Making sense of the quantified self

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Outline

- Lifelogging overview
- Lifelogging technology – wearable sensors and environmental sensors
- Analysing and processing lifelog data
- Lifelog applications

Lifelogging

- **“Undiscriminating (indiscriminate ?) collection of information concerning one’s life and behaviour” - K. O’Hara**

- **Characteristics are … digital format … not selective … always-on … first person … raw and derived data streams … perhaps real-time …**

- **Why ? For work, for personal, for posterity, or initially because we could**

Lifelogging

Insight

- **Creates a (permanent) digital record – human digital archive, a lifelog, personal memory bank**
- **Presents challenges in terms of**
  - Technologies to sense and to capture
  - Technologies to store and transmit
  - Techniques to analyse and understand
  - Techniques to access, retrieve
  - Finding useful applications in which to embed
- **This is the wrong way around … it should be**
  - Problem > Solution > Technologies
- **Instead its**
  - Technologies … looking for problems to solve … hence the slow burn startup

Lifelog Technology

Insight

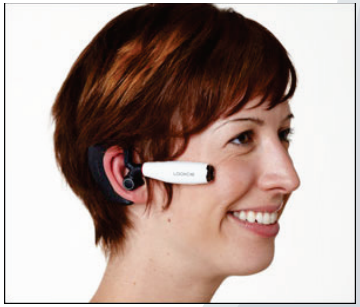
- **Has elements of new sensor technology (chemistry, material science), hardware, minituarisation, comms/storage, analytics, visualisation, etc.**

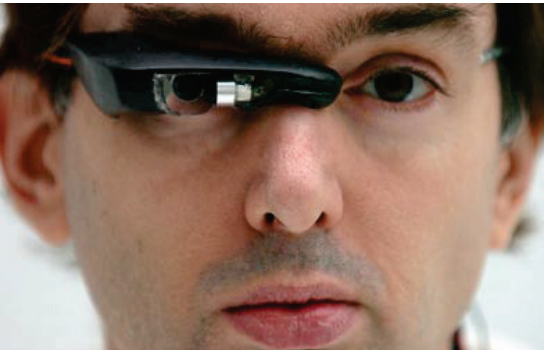
Divided into …

1. ***Wearable sensors*, on body, sense and log body actions, physiological reactions, either voluntary or involuntary. Exclude GSR, fMRI, EEG because these are reactionary within a *session* rather than logging a whole *life*.**
2. ***Environmental* sensors to sense and log the human impact or footprint on a place, indirect lifelogging**

Wearable technologies

Insight





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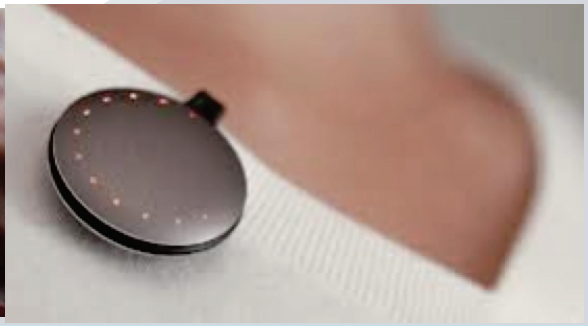
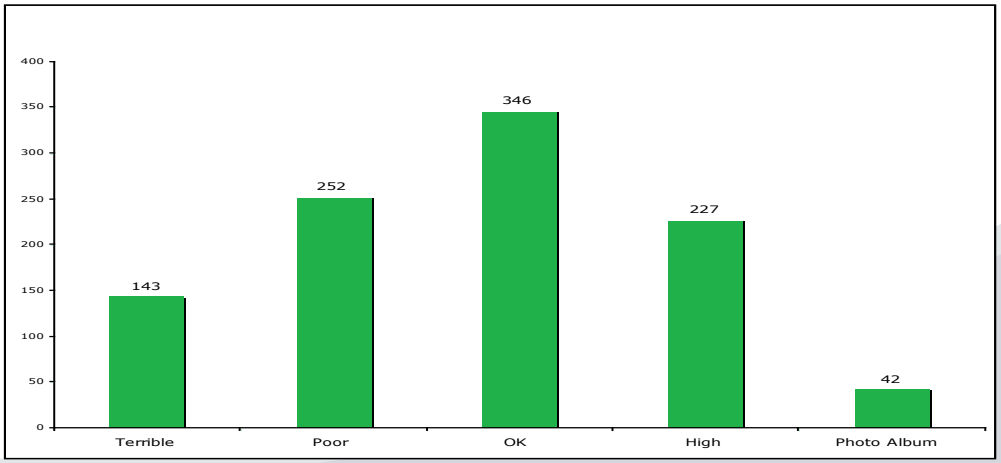
Simpler Wearables

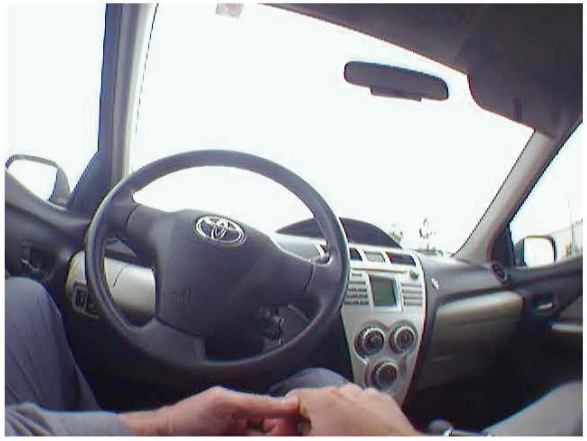
- Fitbit
- Nike Pulse
- Misfit Wearables Shine
- .. All accelerometer based, some feedback, cloud, dashboard, gamified, €99



SenseCam

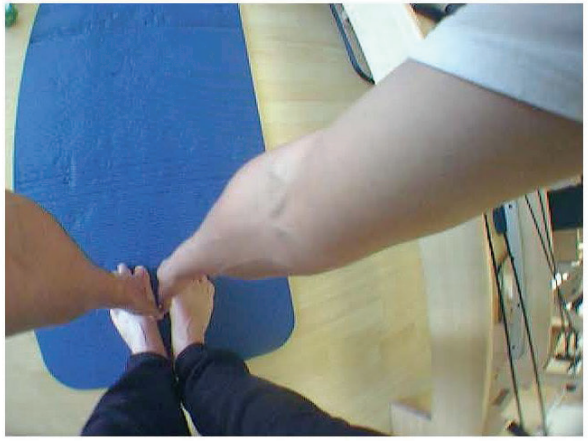
- Much of lifelogging is about recording visuals
- We've use Microsoft SenseCam with various sensors
- Individually poor quality images but can leverage it
- Superseeded by Vicon Revue, Autographer, Memoto
- Over 40 years of cumulative SenseCam data and a background of image and video analysis





Sitting driving car

Sitting riding on a bus



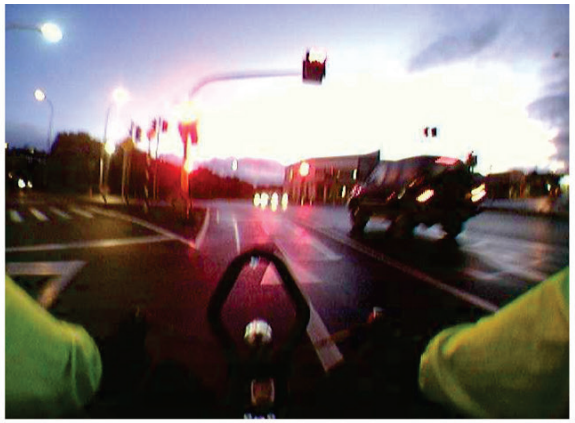
Standing doing conditioning exercise

Sitting using computer screen

Sitting eating and watching TV

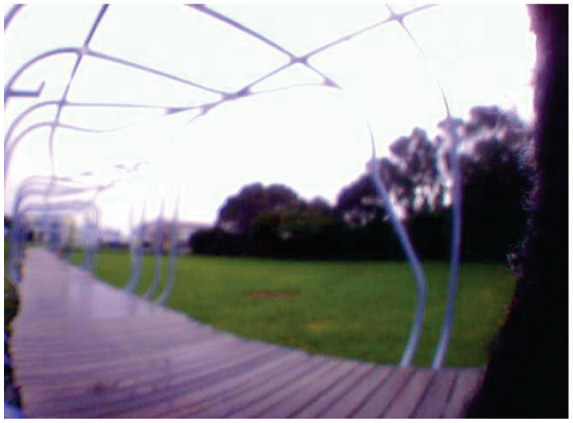
Sitting reading

Cars driving, pedestrians, pedestrian crossing, rain, road good condition, trees



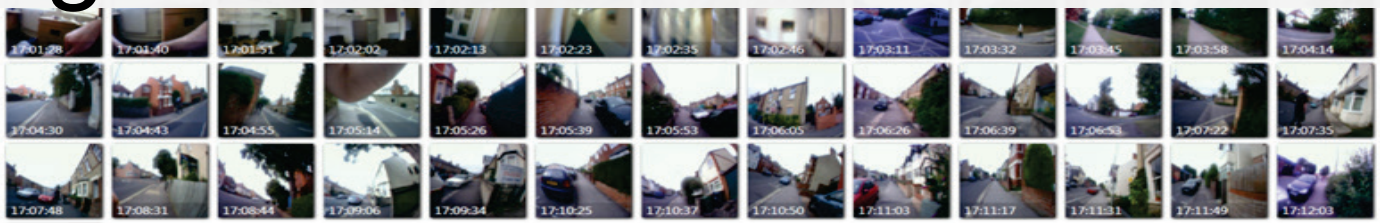
Cars driving, cycle lane, dark, other lights, pedestrian crossing, road good condition

Trees, walkway



Processing wearable camera data...

DAY OF IMAGES



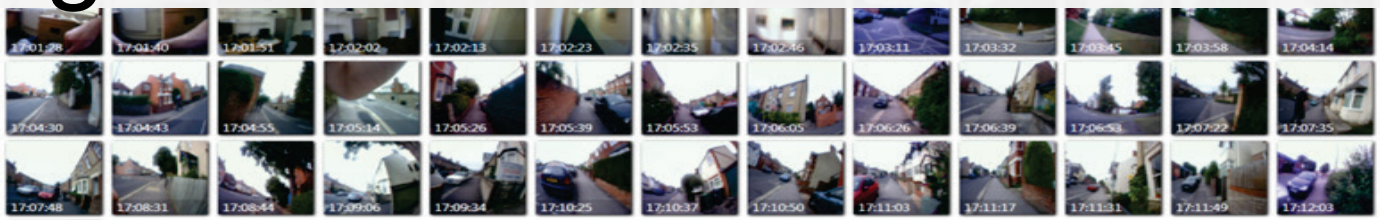
Processing wearable camera data...

