Foot-mounted inertial navigation made easy
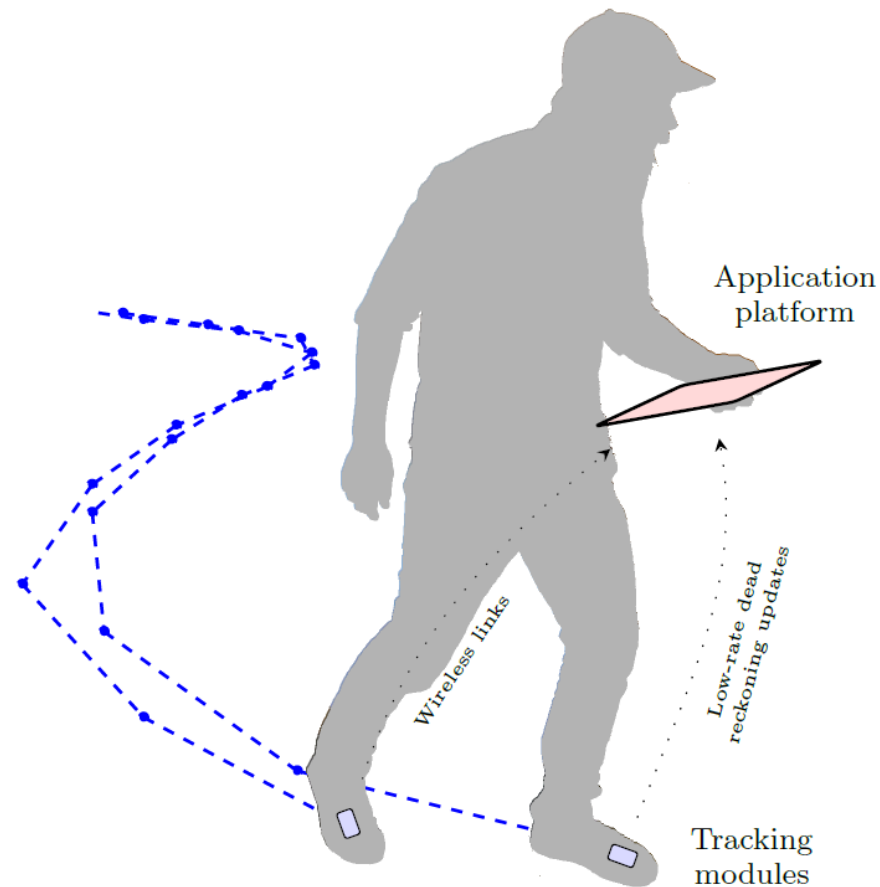
John-Olof Nilsson, Amit K Gupta, Peter Händel

KTH Royal Institute of Technology

IPIN 2014-10-28

# Made easy in the sense ...

Application platform

Wireless links

Low-rate dead reckoning updates

Tracking modules

- We have built a module that modularizes the foot-mounted inertial navigation technology

Why is it important?

- Key engineering principle for large/complex systems
- Greatly reduces communication requirements/enables higher sampling rates

Application platform

Low-rate dead reckoning updates

Wireless links
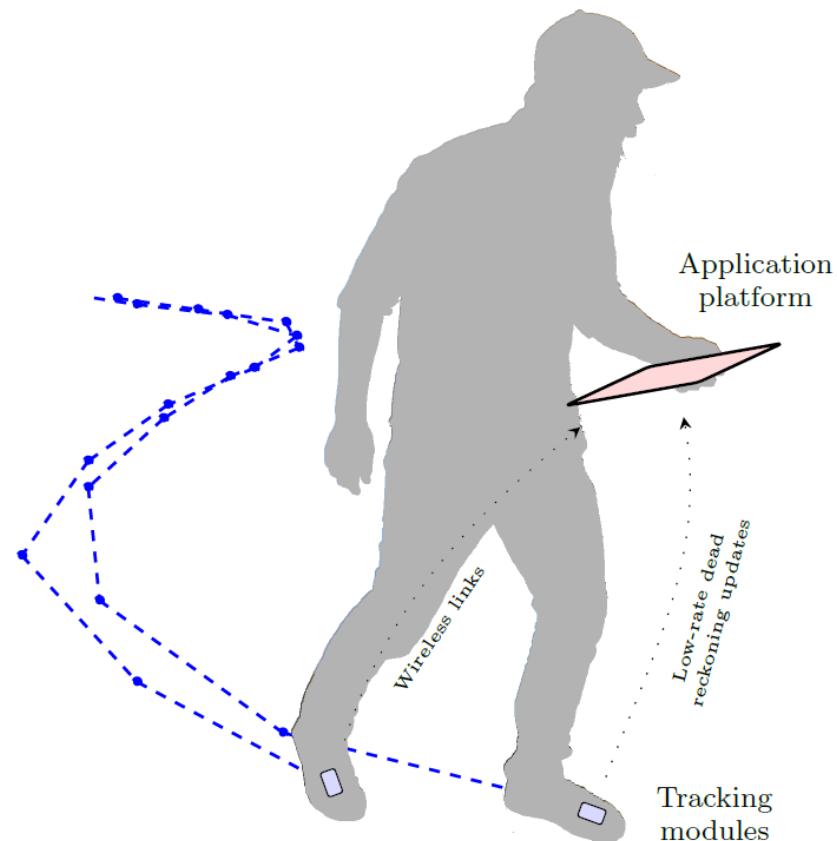
Tracking modules

Bonus

- Open source
- Good performance
- Low cost

Outline

- The modules
  - Modularize how …
  - The implementation
  - Tracking results
- Supporting/supported research
- Final remarks

