S.I.O.
Hand Stabilization
PROJECT PROPOSAL

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Introduction

Abstract

S.I.O. is focused on helping victims of essential tremor (ET) and Parkinson's disease. ET and Parkinson's both affect motor skills through uncontrollable shaking, or "tremors," making everyday tasks much more difficult. The goal of S.I.O. is to develop a device which will counteract the tremors, minimizing the shaking, to allow the individuals to perform the everyday tasks they once enjoyed.

Project Description

The goal of our project is to help alleviate the symptoms of both Parkinson's disease as well as Essential Tremor to such a degree that those who suffer from these diseases can perform fine motor tasks. More specifically, our design will aid those who suffer from Parkinson's and ET to perform routine tasks on a computer, namely via a mouse. If possible we would like for it to allow the person to perform other tasks as well. In order to accomplish this goal we have come up with two alternative designs, which if time allows could be combined into a single more effective design. These two designs attempt to address two separate aspects of the tremors that make it difficult for Parkinson's and ET patients to utilize their fine motor controls. The first design will attempt to stabilize the person's hands by using a gyroscope on top of the hand. The second design will address the finger stabilization by restricting the freedom of the fingers. Both designs will utilize a 3D printed glove (**Figure 1**).

Figure 1 3D printed glove based on GloveOne design

The first design utilizes a gyroscope that is placed on the back of the user's hand. A gyroscope (**figure 2a**) is a disk shaped object that has a mass as far away from the center as possible to maximize the force provided. This is because torque is given as T = r x m*a, with torque increasing proportional to the radius as well as mass. When the gyroscope is spun on its axis at high speeds, it resists movements in certain directions due to conservation of momentum.

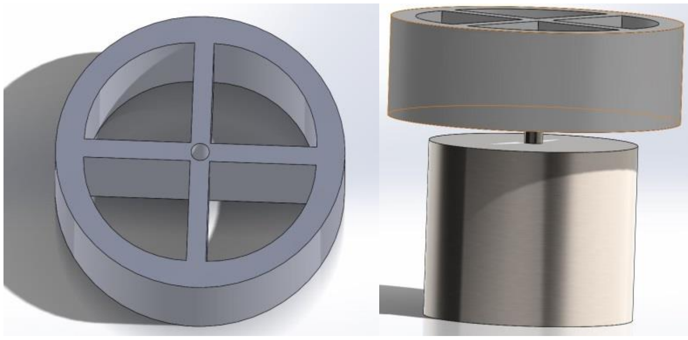


Figure 2 **a)** Gyroscope **b)** with DC motor

While spinning, it contains large amounts of stored energy. If it is moved, the gyroscope will try to compensate for the movement. Using the weight and the speed of the rotating gyro, the angular momentum will cause the hand to stabilize. A DC motor (**Figure 2b**) will power the gyro and cause it to spin once a voice command is given. The DC motor will be attached to the glove.

The second design is to utilize servo motors to pull and restrain the fingers. The entire hand will be covered with a 3D printed frame based off the design of the GloveOne. The frame will be altered to allow for cables to run along the fingers. The restraint system will utilize both cables and springs. The cables will run on top of the fingers and will be attached to springs that sit on the back of the hand. Those springs will then be attached to another set of cables that will feed into the servomotors (**Figure 3**). The springs will allow for some degree of freedom even when the cables are tightened so that small movements like the tremors are negated, but larger movements like those necessary to click a mouse button are not. Five servo motors, one for each finger, will be used to pull and tighten the cables, restraining the hand and reducing the shakes. The servomotors will be placed along the

