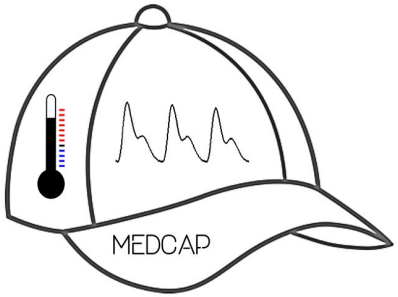


MedCap

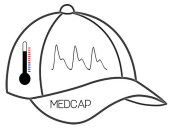
Matt Allen
Michael Balourdas
Nicole Barcori
Miheer Bavare
Tyler Nguyen
Raj Patel

Motivation

- Everyone who spends long periods of time in the sun is at risk for heat illness, especially those who are extremely active
- Every person has a different tolerance for heat, based on a wide variety of factors
- Estimated 9,000 heat related events in high school athletes annually leading to death and disability

Accomplished Requirements: Shall

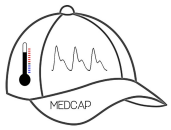
- ✓ Gathered body metrics to determine heat illness
- ✓ Transmitted sensor data from microcontroller to smartphone app
- ✓ Stored and processed data for immediate and historical trends
- ✓ Output a red, yellow, or green to indicate user's stress level
- ✓ Graphs have been displayed to track trends in levels of heat stress



Accomplished Requirements: Will

- Send a text message/alert to directly alert user and user's followers
  - ✓ Alert sent to wearer of the MedCap via an LED in peripheral vision

✓ Use machine learning to better estimate blood pressure from PPG data



Design Process

1. Research - Indication and Processing
2. Cap Design
3. Selecting/Testing Parts
    a. Integrating code
    b. Designing circuitry
4. Ensuring a secure solution
5. Transferring data real-time
6. Storing and analyzing data
7. Displaying and alerting

Design Process: Indication Algorithm

- Heat illness determined by three measurements
  - Independent
  - Weighted
- Data stored and analyzed
  - Organized for raw and processed
  - Processing framework
- Analysis based on data over time
  - Change in MAP
  - Core temperature
  - Local heat index

$$weights: 0 < w_3 < w_2 < w_1 < 1$$

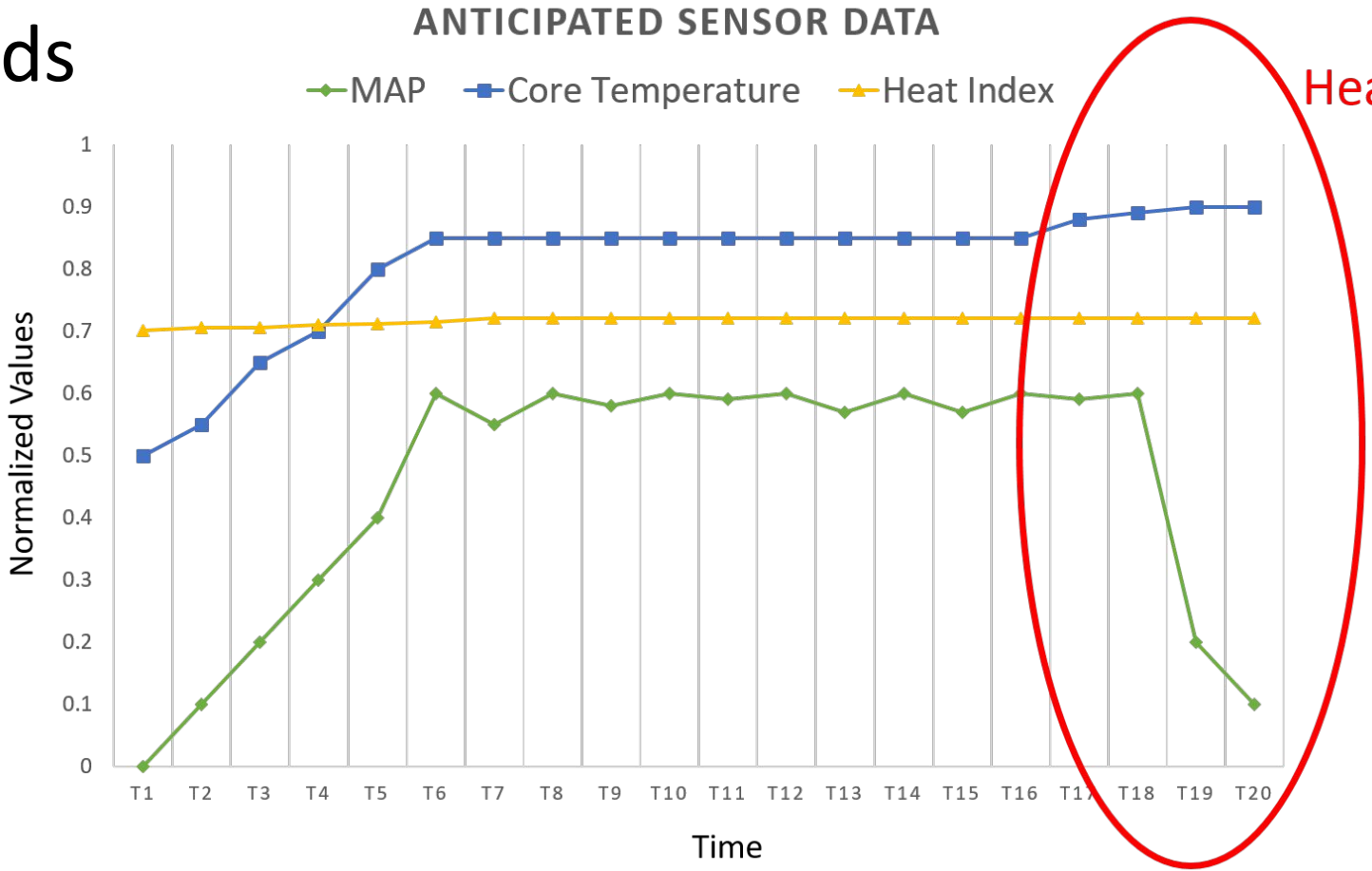
$$m_1: mean\ arterial\ pressure$$

$$m_2: core\ temperature$$

$$m_3: heat\ index$$

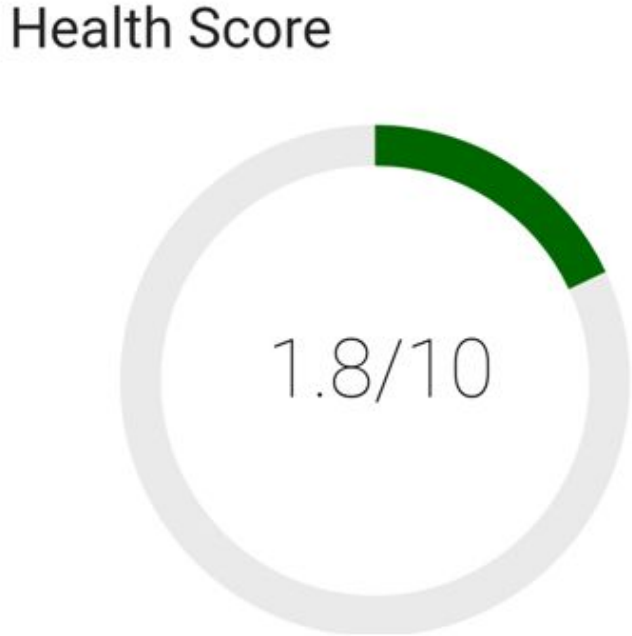
$$\sum_{i=1}^{3} w_i * m_i$$

Trends


ANTICIPATED SENSOR DATA
MAP
Core Temperature
Heat Index
Heat Illness
Normalized Values
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
T16
T17
T18
T19
T20
Time

