Mobile User Localization Using IEEE 802.11b WAPs

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Movitation

- Location service for Mobile Computing Environment
- Installing extra infrastructure (beacons etc)
  - Fine resolution: << meters
  - High cost
- Using existing infrastructure (IEEE 802.11a/b/g WAP’s)
  - Crude resolution: ~ meters
  - No cost
Previous Works

- MSR RADAR
  - Pioneered the idea of using WAP’s for the mobile user localization
  - No tracking
- Rice University
  - Used HMM algorithm for tracking
Our Approach: Bayesian Filtering

- Bayesian Filtering: General probabilistic framework for combining the prior knowledge (how things are moving in general) with the new information (what you observe)

\[
p(x^{(t+1)} \mid z^{(t+1)}) = C \cdot p(z^{(t+1)} \mid x^{(t+1)}) \cdot \int p(x^{(t+1)} \mid x^{(t)}) \cdot p(x^{(t)} \mid z^{(t)}) dx^{(t)}
\]

\(x^{(t)} \in \{s_1, \ldots, s_N\}\), \(N\): # the data collection locations.
\(z^{(t)} \in [\text{min\_SNR}, \text{max\_SNR}]^M\), \(M\): # WAP's
\(z^{(t)} = \{z^{(0)}, \ldots, z^{(t)}\}\)
\(p(x^{(t+1)} \mid x^{(t)})\): Dynamic model (prior knowledge)
\(p(z^{(t+1)} \mid x^{(t+1)})\): Observation model (new information)
Our Approach: Dynamic Model

\[ p(x^{(t+1)} \mid x^{(t)}) \]

Q) How to model \( p_{ij} \) ? Easy
Our Approach: Observation Model I

\[ p(z^{(t)} \mid x^{(t)}) \]

Q) How to model \( p(z^{(t)} \mid x^{(t)} = s_j) \)? Hard!
Our Approach: Observation Model II

Q) How to model $p(z^{(t)} | x^{(t)} = s_i)$?

- Non-parametric model: not enough data and ...
- Parametric model:
  - Gaussian ($\exp(-cx^2)$)
  - Cauchy ($\frac{\alpha}{\alpha^2 + x^2}$)
Data Collection I

- Data collected at 64 locations. (\[ x^{(t)} \in \{s_1, \ldots, s_{64}\} \])
- At each location, the signal strengths from 3 WAP's are recorded for about 30 seconds.
- Orinoco Client Manager was used to collect the data.

→ Very unreliable
Data Collection II

- To collect the ground-truth data, we wrote a small program that shows the moving agent that the data collector should follow

- Segmented the whole path in the small paths
Testbed
Result

- Real data playback
- Real demo
Conclusion and Future Works

- Impulsive nature of RF signal characteristics seems to be better described by Cauchy distribution.

- When the system has “meaningful” reading, the tracking performance seems reasonable.

Future works

- No quantitative analysis done
- Passive listening → Active probing?
- Tracking in continuous state space
- Extend this to IPAQ

and many others