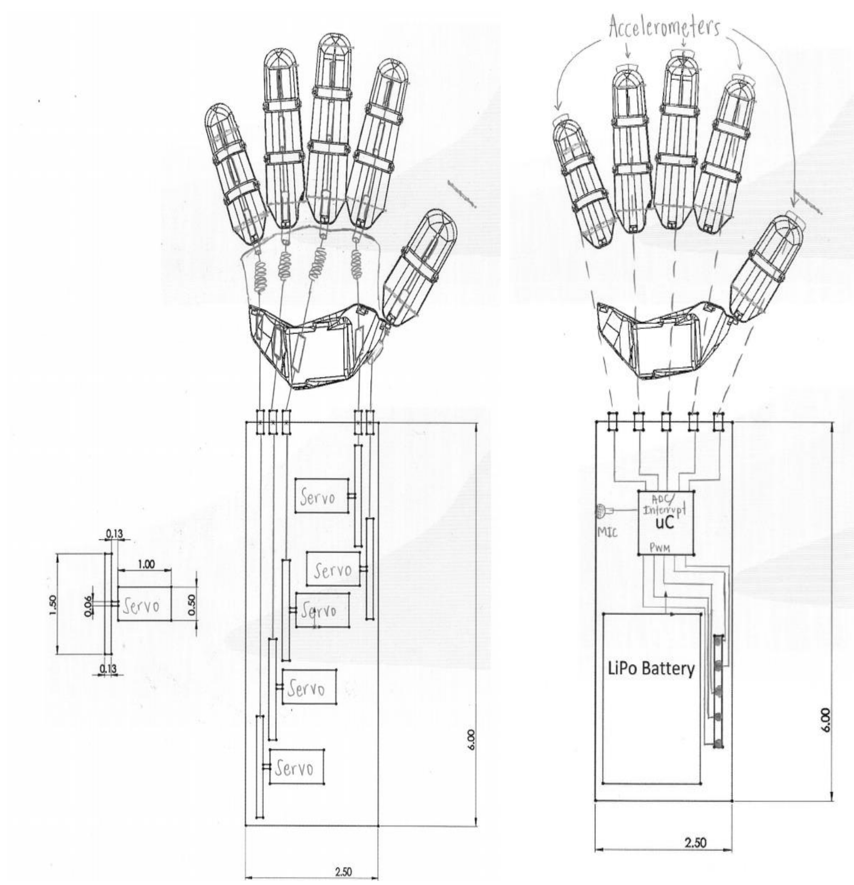


Figure 3 Finger restraint design – top view

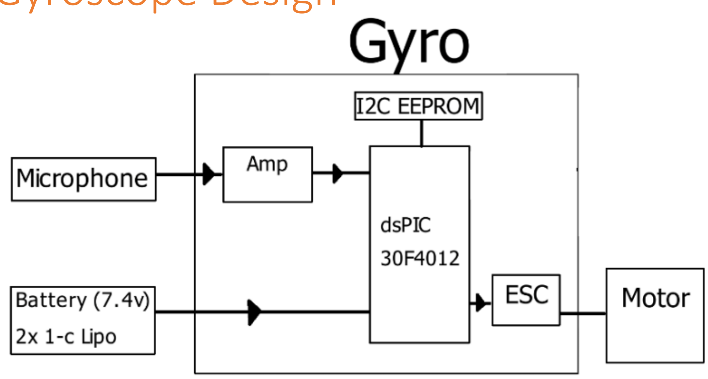
arm in a cascading pattern. Each succeeding servo will be shifted slightly to optimize space. A voice command will be used to signal the servo motors to tighten or release the cable restraints. The design will also utilize accelerometers that will detect the shaking of the fingers. The accelerometers will detect the reduction of shaking and will potentially send a signal to the servo motors to stop once a threshold is reached.

As both designs were created to prevent separate shakes, a method to combine both designs is being investigated.

