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A Real-time Indoor Tracking System by Fusing Inertial Sensor, Radio Signal and Floor Plan.

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Outline

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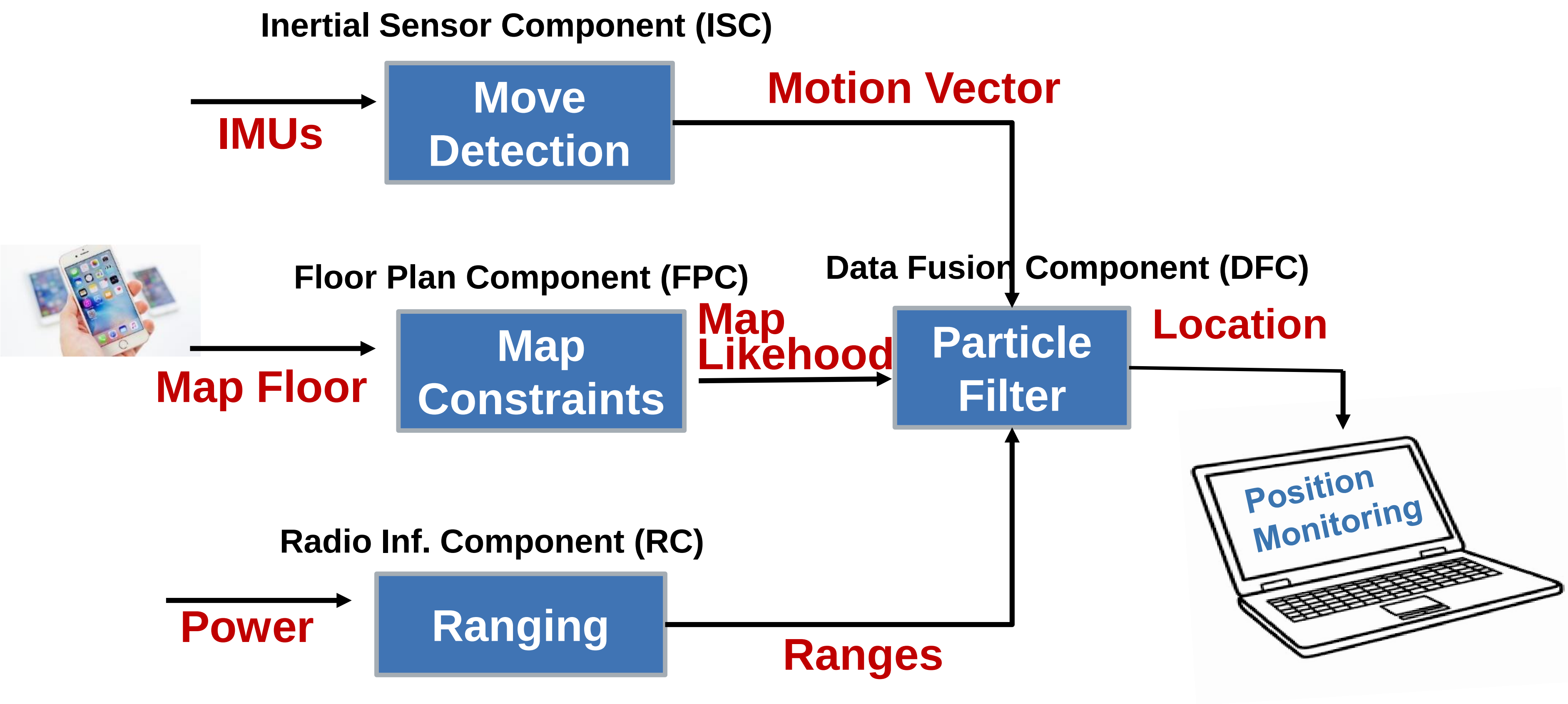
- Proposed Indoor Positioning System
  - Inertial Sensor Component.
  - Radio Information Component.
  - Floor Plan Information Component.
  - Data Fusion Component.
- Implementation
  - Inertial Measurement Unit (IMU) process.
  - Ranging process.
  - Particle Filter.
- Experiments
- Preliminary Results
- Conclusions

