Team 2 - Tremors

Anthony Calvo, Linda Gong, Jake Miller, Mike Sander

2 November, 2017

**Project Proposal**

1. **Introduction**

Parkinson’s is a neurodegenerative disorder that affects nearly 10 million people worldwide and is the 14th leading cause of death in the U.S. [1]. Tremors associated with Parkinson’s prevent proper usage of hands and other extremities, impacting the daily life of those suffering from the disease. While there is currently technology to monitor these tremors, there is a dearth of devices that focus on their reduction [2].

1. **Problem Description**

Parkinson’s patients experience random, uncontrollable tremors, generally occurring in the hands and wrists. Current solutions to treat Parkinson’s are not integrated with the monitoring of the symptoms, and often require invasive techniques such as deep brain stimulation. Technologies that are used to monitor daily symptoms are bulky and not suitable for daily use. This means that patient data is only collected sparingly (when the patient visits the doctor) and not often enough to make a consistent and meaningful impact on treatment customization. Similarly, devices that mitigate the uncontrollable effect of the tremors are not prevalent in day-to-day life.

1. **Proposed Solution**

The project involves three stages: data collection, data analysis, and tremor reduction. In the data collection stage, information about the patient’s arm movement will be gathered. Next, the motion of the patient’s arm will be looked at with frequency and time domain analysis to determine if a tremor is occurring. This stage will also include a form of data visualization for the patient to track how severe the tremor is. Finally, our project will include a system of tremor control electronics that will take action when a tremor occurs to reduce the severity of the tremor. The system will incorporate feedback to adjust on the fly and better mitigate the tremor.

To accomplish this, we propose a bracelet-like device that Parkinson’s patients would wear in their day-to-day life. The bracelet will include an accelerometer that will take data about the patient’s arm movement. The controller monitoring the bracelet will be capable of distinguishing between voluntary arm motion and tremors based on frequency content, and can determine the severity of the detected tremors. The device will communicate with a GUI, allowing users to analyze the collected data as well as visualize the tremor characteristics and the effects of the tremor control electronics on the severity of tremors.

In order to mitigate the tremors, we propose the use of an Electronic Muscle Stimulator (EMS); we believe that an EMS machine can be modified to stimulate muscles using electrical current in such a way that tremor signals are “overridden” by signals that cause muscle contraction. Part of the project will be to determine if an EMS is an effective means to stimulate arm muscles and reduce tremors. If the EMS machine does not work, then the focus of the project will transition to the monitoring of the tremors and developing a better system for doing so. A form of tremor control electronics will communicate with an EMS machine in order to mitigate tremors as they occur. The system will use feedback to determine how strongly and how frequently the EMS machine will output its signal at any given time.

1. **Demonstrated Features**

Bracelet for Data Collection

The bracelet will contain an accelerometer that records the acceleration of the hand in the x, y, and z directions. Most hand tremors occur at a rate of about 4-6 Hz. The sampling rate of the accelerometer must at least satisfy the Nyquist sampling theorem for the tremors. The bracelet will be battery powered. The battery will be required to generate 3.3 V to power the microcontroller for up to 48 hours of continuous use. The battery will be rechargeable and able to regain full power with 5 hours of charge time.

Bluetooth

The device will include a Bluetooth module; this will allow the accelerometer to send data to a computer for further processing and to the tremor control electronics for tremor reduction. The Bluetooth module will be powered by the same battery and needs to have a range of at least 3 feet in order to send the data to an external computer.

Electronic Muscle Stimulation

An EMS machine capable of stimulating wrist and hand muscles as a method of mitigating Parkinson’s tremors will be connected to a controller with the tremor data. The controller will determine how to stimulate the muscles when needed. The properties of the EMS machine will be changed by two factors: strength of the contractions, affected by the voltage and current outputted by the EMS machine, and the frequency of the contractions. The EMS machine will be capable of outputting the ideal value for both variables in order to mitigate tremors most effectively.