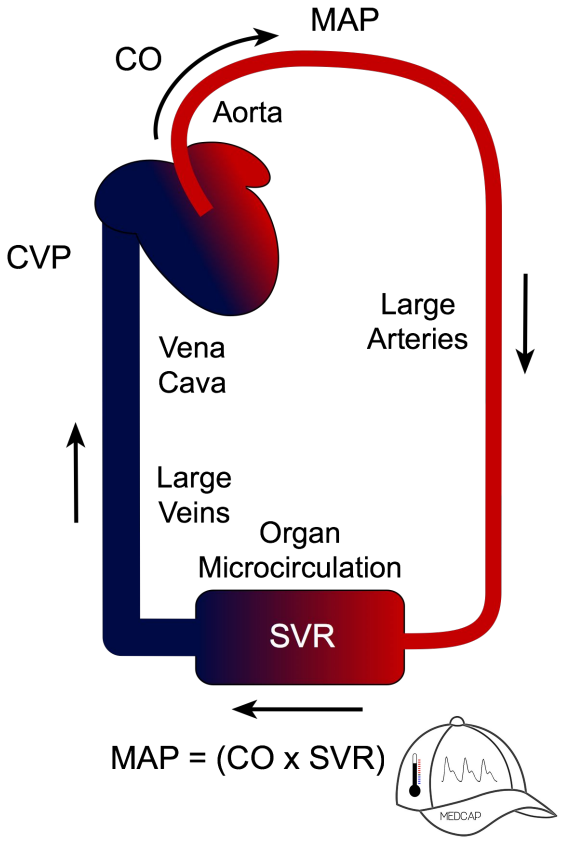
Design Process: Heat Level Score

- Heat level ranges from one to ten



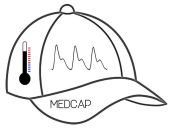
Design Process: Medical Research

- Heat Stress -> Body produces excess heat through muscle contractions
- Clinical Definition of Heat Stroke
  - Core temperature of 40°C+
- Thermoregulation through cardiovascular system

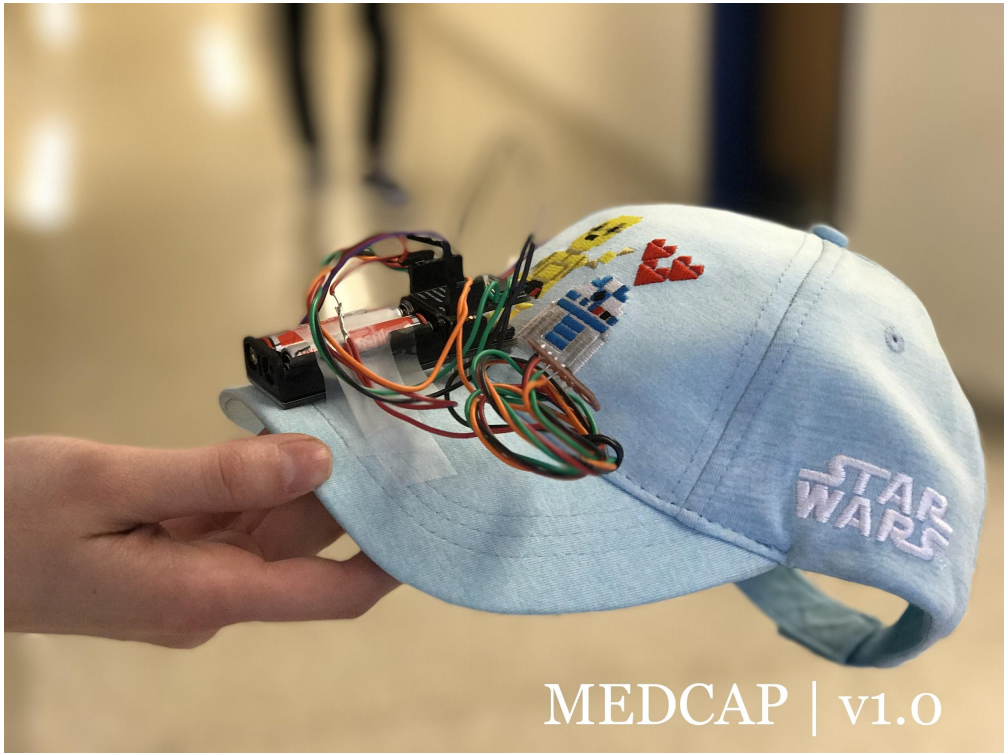


Design Process: Sensing Data

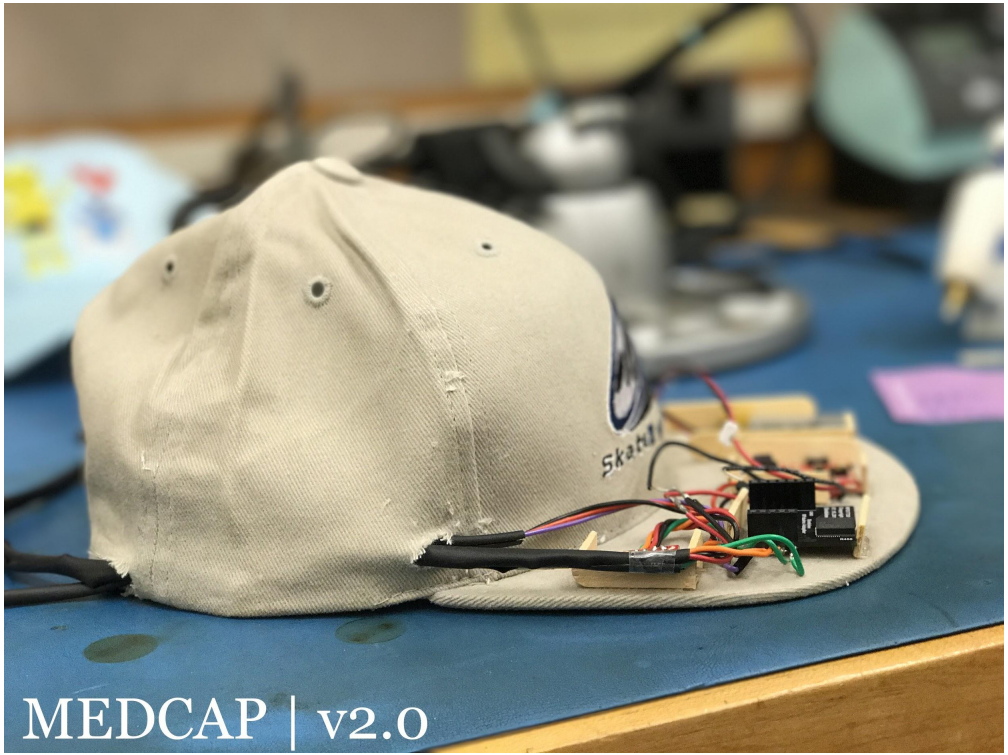
- Problem: Core Temperature is not sufficient to ***solely*** determine heat illness early
- Solution: Team focused on Cardiac Output
  - Currently done in lab using Co2 or sweat output
- PPG to Blood Pressure as cardiac output estimator
  - Directly maps arterial pressure curve and thus can be used as cardiac output estimator
- We expect to see BP decline over time as body cannot sustain thermo regulation indefinitely