Proposed Indoor Positioning System

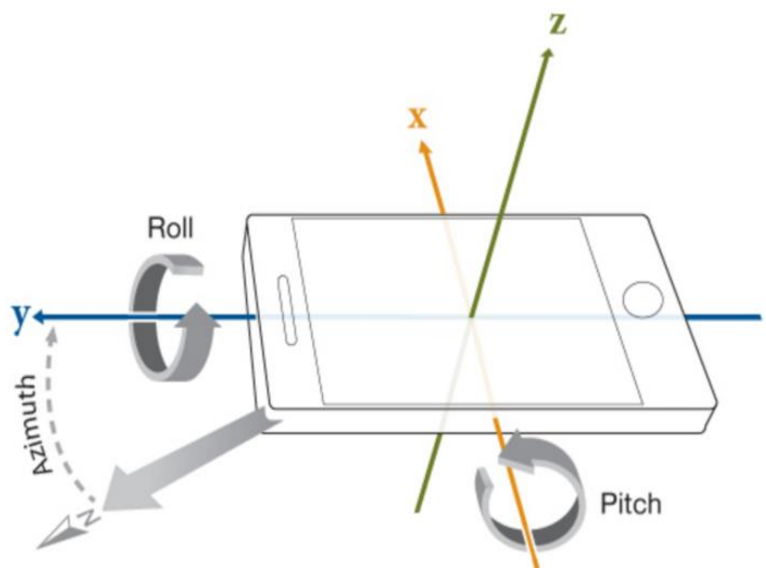


Inertial Sensor Component

Accelerometer:
- Linear acceleration.

