



Aalto University
School of Electrical
Engineering

Crowdsourced Indoor Mapping and Navigation

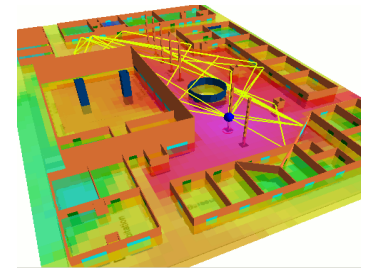
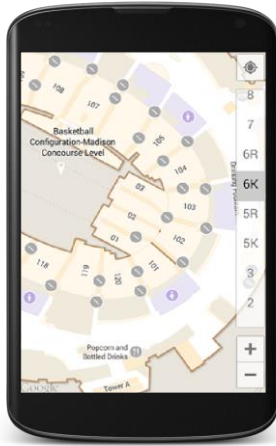
Yu Xiao
Aalto University
28.7.2016

Dong, Jiang; Xiao, Yu; Noreikis, Marius; Ou, Zhonghong; Ylä-Jääski, Antti.
iMoon: Using Smartphones for Image-based Indoor Navigation. in *Proc. of SenSys'15*. 12 pages. 1-4 Nov. 2015.

Dong, Jiang; Xiao, Yu; Cui, Yong; Ou, Zhonghong; Ylä-Jääski, Antti. **Indoor Tracking using Crowdsourced Maps.** in *Proc. of IPSN'16*. 6 pages. 11-14 Apr. 2016.

Motivation

- **Fine-grained and up-to-date indoor maps are still lacking**
- **Conventional indoor mapping requires professional tools and expertise for operating them**

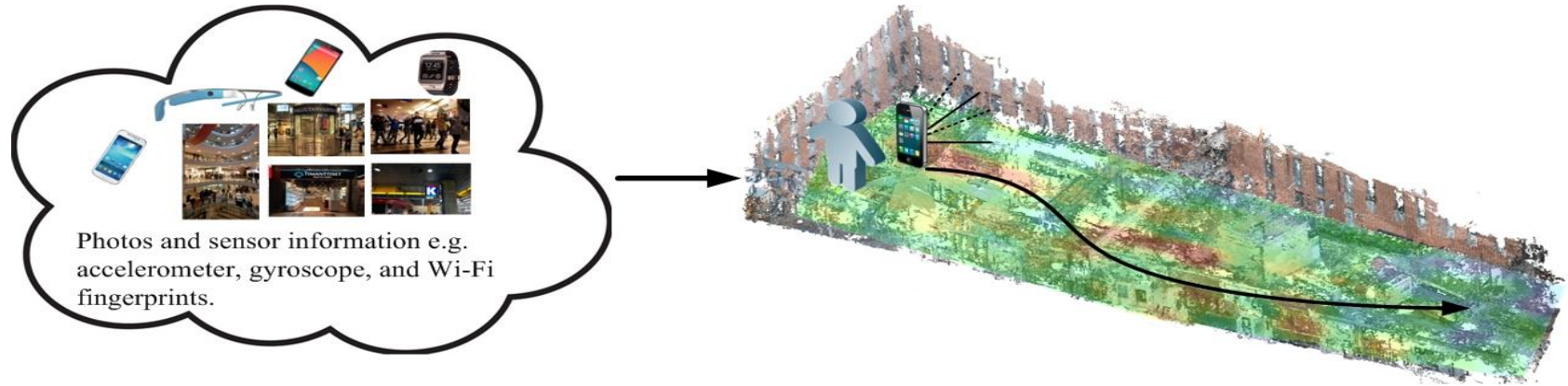


Goals

A novel indoor navigation system using visual and inertial sensors available on mobile devices

