ProsthetiSense

Group 10 - Axolo Metrics

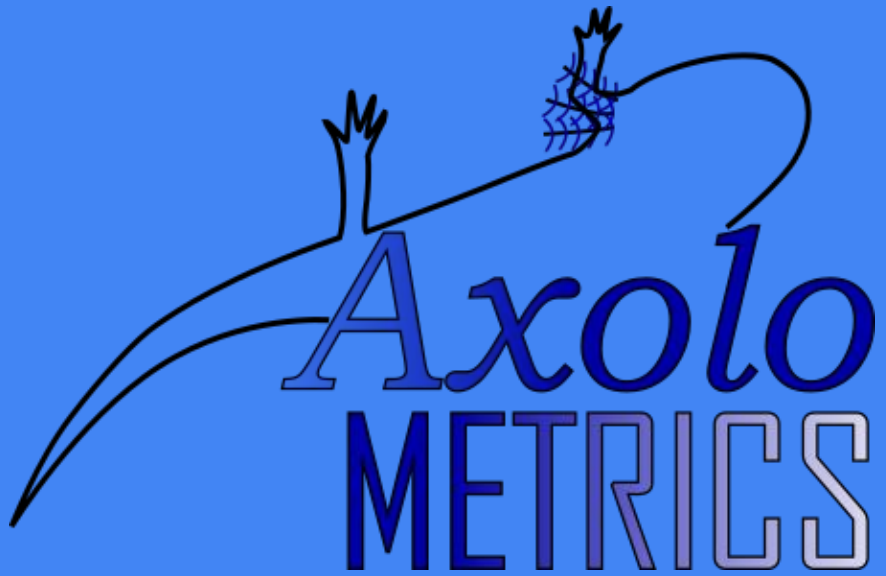
Daniel Dixon - CEO

Vijay Parameswaran - VP Hardware

Kirill Shestakov - VP Technology

Joshua Barrett - VP Software

Tanner Frison - VP Electronics



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Thank you for your understanding.

Overview

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Group Members

Daniel Dixon - Chief Executive Officer

Vijay Parameswaran - Vice President Hardware

Kirill Shestakov - Vice President Technology

Joshua Barrett - Vice President Software

Tanner Frison - Vice President Electronics

Background

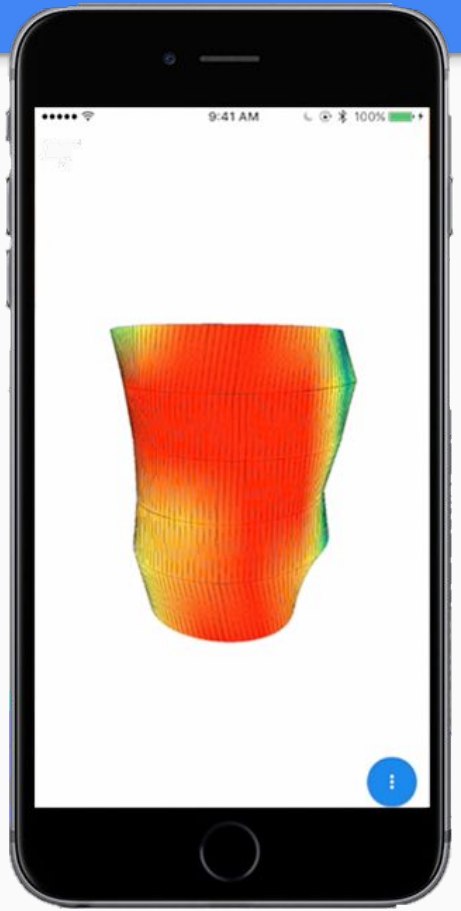
- Functioning Limbs are essential to everyday life
- Prosthetics work to provide mobility to amputees
- 2 million people living with limb loss (US)
- 54% are due to vascular disease (Diabetes) [1]