Gyroscope
- Angular rotation velocity

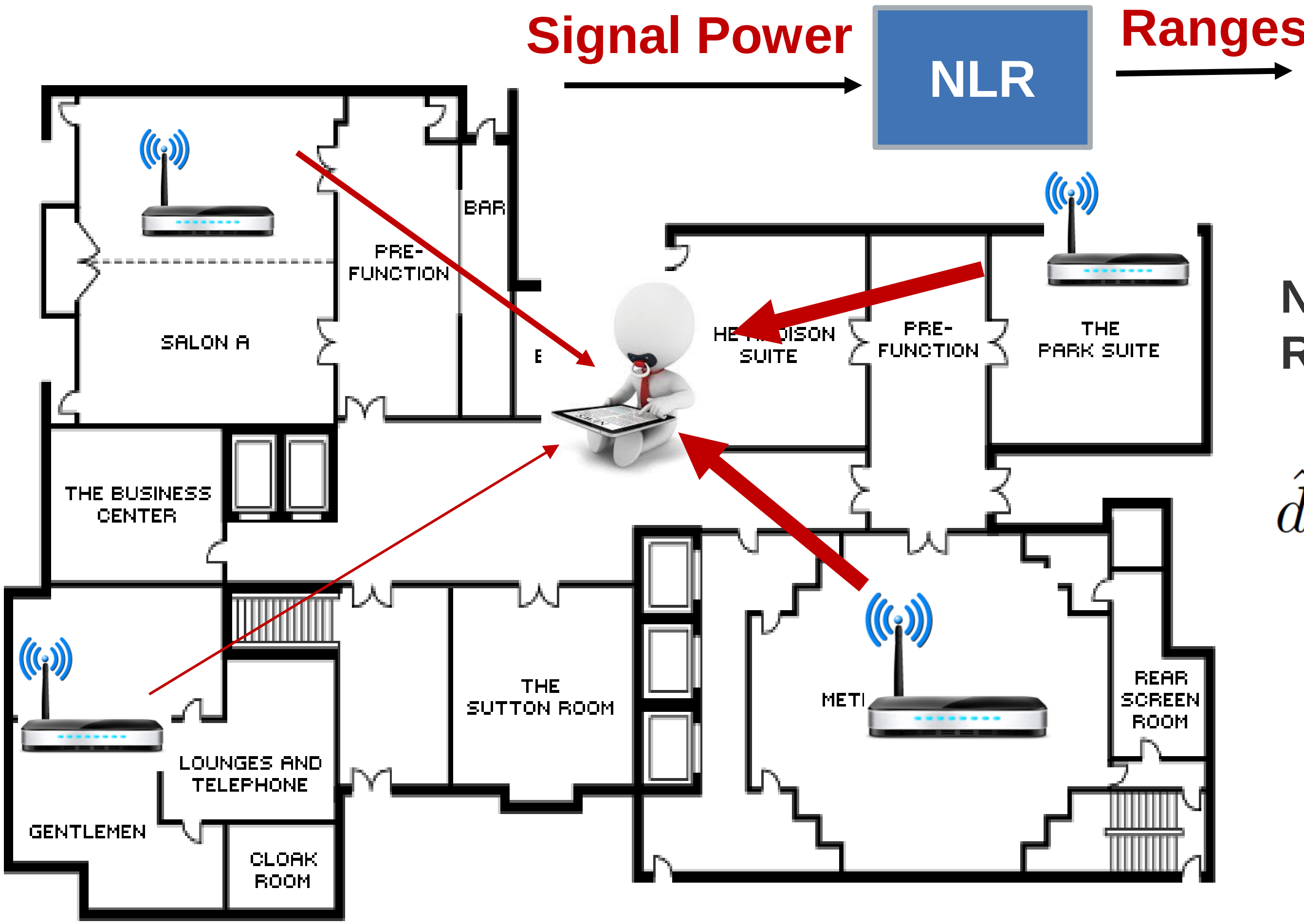
Magnetometer
- Azimuth value



IMUs → **Move Detection** → Motion Vector

[2] P. Nagpal, "Indoor Positioning using Magnetic Compass and Accelerometer of Smartphones", University of Windsor, MoWNET 2013

Radio Information Component



Non-Linear Regression Model [1]

$$\hat{d}_i = \alpha_i \cdot e^{\beta_i \cdot \mathrm{RSS}_i}$$

