Prosthetics Sensor Package

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General Background

- “Inexpensive range and force sensors for smart prosthetic limbs” (George Gollin, Pg. 7)

- But why?

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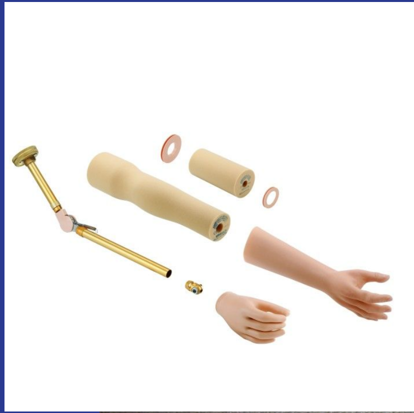
What's Missing

- Actuation
- Control
- Feedback
    - Haptic



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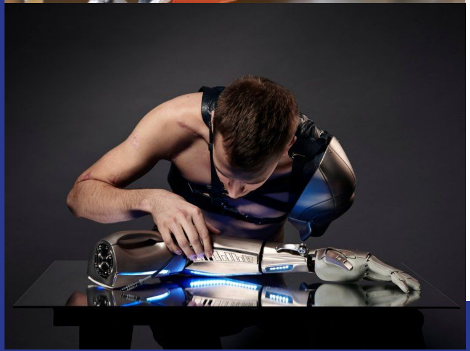
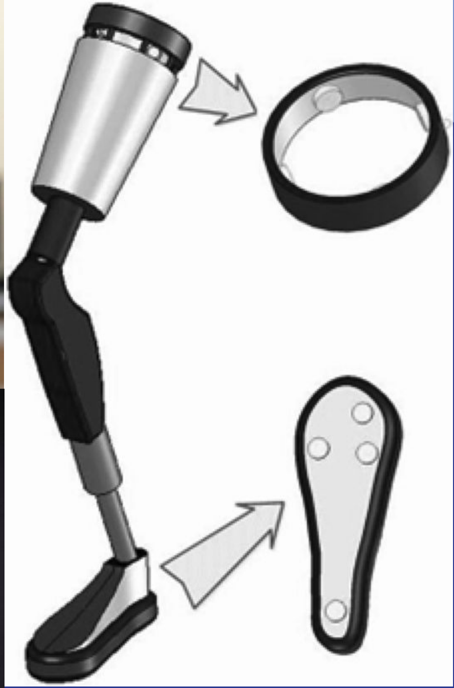
Expensive

- Over complicated
- Anything similar to natural limb
    - $40k-$60k
- Haptic Feedback is currently being developed





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The Hero Arm

- Powered
- Muscle controlled
- Only $6,900
  - 3D Printed
- Haptic feedback
  - Only for notifications
    - Mode changes

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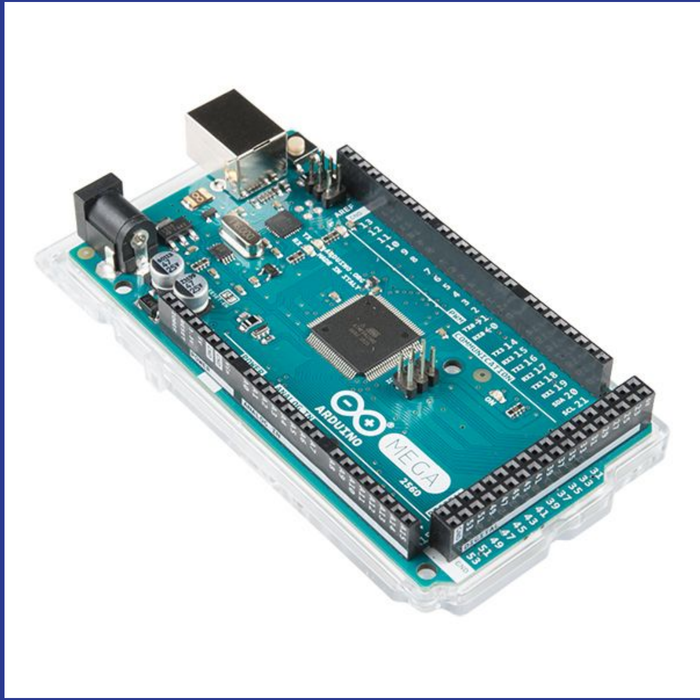
The Scope

- Touch-Based Feedback (Haptic)
  - Contact
  - Squeeze strength
- Integratable to existing prosthetics
  - Relatively simple
- Affordable
  - Developing countries



