Utilising the Ubiquity of the Cell Phone to Record Physiological Activities

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&

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Overview

- **BACKGROUND**
  - **Cell Phone Ubiquity**
  - **Lifelogging**

- CELL PHONE DATA LOGGER
  - A Cell Phone Data Logging Framework

- MY PHYSIOLOGICAL DIARY
  - Reviewing Physiological Data Using Contextual Information

- ONGOING WORK

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Principal Investigators

Prof. Barry Smyth	- *Personalization, recommender systems, mobile computing*
Prof. Alan Smeaton	- *Content-based information retrieval*
Prof. Dermot Diamond	- *Materials research, wearable sensors*
Prof. Noel O'Connor	- *Audio-visual analysis, multi-modal information processing*
Mr. Gregory O'Hare	- *Ubiquitous computing, multi-agent systems*

Associate PIs

Prof. Paddy Nixon	- *Pervasive computing, middleware, security, trust, privacy*
Prof. Niall Moyna	- *Sports Science, wearable sensing*
Dr. Simon Dobson	- *Middleware, pervasive computing*
Dr. Cian O'Mathuna	- *Sensor devices, energy-aware hardware*
Dr. Brian Caulfield	- *Physiotherapy, therapeutic gaming, wearable sensors*

Quick Stats

- **$21.4M over 5 years ($15.4M from Irish government, $6M from industry)**
- **84 researchers (28 academics, 31 post-docs, 25 PhD students)**
- **12 support staff**

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CLARITY What ? "The Sensor Web"

– Increasing availability of cheap, robust, and deployable sensor technologies ushering in a wave of new information sources;

– Ubiquitous, dynamic, noisy, reactive and yielding unstructured data-streams == sensor web

– Realizing the sensor web demands a large-scale, multi-disciplinary research effort == CLARITY

– Moving beyond our research silos to novel research interactions;

– Demonstrator projects in:

Personal health and wellness;

Environmental monitoring;

Cell phone ubiquity

-**4 billion Cell Phones** in World

-Approx 1bn PCs

- Almost **70%** of **new** cell phone **subscriptions** come from **developing nations** (Source: International Telecommunications Union)

- **Bluetooth** is now standard on most cell phones

Source: http://www.dialaphone.co.uk/blog/?p=1485

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RPF on Cellphone as Platform for Healthcare

- **14 universities supported**

- **Cell phones can provide people with access to technology-based healthcare solutions**
  - Who otherwise would have no such opportunities
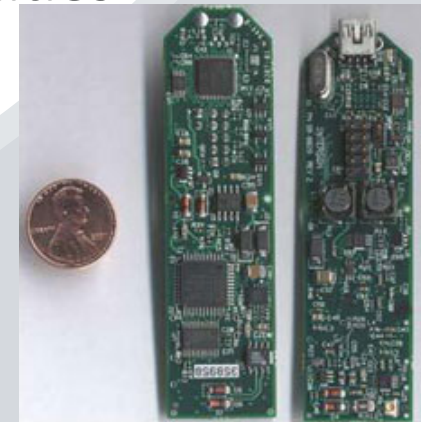
How often do you visit your Doctor?

Visits to Dr.
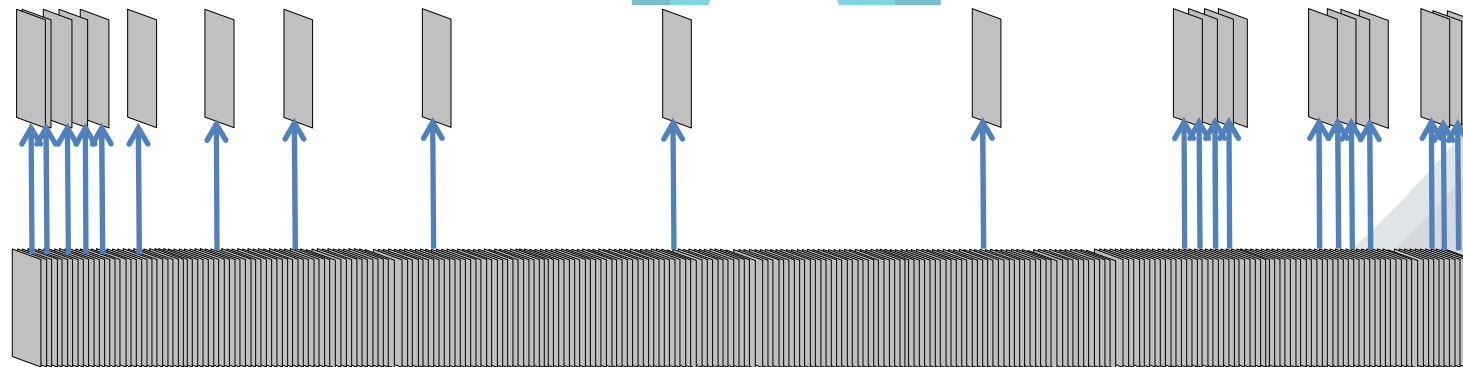
My Life

Lifelogging

Lifelogging is about digitally recording your daily life

Sometimes its for a reason

Work   e.g. security personnel, medical staff, etc.
Personal   e.g. diaries, etc.

Sometimes its for posterity

Recording vacations, family gatherings, social occasions

Sometimes its because we can

And we're not yet sure what we'll do with it e.g. MyLifeBits

Lifelogging Devices

Much past research focus on miniaturising hardware and increasing battery-life + storage e.g. visual lifelogging domain
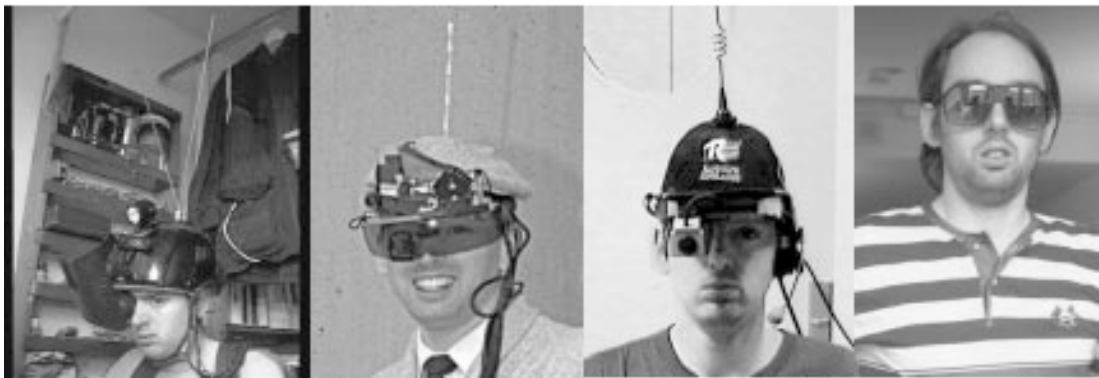
Steve Mann. Wearable computing: a first step toward personal imaging. Computer, 30:25–32, Feb 1997.

