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

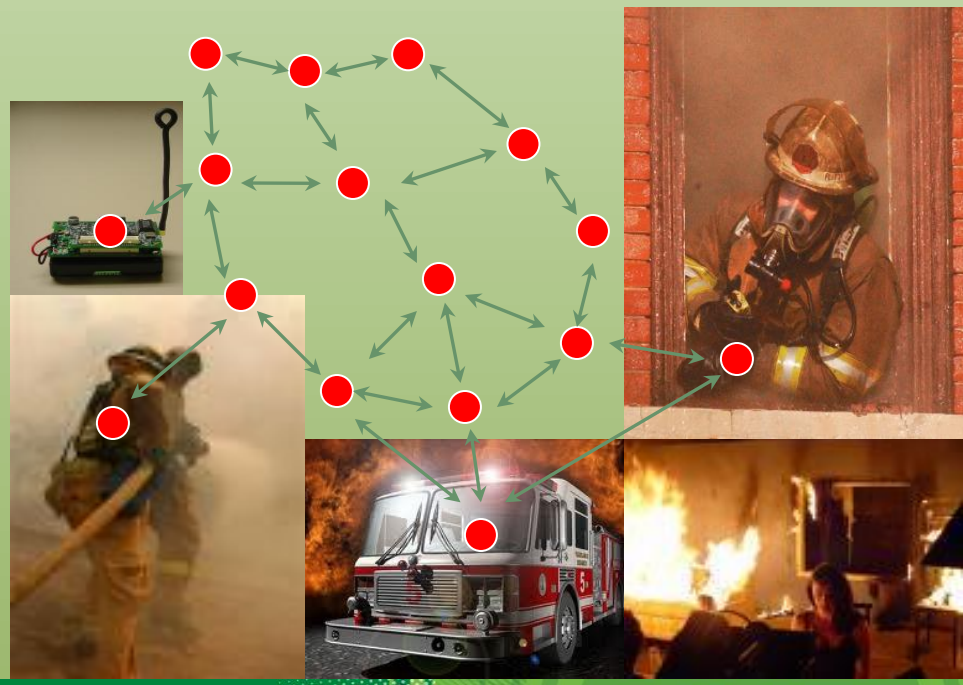
- Collaboration of distributed nodes in sensing is to
  - Provide large-scale sensing coverage, and to
  - Achieve superior sensing capabilities.
  - This is achieved by exploiting various diversity gains, multiple sensing modalities, redundancy in high-density networks, and many other advantageous system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