[1] Z. LI, T. Braun, “A Passive WiFi source localization system based on fine-grained power-based trilateration ”, University of Bern, IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM), June 2015

Floor Plan Information Component

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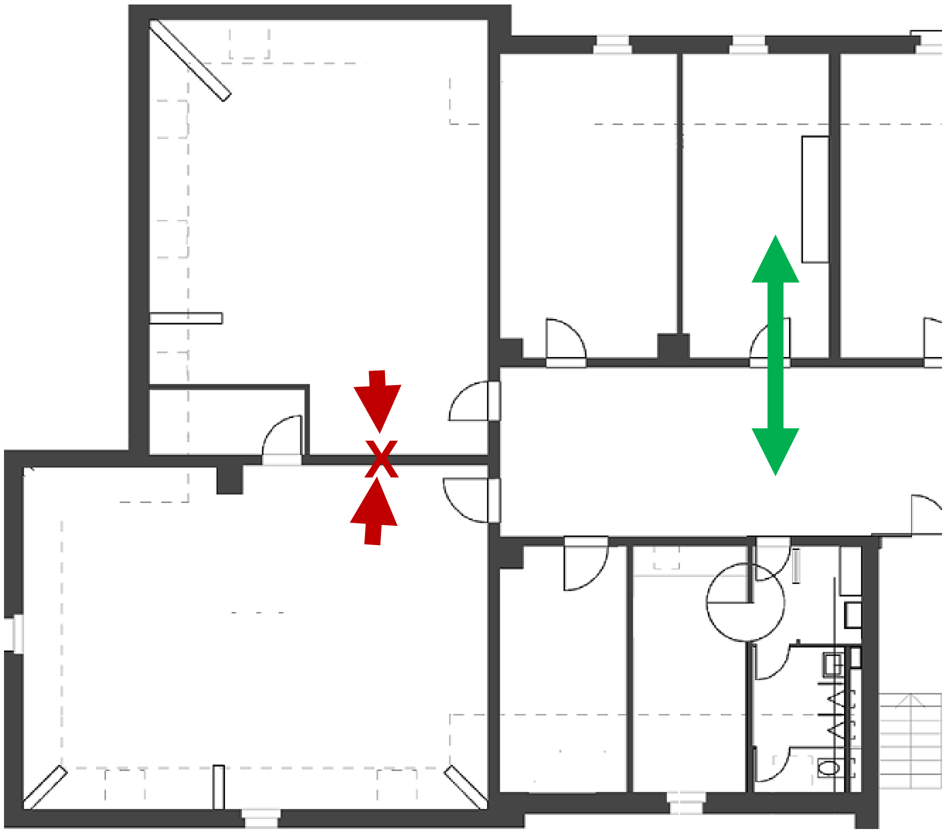
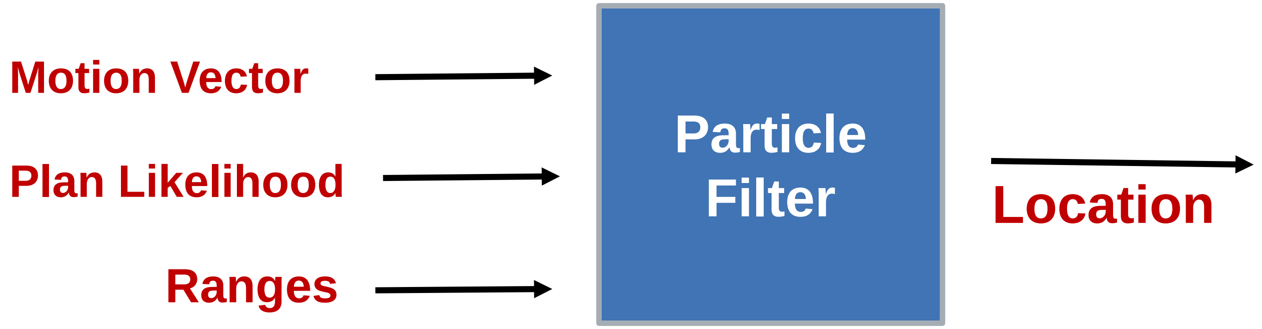