Computer GUI

The computer GUI will be created in a common programming language such as C, Python, or MATLAB. The GUI will receive tremor acceleration data from the bracelet via Bluetooth. The program will plot the data vs. time and visually display the information. The GUI will also save the data to allow the user to access the data at a later time.

1. **Available Technologies**

A number of currently-available technologies are important to our project. The PIC32 microcontroller will be the basis for the data collection bracelet [3]. The microcontroller gives us the ability to manage the other accessories in the bracelet. An important component needed for our bracelet is an accelerometer to track the patient’s wrist movement. There are many potential accelerometers, such as the ADXL335 (chip only: $5.08, on board: $14.95) and the MPU-6050 [4]-[6]. The accelerometer we choose will need to take X-Y-Z axis data for motion and speed, consume low power, and communicate with a PIC microcontroller via I2C or SPI.

We will also use a Bluetooth-enabled chip to communicate with the PIC microcontroller. This chip will communicate with both our GUI and tremor control electronics to allow the user to analyze his or her tremors and for the system to provide relief [7].

Finally, an Electronic Muscle Stimulator (EMS) will be used to mitigate tremors. By controlling the frequency and intensity of the EMS machine’s output, we can control how the contractions occur in a way that best mitigates the tremors. The PIC microcontroller must communicate with the EMS machine in order to determine these values [8], [12].

1. **Engineering Content**
   1. Hardware design

We will design a PCB for the wearable bracelet that includes the accelerometer, PIC32 microcontroller, and the Bluetooth chip.

* 1. Programming

To run the GUI, we will write code that can receive Bluetooth data, analyze the tremor information, and visually display the data.

* 1. Signal Processing

Signal processing will be utilized to distinguish between voluntary movements and tremor movements based on the frequency content of the accelerometer data.

* 1. Feedback to combat tremors

The accelerometer data will be used to evaluate the effectiveness of treatment. A feedback network will be implemented between the EMS machine and bracelet. This will vary the strength and frequency of the EMS output signal in order to minimize the severity of tremors detected via the accelerometer.

* 1. Simulation design

To test the bracelet, a method for simulating Parkinson’s tremors will be developed; the simulation would be required to generate data that corresponds to Parkinson’s tremors and standard arm movements.

1. **Conclusion**

The end result of this project will be a closed-loop system that both monitors tremors and uses feedback to reduce the tremors of a Parkinson’s patient. Our project addresses many issues present in current Parkinson’s treatments: the bracelet is suitable for daily use; the bracelet is non-invasive; and the bracelet performs constant data collection to allow for quick recalibration of feedback. The three main tasks our project performs (data collection, data analysis, and tremor reduction) will provide Parkinson’s patients with relief from tremors and allow them to better operate in their daily lives. An open issue that remains to be solved is whether an EMS machine will perform as we expect to reduce tremors.

**References:**

1. <http://www.pdf.org/parkinson_statistics>
2. <http://www.parkinson.org/understanding-parkinsons/what-is-parkinsons>
3. <http://www.microchip.com/design-centers/32-bit/architecture/pic32mx-family>
4. <http://www.analog.com/en/products/mems/accelerometers/adxl345.html#product-overview>
5. <https://www.adafruit.com/product/163>
6. <https://www.sparkfun.com/products/10937>
7. <https://www.adafruit.com/product/2995>
8. <https://www.amazon.com/Santamedical-Channel-Electrotherapy-Relief-Device/dp/B01GIKYYVG/ref=sr_1_8_a_it?ie=UTF8&qid=1509308445&sr=8-8&keywords=ems+machine>
9. (unused)<http://www.mayoclinic.org/diseases-conditions/parkinsons-disease/basics/treatment/con-20028488>
10. (unused) <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3367543/>
11. PowerDot EMS machine: <https://www.powerdot.com/products/powerdot-muscle-stimulator>
12. (unused)<https://www.digikey.com/en/articles/techzone/2012/oct/what-you-need-to-know-about-vibration-sensors>