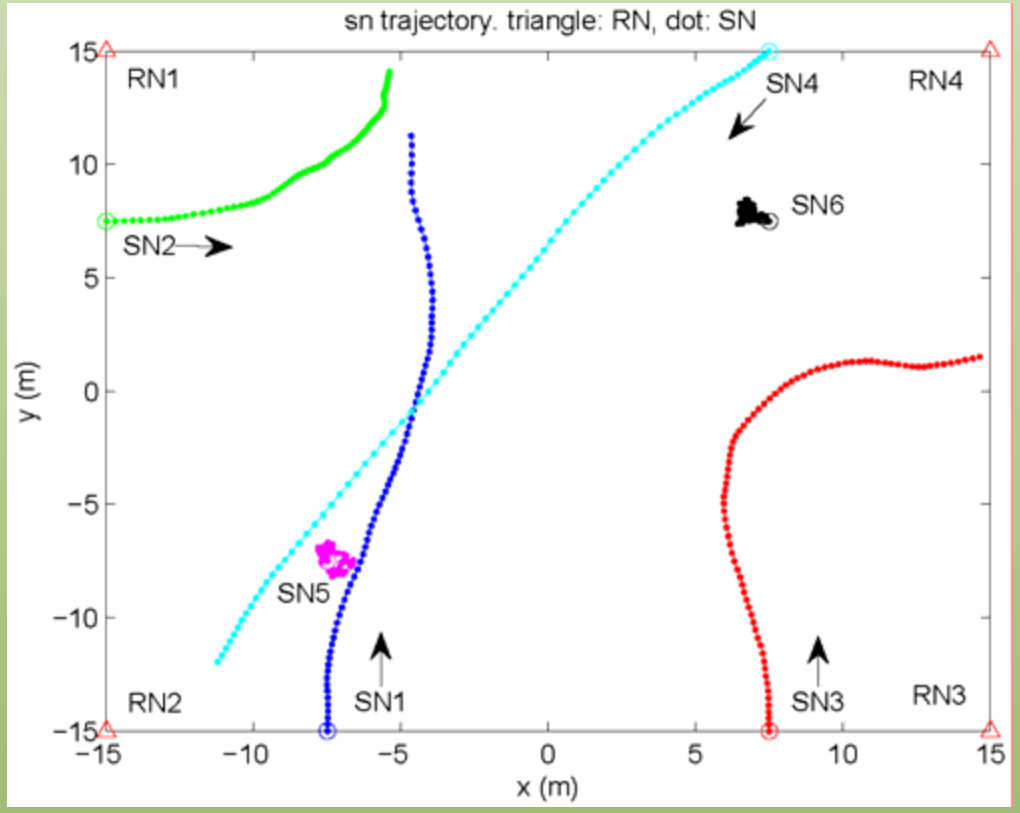
- Non-Collaborative
  - Each sensor node is located based on measurements between the node and reference nodes
- Collaborative
  - Measurements among sensor nodes are exploited
  - Every sensor node can act as pseudo-reference node to other sensor nodes
  - This may provide opportunities to improve geometric conditioning and to mitigate adverse multipath and NLOS effects

Collaborative Multi-Sensor Tracking (CMST)

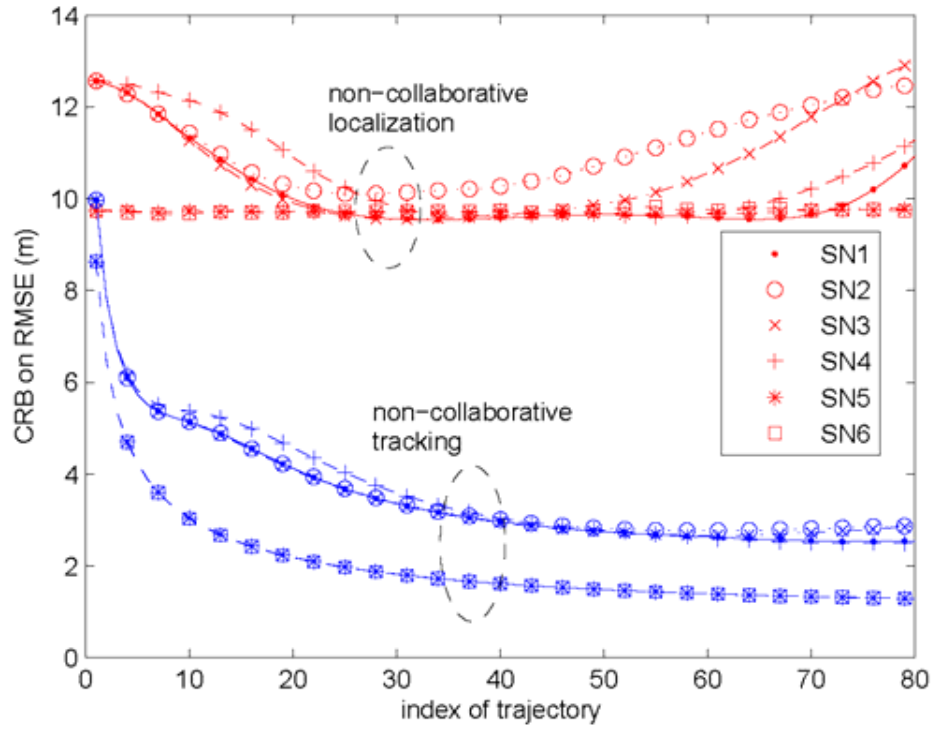
- Tracking
  - To exploit mobility of sensor nodes
- Collaborative multi-sensor tracking
  - To combine the power of collaboration and tracking.