- **Without prerequisites of fine-grained indoor maps or floor plans**
- **Does not require installation of extra hardware in the buildings**

iMoon



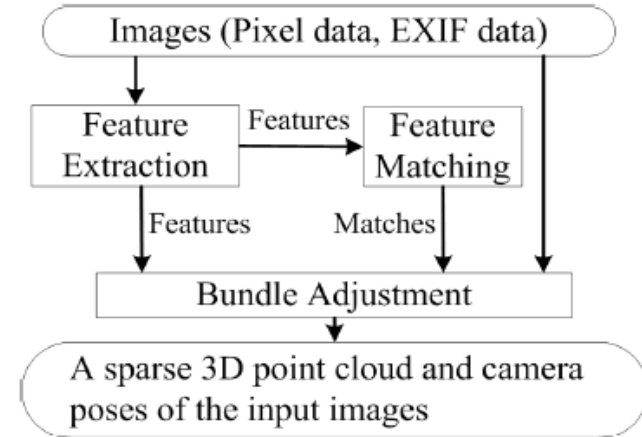
- **iMoon** is an indoor mapping and navigation system based on **sensor-enriched 3D models** that are created and constantly maintained using crowdsourced photos and sensor data.

3D Modelling using Structure-from-Motion (SfM)



Build Rome in a day [S. Agarwal et al.]

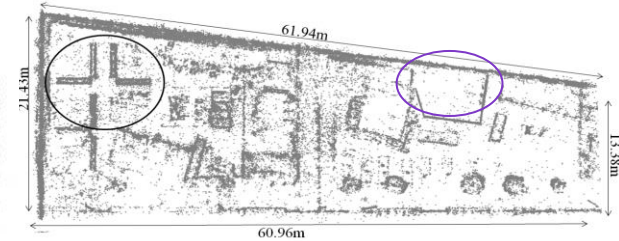
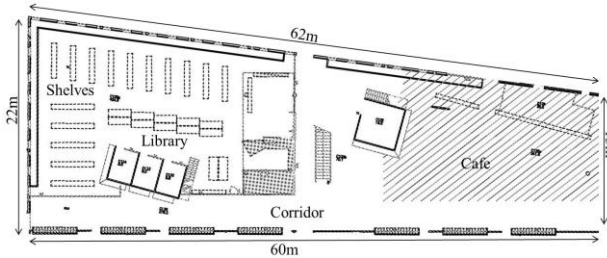
Gallen-Kallela Museum