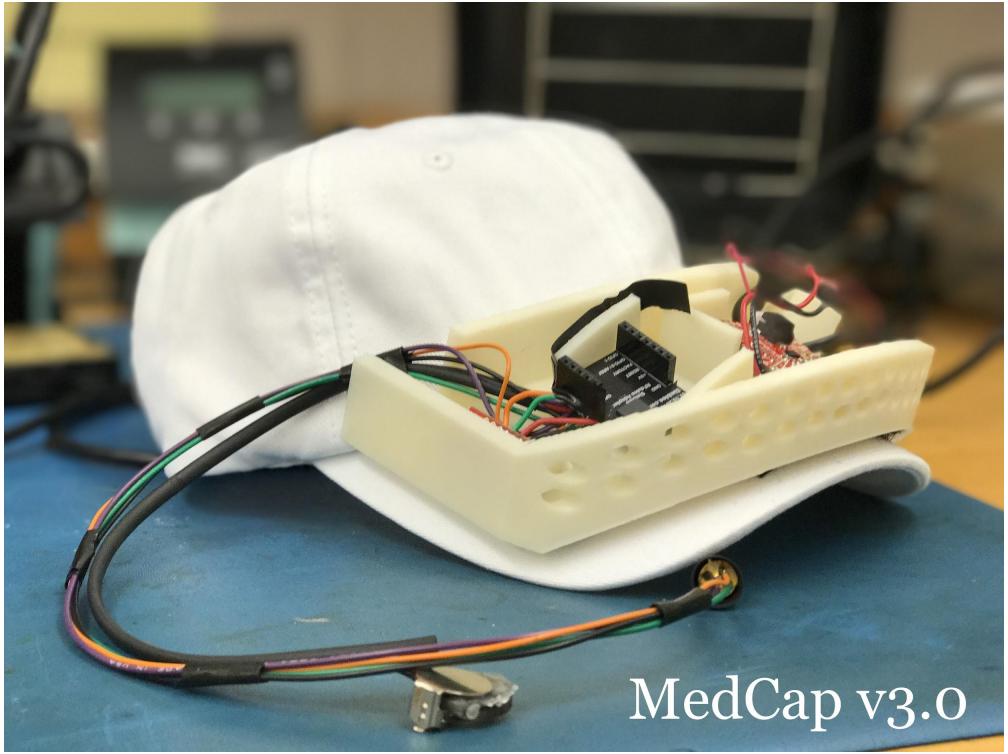
Product Stage - Version 1



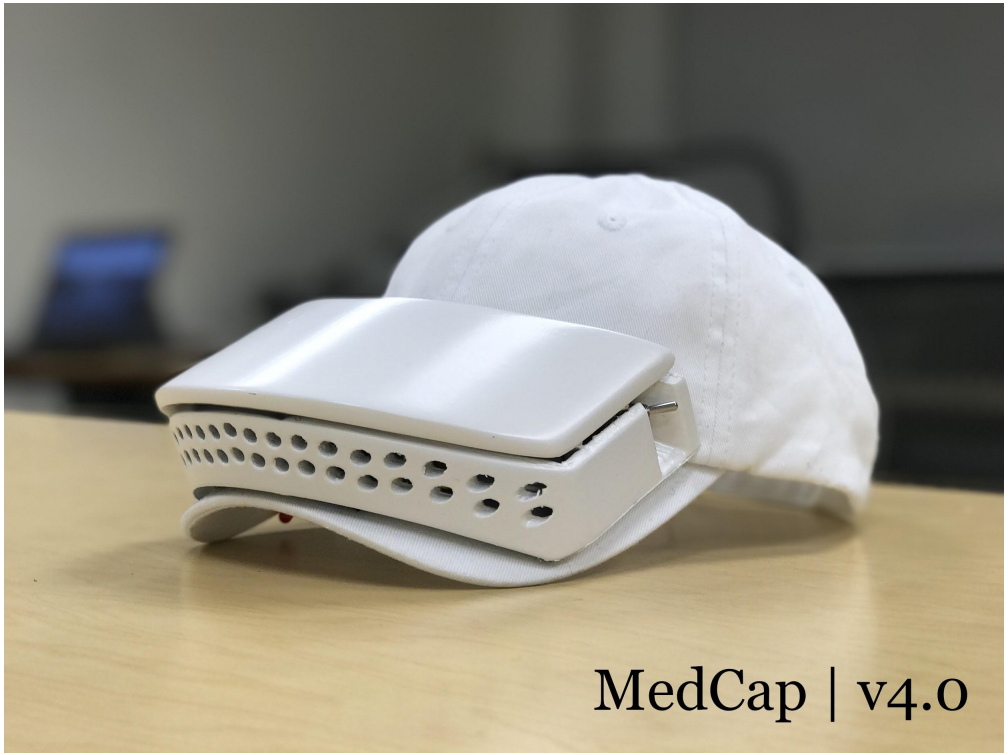
Product Stage - Version 2



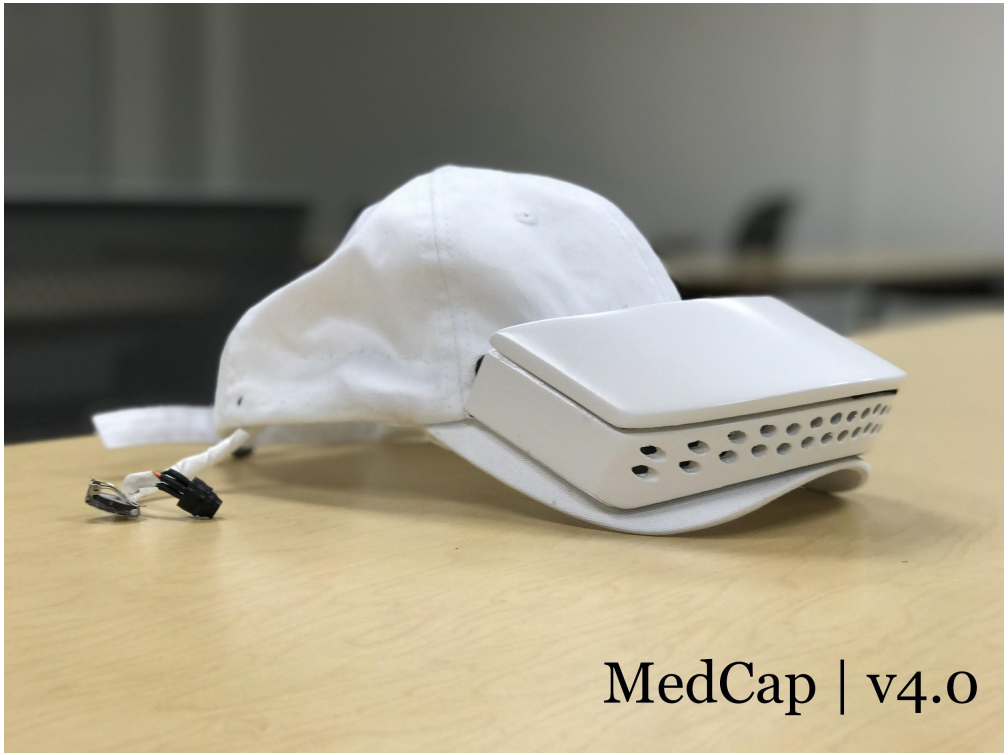
Product Stage - Version 3



Product Stage - Version 4 (Final)

