Participatory Sensing: from ecosystems to human systems

Enabled by $>3 \times 10^9$ mobile phone users, increasingly with gps, imagers, Ul

Motivated by $6 \times 10^9$ people on planet earth and their concerns...

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Mobile smartphones + web/cloud services + social networking

real time
(always on)

real place
(always carried)

real context
(historical, environmental, spatial, social)

applications:
civic data campaigns
transportation patterns
health
Civic and Citizen Data Campaigns
coordinated, real-time, geo-coded, tagged, images and prompted entries

GarbageWatch
Recycling Practices on Campus

What’s Bloomin
Blooming Flora on Campus

CENS
Center for Embedded Networked Sensing
Invasive Plants Campaign - “What’s Invasive!”

w/National Park Service, Santa Monica Mountains

TOP 6 INVASIVES!

Harding grass
Perennial pepperwood
Poison hemlock
Spanish broom
Terracina spurge
Yellow starthistle

http://whatsinvasive.com

mobile app available on Android Market and iphone App store
Invasive Plants Campaign - “What’s Invasive!”

The weed survey that ended in 2006 took 2 years and thousands of person-hours to complete.

Results from the two-week What’s Invasive! indicate data quality is comparable.

New distributions and significant advancement of some invasive species have occurred within that last 3 years since the original survey.

Conservation specialists at the NPS, armed with this new data, can focus attention on managing areas that are newly invaded.

Hansen, Graham, Reddy, ...
Personal and community sustainability tool: PEIR: Personal Environmental Impact Report

http://peir.cens.ucla.edu
Program helps kids find their carbon impact
Catalina Gutierrez (center) and twin brother Trevor are learning to make better carbon-based transit decisions. (Brant Ward / The Chronicle)
Biketastic:
bicycle commuters document, plan, share route data
...to promote safe cycle commuting

location+motion trace augmented
with images and tagging

Capture & share route features

Collects: location, duration, stops/starts, roughness, prompted images/tags

Web interface compares route qualities

Future: mash up routes with air quality, traffic conditions, accidents

http://biketastic.com, mobile app available on Android Market
Monitoring exposure to cookstove pollution in rural India: profile daily activities, exposure to indoor air pollution, at unprecedented detail (Ramanathan et al)

- GPS, accelerometer traces
- Bluetooth temperature sensor beacons
- Images of a special filter

Outdoor activities → Cooking duration → Pollution levels → Exposure Model

Ramanathan, et al
Participatory Sensing for health and wellness

what can we learn,
what impact can we have,
with access to

...all 168 hours of the week...
...all 1440 minutes of the day...
Monitor health indicators and behaviors using prompted inputs (EMAs), activity traces, realtime analysis.

**Mobile Client**

- Geocoded and time-stamped EMAs
- Mobility traces

**Data Storage Service**

- Aggregate measures, trends, patterns
- Event detect

**Visualization Platform**

- Blood Pressure
- Mobility traces
- Event detect

**Processing Module**

- Aggregate measures, trends, patterns
Integrated personal data stream creates a *Living Record*

Automatically prompted, geocoded, uploaded:
- physiological (BP, glucose...)
- patient reporting (medication, symptoms, stress factors)
- location traces
- contextual, environmental, social factors

And it doesn’t require a smartphone to generate telling traces...

[http://your.flowingdata.com](http://your.flowingdata.com)
Capture your life in data. One tweet at a time.

Get Started Now »

Step 1. Follow @yfd on Twitter
Step 2. Sign in to your.flowingdata with Twitter
Step 3. Start recording data (via direct messages) following a few simple guidelines

Making Choices

We make tiny choices every day. Those choices become habits, and those habits develop into behaviors. your.flowingdata helps you record these choices.

Collect data anywhere.
The ubiquity of Twitter allows you to record data from just about anywhere. If you can tweet, you can record data.

Interact with your data.
Data is meant to be played with. Use interactive data visualization and explore your data.

Customize views to your data.
All data is not created equally. Create custom visualization pages for what you’re most interested in.

Share your findings.
Some data is meant to be private, but some is worth sharing. You decide what others can and can’t see.

Understand yourself.
In the same way you can see growth from reading old entries in a diary, monitor your growth and progress through data.

Explore your data easily.
your.flowingdata was designed by a statistician, but you don’t have to be one to play with your data.

Follow @yfd on Twitter and Get Started Now
General mobile to web architecture supports scalable, affordable, quickly-deployable use-cases

**General flow**

**APPLICATIONS**
- web, researchers/health providers/community

**PROCESSING**
- mobile device and web Services

**DATA CAPTURE**
- mobile device and individual

**Meaningful use-cases**

- Chronic disease monitoring/mgmt
- Activity, mobility trends
- Location traces

- Health behavior change/adherence
- Health behavior diaries
- Geo-coded, prompted entries

- Health worker/Caregiver support
- Per patient record: condition, treatment, followups, triggers
- Geo-coded entries, image, annotation

Center for Embedded Networked Sensing
Privacy concerns: Granular Personal Data

Sensitive data
- Quantify habits, routines, associations
- Increasingly easy to share, mine
- Anonymizing location traces/geocoded time series is often infeasible
- Available to government, insurance, employers, creditors, ...

Diverse usage
- Collected by individuals
- Using apps authored by ... anyone?
- Shared with nobody, everybody, or some set in between
Opportunity to promote new privacy infrastructure and best practices

Individual captures and shares her own data
- different from data held by regulated mobile carriers, credit card companies.
- lure of free apps, free services: “Everything is free to you, except for the data we collect about you”

Explore legal and technical mechanisms to protect our telling traces.
- beyond consent or anonymization: personal data vault
- beyond access: legibility
- beyond redress: long-term engagement
Personal Data Vault (PDV): allowing participants to retain control over their raw data

- vault + filters = granular, assisted control over what you send to who, what that data says about you, whether you reveal who you are or share anonymously, ...

Data Capture

Personal Data Vault (PDV)

- Data Filters
- Partitioned applications
- User Interface

Third Party Applications

- data legally-accessible only to Individual
- filtered data shared with specific service providers

Privilege: Protection of vault data from subpoena, discovery?
Our role?: foster innovation and public good

Explore and develop architecture, services, APIs, best practices, through iterative and open prototypes and pilots
Conclusion

If you can’t go to the field with the sensor you want…
go with the sensor you have! (Anon)

The power of the Internet, the reach of the phone (Voxiva)

It takes a healthy research ecosystem (like CENS!) to bring
information technology innovations to meaningful societal use