Map Floor → **Map Constraints** → Map Likehood

Define “allowed” zones

[3] F. Hong, “Indoor Localization and Tracking using WiFi-Assited Particle Filter”, Ocean University of China, IEEE LCN 2014

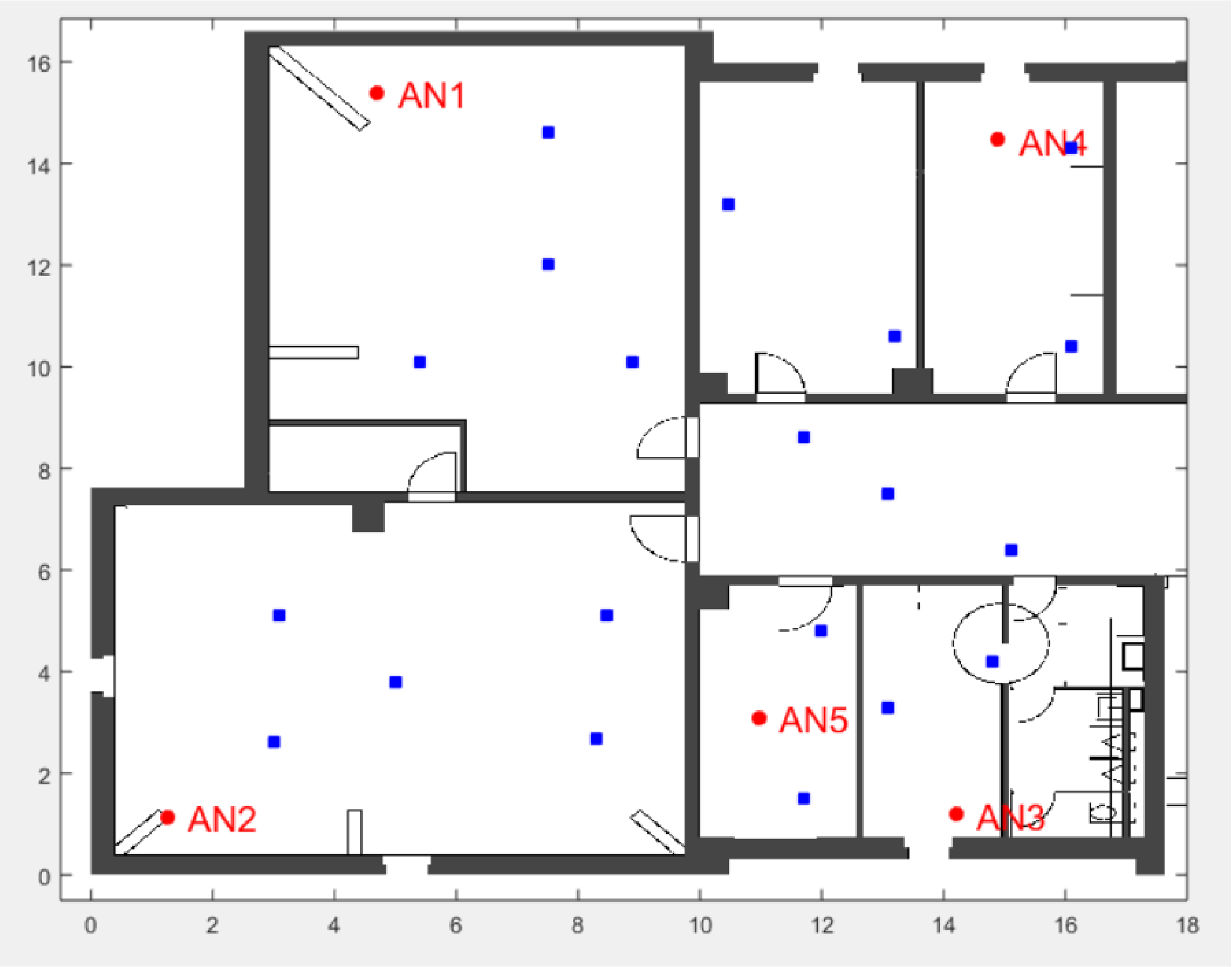
Data Fusion Component



Bayesian Filter

- Represents a PDF as a set of samples (particles).
- Model of how state changes in time.
- Model of what observations you should see.
- Belief of the current state given all the observation so far.