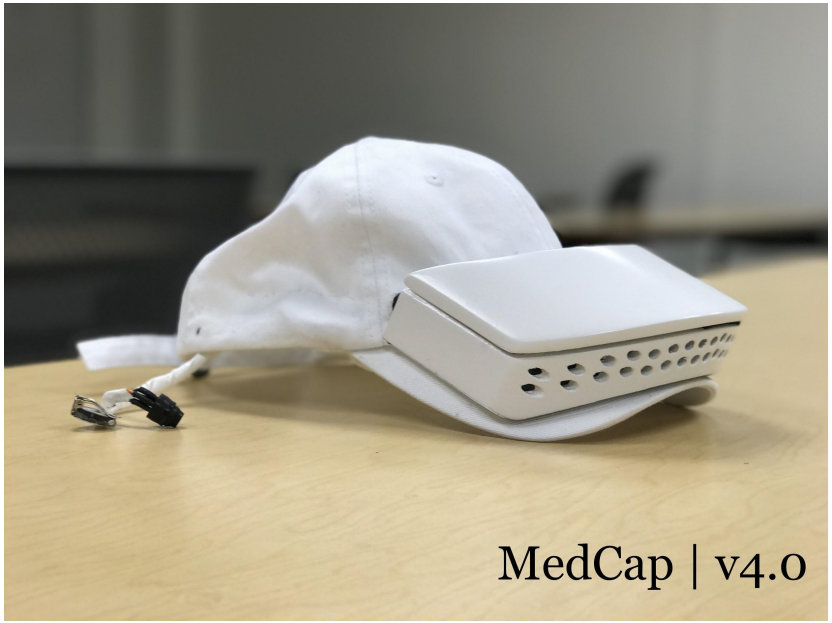


Product Stage - Version 4 (Final)

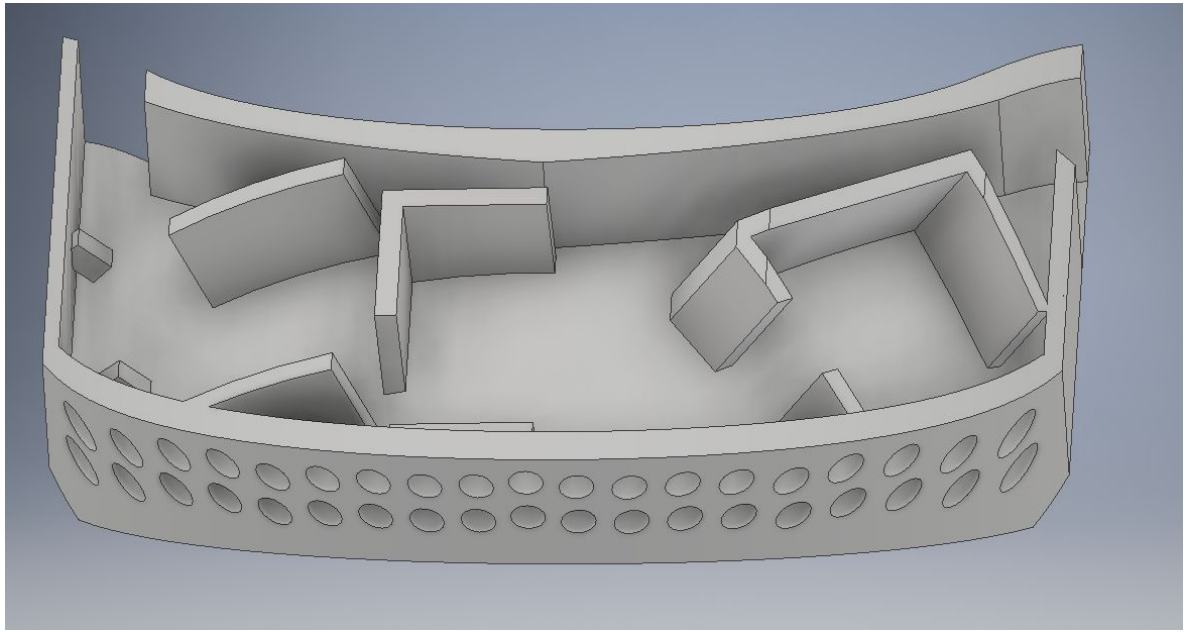


Design Process: Cap Design

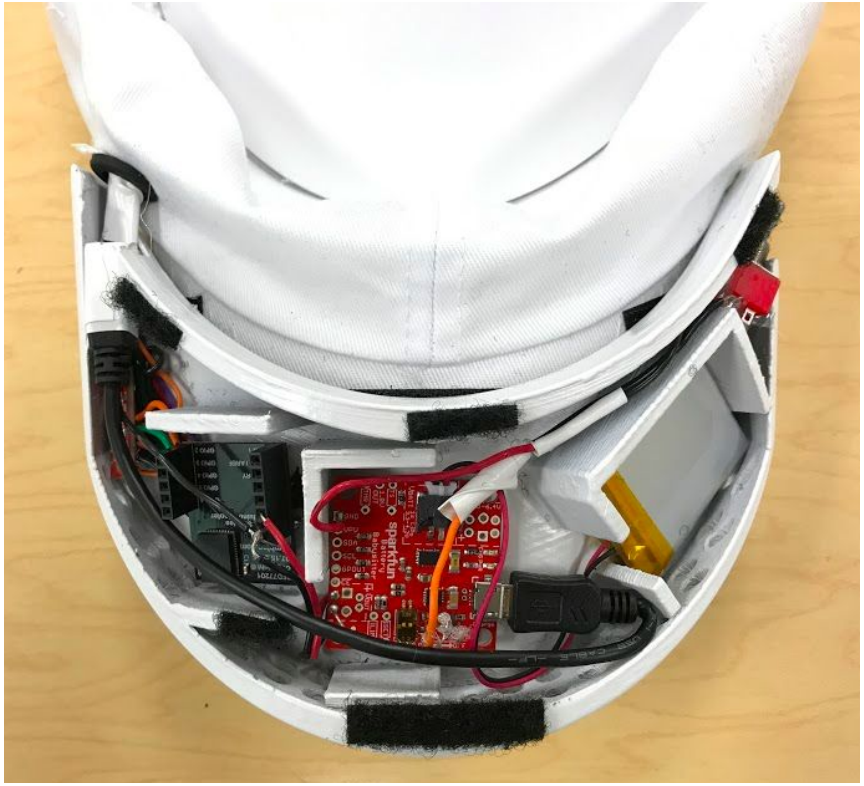
- Can be added to any hat with minimal modification
- Soft cap compatibility
- One-size-fits-all
- 3-D Printed Enclosure
- LED Indicator