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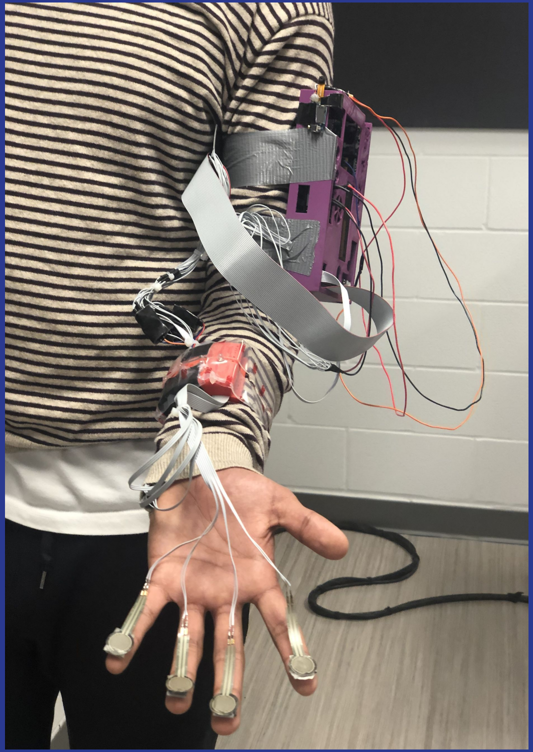
Components

- Real Time Sensor Implementation
  - Sensor package gives live feedback to the user

- Offline Data Analysis
  - Python script for data analysis



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Parameters

- Force on each fingertips
  - Force Sensitive Resistors were taped on to a latex glove
- Proximity of fingertips from object
  - Capacitive touch sensors taped in the front of FSR’s
- Acceleration and Angular Velocity in x, y and z direction
  - The 9 axis accelerometer sensor was strapped to the shoulder

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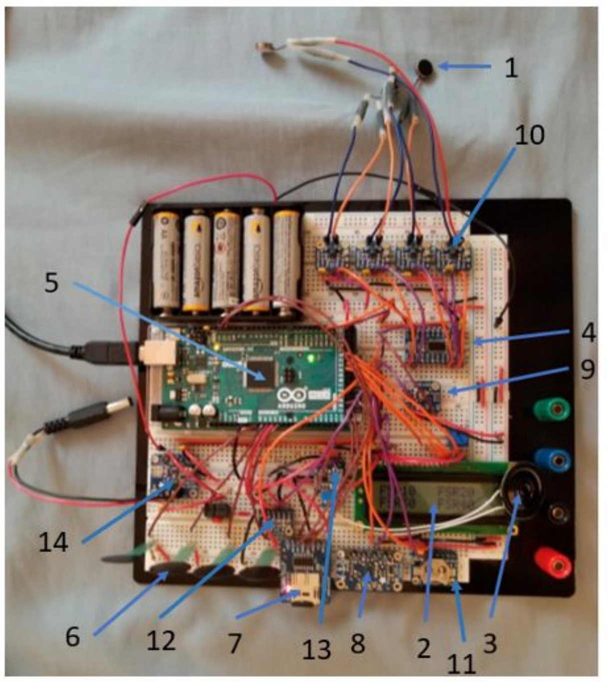
Hardware

- Haptic Feedback Driver
- Vibrating Motors
- Force Sensitive Resistors
- Capacitive Touch Sensor
- 9 Axis Accelerometer
- Spy Camera
- Speaker



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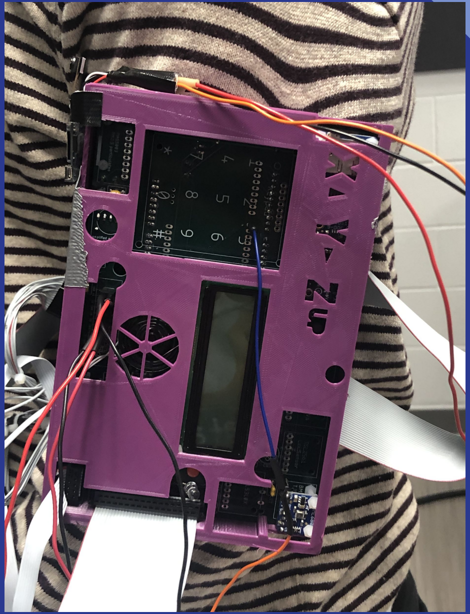
Experimental Setup

- All the components were mounted onto the PCB
- The case were strapped to the shoulder.
- The FSR's and Capacitive Touch Sensors were attached on finger tips.
- Haptic feedback motors were mounted to the forearm.



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Data Acquisition

- Text (.txt) files were created by the arduino with data.
- Measurements of Force, Acceleration, Time, and Photo Count were recorded every 150 milliseconds.
- The camera was triggered every time the Force reading was greater than 0.
- Python script calculated orientation angle and corrected acceleration readings.

