

# Wearable Sensor For Real-Time Health Monitoring



Iowa State University  
Fall 2019 - Senior Design **Team 20**  
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# Problem Statement

- Problem
  - Personal health monitoring device options lack affordability and utility
  - Devices such as apple watches only provide bpm
  - Wet electrodes are available only in clinical setting where they dry out quickly
  - Not cost effective

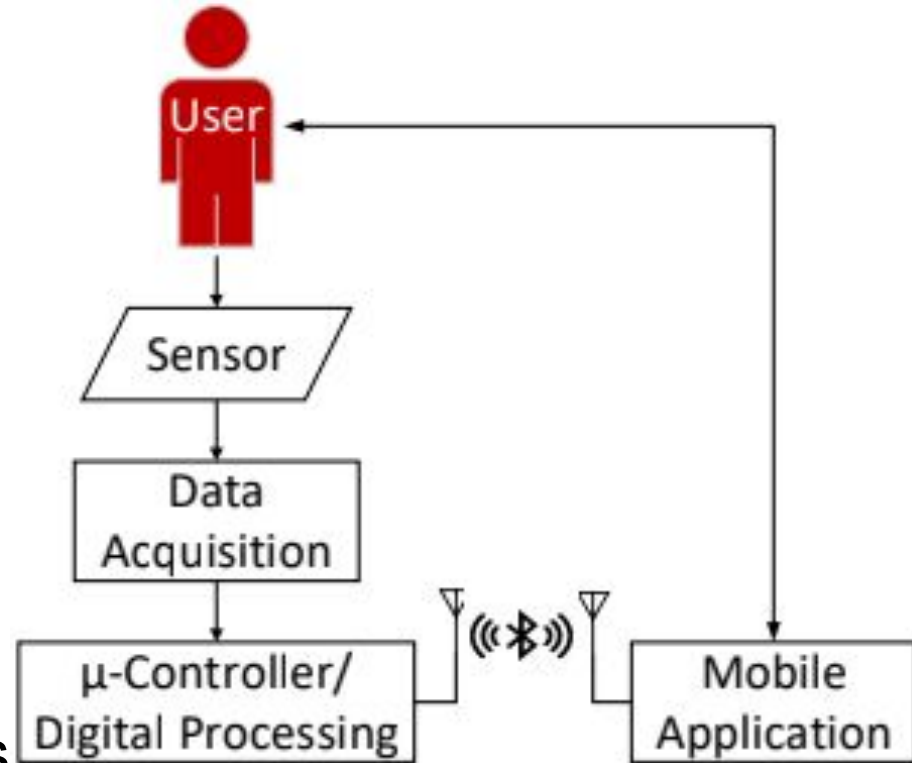


# Problem Statement

- Solution
  - A new system of sensors using
    - Lost cost fabrication method
    - Dry electrodes
    - Communication Circuit
    - User friendly mobile application

# System Conceptual Sketch

- Sensors
  - ECG
  - Mobility
- Application
  - Display data from sensors
    - Graphs
    - User reports
  - Add/Remove Sensors





# Newly Implemented Electrode

- Dry electrode : Easy to apply and remove also reusable
- Diversity of sensor utilization : ECG, mobility sensor, EMG
- Cost efficiency : Silver chloride electrode pack of 100 cost \$10, 10 cents per electrode
  - New sensor system 3 cents per electrode



# Functional Requirements

- Durable sensor to monitor joint movement and angle of change
- Conductive electrodes to monitor cardiovascular activity
- Transfer sensor data using Bluetooth Low Energy
- Display data in graphs and reports within application

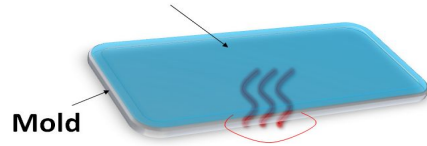


# Non-Functional Requirements

- Sensors are safe to wear and will not harm user
- Application will remain functional during computations

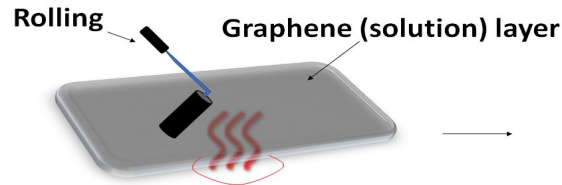
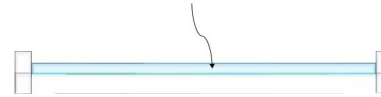
# Sensor Fabrication

Eco-flex layer (not fully cured)



(a) 65 °C for 8 minutes (90% Curing for fusion )

Uncured Eco-flex

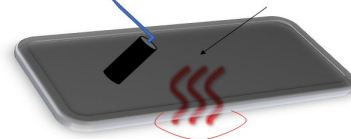


(b) Put the Graphene solution, then rolling after drying

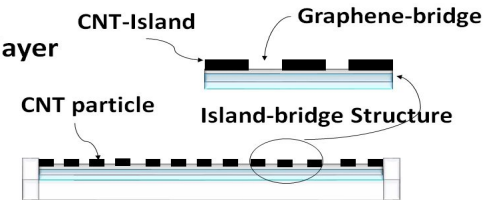
Graphene  
Eco-flex  
(Fusion)



Rolling  
Carbon Nano Tube(solution) layer



(c) Put the CNT solution, then rolling after drying

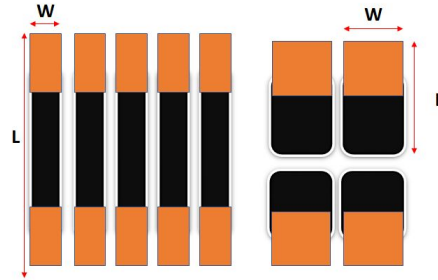




# Sensor Fabrication



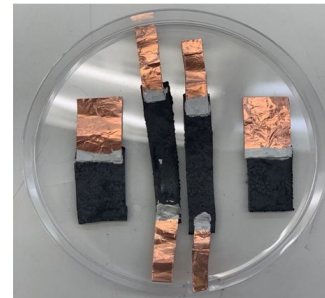
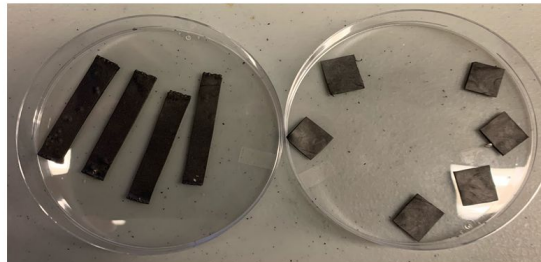
Height: 0.5 mm



<Mobility Sensor>  
Width: 0.5 cm  
Length: 3.2 cm

<ECG Sensor>  
Width: 0.8 cm  
Length: 1.2 cm

(d) After peeling off from the mold, cut it. Then, put the connector (Copper tape) using Ag/AgCl paste.



