LiftOff

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Product Pitch

Oftentimes, people are apprehensive about lifting weights because they are unsure of proper techniques and are afraid of hurting themselves. Even amongst veteran weightlifters, having the reassurance that they are doing an exercise properly can increase their confidence and improve their performance with their lifts. Our project consists of two wearable devices that will track the user's back orientation and applied pressure on both feet, and report it back to our web application. The back device will act similarly to a harness with sensors on it. The pressure detection device will sit in the shoe, and be accompanied by an ankle strap. On the web application, users will be able to see feedback and visualizations from their lifts and **track their progress**.

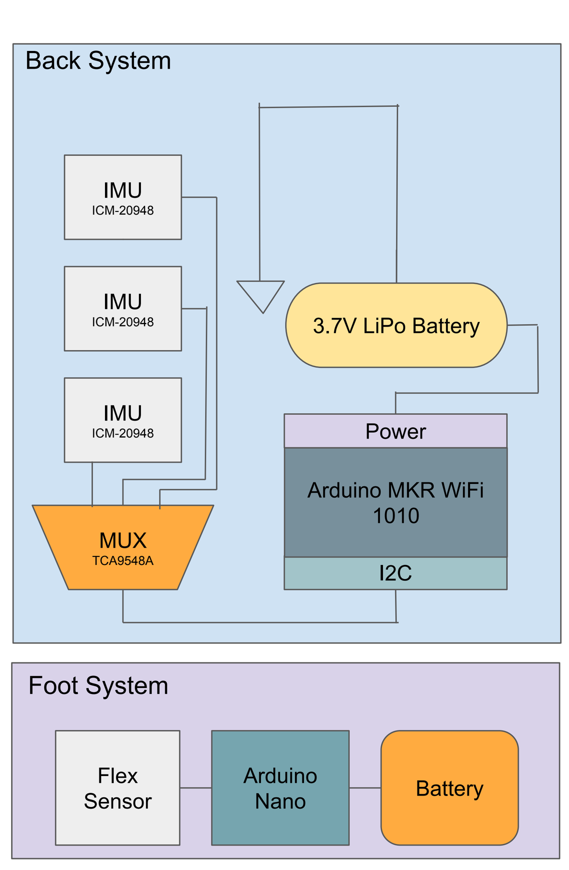
With this system, users can **improve their deadlifting and squatting techniques** as we are able to provide them with a **light-weight**, **easy-to-setup** system, that can **quickly provide feedback** after each set.

System Architecture

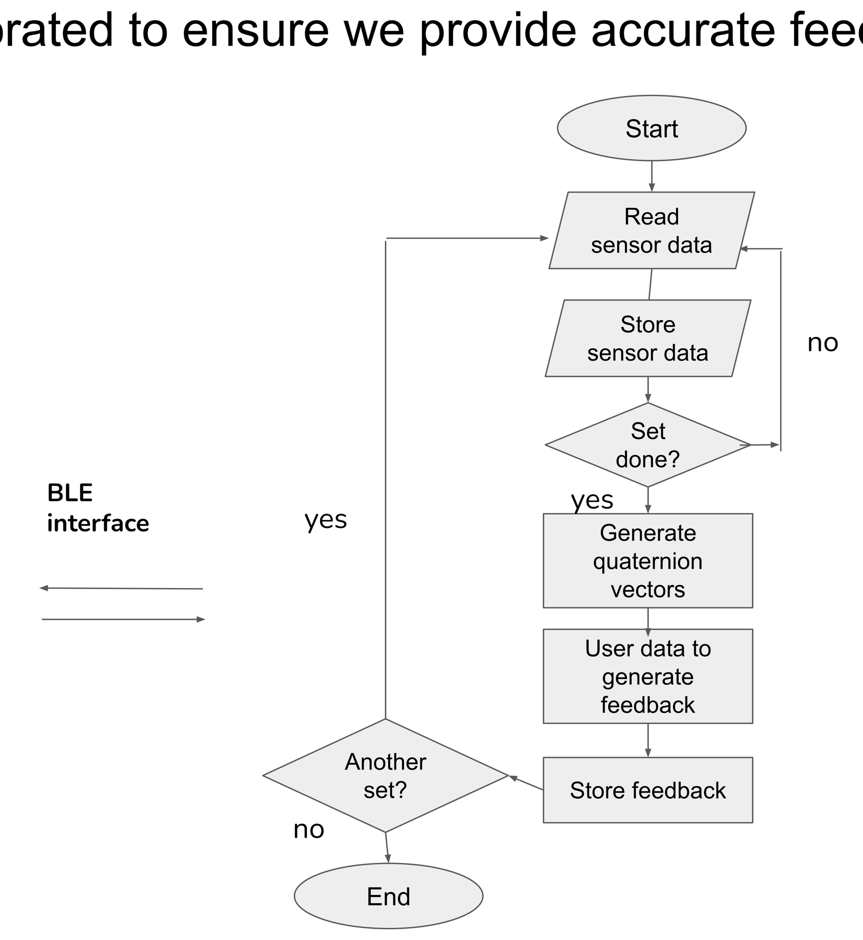
When a user begins tracking their set on the web application, the devices are notified to begin sending data to the web application. The back device consists of a set of 3 inertial measurement units, which give positional data relative to the orientation of the Earth. For our project, we are most interested in gathering quaternion data from our sensors. Quaternions give 9 axis rotation information, allowing us to measure how the users back is rotating in the 3d plane. This information is polled at a rate of 10 samples per second, and forwarded to the website via bluetooth at that rate. Notably, we are limited by the hard wired I2C address of our sensors, which limits us to polling one sensor at a time via a multiplexer.