DAY OF IMAGES

1 EVENT SEGMENTATION

Processing wearable camera data...

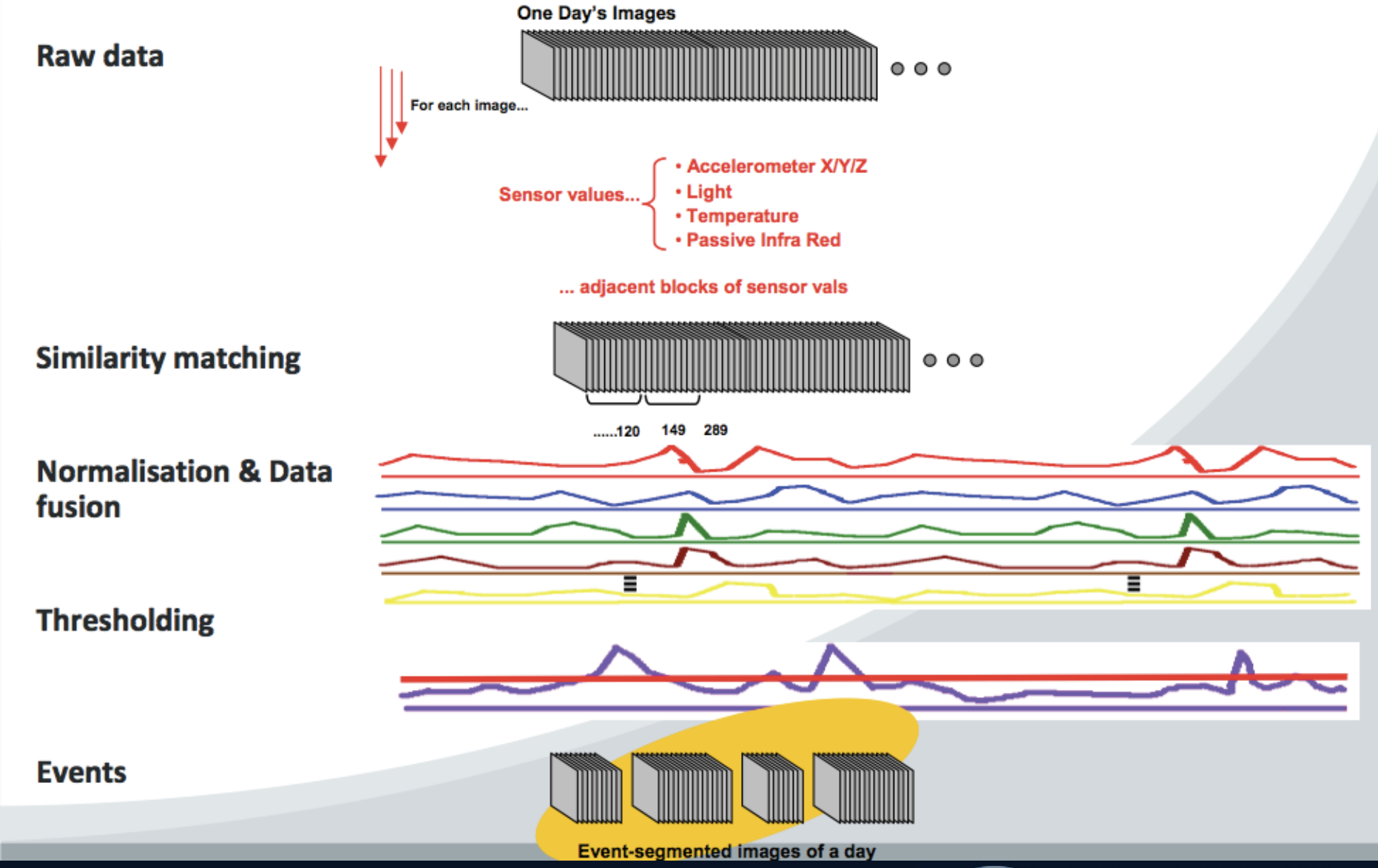
DAY OF IMAGES



1 EVENT
SEGMENTATION

1 EVENT
IDENTIFICATION

Event segmentation overview...



Doherty 2011; Memory 19(7):785-795

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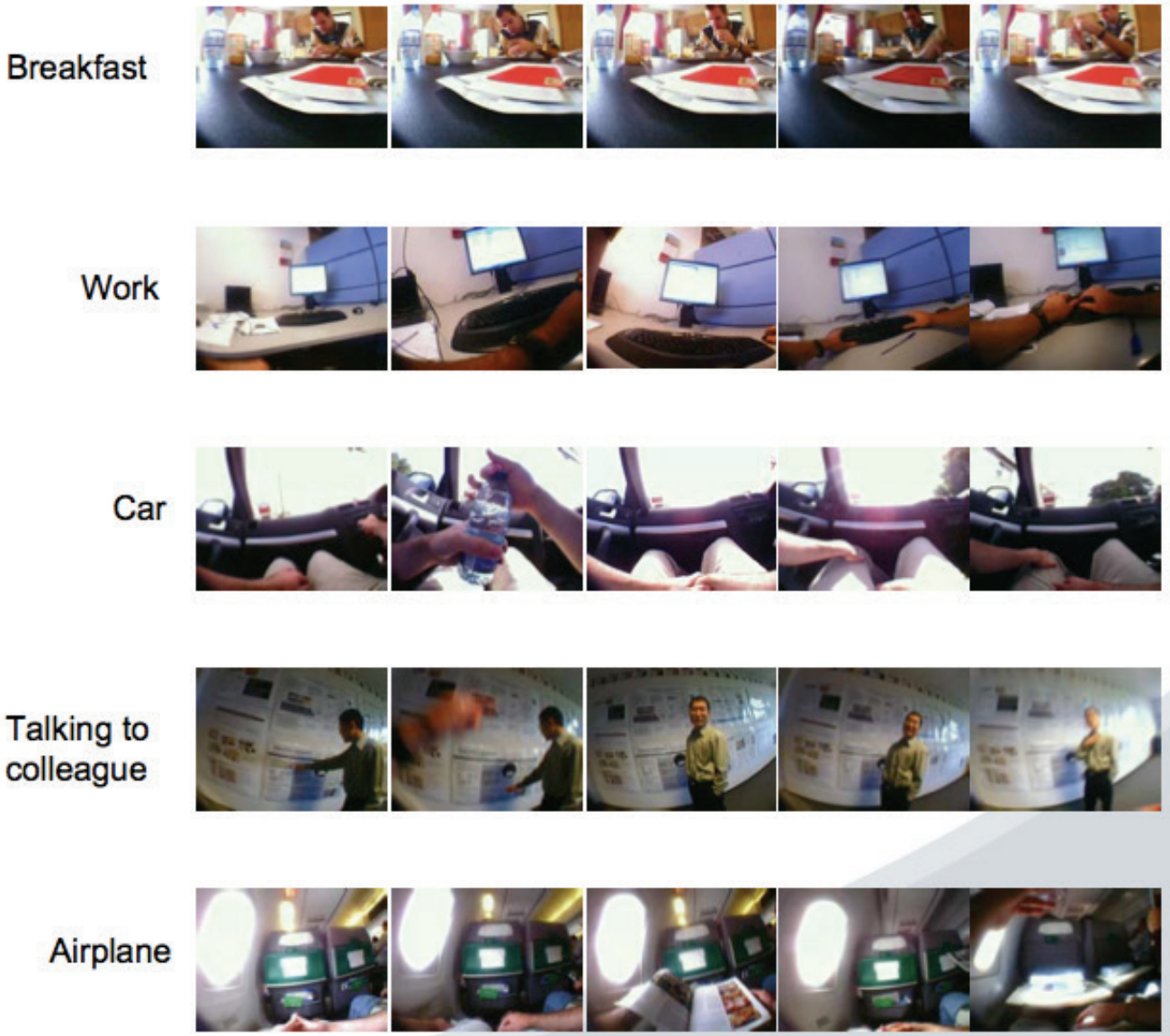
Event segmentation overview...



Event identification overview...

Activity Recognition *using Images*

- 27 "activities"
- Validated on 95k annotated images

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Activity capture

Insight

- Motion capture (Vicon, Kinect) is high-end, other times we don't need full motion capture, just activity classification .. What can we do using simple accelerometers ?
- You only need one accelerometer-enabled phone and some clever software… to get 98% accuracy in classifying activties !