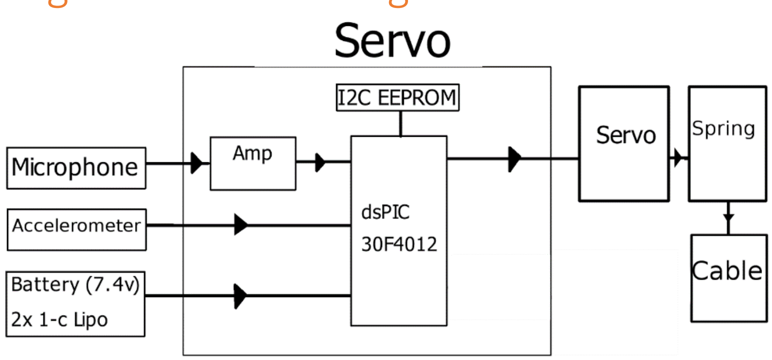
System Design

Block Diagrams

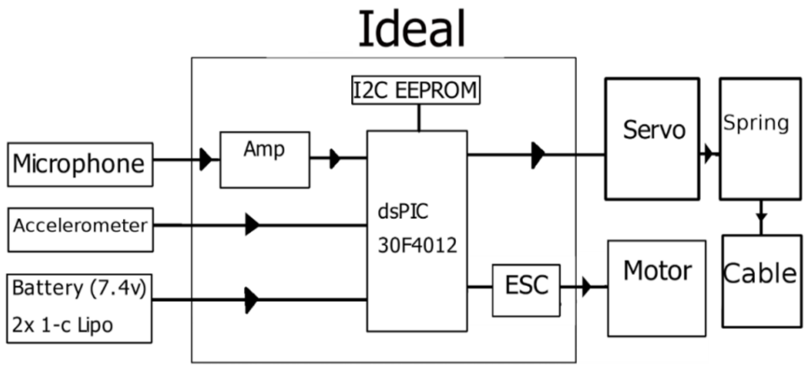
Gyroscope Design



Finger Restraint Design



Ideal (Combination of both designs)



Battery

The battery will utilize two single cell lithium polymer batteries in series in order to provide 7.4v. The capacity of the battery will be sufficient such that using two sets of them allows the user to charge one set while using the other.

Microphone

We plan on using an electret microphone which has a response of at least 100 Hz to 10 kHz.

Amp

We will use an amplification circuit in order to boost the low peak to peak voltage from the electret microphone so that the swing of the microphone lies between 0 V and 5 V.

dsPIC304012

The project will use a dsPIC which will allow for digital signal processing to verify voice commands. We will also use it to control the motor and/or servo.

I2C EEPROM

This will serve as a storage device for the trained voice commands and allow us to compare the user input to the trained commands.

ESC

An Electronic Speed Controller that we will communicate with in order to drive the dc brushless motor for our gyro.

DC Motor

This will be the Gyroscope itself. We will use a dc brushless motor to drive the gyroscope. Our dc brushless motor will run off of 7.4 V. Using a 2000 kV motor, this will give us a maximum rotational velocity of 14,800 rpm. If the motor is able to produce enough torque we will use a metal gyroscope with most of its mass on the outer edge. The gyroscope will be 30 mm wide and 10 mm tall. It will be hollowed out like a wheel such that most of the mass is around the edge of the gyroscope, the model seen in the project description section.

Servo Motor

We will be having five high torque servos being run at 6 V to control the tension pulled on the fingers. Attached to the servos will be springs, which will then be attached to cables connected to the fingers. The servos will provide 3.75lbs/inch to stabilize any tremors which will be detected by each finger's own accelerometer. The servos are controlled by voice commands which tell them to relax, pull, or move to a set position by a saved command.

Springs

Springs will be attached to each servo to give the user flexibility even when the servos are at maximum tension. This gives the user mobility in the fingers while the servos are preventing minor movements caused by tremors.

Software Requirements

- Recognize when a person begins to speak
- Recognize an "On" command
- Recognize an "Off" command
- Potential to Recognize four more commands
- Communicate with the ESC in order to control the motor
- Control the servo

Hardware Requirements

- Provide sufficient amplification for the microphone signal so that it can be used by the microcontroller
- Provide effective stabilization using a gyroscope
- Provide effective stabilization using a cable based finger restraint system tightened by a servo
- Have a charging system for the 2x 1c LiPo batteries
- Removable system for the LiPo batteries

Testing and Verification

Testing Procedure and Benchmarks for Subsystems

Electronic Speed Control

- Test: Connect the ESC's signal pin to a function generator and the output to an oscilloscope.
- Benchmark: Verify that the output matches the incoming signal.

DC Motor

- Test: Connect the ESC's signal pin to a function generator and the output to the motor and test the RPM achieved with the motor using a tachometer.
- Test: Place varying disks on the motor to see the range of loads that the motor can drive. In addition, verify the max RPM achieved with each load.
- Benchmark: Produce a high enough RPM to drive a disk to resist small movements.

