Participatory Sensing for Sustainable Urban Life

Matthias Stevens & Ellie D'Hondt

Software Languages (SOFT) & AI (ARTI) labs, Vrije Universiteit Brussel

{mstevens,eldhondt}@vub.ac.be

1. Challenge: Sustainability of Urban Life

- UN data shows that: [UN2006]
  - In 2005, 49% of the world's population were city dwellers
  - By 2030, this number is expected to hit 60%
- Urbanisation is rising even faster in developing nations [UN2006]
  - In 2005, 74% of all city dwellers lived in the developing world
  - By 2030, developing counties are expected to account for 81% of city dwellers
- Rapid urbanisation threatens quality of urban life
  - Mobility issues
  - Housing shortage
  - Social injustice
  - Lack of green space
  - Air, soil, water & noise pollution

→ **Limits to growth**

[UN2006] UN, Dept. of Economic & Social Affairs, Population Division (2006). *World Urbanization Prospects: The 2005 Revision*. Working Paper No. ESA/P/WP/200.

What can Computer Science do to help build a sustainable world?

- Aid in simulating the environment to get better predictions of the future and thus encourage the need for action
- Better exploitation of available computing resources by distribution of computation and the development of energy-efficient soft- and hardware solutions

- Improve the grain-size and quality of environmental measurement data
- Increase awareness of citizens about the conditions in their environment and thus provide support for political action

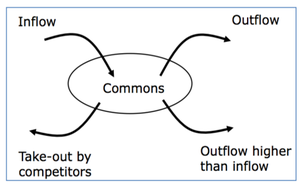
L. Steels (2009), *Participatory Mapping and Social Networking for a Sustainable World*. Sony CSL Open House 2009 Symposium talk.

2. "The Tragedy of the Commons"

Over-exploitation of common resources which are not replenished

No one owns the Earth's atmosphere. Therefore, it is treated as a common dump into which everyone may discharge wastes. Among the unwanted consequences of this behaviour are acid rain, the greenhouse effect, and the erosion of the Earth's protective ozone layer.

Industries and even nations are apt to regard the cleansing of industrial discharges as prohibitively expensive. The oceans are also treated as a common dump. Yet continuing to defend the freedom to pollute will ultimately lead to ruin for all. Nations are just beginning to evolve controls to limit this damage.



More examples: irrigation systems, space in streets, **noise ↔ silence**, forests ↔ logging, ...

G. Hardin (1968). *The Tragedy of the Commons*. Science, 162(3859): p.1243-1248.

Managing common pool resources

1. Clearly defined boundaries
2. Congruence between appropriation and provision rules and local conditions
3. Collective-choice arrangements allowing for the participation of most of the appropriators in the decision making process
4. Effective monitoring by monitors who are part of or accountable to the appropriators
5. Graduated sanctions for appropriators who do not respect community rules
6. Conflict-resolution mechanisms which are cheap and easy of access
7. Minimal recognition of rights to organize

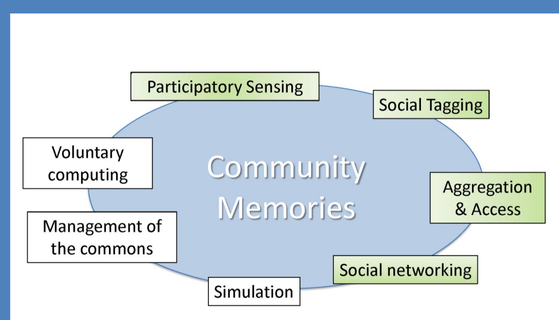
Elinor Ostrom (1990). *Governing the Commons. The Evolution of Institutions for Collective Action*. Cambridge University Press.