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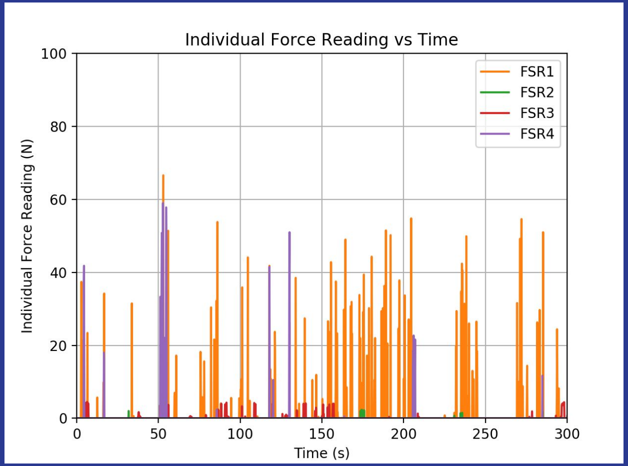
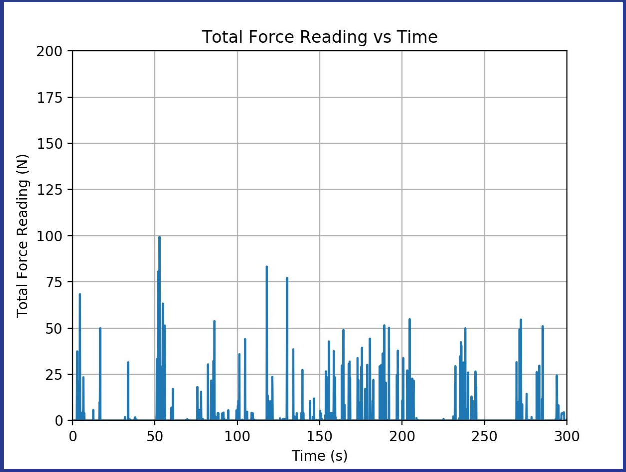
Typing

- Typing was conducted on a 2017 Macbook Pro™ for 300 seconds. Data collected was while user sent an email.





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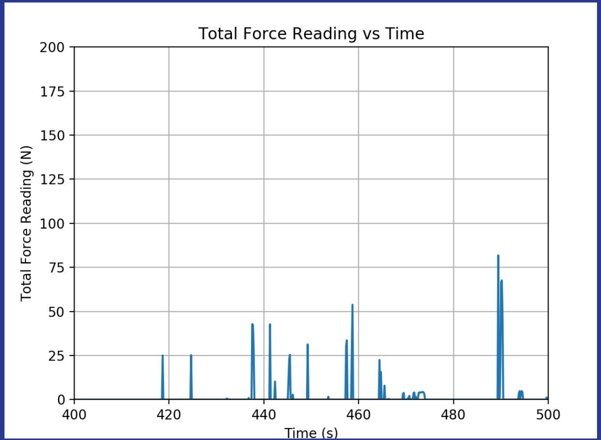
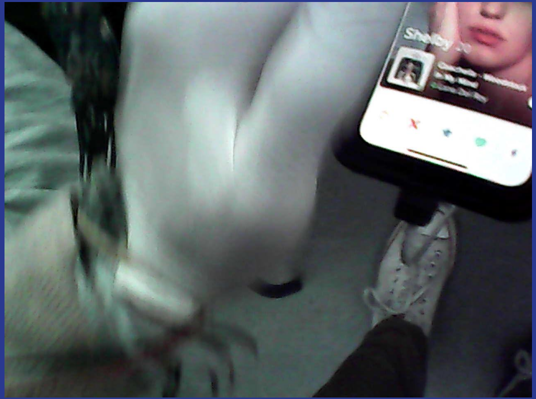
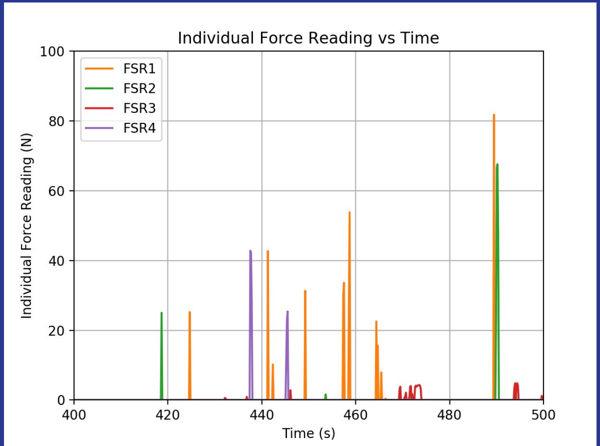
Typing Continued

