Exploiting Human Mobility Trajectory Information In Indoor Device-Free Passive Tracking

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WINLAB | Wireless Information Network Laboratory

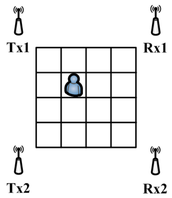
Chenren Xu, Bernhard Firner, Yanyong Zhang, Richard Howard, Jun Li
Wireless Information Network Laboratory (WINLAB), Rutgers University
{lendlice, bfirner, yyzhang, reh, jonjunli}@winlab.rutgers.edu

Motivation

- Monitor human mobility. E.g. for health/elder care, safety and security, or traffic flow
- Provides privacy protection
- Use existing wireless infrastructure

Proposed Solutions

- High dimensional space
  - Measure radio signal strength (RSS) changes in multiple transmitter and receiver links.
- Cell-Based Localization
  - Classification approach
  - Take radio training data for each cell
- Linear Discriminant Analysis Classifier
  - Prevent under-fitting and over-fitting
- Trajectory-Based Tracking
  - Improve accuracy by using constraints on mobility. E.g. people cannot walk through walls or cross rooms instantly.



Trajectory Related Terms

- **Cell Neighbors**

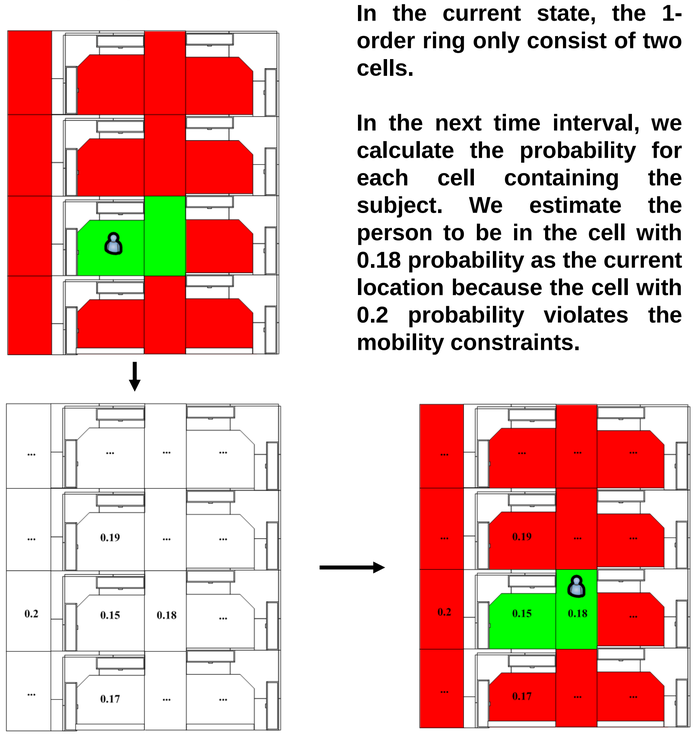
  A list of adjacent cells which can be entered without violating mobility constraints.
- **Order of Neighbor**

  The number of cells a person must pass through to reach a specific cell from the current cell without violating mobility constraints.
- **N-order Ring**

  The area consists of all the cell neighbors of the specific cell with an order less than or equal to N.

Trajectory Exploitations

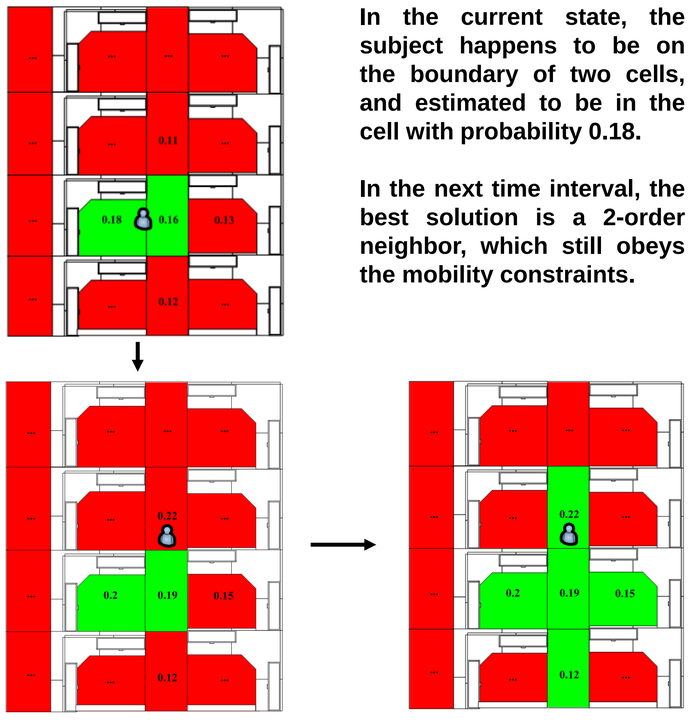
- 1-order Ring



In the current state, the 1-order ring only consist of two cells.

In the next time interval, we calculate the probability for each cell containing the subject. We estimate the person to be in the cell with 0.18 probability as the current location because the cell with 0.2 probability violates the mobility constraints.

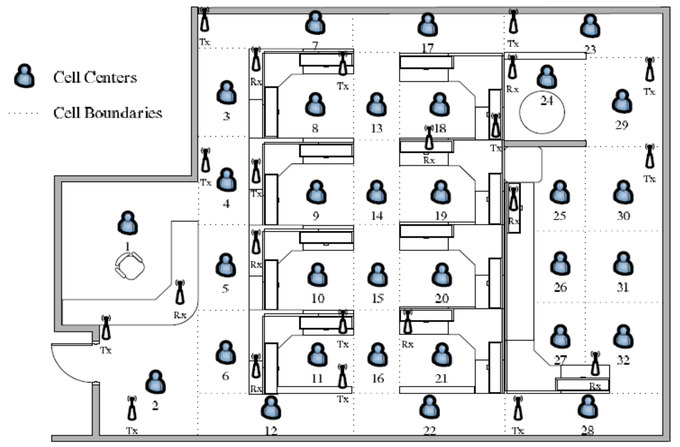
- 2-order Ring



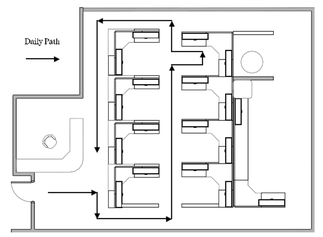
In the current state, the subject happens to be on the boundary of two cells, and estimated to be in the cell with probability 0.18.

In the next time interval, the best solution is a 2-order neighbor, which still obeys the mobility constraints.

Experimental Deployment

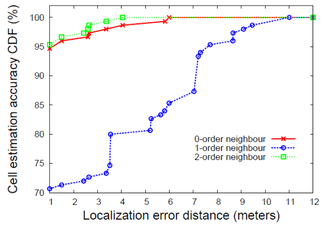


Experimental Results



Experimental trajectory simulating a subject's daily path in a office environment.

"A subject enters the room, crosses an aisle, prints paper in her cubicle, and walks through another aisle to retrieve her paper."



"1-order neighbor" has the worst performance because a single mistake in one interval may cascade to subsequent intervals. "2-order neighbor" greatly reduces this problem.

Neighbor Order	Cell Estimation Accuracy (%)	Localization Error Distance (m)
0	94.7	1.2
1	70.7	2.5
2	95.3	1.0

Trajectory information bounds the maximum error distance, greatly improve the performance.

Mobility constraints greatly improve accuracy!

Future Work

- Localize a known number of individuals.
- Estimate an unknown number of individuals in a space.

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