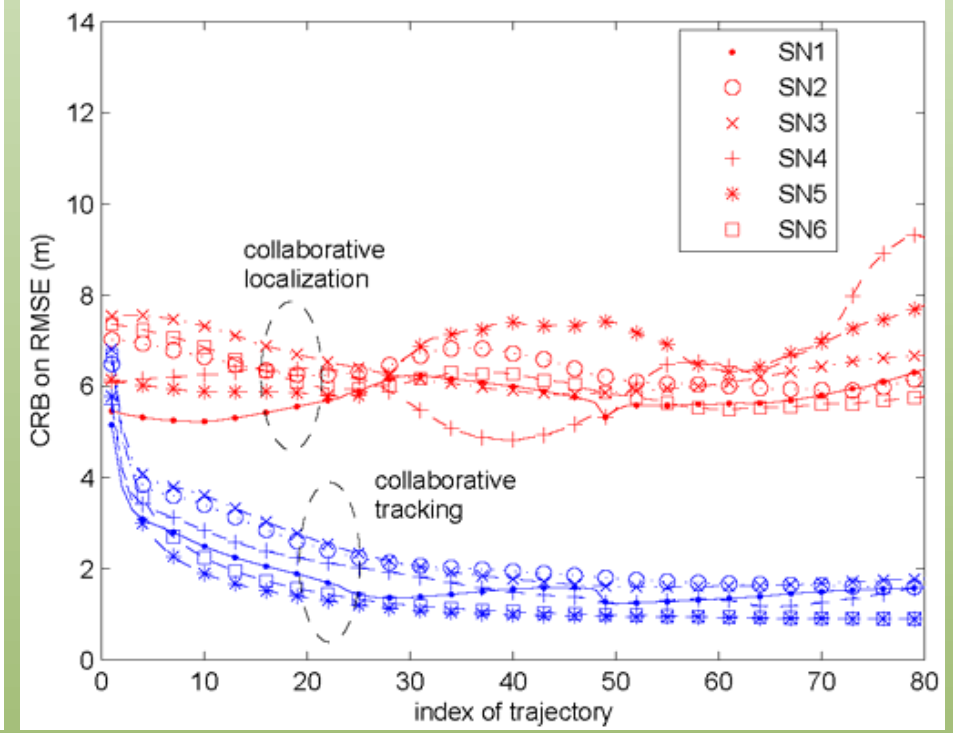


An Example

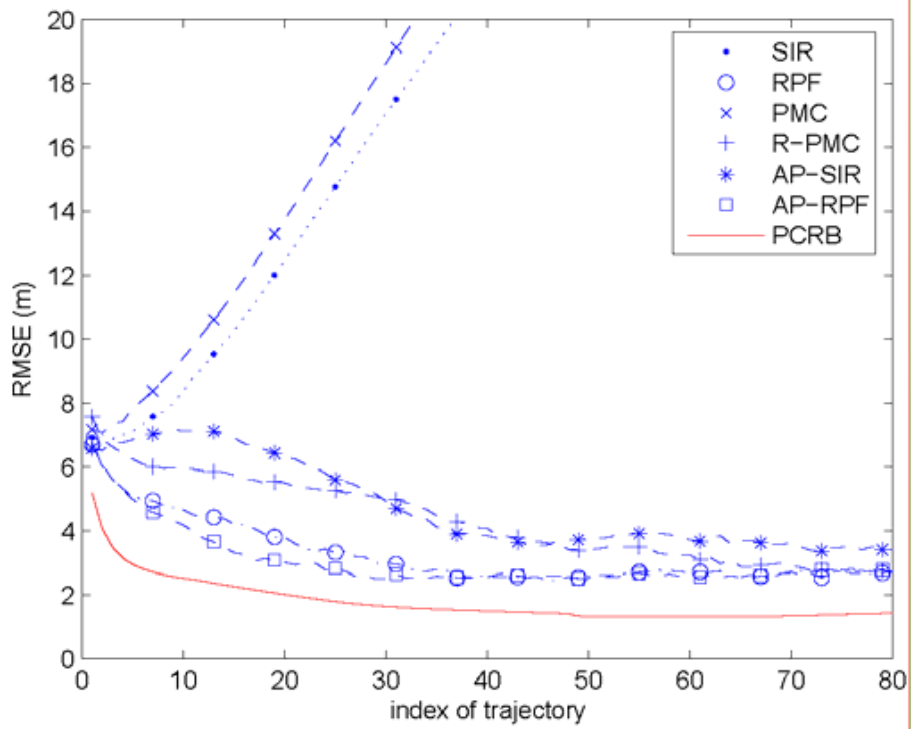

sn trajectory. triangle: RN, dot: SN
RN1
RN2
RN3
RN4
SN1
SN2
SN3
SN4
SN5
SN6
y (m)
x (m)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15

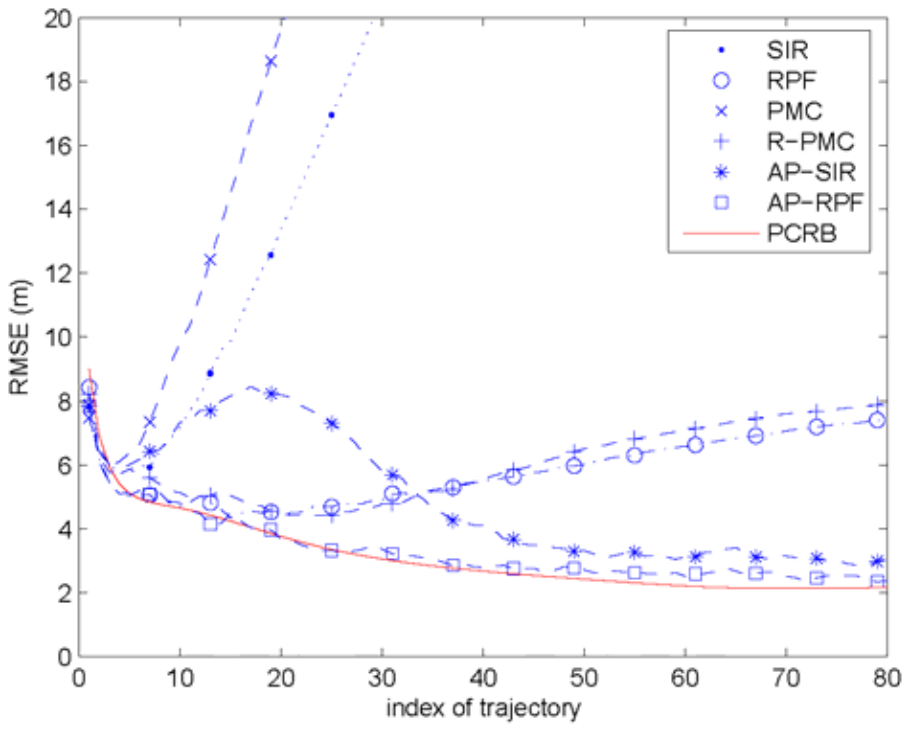
RMSE CRB Comparison





Particle Filters to Implement CMST





Selected Publications

- Xinrong Li, "Collaborative multi-sensor tracking in mobile wireless sensor networks," *International Journal of Sensor Networks* (IJSNET), InderScience Journals, Vol. 8, No. 3/4, 2010.
- 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.
- Xinrong Li, "Collaborative localization with received signal strength in wireless sensor networks," *IEEE Transactions on Vehicular Technology*, vol. 56, no. 6, pp. 3807-3817, November 2007.
- Xinrong Li and Jue Yang, "Sequential Monte Carlo methods for collaborative multi-sensor tracking," *IEEE Military Communications Conference* (MILCOM), Orlando, FL, October 2007.