A Closed-Loop System to Monitor and Reduce Parkinson's Tremors

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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].

Solution

The solution is a combined tremor-monitoring and tremor-controlling system that is suitable for daily use. A bracelet containing a processor and accelerometer is utilized to detect the tremors and interface with an Electrical Muscle Stimulation (EMS) machine to counteract the tremors. EMS machines provide a non-invasive method for stimulating muscles to counteract the tremors via electrodes attached to the arm [3]. The fully designed PCB that monitors the tremors communicates to a cell phone app to display tremor statistics to the user.

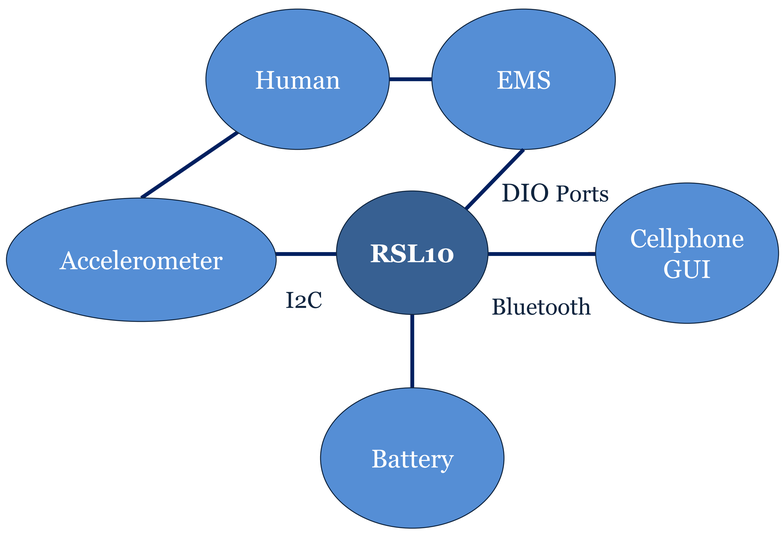

Figure 1: Block Diagram

Subsystems

Accelerometer: An ADXL345 digital accelerometer was chosen for the project because of its I2C capabilities. Using a multibyte read, acceleration data is read from the x/y/z directions.

Signal Processing: The signal processing subsystem is implemented within the cellphone application. A Fourier transform is performed on the data and the magnitude of the tremors between 4-6Hz is used to determine if tremors are occurring.

Bluetooth: The Bluetooth subsystem utilizes UART and the DMA data transfer registers to send accelerometer data between the RSL10 and a paired cell phone using the GATT Bluetooth protocol. The cellphone application sends commands back to the RSL10 via Bluetooth to control the EMS.

EMS: The EMS subsystem is a modification of the existing MPO 8500 Combo EMS device so that it can be controlled by the RSL10. The RSL10's output ports are used to drive circuitry (MOSFETs and resistors) that electrically short the EMS device's buttons.

Cell Phone App: The app stores and displays data collected from the accelerometer. The app is Bluetooth enabled and a notification shows if a tremor is occurring or not occurring, which is determined by the signal processing subsystem.

Battery: The power system subsystem is responsible for powering the RSL microcontroller, the ADXL accelerometer, and the EMS control electronics. We determined that a single CR2032 coin cell battery provided us with sufficient capacity, voltage, and current.

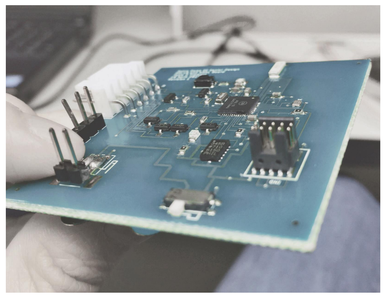

Figure 2: An RSL Awakens

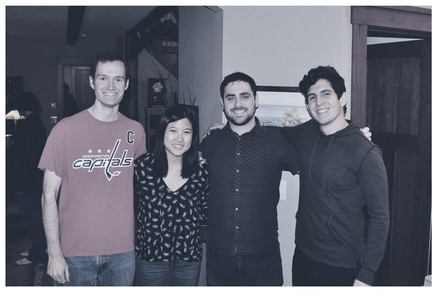

Figure 3: Rager at Dr. Stevenson's House

Figure 4: Single EMS Pulse

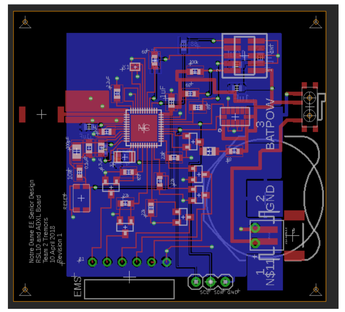

Figure 6: Board in Action

Figure 5: Cellphone App screenshots

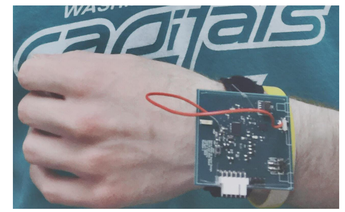

Figure 7: PCB Eagle Board Layout

Results and Conclusions

Our project required designing a PCB that contained the RSL10, EMS control pins, an accelerometer, and a Bluetooth antenna. The RSL code manages the Bluetooth connection, the EMS machine, and data collection from the accelerometer. The cellphone app provides a user-interface, EMS control logic, signal processing, and Bluetooth communication. Overall, our system worked as designed, and does so with a relatively small PCB footprint of 4 in^2, which is required for a system designed to fit on a wrist.The app is relatively easy to use, and our battery choice successfully powers the system.

References:

1. http://www.pdf.org/parkinson_statistics (Statistics about Parkinson's)
2. http://www.parkinson.org/understanding-parkinsons/what-is-parkinsons (Information about Parkinson's)
3. http://www.kau.edu.sa/files/0053044/subjects/1-es.doc (EMS can combat tremors)