translates to "electricity resulting from pressure" [Wikipedia]. Certain special materials behave in such a manner, that whenever they experience stress or pressure, an electrical charge is accumulated inside the material which is directly proportional to the stress that the material experienced. These materials are so sensitive that they are able to very accurately sense the gravitational pull of the Earth. As the piezoelectric material is pushed or stressed, a proportional electrical charge is created inside the material. The piezoelectric accelerometer takes advantage of this phenomenon by surrounding a mass by a piezoelectric material. As the accelerometer is moved to different orientations, the mass is slightly moved due to gravity and "stresses" or "pushes" the piezoelectric material around it, creating a proportional electric charge, which is then captured by the signal leads which go out into the processor. Below is a low-detail image which illustrates the working principle of the piezoelectric accelerometer.



## C: Bluetooth Communication

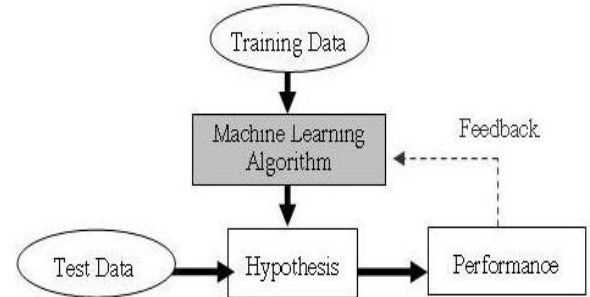
The sense glove, with the help of the flex sensors and accelerometer described above, has the capability of sensing the position of the user's hand and sending accurate information to the processor. After the processing of the data has been done and a decision has been made on what to do (which output pin to activate) the glove needs to communicate this information to the user interface. There are a number of methods that can be used to communicate this information.

The most natural method of communication for this application would simply be a hard-wired connection between the printed circuit board and the device. However, this presents many challenges and inconveniences such as length and the tangling of wires. To remediate this, we have decided to incorporate the use of Bluetooth communication in our design. Bluetooth is a standard for the short-range wireless connection of electronic devices. Bluetooth enables devices to connect with each other wirelessly to transmit data via radio waves. Bluetooth operates exclusively between the frequencies of 2.402-2.480 GHz. This range of frequencies is split into 79 individual channels, each with a bandwidth of 1MHz. [<http://www.bluetooth.com/Pages/Fast-Facts.aspx>] These 79 channels are used to send and receive information between devices, which happens at a rate of 720 kilobytes per second. Bluetooth communication uses what is known as “frequency-hopping”, which is the constant switching of channels by paired devices. This frequency-hopping occurs at a rate of 1600 hops per second, and is done for security reasons and to ensure that the communication will not experience interference from other devices sending signals on those frequencies. A big limitation of Bluetooth is its relatively short distance of coverage. Given that Bluetooth is sending radio waves, increasing the power of the carrier signal will significantly increase the range of Bluetooth-connected devices. However, this is not possible for Bluetooth because the frequency band that Bluetooth operates in (2.402-2.480 GHz) is known as the industrial, scientific and medical (ISM) band. This frequency band is used in specialized medical and scientific equipment. Bluetooth is safe because the low power of the signals limits the reach of the signal, making it highly unlikely to interfere with medical equipment.

#### **D: Microprocessor and Software**

Naturally, all of the data collected from the hardware in this design will be processed through the use of an embedded processor. This processor needs to be programmed so that it can recognize different information from the hardware and make appropriate decisions. It would be difficult and ineffective to program the processor with specified, exact arguments. This is due to the fact that people’s hands all come in different shapes and sizes. In addition, a single person can move their finger or hand in a slightly different motion when attempting to perform the same gesture. For these reasons, there needs to be another way of “training” the processor to know what range of inputs from the hardware (hand motions) can be considered to be one single command. This leads us into the research of “machine learning”. Machine learning is a subfield of computer science that explores the study and construction of algorithms that can learn from and make predictions on data [Wikipedia]. Our research into the Machine Learning area is currently premature, but the idea is to ultimately have an algorithm that can “train” a system by going through a series of similar, non-identical inputs from the hardware and attempt to make the correct decision consistently. Through the use of machine learning algorithms, a programmer can “train” a processor by employing different types of “learning styles”. For the purposes of the sense glove, the most intuitive learning style would be “supervised learning”. Supervised learning is when the system is trained in a manner in which it is asked to make decisions based on certain inputs and it is corrected immediately when the decision is wrong. This can be done by having different people wear the glove and perform each gesture multiple times. After enough iterations of a gesture have been performed (hundreds, or thousands) during “training”, the processor will have a big enough pool of data that it can make correct decisions at a near-

perfect rate, despite variances in the inputs. To the right is a low-detail flowchart that shows the basic principle behind using a machine learning algorithm. This is used to train and correct a system that needs to analyze imperfect data and still make correct decisions.