# Sensor Testing

- **Mobility sensor**

- Test resistance of original state and stretched state using DMM (digital multimeter)



Original State

700K ohms



Stretch

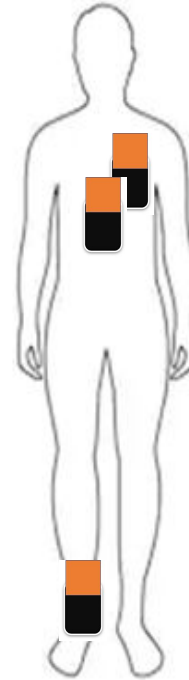
1cm stretched : 10M ohms

2cm stretched : 23M ohms

# Sensor Testing

- **ECG Sensor**

- **ECG** : Electrocardiogram
- Two electrodes on chest and one electrode on right ankle.
- Track signal with Oscilloscope



# Sensor Testing

- **Mobility sensor**

- Detect motion of user
- ex) Vocal cords
- Muscle movement
- Knee movements



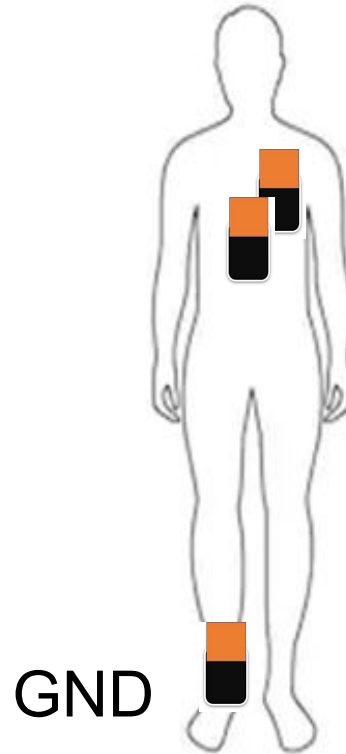
100% length



150% length

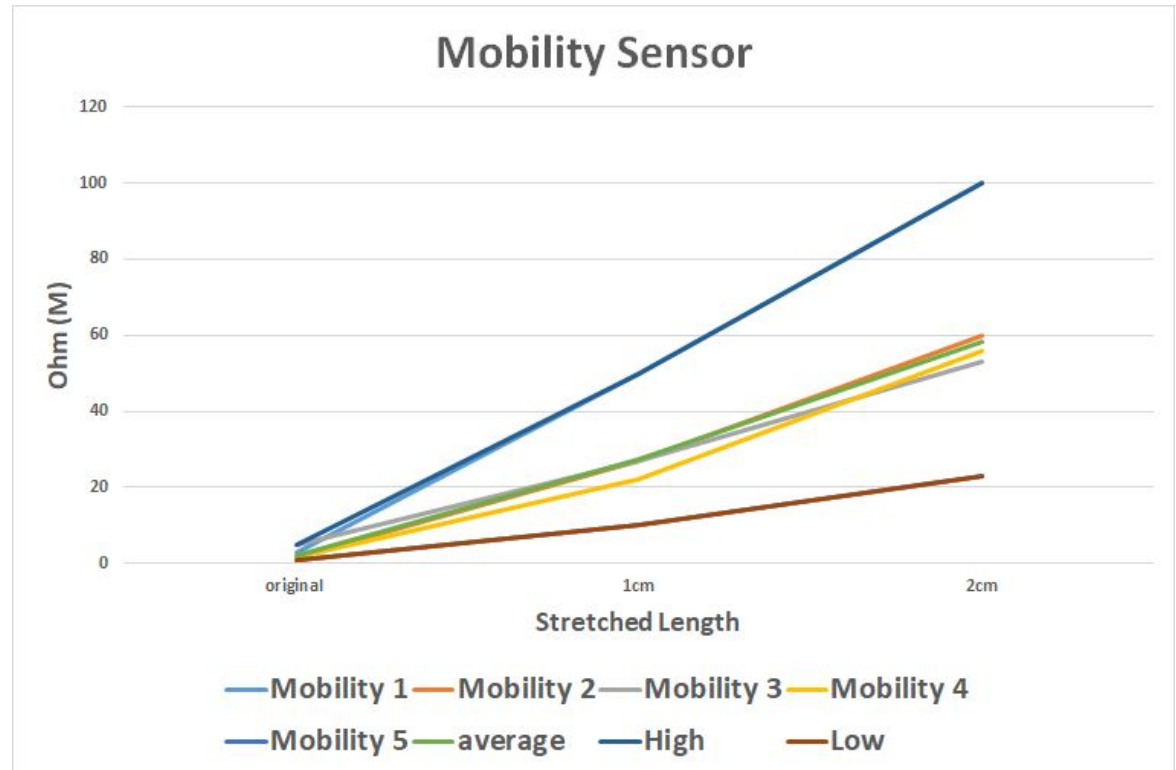
# Sensor Testing

- **ECG Sensor**
  - Tracking signal generated from heart
  - Display a change in voltage over time
  - Track User's health condition



# Sensor Testing

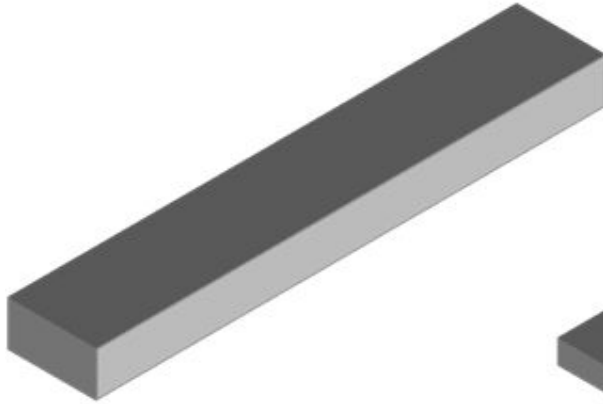
	Original 3.2 Cm	25%	50%
Mobility 1	2.7	50	100
Mobility 2	1.6	27	60
Mobility 3	4.8	27	53
Mobility 4	1.5	22	56
Mobility 5	0.7	10	23
average	2.26	27.2	58.4
High	4.8	50	100
Low	0.7	10	23