3. Community Memories & Participatory Sensing

- Collection of ITC tools to collectively manage common pool resources
- Early predecessors:
  - Bulletin boards [Colstad1975]
  - Open expert systems [Steels1986]
- Technological advances have enabled many new ingredients:
  - Mobile, participatory sensing
  - Social tagging
  - Geo-localisation
  - Aggregation, simulation and visualisation

[Colstad1975] K. Colstad & E. Lipkin (1975). *Community Memory: a public information network*. ACM SIGCAS Computers and Society, 6(4): p.6-7.

[Steels1986] L. Steels (1986). *From Expert Systems to Community Memories*. In T. Bernold (ed.), Expert Systems and Knowledge Engineering. Conf., G. Duttweiler Institute, Ruschlikon, Switzerland. p.17-29.



L. Steels (2009), *Participatory Mapping and Social Networking for a Sustainable World*. Sony CSL Open House 2009 Symposium talk.

4. Participatory Sensing

« *Participatory Sensing* […] *takes everyday [sensor equipped] mobile devices […] to form interactive, participatory sensor networks that enable public and professional users to gather, analyze and share local knowledge* »

[Burke2006]

« *Pervasive computing in the form of embedded networked sensing has leapt from the laboratory to the natural environment. Simultaneously […] pervasive computing has entered the backpack, purse, and coat pocket in the form of mobile phones, […]. We characterize this contextual shift as "urban sensing"* »

[Cuff2008]

[Burke2006] Burke et al. (2006). *Participatory Sensing*. WSW'06 at SenSys '06, ACM Press.

[Cuff2008] Cuff et al. (2008). *Urban sensing: Out of the woods*. Comm. of the ACM, 51(3): p.24-33.

Participatory Sensing & Sustainability

Opportunity:

Platform: Ever more popular, cheaper "smart phones"

[Time Magazine, 2006]

Cultural shift (*Web 2.0*): User-generated content, participation

Concerns: Growing interest for environmental/sustainability issues

- Significant computational power
- Semi-permanent Internet access: WiFi, GPRS/EGDE, 3G
- Integrated sensors: Camera's, GPS, motion, touch, ...

The (mobile) Web continues to change how we create, share and consume information...

