Wearable Sway Referenced Haptic Device

Devon Donahue, Ryan Elder, Bryan Fosmire, Charles Haneberg, Steven Howard
Advisors: David Hansen and Nathan Slegers

George Fox University
Physical Therapy

Background

Falls among the elderly and other individuals with sensorimotor impairments (i.e. post hip fracture; reduced vision; etc.) are an epidemic and extraordinarily costly. George Fox Physical Therapy is working on a project to aid these people. This project addresses the problem of poor balance through a wearable device that translates body sway into modes of haptic feedback (physical touch) that have already been demonstrated to improve stability through the application of neurophysiologic principles. Last year, a group of students developed a prototype that didn't quite meet all the specifications. Over the summer, testing was done to find new ways of improving the design. This year, Dr. Meszaros has once again enlisted the aid of the Engineering Dept. to build a prototype to address this problem.

Figure 1. Client: Dr. Andrew Meszaros.

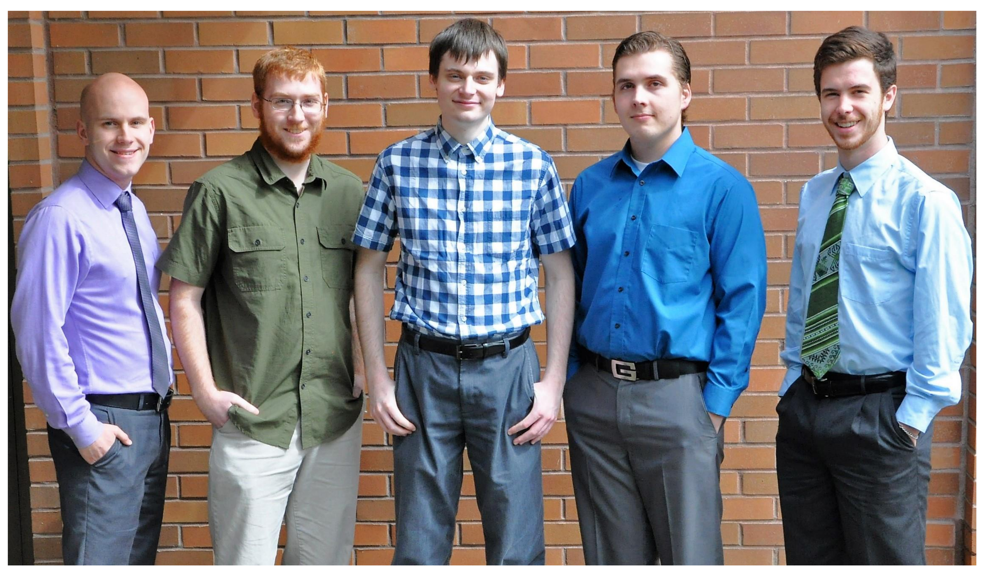

Figure 2. Team Members (From Left): Ryan Elder, Bryan Fosmire, Charles Haneberg, Steven Howard, Devon Donahue.

Objectives

Design a wearable device that helps the user to balance. The final solution should:

- Sense if the user sways outside of set tolerances.
- Detect different tasks the user does and adjust accordingly (e.g. walking, turning, sitting/standing, etc.).
- Provide adequate haptic feedback to alert the wearer subconsciously.
- Respond to changes in sway within 30ms.
- Reduce size and noise of actuators from last year.
- Provide an easy to use GUI that allows adjustment of sway tolerances for each actuator.
- Be adjustable to fit different body types.

Final Design

Garment

The garment is a harness system of straps and elastic that can be adjusted to fit most body types. The actuators can be moved along the straps as needed for proper placement. The Arduino board and shield attach to the back of the harness

Figure 3. The harness without actuators attached.

Actuators

The actuators use two DC motors in a rack-and-pinion system to displace a sliding tactor and provide haptic (or touch) feedback to the user. The motors are contained in a 3D printed housing with slots on the side flanges and on the removable lid for attachment to the garment. This also allows for adjusting the actuator placement.