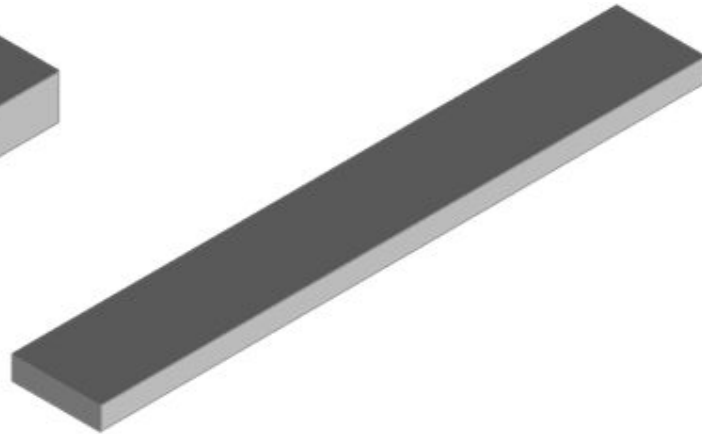


# Hardware...

# Mechanism of Transduction: Mobility Sensor



Static Sensor



Deformed Sensor (Stretched)

$$R = \frac{\rho L}{A}$$

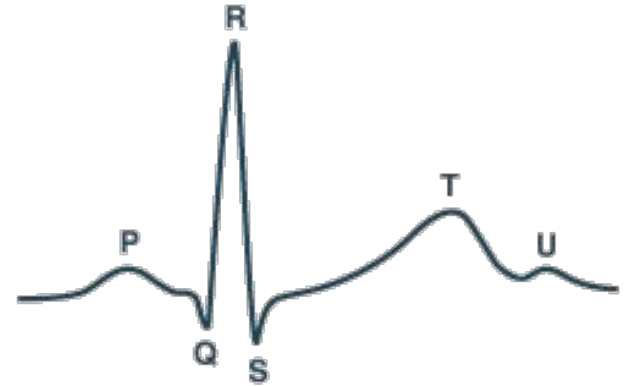
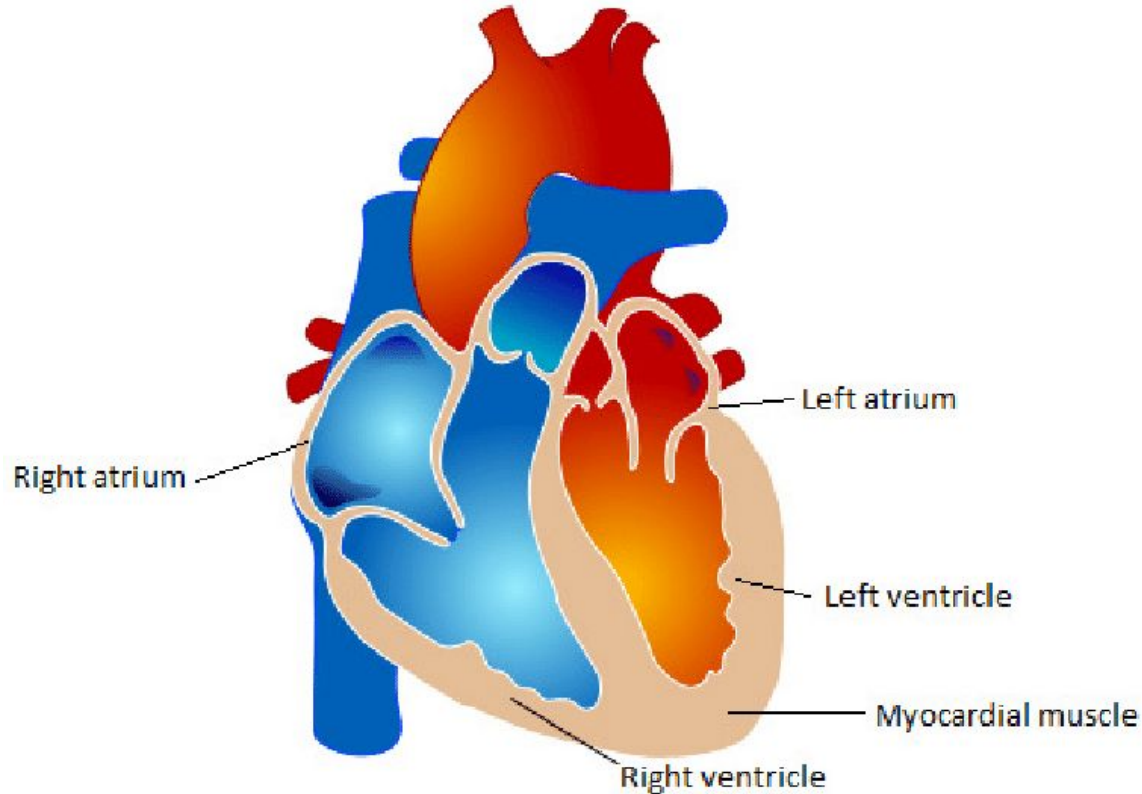
$\rho$  = resistivity

