Future Wearables

Dec15-04

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Problem Statement: Our goal is to research and prototype a wearable device that is able to monitor back posture and muscle activity. This data will then be sent to a smartphone that will be able to analyze and display the data for patients and medical professionals to interpret. The device is intended to be used by physical therapists to analyze the relationship between back muscle activity and posture in patients. There are opportunities to use this device to analyze athletes with repetitive tasks, such as baseball pitchers and golfers. It could help detect when an athlete is starting to fatigue, which could be crucial to preventing injuries.

Solution: Our device is a wearable sensor array, designed to monitor back muscles and back posture. It uses 4 Inertial Measurement Units (IMUs) to track the patient's back orientation and 2 Electromyographys (EMGs) which measure muscle activity. A microcontroller retrieves the data from these sensors and transmits it over a bluetooth connection to a paired android device. The android device analyzes the received data and displays it on graphs for the medical professional to interpret.

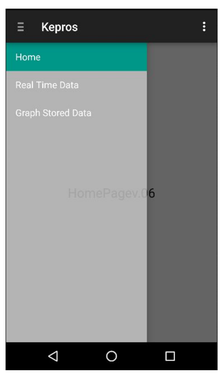
Device Requirements

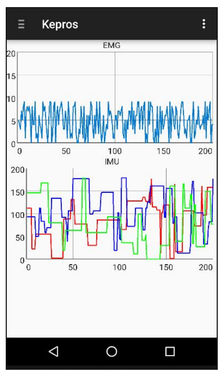
Functional Requirements:

- The device shall track back posture from 4 points on the back.
- The device shall measure relative muscle activity of the primary back muscles.
- Data collected by the device shall be available to view on a tablet or smartphone via bluetooth.
- The device shall be powered by a battery.
- The device shall be wearable

Non-Functional Requirements:

- The device shall be light and comfortable to wear.
- The device shall have a rechargeable battery.
- The device's battery shall last a full day without needing to be recharged.



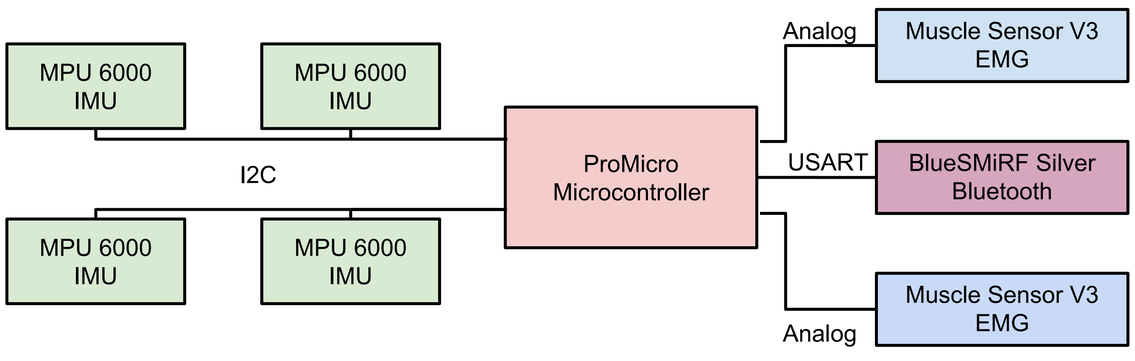


Software Components

The microcontroller code is written in C. We utilized an I2C hardware library from Arduino and one I2C software library for interfacing with the IMUs as well as a UART library from Arduino for interfacing with the bluetooth chip.

The Android application was developed in Android Studio using Java. When the the connect button is hit the application uses Android's Bluetooth package to retrieve the data. This data is then displayed in the real time graph fragment and stored in the SQLite database. The select time frame allows the user to pick a time frame the stored data graph fragment then retrieves the data from the SQLite database and displays it on a graph.

The application uses an open source graphing library call Graph View to take care of the graphing of the data.



Validation

We had several meetings with our client to ensure validation of the posture wearable device.

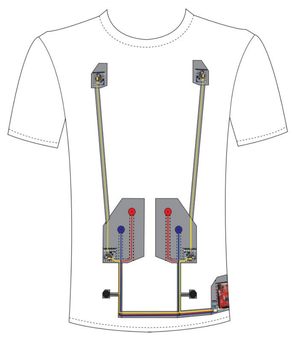
Meeting 1: Gain a clearer understanding of what the goals of the project were and how to best go about achieving these goals.