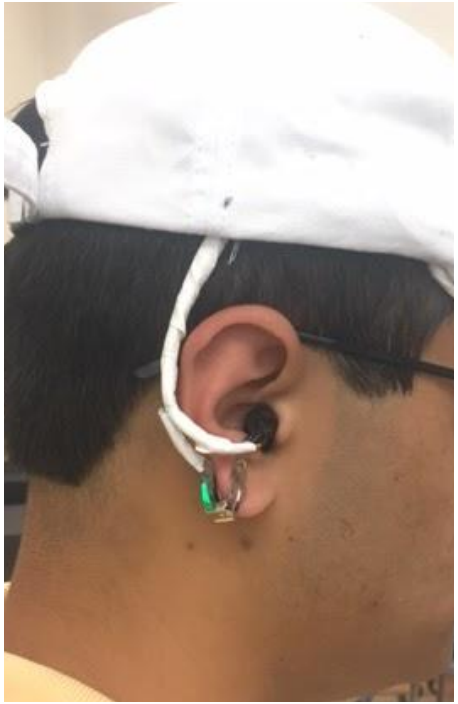
Housing CAD



Printed Housing

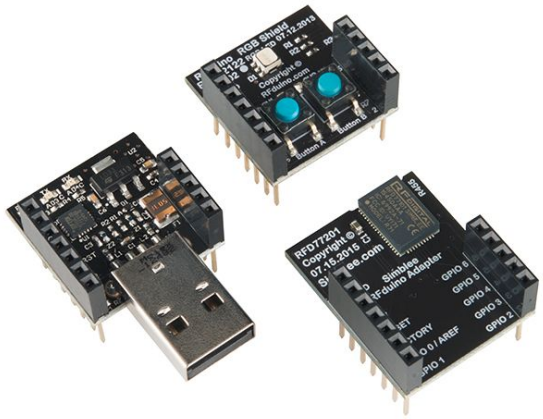


Ear Piece



Design Process: Microcontroller

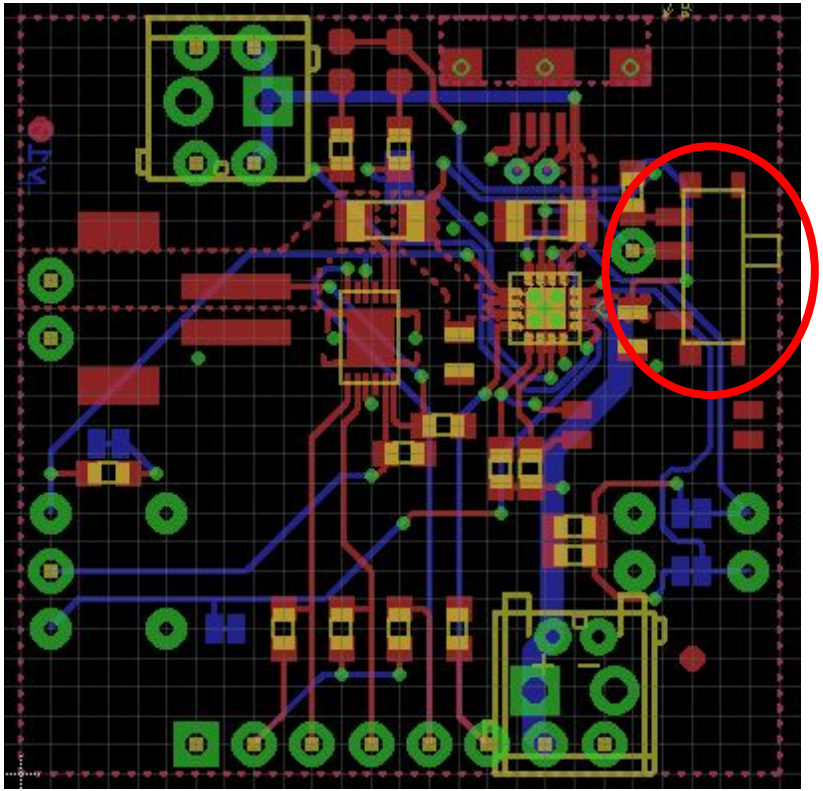
- 7 configurable GPIO pins
  - DI/DO, I2C, etc
- I2C capability on all GPIO pins
- Removable development module
- 10-bit analog input capable
- Built in BLE antenna w/ ~ 100m range
  - 2.4-2.48 GHz band



Design Process: Battery/ Power

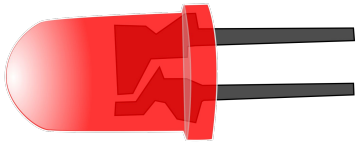
- Circuit pulls 7.2mA → fully loaded
- Lithium-ion battery powers the circuit
  - 850mAh
  - Rechargeable
  - Low profile
- Battery Life: ~118 hour battery life (minimum)
- ON/OFF switch electrically extended for ease of use

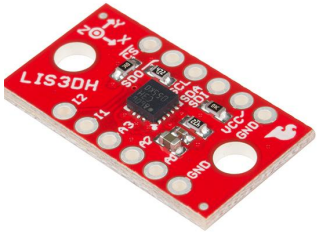
Design Process: Switch extension



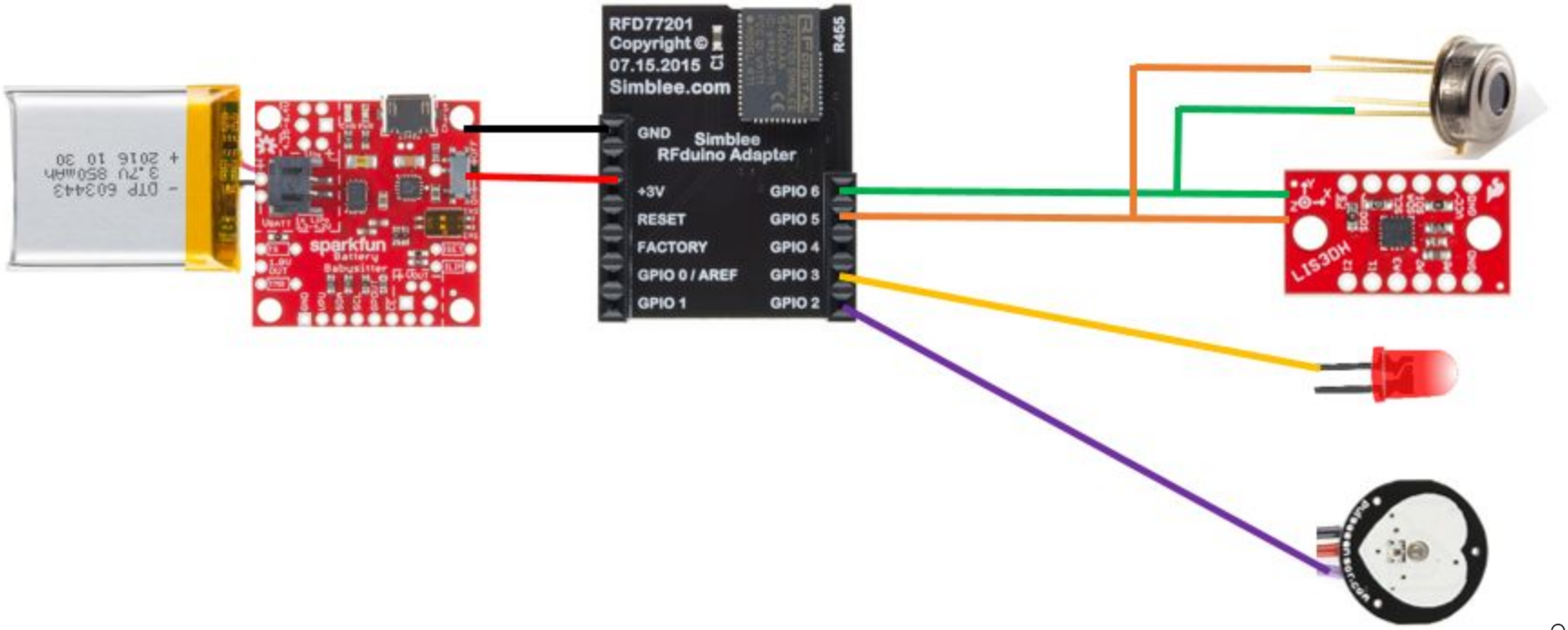
Design Process: Electrical Sensors/Design

- Sensor Selection
  - I2C Bus and Analog Signal Types
- How and Why Do the Sensors Communicate
  - Bluetooth Low Energy
- Alerting User with Red LED





Wiring Diagram



Building Security into MedCap

- Enforced 256-bit encrypted data link between mobile device and cloud
- Enforced unique sequence numbered messages
- Leveraged HIPAA compliant Amazon Web Services
  - EC2 and DynamoDB
- Separated SPI (Sensitive Personal Information) from health metrics
  - Relationship between SPI and health metrics via user aliasing