Servo Motor

- Test: Connect the microcontroller's PWM pin to the signal wire of the servo motor.
- Test: Find the force being generated by the servo when it's pulling.
- Benchmark: Verify the range at which different signals will rotate the servo.

Microcontroller

- Test: Generate varying PWM signals to feed the ESC by connecting the ESC to an oscilloscope.
- Benchmark: Verify that the signals being generated match.
- Generate varying PWM signals to feed the ESC by connecting the ESC to the motor.
- Benchmark: Verify the RPM being generated by the motor is correct.

Battery

- Test: Connect the battery to a digital multimeter.
- Benchmark: Verify the current and voltage generated from the battery, the amount of time it takes the battery to be recharge to full, and the time it takes the battery to discharge while in use.

Microphone

- Test: Connect the microphone to a boosting circuit which will amplify the signal being generated and connect the output to an oscilloscope to see frequency being generated.
- Benchmark: Obtain a trace on the oscilloscope able to be used for ADC.

EEPROM

- Test: Write to the EEPROM via the I2C bus from the microcontroller. Read from the EEPROM via the I2C bus to the microcontroller.
- Benchmark: Store a voice command and match it to a test command.

Voice Recognition

- Test: Connect the microphone to the ADC input pin of the microcontroller. The microcontroller should distinguish from low frequency signals and high frequency signals in order to determine which signal it should output.
- Benchmark: The output signal sends “ON” or “OFF” signals to the devices.

Testing Procedure and Benchmarks for the System

Gyroscope

- Test that the microcontroller can distinguish six different voice signals.
- Issue a voice command to spin the Gyroscope at a predetermined rate.
- Use a variety of weights to determine the maximum load for the motor and determine the max speed with each load.
- Find the PWM rate that will provide the RPM needed to drive the motor.
- Issue a voice command to turn off the Gyroscope and slow it down.

Finger Restraint

- Test that the microcontroller can distinguish six different voice signals.
- Issue a voice command to activate the finger restrain to lock your hand in a desired position.
- Test the spring extension by attaching a string to one end and different size weights to another end.
- Attach a wire to the servo motor and test the amount of load that the servo can handle before stalling.
- The servo should pull the wires and apply enough pressure to stabilize the fingers.
- Test the accelerometers by connecting it to the microcontroller using I2C and displaying the values onto a computer.
- Issue a voice command to disable the finger restrain to allow for free hand movement.

Project Management

Task Decomposition

The team has been broken up into four different sub-teams to allow us to work in parallel.

Team 1

Team 1 is responsible for the sensors and microcontroller. This team will integrate the sensors with the microcontroller so that they are able to communicate with each other effectively.

Team 2

Team 2 is responsible for power and motors. This team will select the battery, power up the motors, and design a power bussing system.

Team 3

Team 3 is responsible for programming. This team will program the microcontroller using a strategic algorithm to obtain the desired functions.

Team 4

Team 4 is responsible for the mechanical designs. This team will design and build the glove and other parts for the project

