Development of the Electronics for a Gait Retraining Device

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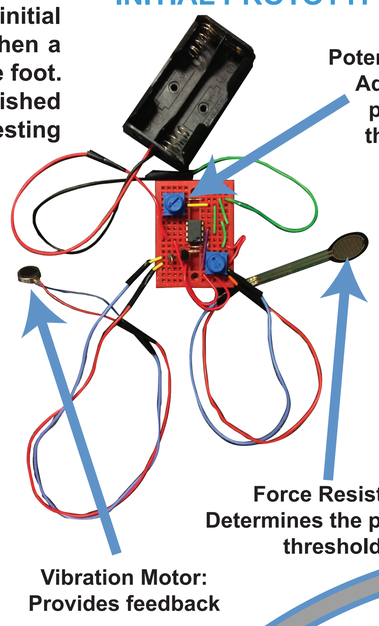
1. Tested the Existing Prototype

The electronics team began by working with the initial prototype to evaluate how to improve the device. The initial prototype was developed to trigger a vibration motor when a pressure threshold is surpassed on the lateral side of the foot. After evaluating the prototype the electronics team established an objective of optimizing the electrical circuit towards testing usability as well as proper and reliable functionality.

INITIAL PROTOTYPE



OBSERVATIONS

- Two potentiometers create a threshold, one as a reference and the other to assigns a relative voltage threshold value needed to turn on the motor.
- The voltage depends on the force exerted on a force-sensitive resistor (FSR) attached to the bottom of the subject's foot
- Accomplished the desired behavior to set a threshold for a motor, dependent on the changing weight the subject exerts on the FSR.

PROBLEMS

- Establishing a threshold for each subject became very subjective
- Potentiometers would each need to be constantly adjusted without any specific or knowable placement.
- A reoccurring issue with setting threshold values for each individual
- Electrical components became unattached when the subject would walk
- The bulky design additionally made data collection difficult when trying to track walking patterns

2. Redesigned Circuit

The goal of the redesign was to simplify the circuit to include fewer parts, make it easier to use, and secure the connections while maintaining its original function. Although the redesigned circuit was successful and more sensitive to various individual users, it still faced various issues.

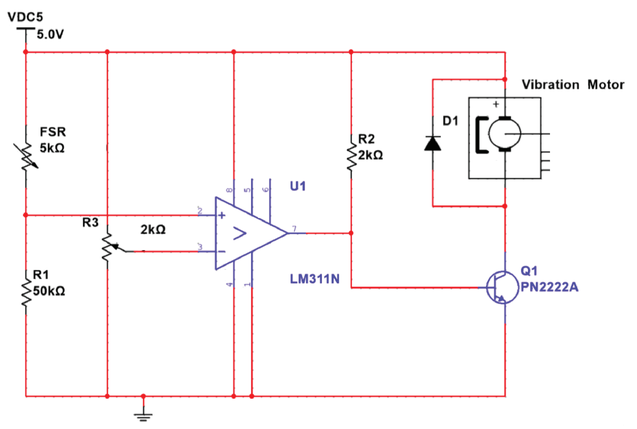


Figure 1. Redesigned Circuit Schematic.

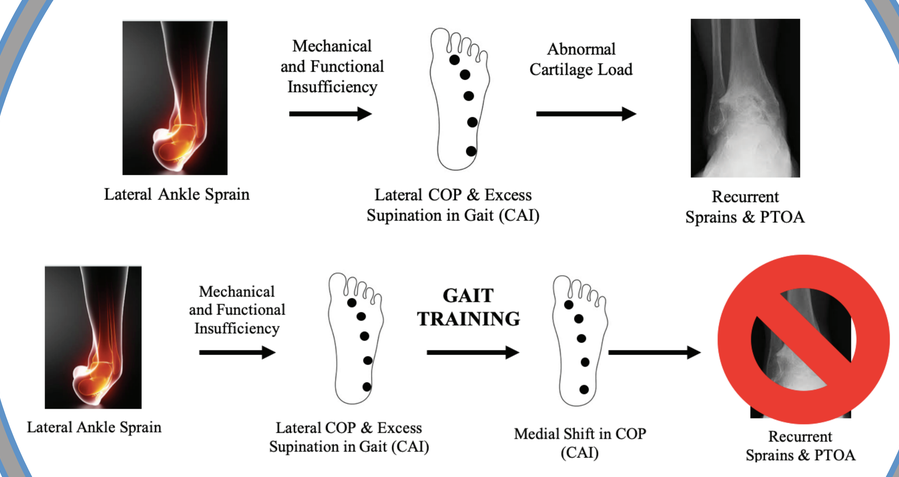
GOALS

- Make the device easily adjustable for each person.
- Replace the operational amplifier with an LM311 comparator to conduct the comparison between the FSR signal and a reference signal.
- Remove a potentiometer and replace it with a single resistor
- Limit the device to a single varying part.
- Soldered to a board to prevent wires from coming loose.