TIMELINE

Tano *et. al.* University of Electro-Communications, Tokyo, Japan   Microsoft Research SenseCam

Aims of this project

- **Utilise cell phone ubiquity**
  - Logging platform on Windows Mobile devices
  - Framework allows easy integration of new BT sensors

- **Reviewing physiological values**
  - Interface to monitor, analyse & browse through huge volumes of sensor data
  - "Individualise" medical baselines

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SmartLogger Overview

Heart Rate

Location

Images

Body Temperature

Cellular
Wi-Fi
LAN
ActiveSync
...

Data
Store

Easily include new sensors

Heart Rate

Location

Images

Body Temperature

XML

SWITCH OFF

READING

Connection error... no data

EXIT

My Physiological Log

Sleep apnea neck cuff with oximeter, accelerometer, microphone, & gsr sensors

Zephyr HxM: An example of a modern biometric sensor sending out BT readings
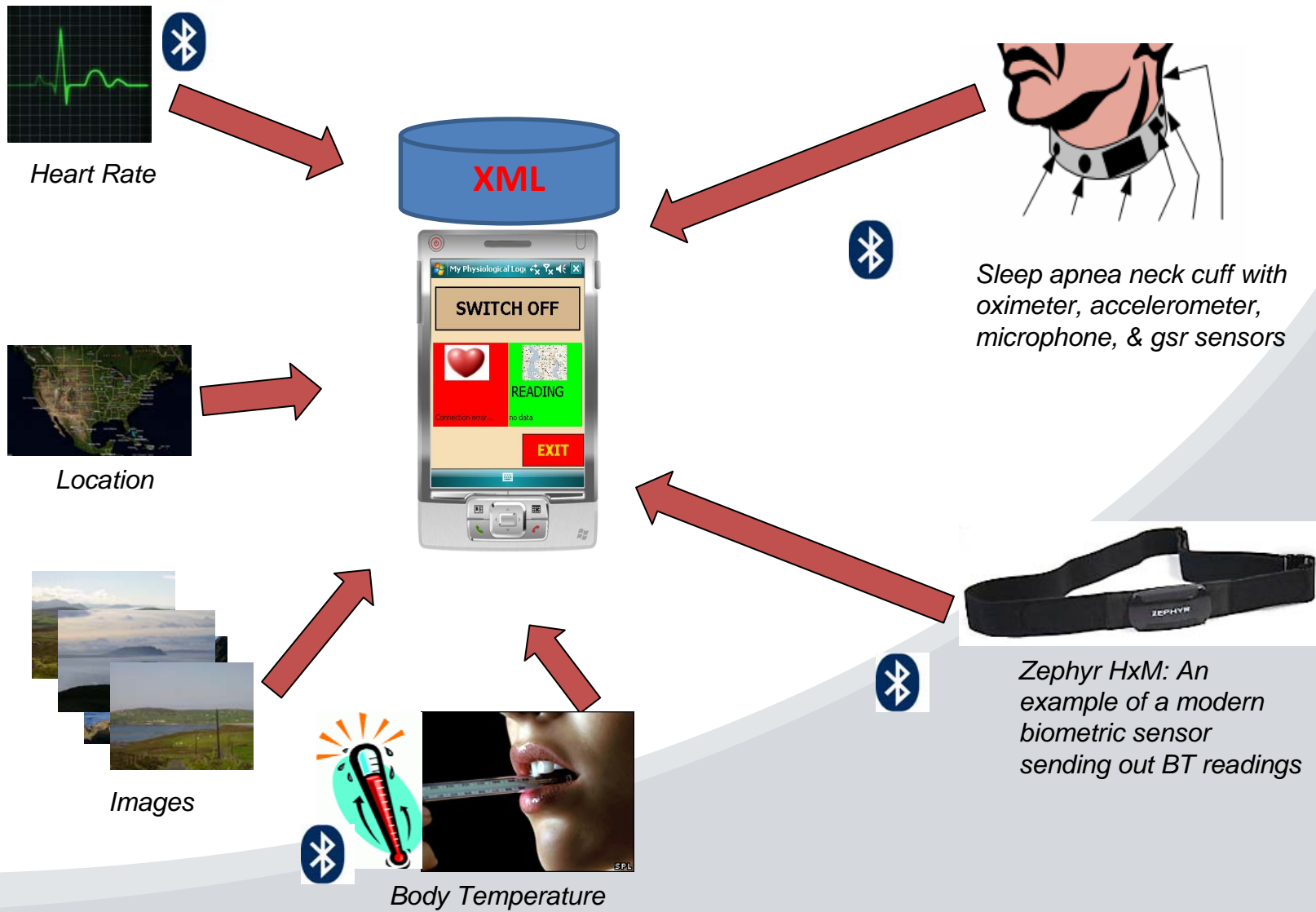
Data Logger Summary

- .NET Windows Mobile

- Easy to incorporate additional Bluetooth sensors

- Has to deal with incomplete and heterogeneous data

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How to review lots of data?

Physiological data:

Little emphasis on visualisation

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Simple view of Human Memory

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- SENSORY

- SHORT – TERM

- LONG – TERM
  - PROCEDURAL
  - DECLARATIVE
    - Semantic
    - EPISODIC/ **AUTOBIOGRAPHICAL**

Cued Recall & Visual Encoding

- **"Cued Recall" better than "Free Recall"** *(Purdy, '01)*

- Memories can be temporally encoded *(Larsen, '96)*

- Distinct memories are more strongly encoded *(Purdy, '01)*

- Memories stored by association *(Baddeley, '04)*

Our Take...