The Problem

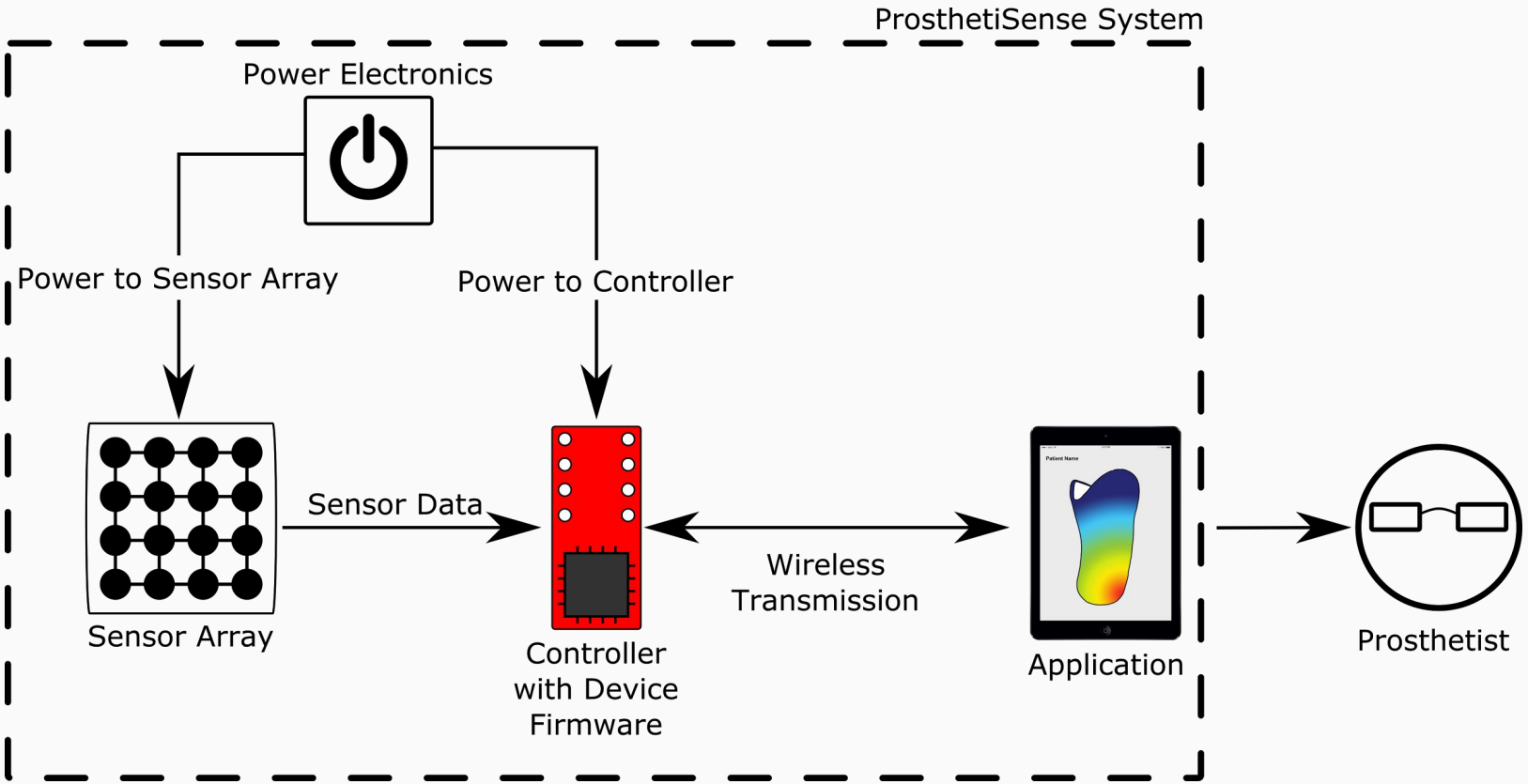
- Amputations occur when ulcers and sores go unnoticed
- Diabetes patients lose sensation in their limbs, as a result they have trouble describing areas of discomfort to their prosthetist
- Improperly fit prosthetics lead to further skin breakdown
- Barber Prosthetic Clinic looking for solution

The Solution

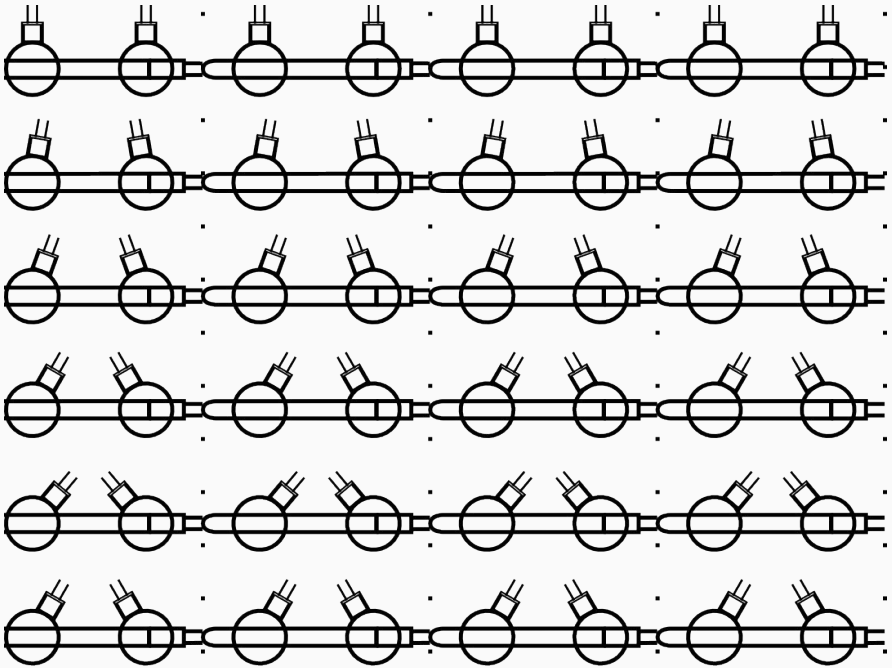
- ProsthetiSense, a tool to help prosthetists size and better fit prosthetics and determine areas where modifications should be made
- Maps forces inside the prosthetic socket
- Ideal prosthetic spreads forces equally so prosthetists can easily determine problem areas with our product



