NoiseTube : Citizen Noise Pollution Monitoring[1]

www.noisetube.net

SONY

Tagora

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Abstract

We present a new participatory [2] approach to monitor urban noise pollution. We enable citizens to measure their personal exposure to noise in their everyday live by using GPS-equipped mobile phones as noise sensors. The project thus aims to involve citizens directly in the assessment of urban pollution by building *collective maps as digital traces of their shared exposure to noise*.

Motivation

(Eric Paulos/Intel Research)

A new "green" user experience
"How much decibel am I exposed to now?"
People-centric [3] focus: democratising personalized environmental information allows *to raise awareness and change behaviour.*

Rio Declaration, 1992

Society: empowering citizens
"Environmental issues are best handled with the participation of all concerned citizens" [*Rio Declaration,* 1992]
The current role of citizens is limited, despite international agreements. By enabling people to measure their exposure to pollution, we want empower them to *inform the community about their environmental conditions and tackle the issues*.


Simulation-based noise map of Paris
(Bruitparif / Mairie De Paris)

Science: Collect *real* exposure data
- **Issue:** Scarcity of fine grained data on pollution exposure at the level of the individual
- Simulation vs. real measurements
- Average emissions vs. actual exposure
- Simulations only account for limited/predefined sources of pollution
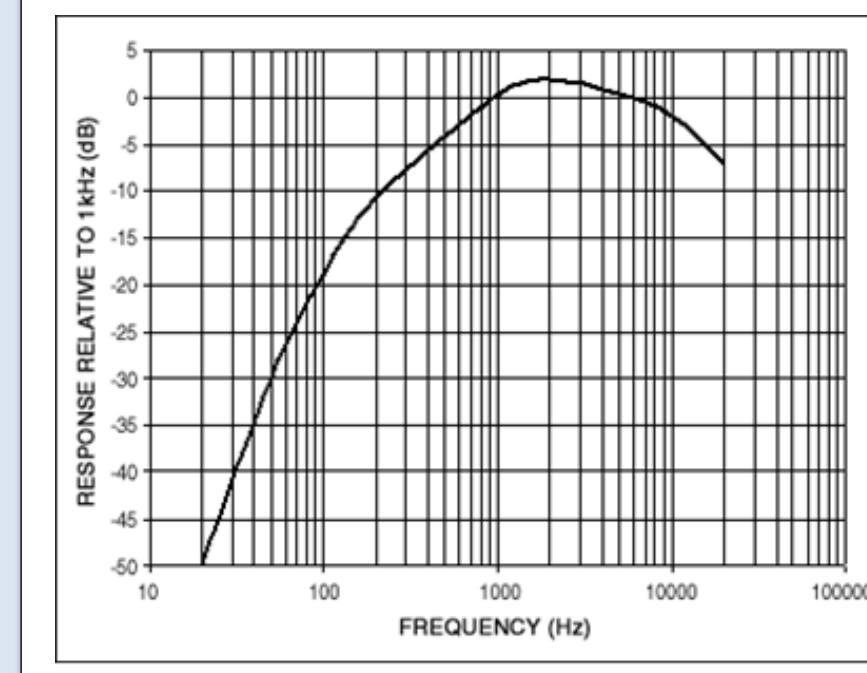- Sharing data to create an environmental data commons