Implementation
Ranging I



Implementation Ranging II

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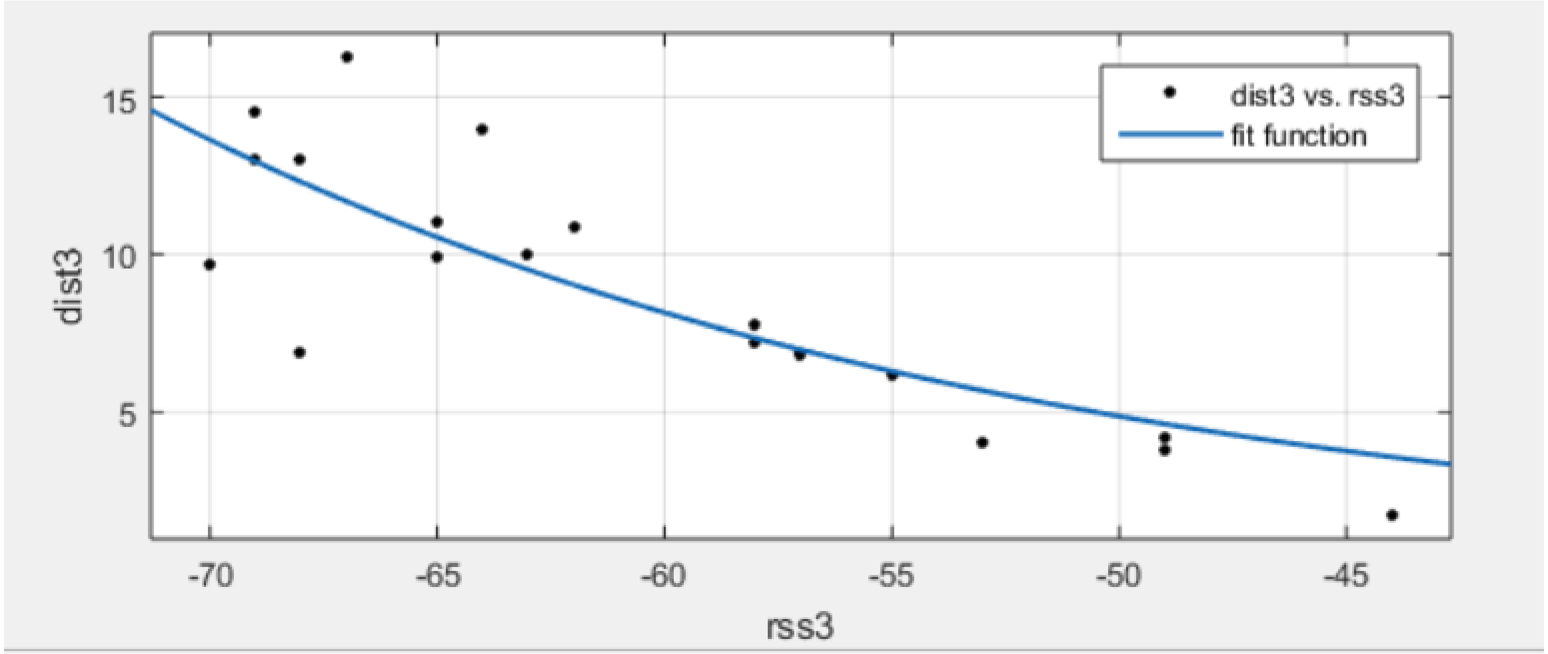
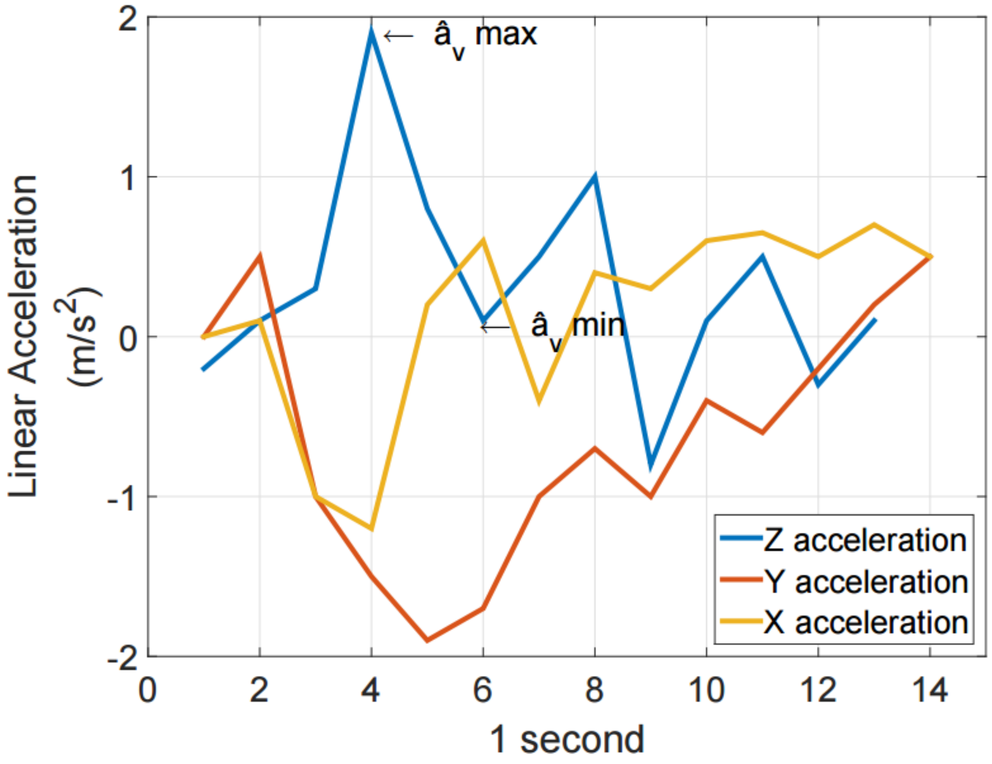
Non-Linear Regression Model