- Walking, standing, running, driving, and so on…

Labelling

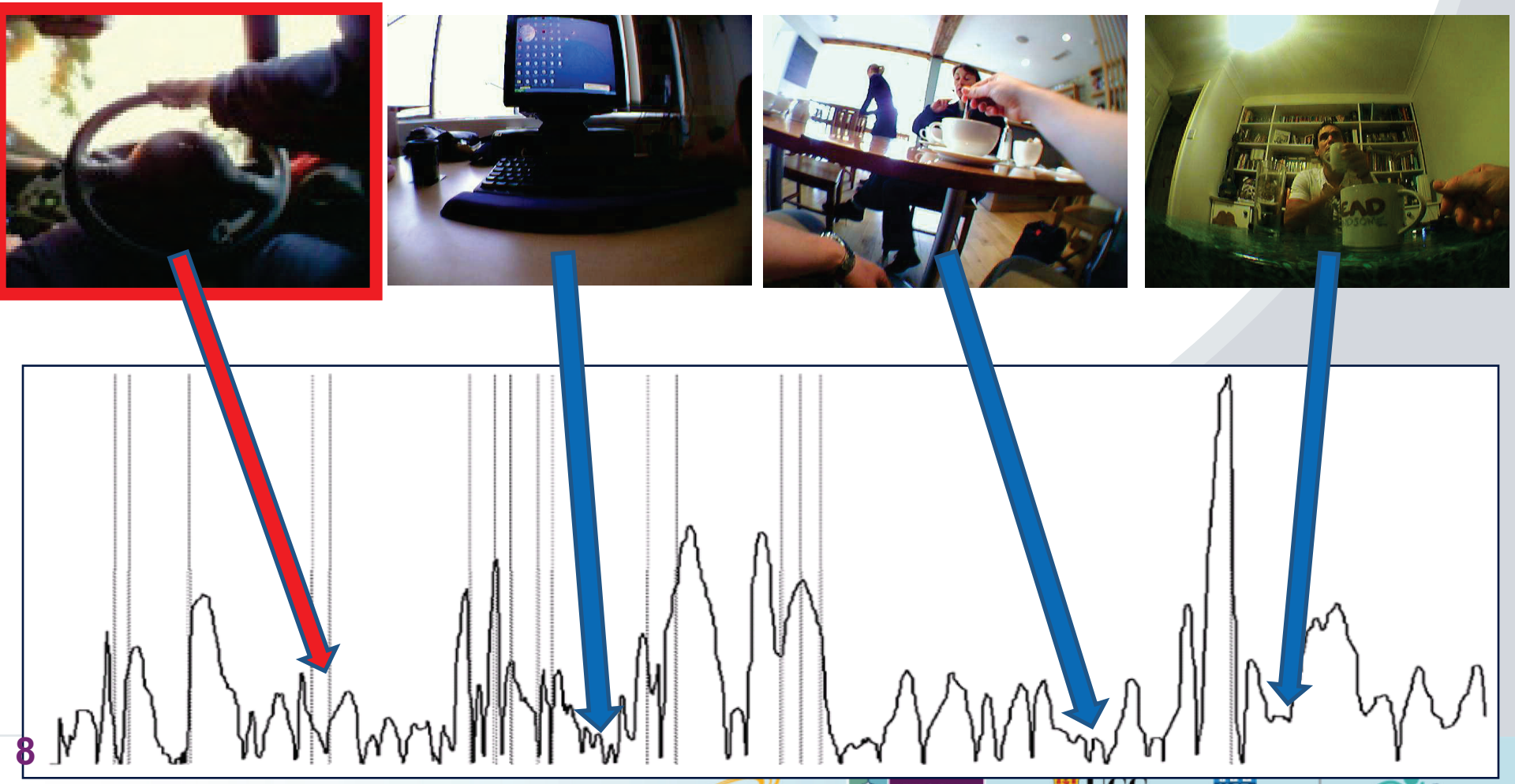
- **The accelerometer data is a stream of three numbers (tri axial) arriving at (at least) 1 HZ**
- **These numbers need to be converted into activity labels … this is the science bit**
  - This is done using Machine Learning with SVMs.
  - So what does that mean....
- **The activity labels are then validated by checking it against a groundtruth of the 'correct answers'**

Validation

- A key component of our validation was the SenseCam.
- The accelerometer readings from the SenseCam are time-aligned with the photos (3 per minute) so we have a perfect groundtruth

How to identify human activity from accelerometers?

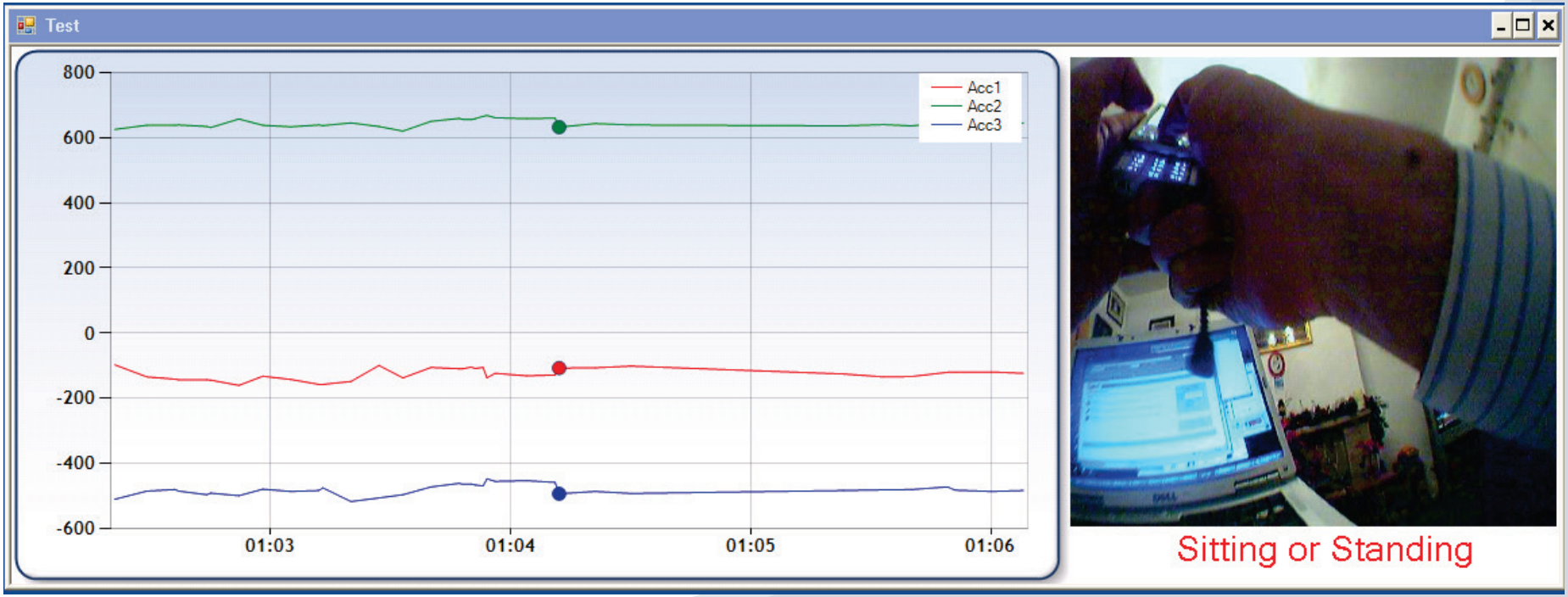
- 1 week groundtruth (132,247 acc readings)
- SVM – 39 features (mean/range/stdev of previous 1/5/20/120/300 on X/Y/Z axes)
- Precision score of 0.82 recorded after re-occurrence smoothing



Identifying Activities

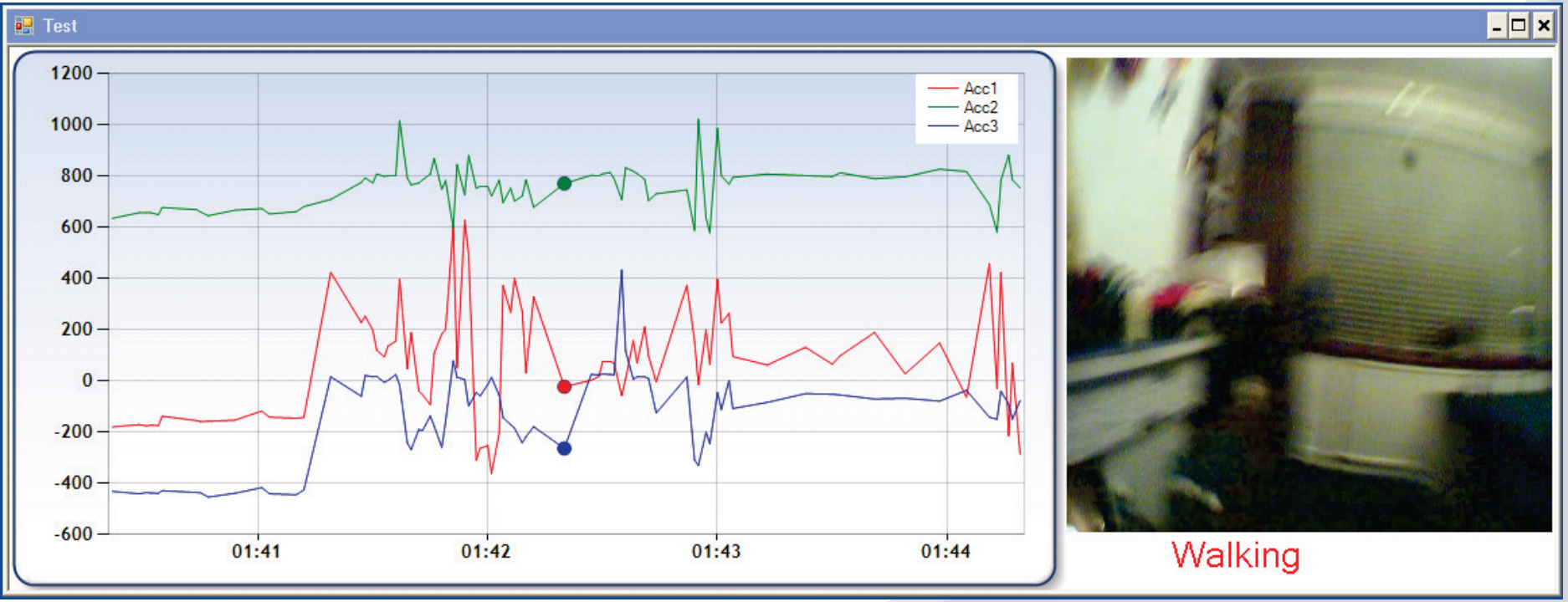
Sitting/Standing = 93% accurate

Using a range of classifiers: Logistic Regression, Naïve Bayes, J48, SVM, etc.