The foot device has a voltage divider circuit consisting of a force sensor and a 100k resistor, powered by battery. The force sensor changes resistance with the pressure applied to it, leading to a change in voltage drop. The arduino compares the two voltage values generated at the same time. If the values are significantly different, the user is likely to put more weight on one foot than the other.

After a user finishes a set, data is processed in the backend of the web application. Three.js is used to create quaternion visualizations and the back algorithm is applied to ensure the users' back was neutral throughout the set and generate feedback. To determine if the back is kept straight, the algorithm checks to see if the sensors are properly aligned when a user is performing the set. Calibration phases are also incorporated to ensure we provide accurate feedback.



Hardware System



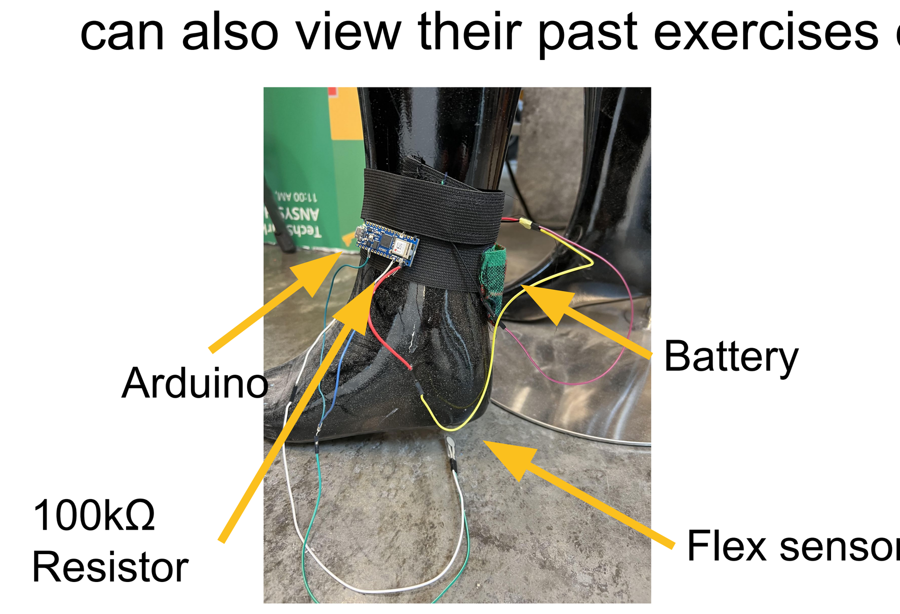
Software System

System Description

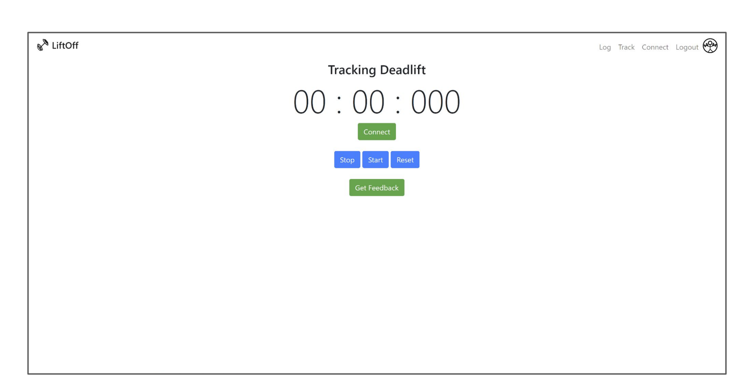
Our project consists of three subsystems: the back device, foot device, and web application. As shown in the system diagram, the back device and foot devices collect data, then send data to the web application for processing via bluetooth. Our back device we have three sensors that are placed at the top back, mid back and low back, which allows us to capture important information about the overall back orientation relative to the Earth.