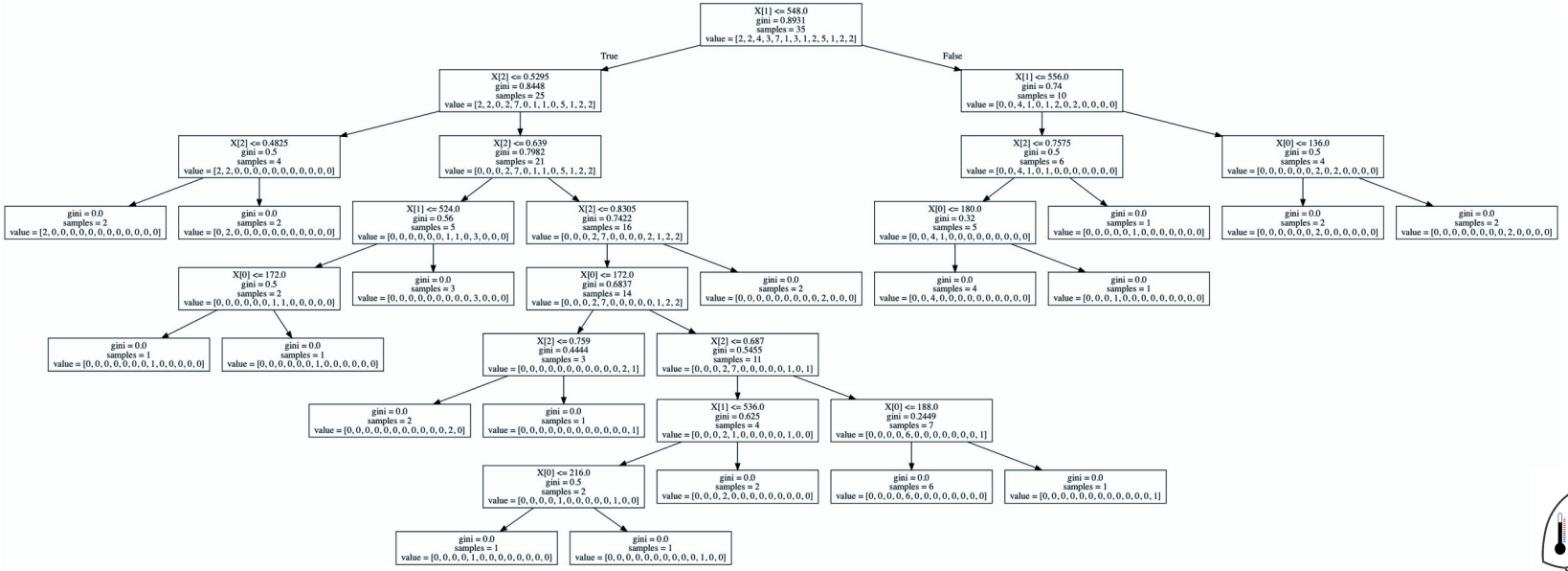
HIPAA COMPLIANT HOSTING

amazon web services | Partner Network
ADVANCED CONSULTING PARTNER
HEALTHCARE COMPETENCY

MEDCAP

Design Process: Mapping PPG to Diastolic BP

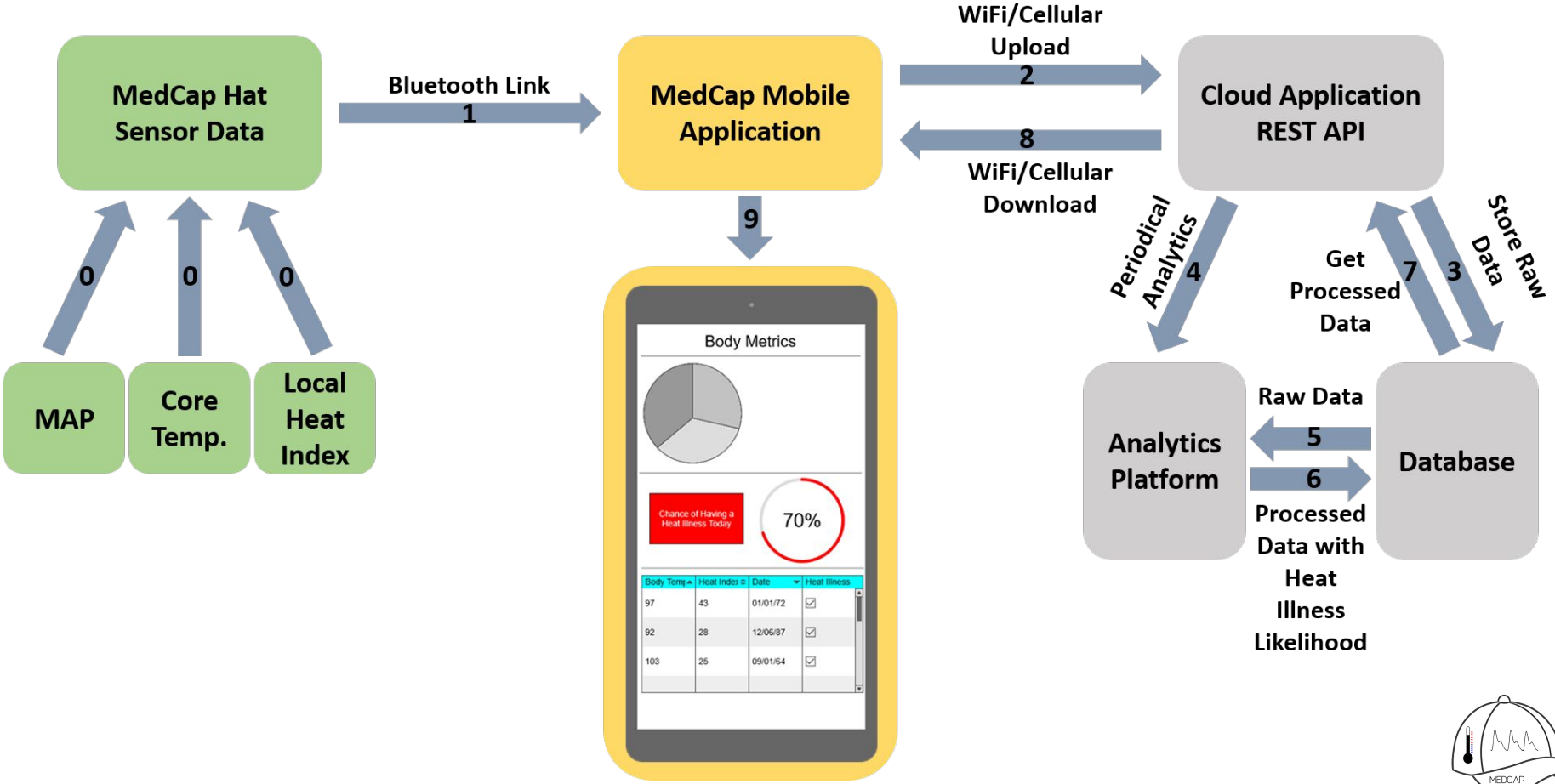
- Initially researched linear relationship: **30% accuracy**
- Progressed to clustered machine learning: **30% accuracy**
- Finalized on decision tree machine learning: **85% accuracy**



Design Process: Data Processing

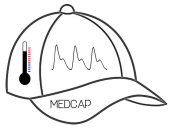
- Raw data points received by MedCap Mobile Application
  - REST API
- Input into unprocessed database table
- Analytics framework pulls from unprocessed data queue
  - Poll from the last *n* seconds
  - Scan for differences and values
- Gather processed data and consolidate time intervals
- Input into processed data queue
- Processed data available to MedCap Mobile Application

Data Flow and Cloud Architecture

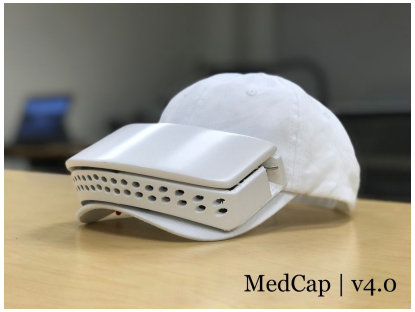


Design Process: User Interface

- Ionic
  - Reusable components, multiple platforms
- Open-Sourced Bluetooth Integration Modules
- UI/UX will be derived from Fitbit’s mobile application
  - Graphs, Tables, and Interactive Flowcharts
  - Minimalistic
- User Profile
  - Login
  - Handle multiple users

