Opportunities and Challenges in Wearable Sensor Data

Yadid Ayzenberg
Affective Computing Research Group
MIT Media Lab

Secondary Use of Big Data from Critical Care
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yadid@media.mit.edu
Wearable Sensor – a device that is attached to the human body and has the ability to record signals generated by our physiology, environment, or our interactions with the environment and one another.
Principle 1 - Signal Sampling and Feature Extraction
Principle 1 - Signal Sampling and Feature Extraction
Principle II - Derived Signal

Sympathetic division
Stimulation: “fight or flight”

Parasympathetic division
Inhibitory: “rest and digest”

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Electrodermal Activity

[Diagram showing conductance meter with scale from 0 to 30 Siemens]

Skin

Sweat Gland

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Electrodermal Activity

Conductance

Siemens

Skin

Sweat Gland
Sampling Derived Signals

Affectiva Q
Electrodermal Activity

Mio Alpha
Heart Rate

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Opportunities

• Continuous monitoring
A Day in the Life

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Opportunities
Opportunities

• Non invasive ➔ Better Adherence
Opportunities

• Low Cost → Wide deployment

Worldwide Revenue Forecast for MEMS Motion Sensors in Wearable and Fitness Devices (Millions of US Dollars)

Source: IHS iSuppli Research, April 2013

Global Infrared Proximity-based Gesture Sensor Revenue Forecast (in Millions of U.S. Dollars)

Source: IHS, May 2011
Opportunities

• Enable Real-Time interventions
Opportunities

- Engage patients in their care
Challenges

• Data is “Dirty”
Challenges

• Missing context
# Mobile Phone – The Perfect Proxy

<table>
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<th>Communication</th>
<th>Schedule</th>
<th>Content consumption – Email, Web, Apps</th>
<th>Wearable Biophysiological Sensors and Smart phone sensors</th>
<th>Location and Proximity</th>
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FEEL - Frequent Event & EDA Logging

Sunday, April 22, 2012
- 01:44:01
  - Ifaet Ayzenberg - 16179552030
- 00:00:07
  - Rosalind Picard - paper PR
- 00:06:03
  - Mehmet Akif Celinkaya - Re: EDA uploads

Electrodermal Activity Plot
- Events
  - 13:30:00-14:30:00 Meeting: Reid Hoffman
Challenges

- Data Storage - Where?
Challenges

• Data Storage - Where?

• Hospital
• Sensor Manufacturer
• Government
• User cloud account
• Google/Yahoo/Dropbox
Challenges

• Data Storage and Retrieval - How?

• Inventory Management and Interface
Challenges

• Data Ownership, Privacy and Misuse
Wearable Sensor
Use Cases
Analysis: summarizing normative data
Clusters as “physiological phenotypes”

Groden center, 60 days x 5 children with ASD
Analysis: summarizing normative data
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State of the art:
- Built sensor & algorithms
- Detects “peak storms” (90% in Non-REM)
- Measuring connections to learning & memory & stress

(Sano & Picard; MIT, EMBC 2011, collaborations with Bob Stickgold, Harvard & Beth Israel hospital, Chuck Czeisler, Harvard & Brigham & Women’s hospital)
Visual Discrimination Task (VDT)

(Reprinted with permission from (Stickgold et al., 2000))
Accuracy predicting top/bottom performers based on %SWS in Q1 of sleep and %REM in Q4 of sleep.
Standalone EDA is a better predictor of memory performance improvement in VDT.
Seizures labeled from EEG

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Autonomic response (from wrist) is correlated with duration of EEG suppression (SUDEP biomarker)
Conclusions

• Longitudinal vs Snapshot monitoring approach
• Increase Patient Engagement
• “Big Data” challenges: Inventory, Storage, Analytics, Standards, Privacy
• Serendipity is your friend