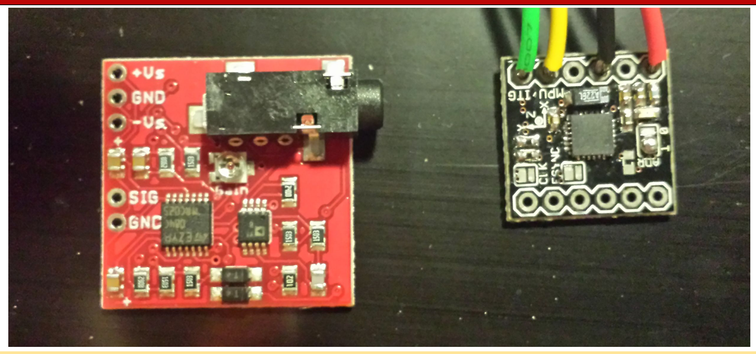
Meeting 2: Review the parts list and go over why each part was selected.

Meeting 3: Test the initial prototype and review the validity of the data being retrieved.

Meeting 4: Test and demonstration the second iteration of the product. Verify validity of data that we received.

Meeting 5: Final demonstration of the product. Get final design opinions of the product.





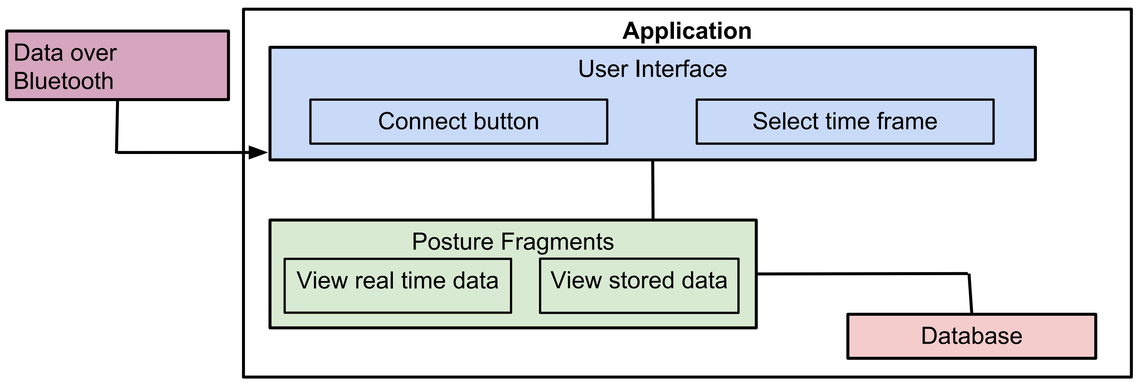
Application Requirements

Functional Requirements:

- The application shall retrieve data wirelessly from the wearable device.
- The application shall display the information retrieved
- The application will store the data into a database
- Analyze data from device

Non-Functional Requirements:

- Performance (speed of retrieving, storing, and reading data)
- Reliability (Retrieving, reading, and displaying data)



Hardware Components Description

MPU 6000: The MPU 6000 is a 3 axis inertial measurement unit (IMU). IMUs are a combination of an accelerometer and a gyroscope; giving detailed information about orientation and rotation. This makes them ideal for measuring posture. The MPU 6000 communicates via I2C, a standard bus protocol.

Muscle Sensor V3: The Muscle Sensor V3 is a surface electromyography (EMG). An EMG measures the electrical potential of muscles and produces a signal related to the magnitude of the electrical potential. When the muscle activates, the output signal increases; when the muscle relaxes, the output signal decreases.

BlueSMiRF Silver: The BlueSMiRF Silver is a bluetooth radio chip. Using a basic serial communication, the microcontroller can transmit all of the sensor data to a paired android device. This chip is capable of transmitting over 18 meters, suitable for the physical therapist' s use.

ProMicro: The ProMicro is a microcontroller. This chip manages communication between each sensor and the bluetooth chip. The device is compatible with Arduino, a series of libraries that are useful for rapid prototyping.

Verification

- Hardware
  - Test parts individually to ensure they will work as needed.
  - Add groups of parts together to test ex. EMG and conductive fabric.
  - Connect all the parts to the micro controller to ensure it works as a system
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- Embedded System
  - The device is getting the EMG data
  - The device is getting all four of the IMUs' data
  - The device is transmitting over bluetooth
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- Android Application
  - The application receiving correctly over bluetooth
  - The application is not missing data
  - The application is correctly parsing and storing data
  - The parsed and stored data is being correctly graphed