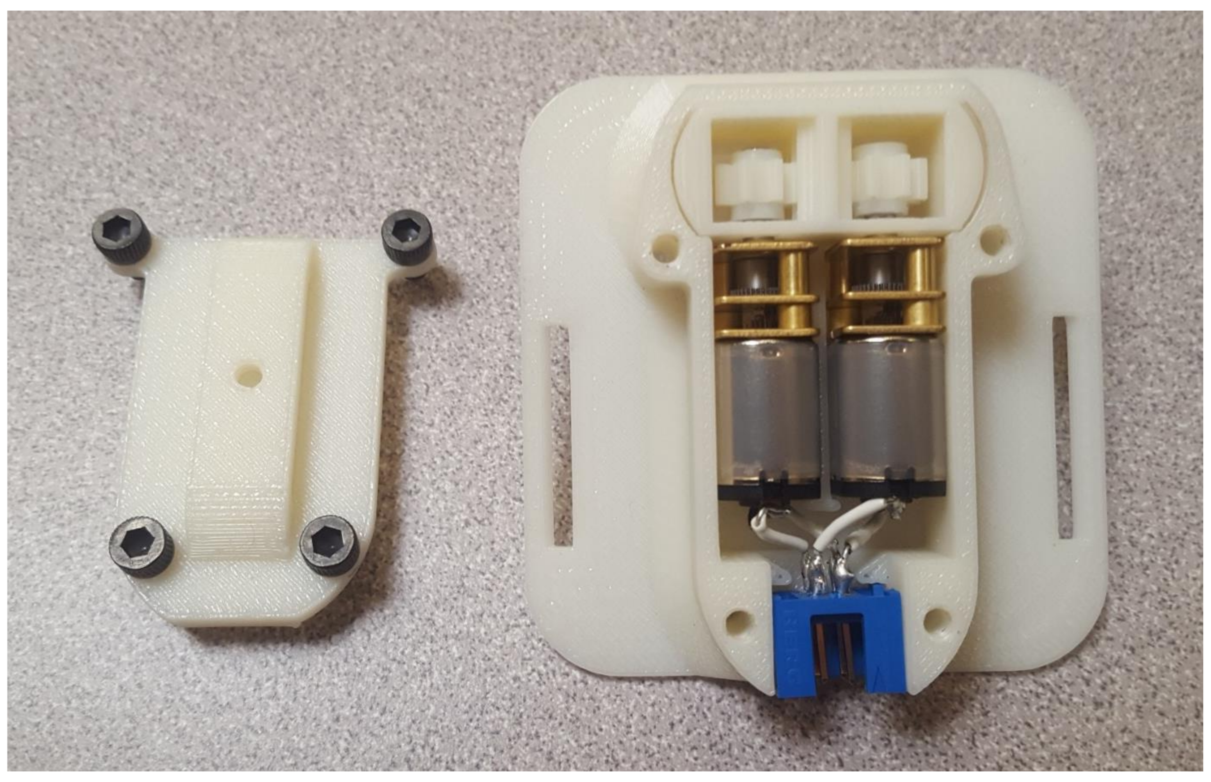

Figure 4. One actuator with lid removed.

Control System

An Arduino MEGA 2560 and custom *Stratus Shield* (named after the Latin word for balance), control the detection of sway and driving of the actuators. The Stratus Shield includes headers for connection of the sway-sensing IMU, one H-bridge motor driver chip with supporting circuitry for each actuator, and other power connection and control circuitry.

