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
# CLARITY

## Principal Investigators

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Areas</th>
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<tbody>
<tr>
<td>Prof. Barry Smyth</td>
<td>Personalization, recommender systems, mobile computing</td>
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<tr>
<td>Prof. Alan Smeaton</td>
<td>Content-based information retrieval</td>
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<tr>
<td>Prof. Dermot Diamond</td>
<td>Materials research, wearable sensors</td>
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<tr>
<td>Prof. Noel O’Connor</td>
<td>Audio-visual analysis, multi-modal information processing</td>
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<tr>
<td>Mr. Gregory O’Hare</td>
<td>Ubiquitous computing, multi-agent systems</td>
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## Associate PIs

<table>
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<th>Name</th>
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<tbody>
<tr>
<td>Prof. Paddy Nixon</td>
<td>Pervasive computing, middleware, security, trust, privacy</td>
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<tr>
<td>Prof. Niall Moyna</td>
<td>Sports Science, wearable sensing</td>
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<tr>
<td>Dr. Simon Dobson</td>
<td>Middleware, pervasive computing</td>
</tr>
<tr>
<td>Dr. Cian O’Mathuna</td>
<td>Sensor devices, energy-aware hardware</td>
</tr>
<tr>
<td>Dr. Brian Caulfield</td>
<td>Physiotherapy, therapeutic gaming, wearable sensors</td>
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## 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
CLARITY

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
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?
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


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

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
Simple view of Human Memory

• 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
Result – OpenSource

- Allows sensor device researchers concentrate on 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
Future – Health Vault

Heart Rate

Location

Images

Body Temperature

Data Store

Cellular
Wi-Fi
LAN
ActiveSync
...
Future – Symptom detection

You appear to be showing some symptoms of sleep apnea.
Dublin SenseCam Work Activity Recognition

27 “concepts”

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

- steeringWheel
- eating
- insideVehicle
- vehiclesExternal
- reading
- holdingPhone

standard deviations away from sample mean

user 1  user 2  user 3  user 4  user 5
Future – Zigbee

Heart Rate

Location

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Body Temperature

Cellular
Wi-Fi
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ActiveSync...

Data Store

UNIVERSITY COLLEGE DUBLIN • DUBLIN CITY UNIVERSITY • TYNDALL NATIONAL INSTITUTE
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
  • “Individualise” medical baselines

• Lot’s of exciting future directions!!!
Thank You

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