1 Mobile phone as environmental sensor[4]

Challenge: Use mobile phones to measure loudness in real-time
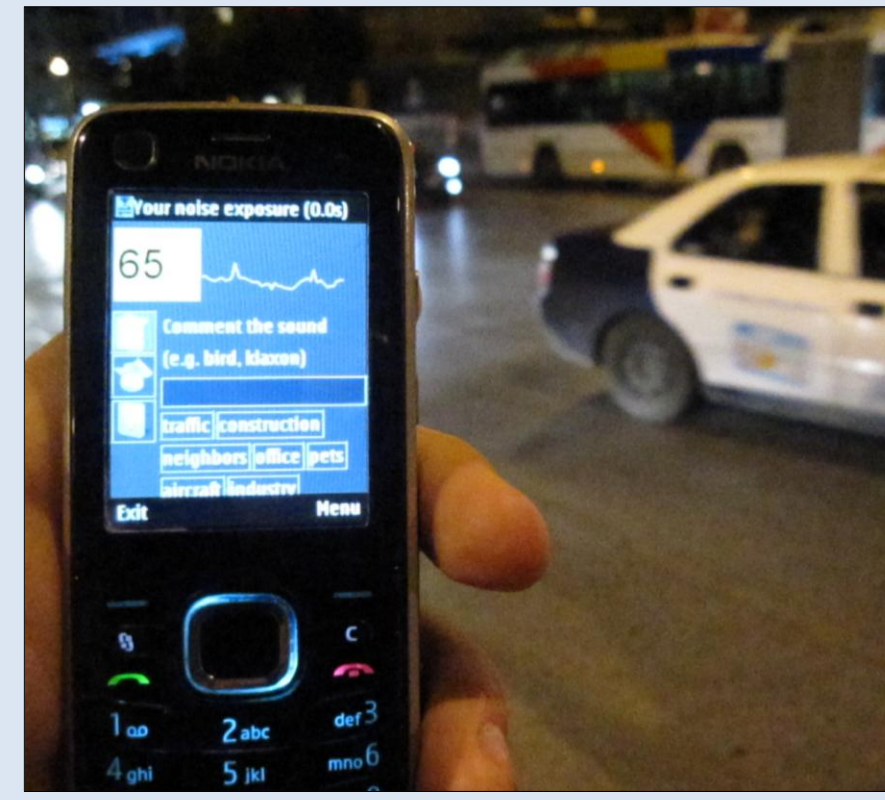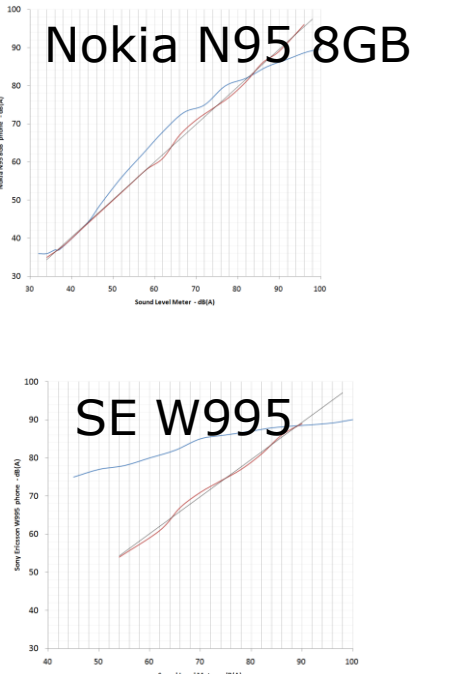

Phone as noise sensor

Signal processing algorithm to compute L_eq(A)

$$L_{eq} = 10 \log \frac{1}{T} \int_0^T \frac{p^2}{p_0^2} dt$$

A-weighted filter (models perception and frequency range of human ear)

Computation of equivalent continuous sound level (L_{eq} measured in dB(A))

