SenCam: Towards Robust Device-Free Passive Localization Through Automatic Camera-Assisted Recalibration

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Motivation

- Monitor human mobility.
  - Health/elder care, home security, traffic flow statistics.
- Use existing sensor infrastructure.
  - Wi-Fi devices, surveillance camera.
- Fingerprint data degrades over time.

Challenges in Long-Term Test

- Problem Formulation
  - Fingerprinting subject’s presence in each location as a class \( k \)
  - Feature extraction and apply classification algorithm
- Radio Frequency Approach
  - Radio signal strength (RSS) space
  - Linear discriminant analysis
- Computer Vision Approach
  - Background subtraction + edge detection
  - Support vector machine

System may fail to work in only one month! Frequent manual recalibration can be painful!

Sensor-Camera Collaboration

- Initialization Phase
  - Take both radio and image fingerprinting data when profiling the system
- Recalibration Phase
  - Camera module identifies people’s location
  - Radio sensor module updates the estimated location’s profiling information.
- Why not Camera-Only?
  - Fails to work in dark or smoky environments
  - Costly for full area coverage
  - Privacy concerns

Multimodal Solution

- Radio space has changed a lot…
- Without recalibration leads to 56% cell estimation accuracy.
- More recalibration, the better accuracy.
- Using 2 paths’ recalibration, the cell estimation accuracy can back to 90%

Automatic camera-assisted recalibration greatly improves accuracy over long-term!

On-going and Future Work

- Localize multiple people
- Reduce the effort in profiling system
- Large-scale deployment
- Apply into more applications through crowdsourcing

Experimental Deployment

- Total Size: 400 m²
- Cell Size: 2 × 2 m
  - 16 cells
  - 10 radio transmitters
  - 6 radio receivers
  - 1 webcam

Experimental Results

A random path chosen to test of the performance of SenCam system as a proof-of-concept in an open indoor environment.

“One month after the initial profiling, radio space has changed a lot…”

Automatic camera-assisted recalibration greatly improves accuracy over long-term!