GEORGE FOX UNIVERSITY
PHYSICAL THERAPY

Wearable Sway-Referenced Haptic Device

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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. This project solves 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.

Specifications

The wearable device must be able to detect when the user is swaying and apply pressure to the user based on how much the user is swaying. The device should be adjustable and fit multiple people. The client must be able to adjust how much force is applied at different sway points in order to adjust the device to each particular patient.

Theory

The torso of the human body was simplified to be a rigid triangle, with the corners at the belt buckle and shoulders. A Matlab model was constructed to simulate both swaying and walking motion over time. The data from this simulation provides values that mimic the output from the IMU chip. These values were then used to design an algorithm that determined the pitch and roll of the torso. This algorithm was used to calculate the pitch and roll of the IMU on an Arduino in real time.

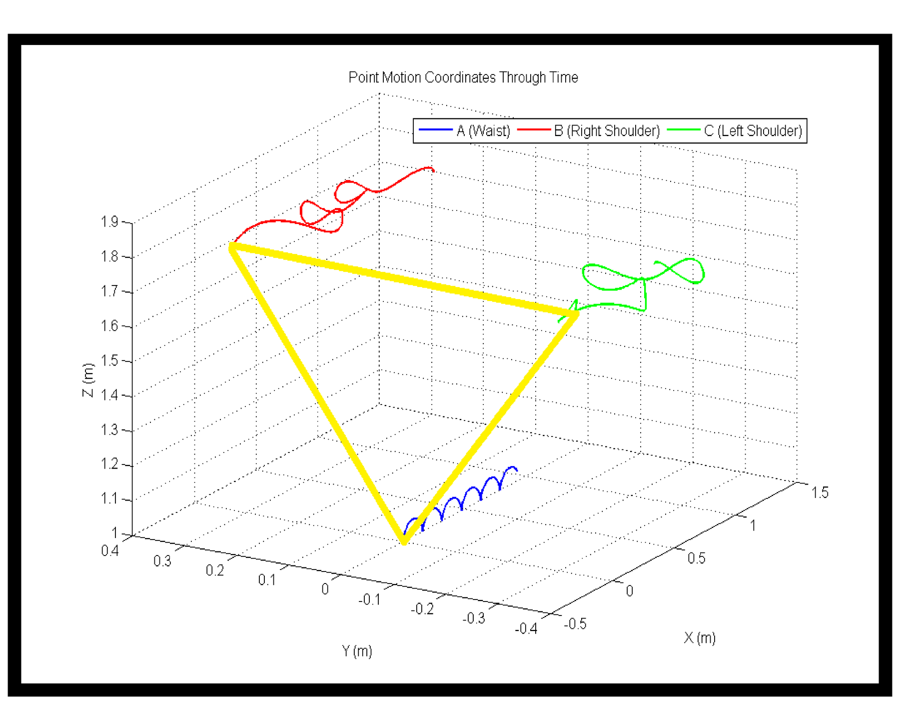

Figure 1. Simulated Motion in Shoulders and Hips While Walking

Figure 2. Daniel Shrewsbury, Cameron Adams, Dieter Mueller, Tyler Howell, Melissa Nugent, Anthony Seebart

Final Design

Figure 3. Prototype Delivered to Client

Our design consists of a wearable device that detects if the user is "swaying" using an IMU and gives them responsive haptic feedback to correct their balance. The wearable consists of adjustable velcro straps, six haptic response buttons, and an Arduino hookup on the back for detecting the test subject's sway.

Components

WEARABLE HARNESS

The adjustable velcro shoulder straps connect together at the back where the Arduino interface is located. Using the velcro on the straps, a button is attached to each required contact point to provide the necessary haptic response. There are small flat rivets pushed through the material that allow the test subject to feel the haptic feedback on their skin. The Arduino has a shield that allows for quick disconnect of the buttons and IMU.

