Spatial Localization Light-Seminar
Spring 2005

Seminar

- Survey of Localization technologies
  - Techniques
- Evaluation
  - Metrics
  - Performance
  - Cost

Techniques

- Multi-lateration and triangulation
- Fingerprinting and classification
- Ad-hoc and range/free
- Graph rigidity
- Identifying codes
- Bayesian Networks
- Optimization
- Multi-dimensional scaling

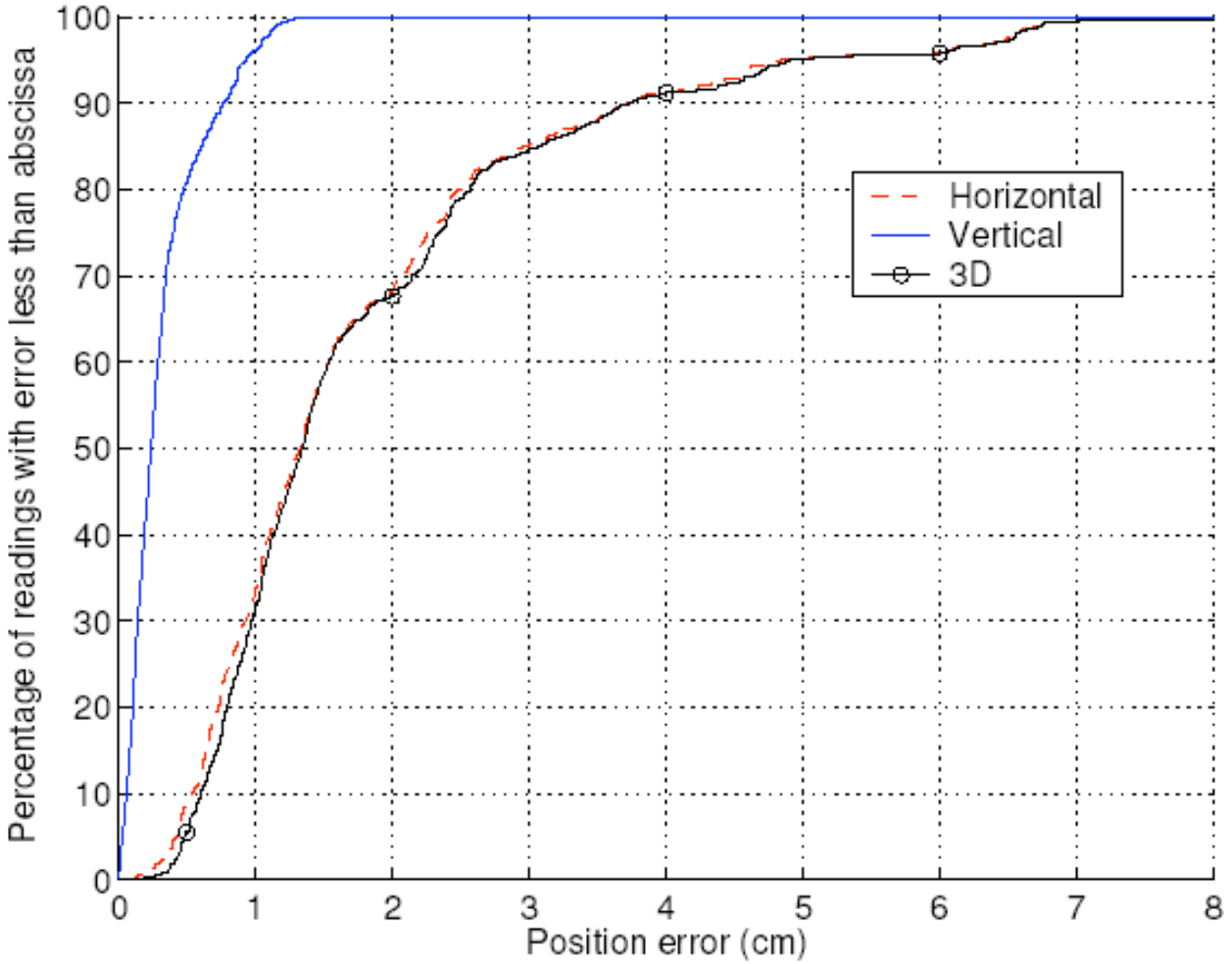
Multi-Lateration and Triangulation

- Use geometry:
  - 3 sides or 3 angles and 2 known positions define the location of an unknown point.
  - E.g. cosine rule: $c^2=a^2+b^2-2ab[\cos(C)]$
- Tricky part is getting the distances or angles to the known positions (the landmarks)
- Lateration:use distances
- Angulation: use angles
- More angles and distances can improve accuracy

Getting distances to landmarks

- Measure time directly from clocks in sender and receiver
  - GPS
- Time-difference of arrival between media (radio, ultrasound)
  - Medusa
  - Hazas/Ward
  - Cricket