Identifying Activities
Walking = 97% Accurate

Insight



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Identifying Activities
Driving = 98% Accurate

Insight

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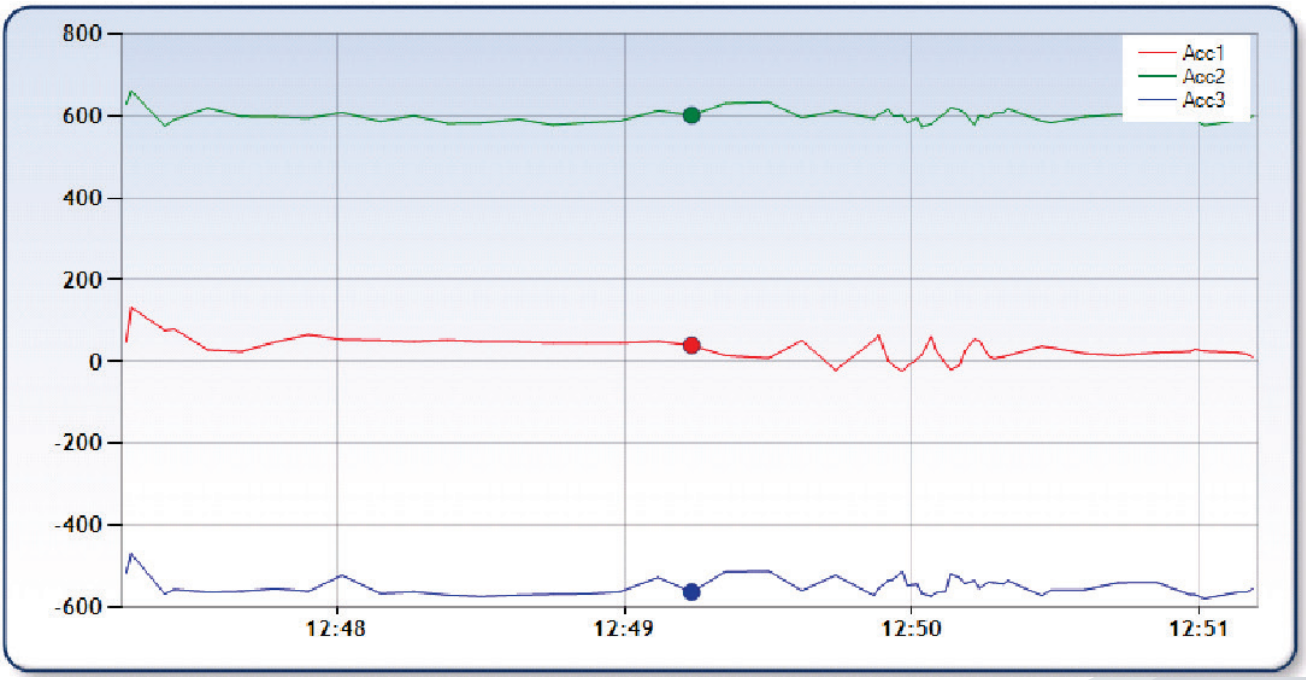
Identifying Activities
Lying = 98% Accurate

Insight



Lying

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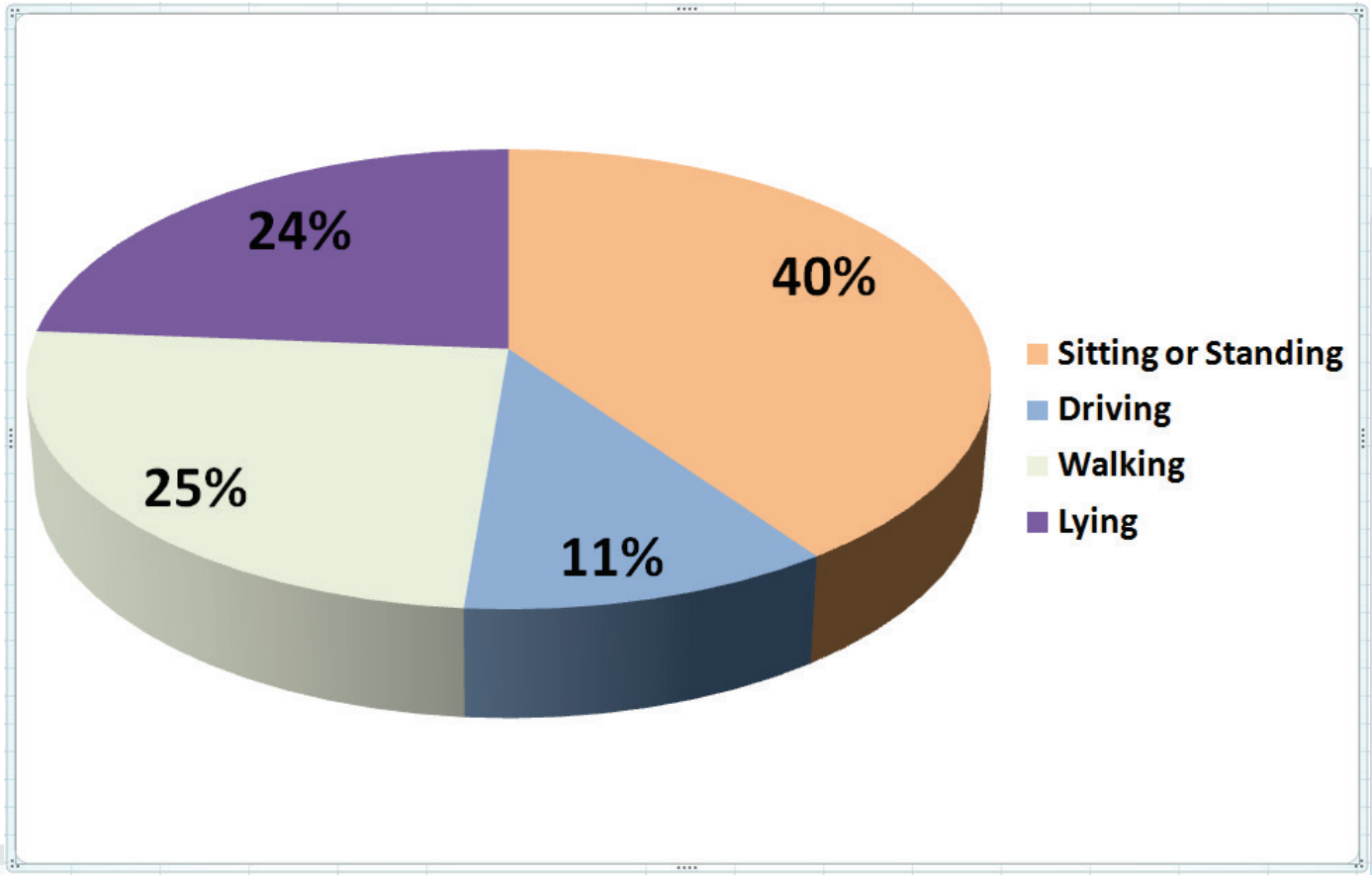
1 week's activities

- **Fitbit etc. don't do this, yet, why ?**



Lifelogging Applications

Insight

- **Very diverse range of lifelog application areas:**

1. Healthcare – self monitoring

- Many devices for logging energy expenditure – Apple and FitBit, Nike Fuelband, Lark – count steps or calories or Nike Fuel "points"
- Accelerometer / gyro, wristband typically
- Wrapped into a gamification model – CHI workshop 2013 "competition"
- Can go further to self-assess genetic composition, 23andme for example
- Standard OTS sensors are not great at logging some exercises … cycling, swimming

Applications

Insight

2. **Devices for logging your sleep – duration and quality**
   - Wristband (worn), or device under the pillow using accelerometers/ gyros
   - Logging of breathing patterns – *Gear4 Renew Sleepclock* uses low-power radio waves and measuring refraction as we breathe/move, so it is contactless
   - Should really be used in IC units in hospitals but it's a product !

- **Why do we bother self-monitoring ?**
  - No medic has ever been delighted to see you bring in your data like this

Insight

« Week
May 5 - May 11

SUN MON TUE WED THU FRI SAT

Thu, May 9, 2013

Good evening
alan.smeaton@dcu.ie
54 M, 185 lbs, 5' 11" , Switcher

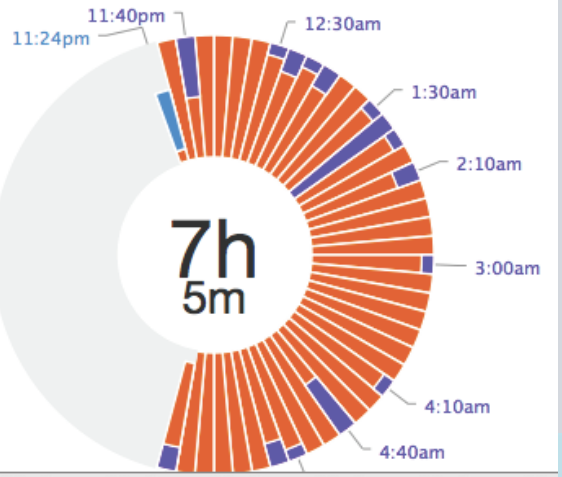
You slept OK.

Sleep Stats

Time Asleep	Sleep Quality	Fell Asleep In
6h 23m	9.0 out of 10	5 min
		Woke Up 15 times

Sleep Pattern

Total time in bed	7h 5m
Bedtime	11:24 PM
Wake up	6:29 AM



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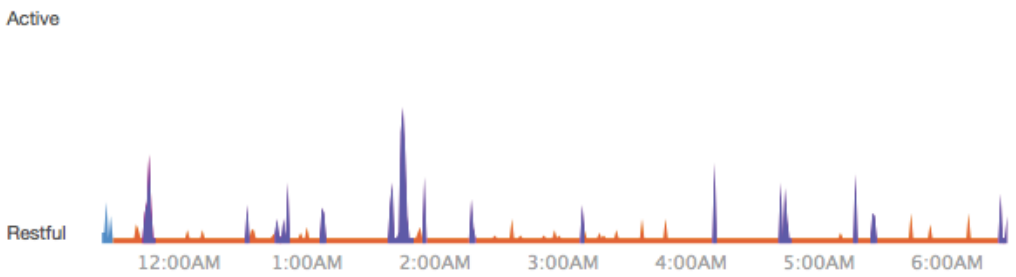
Insight

Actigraph



Historical stats

Since March 01, 2012

Data for
324 nights

Rate of use
74%

Avg Time Asleep
6h 31m

Avg Total Time in Bed
7h 36m

Avg Bedtime
11:55 PM

Avg Wake Up
7:31 AM

Avg Sleep Quality
8.6

Avg Time to Fall Asleep
25 min

Avg Times Awaken
17 times

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Applications

- **Why healthcare self-monitoring ..**
  - Because we can
  - Because its been gamified
  - Because its cheap and satisfies a self-curiosity
  - Because its marketed at us

- **Healthcare self-monitoring has other applications**
  - Diet monitoring – difficult to sense what you eat automatically, easy to cheat, so used as a memory trigger for manual log
  - Smoking cessation – likewise difficult to sense smoking automatically so apps used as a conscience trigger