System Overview



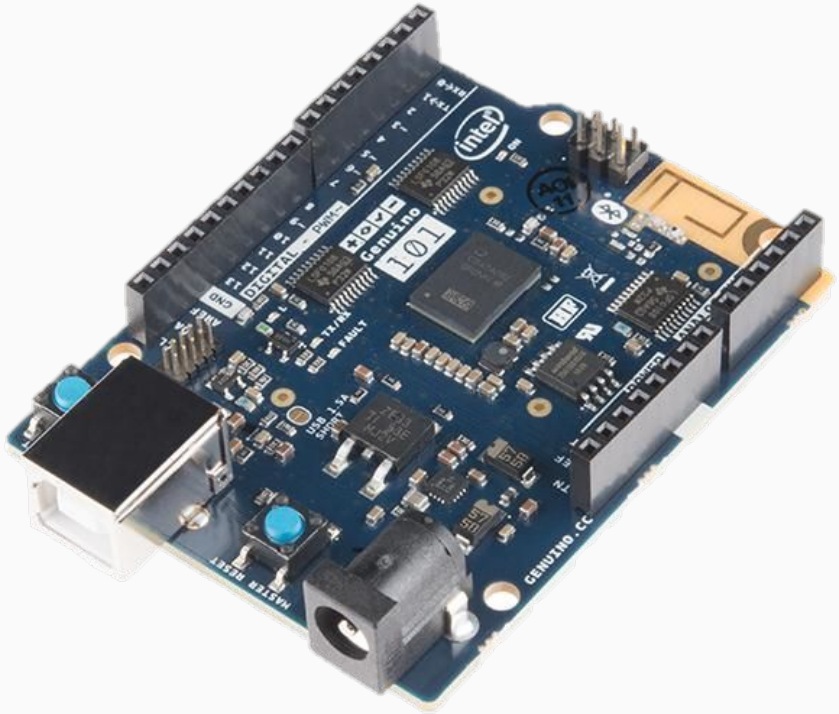
Design - Sensor Array



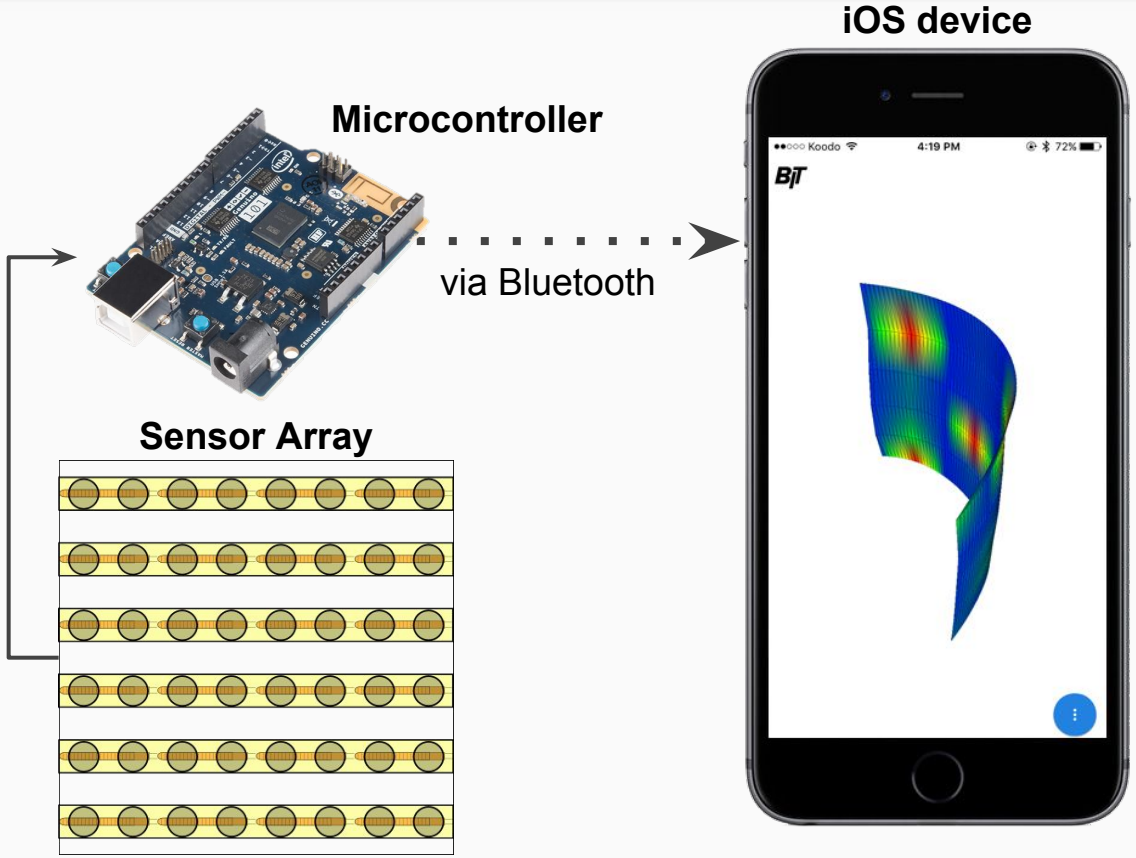
- Uses 48 Pressure Sensors and 24 Flex sensors
- Pressure Sensors measure forces against them
- Pressure Sensors are equally spaced apart
- Uses two pressure sensors per flex sensor
- Flex sensors measure the shape of the residual limb

Design - Microcontroller Firmware

- Reads the pressure sensor and flex analog data from the sensor array
- Encodes raw data for transmission
- Transmits data over Bluetooth Low Energy
- Designed for minimal computation for maximum data throughput to app