To effectively help people understand their physiological data:

- Passively logged cell phone data gives potential "cues"

- Query data on *"temporal"* axes (calendar constraints)

- Highlight *more "distinctive" events* (charts)

- *"Associate" related events* (location + images)

My Physiological Diary

My Physiological Diary: Location Context
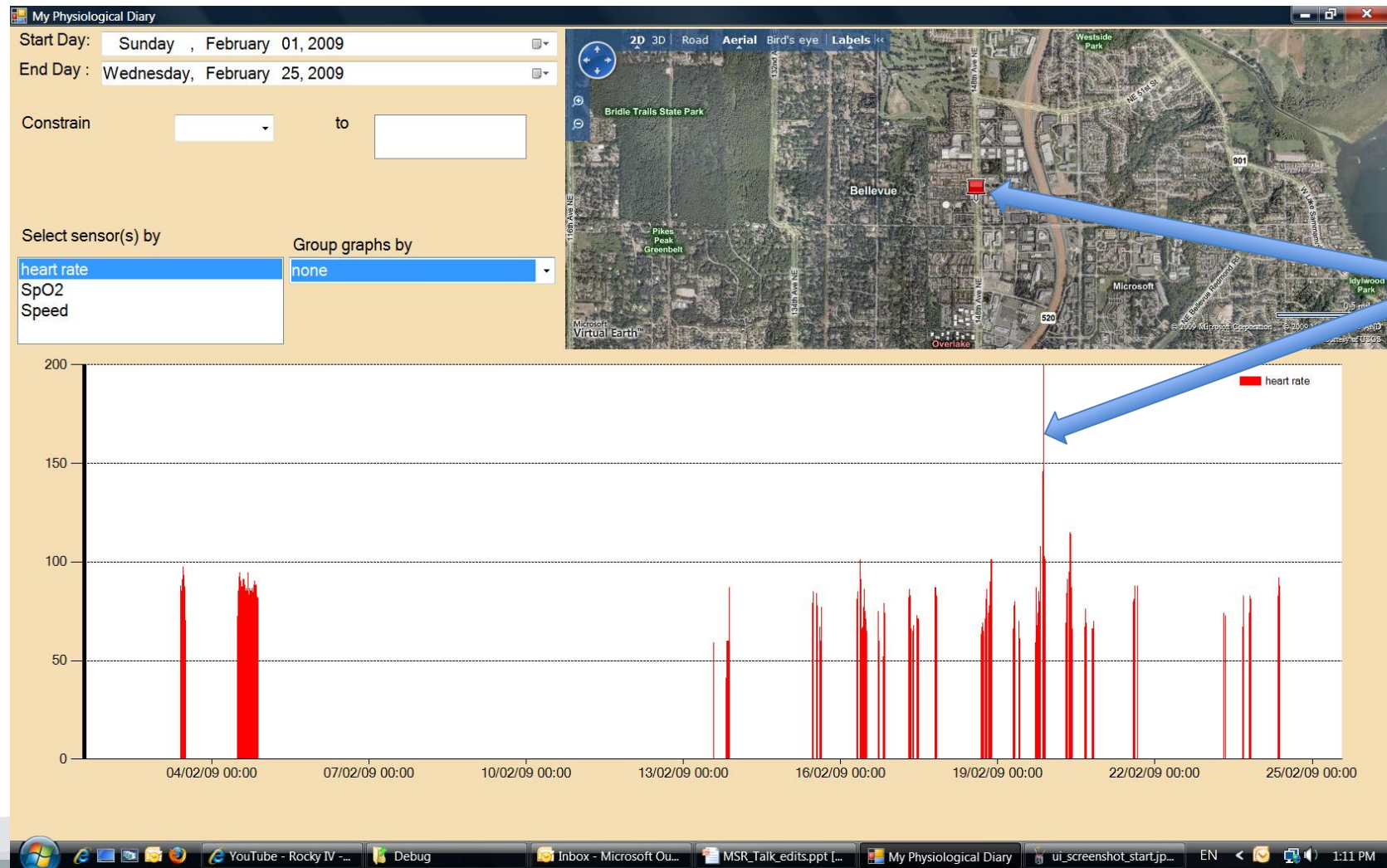
