Collaborative Localization and Tracking in Wireless Sensor Networks

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Fundamental Limits of Localization with RF Signals

• Location sensing modality:
  – TOA, TDOA, RSS, AOA, proximity, fingerprinting, ...

• Sources of uncertainties in location sensing:
  – Multipath, no-line-of-sight (NLOS)/blockage, interference, noise, system/hardware incapability, ...

• Localization-denied environments:
  – Indoor/in-building, and other multipath environments.
  – Also depends on application-specific accuracy requirement
Collaboration in Sensor Network

• Individual sensor nodes have limited sensing, computing, and communication capacities.

• Collaboration is the key –
  – To achieving substantial sensing and processing capabilities in the aggregate, and
  – To providing collectively reliable network behavior in mission critical applications.

• With collaboration, distributed sensor nodes are aggregated to form a *single collaborative system* rather than *greedy adversarial participants*.
Collaboration in Sensing and Processing

• Collaboration of distributed nodes in sensing is to
  – Provide large-scale sensing coverage, and to
  – Achieve superior sensing capabilities.
  – This is achieved by exploiting various diversity gains, multiple sensing modalities, redundancy in high-density networks, and many other advantageous system and environmental conditions.

• Collaboration in processing is to
  – Share the processing load among nodes to minimize energy consumption at each node, and/or to
  – Achieve substantially higher processing capacity in the aggregate than any node can offer individually.
Collaborative Localization

• Non-Collaborative
  – Each sensor node is located based on measurements between the node and reference nodes

• Collaborative
  – Measurements among sensor nodes are exploited
  – Every sensor node can act as pseudo-reference node to other sensor nodes
  – This may provide opportunities to improve geometric conditioning and to mitigate adverse multipath and NLOS effects
Collaborative Multi-Sensor Tracking (CMST)

- **Tracking**
  - To exploit mobility of sensor nodes

- **Collaborative multi-sensor tracking**
  - To combine the power of collaboration and tracking.
An Example
RMSE CRB Comparison
Particle Filters to Implement CMST
Selected Publications


• Xinrong Li, "Distributed implementation of particle filters for collaborative tracking in mobile ad-hoc and sensor networks," *International Conference on Signal Processing* (ICSP), Beijing, China, October 2008.