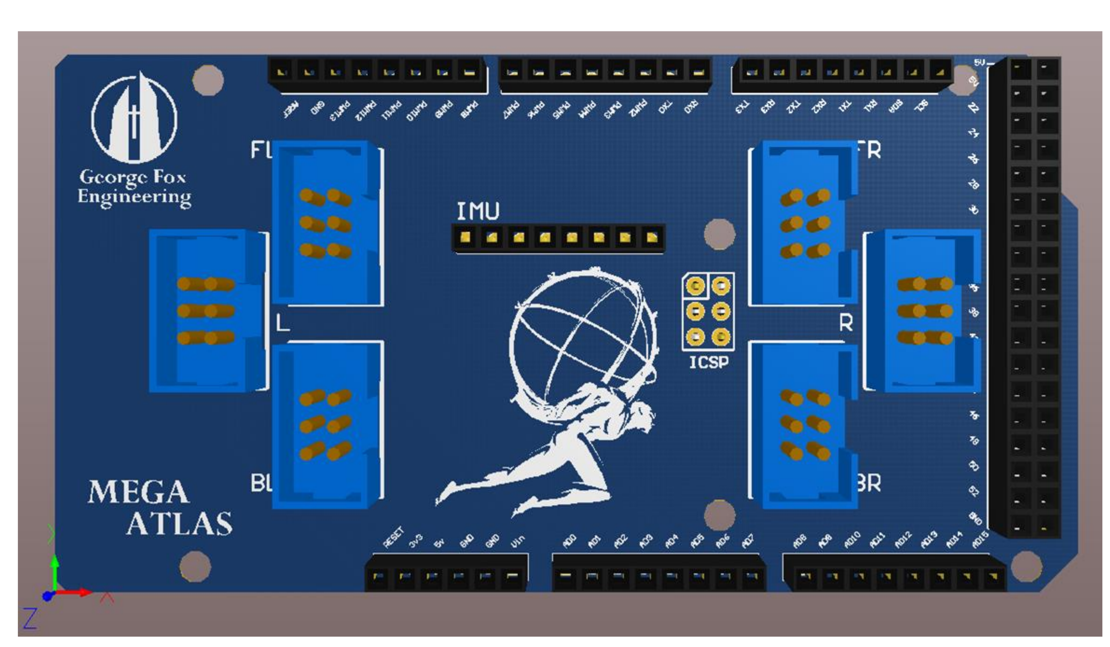

Figure 4. Arduino shield

BUTTON

The button is designed to take a force input and translate it into a linear push on the corresponding contact point. The button ensures the correct amount of force being applied to the test subject based on the amount of sway tracked by the IMU. The button consists of a servo motor, a Flexiforce sensor, and a spring mechanism to disperse the force being applied to the test subject.