- User swiped and typed on the iPhone







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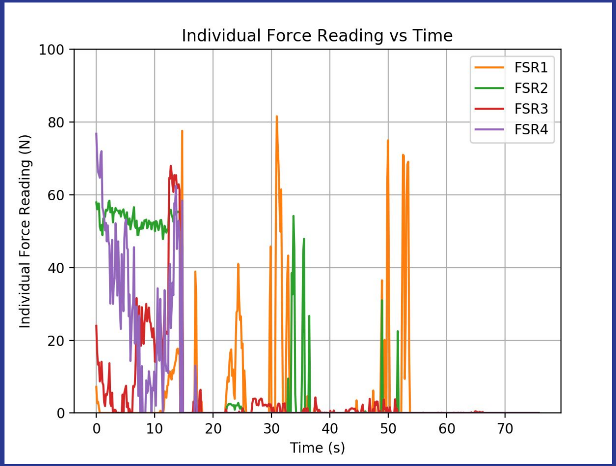
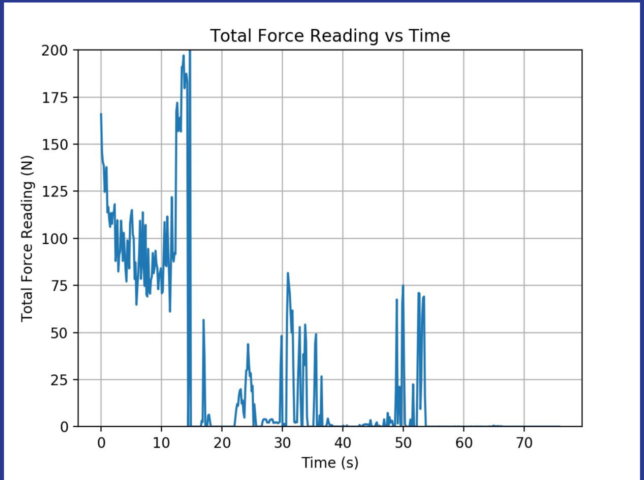
Rigid Body

- Tested by lifting a bottle to drink water and maintaining a grip of the bottle. Lasted 70 seconds.
- The rigid body we used was a 24oz stainless steel water bottle with a circumference of 8.8 inches





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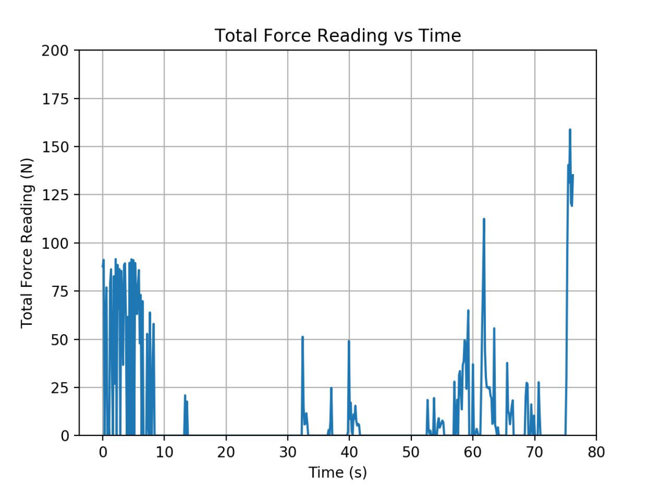
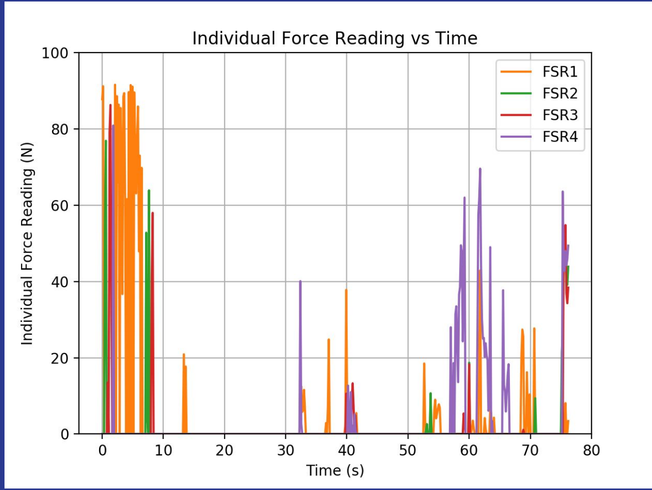
Bicycling

- The activities included unlocking the cycle lock, mounting the lock, and gripping the handlebars during motion.
- Conducted on a standard flat bar bike and chain lock.