Update 3D Models with New Images

1,100 m²

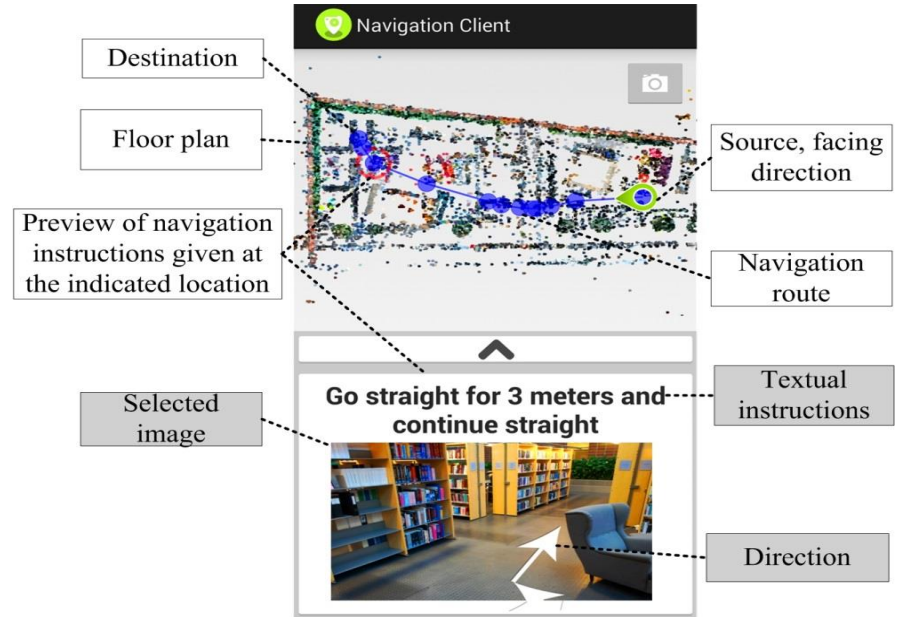
2,552 photos, 150 walking traces



Nov. 2014

March. 2015

Image-based Localization and Visual Navigation

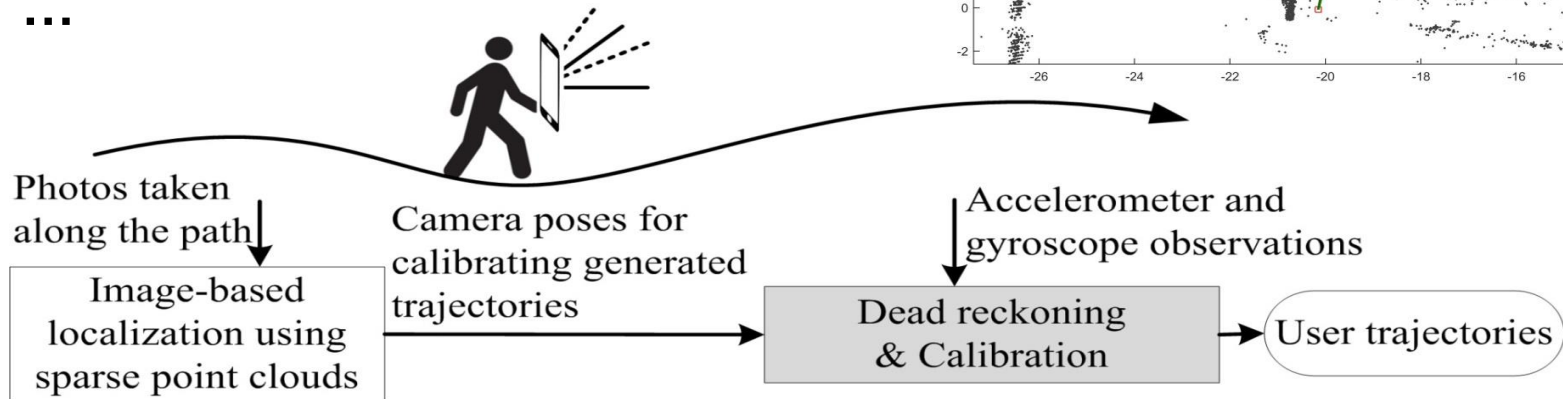
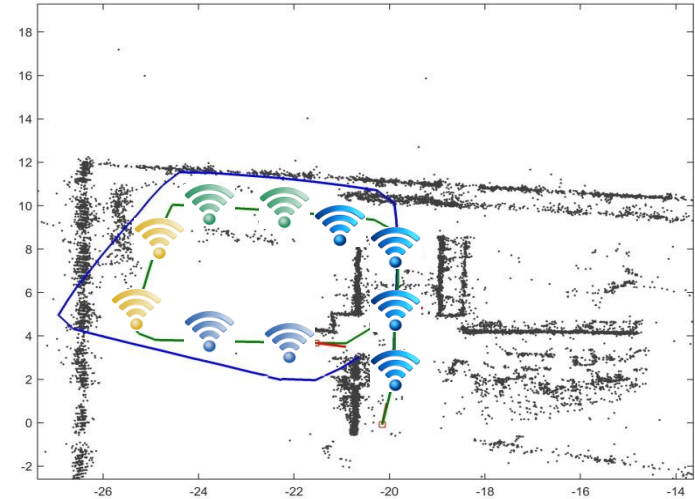