My Physiological Diary: Image Context
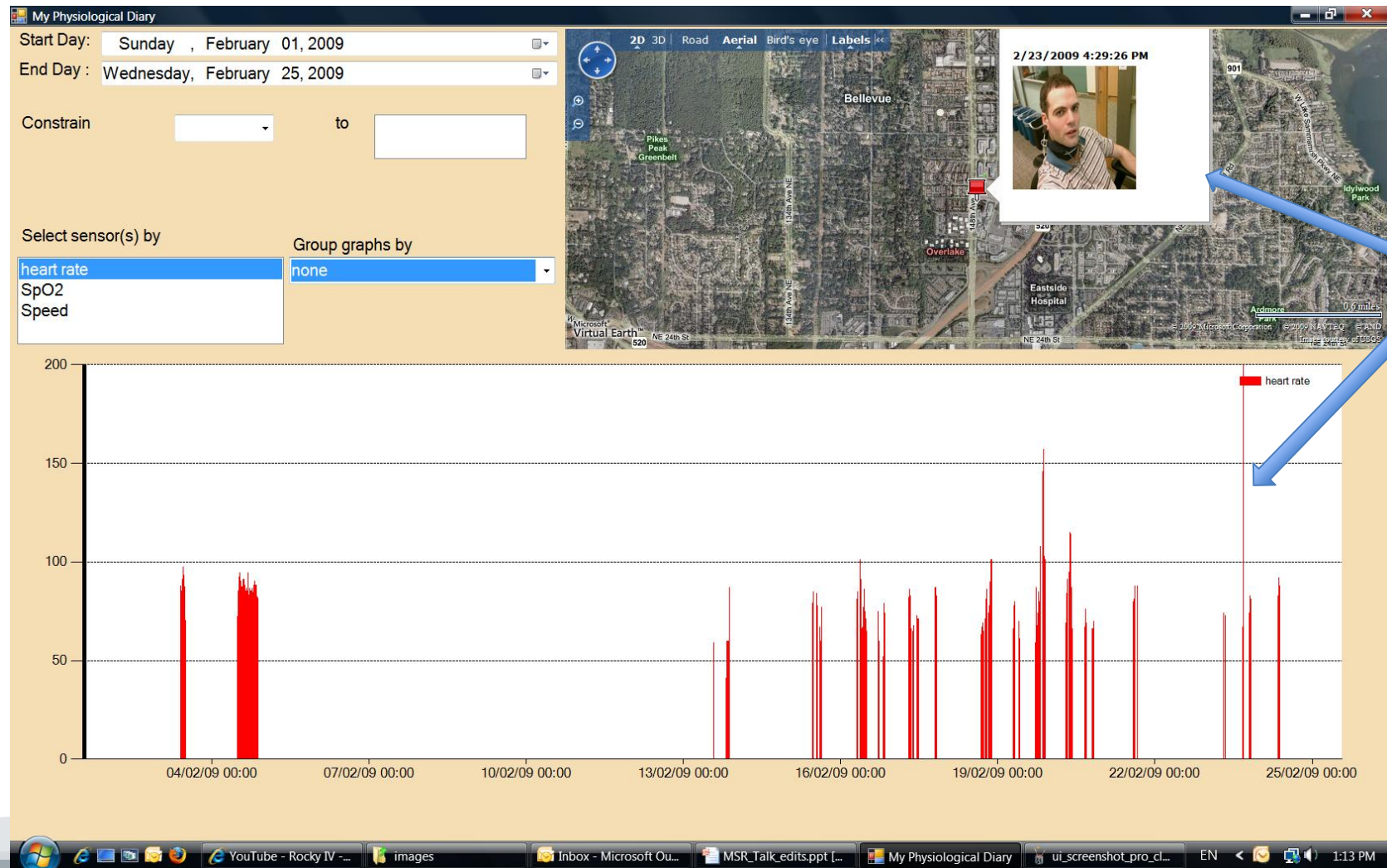
My Physiological Diary: Compare across days/months/years
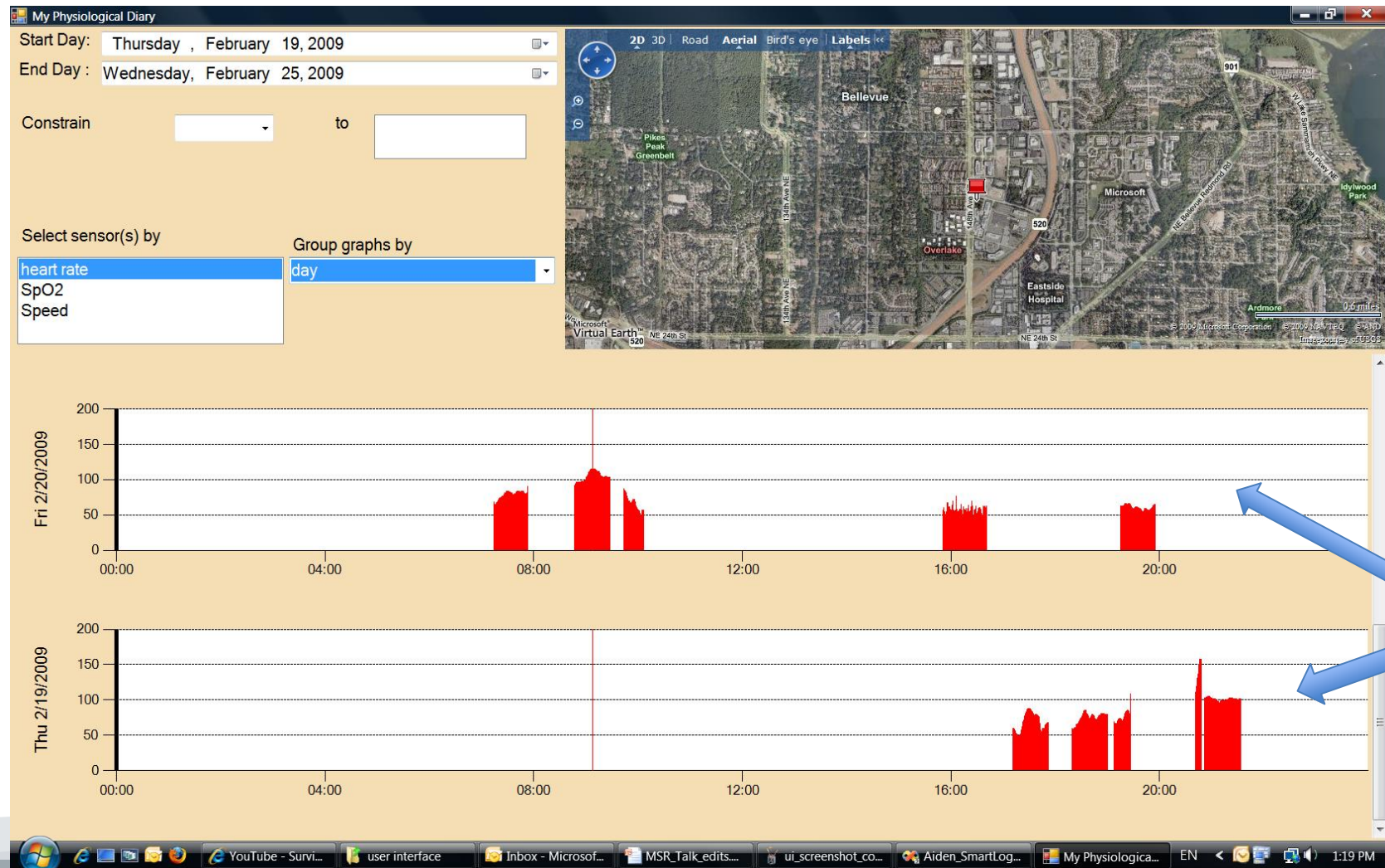
My Physiological Diary:
Display normalised values
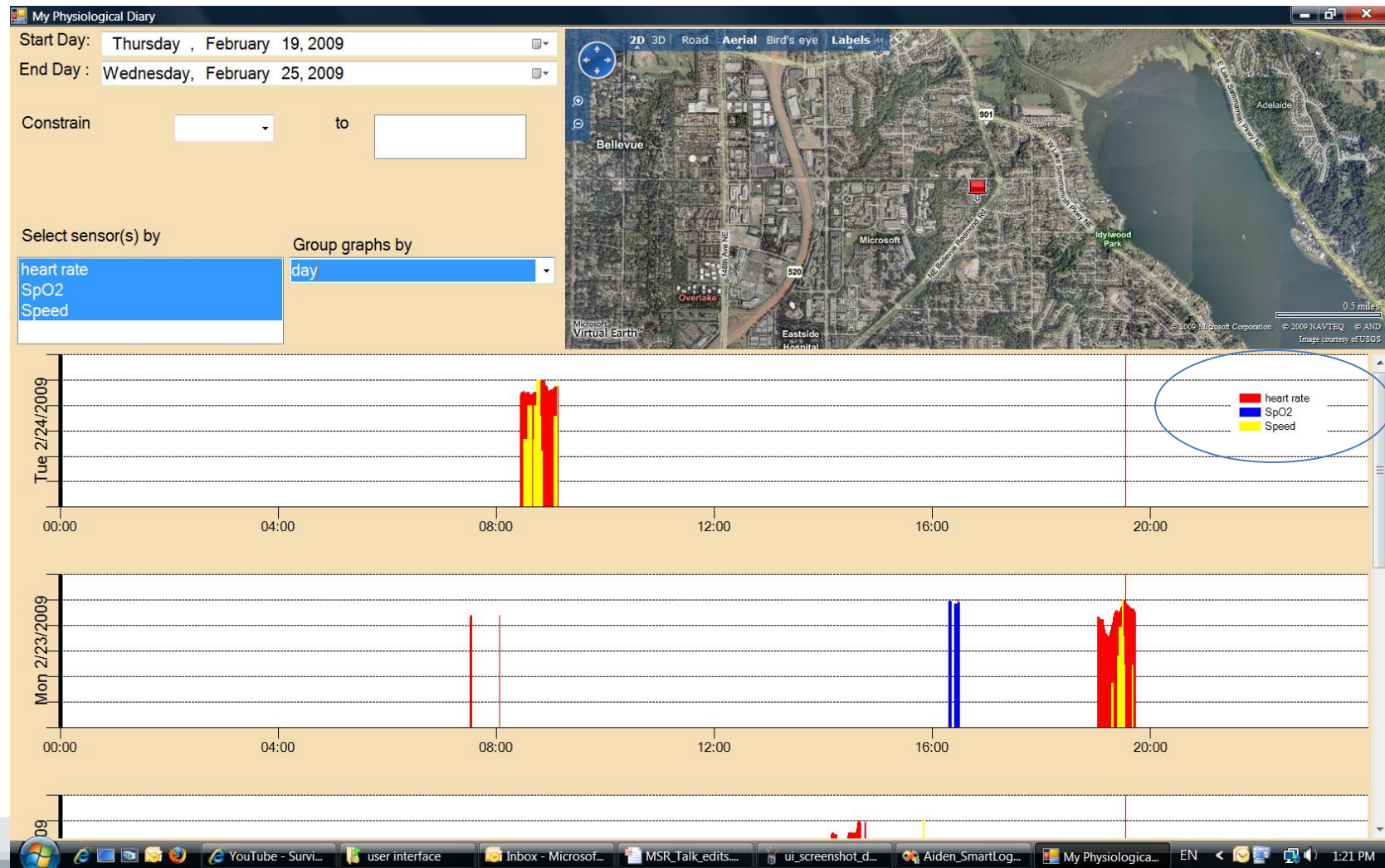
My Physiological Diary:
Delve deeper into data
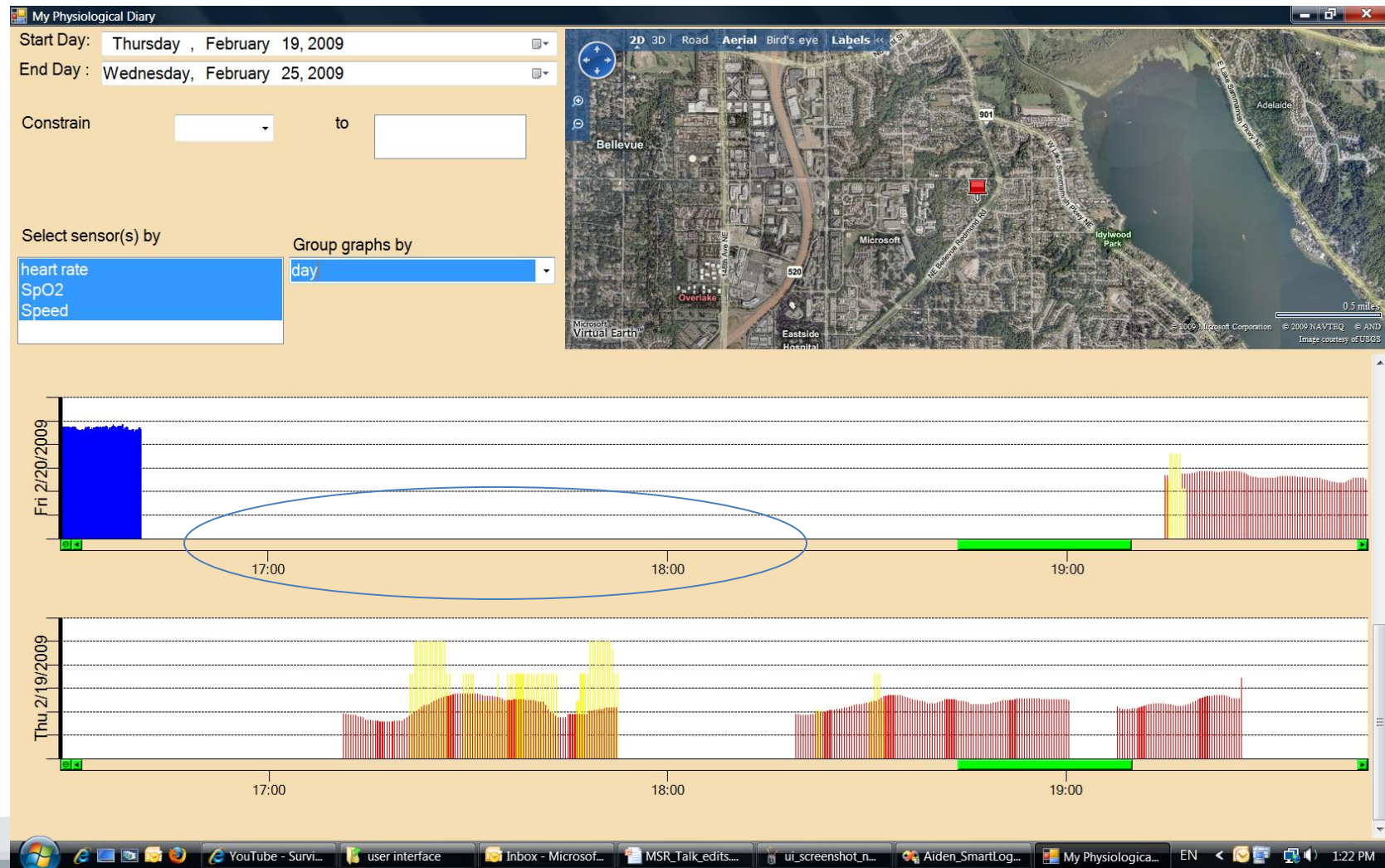
My Physiological Diary:
Adaptively query based on time