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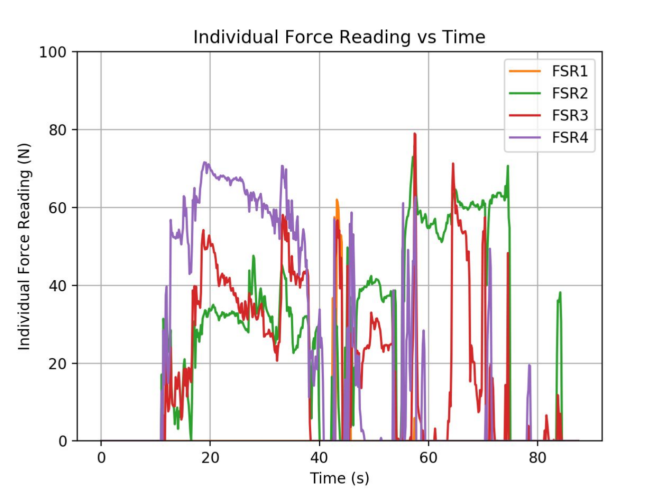
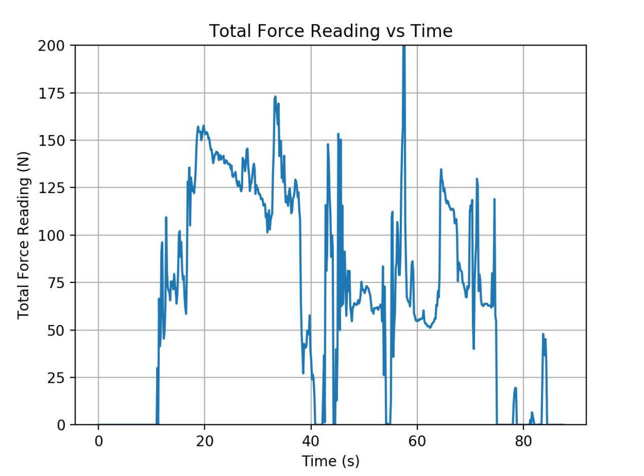
Soft Body

- User held a trash bag while objects were incrementally added.
- Objects include 2 water bottles, a textbook, and a metal rod. Activities lasted 80 seconds.





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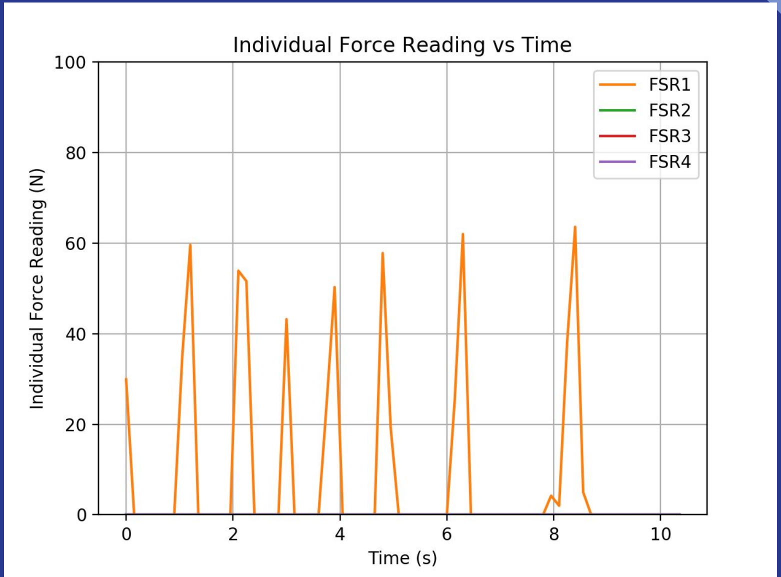
Tapping

- User tapped a table 60 times as fast as he could
- Conducted to test response rate of the sensor package



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Capacitive Touch

Before

After

- Found that it was hindering user from conducting activities
- Removed capacitive touch sensors to improve data quality

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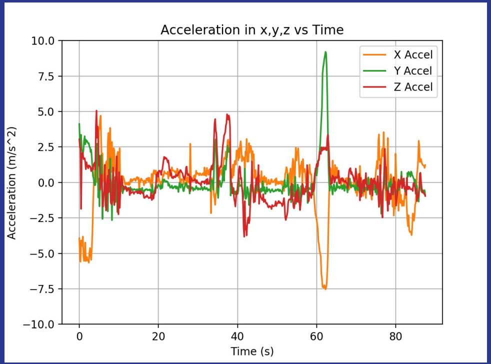
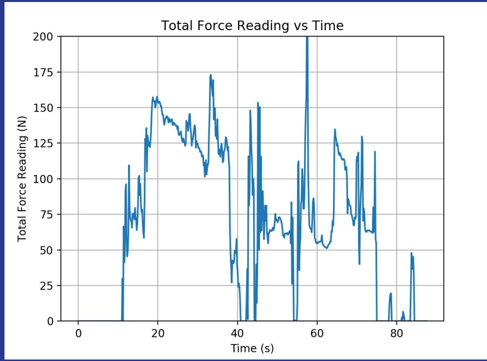
Analysis

- Acceleration values peaked at 10 m/s^2 during impulse loading situations.
- Maximum force experienced by the user was around 51.7 lbs during a jerk.
- Torques experienced by the user was around 36 Nm considering a lever arm of 12”.