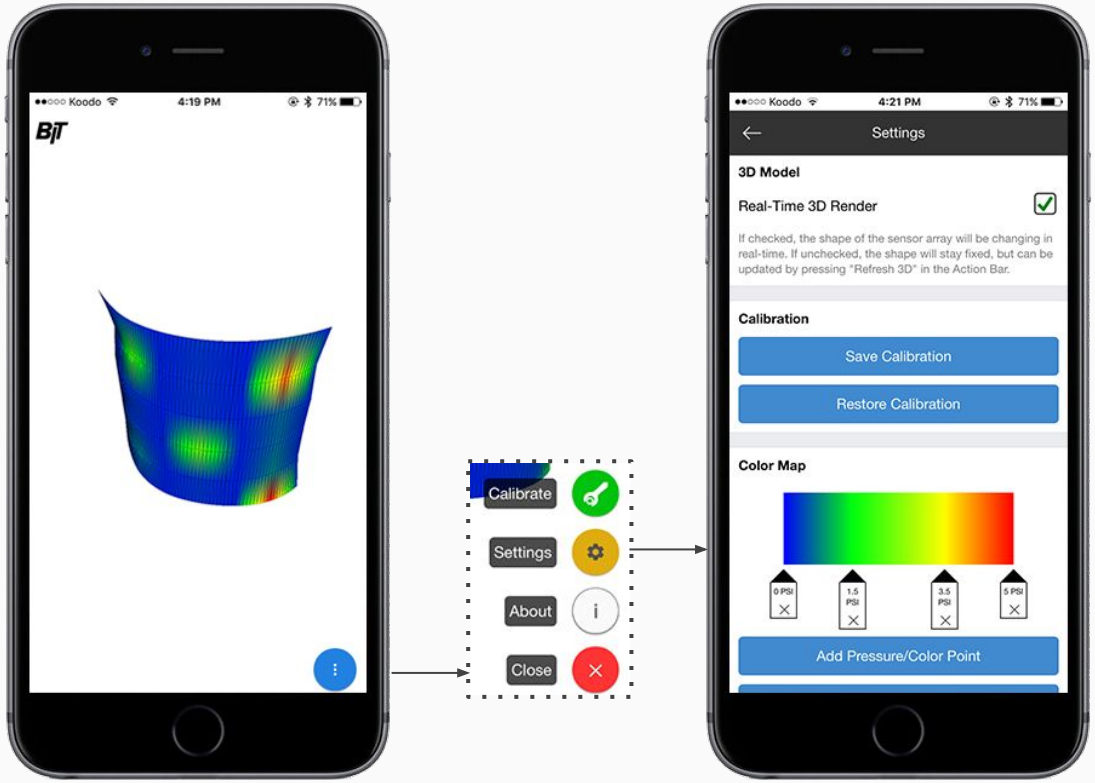
Design - iOS App



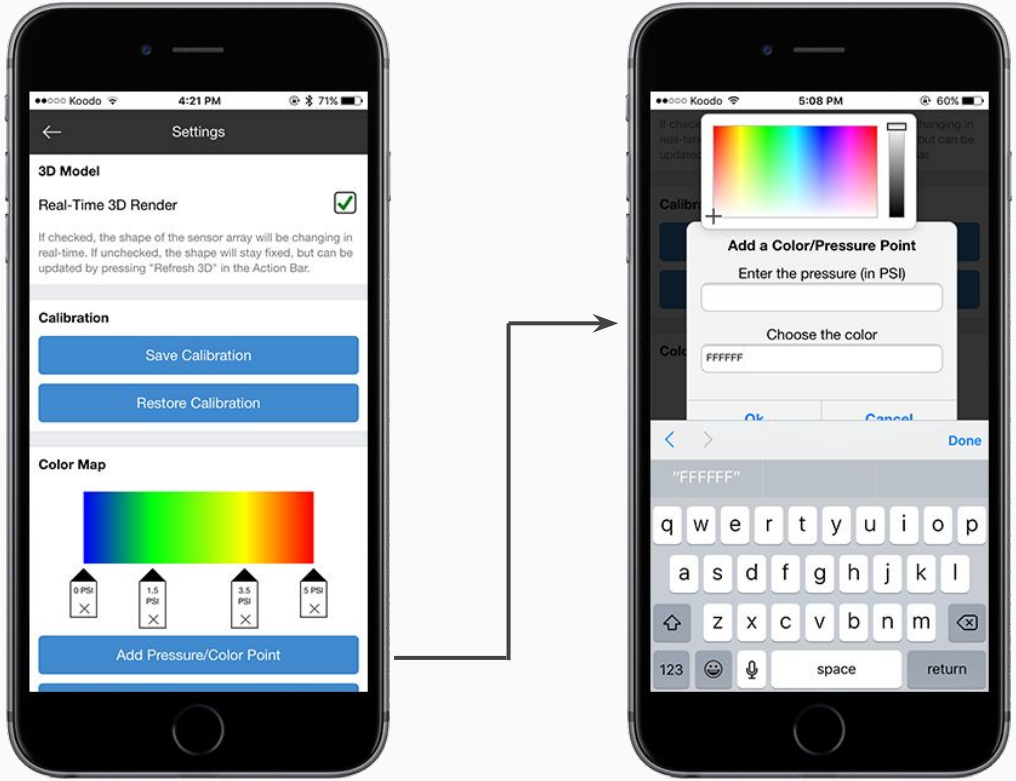
Simple Idea:

- Microcontroller takes flex and force sensor readings
- Microcontroller sends data to iOS app via Bluetooth
- iOS app performs 3D modelling