$L$  = length

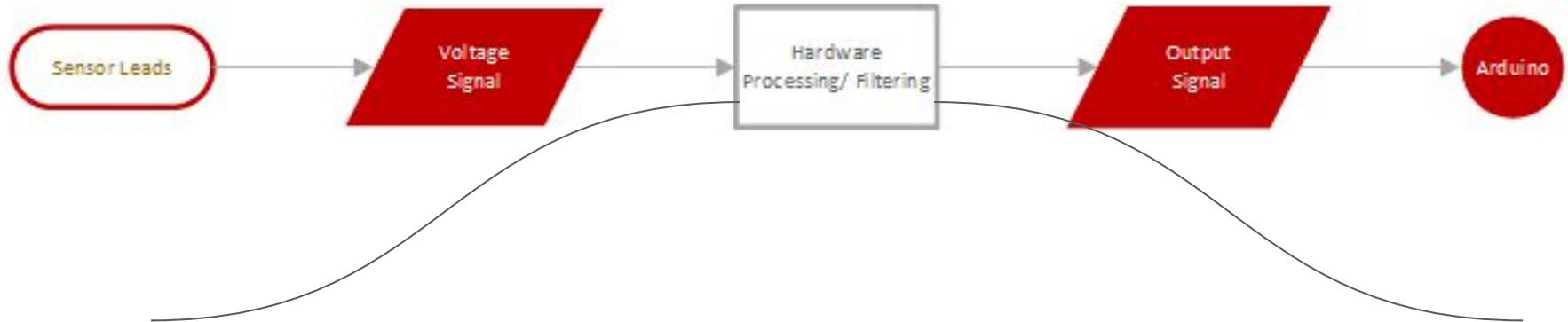
$A$  = cross sectional area



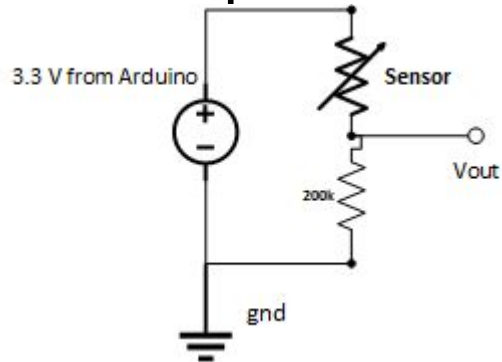
# Mechanism of Transduction: ECG



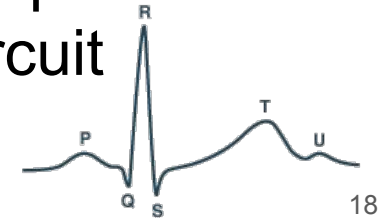
# Hardware-Microcontroller Interface



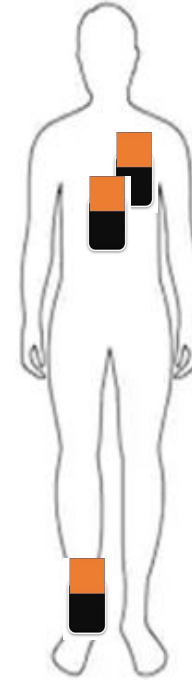
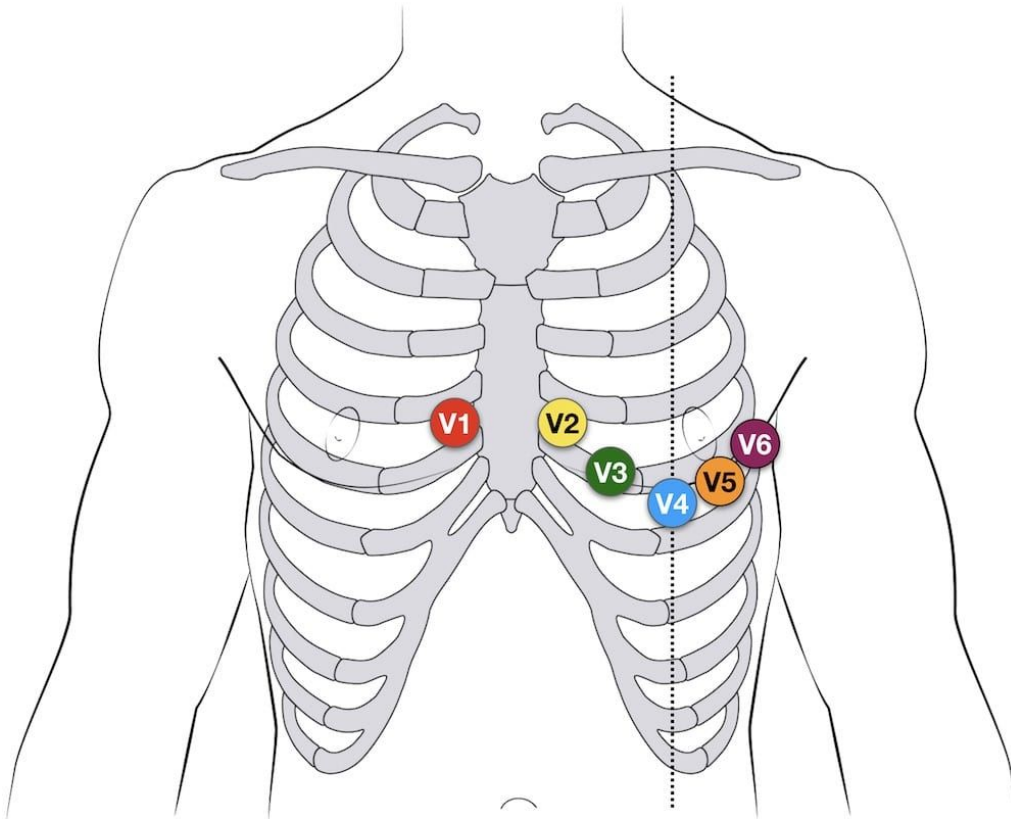
## Mobility Sensor Data Acquisition Circuit