Phone-specific correction function

Nokia N95 8GB

SE W995

Experiments to evaluate accuracy

Phone in hand	Handsfree kit	Phone in pocket
± 2.5 dB	± 4.5 dB	± 6.5 dB
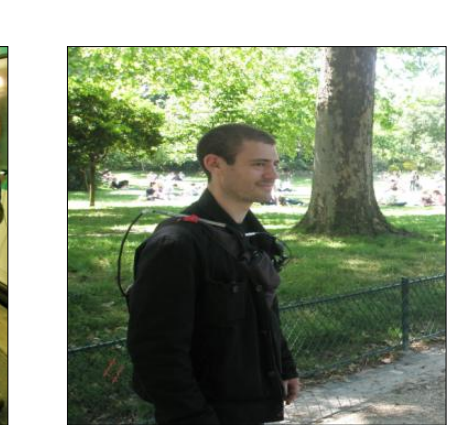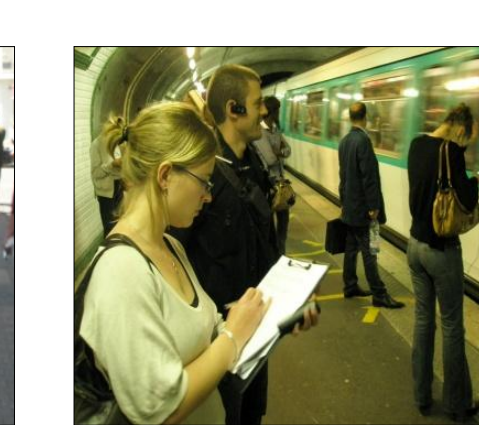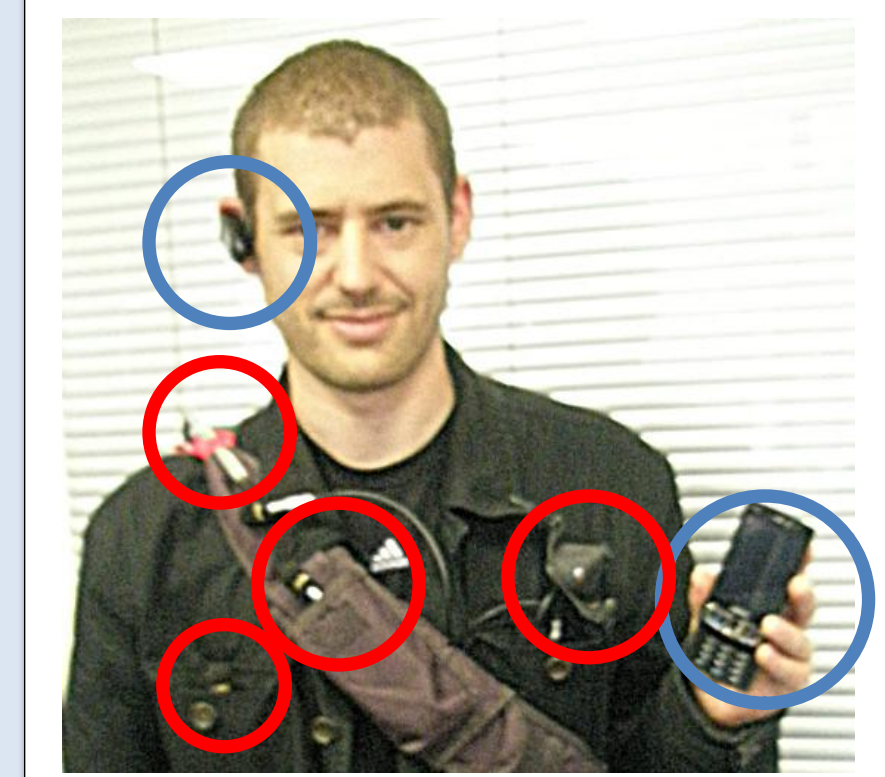
In collaboration with

Bruitparif
Observatoire du bruit en Île-de-France

2 Environmental social tagging[5]

Issue: Lack of semantic information to facilitate interpretation of sensor data

→ **People as semantic sensors**

Users tag sources of noise, perceived annoyance, etc.
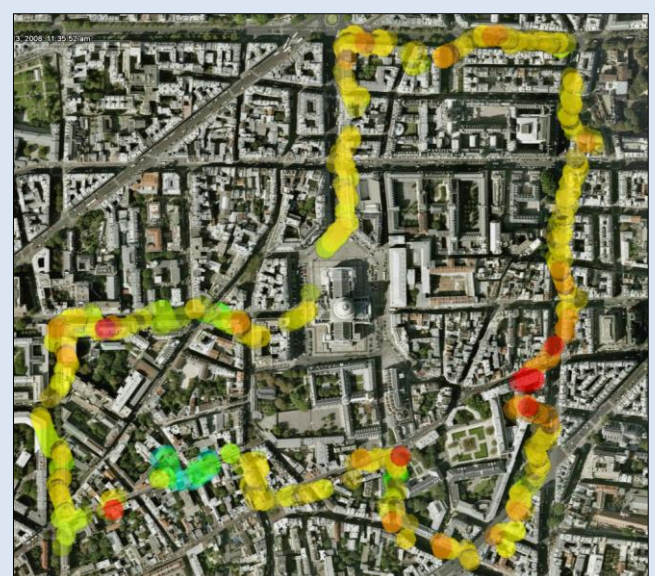
Tags are sent and stored with raw data

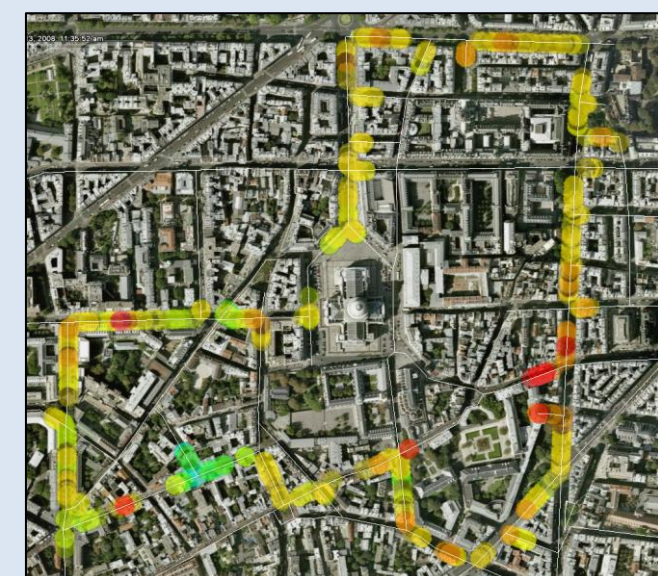Tags are used to create rich, annotated noise exposure maps