Sample Localization Accuracy



Multi-Lateration

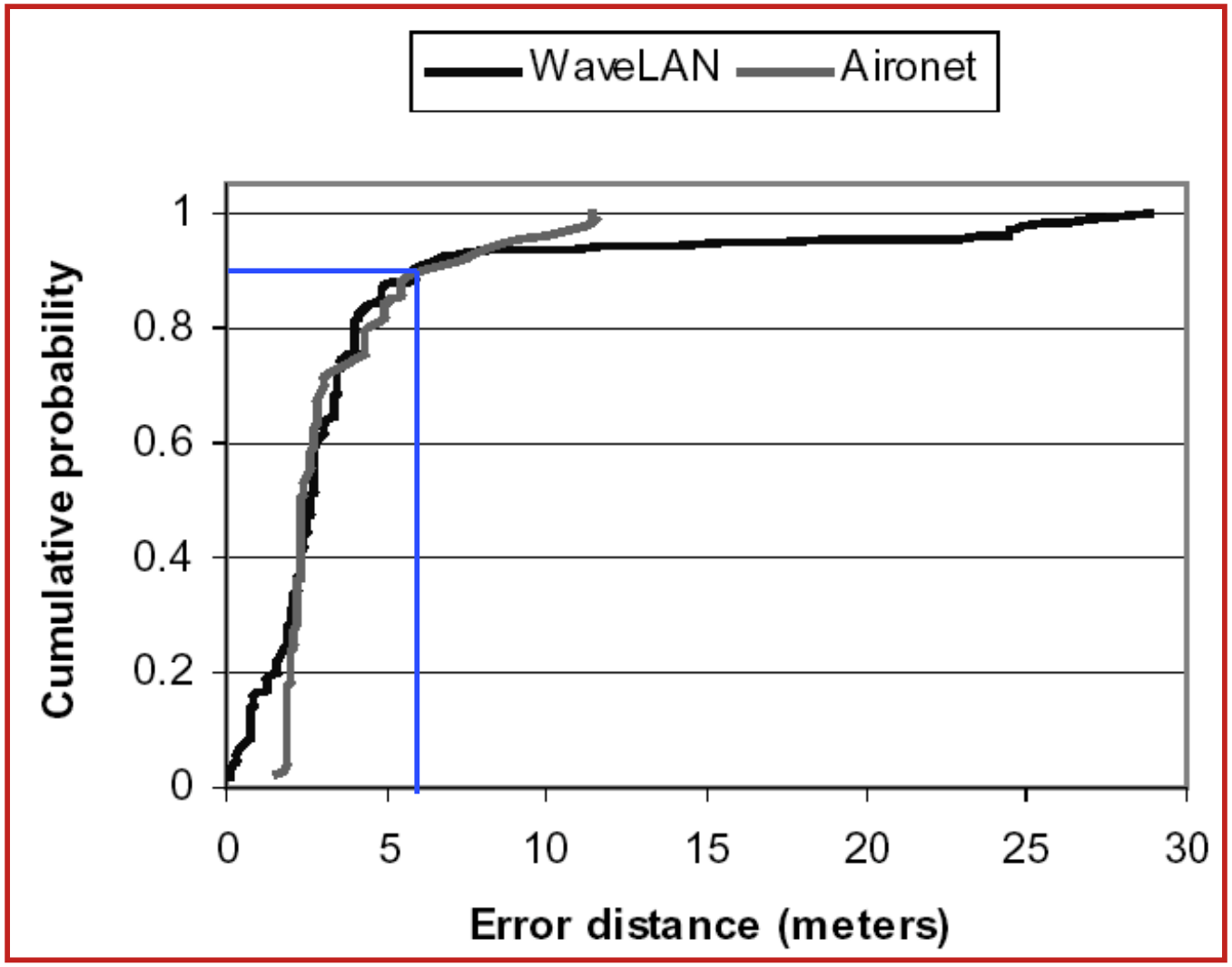
- Accurate distance measure from sender to receiver

- Line-of-sight to landmarks critical
  - Both for GPS, ultrasound
- Is this valid indoors?
  - How to obtain coverage in this case?
  - How hard is infrastructure?

Fingerprinting, classification and scene analysis

- Observe properties of the radio spectrum
- Match properties to locations on a map
  - MS RADAR
    - Sampled points, signal space mapping
  - CMU Triangulation, Mapping, Interpolation
  - UMD Bayesian
- How to build the map?
  - Someone walks around and samples?
  - Automatic?
- Fingerprint is a location on the map based on some feature
  - E.g. mean signal strength of N landmarks.

Normal RADAR accuracy



Sampling + Scene Analysis

- Pro: little added infrastructure
- Con: sampling
- Open issues:
  - AP density, placement
    - “auto sampling”?
  - Sampling density
  - Scene changes over time
  - Area/volume analysis vs. point analysis
  - Is 3-4m accuracy really the best possible?

Add-hoc Approaches

- Ad-hoc positioning (APS)
  - Estimate range to landmarks using hop count or distance summaries
- APS:
  - Count hops to landmarks
  - Find average distance per hop
  - Use multi-lateration to compute distance
- Range free = do not measure ranges to landmarks.

Graph rigidity

- View system as a graph with nodes and edges.
- A graph is rigid if no node can be moved without compromising the topology.
- A rigid graph means position of all the nodes can be known with no ambiguity.

Optimization

- Can view system of nodes, distances and angles as a system of equation with unknowns.
- Can add inequalities about maximum minimum distances
  - E.g. radio range is at most X units.
- Can solve resulting system of inequalities as an optimization problem.

Bayesian Networks

- View positions as random variables
- Build network to describe likely values of these variables given observations
- Pros:
  - Captures any set of observations and priors
- Cons:
  - Computationally expensive
  - Accuracy

Multidimensional Scaling

- View system as a high-dimensional system mapped into 2D or 3D
- E.g. N points and N(N-1)/2 dimensions
- Generated from 2D or 3D
- Find most likely mapping