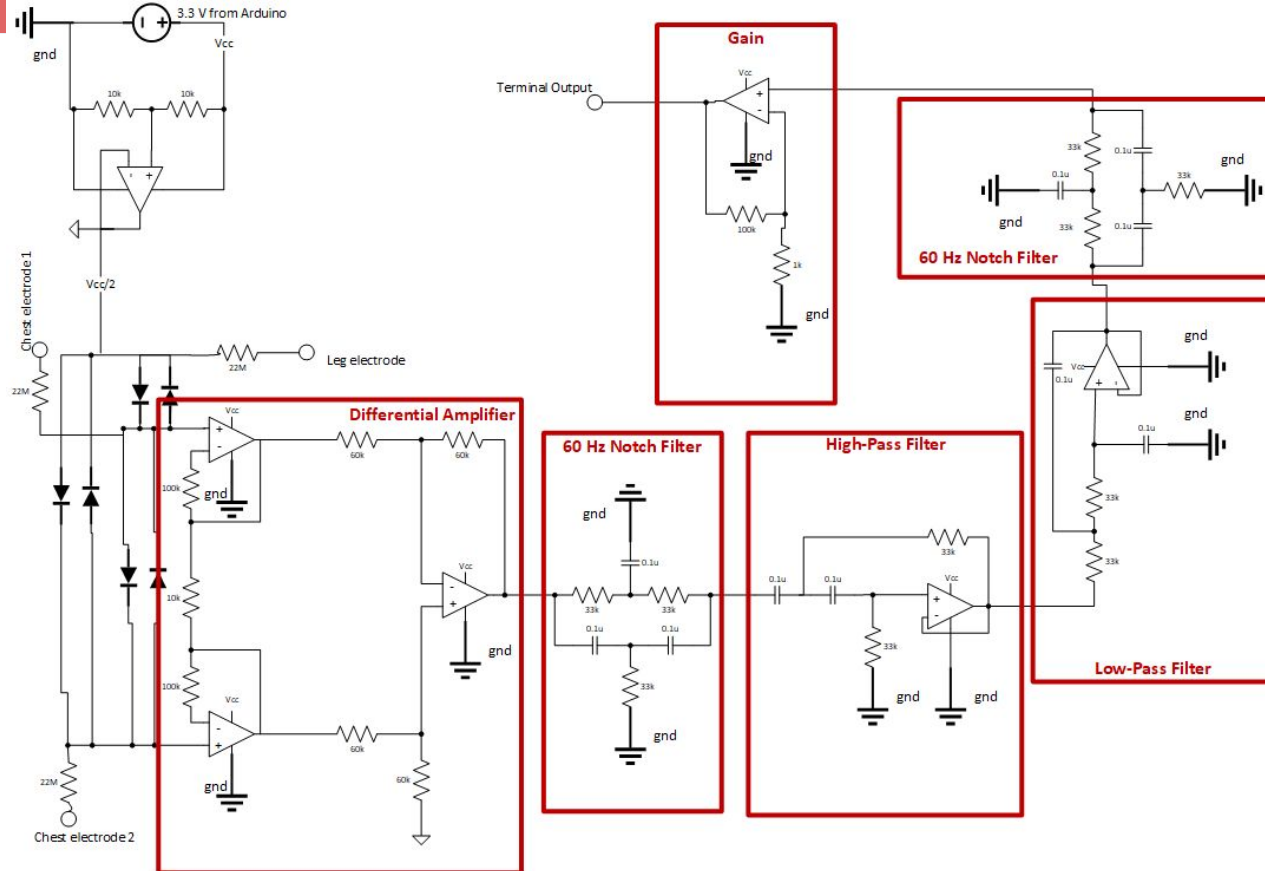
## Electrocardiogram Data Acquisition Circuit



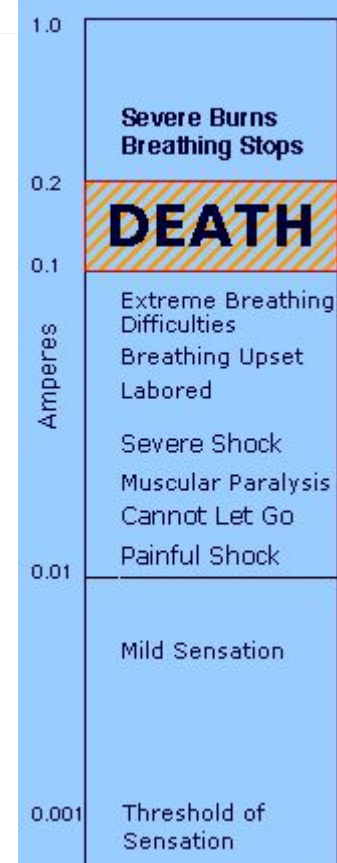
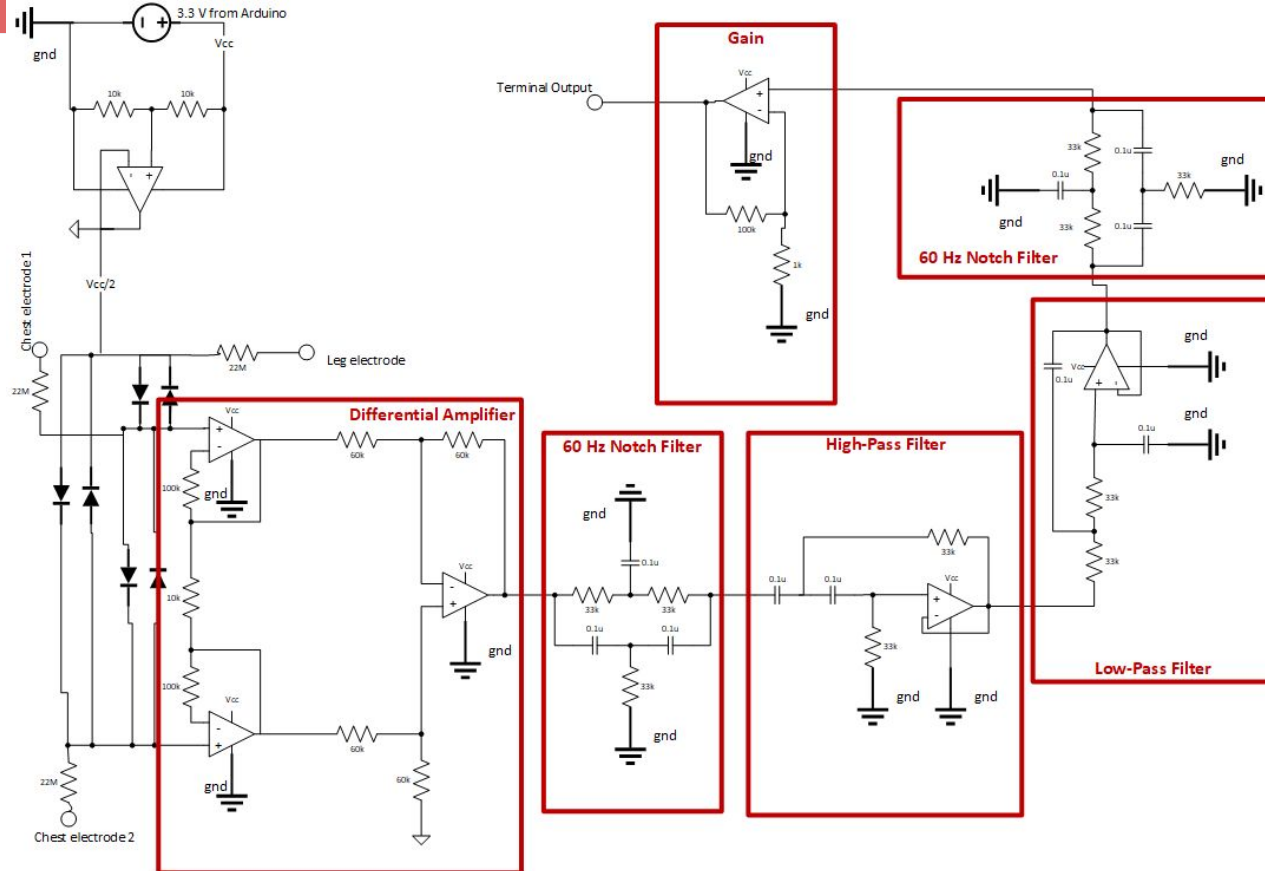
# Electrocardiogram Data Acquisition Circuit