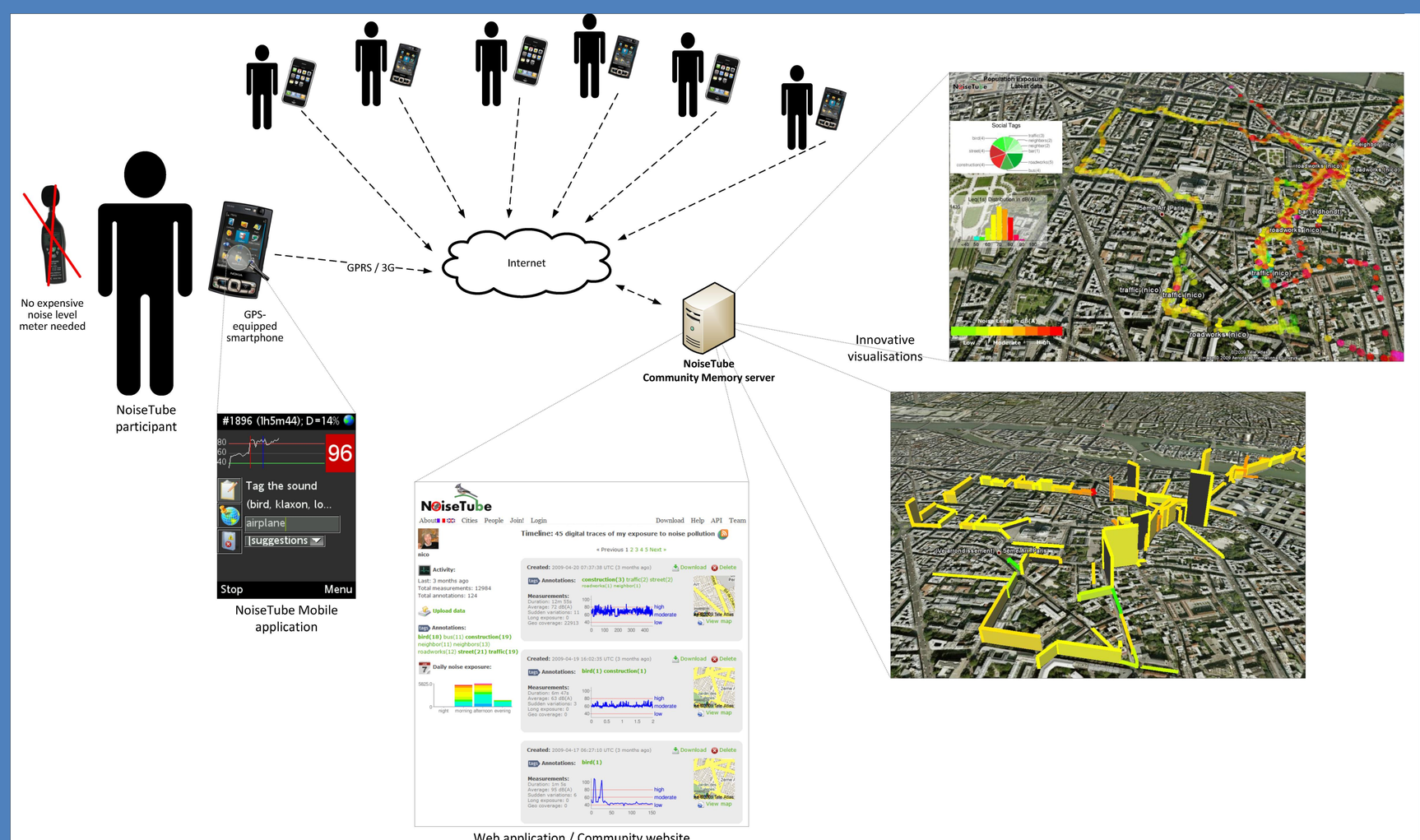
Climate change (*Inconvenient truth*, IPCC), desertification, global migration, urbanisation, mobility, energy efficiency, air pollution (e.g. fine particles), ...

5. NoiseTube

Nicolas Maisonneuve & Matthias Stevens

Sony CSL
Sony Computer Science Laboratory Paris

- Participatory sensing applied to the problem of urban noise pollution
  - Real-time sound level meter app. for smart phones (J2ME; free download)
  - Geo-location through GPS
- Social Tagging (+ automatic tagging) to add semantics to raw data
- Web-based Community Memory: central infrastructure for data sharing, storage, analysis & visualization as well community features
- Visit **www.NoiseTube.net** for more information and join the noise mapping effort!



6. Future work

- Combine participatory sensing data with physical modelling to improve aggregation output (sound propagation, etc.)
- NoiseTube approach needs proper validation
  - Case study: sufficient participants, delimited in space & time, compare w/ other approaches/existing noise maps
- Incorporate context-orientation technology
- Project for Brussels region: "Community memories for sustainable urban living" (funding requested at IWOIB/IRSIB)
  - Focused on: noise, microclimate, atmospheric pollution

References

- N. Maisonneuve, M. Stevens, M. E. Niessen, P. Hanappe & L. Steels (2009). *Citizen Noise Pollution Monitoring*. Proceedings of the 10th Annual Int. Conference on Digital Government Research, 390:p.96-103.
- N. Maisonneuve, M. Stevens, B. Ochab (2009). *Participatory Noise Pollution Monitoring using Mobile Phones*. Information Polity journal, Special issue on "Social Networks: Making Connections between Citizens, Data & Government" (under review).
- J. Vallejos, M. Stevens, E. D'Hondt, N. Maisonneuve et al. (2009). *Context-aware Resource Sharing for People-centric Sensing*. First Int. Workshop on Software Research and Climate Change (WSRCC'09).

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