$$\hat{d}_i = \alpha_i \cdot e^{\beta_i \cdot \mathrm{RSS}_i}$$



Implementation
Inertial Measurement Unit I



Accelerometer

Step Recognition

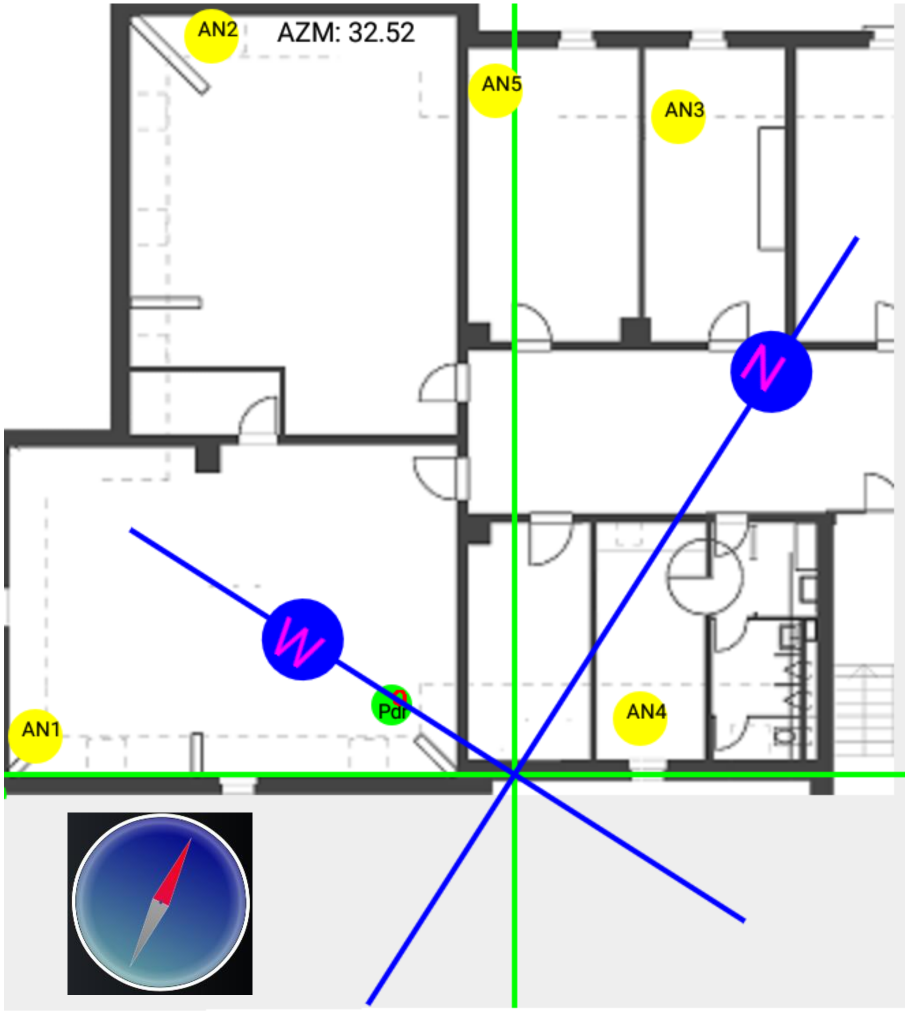
$\hat{a}_{z,t} > Threshold$ &&

$\hat{a}_{z,t-1} < \hat{a}_{z,t}$ &&

$\hat{a}_{x,t} < \hat{a}_{z,t}$ &&

$\hat{a}_{y,t} < \hat{a}_{z,t}$

Implementation
Inertial Measurement Unit II



Magnetometer, Accelerometer

Heading Orientation

OffsetX: Inclination X axis Magnetic North
Azimuth: Magnetic North and Y axis

θ=(*OffsetX-Azimuth****).***
st=*stride length.*

Implementation
Particle Filter

Particle Propagation → Particle Correction And Resampling → System State

Motion Vector

$X = \widehat{st} * \cos(\theta).$

$Y = \widehat{st} * \sin(\theta).$

Likelihood

RSS observation

- Ranging

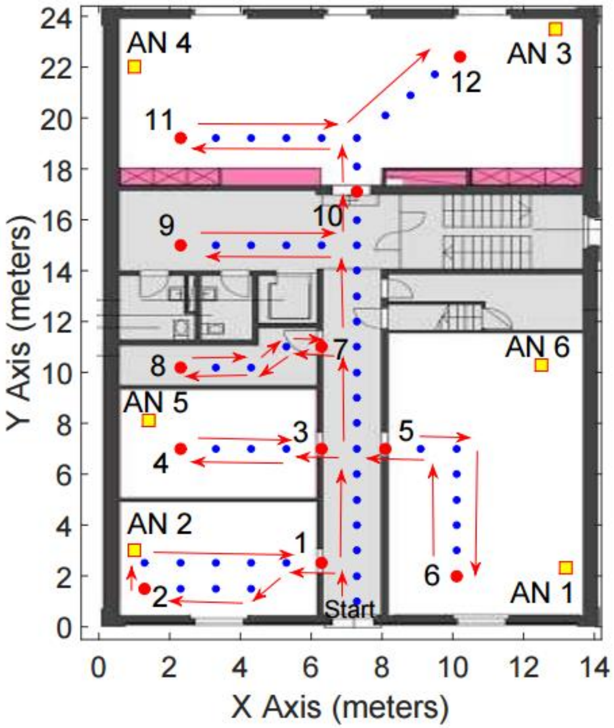
Floor Plan

- Constraints

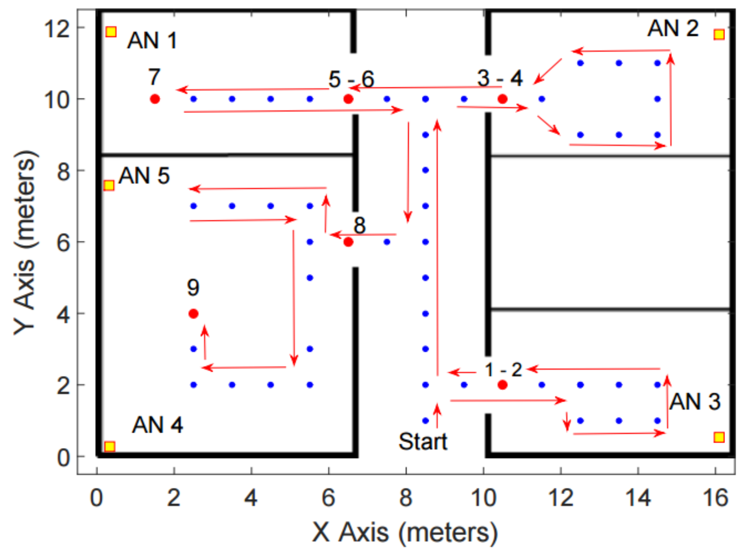
$$\mathbf{x}_k = \sum_{i=1}^{N_s} w_k^i \mathbf{x}_k^i \vdots$$

