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Doors as Visual Landmarks for Indoor Positioning

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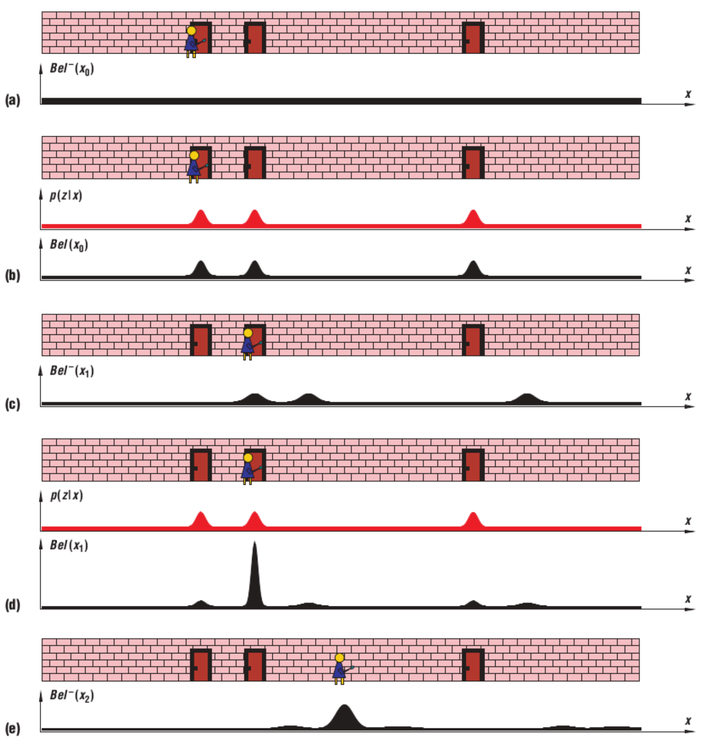
Bayesian Filtering

implementations:

- Kalman filter
- particle filter
- grid-based filter

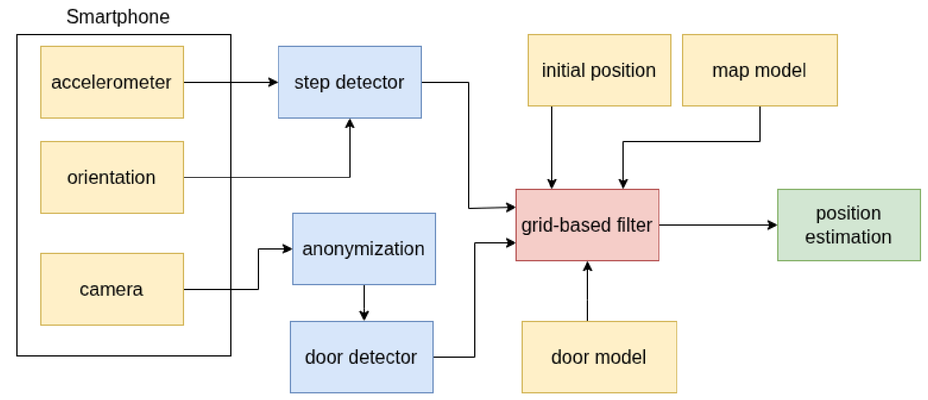
Iteration:

- **transition** (prediction)
- **correction** (observation)



V. Fox, J. Hightower, L. Liao, D. Schulz, G. Borriello, Bayesian filtering for location estimation, IEEE pervasive computing 2 (2003) 24–33.

Positioning Framework



Transition

PDR

Step detection from smartphone sensors. Step length and heading estimated.

Correction

MAP

Accessibility of the position (or transition) based on floor plan.

DOOR

Comparing **visible detected doors on camera image** with **known door positions in the map model.**

Position

Initial - provided

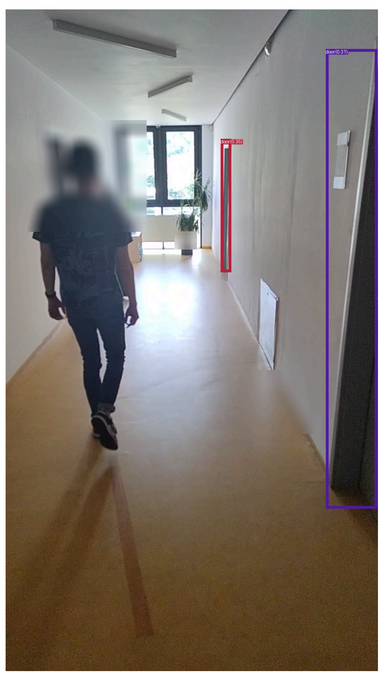
Estimated - grid cell with highest belief value

Grid-based filter

Floor plan tessellated into a grid. Belief calculation for all positions (grid cell centers) triggered by step detection.

Door detection

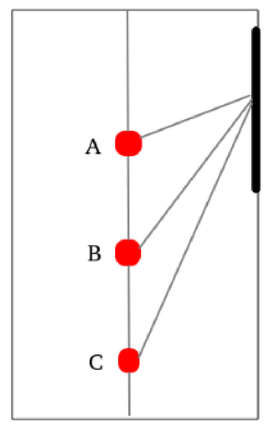
Anonymization

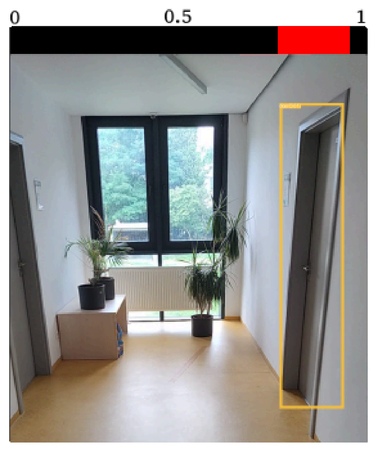


Blurring based on Haar features detection for upper bodies.

- Visible angles in range <0, 1>
- Depends on camera field of view (56° for Xiaomi Mi 10)
- Grounding DINO with prompt *door*

Match between detected doors in image and visible doors from map position





Belief for a grid cell

$$B(x)^t = \sum_{x' \in G} B(x')^{t-1} M_l(x, x') \prod_{d \in D_t} \prod_{e \in E} P(d, e) C(d), \forall x \in G$$

Detection confidence

Probability of the match derived from normal distribution

Probability of transition from another grid cell

For each detected door in the image

For each door within the visible range

Evaluation

Setup

- 1D scenario designed to highlight the effect of door detection
- **30-meter-long corridor**
  - First 12 m: error accumulation from step length estimation
  - **8 doors** (5 on the right, 3 on the left) at various positions
  - 2.75 m from finish point to corridor end
- Grid-based filter with **10 cm resolution**

Door detection results

- Confidence: 30 - 69% (threshold-dependent)
- **Max 3 doors** per frame detected
- Up to **10 m** from camera

Errors in meters	Scenario 1	Scenario 2	Scenario 2 + anonymization
Grid	3.75	5.25	5.25
Grid + map correction	3.35	3.35	3.35
Grid + door detection	**1.15**	**3.45**	**3.45**
Grid + door detection + map correction	1.15	3.25	3.35

Scenario 1 - empty corridor, first door open
Scenario 2 - same path, 2 people (one walking, one standing)