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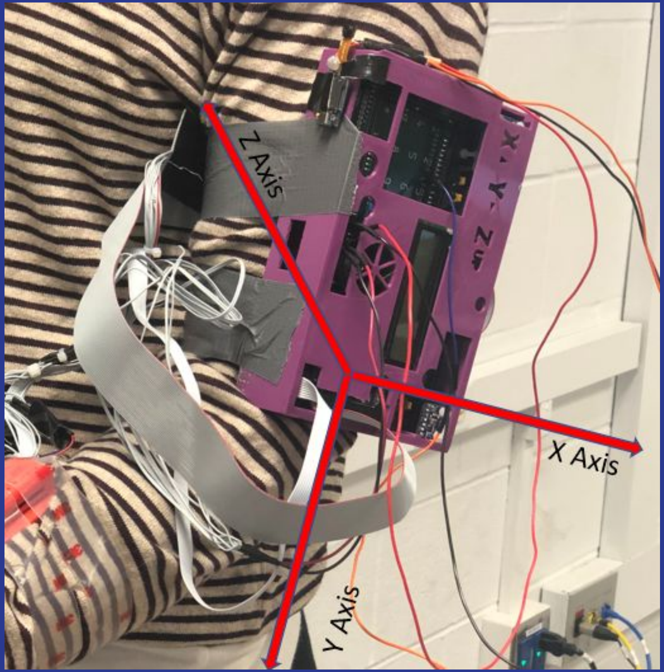
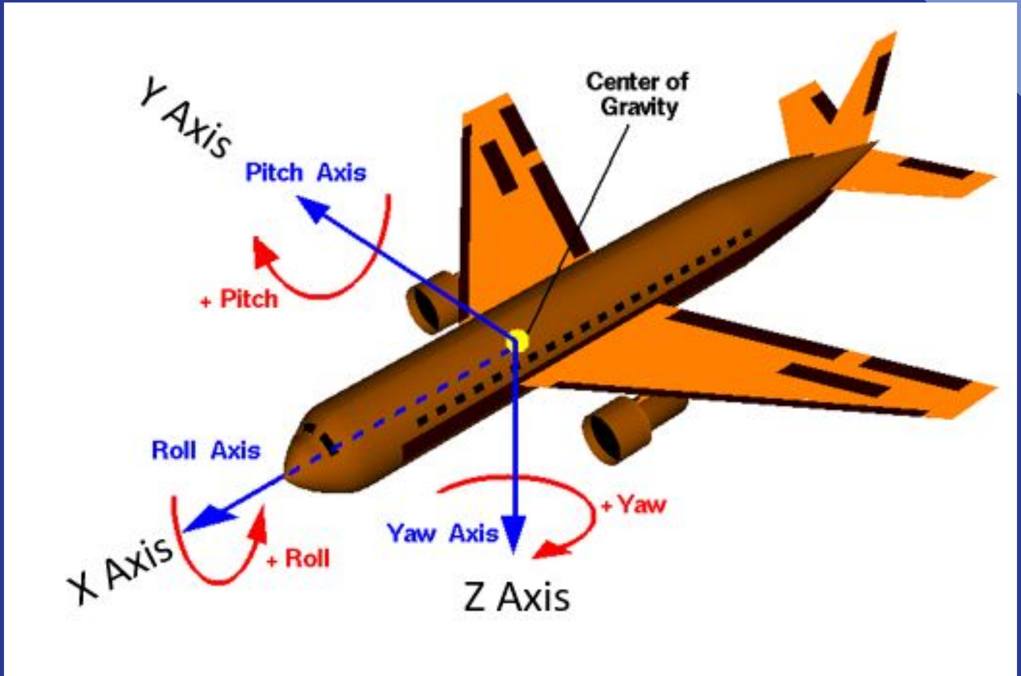
Analysis





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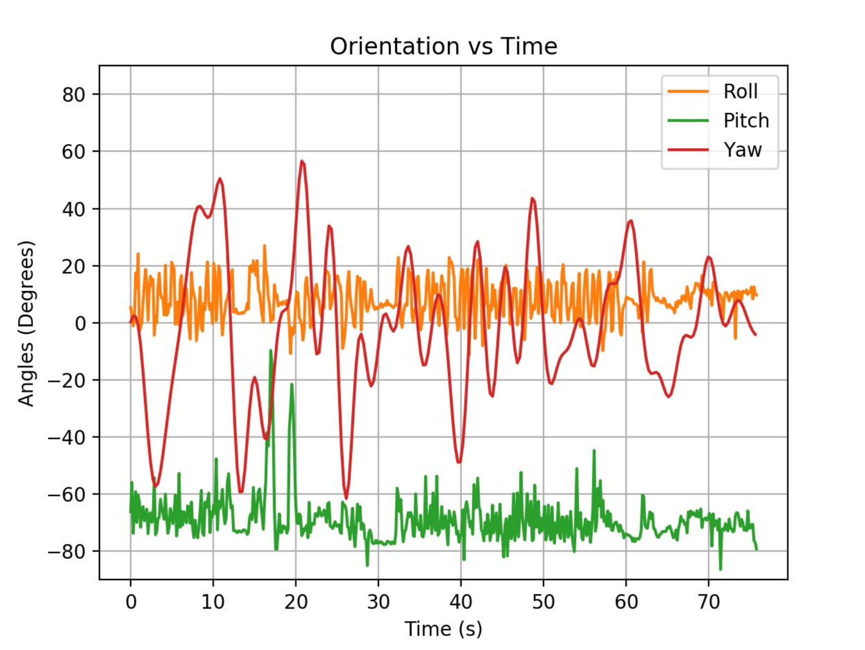
Analysis

- Orientation data gives dynamics of upper arm.
- Model of user requirements generated from data.
- Orientation data gives insight into mounting mechanisms and stability of prosthetics.