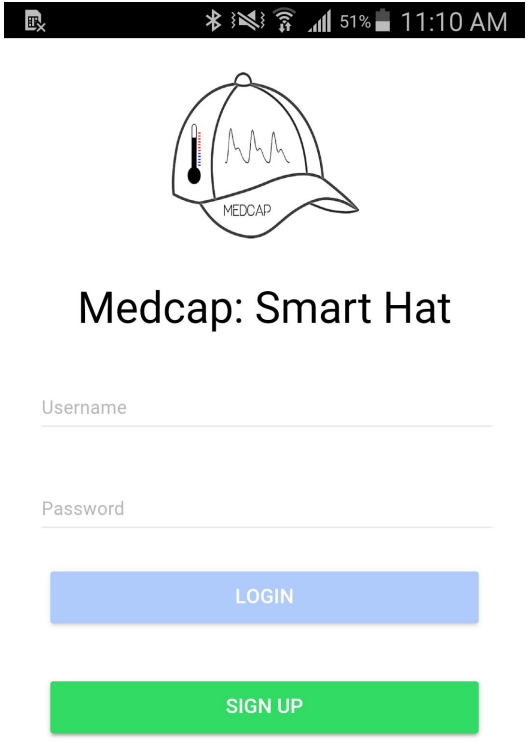


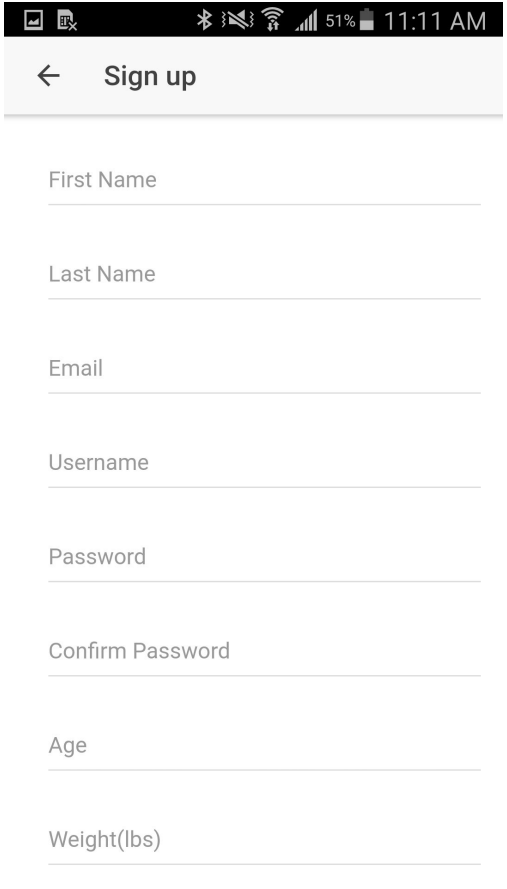
Design Process: Real-Time Data

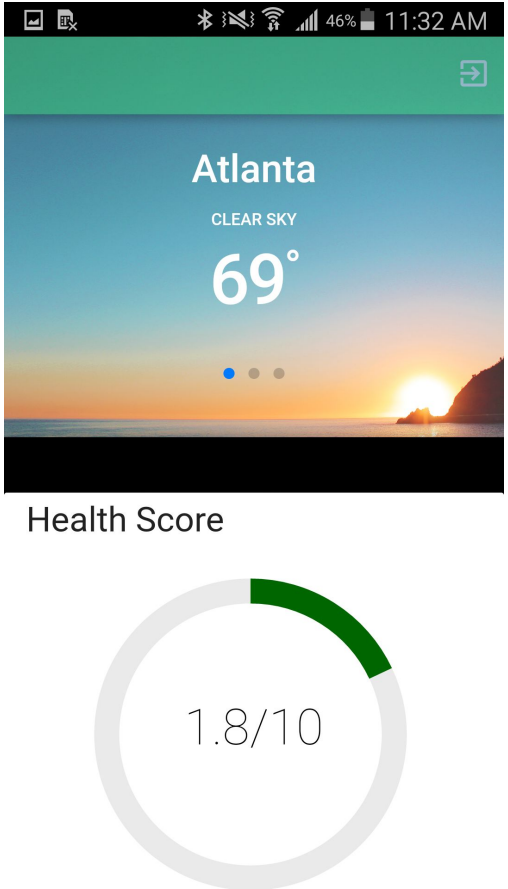


Every 10 Seconds

Every 10 Seconds
Receive and Send


51% 11:10 AM
MEDCAP
Medcap: Smart Hat
Username
Password
LOGIN
SIGN UP


51% 11:11 AM
Sign up
First Name
Last Name
Email
Username
Password
Confirm Password
Age
Weight(lbs)

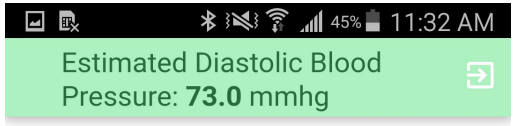

46% 11:32 AM
Atlanta
CLEAR SKY
69°
Health Score
1.8/10

MEDCAP

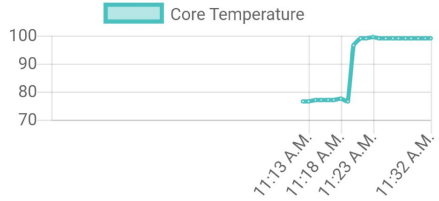
Health Score

Core Temperature: **99.16** ˚F

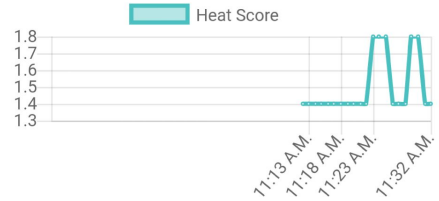
Estimated Diastolic Blood Pressure: **73.0** mmhg

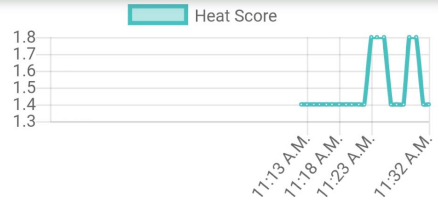


CORE TEMPERATURE



HEAT SCORE





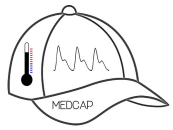
Tips for Avoiding Heat Illness

To prevent heat related illness and fatalities:

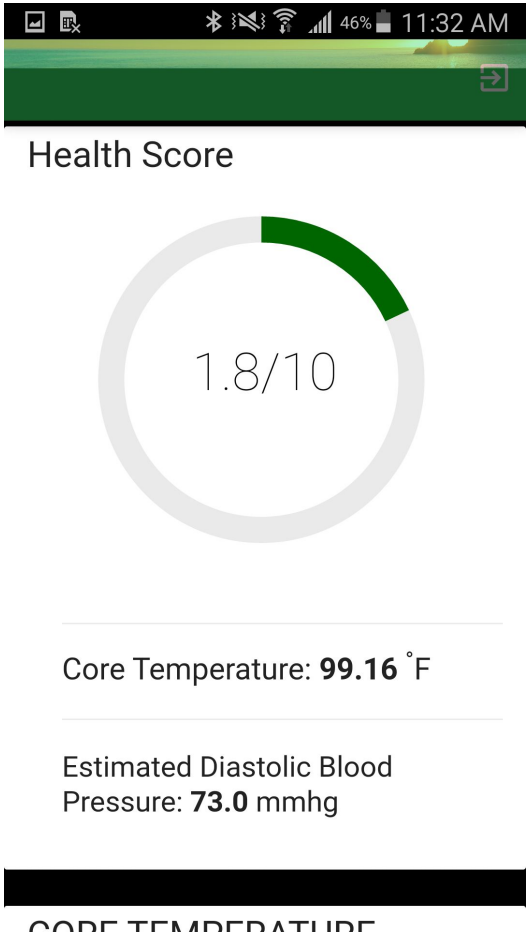
Drink water every 15 minutes, even if you are not thirsty.