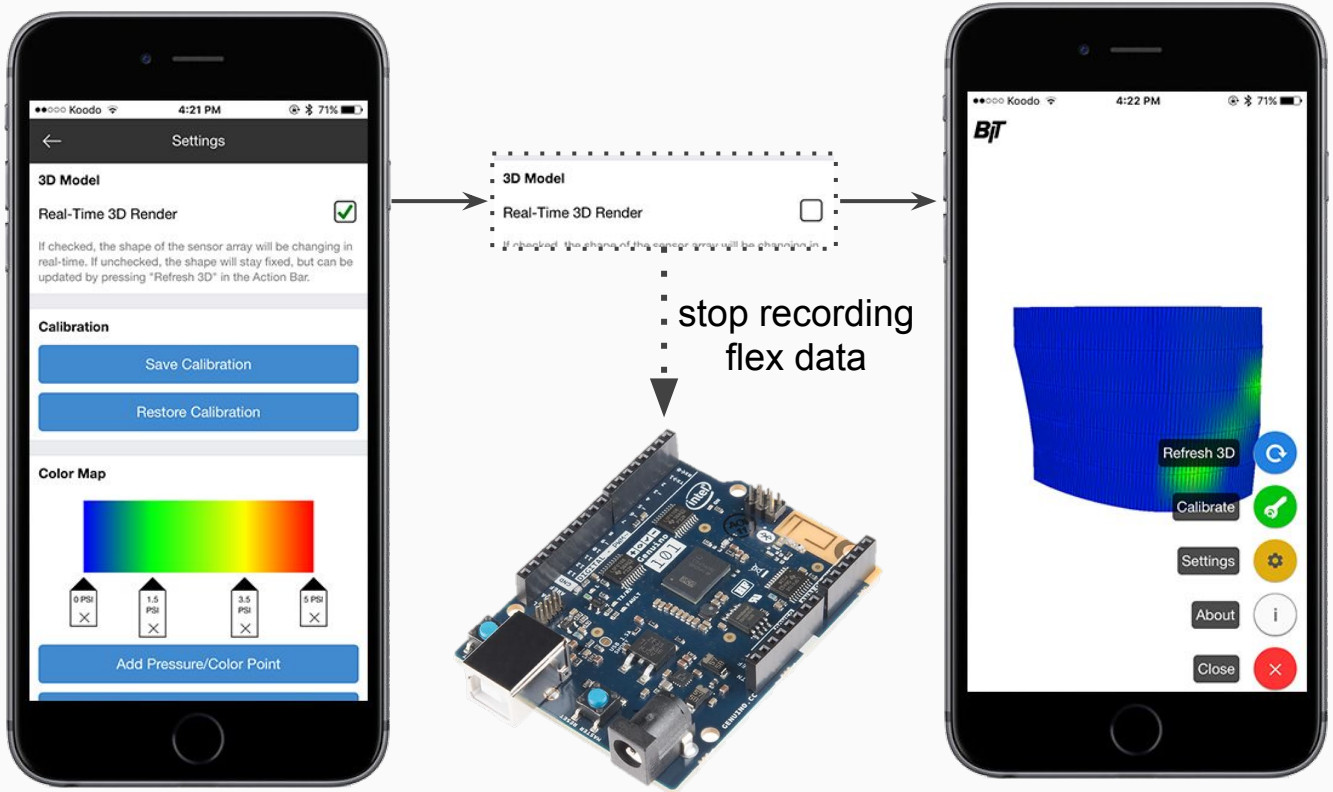
Design - iOS App - Features



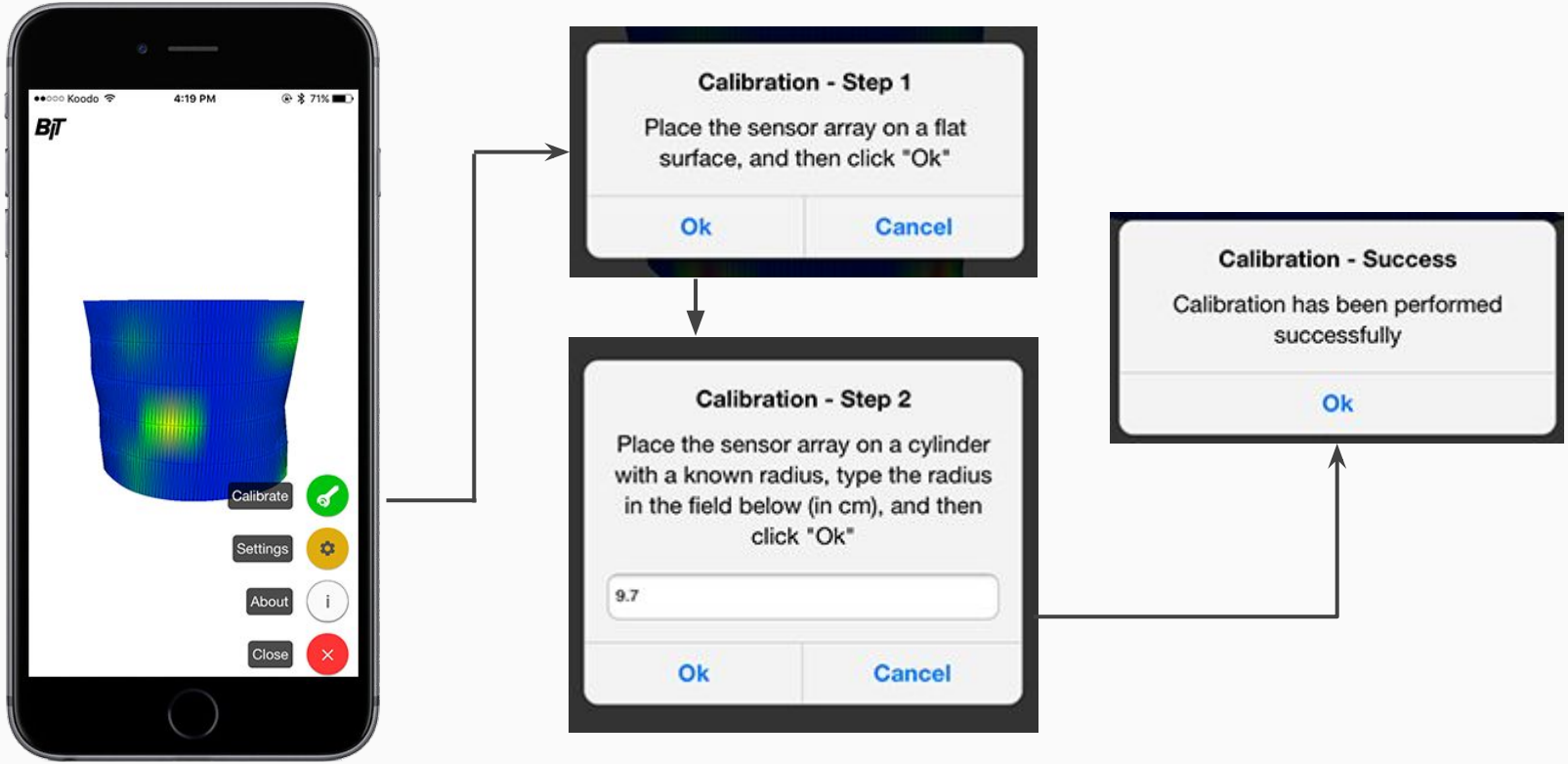
Design - iOS App - Color Map



Design - iOS App - Real Time 3D Shape



Design - iOS App - Flex Sensor Calibration



Budget

Hardware

Item	Estimated Cost	Actual Cost
Genuino 101 Microcontroller	$50	$94.71
Bluetooth LE Transceiver	$40	-
Liner Materials (Fabric)	$50	$24.11
Printed Circuit Board	$80	-
Soldering Materials	$25	-
Sensors (FSRs, Flex Sensors, and Strain Gauges)	$600	$955.33
Multiplexing Electronics	-	$15.97
Power Supply Electronics	$30	$61.37
Cypress BLE Pioneer Development Board	-	$118.29
Wiring + connectors	-	$22.70
Subtotal	$875	$1292.48

Software

Item	Estimated Cost	Actual Cost
Apple Developer License	-	$133.28
Subtotal	-	$133.28

Other Costs

Item	Estimated Cost	Actual Cost
20% Contingency	$175	-
Expedited Shipping/Handling + Duty Charges	-	$53.18
Subtotal	**$**175	$53.18

Total	$1050	$1478.94

Business Case - Proof of Concept System Price

Item	Cost
Genuino 101 Microcontroller	$47.36
Fabric Materials + Electrical Tape	$8.76
Printed Circuit Board	Thanks Gary Shum!
Sensors (Force & Flex)	$490.48 + $278.45
