OPENSENSE
OPEN SENSOR NETWORKS FOR AIR QUALITY MONITORING

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OpenSense Vision

Community driven, large-scale air pollution measurement in urban environments

- Important problem: air pollution
  - Affects quality of life and health
  - Urban population increasing
  - Air pollution is highly location-dependent
    - traffic chokepoints
    - industrial installations

- Few monitoring stations measure pollutants

- Important technical opportunities and challenges
  - Massive measurements that exploit
    - Wireless sensor networks
    - Mobile stations
    - Community involvement
  - More data, more noise, but also more redundancy

- Can we produce better quality data?

Address key challenges in communication and information systems for urban air quality monitoring
Basic Sensing Infrastructure

Mobile sensor nodes on public transportation and private mobile devices

Wireless sensing and communication infrastructure
Overall Goal

SENSING SYSTEM
From many wireless, mobile, heterogeneous, unreliable raw measurements ...

INFORMATION SYSTEM
... to reliable, understandable and Web-accessible real-time information

sensor network control
optimization of data acquisition

interpretation and presentation of data

mobile nodes
wireless fixed nodes
GPRS
GPS
Internet

NANO
TERA
Scientific Challenge

Is massive sensing with large numbers of heterogeneous and mobile sensors technically feasible and practically useful?

HETEROGENEOUS SENSOR NETWORKS
Many sources of correlation

MOBILE SENSORS
Controlled vs. uncontrolled mobility patterns

COMMUNITY SENSING
Reliability and trustworthiness of measurements and interpretation
Scientific Questions

Correct interpretation of sensor measurements requires understanding of their context!

**HETEROGENEOUS SENSOR NETWORKS**
Correlation to other measurements:
- Physical Models
- Simulation Models
- Data analysis

**MOBILE SENSORS**
Loc. and time of measurement:
- Sampling under mobility
- Intermittent connectivity
- Control of node activity

**COMMUNITY SENSING**
Producers and users of data:
- Data quality and reputation
- Qualitative models
- Efficient access to model data
Utility-based control

- The problem of control in community sensing networks needs to consider a wide variety of factors:
  - quality of measurements (classical problem), energy consumption, communication cost, mobility patterns, privacy violation, personal relevance, etc.
- Utilitarian approach towards sensing and data management:
  - Models utility of data being produced and consumed
  - Uses utility to control data production
- Layered utility model:
  - Models several levels of abstraction depending on capacity of devices (cloud computing vs. low-power sensor)

Verify our approach by a real system deployment

1. Preventive Health Studies
   - In collaboration with Swiss Institute for Tropical and Public Medicine
   - Sapaldia Study

2. Deployment on public transportation networks
   - Lausanne and Zürich
   - Community involvement
IC Infrastructure

- Existing platforms in use for hydrological and geophysical engineering

- Fixed wireless sensor networks based on SensorScope stations
  
- Flexible configuration

- Mobile nodes based on PermaSense nodes
  
- Robust and long-lived

- Web-based information system based on the Swiss Experiment platform
Sensors

- Sensorscope Smart Interfaces
- Sensorscope DataLogger
- Power suppliers

- pDr1000: ultrafine particles (FH Nordwestschweiz)
- SHT75: air temp and humidity
- Telaire T6613: CO2
- Langan T15n: CO

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### Sensors

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Normal range in urban environment</th>
<th>NAQOS Levels/Averaging time</th>
<th>Sensor choice</th>
<th>Resolution/Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td>0.008-0.04 ppm</td>
<td>0.016 ppm Annual avg</td>
<td>Alphasense NO2 BA (under test)</td>
<td>± 0.005 ppm/NA</td>
</tr>
<tr>
<td>CO</td>
<td>0.5-5 ppm (normal)</td>
<td>5-20 ppm (near gas stoves)</td>
<td>Langan CO T15d</td>
<td>0.05 ppm (0.005 optional)/NA</td>
</tr>
<tr>
<td>CO₂</td>
<td>500-1500 ppm</td>
<td>Telaire T6613</td>
<td>NA/±3 ppm at 500 ppm</td>
<td></td>
</tr>
<tr>
<td>Temp/Hum</td>
<td>NA</td>
<td>NA</td>
<td>SHT75</td>
<td>±0.4°C/±0.4%</td>
</tr>
<tr>
<td>Particles</td>
<td>???</td>
<td>???</td>
<td>DISC (to be adapted)</td>
<td>Range: 10-200 nm/NA</td>
</tr>
</tbody>
</table>
Conclusions

- Unique project in community sensing in terms of scope
  - End-to-end perspective
- Applications in personal and preventive health
  - Transfer of results to cities in emerging countries
- Pronounced interest by public authorities and industry