Results: Raw Data

timestamp	core_temp	diastolic_time	heatIdx	humidity	peak_voltage	systolic_time	temperature
2017-04-19 17:51:47	98.9571428571	315.571428571	72	73	533.285714286	144.142857143	71
2017-04-19 17:51:07	99.2666666667	365	72	73	576	121	71
2017-04-19 17:54:07	99.6	335	72	73	513	144	71
2017-04-19 17:59:49	99.2	312	72	73	961	157	71
2017-04-19 18:03:17	99.7333333333	365	72	73	643.111111111	145	71
2017-04-19 17:53:37	99.725	343	72	73	679.25	292	71
2017-04-19 17:50:07	99.86	350.8	72	73	691.4	178.8	71
2017-04-19 17:55:37	99.8	313	72	73	541	239	71
2017-04-19 18:00:37	98.6266666667	389	72	73	898.2	206.066666667	71
2017-04-19 17:56:17	99.7	359	72	73	527.4	121	71
2017-04-19 18:00:47	98.4714285714	389	72	73	817.142857143	135.142857143	71
2017-04-19 17:50:57	99.2625	324.375	72	73	591.75	166.625	71



Results: Processed Data



Future Improvements

- Design PCB to make electrical design cleaner/ wiring simpler
- More evenly distribute weight on hat
- Improve pulse oximeter clip
- Leverage a medical environment to create specific machine learning training set
  - Use-case specific: Heat Illness
  - MedCap + EKG → More Viable Machine Learning Training
  - Gather data and set thresholds for alerting

Challenges

Software

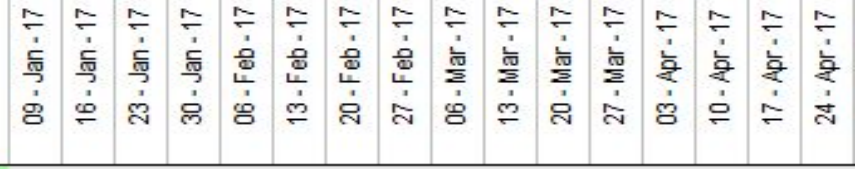
- Bluetooth Integration
- API Integration with Security
- API Endpoint Errors

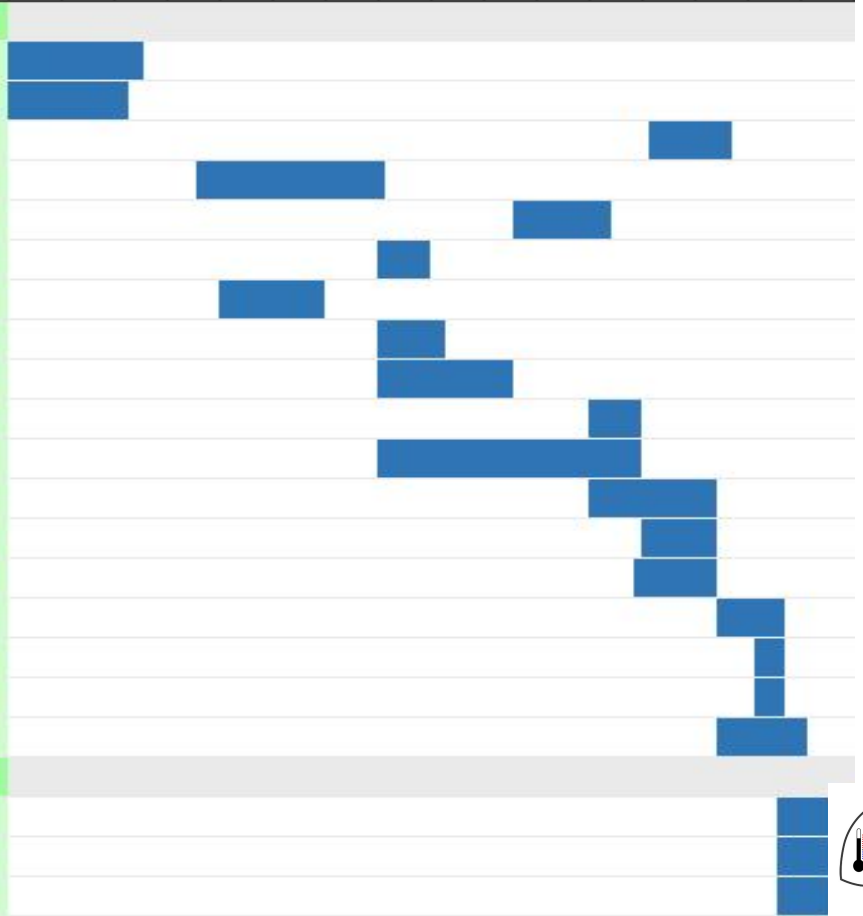
Hardware

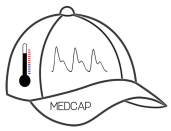
- Switch Extension
- Earpiece
- Wiring
- CAD/3D Printing

Schedule

WBS	Tasks	Start	End	Duration (Days)
2	**ECE 4012**	1/9/17	4/25/17	107
2.1	Update Proposal and PSF	1/9/17	1/25/17	17
2.2	Proposal Oral Presentation	1/9/17	1/24/17	16
2.3	Website	4/3/17	4/14/17	12
2.4	Order Parts	2/1/17	2/28/17	28
2.4.1	Order Parts (Round 2)	3/16/17	3/29/17	14
2.4.2	Test Parts	2/28/17	3/6/17	7
2.5	Hardware System Design	2/5/17	2/20/17	16
2.5.1	Hardware Subsystems Integration	2/28/17	3/7/17	8
2.6	Mechanical Housing Design	2/27/17	3/17/17	19
2.6.1	Mechanical Housing Manufacture	3/27/17	4/2/17	7
2.7	Software System Design	2/27/17	4/2/17	35
2.7.1	Software Subsystens Integration	3/27/17	4/12/17	17
2.8	HW/SW Integration	4/3/17	4/12/17	10
2.8.1	Aesthetic Modifications	4/2/17	4/12/17	11
2.9	Test Integrated Prototype	4/12/17	4/20/17	9
2.9	Final Presentation	4/17/17	4/20/17	4
2.9.1	Final Demo	4/17/17	4/20/17	4
2.10	Capstone	4/13/17	4/25/17	13
3	**ECE 4012-Post Capstone**	4/20/17	4/27/17	8
3.1	Final Project	4/20/17	4/27/17	8
3.1.1	Final Project Report	4/20/17	4/27/17	8
3.1.2	Final Project Summary	4/20/17	4/27/17	8

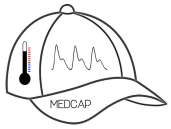






Thank You!

Questions?



Team Member Responsibilities

- Matt → Electrical Design, Power and Wiring
- Michael → Mechanical Design and Layout
- Nicole → Electrical Design, Communication and CAD Expertise
- Miheer → User Interface and Team Site
- Tyler → Medical Research and Data Validation
- Raj → Embedded Processing, Cloud Architecture and Data Analytics