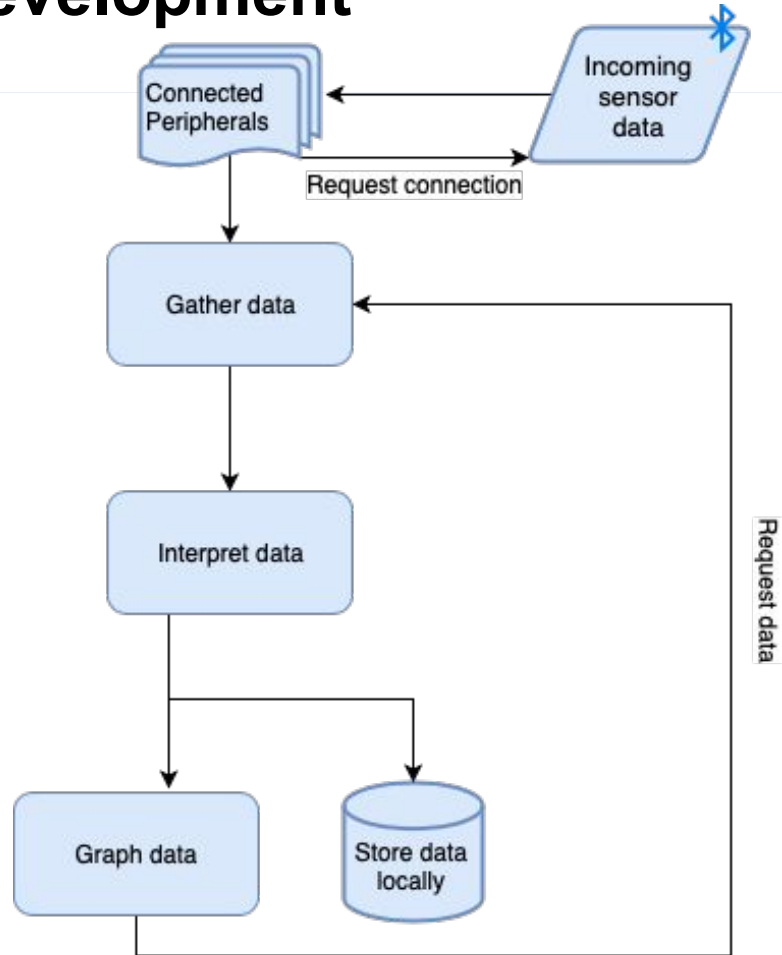
# Electrocardiogram Data Acquisition Circuit



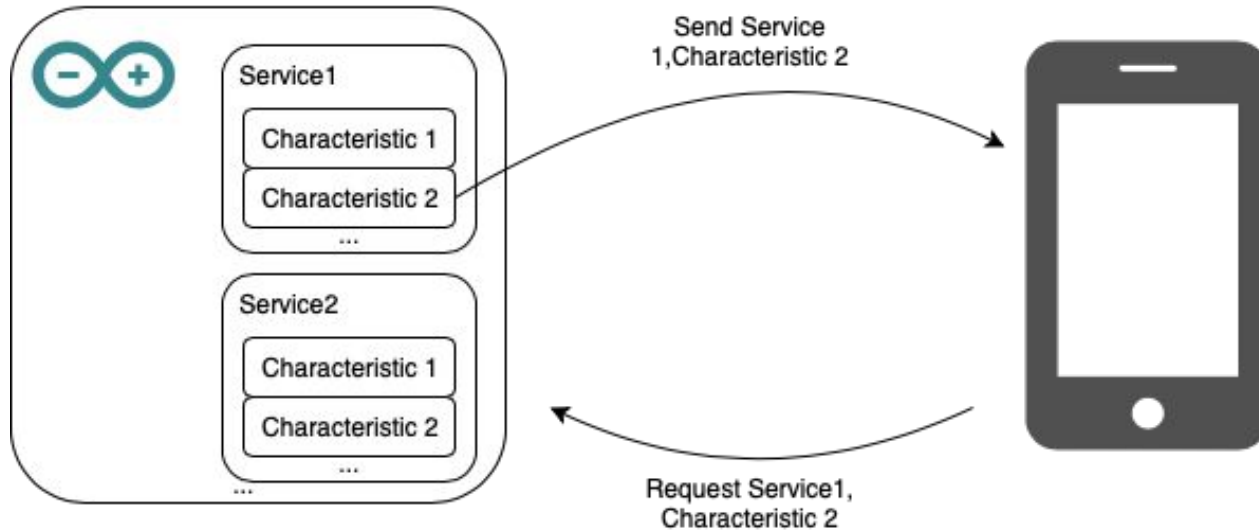
# Electrocardiogram Data Acquisition Circuit



# Software Development



# Software Development - BLE





# Software Development - Embedded Systems

- Arduino Libraries
  - ArduinoBLE
- Language
  - CPP
- Development Tools
  - Arduino Studio