Individual Responsibilities

Project Manager

Alex Friedman

Secretary

Will Alarcon

Parts Manager

Victor Ho

Editor

Mike Yao

PowerPoint Manager

Alvin Somvilay

Repository Manager

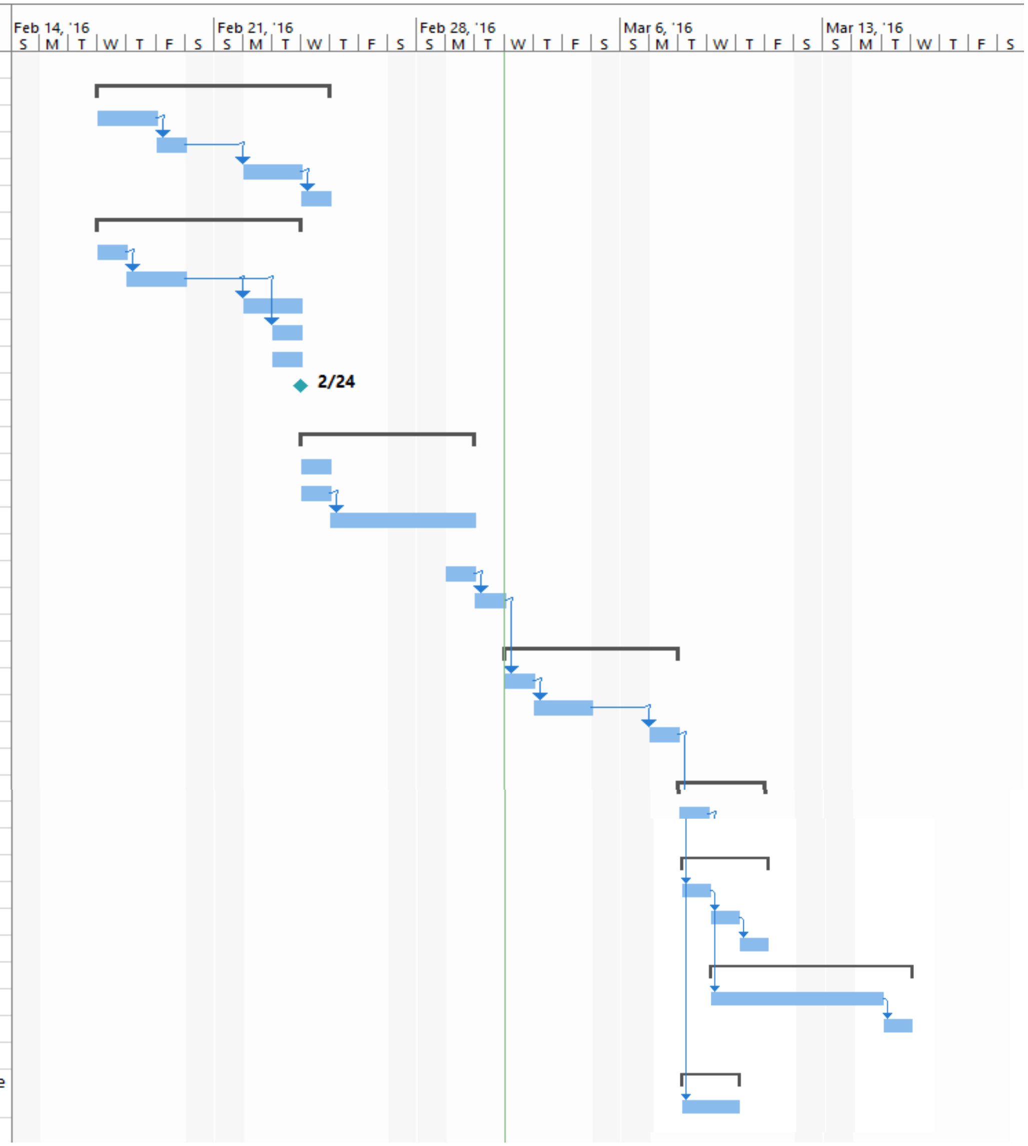
Joshua Black

Web Designer

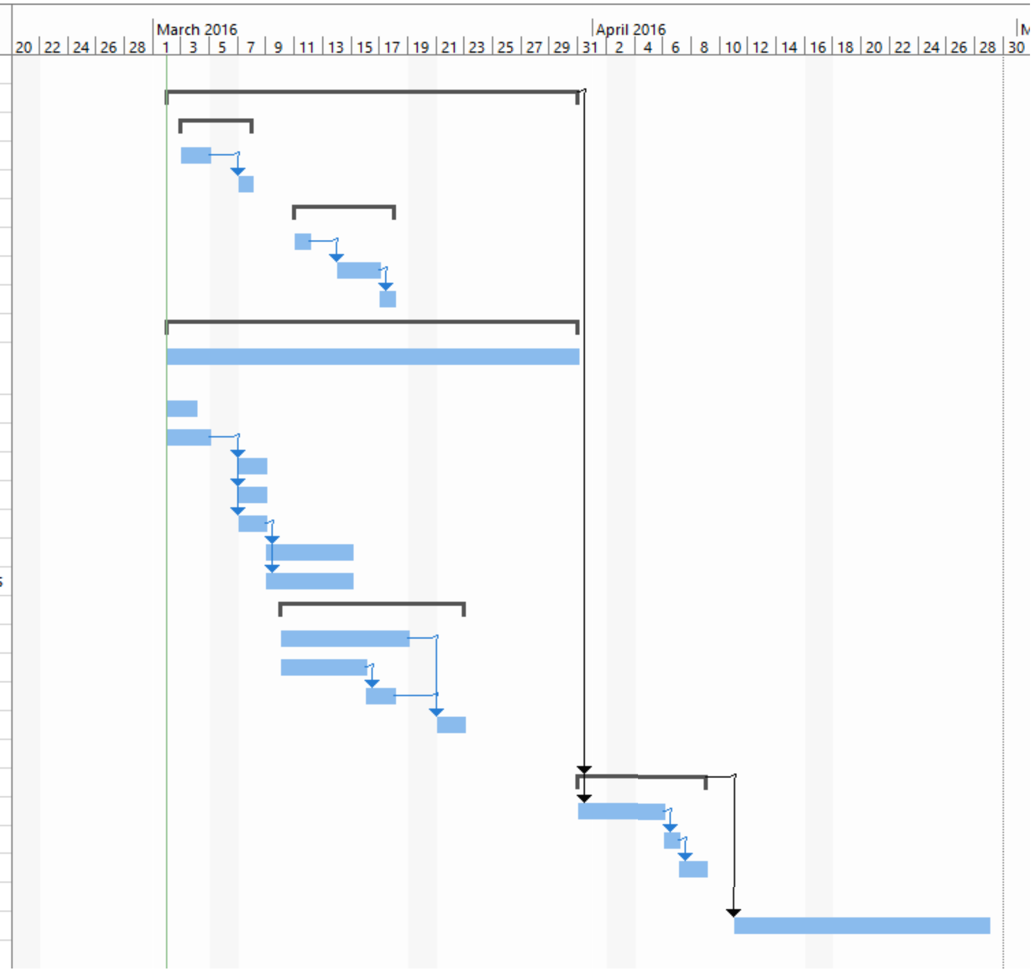
Joe F. Nuñez

Task Schedule

ID	Task Mode	Task Name
1		
2		**Gyroscope Sub Group - Motor Week**
3		Decide upon Motor for gyro
4		Decide upon ESC for Motor
5		Create 3D mock-ups for some example gyroscopes
6		Create block diagram
7		**Servo Sub group**
8		Test stength of a servo
9		Decide upon method of finger stabilization
10		Develop 3D model for finger stabilizers
11		Create block diagram
12		Create Outline
13		Outline of Project Proposal Complete
14		
15		**Speech Recognition**
16		Decide upon how much we wish/need to recognize
17		Decide upon a method for speech recognition
18		Develop a prototype for speech recognition
19		
20		Write Project Proposal
21		Create Project Proposal Powerpont
22		
23		**Speech Recognition**
24		Test Speech Recognition Prototype
25		Develop a prototype using the dsPic
26		Compare Prototype to the use of the dsPic
27		
28		**Gyroscope Sub Group**
29		Test Motors
30		Test ESC
31		Develop gyroprotype and test with motors
32		**Power**
33		Decide how we will provide power
34		Order parts necessary
35		
36		**Servo Sub group**
37		Create finger stabilization prototype
38		
39		Have a working prototype to stabilze the hand using one of the two designs.
40		



ID	Task Mode	Task Name
40		
41		**Design**
42		**Electrical Systems**
43		Design Microphone amplifier and bias
44		Design analog filter for microphone
45		**Power**
46		Design 2x 1c Li-po batteries
47		Design power distribution circuit
48		Design removable system for lipo batteries
49		**Software**
50		Develop system to recognize 6 words (on/off/lock/unlock/left/right)
51		setup pwm
52		setup ADC
53		Interface with the ESC
54		Interface with the Servo
55		interface with Accelerometer
56		Design accelerometer feedback for gyro
57		Design accelerometer feedback for servo finger restraints
58		**Motors**
59		Design Gyroscope
60		Design Servo finger restraints
61		Design System to attach servo to hand
62		Determine required current capacity
63		
64		**Integration**
65		Design circuit board layout
66		Print PCB
67		Build circuit
68		
69		**Testing and Verifcation**
70		