PROBLEMS

- The device was not user-friendly
- Required manual changing of the physical potentiometer
- Still possessed a poor FSR connection, resulting in misreadings and frequent replacements of the FSR.

Gait Retraining for Lateral Ankle Sprains



3. Added Microcontroller

The microcontroller has various capabilities to both take in and send out a signal based on the code that is integrated within it. Although we were able to achieve many more capabilities with the microcontroller, we still lacked ease of use for any person to use the device on their own without manipulating the device.

GOALS

- Remove physical interactions needed with a potentiometer
- Be able to enter exact threshold
- Simplify circuit down to just a microcontroller and FSR
- Provide easy access for data extraction
- Bridge gap towards a mobile app

Figure 2. Teensy 3.2 USB Development Board used in the circuity of the device

PROBLEMS

- Code needed to be modified for each person
- Needed to add a motor drive circuit with a separate power source to drive the vibration motor

5. Developed an App

The initial mobile application prototype was developed using Figma, React Native, and Flutter, with the goal of allowing users to collect data from the physical prototype via Bluetooth 4.0 BLE communication. The app was meant to assess visual reinforcement of the user's error in combination with the vibration provided to the foot by the physical prototype's vibration motor.

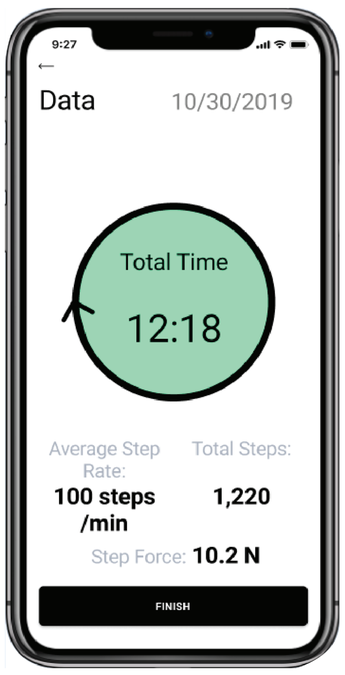


Figure 4. Screen grab of the active collection screen in the app

GOALS

- Provided a visual interface for users to interact with
- Provided real-time feedback to the user on the time, number of steps, and step force per step
- Flash the screen green or red depending on the amount of satisfactory/unsatisfactory step force provided by the user.
- Record, review, and stream data from various trial sessions
- Upload the data to a central web app/database for further analytical processing, these analytics would be available on both the client (user) and admin (researcher) interfaces.

PROBLEMS

- Minimal documentation in connecting the app to third-party firmware for Bluetooth connection
- Complications in receiving accurate, real-time data with little to no noise
- Complications with maintaining stable connections between the physical prototype's sensor and the mobile application.

4. Added Bluetooth

To allow the app the ability to extract data and quantitatively present the progress of the subject, it was essential to add a Bluetooth connection. Establishing a connection is the first step moving towards long term functionality beyond the lab setting.

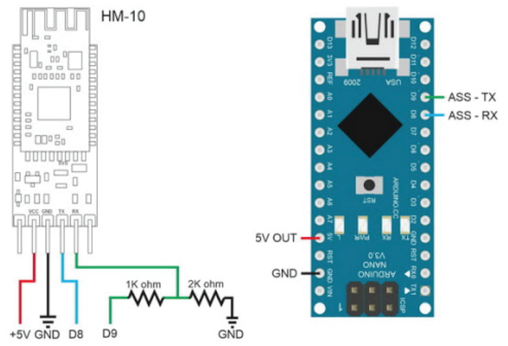


Figure 3. Schematic of the DSD TECH HM-10 Bluetooth 4.0 used to establish a bluetooth connection

GOALS

- Establish communication between the app and the device
- Add a DSD TECH HM-10 Bluetooth 4.0 to the circuit due to its easy implementation and compact size
- Alter code to have the threshold value be set and changed with the app instead of hardcoded into the Arduino
- Alter code to allow for the microcontroller to "listen" for incoming data

6. Future Plans

Moving forward we plan to keep improving the prototype until there is seamless communication between the wearable component and then phone application. In order to improve the physical prototype, the soldered circuit board will be made into a printed circuit board. New FSR's will be tested in order to select a sensor that is durable enough for constant wear. The next iteration of this device involves combining the haptic feedback from the motor with visual feedback. In order to provide visual feedback, we plan on mounting a laser to sit on the top of the foot. The laser will also be controlled through the app, thus both the hardware and software will need to be updated to accommodate the addition.

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