$$w_k^i = \hat{w}_k^i / \sum_{n=1}^{N_s} \hat{w}_n^i$$

Experiments



(a) Scenario 1, trajectory 1



(b) Scenario 2, trajectory 2

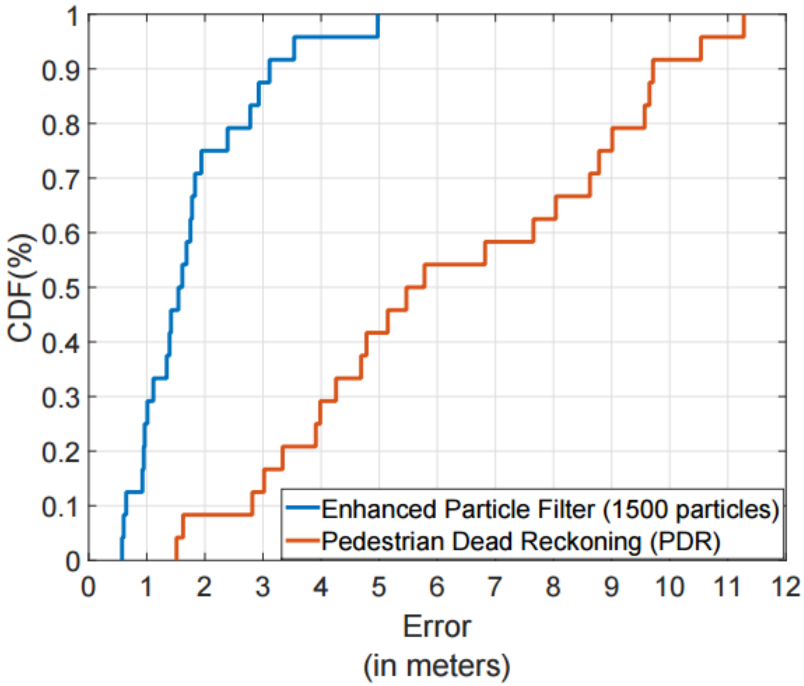
EXPERIMENT 1

- University of Bern.
- Target area: 336 m² (3 floors)
- 12 Check Points

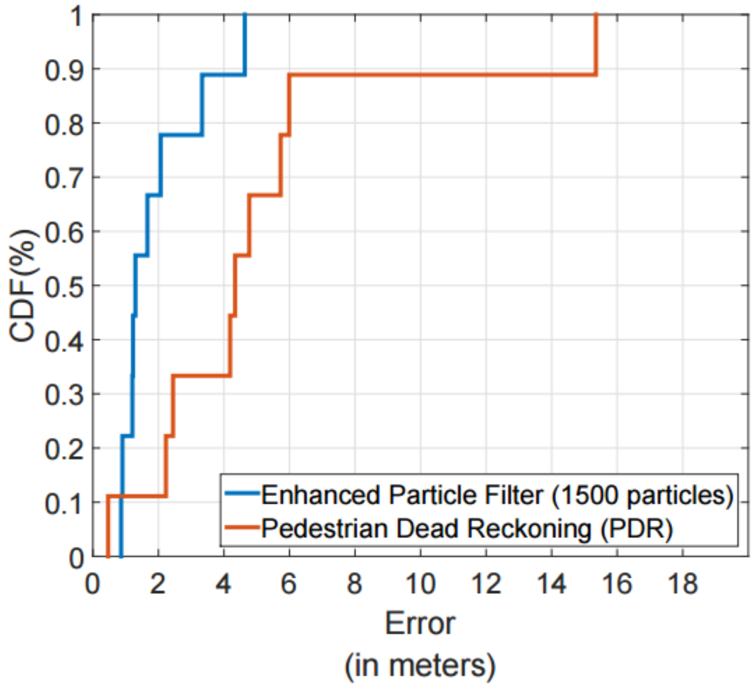
EXPERIMENT 2

- University of Geneva.
- Target area: 192 m²
- 9 Check Points

Results



(a) Particle Filter vs PDR, Scenario 1



(b) Particle Filter vs PDR, Scenario 2

Tracking Approach	Mean error	S.D	90% Acc.
Particle Filter Scenario 1	1.7m	1.0m	3.2m
Particle Filter Scenario 2	1.9m	1.27m	4.3m
PDR Scenario 1	6.2m	2.9m	10.5m
PDR Scenario 2	5.1m	4.25m	15.7m

Conclusions

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- Tested complex scenario. Room entrance prone to error.
- Proposed Ranging-PF assisted approach higher accuracy, stable than PDR.
- PF outperforms PDR around 72.6% with 90% accuracy.
- Use RSSI-based ranging information to recalibrate PDR to deal with accumulative errors.
- RSSI-based ranging information requires ANs position.
- Remarks from competition
  - Outdated AP locations/MAC information provided
  - Large scenarios (50000 m^2) take long survey period
  - Ranging or fingerprinting?

Questions?

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