### Project Constraints:

There will be some limitations and constraints that we need to be ready for if we want to make the glove lightweight, portable and energy efficient. There is so much data that we can collect out of the sensors, but making sure that the software and the machine both understand the data we are sending to them will be our greatest challenge. Anyone that uses the glove will do the gestures slightly differently, even if it's the same person. This means that the machine and the software both need to be dynamic enough to be able to make the correct command.

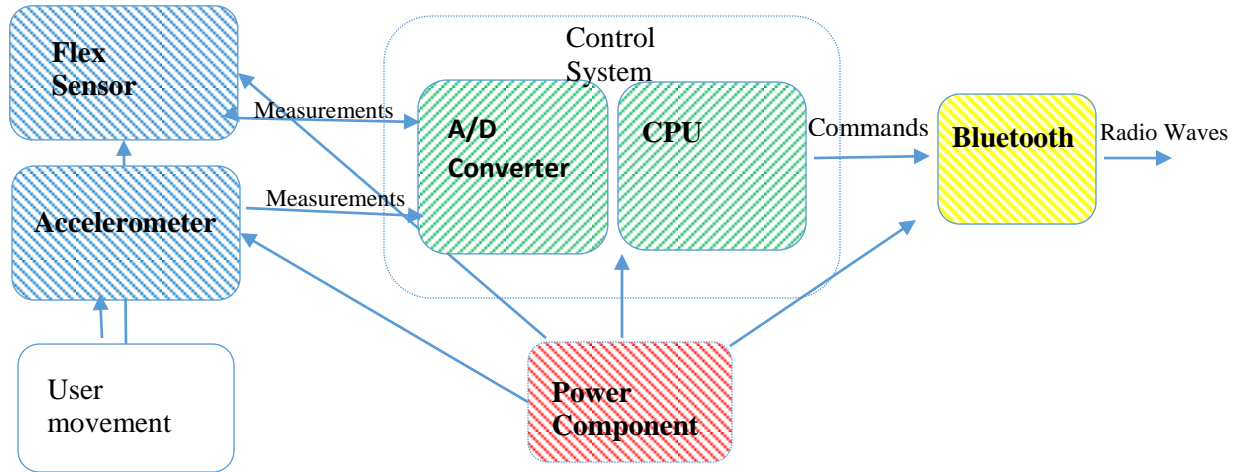
In order to accomplish this “smart” glove, we need to take into consideration how many parts we will need. We anticipate to use at least five flex sensors (one for each finger), one accelerometer since is just one glove, one microcontroller and one li-ion battery. Since the glove should be energy efficient, we want the user to just have to charge it for two hours for every 24 hours of normal usage.

### Specifications:

- Color – Black
- Wearing Style - Right handed glove
- Dimensions - 151mm x 196mm x 33mm
- Glove Weight - 1.8 lb
- Connectivity - Bluetooth 4.1 (50 Ω antenna connector)
  - Wireless Transmission Range: 100 feet
  - Operating Temperature: -40 degrees Celsius ~ +85 degree Celsius
  - Operating Frequency Band: 2.4GHz ~ 2.48GHz
  - Operating Voltage: +3.3 V and +5.0 V
  - Microcontroller – Arduino (Dimensions: 6.8cm (L) x 5.3cm (B) x 2.3cm (H) / Weight: 24 grams)
- Battery Type: Lithium-ion
- Device Battery Life: 12 hours
- Flex Sensor
  - Flat Resistance: 25K Ohms
  - Resistance Tolerance: +/- 30%
  - Bend Resistance Range: 45K to 125K Ohms
  - Power Rating: 0.5 Watts continuous. 1Watt Peak

## Block Diagrams:

### Hardware



### Software




### Legend

Christopher

Emmanuel

Ramon

Jason

 To be acquired

Flex Sensor- Measures the degree to which a person's fingers are flexed and relates this measurements as a varying voltage.

Accelerometer- Measures other motions such as the tilting of the hand.

