SCALABLE ALGORITHMS FOR SENSOR LOCALIZATION

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A DIFFICULT PROBLEM

Sensor localization

Ad hoc wireless sensor network
A few anchors have known locations
Known distance measurements among sensors
Determine positions of all other sensors

Geometric model with noisy distances

x_i vectors in 2D or 3D
r radio range

$$\begin{array}{llll} \text{minimize } \sum |\alpha_{ij}| & & & \\ \|x_i - x_j\|^2 + \alpha_{ij} & = & d_{ij}^2 & \text{(some } i,j) \\ \|x_i - x_j\|^2 & \geq & r^2 & \text{(most } i,j) \\ x_k & = & a_k & \text{(anchors)} \end{array}$$

Non-convex constrained optimization

HIERARCHICAL SOLUTION METHOD

Semidefinite programming (SDP): $<$ 20 nodes

SpaseLoc algorithm: $<$ 10000 nodes
Adaptive sequence of tiny SDP subproblems

Distributed algorithm: arbitrary network size
SpaseLoc called in parallel
Adaptive sequence of parallel clusters

Moving sensors: dynamic network
SpaseLoc called each time step

COMPUTATIONAL RESULTS

Implementation
MATLAB with Mex interface to SDP solver

Parameters
Radio range, no. of anchors,
noise level, no. of moving sensors,
no. of clusters

Simulations
Varied topologies of anchor/sensor placement
2D, 3D
Dynamic sensor tracking
Distributed computation
Bus arrival reporting system

Results
SpaseLoc accuracy and speed $\gg$ pure SDP
SpaseLoc linear complexity
Distributed algorithm also linear complexity

IMPACT

Deployable algorithms enable myriad applications:
forest fire detection, building automation,
traffic monitoring, security services,
preemptive maintenance

Soon 100 million sensors in use in industry

Software essential, scalability essential
Real-time results from lower-power CPUs