Unsupervised Indoor Localization (UnLoc)
Pedestrian Dead Reckoning (PDR)

- accelerometer
- compass
- gyroscope
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Step length
Walking direction
Pedestrian Dead Reckoning (PDR)
Charles Lindbergh landed in Paris from New York.

No GPS

He used dead reckoning and obtained fixes from the stars.
Pedestrian Dead Reckoning (PDR)

If we had “indoor stars” …
meaning some form of “electronic landmarks” …
the IMU could periodically course correct
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Idea

If sensor data about the ambience embed natural patterns in them,
can these patterns be viewed as landmarks …
and can those landmarks be used for PDR course correction
Unsupervised Localization (UnLoc)
Automatically identify sensor landmarks and recalibrate IMU errors
Acceleration pattern

Pressure change
3 step iterative algorithm

1. Detect landmarks (from ambient sensing)
2. Estimate rough landmark locations (from rough PDR and multiple measurements)
3. Localize users from landmarks and refine landmarks from users (iterate until convergence)
1. How to automatically detect landmarks
Raw Sensor → Landmarks
Raw Sensor $\rightarrow$ Landmarks

sensor space

<location, f1, f2, f3, ...>

Feature Extraction

<location, sensor data>
Raw Sensor → Landmarks

Sensor space

Clustering

<location, f1, f2, f3, ...>

Feature Extraction

<location, sensor data>

Raw Sensor → Landmarks
Raw Sensor $\rightarrow$ Landmarks

sensor space

Clustering

Feature Extraction

<location, f1, f2, f3, ...>

Landmark

<location, sensor data>
Landmarks from Multiple Sensors

Feature Extraction

<location, sensor data>

Clustering

<location, f1, f2, f3, …>

Inertial, Magnetic, Wi-Fi

Feature Extraction

<location, sensor data>
Say we find many landmarks (using multiple sensors). Are we done?
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No, landmark locations can be very poor.
landmark 1

landmark

Uncorrelated errors
origin

landmark 1  landmark 2  landmark

[Diagram with origin, landmark 1, landmark 2, and landmark connections]
Growing landmarks outward from initial location
Growing landmarks outward from initial location
Recursive Algorithm

- Users’ motion traces: \(<\text{time, sensor value}>\)
- Landmarks
  - Unique Sensor Fingerprint?
- Find Landmark Location
- Update Landmark list
- Dead Reckon using existing landmarks
- User Location Error
- Landmark Location Error
UnLoc Demo
Questions?
Evaluation:
- Deployed in 6+ buildings
- Shopping mall, univ., industry
- Results from 5 Android models
- 20 users
- Running live in CSL 2\textsuperscript{nd} floor
- Landmarks 6 months stale
- Robust
Performance

Experimentation on 8000 sq. meters
Shopping mall, ECE and CS buildings

CDF

Localization Error in meters

(1.63m, 50%)
Indoor environments rich in landmarks

1.63m accuracy
No infrastructure cost
No calibration needed