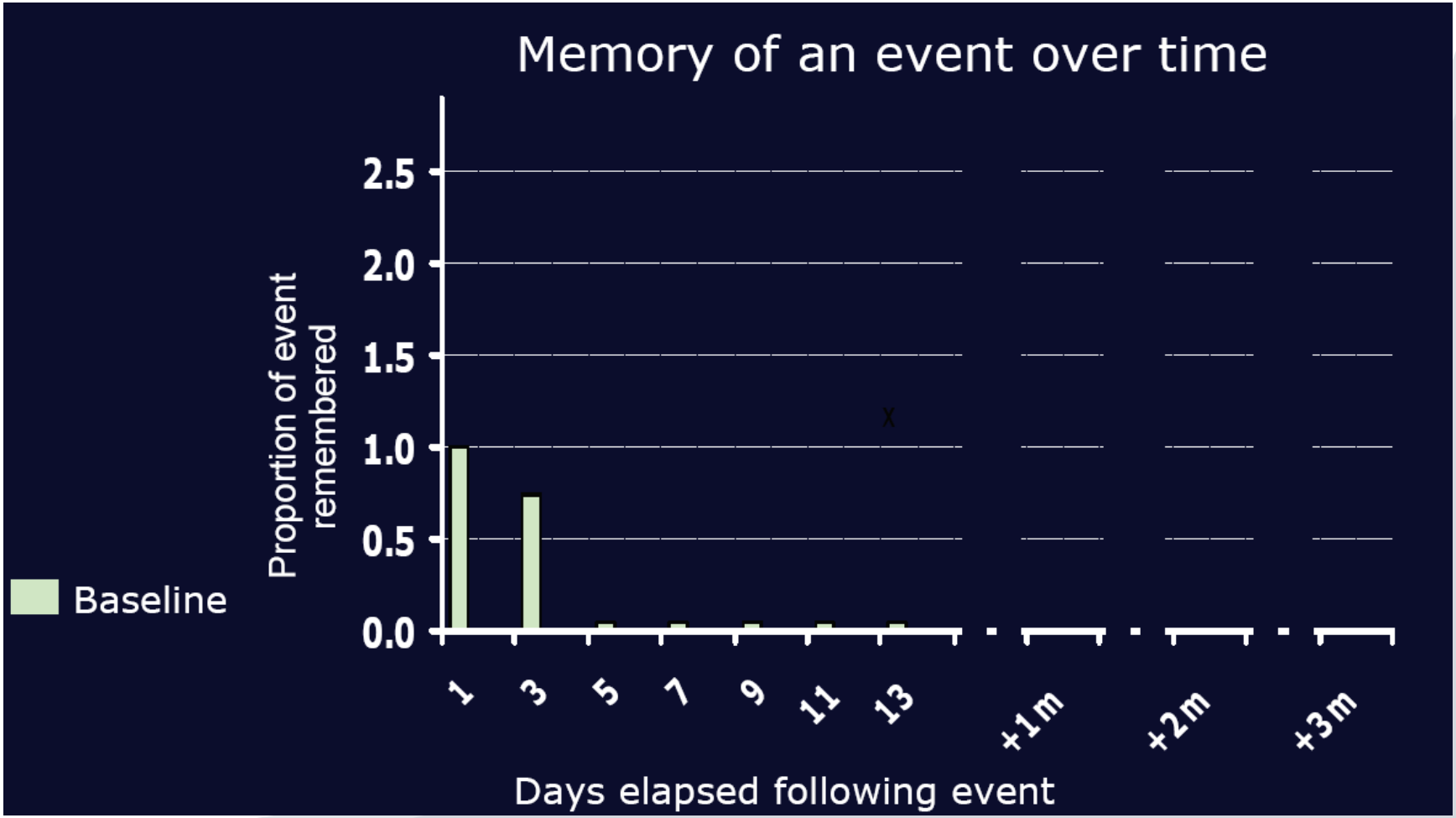
Healthcare Applications

Insight

3. Memory prosthesis for people with dementia

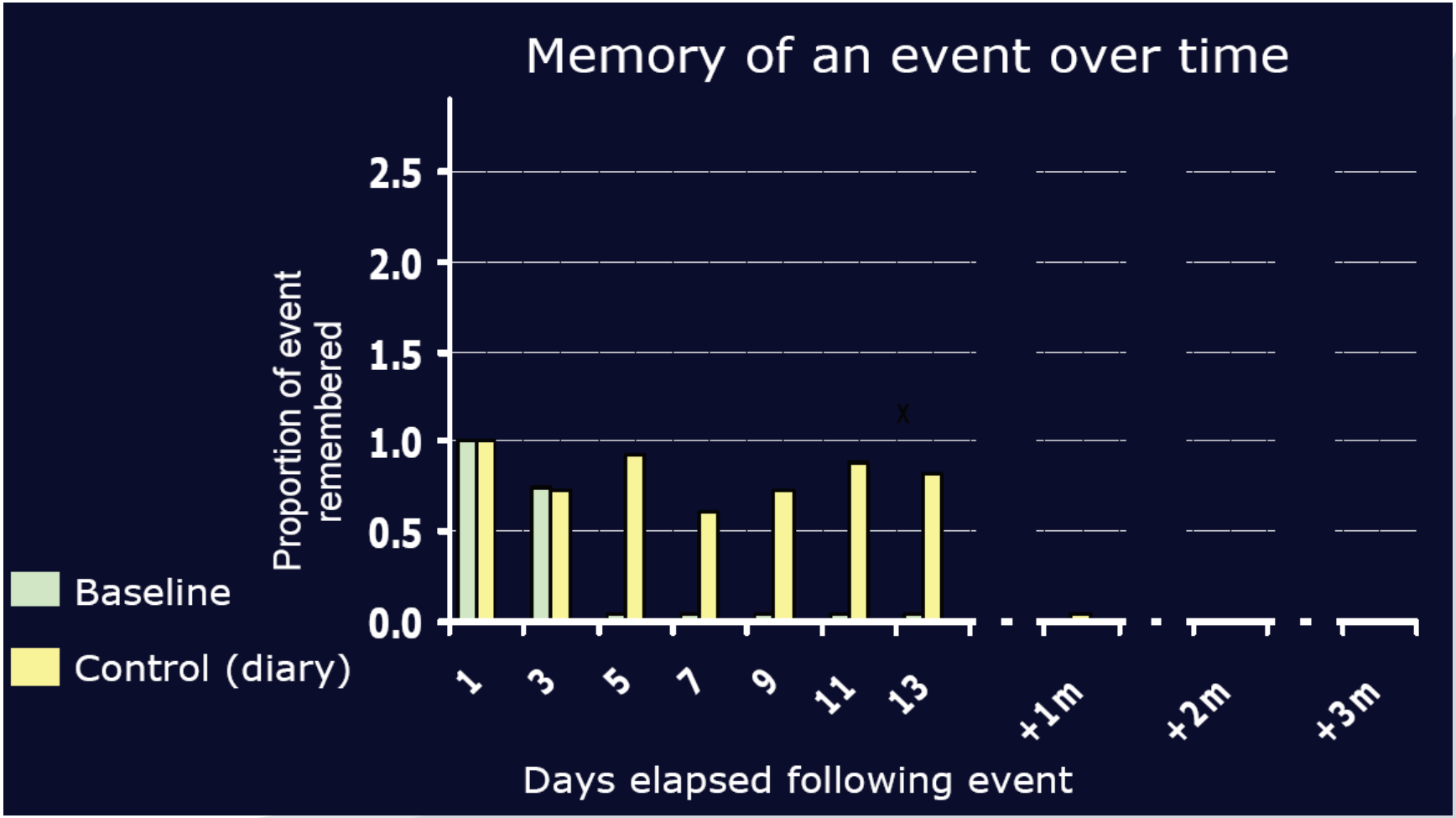
- Re-living a recent experience from a lifelog can induce a Proustian recall … trigger can be a smell, sound, image, object, etc. … or from your own lifelog
- Lots of work using SenseCam especially, to log and then re-play a day … today … giving short-term recall, opening cognitive pathways
- Studies at Addenbrooks hospital show measurable effects of replay of today's activities

Addenbrooke's: SenseCam Work



Microsoft Research Cambridge presentation: http://research.microsoft.com/~shodges/presentations/UBICOMP_senseCam.pdf

Addenbrooke's: SenseCam Work



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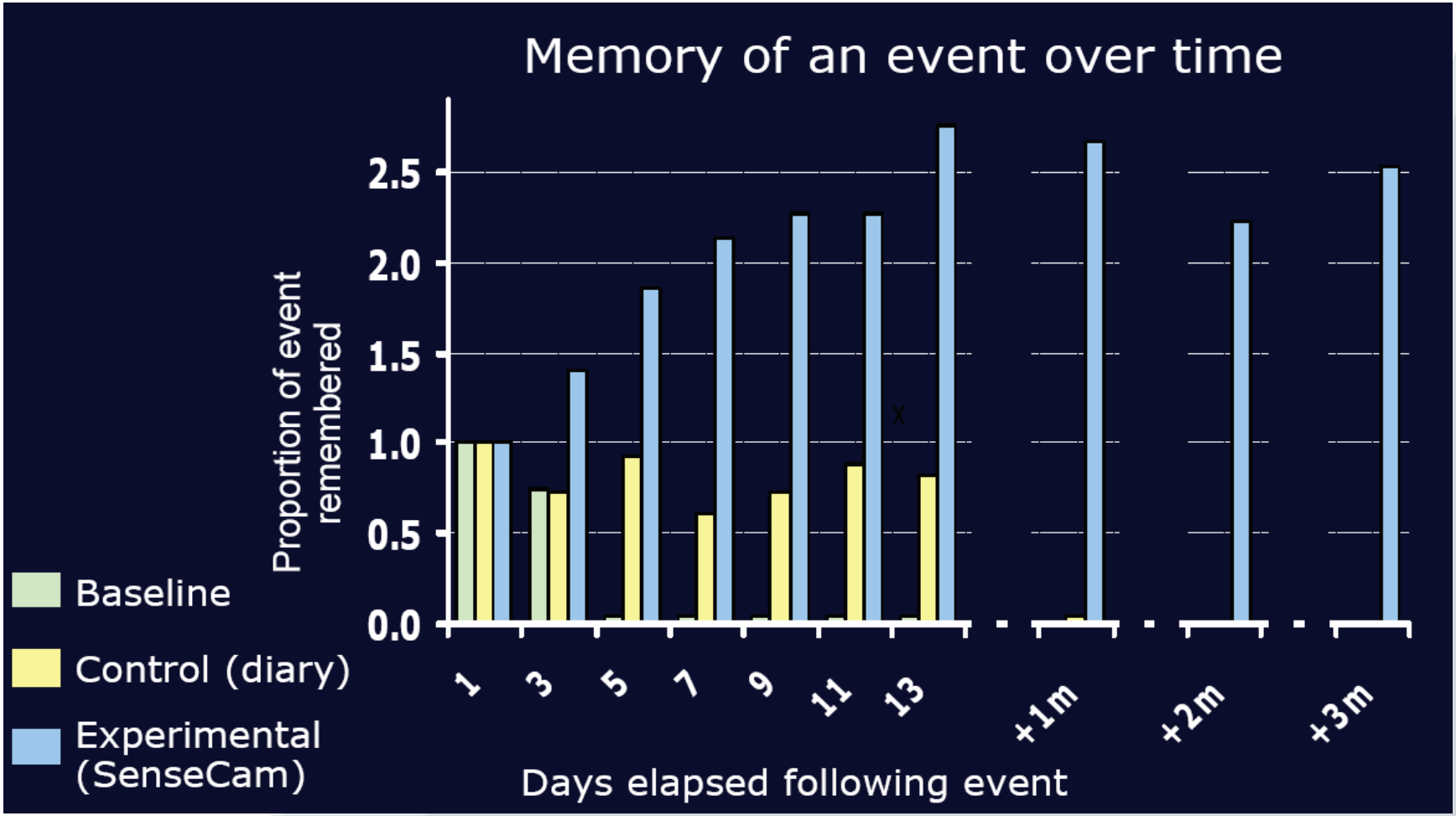