Multiplexing Electronics	$8.13
Power Supply Electronics	$48.66
Wires and Connectors	$11.00
Total	892.84

- We could sell this product for $1500
- Major Changes that would be required for a final product:
  - advanced sensors

Business Case - Market

- Estimated 185,000 new lower limb amputees every year (US) [2]
- Almost 30 registered prosthetics clinics in BC [3]
- Product is a proof-of-concept that has more applications

Business Case - Competition

- A couple competitors on the market already
- Pressure Guardian is the primary local competition for this product
- Uses Tekscan's FlexiForce sensors to read data from 4 spots on the limb (normal forces)
- Comes for the low price of 5000$

Business Case - Competition Cont'd

- Similar technology also created by Sandia National Laboratories
- Federally funded by the US government
- Uses proprietary sensors to measure normal and shear forces
- Liners created on a per-patient basis
- Not market available

Timeline


February 2016
March 2016
April 2016
09 12 15 18 21 24 27 30 02 05 08 11 14 17 20 23 26 29 03 06 09 12 15 18 21 24 27 30 02 05 08 11 14 17 20 23
Name
1 Information Gathering
2 General Prosthetic Tech Research
Daniel; Joshua; Kirill; Tanner; Vijay
3 Stakeholder Requirements Collection
Daniel; Joshua; Kirill; Vijay; Tanner
4 Sensor Research
Tanner; Kirill; Vijay
5 Preliminary Development
6 Write Formal Proposal
Daniel; Joshua; Kirill; Tanner; Vijay
7 Source Parts
Tanner; Daniel
8 Create App Shell
Daniel; Joshua
9 Research Implimentation Options for Sensor Array
Vijay; Kirill
10 Design Multiplexing/Power Electronics
Tanner
11 Write Functional Specification Document
Daniel; Joshua; Kirill; Tanner; Vijay
12 Development
13 Arduino/iOS Interfacing (Non-Multiplexed)
Joshua; Daniel
14 Second Round of Sourcing (If Necessary)
Daniel; Tanner
15 Implement Sensor Array
Kirill; Vijay
16 App Heat Map/GUI (Few Sensors)
Daniel; Joshua
17 Manufacture Multiplexing/Power Electronics
Tanner
18 Write Design Specification Document
Daniel; Joshua; Kirill; Vijay; Tanner
19 Develop Arduino Firmware for Multiplexing
Daniel; Joshua
20 Multiplexed Heat Map Implemenation
Joshua; Daniel
21 Write Progress Report
Daniel; Joshua; Kirill; Tanner; Vijay
22 Post-Development
23 Testing
Daniel; Joshua; Kirill; Tanner; Vijay
24 Prepare Final Presentation
Daniel; Joshua; Kirill; Tanner; Vijay