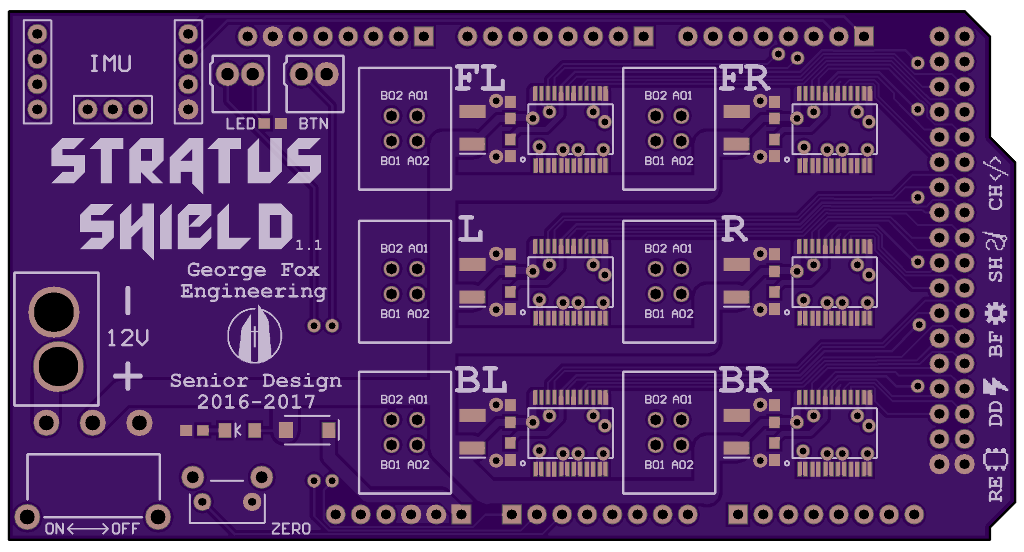

Figure 5. Computer render of Stratus Shield PCB.

Sway Algorithm

An Arduino based algorithm is used to control the response of the actuators based on data from the IMU and user controlled parameters that can be set using the GUI. This algorithm can detect sway while standing as well as identify walking, turning, and standing up to avoid false positives.

GUI

The graphical user interface was developed using Python. It contains the ability to control the different parameters that are used in the sway algorithm. In addition, it can save sets of those values for each patient. The GUI can also be used to calibrate the IMU.

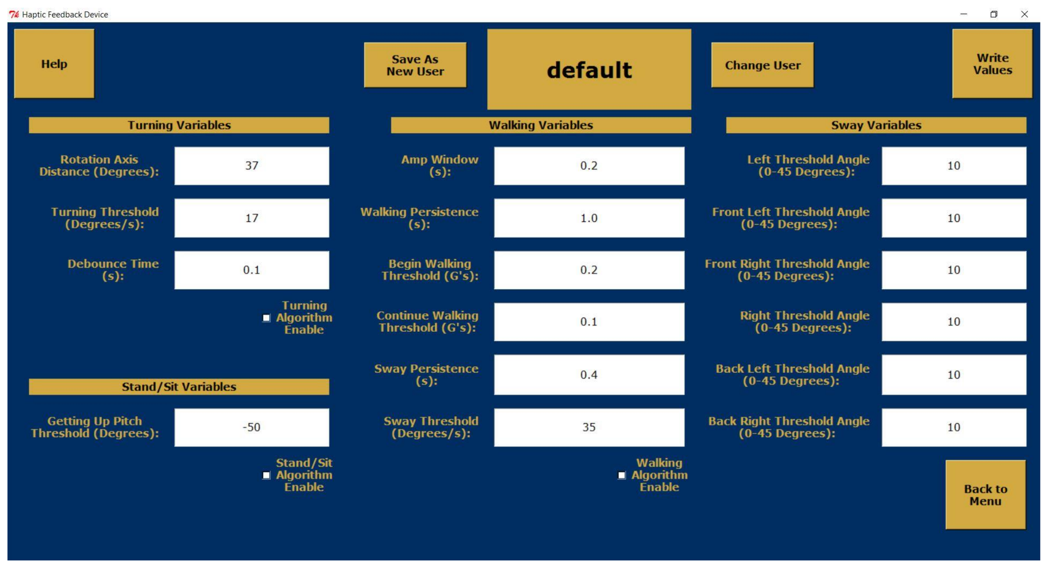

Figure 6. Main screen of the GUI for adjusting algorithm parameters.

Deliverables

- Prototype harness with 6 haptic feedback actuators and control system for detecting sway, driving actuators, and communicating with GUI.
- Instruction video on the assembly of the harness
- Algorithm to allow the sensor to measure the sway of the user while also detecting walking, turning, and standing up.
- Report containing history of design and production of prototype.
- Computer app to allow users to interface with the sensor settings on the prototype.
- Two functioning prototype copies and extra parts for repairs as needed.

Future Additions

While we fulfilled all of the expectations that Dr. Meszaros asked for this year, we identified with him different ways that this project could be enhanced in the future. The biggest addition that should be made is the inclusion of a machine learning system to allow the device to identify and filter out a wide variety of activities, like washing dishes or picking up a book. Another addition that could be made to next year's design would be a custom PCB that combines the Arduino with the Stratus Shield. This would streamline the system and allow for various improvements such as an increase in computational power.