3 Collective maps

Challenge: Create dynamic aggregated maps of all shared exposure data

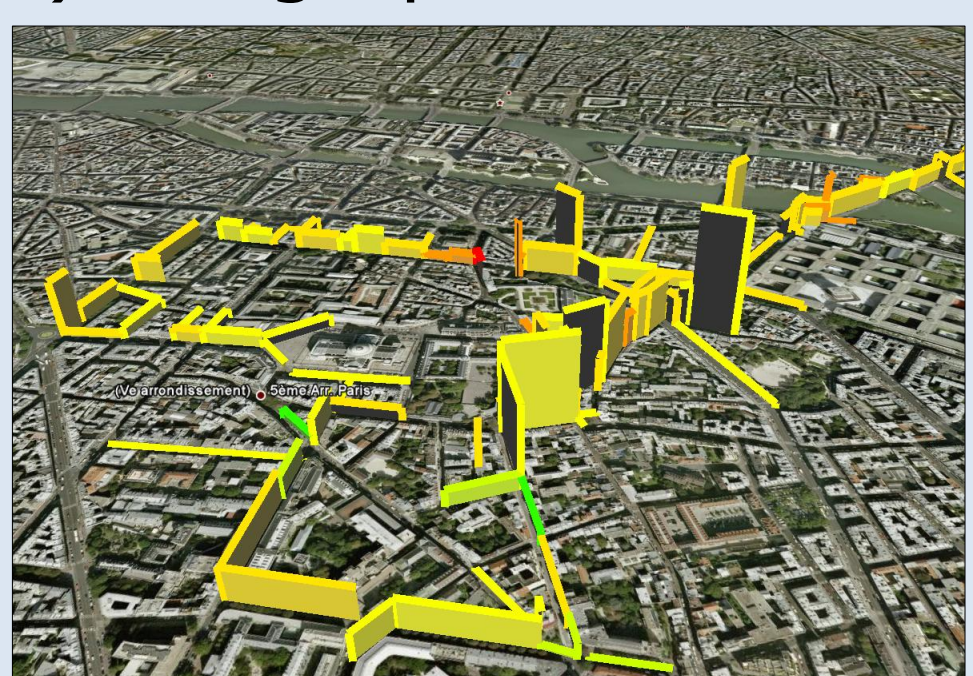1) Geo-spatial correction using city topology

Before correction   After GPS correction

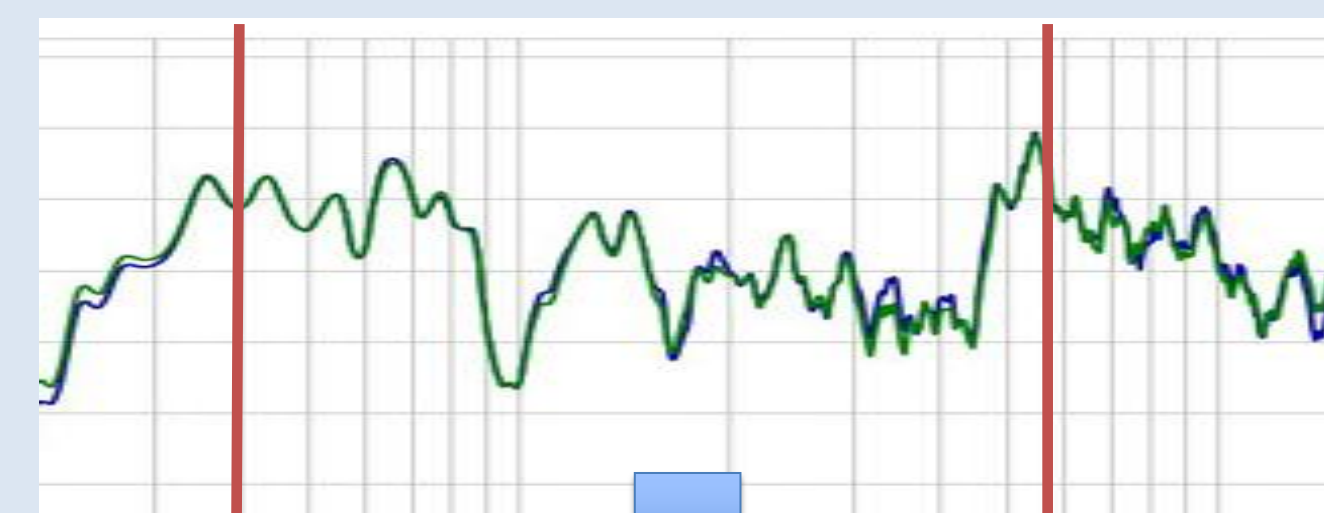2) Geographical clustering by urban elements