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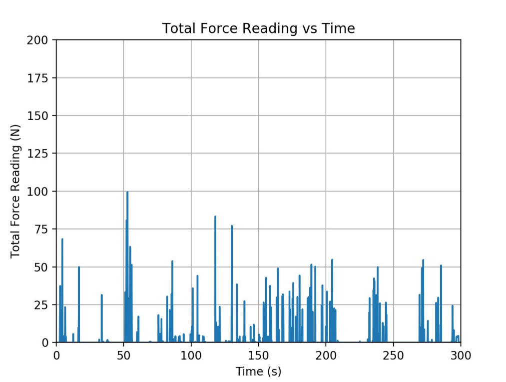
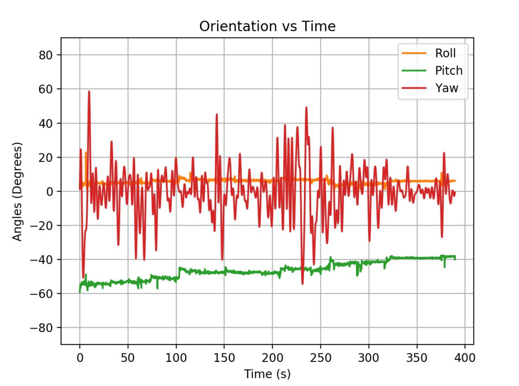
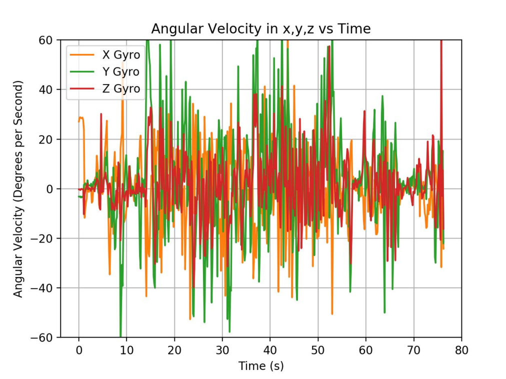
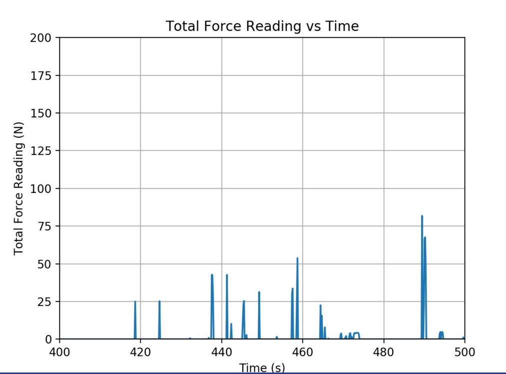
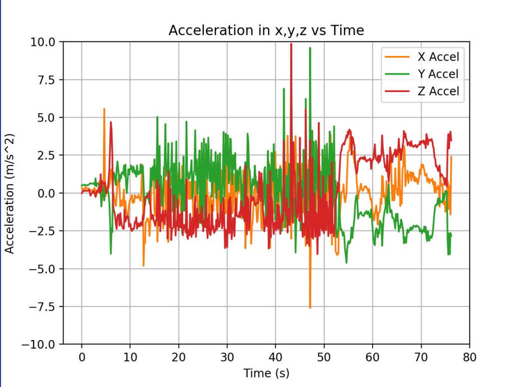
Analysis