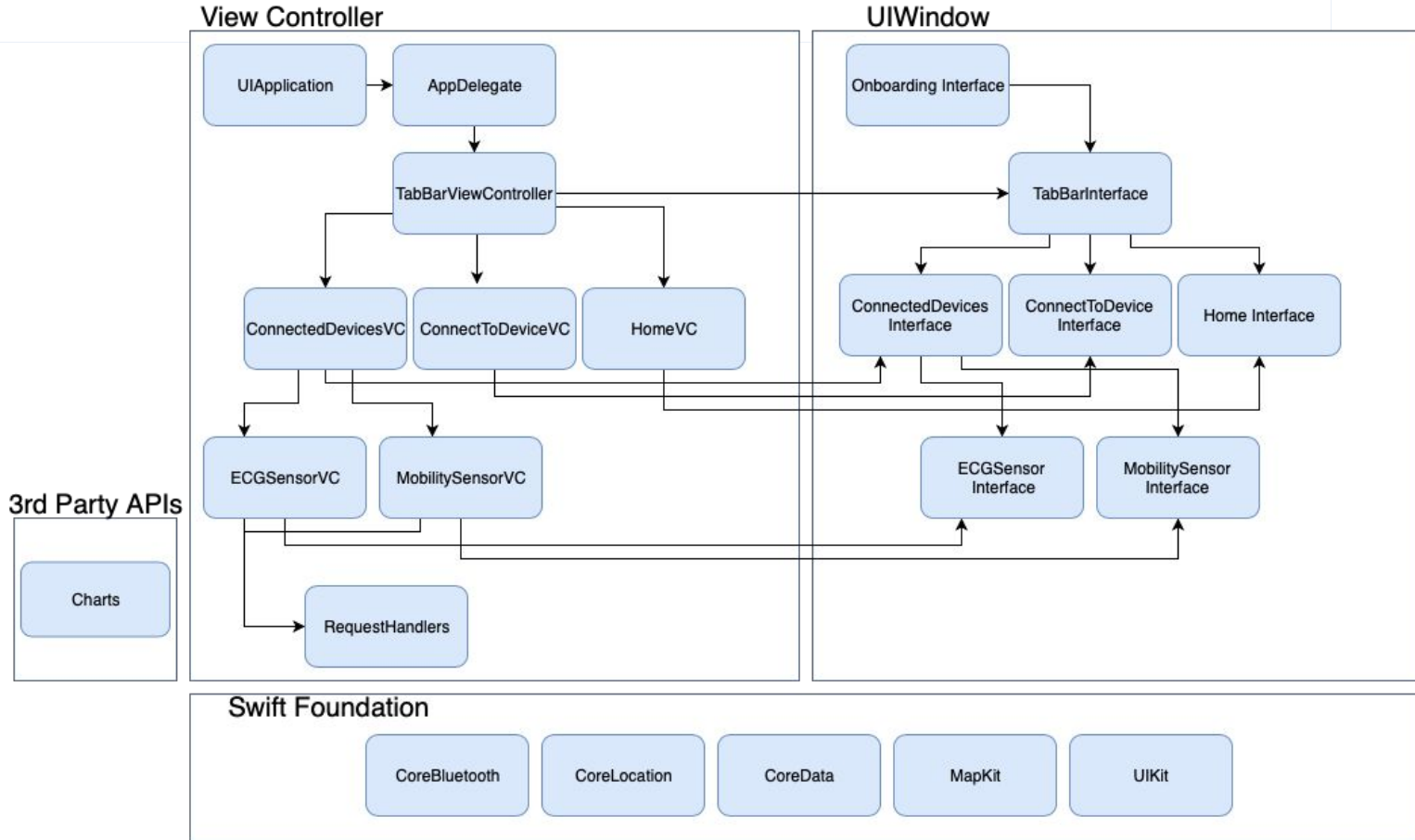




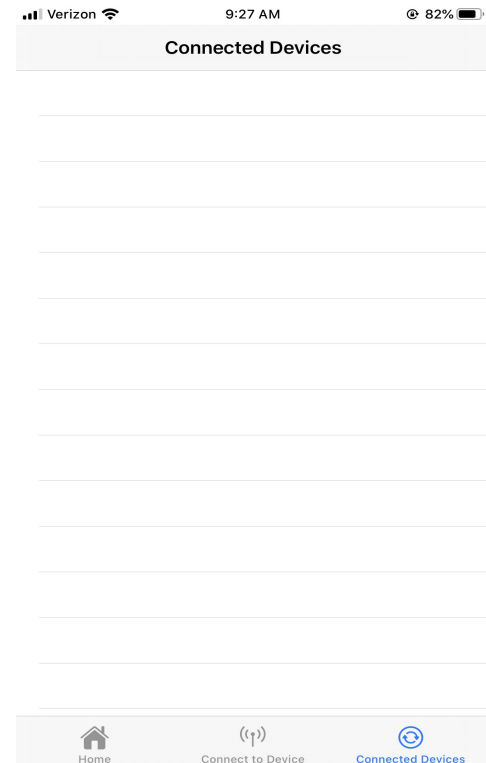
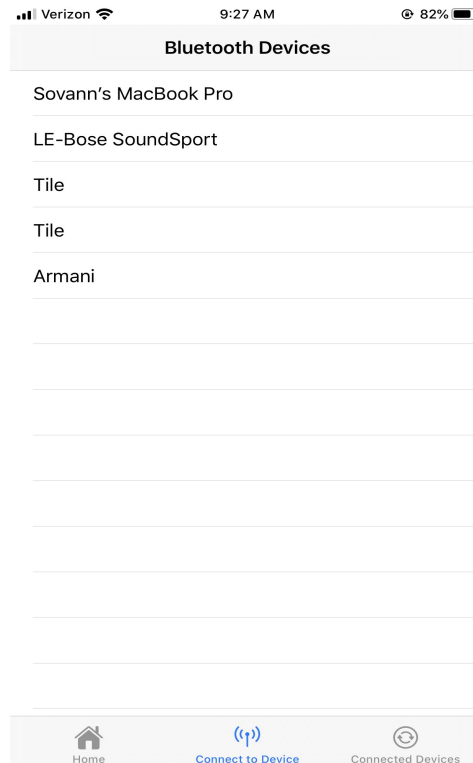
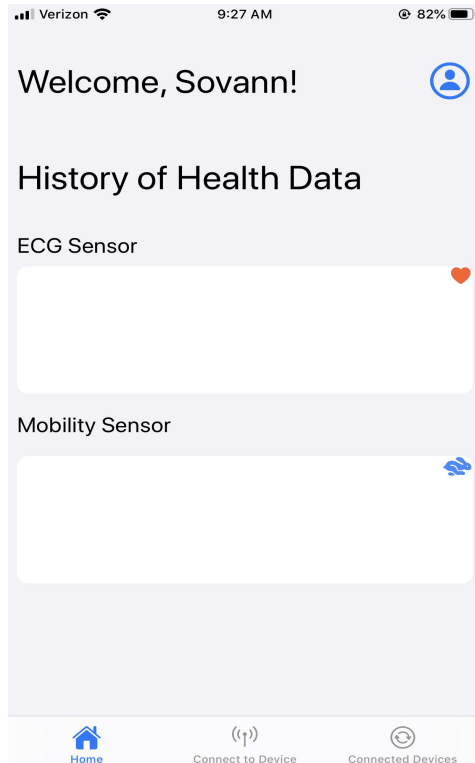
# iOS Application