The foot device detect the pressure from both feet to compare the pressure value. Difference in values indicate an imbalance in the distribution of weight.

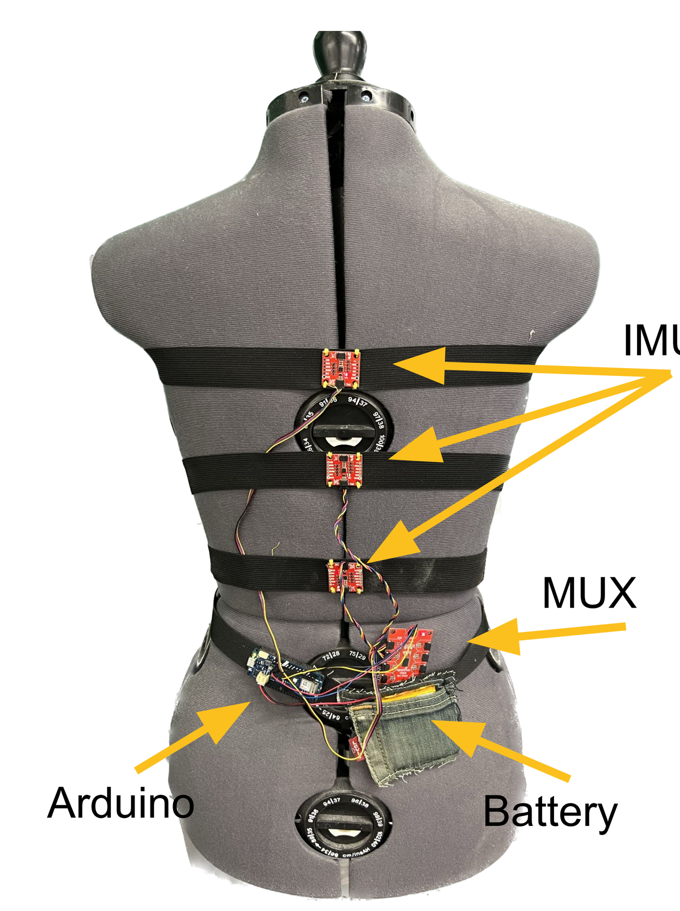
On the web application, users can time and track their set. Once the data from the devices are processed, users receive their feedback on what they did correctly, what they did wrong, and how to improve. On the feedback page, there is also an option to view their quaternion visualization and users can also view their past exercises on the log page.



One unit of the foot device



Tracking page of the web app



Back device

System Evaluation

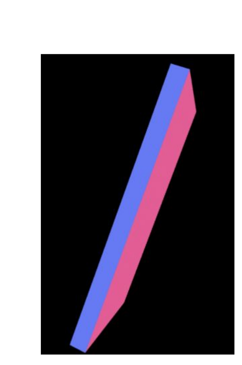
With regards to testing, we looked at each subsystem individually, then did some minor integration testing. For the back system, we first held each sensor at various angles, and confirmed the reported quaternion values matched the perceived angle. Then, we began forwarding the information to the website over bluetooth, and confirmed that the values received on the website matched our wired reading. Finally, we started work on the visualizations pictured below, which we confirmed visually, by checking if the held sensor orientation matched that displayed on the screen.

To ensure the algorithm was working properly, we used different back positions and verified the generated feedback was correct. Furthermore, we did different variations of squats and deadlifts, ensuring that the visualization and feedback were correct.

To test the foot device, we applied different weights on the pressure sensor and recorded the average resistance over 3 trials each. To verify the device is properly working, we made sure that the resistance measured was changing accordingly.

Weight (lbs)	Force Sensor Resistance (kOhm)
0	158
5	162
20	174
30	184

Results from testing the foot device



Visualization generated of one sensor

Conclusions & Additional Information

Scan this to learn more about our project!

http://course.ece.cmu.edu/~ece500/projects/s23-teama3/

Overall our system did turn out the way we designed it, however, with the current product we have, we've realized we should have put more thought into the design. There are definitely a lot of improvements that can be made. For example, an ML classifier can be created to analyze the sensor data and determine if the back is properly oriented. Furthermore, the back device can be redesigned to improve usability.

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