Power Component- Supplies energy to other components.

A/D converter and CPU- will process the data and interpret it as commands, letters, etc.

Bluetooth- Communicate decisions wirelessly to the application

Sensor Interface- Gather data from the sensors

Data Interpretation- Create decisions from data collected

User Interface- Format data to be transmitted to the application

## Project Budget:

The proposed budget for the sense glove takes into consideration all of the parts required to make the product as well as extra/replacement parts along the way. The prices listed are estimates from online research and will be updated in the future once the final product is built. As of now, there is no sponsor for the sense glove and all of the costs will be distributed among the group members.

Part Description	Price (\$)	Quantity	Cost (\$)
Power source	10	1	10
Microcontroller	25	1	25
Flex sensors	13	5	65
Accelerometer	30	1	30
Glove	20	1	20
Bluetooth adaptors	13	1	13
Feedback LEDs	0.2	5	1
Miscellaneous parts	30	?	30
Total Cost			194

**Project Milestones:**

Number	Task	Start	End	Duration (weeks)	Responsible
<b>Senior Design I</b>					
1	<b>Brainstorming</b>	9/1/2015	9/8/2015	1	The Team
2	<b>Project Selection &amp; Role Assignments</b>	9/8/2015	9/15/2015	1	The Team
	<b>Project Report</b>				
3	Initial Document - Divide & Conquer	9/8/2015	9/15/2015	1	The Team
4	First Draft	9/15/2015	11/3/2015	7	The Team
5	Final Document	11/3/2015	12/8/2015	5	The Team
	<b>Research &amp; Documentation</b>				
6	Bluetooth	9/15/2015	10/5/2015	3	Ramon
7	Flex Sensors	9/15/2015	10/5/2015	3	Chris
8	Accelerometers	9/15/2015	10/5/2015	3	Chris
9	Software	9/15/2015	10/5/2015	3	Jason
10	Power Source	9/15/2015	10/5/2015	3	Jason
11	Microcontroller	9/15/2015	10/5/2015	3	Emanuel
	<b>Design</b>				
12	Bluetooth	10/6/2015	11/3/2015	4	Ramon
13	Flex Sensors	10/6/2015	11/3/2015	4	Chris
14	Accelerometers	10/6/2015	11/3/2015	4	Chris
15	Software	10/6/2015	11/3/2015	4	Jason
16	Power Source	10/6/2015	11/3/2015	4	Jason
17	Microcontroller	10/6/2015	11/3/2015	4	Emanuel
18	<b>Order &amp; Test Parts</b>	11/3/2015	12/8/2015	5	The Team
<b>Senior Design II</b>					
19	<b>Build Prototype</b>	1/11/2016	3/1/2015	7	The Team
20	<b>Testing &amp; Redesign</b>	3/1/2015	3/29/2015	4	The Team
21	<b>Finalize Prototype</b>	3/29/2015	4/15/2015	2	The Team
22	<b>Peer Presentation</b>	TBA	TBA		The Team
23	<b>Final Report</b>	TBA	TBA		The Team
24	<b>Final Presentation</b>	TBA	TBA		The Team



## Application Decision:

We chose the sign language application for our sense glove after narrowing our options to the ones below and weighing pros and cons. The first as mentioned can recognize the signs for the letters of the alphabet and display them on some sort of interface, the second will control the motion of a RC car and the third will allow the user to send pre-determined text messages by using certain hand movements. Below is a matrix we used to weigh the pros and cons for each possible application for our motion-sensing glove.

<b>Application Matrix</b>	<b>Sign Language</b>	<b>RC Car Control</b>	<b>Silent Messenger</b>
<b>Cost</b>	Minimal Cost	Increased cost since it would require purchase of an RC car	Minimal Cost
<b>Sponsorship</b>	Easier to obtain with this type of application.	More difficult for a leisurely application.	More difficult for a leisurely application.
<b>Familiarity</b>	Elementary understanding of technology but no experience using it	Same technology	Same technology
<b>Educational Goals</b>	Can learn considerably with diverse technologies	Same technology	Same technology
<b>Motivation</b>	Interesting and challenging	Amusing but not as useful/rewarding	Less interest
<b>Creativity</b>	Similar projects have been attempted before.	Similar projects have been attempted before.	Fewer attempts to creating similar project
<b>Reliability</b>	Standard reliability	Extra components mean more room for error	Standard reliability

## Citation List:

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