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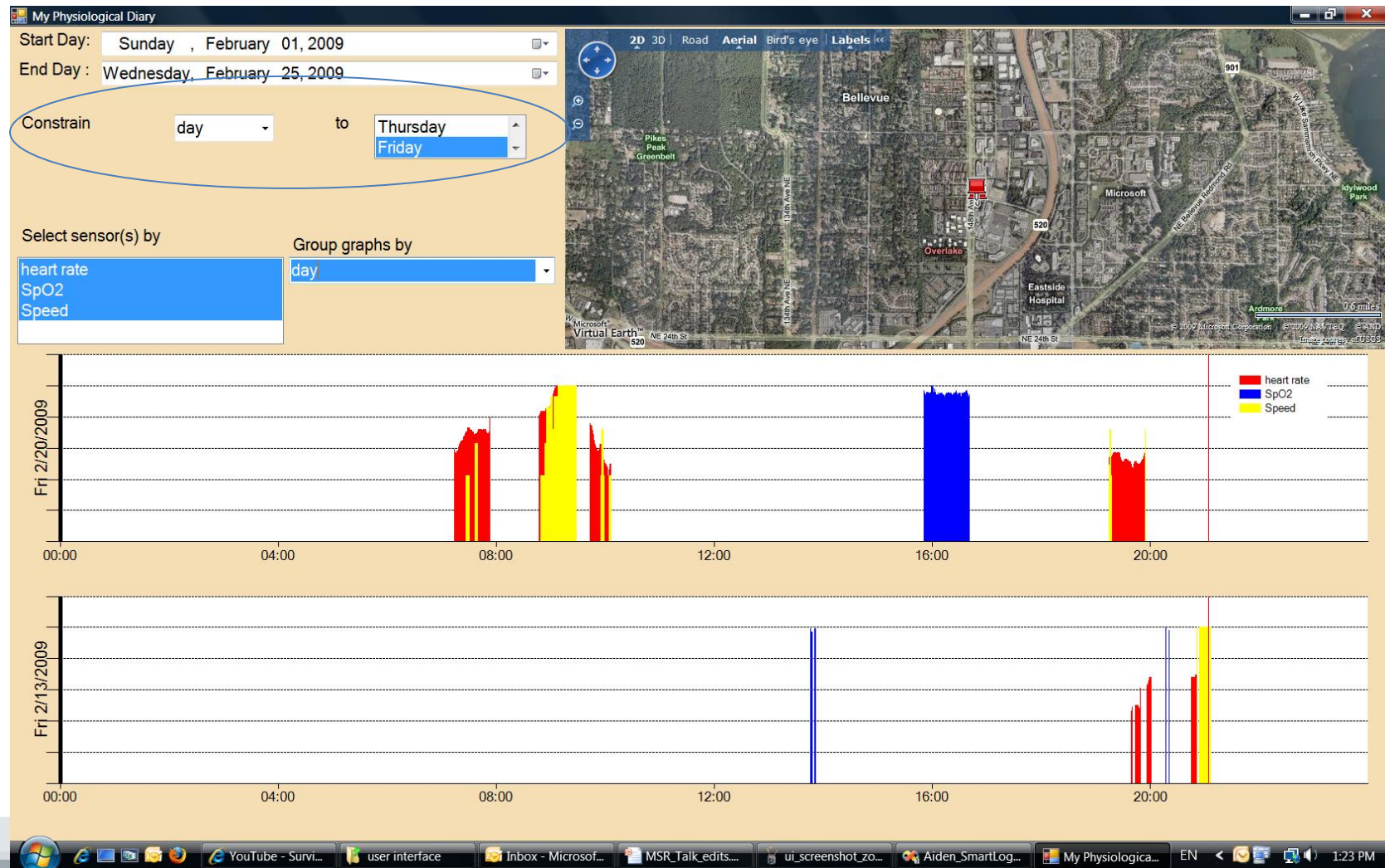
Result – OpenSource