Demo Video

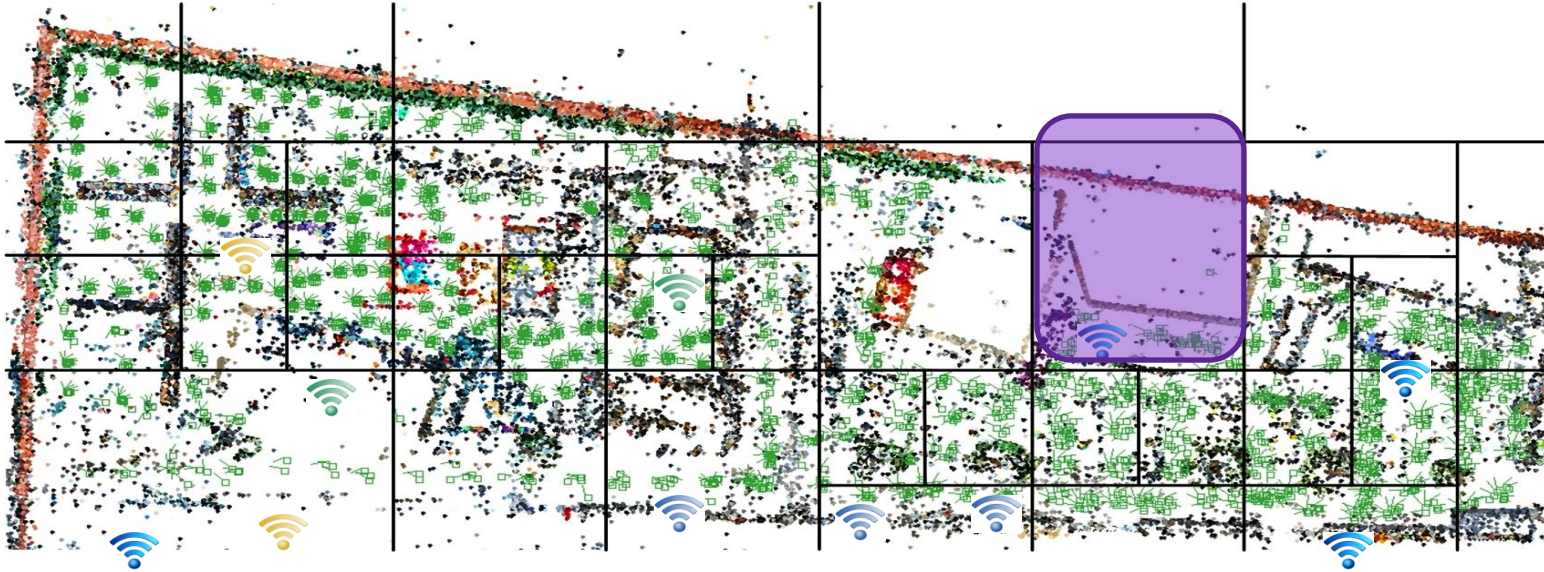
https://www.youtube.com/watch?v=sNvf7N_s59c&feature=youtu.be

Geo-referencing Sensor Fingerprints

- **Wi-Fi fingerprints**
- **Magnetic field**
- **Cellular cell ID**
- **Barometer**
- **Bluetooth beacon**
- ...



