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

RUTGERS
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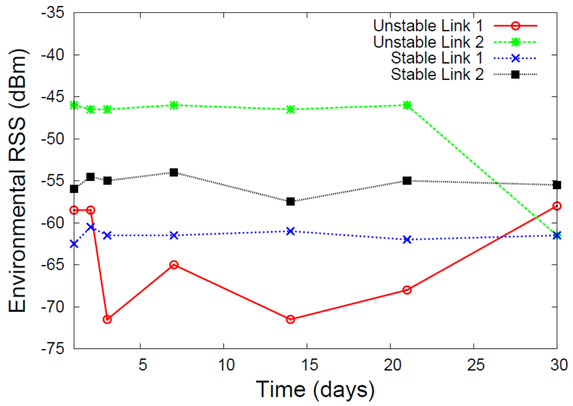
Motivation

- **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



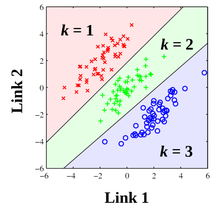
System may fail to work in only one month!
Frequent manual recalibration can be painful!

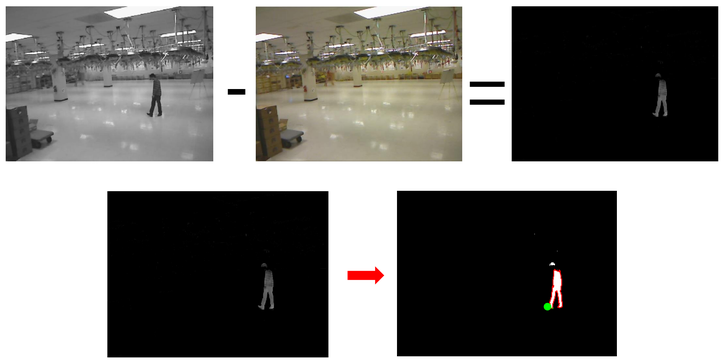
Sensor-Camera Collaboration

- **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**

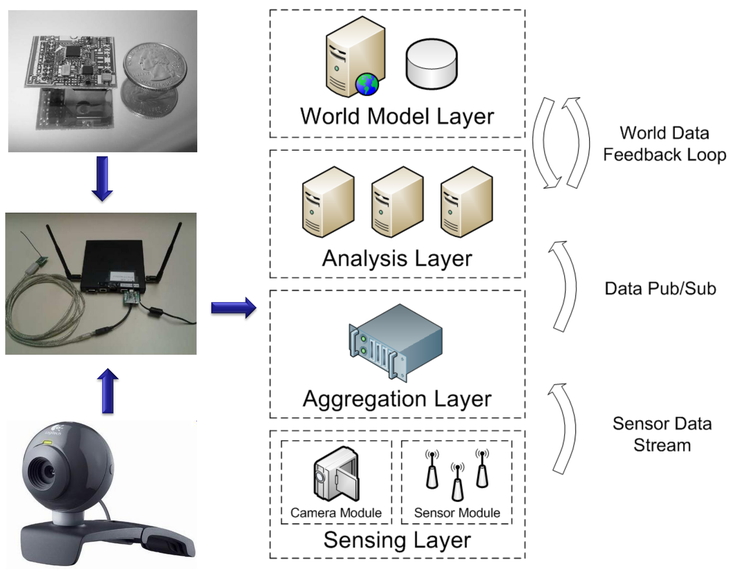
Multimodal Solution

- **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**





SenCam Architecture



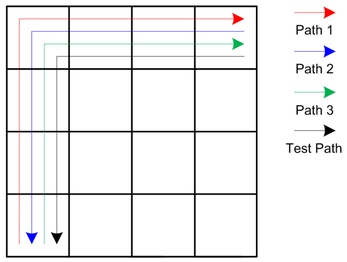
Experimental Deployment

Total Size: 400 m²

Cell Size: 2 × 2 m

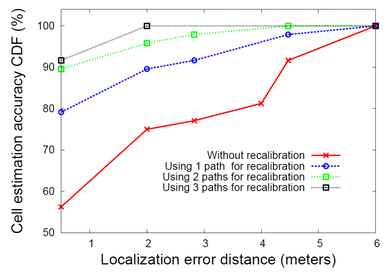
- **16 cells**
- **10 radio transmitters**
- **6 radio receivers**
- **1 webcam**

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…"



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**

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