**Tack:** Learning Towards Contextual and Ephemeral Indoor Localization With Crowdsourcing

Liyao Xiang
ECE Dept.
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Indoor Localization

- Traditional localization infrastructure is costly.
- Most user devices are common smartphones.
- We want **accurate** and **cheap** indoor localization solutions!
Localize by Bluetooth Signals

- **Bluetooth transmitters** (<10$, 50+m range)

- Users detect Bluetooth signals for positioning.
Localize by Crowdsourcing

- Use encountering info to further enhance accuracy.

Location errors propagate!
Probabilistic Inference

- User/Bluetooth transmitter locations as clear nodes, and their encountering state with other users/transmitters as dark nodes.
Probabilistic Inference

- Update the **most likely position** of the clear nodes repeatedly with probabilities conditioned on the state of dark nodes.
Probabilistic Inference

- Expand the inference to incorporate each node’s history.

- time window = 3
We not only estimate current locations, but also correct history locations.

The more information included, the more accurate localization.
With code-level optimization, common smartphones can support our algorithm.

Architecture
29.1, 14.2

Position (x, y)

User Interface

Run on iOS.
Results

Tested on iPhone 6S.

Experiment Setting: 7 beacons, 7 users

Mean error for all users in different settings:

- HMM
- Window = 3
- Window = 5

<table>
<thead>
<tr>
<th>Mean/(STD)</th>
<th>WiFi</th>
<th>1 User</th>
<th>4 Users</th>
<th>7 Users</th>
<th>10 Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%-dropping time (s)</td>
<td>80.62</td>
<td>198.33</td>
<td>185.0</td>
<td>172.25</td>
<td>153.75</td>
</tr>
<tr>
<td>Localization latency (s)</td>
<td>–</td>
<td>0.34/0.14</td>
<td>0.44/0.11</td>
<td>0.58/0.13</td>
<td>0.73/0.18</td>
</tr>
</tbody>
</table>
**Tack:** Takeaway

- inexpensive ( < 10$ transmitter costs, > 2 years )
- accurate ( 2~4m )
- energy-saving ( 40% less smartphone battery )
- easy to deploy
Thank you!

Any questions?