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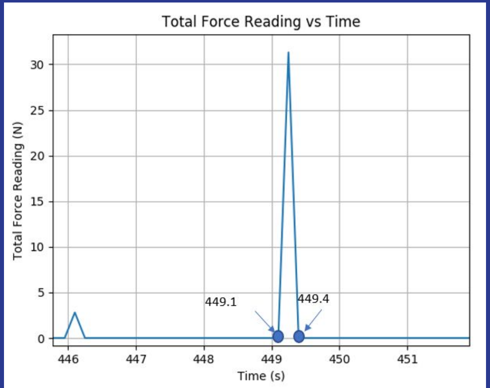
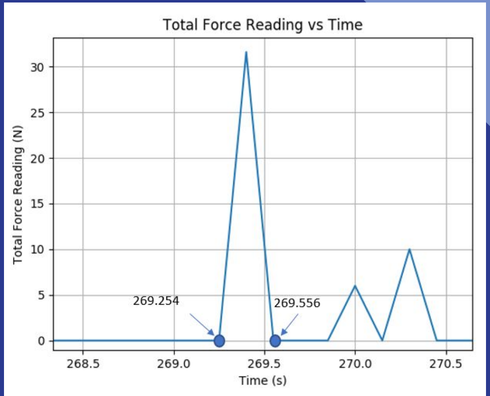
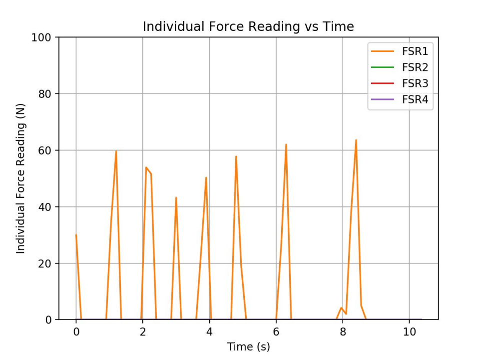
Analysis

- Tap times correspond to 0.3 seconds for both typing on the phone and the keyboard.
- Minimum sample rate 3Hz for best results must sample at twice the minimum sample rate.







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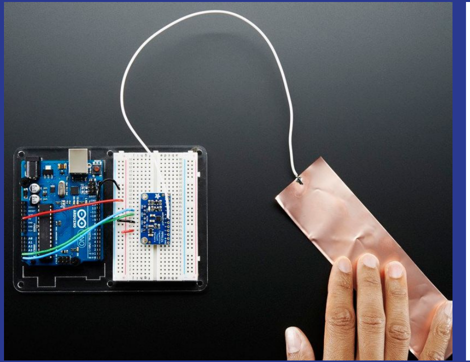
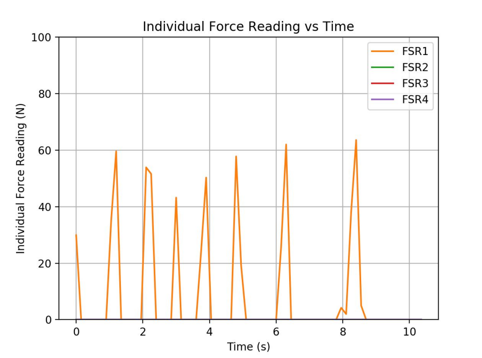
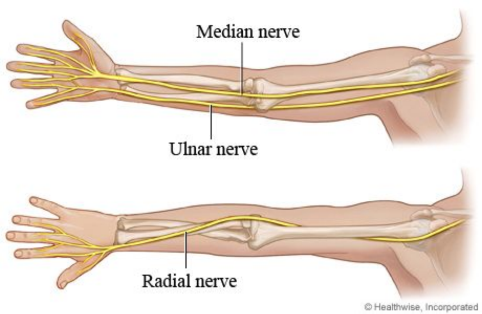
Recommendations

- Sensor instrumentation had 3 main drawbacks
  - Capacitive Touch Sensors were not ergonomic on finger tips.
  - Haptic Feedbacks were not distinguishable by the user.
  - Sample rate was too low.







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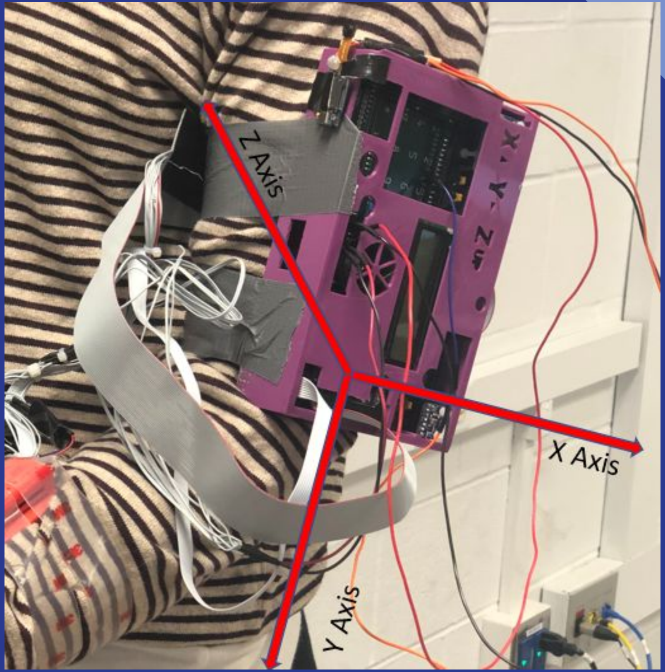
Conclusion

- Studied sensor packages that could bring functionality of a $20,000 prosthetic for $335
- Analyzed drawbacks of current prosthetics and determined rough minimum specifications for affordable prosthetics



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