Street level   District level

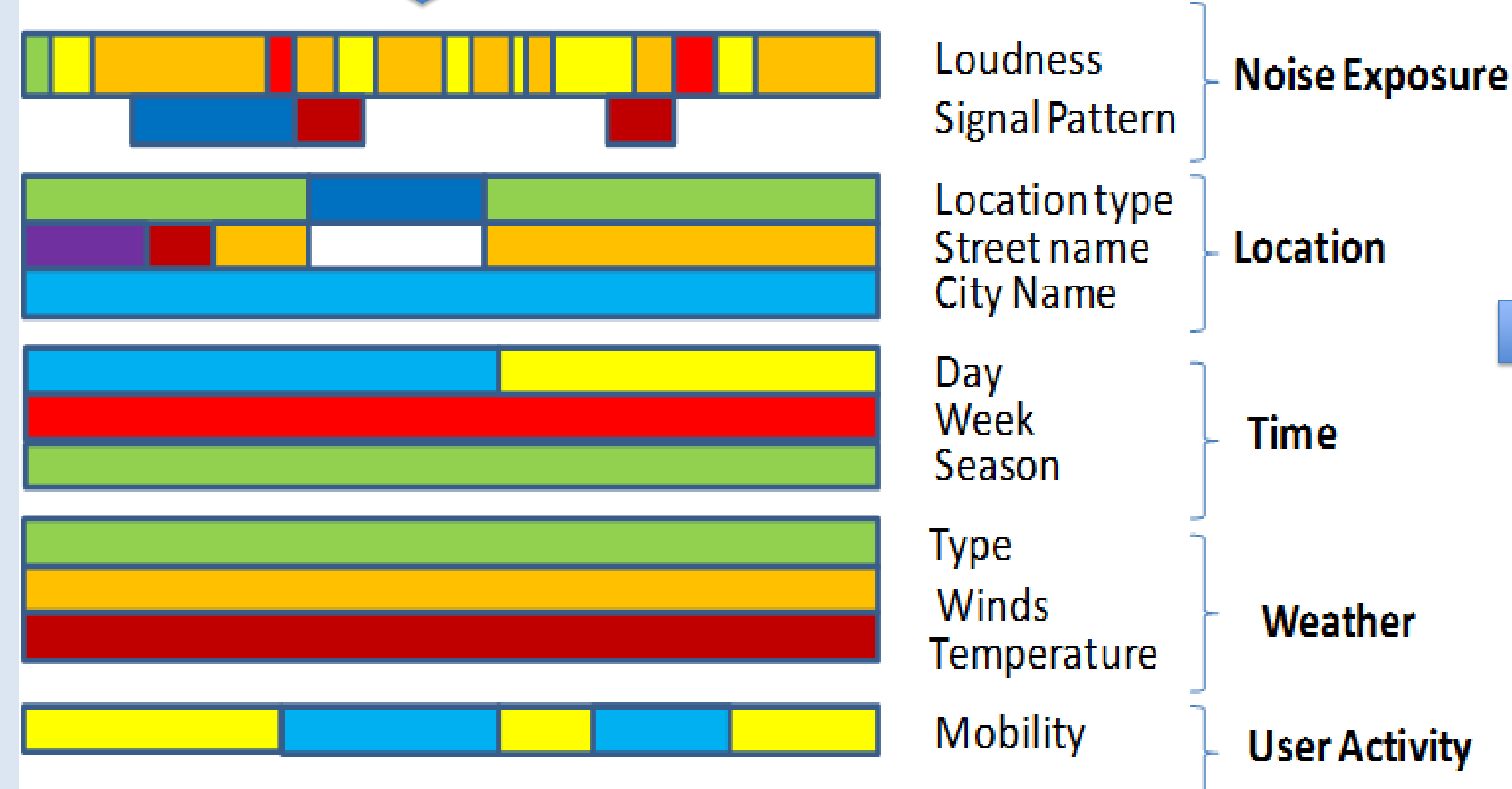3) Measurement aggregation: $10 \log \left(\sum_i 10^{\frac{L_{pi}}{10}} \right)$

4 Enriching the context with classifiers

Issue: Searching & navigating through sensor data is hard due to numerical nature

Road works   Neighbours

→ We developed a set of classifiers, each related to different contextual aspects (e.g. spatial, time, user activity, weather), and apply them to the measurement data to generate enriching contextual tags which facilitate *semantic exploration* of the dataset.