- Allows **sensor device researchers** concentrate on the their hardware/chemistry/physics strengths

- Will allow **machine learning researchers** easily aggregate data to apply their techniques

- Will allow **health conscious individuals** more easily make sense of the data they've been collecting

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Use Case – Sleep Apnea

- **12 million people in USA have sleep apnea**

- **Process of diagnosis can involve going to "sleep lab"**

- **In preliminary discussions with Sleep Disorders Center in UW Medical School**
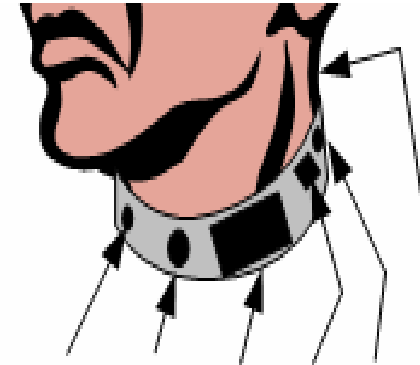
Sleep apnea neck cuff with oximeter, accelerometer, microphone, & gsr sensors

Future challenge – Security

Heart Rate

Location

Images

Body Temperature

Cellular
Wi-Fi
LAN
ActiveSync

Data Store

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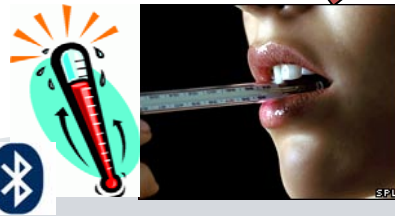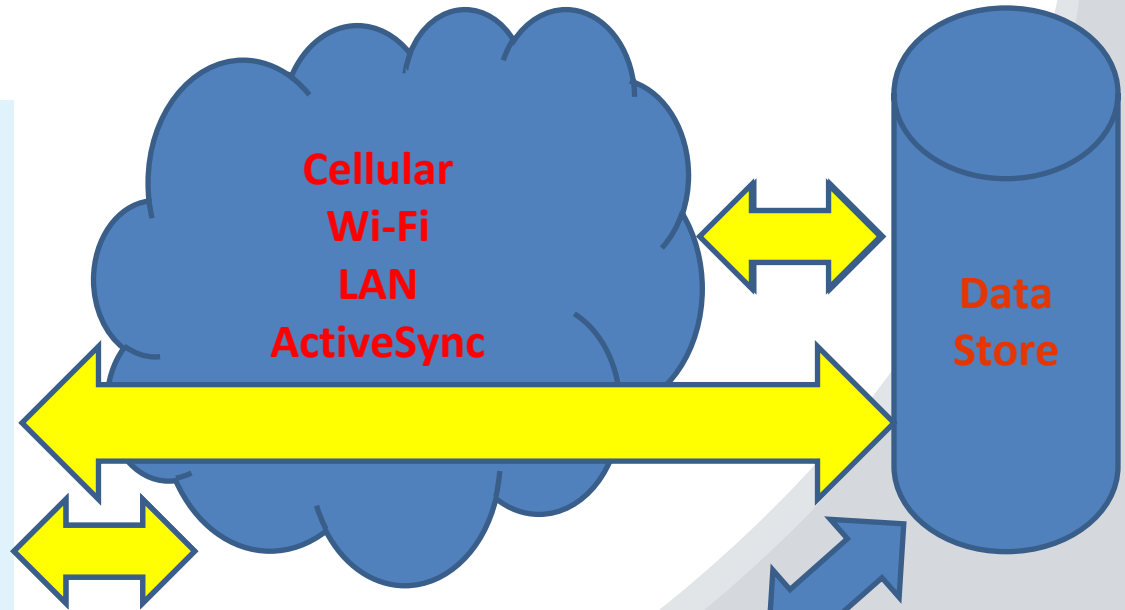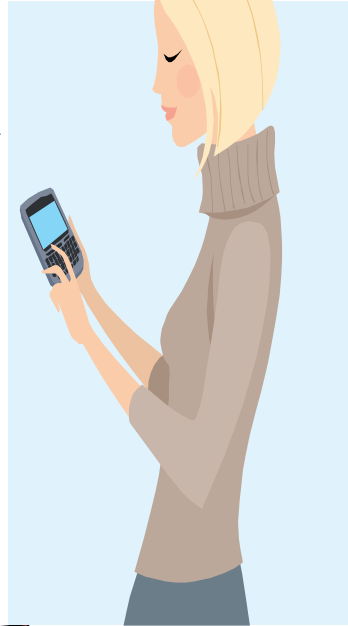
Future – Health Vault

