Session on Signal Processing and Sensing

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Acknowledgements

The Organizers
Nice to be here 😊

Sponsors
NSF Thank you !

Collaborations
Jose, Michael and Greg

Discussions and Interactions
The usual suspects
Outline

Introduction
  Signals are everywhere, just sense them

Sensing
  New sensors, new modalities, old constraints

Environmental monitoring
  A cute but challenging application

In-Network signal processing
  Distributed, self-organized

Communication and computation
  To separate or not!

Very large data sets
  Google and sensing

Conclusions
Introduction

Signals are everywhere, just sense them!
Sensing
Sensing

• Pointwise sensing
  – Classic and new modes
  – Spectrography, lasers

• Tomographic sensing
  – Integral sensing (fine particles, sound speed)
  – Quadratic gain factor

• Sensors are everywhere
  – Mobile phones
  – Cars
Sensing: Challenges

• Calibration
  – Autocalibration, drift, outlier detection

• Energy
  – Interesting sensing is often power hungry

• New sensors
  – Integration, MEMS, Arrays
  – New sensors

• New modalities
  – Integrated Sensing and Processing (ISP)
  – Compressed sensing
  – Inverse problems
Environmental monitoring

Der Triftgletscher im Berner Oberland im Jahr 1948 (photo E. Gyger), 2002 und 2006
The X trillion dollar question

So, is it 2035 or 2350?
• **Method**
  – Problems statements (by env. eng.)
  – Models
  – Measurements
  – Calibration
  – Data analysis

• **Examples:**
  – CENS
  – SensorScope
Environmental monitoring
SensorScope

From 1-1 to many-many – Revisit all the
In-Network signal processing

• Gossip
  – Distributed average concensus
  – Convergence, speed
  – Algorithms (pairwise, path etc)

• Voting
  – Quantized DAC
  – One bit versus two bit voting

• When will such methods become “practical”?
In-Network signal processing

Questions

• Communication versus sensing
  – “Consensus” (iteration) time scales, how often to update
  – Temporal sensing rates, how often to sense

• Computation versus communication
  – How complex the algorithm
  – How fast does it converge

• E.g.: Stochastic approximation type algorithms
  – Slow convergence smaller error
  – Fast convergence smaller error
In-Network signal processing

Networked Systems: Emergent Behavior

• Large scale:
  – Networked
  – Dynamical nodes
  – Sparse

• Global behavior:
  – Infer from network characteristics global dynamics
  – How does network topology affect behavior

• Qualitative behavior:
  – Metastability: different equilibria
  – Phase change: small changes may cause dramatic behaviors
Communication and computation

- Sensor network riddle
- Computation codes: bits in multi-user IT...
- Hierarchical networks
Analysing very large data sets

• Questions
  – Heterogeneous data
  – Outliers
  – Modeling
  – Predictions

• Methods
  – Machine learning
  – Signal processing on graphs
Applications

- Omnisensing: large deployment of campus/city wide networks, multimodal sensing, heterogeneous technologies, supporting many different applications
- Large scale infrastructures: from environment to power grid, from airports or harbors to transportation networks
- Internet of “things:” IBM smart planet initiative
- Large scale supply networks: from Walmart size surfaces to distribution networks
Conclusions

• **Large Scale, Large Dimension, Large Data**
  – Physical system: *large* physical networked systems
  – Sensing/ Communication: *large* network of sensors, inc. multiple networks
  – Actuation: *large* network of agents

• Interdisciplinarity (the “I” word)

• Will the topic get googled up? (or CS versus EE)
Thank you for your attention!

Any question?
“Would you like to see the top on Google Earth?”