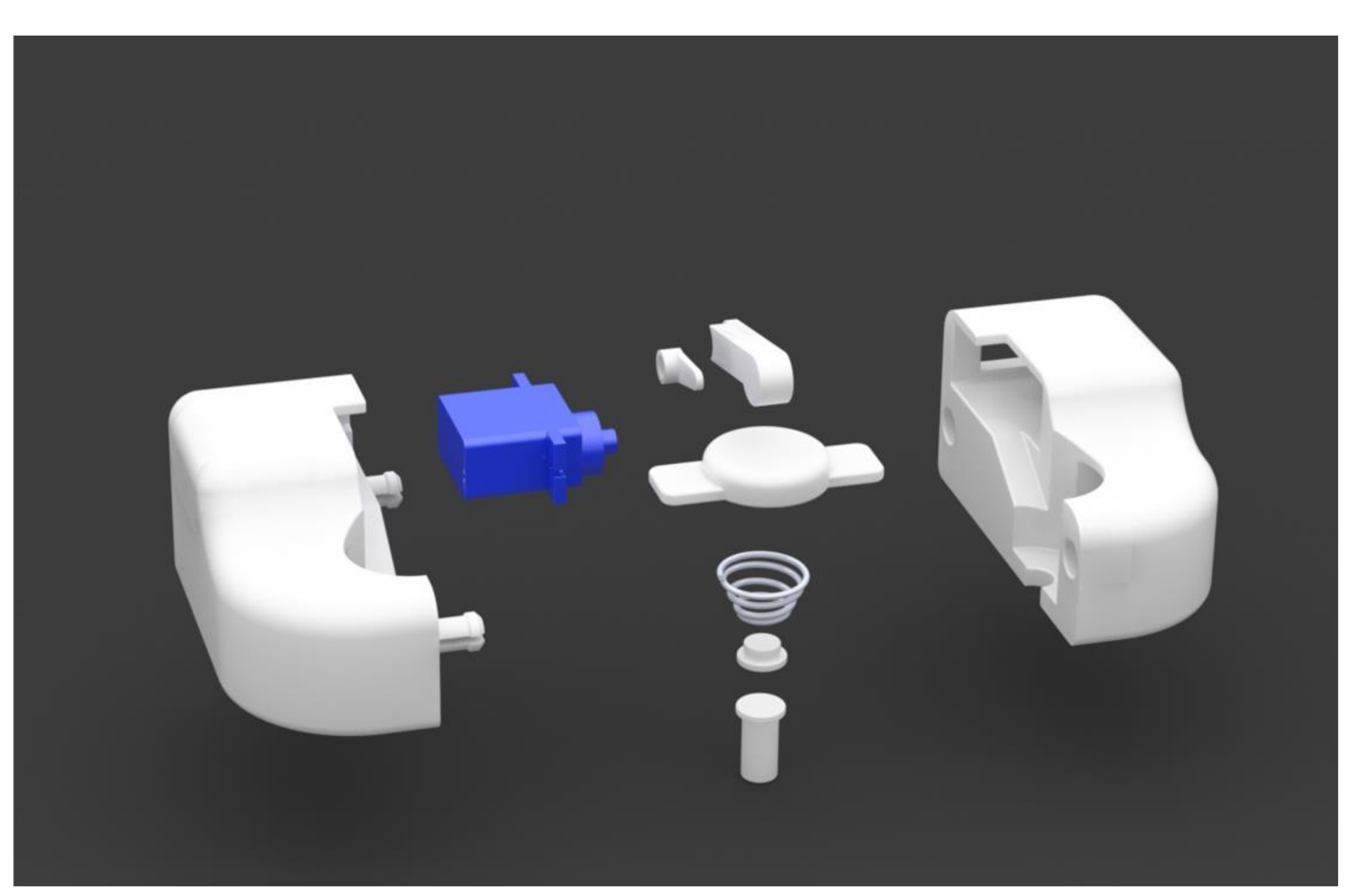

Figure 5. Exploded view of the button with the servo motor, spring mechanism

SERVO

The servo motors are high speed, metal gear digital micro servo motors. This specific motor has been included in the design due to the ability to achieve fast response times and high torque applications.

Figure 6. Servo motor utilized to apply appropriate force

IMU

The IMU utilized for this device is the MPU6050. This IMU has a three axis accelerometer and a gyroscope sensor that is used to determine when a person is starting to sway.

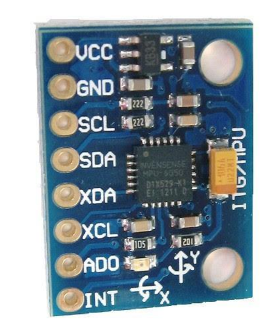

Figure 7. MPU6050 utilized to detect test subject sway

FLEXIFORCE SENSOR

The FlexiForce sensor resides inside the button to provide an accurate feedback measurement of the amount of applied force the user is experiencing.

Figure 8. FlexiForce Sensor

GRAPHICAL USER INTERFACE

This portable application allows the client to adjust sway tolerances for the test subject before the haptic response occurs, as well as how much force is applied at each degree of sway. These values can be written to the haptic feedback device as well as saved to a computer to store unique tolerances for each individual test subject.

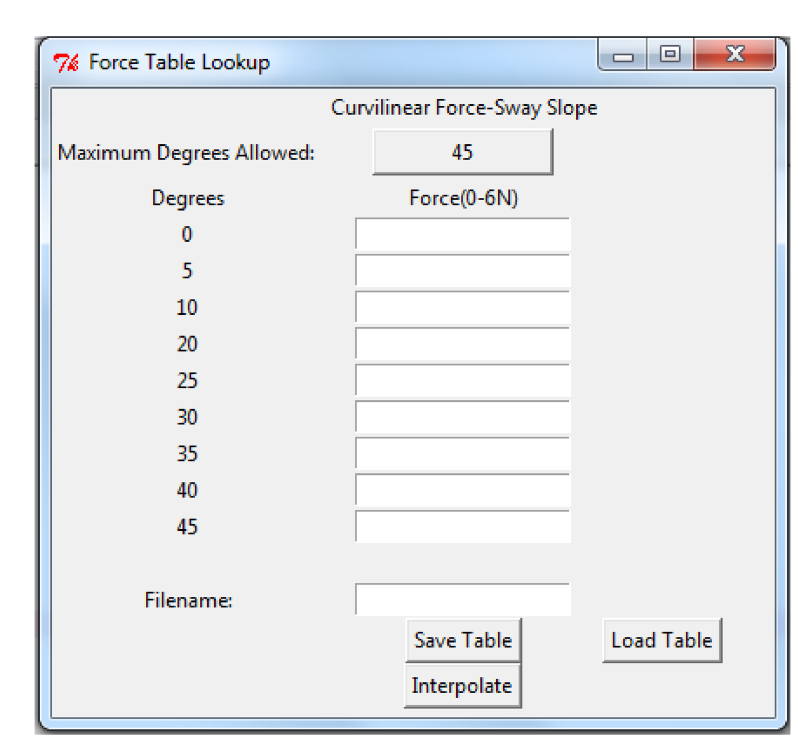

Figure 9. GUI used to adjust sway tolerances

Deliverables

- Prototype harness with one IMU sensor and six haptic feedback buttons.
- Software that allows the client to interact with the haptic feedback device and adjust key variables
- Project Report

Senior Design
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