Wearable Sensor For Real-Time Health Monitoring

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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

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

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

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

<table>
<thead>
<tr>
<th>Original State</th>
<th>Stretch</th>
</tr>
</thead>
<tbody>
<tr>
<td>700K ohms</td>
<td>1cm stretched : 10M ohms</td>
</tr>
<tr>
<td></td>
<td>2cm stretched : 23M ohms</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Mobility</th>
<th>Original 3.2 Cm</th>
<th>25%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility 1</td>
<td>2.7</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Mobility 2</td>
<td>1.6</td>
<td>27</td>
<td>60</td>
</tr>
<tr>
<td>Mobility 3</td>
<td>4.8</td>
<td>27</td>
<td>53</td>
</tr>
<tr>
<td>Mobility 4</td>
<td>1.5</td>
<td>22</td>
<td>56</td>
</tr>
<tr>
<td>Mobility 5</td>
<td>0.7</td>
<td>10</td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>average</th>
<th>2.26</th>
<th>27.2</th>
<th>58.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>4.8</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.7</td>
<td>10</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
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

3.3 V from Arduino

Sensor

200k

Vout

gnd

P

QRS

T

U
Electrocardiogram Data Acquisition Circuit
Electrocardiogram Data Acquisition Circuit

- **Differential Amplifier**
  - **60 Hz Notch Filter**
  - **High-Pass Filter**
  - **Low-Pass Filter**

- **Gain**

- **Terminal Output**

- **60 Hz Notch Filter**

- **Gnd**

- **Grounded Electrode**

- **3.3 V from Arduino**

- **Cheek Electrode 1**

- **Cheek Electrode 2**
Electrocardiogram Data Acquisition Circuit
Software Development

![Flowchart for Software Development]

1. **Connected Peripherals**
   - Request connection

2. **Gather data**

3. **Interpret data**

4. **Graph data**

5. **Store data locally**

**Use Case**

- **Incoming sensor data**
Software Development - BLE

[Diagram showing a conceptual sketch of BLE services and characteristics.]
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

Welcome, Sovann!

History of Health Data

ECG Sensor

Mobility Sensor

Bluetooth Devices
- Sovann's MacBook Pro
- LE-Bose SoundSport
- Tile
- Tile
- Armani

Connected Devices

sddec19-20
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?