Microsoft Research Cambridge presentation: http://research.microsoft.com/~shodges/presentations/UBICOMP_senseCam.pdf

Healthcare Applications

- Using lifelogs for detection of longer-term cognitive decline or gradual behaviour change, for example, is far more difficult because of daily variations … there is no *normal* day in our lives
- Many AAL projects instrumenting homes, storing data and seeking patterns, e.g. GNH with 100+ sensors per home … PIRs, contacts, power use, switches, audio, water, mattress, etc.

Other Applications

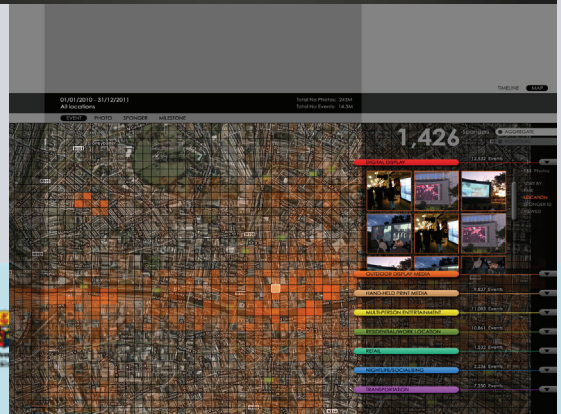
Insight

4. Corporate Memory - Capture procedures

- Past work on healthcare workers in clinical practice, logging their work at the end of shift
- Police forces do this, warfighters do this, and more …

5. Market research – novel qualitative analysis

- Past work on music festival attendees with visual lifelogging and location-tracking (Android)
- Information aggregated and images are then searchable.
  Can gain insights into who saw what, where and when



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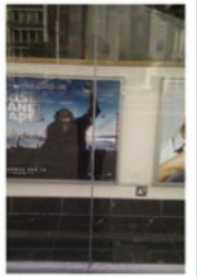
Market Analysis

Insight

- Worked with an Irish SME to develop a system to allow upload of lifelog images and data
- Field-tested at 2011 Electric Picnic where 100,000+ images were uploaded from 11 individuals
- Subsequently analysed behaviour patterns; using SIFT/SURF techniques we are able to search for logos/brands
- Now moving to eye-glass based video capture, with eye-tracking



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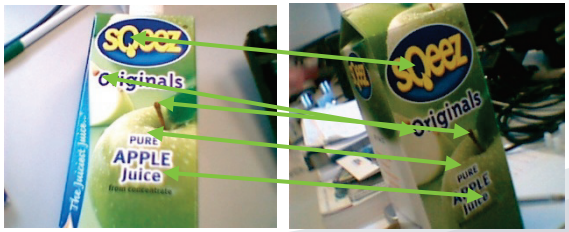
Lifelogging for Market Analysis

Insight

SURF features are extracted

Each feature point casts a weighted vote against multiple database images

Votes are accumulated & the best match is found



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Applications

- So lots of application areas, mostly driven by throwing technology at problems … what about availability of tools ?

- personalinformatics.org is a good starting point

Know thyself.

Personal informatics is a class of tools that help people collect personally relevant information for the purpose of self-reflection and self-monitoring. These tools help people gain self-knowledge about one's behaviors, habits, and thoughts. It goes by other names such as *living by numbers*, *personal analytics*, *quantified self*, and *self-tracking*.

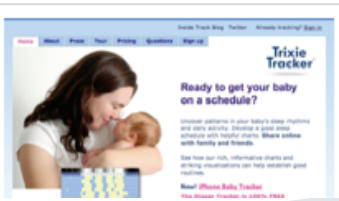
This site is a resource for all things related to personal informatics.

Tools See all »

SweetSpot
Collaborative diabetes management

Garmin Connect
Community of Garmin users who track and share their activities

your.flowingdata
Capture your life in data. One tweet at a time.



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Send links to questions, articles, research, and applications to Ian Li: ianli@personalinformatics.org

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Tools

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A visual guide to good food and where to find it.

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Master yourself.

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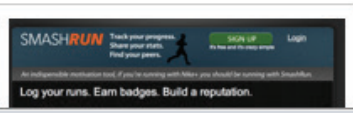

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Submit a personal informatics tool.

Tags

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Personal Informatics

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23andMe

Genetics just got personal

https://www.23andme.com/

23andMe is a genetic testing service that provides information and tools to understand your DNA. Its mission is to be the world's trusted source of personal genetic information.

TAGS genetics

Posted on December 29, 2009

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9 time management
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It's your life.

Drinking Diary
Monitor how much alcohol you drink - and reduce it!

SmashRun
Stats for runners

Chart Myself
Know yourself better than your doctor

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gottaFeeling? Share it

Catch
Capture what matters

textWeight
A simple way to track your weight and see your progress

MyMigraineJournal
Statistical analysis of your migraine triggers

Dailee
The first icon online diary & journal

gas mileage	12
genetics	2
goals	10
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menstruation	3
migraine	2
mood	12
mouse activity	1
music	4
notes	3
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smoking	1
social web	4
sustainability	1
swimming	1
time management	9

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textWeight
A simple way to track your weight and see your progress

MyMigraineJournal
Statistical analysis of your migraine triggers

Daileez
The first icon online diary & journal

FridgeGraph
A free on-line service to make losing weight a bit more fun!

Choice by Choice
Achieve your goals - one choice at a time.

Health Month
Live healthy, for fun.

LoungeLog
Track, Review and Share Any Kind of Media

GoalsOnTrack
Keep your goals on track and get things done.

social web	4
sustainability	1
swimming	1
time management	9
timeline	8
travel	4
twitter	10
virtues	1
web activity	5
weight	9
wellbeing	1

5 diabetes
6 electricity
29 exercise
8 finance
15 food
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23andMe

Genetics just got personal

https://www.23andme.com/

23andMe is a genetic testing service that provides information and tools to understand your DNA. Its mission is to be the world's trusted source of personal genetic information.

TAGS genetics

Posted on December 29, 2009

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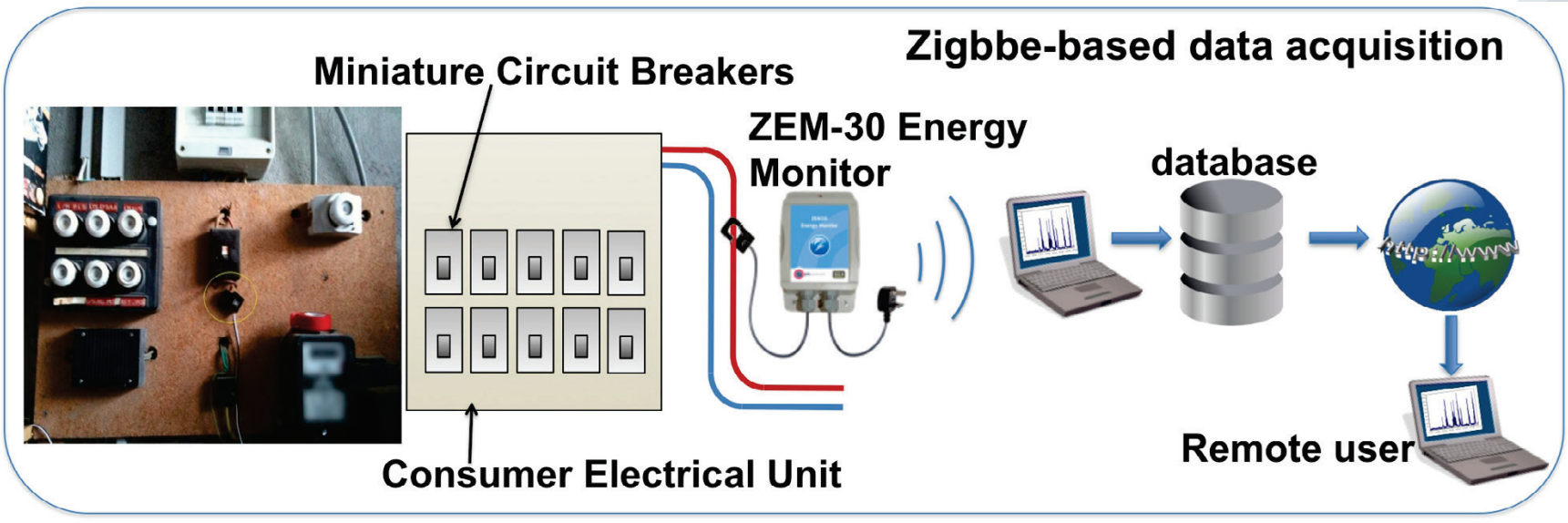
Sensing Physiology