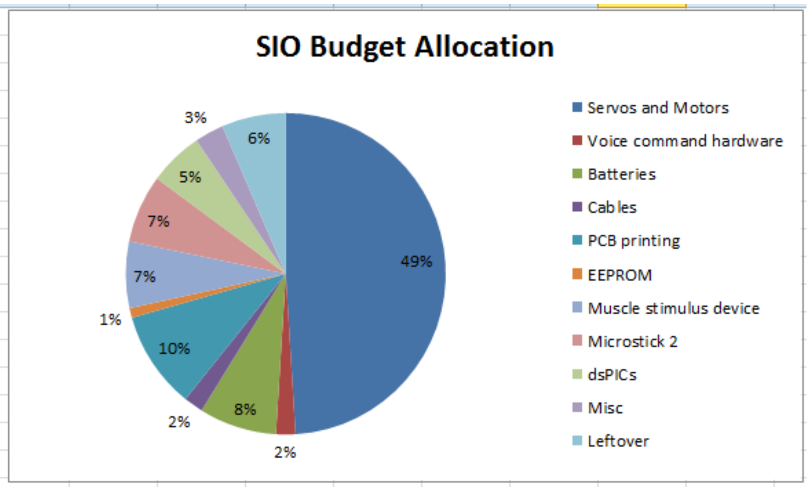
Milestones

ID	Task Mode	Task Name	March 2016 – April 2016
70			
71		demonstrate ability to use PWM on dspic by using it to control position of a servo	3/1
72		demonstrate ability to use ADC by reading a potentiometer and controlling an LED from dspic	3/5
73		demonstrate ability to use UART by pushing speech samples from the microphone through the dspic and out the serial pins	3/9
74		demonstrate the gyroscope's ability to damped hand shake using a prototype	3/10
75		demonstrate the servo-finger restraint's ability to dampen finger shake using a prototype	3/10
76		demonstrate ability to drive motor through the esc using the dsPic	3/15
77		demonstrate ability to drive servo using the dsPic	3/15
78		plot speech samples from microphone, received via uart, on matlab	3/16
79		demonstrate ability to interface with an Accelerometer by pushing axial measurements out the serial pins	3/18
80		demonstrate ability to recognize one word by lighting up an LED in response to word recognition	3/23
81		demonstrate ability to distinguish between multiple words by lighting up different LED's in response to on/off/lock/unlock/left/right	3/30
82		demonstrate ability to write to and read from an EEPROM memeory device via i2c	3/31
83		demonstrate final handshake stabilization design	4/7
84		demonstrate GUI by displaying data pulled from the dspic via serial connection	4/13
85		Testing complete	4/2

Budget

The following chart includes expected expenses including the costs of materials bought for testing. The budgeting limits are $500 for prototyping with the goal of a final product that costs under $100.

Items	Cost	
Servos and Motors	$	250.00
Voice command hardware	$	10.00
Batteries	$	40.00
Cables	$	10.00
PCB printing	$	50.00
EEPROM	$	5.00
Muscle stimulus device	$	34.00
Microstick 2	$	35.00
dsPICs	$	28.00
Misc	$	15.00
Leftover	$	33.00
3D Printing	FREE	
Total	$	500.00

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SIO
To aid those with Parkinson's Disease and Essential Tremors, the SIO Glove seeks to stabilize the shakes, letting the user to complete desk tasks without interference.
Features
Custom Built Gyro
Servo Powered Cable Restraint
Voice Commands
Battery Powered Motors
Will Alacorn
Secretary
Josh Black
Repository Manager
Alex Friedman
Project Manager
Victor Ho
Parts Manager
Joe Nunez
Web Designer
Alvin Somvilay
Powerpoint Manager
Mike Yao
Editor
Hugh Molesworth
Sponsor
Design Day!
May 4, 2016