Loudness
Signal Pattern → **Noise Exposure**

Location type
Street name
City Name → **Location**

Day
Week
Season → **Time**

Type
Winds
Temperature → **Weather**

Mobility → **User Activity**

Semantic profile of measurement context

Semantic exploration

Noise Exposure
Type annoying, noisy, quiet, risky,
Signal long noisy exposure, short-term risky exposure,
behavior sudden peak, suddent peak,

Social (by the users)
Tv, airplane, annoying, bar, bird, bus, club, club..., construction, home, bedroom, live music, neighbor, neighbors, null, people, pets, resto, richard pender st, roadworks, shopping mall, street, the red room, traffic, traffic, traffic construction, truck, vancouver,

User Activity
Mobility stationary, using transport, walking,

Weather
Type clear, cloudy, fair, haze, mist, mostly cloudy, n/a, partly cloudy,
Temperature hot, moderate,
Wind breeze, calm, light air,

Time
Day afternoon, evening, morning, night,

Future work

- **Measuring exposure to air pollution** (using wearable sensor device)
- **Case studies:** - **Open House 2009**
  - Paris subway
  - Mumbai, India
  - Tuscany, Italy
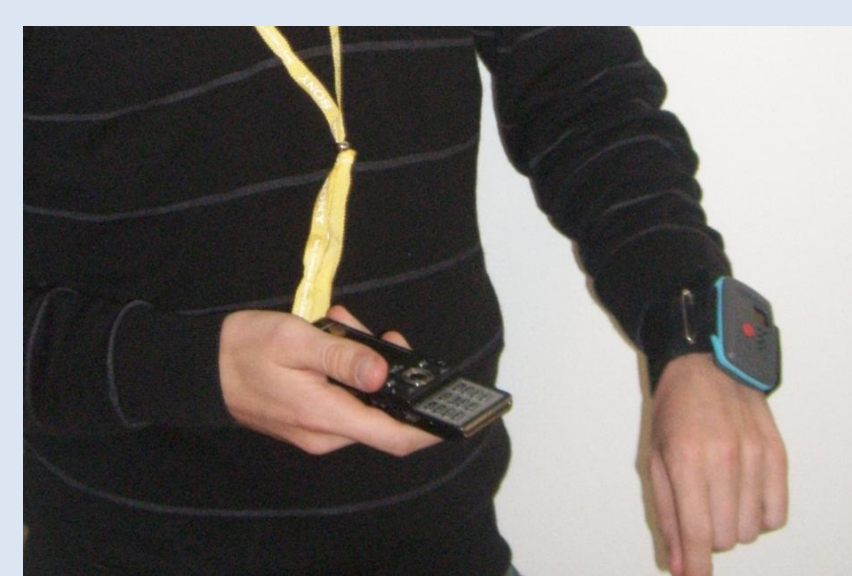
Combination of phone & "environmental watch"

Noise exposure map of 2 subway lines in Paris

References

[1] Maisonneuve, Stevens, Niessen, Hanappe & Steels. *Citizen Noise Pollution Monitoring*. Proceedings of the 10th Annual International Conference on Digital Government Research, 2009.
[2] Paulos. *Citizen Science: Enabling Participatory Urbanism*. Handbook of Research on Urban Informatics, IGI Global, 2009.
[3] Campbell et al. *The Rise of People-Centric Sensing*. IEEE Internet Computing, 12(4), p.12-21, 2008.
[4] Patel-Predd. *Cellphones for Science*. IEEE Spectrum, 46(2), p.16, 2009.
[5] Steels & Tiselli. *Social Tagging in Community Memories*. Proceedings of the AAAI Spring Symposium on Social Information Processing, 2008.
[6] Defréville, Roy, Rosin & Pachet. *Automatic Recognition of Urban Sound Sources*. Proceedings of the 120th AES Conference, Paris, France, 2006.

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