Heart Rate

Location

Images

Body Temperature

Cellular
Wi-Fi
LAN
ActiveSync
...
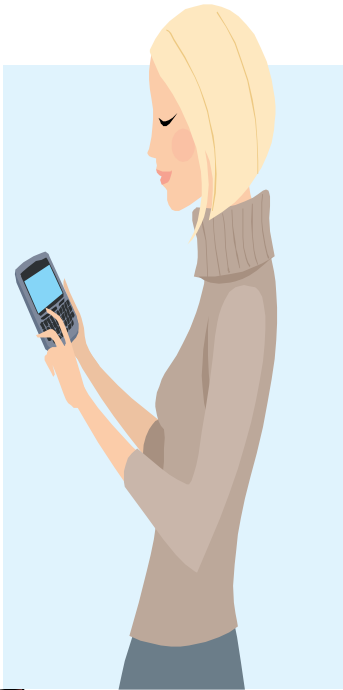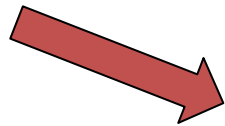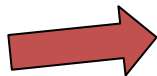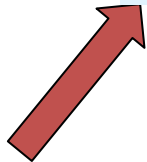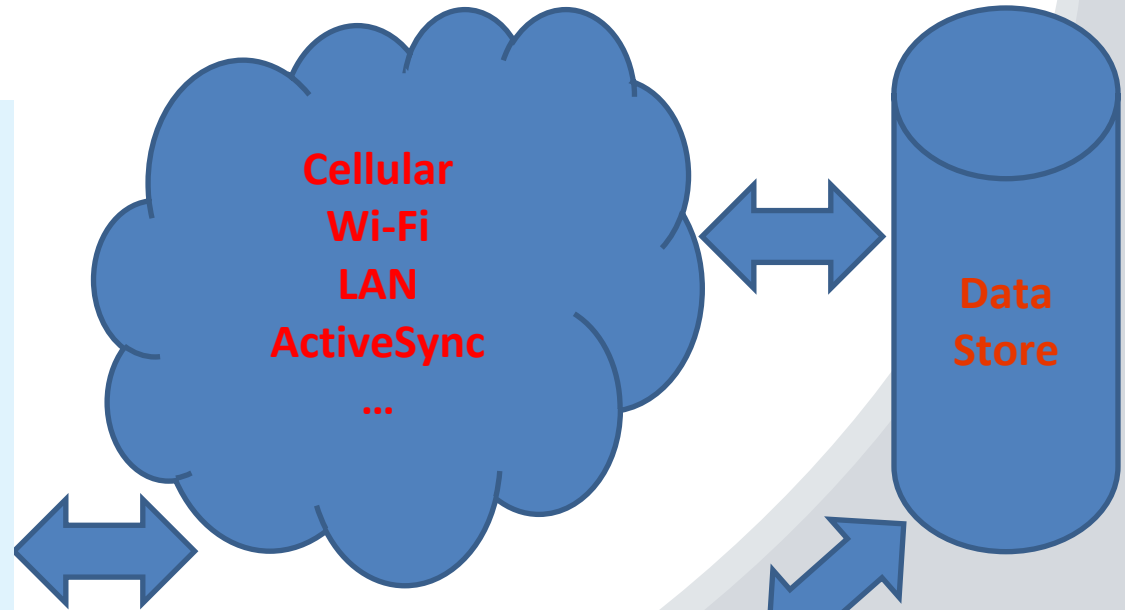
Data Store

Future – Symptom detection
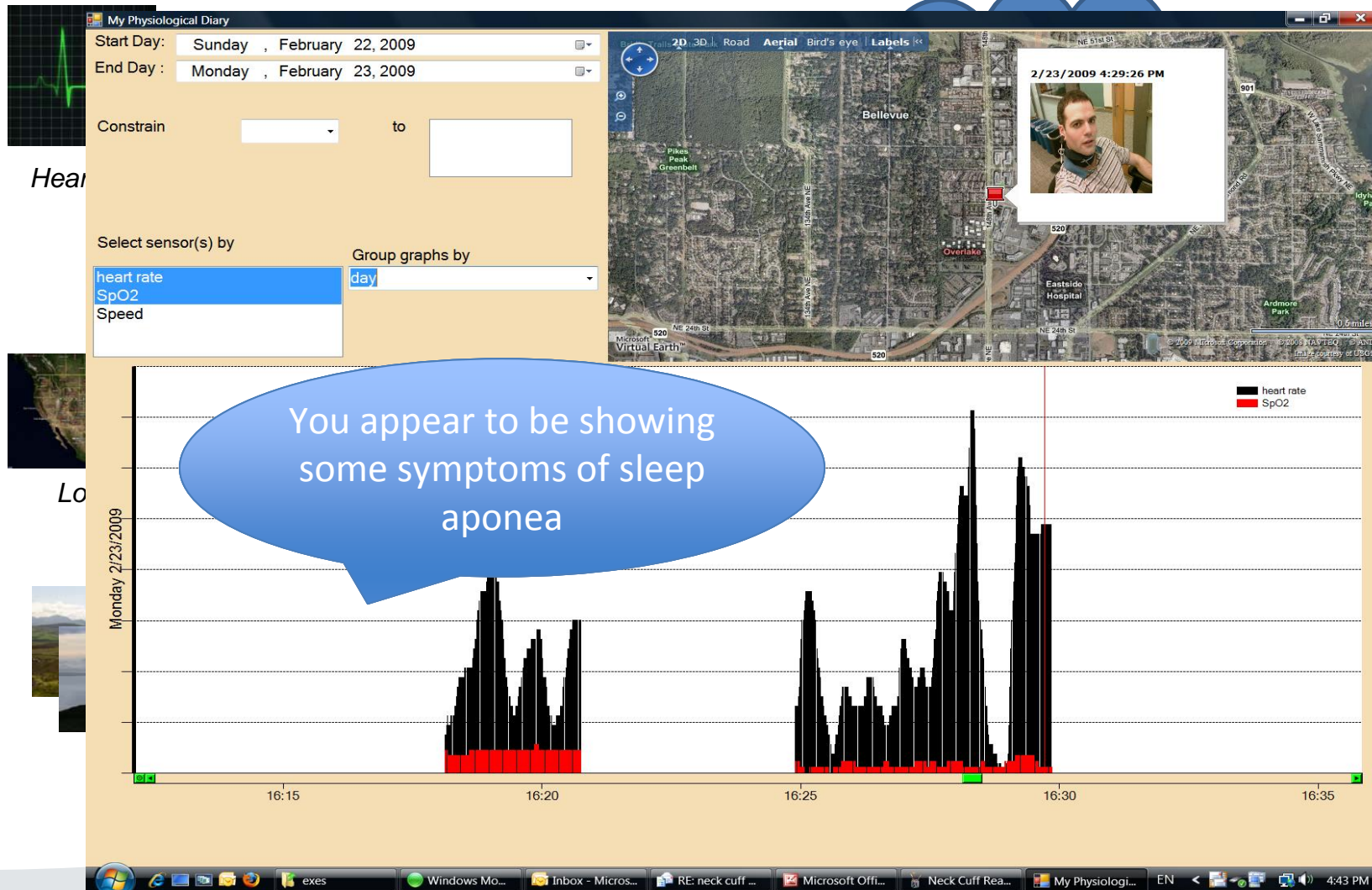
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Dublin SenseCam Work