- APIs
  - iOS Charts
  - Swift Frameworks
- Language
  - Swift
- Development Tools
  - XCode

# iOS Architecture

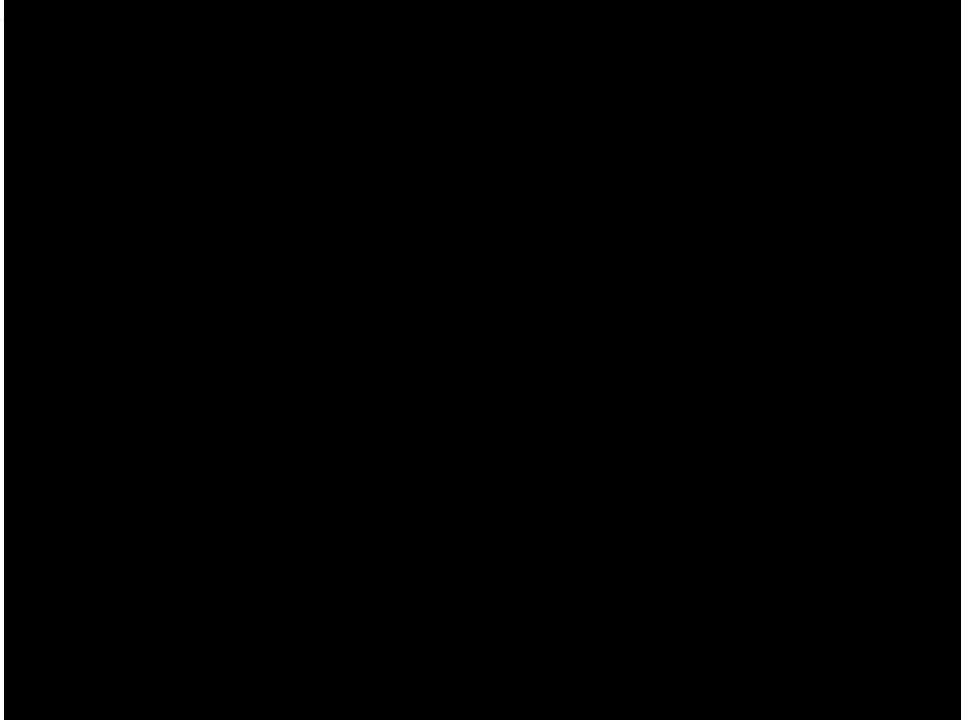


# iOS UI



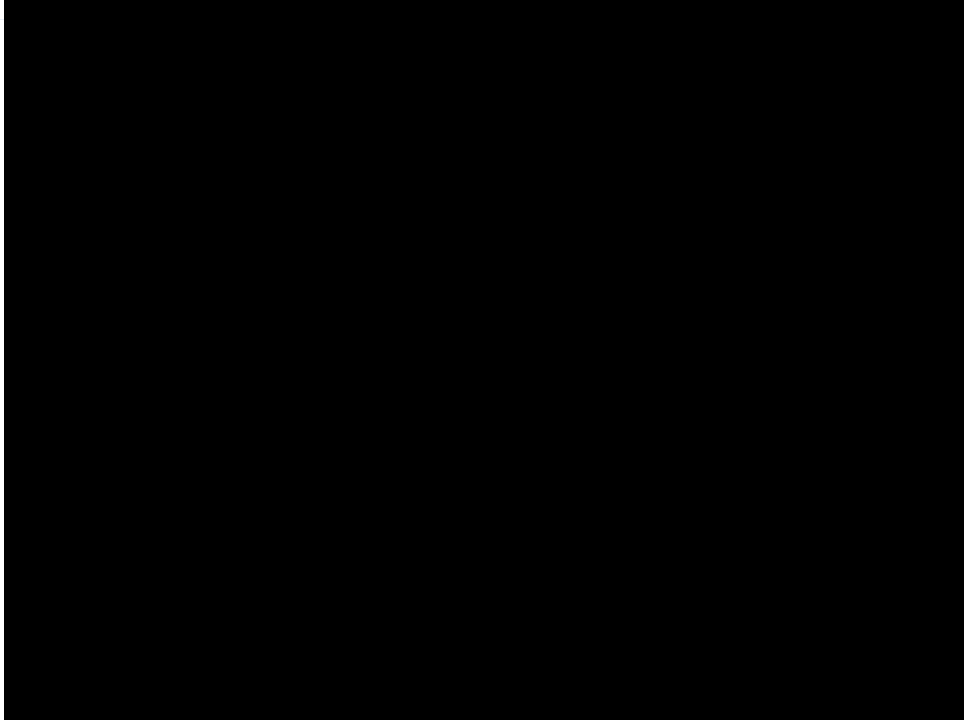


# iOS UI





# iOS UI





# Software Challenges

- Software developers' first mobile application
- Bluetooth Low Energy implementation
  - ArduinoBLE API documented incorrectly and poorly
- Some sensor noise after integrating



# Future Improvements

- Machine Learning
- Ability to share data with medical professionals
- Digital Filtering
- Reduce thickness of wearable further
- Possible integration in athletic clothing



# Questions?