Fast Localization – Model Partitioning



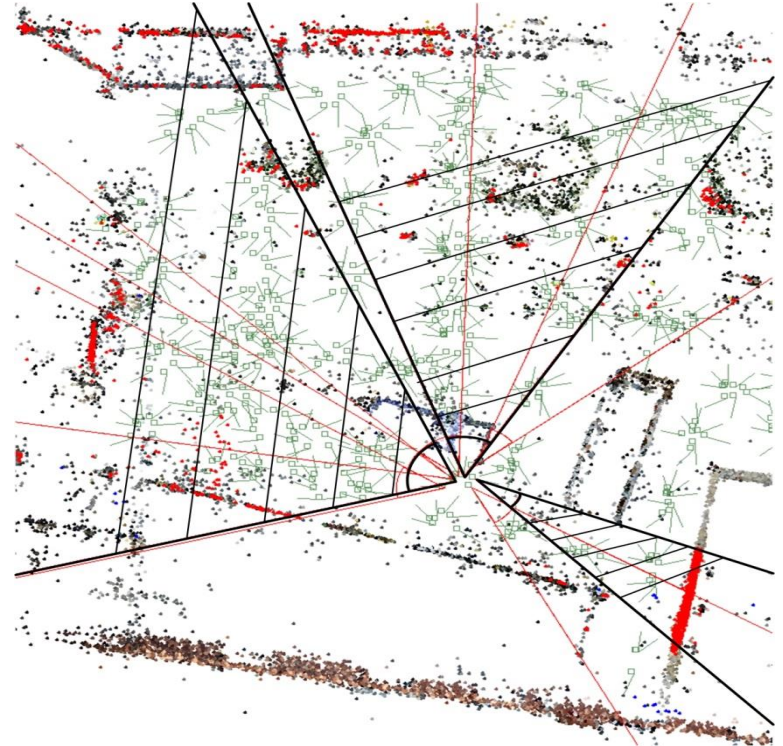
Each partition includes points corresponding to features extracted from no more than 100 photos. Both the width and length of each partition are larger than 5 meters.

Fast Localization

Estimating Coarse location

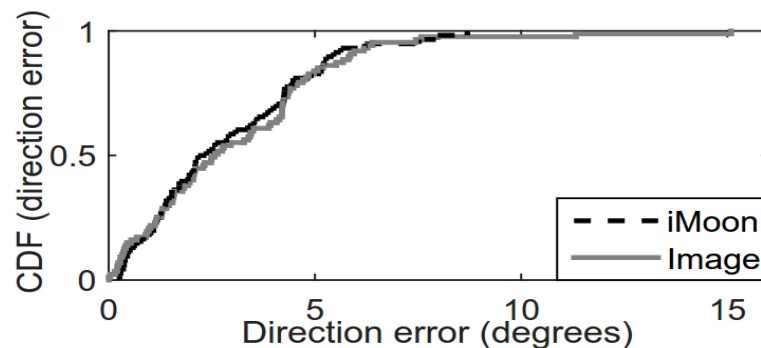
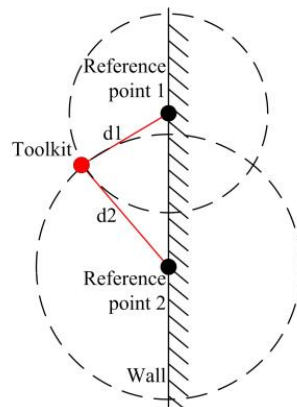
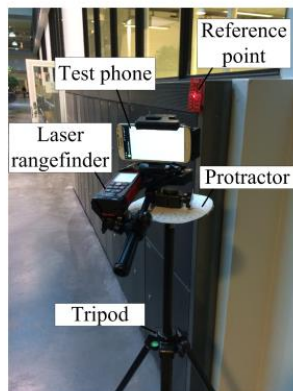
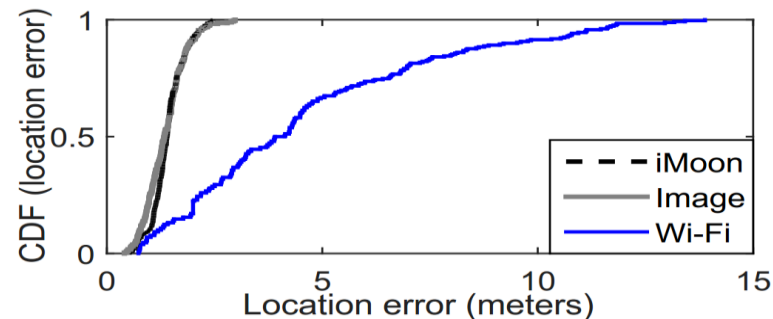
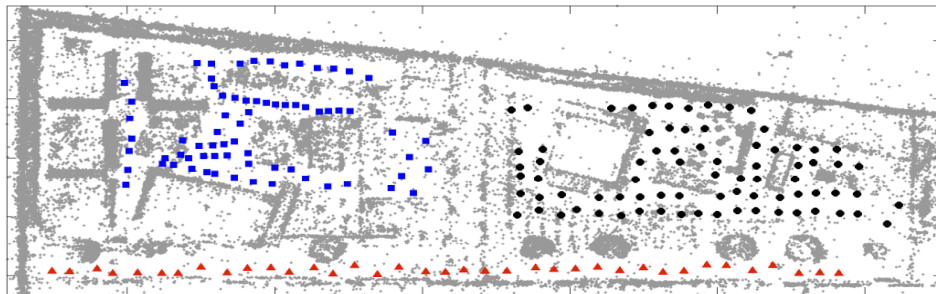
- Selecting partitions
- Choosing photos nearby