- We can sense human physiology, untethered, and how it is an indicator of stress, tension, relaxation
- We can measure HR, breathing (RR), GSR
- We could also do mobile GSR, mobile EEG, in-lab fMRI but these are sessional rather than lifelog
- Why do our physiology readings change, what induces stress, annoyance, discomfort, fear, relaxation, etc.
- If we detect the physiological symptoms we can search the rest of the lifelog

Environmental Lifelogging

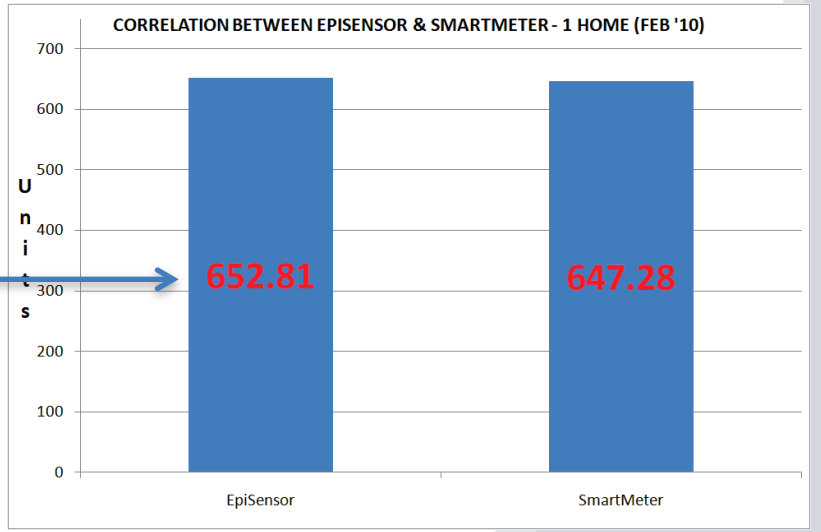
- **Much of our environment is monitored**
- **What can we learn from an instrumented environment ?**
- **This isn't surveillance, its sousveillance**
- **Not applicable to public spaces, or shared environments, like here, but to our personal spaces**
- **What sensing in our homes ?**
  - Our homes may have PIR and contact sensors for burglar alarms and companies do log these and monitor patterns and deviations
  - Our homes have, or will have, sensing of energy consumption for smart metering

Experimental set-up



CLARITY Deployments

- 24 domestic participants, 2 lab settings sampled every 50s
- Geographic and demographic distribution
- Data accurate to within 1% of National Smart Meter
- Normal 5-7pm peak in electricity consumption
- Direct conversion from KW/h to CO_2

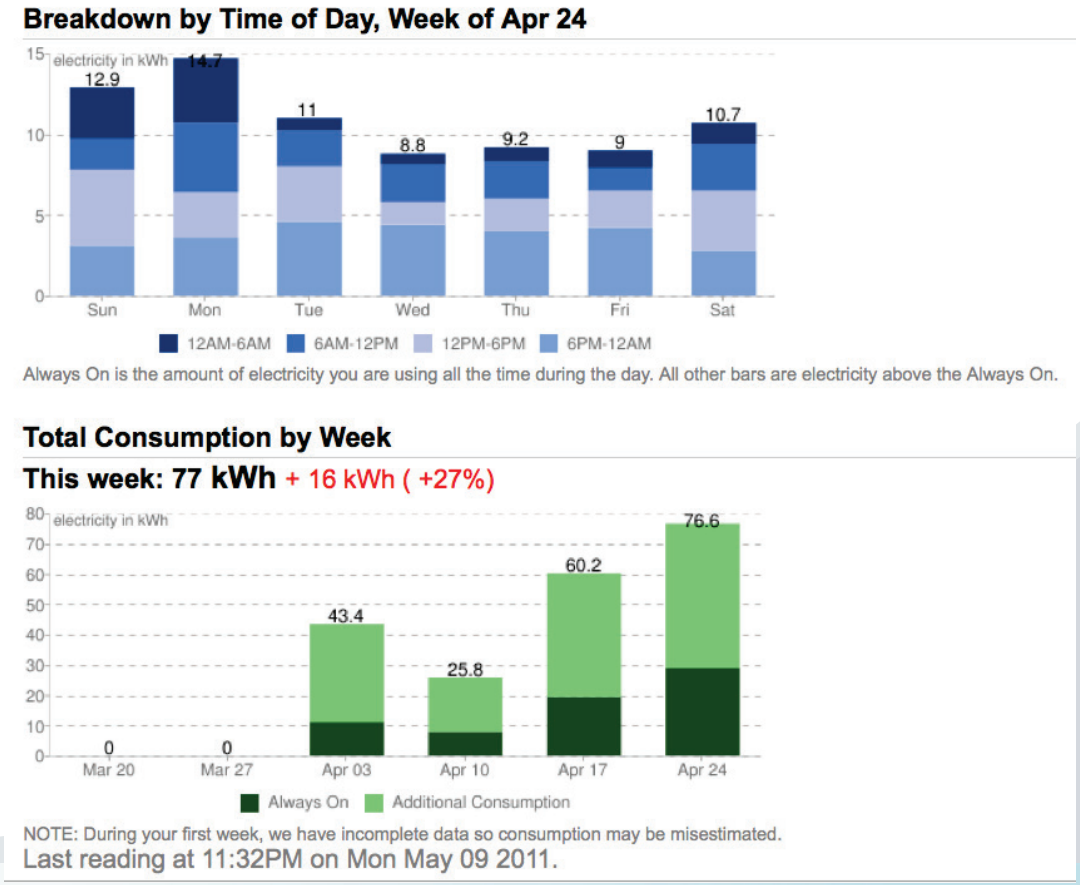


	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mon	23.30%	10.27%	2.29%	0.41%	1.70%	9.66%	17.55%	29.96%	38.69%	38.50%	39.92%	34.18%	36.60%	29.62%	32.49%	43.57%	51.69%	71.31%	91.22%	83.01%	71.93%	61.94%	54.76%	44.15%
Tue	29.29%	6.49%	0.50%	0.30%	4.10%	6.27%	10.33%	32.53%	36.70%	45.49%	42.51%	36.06%	33.77%	35.37%	41.86%	42.16%	52.22%	75.31%	100.0...	77.10%	71.93%	73.14%	60.81%	44.28%
Wed	20.00%	7.48%	0.01%	0.00%	3.66%	8.78%	15.70%	29.18%	43.00%	39.66%	37.49%	34.90%	30.08%	27.72%	34.92%	34.47%	50.77%	68.57%	99.50%	91.12%	76.78%	60.16%	53.13%	40.88%
Thu	21.24%	5.30%	1.93%	1.41%	3.92%	7.47%	16.15%	43.85%	44.76%	45.73%	43.50%	41.94%	47.68%	35.01%	50.02%	53.48%	69.46%	86.10%	98.74%	95.09%	70.76%	55.37%	49.95%	39.99%
Fri	21.27%	9.18%	4.50%	1.90%	2.00%	7.33%	14.02%	29.99%	45.46%	40.45%	35.79%	28.99%	27.58%	37.63%	43.37%	38.67%	47.61%	58.54%	76.15%	75.50%	74.42%	65.59%	52.69%	41.93%
Sat	28.16%	18.36%	6.12%	3.75%	3.07%	9.19%	6.31%	7.59%	22.78%	41.62%	48.43%	45.68%	49.70%	53.88%	60.18%	47.98%	55.20%	75.86%	84.03%	70.21%	61.38%	51.15%	45.15%	42.90%
Sun	27.93%	18.69%	9.97%	10.04%	4.21%	12.08%	7.45%	7.73%	20.35%	32.55%	53.73%	63.35%	57.50%	49.85%	49.29%	59.99%	68.39%	76.22%	93.03%	82.27%	80.68%	67.26%	61.48%	37.75%

Weekly Email

Insight

Weekly email … Google Powermeter did this …



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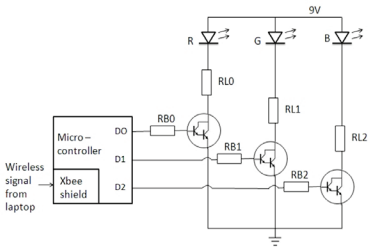
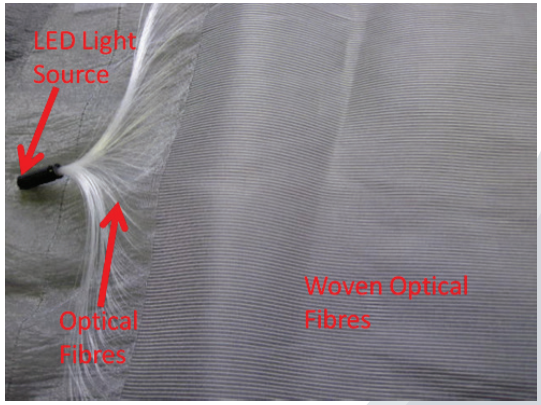
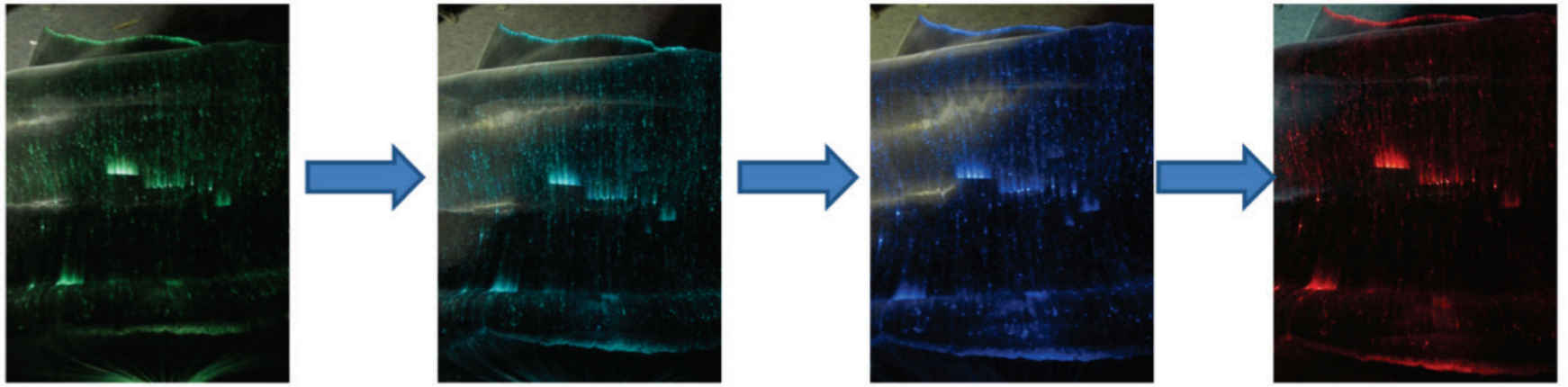
More ``exotic" ambient