Activity Recognition

27 "concepts"

Outputs manually judged on ~95k images (5 users)
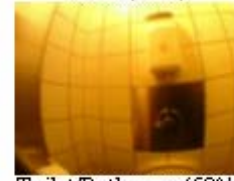
Comparison of Lifestyle Within Social Groups

Future – Zigbee

Heart Rate

Location

Images

Body Temperature

Cellular
Wi-Fi
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…
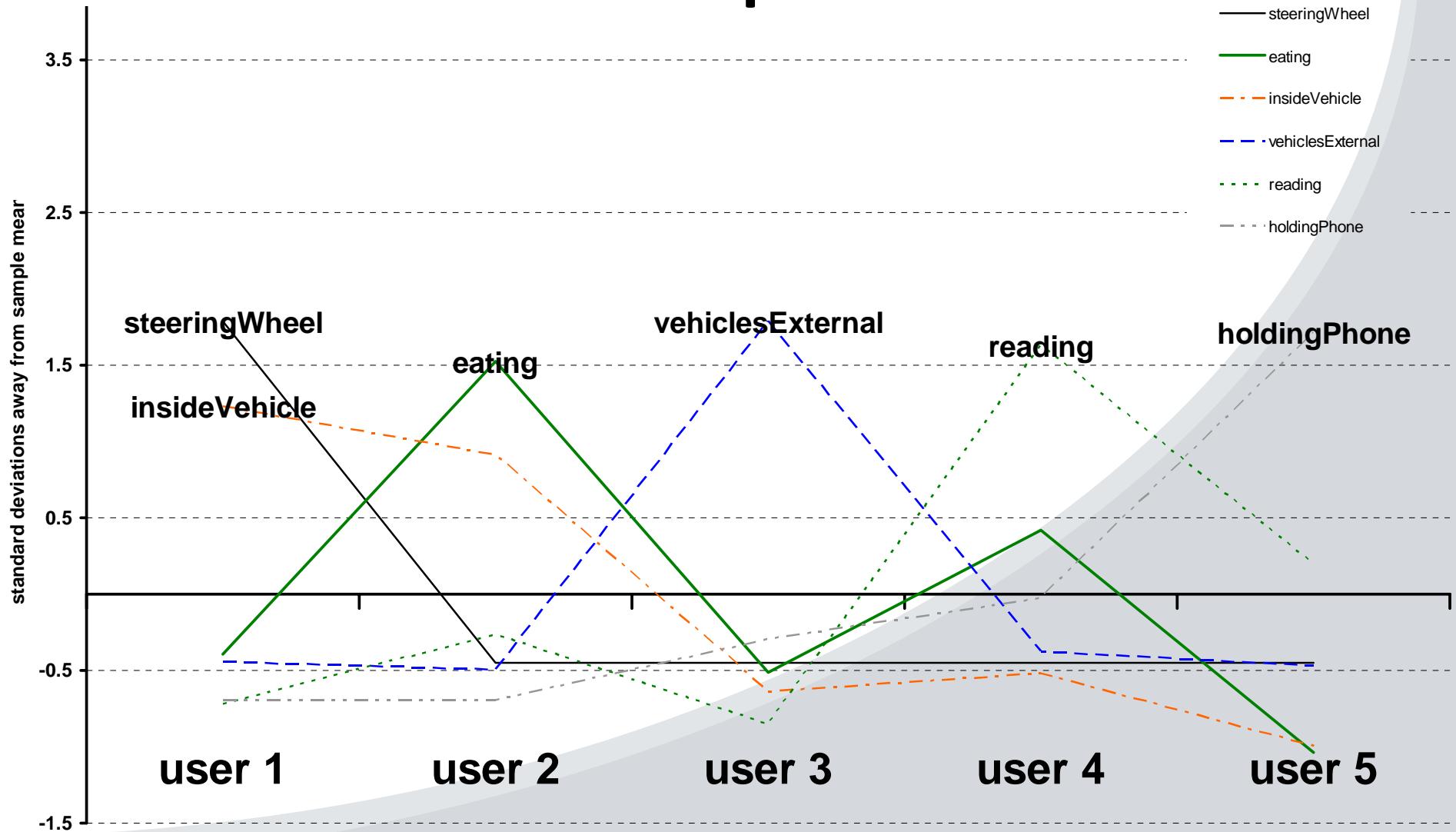
Data
Store

Conclusions

- Utilising cell phone ubiquity
  - Logging platform on Windows Mobile devices
  - Framework allows easy integration of new BT sensors

- Reviewing physiological values
  - Interface to monitor, analyse & browse through huge volumes of sensor data
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- Lot's of exciting future directions!!!

Thank You

Special thanks to Kristin Tolle, Tim Chou, Mike Sinclair, Kristin Lauter, Eric Horvitz, Roger Barga, and Jim Gemmell.

further information:
http://www.cdvp.dcu.ie/SenseCam