Feature matching with each of the selected photos

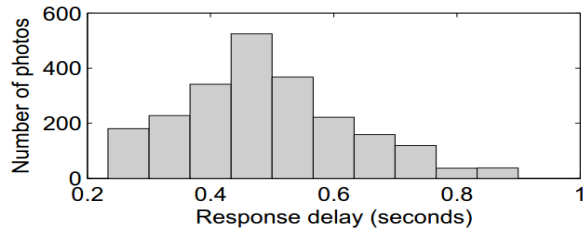


Accuracy

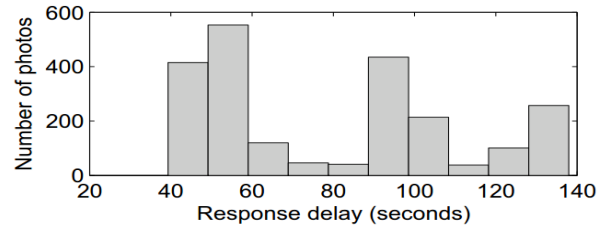
185 measurement points
2,200 photos



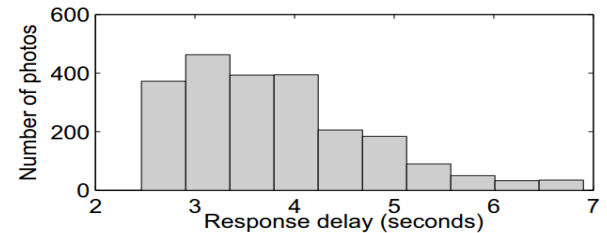
Processing Delay



(a) Wi-Fi Fingerprinting



(b) Image-based localization



(c) iMoon

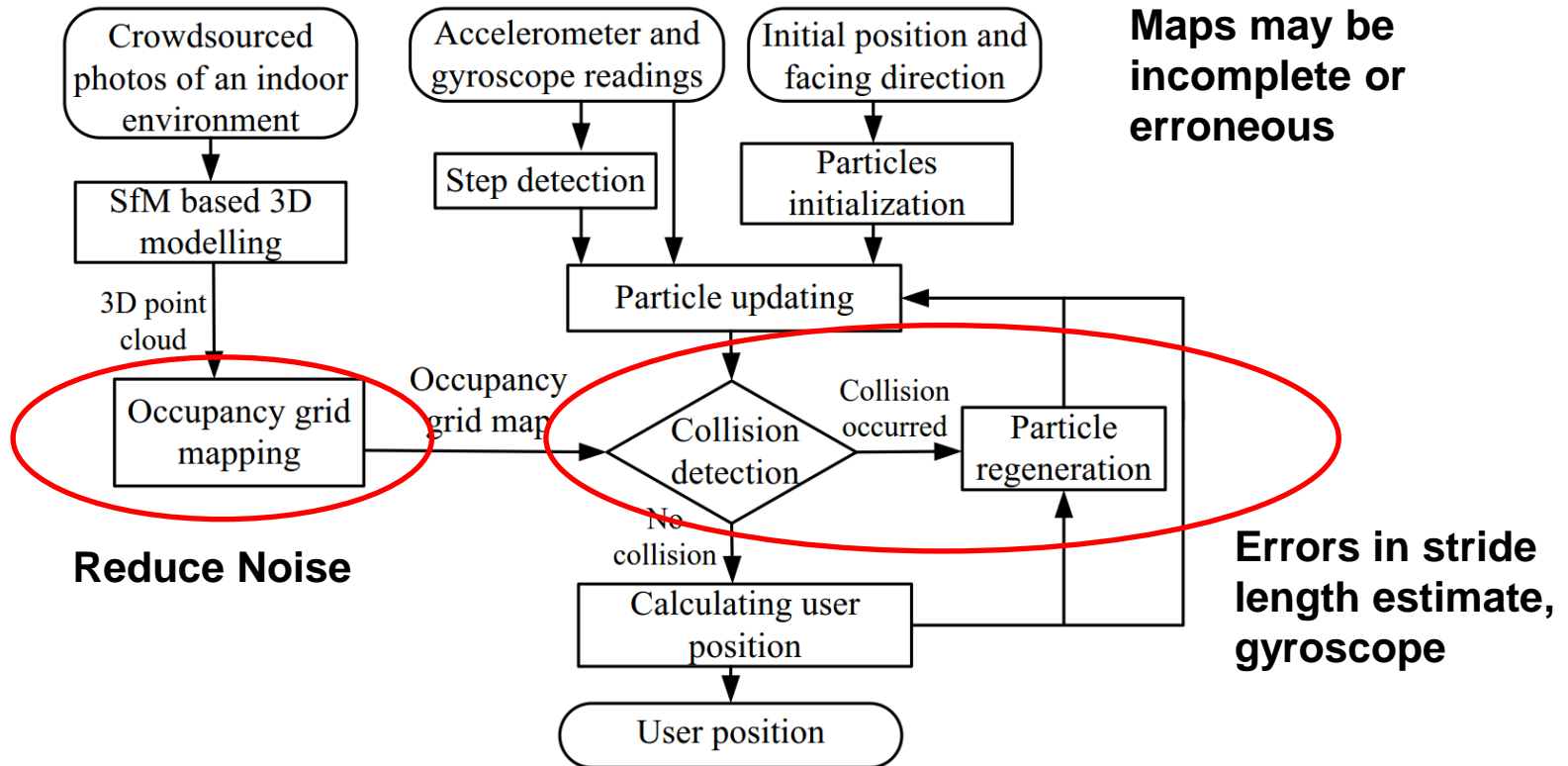
iMoon server was running on a machine equipped with an Intel Xeon processor E5-2650 (8-core, 2.6GHz), 64GB RAM, and a Tesla K20C GPU.
(*we have managed to reduce the delay to 1.5s in July, 2016.)

Limitation of Image-based Localization

Area	No. Measurement Points	No. of Photos	Hit rate		
			Image	Wi-Fi	<i>iMoon</i>
Cafe	78	936	91%	100%	91%
Corridor	37	444	100%	100%	100%
Library	70	840	98.6%	100%	97.1%
Total	185	2,220	95.7%	100%	95.1%