Insight

Colour-changing soft furnishings
Tablecloth, cushions, etc. - where colour changes ambiently reflect the +/- energy usage vs. historical norm for that day/time



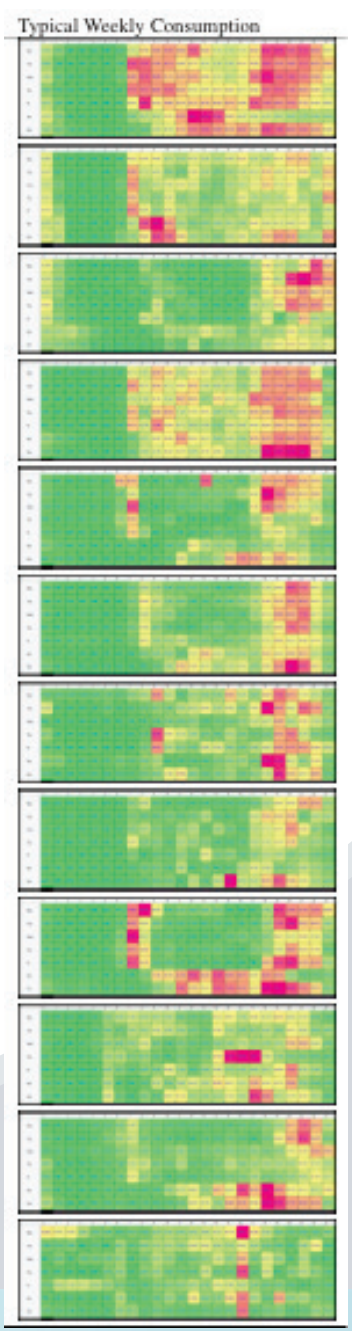


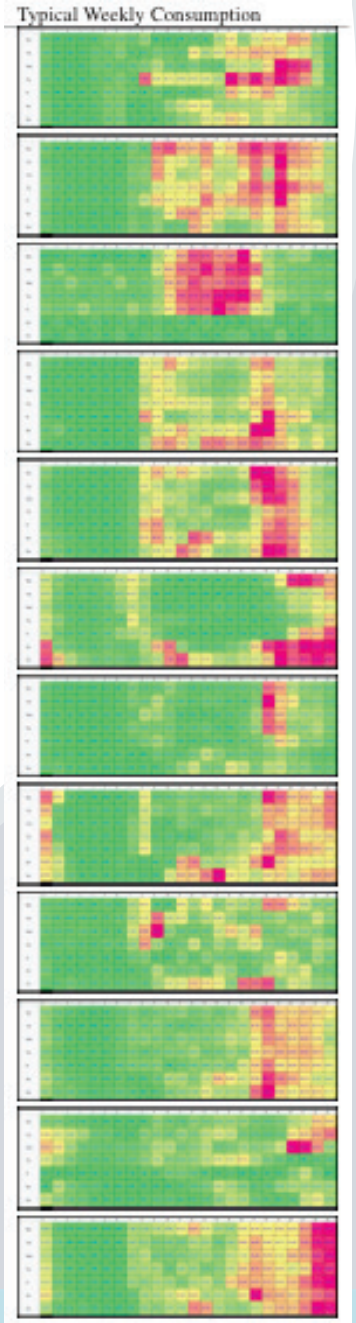


Anecdotes

We found the same as everyone else … initial enthusiasm gives way to bad habits

Interest in the heatmaps as a tool to summarise lifestyles;





Sensing The Home

Insight

Since each electrical appliance has a signature (duration, load, etc.) we learned signatures for devices, automatically

Applied signature recognition to sensed data using SVM allowing appliance recognition and usage

Off-line and archival, but could be realtime

Use Case: My Shower Usage, 6 months

- 520 showers
- Average duration = 8 minutes (min = 3 min, max = 27 min)
- 8am Tuesday morning is peak time

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mon	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.15%	26.14%	53.59%	49.02%	75.16%	66.67%	54.90%	33.99%	25.49%	0.00%	10.46%	1.96%	4.58%	7.19%	11.76%	0.00%	0.00%	2.61%
Tue	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.19%	50.33%	100.0...	64.71%	37.91%	57.52%	0.00%	37.25%	5.88%	6.54%	6.54%	1.96%	5.88%	0.00%	0.00%	3.27%	11.11%	0.00%
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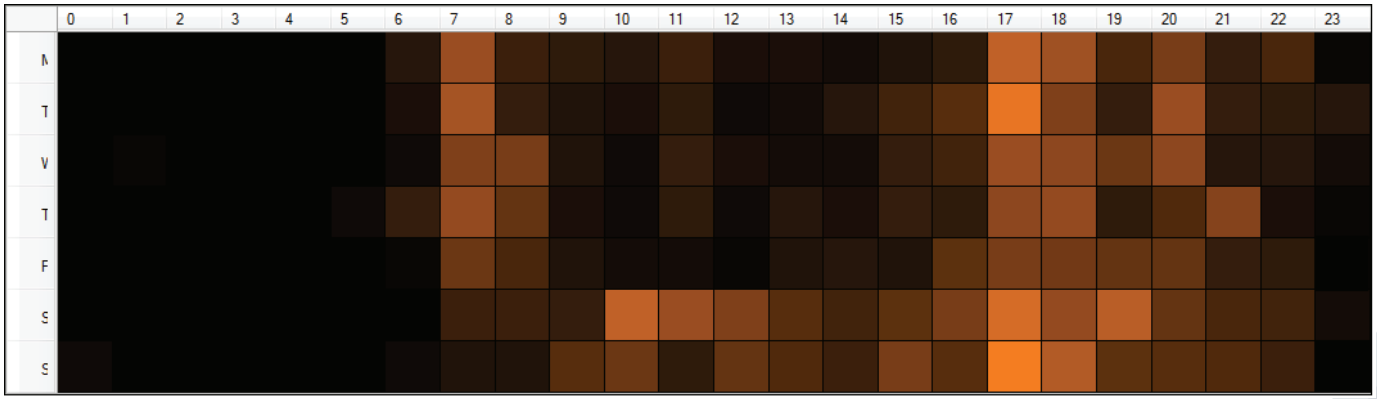
Thu	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.27%	77.12%	60.78%	96.73%	56.21%	58.17%	19.61%	33.33%	22.22%	9.15%	14.38%	0.00%	0.00%	13.07%	7.19%	8.50%	3.27%	0.00%
Fri	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.76%	46.41%	64.05%	64.05%	13.07%	30.72%	16.34%	31.37%	19.61%	3.27%	33.99%	25.49%	0.00%	0.00%	8.50%	1.96%	0.00%	0.00%
Sat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.73%	29.41%	33.33%	13.07%	33.99%	85.62%	79.08%	50.33%	29.41%	33.33%	14.38%	5.88%	5.88%	4.58%	0.00%	7.19%	3.27%
Sun	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	18.30%	18.95%	13.73%	43.14%	32.03%	50.33%	25.49%	30.07%	18.30%	28.76%	24.18%	4.58%	0.00%	7.84%	7.84%	4.58%	0.00%

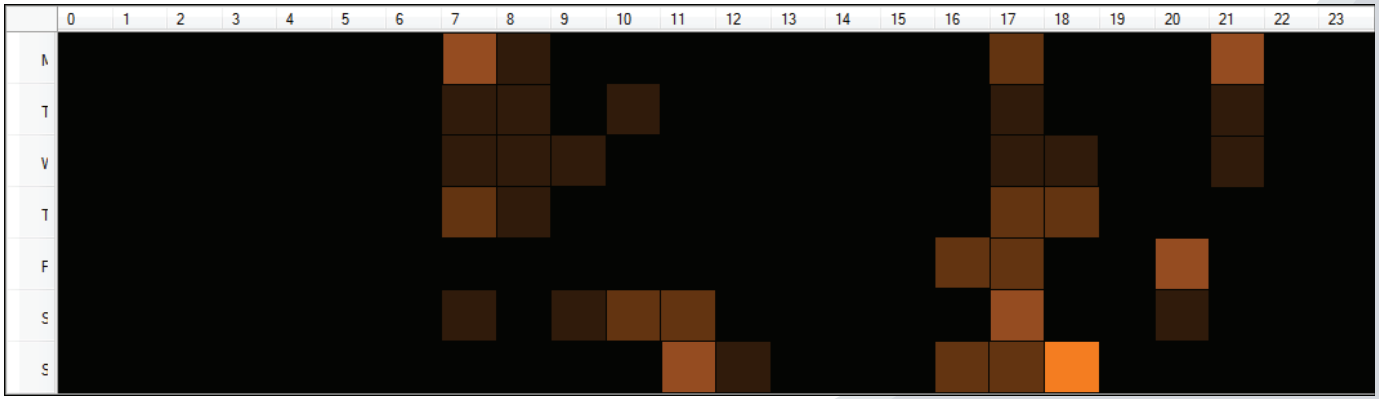
Kettle usage, chez-moi !

Insight

Annual



June



This is useful for energy analysis but also environmental lifelogging, what is happening in the home from 1 cheap ambient sensor

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Lifelogging - multiples

Insight

- Lifelogging is about sensing
- Sensing any natural phenomenon benefits from a multiplicity of viewpoints
- It is the combination and correlation across sensors that gives us insights to get holistic viewpoints
- It is the combination of heterogeneous sensing that gives us the insights
- There is no single best sensor, not even video
- Lifelogging is best when it combines

Lifelog Platforms

Insight

- **There is no universal platform for "mashing" personal sensor data, though Microsoft's HealthVault is pretty useful, and open**
- **Most OTS products have open APIs**
- **It is both good, and bad, that there is no universal storage approach for personal data**
  - Good – there is no single company dominating, c.f. search
  - Bad – there is a lack of progress

Wrap-up

- Lifelogging is a new form of multimedia information
- It is personal, and has many as yet undeveloped applications
- It is a source of information, to be captured, analysed, indexed, organised, and accessed, but it is different
- It has many challenges in the “information space” as well as the other challenges of ethics, privacy, security and use cases.