

Privacy and Incentives in Data Gathering from the Crowd

Adish Singla, Andreas Krause

Learning & Adaptive Systems Group, ETH Zurich

Community Sensing

Estimate spatial phenomenon

• Community owned devices

Privacy and Incentives

Privacy concerns

• Sharing of private attributes, e.g., location



ETHzürich

- Low-cost sensors
- Dense sensing network



Mobile Millenium: Traffic monitoring Berkeley, California





OpenSense 2:

Lausanne/Zurich

Air Quality monitoring

- Inference of location from GPS traces
- General anxieties



KEY QUESTION: How to **valuate** and **negotiate** access to **private information**?

KEY IDEAS: **Privacy via obfuscation**: Users share obfuscated location **Monetary incentives** to **compensate** for **information shared**

Protocol: Mechanism and Users

Mechanism

Privacy profiles and bids from all users

Allocate next participant Makes a payment to the participant

Participant reveals the actual location Sends the sensing data

(budget exhausts)



Main Research Problem Addressed

Mechanisms for recruiting participants:

Privacy Aware Truthful Payments Adaptive Selection

With following desirable properties:

- Budget feasibility
- Polynomial time computation

[Singla & Krause, HCOMP'I 3]

NODECO

Case Study of Air Quality Monitoring

Environment

- Zip data for Nevada State (220 zip codes)
- Population statistics to simulate users' locations

Data from Mechanical Turk

- Survey about participation in application
- 75% users responded positively for participation
- Realistic cost distributions
- Mobility data to simulate sensing radius for user

Results: Varying required utility

- RANDOM : Naïve Baseline with unrealistic access to true costs
- SEQGREEDY : Near-optimal with unrealistic access to true costs
- **CONSTTGREEDY** : Non-adaptive truthful (<u>Singer'10, Chen'11</u>)





NODE Sensor Platform for Crowdsensing

NODE sensor platform

- Under 500 SFr. (base module + two gas sensors) by Variable Inc.
- Lightweight and works via Bluetooth communication with a smartphone
- Can be easily mounted on a bike/car or kept in user's pocket

Bikesense prototype

• Built a prototype of sensing platform with NODE sensors mounted on bikes (w/ ElectricFeel)









Quality testing of NODE sensors at EMPA

Budget required for specified utility

 I6
 Random

 14
 Const Truthful Greedy

 10
 Seq Truthful Greedy

 8
 Seq Greedy

 6
 Seq Greedy



Results: Varying obfuscation

- % Gain from Adaptivity
- . % Loss from Truthfulness
- % Loss from Privacy



Ongoing work

- Scaling up the existing Gaussian Process (GP) models developed as part of OpenSense
- Extending the models with new features for improved predictions
- Extending the models with temporal features for fine-grained temporal predictions

- Collected CO and CO2 recordings over two days
- Reference measurements provided by EMPA
- Promising quality for CO2 sensors





[w/ Christoph Hüglin, Beat Schwarzenbach]

Ongoing work

- Further tests and calibration (timing, variation across sensors, ..)
- Testing other gas sensors (NO, NO2, CO)
- Testing of sensors in areas with higher exposure