Indoor Tracking

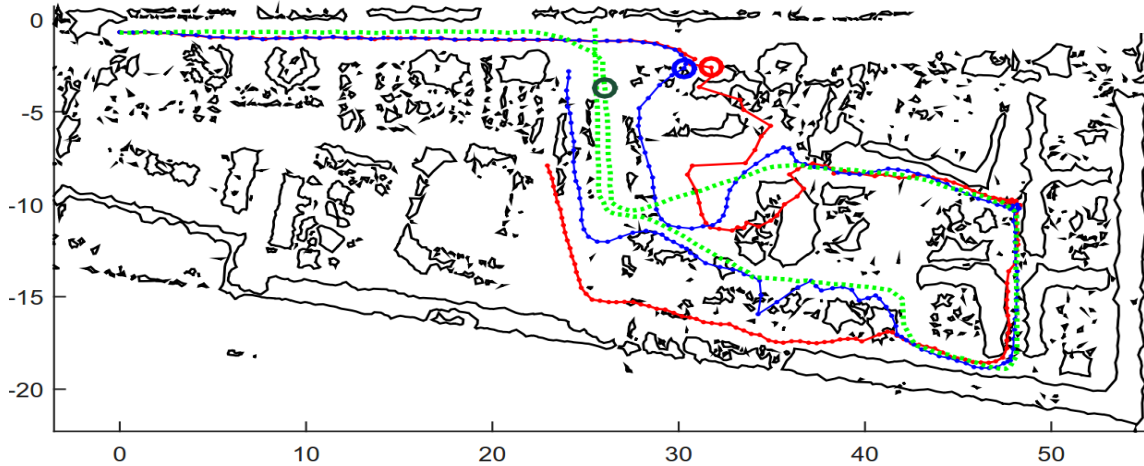
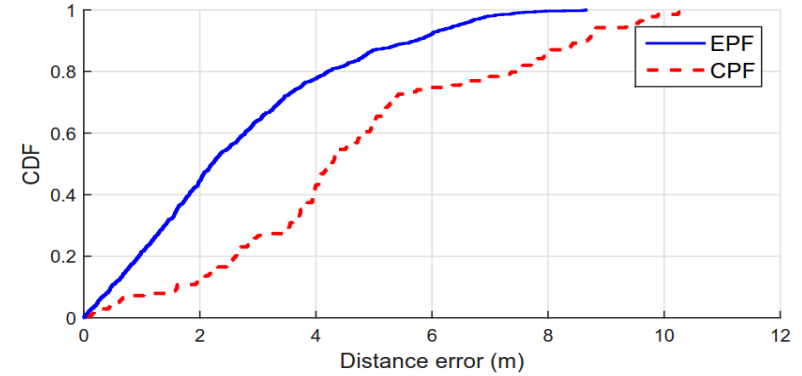


Demo Video:

<https://www.youtube.com/watch?v=WU96VXzWkrQ&feature=youtu.be>

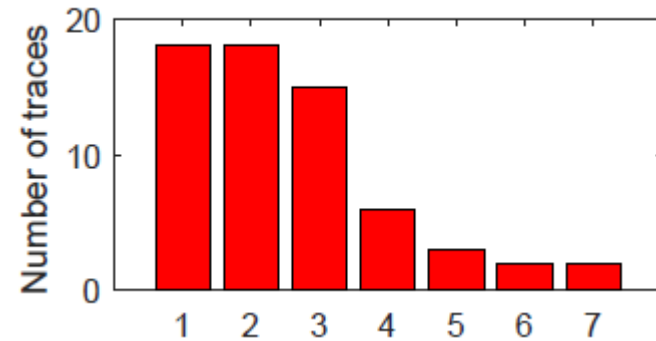
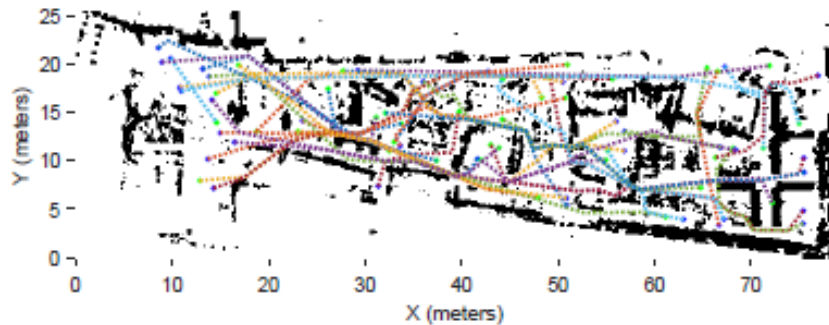


Accuracy of Indoor Tracking



Ongoing Work

- Utilize user trajectories for correcting navigation maps



Thank You!

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