Problems Encountered - Low Transfer Speeds

- Bluetooth Low Energy designed for very small amounts of data
- Current maximum transfer speeds are 4 readings/second
- Future iterations will employ full energy bluetooth for improved data transfer speeds

Problems Encountered - Sensor “Cross Talk”

- Initially, sensors along the same column would affect each other’s readings when activated
- Circuit analysis determined problem is inherent to the design and is not actually cross talk between the sensors
- True source of error identified, understood, and mitigated with software

What we Learned - Technical Skills

Improvement of technical skills

- Bluetooth Low Energy and wireless communication
- Physical implementation of sensors
- Identifying and troubleshooting hardware issues
- Mobile app development

Writing technical documentation

- Concise and clear writing
- Proper use of figures

What we Learned - Team Dynamics

Importance of communication

- Weekly meetings and keeping the team up-to-date.
- Discussing project issues with team members

Time management

- Balancing capstone obligations with requirements of other courses.
- Not biting off more than you can chew

Conclusion - What did we achieve?

A functional proof of concept.

- Flex sensors could be used for 3D Modeling of a patient's residual limb
- Pressure sensors can be used for pressure detection on the residual limb
- Sensor data can be transmitted and modeled in near real time

Positive Reception from Prosthetists

- "I would use this as part of every patient's fitting process" - Loren at Barber Prosthetics

Conclusion - Moving Forward

- Carried on by Barber Prosthetics and BioInteractive Technology

Acknowledgements

- Lukas-Karim Merhi and BioInteractive Technologies
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  - Jamal Bahari
  - Mahssa Abdollahi
  - Mona Rahbar
  - Soroush Haeri

References

[1] Amputee Coalition, “Limb Loss Statistics”, 2015 [Online]. Available: http://www.amputee- coalition.org/limb-loss-resource-center/resources-by-topic/limb-loss-statistics/limb-lossstatistics/. [Accessed: 11-Apr-2016]

[2] Advancedamputees.com, "Amputee Statistics You Ought to Know", 2016. [Online]. Available: http://www.advancedamputees.com/amputee-statistics-you-ought-know. [Accessed: 24-Jan- 2016].

[3] "Organizations | Orthotics Prosthetics Canada (OPC)", *Opcanada.ca*, 2016. [Online]. Available: http://www.opcanada.ca/english/resources/organizations.html. [Accessed: 11- Apr- 2016].

Image References

- Image Courtesy of the US Army: https://commons.wikimedia.org/wiki/File:Flickr_-_The_U.S._Army_-_U.S._Army_World_Class_Athlete_Program_Paralympic.jpg (Running Amputee Image)
- http://www.aofas.org/footcaremd/treatments/Pages/Below-Knee-Amputation.aspx (Residual Limb Image)
- https://cdn.sparkfun.com//assets/parts/1/1/4/5/7/13788-01.jpg (Genuino Image)
- https://www.tekscan.com/sites/all/themes/tekscan/images/logo.svg (Tekscan Logo)
- http://www.pressureguardian.com/images/logo.gif (Pressure Guardian Logo)
- https://www.tekscan.com/sites/default/files/images/group/banner/embedded-sensing-force-sensors-banner.jpg (FlexiForce Image)
- http://newton.physics.uiowa.edu/~sbaalrud/images/sandia_logo.jpg (Sandia National Labs Logo)
- http://www.sandia.gov/research/robotics/_assets/images/thumbnails/pressure_measurement.png (Sandia's Sensor)
- http://mbientlab.com/blog/wp-content/uploads/2014/01/bluetooth-4.0.jpg (Bluetooth 4.0 Logo)
- http://www.barberprosthetics.com/~barber1/images/logo.png (Barber Prosthetics Logo)
- http://static1.squarespace.com/static/5580f341e4b0f9f986f9eaeb/t/55f65d99e4b02b9a7bddb89b/1457559924661/?format=1500w (BioInteractive Technologies Logo)

Questions?