The modularization problem

- Typical implementation
  - Measurements from foot-mounted IMU to application platform
  - Processing on application platform

- Required for fusion but exposes system complexity and requires high rate communication

Stepwise dead reckoning

The modularization

Dead reckoning

Application platform

Low rate dead reckoning updates

Wireless links

Tracking modules
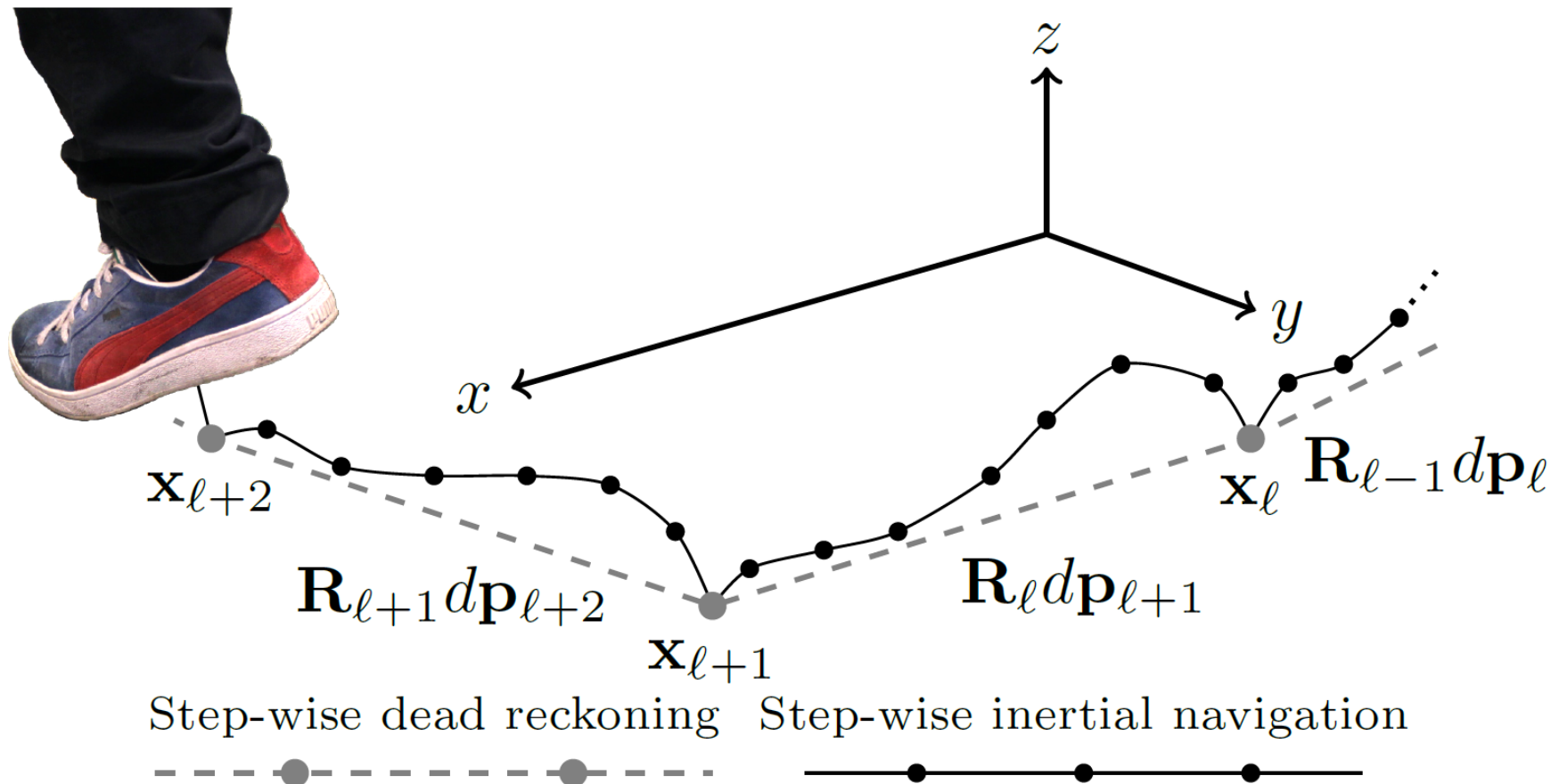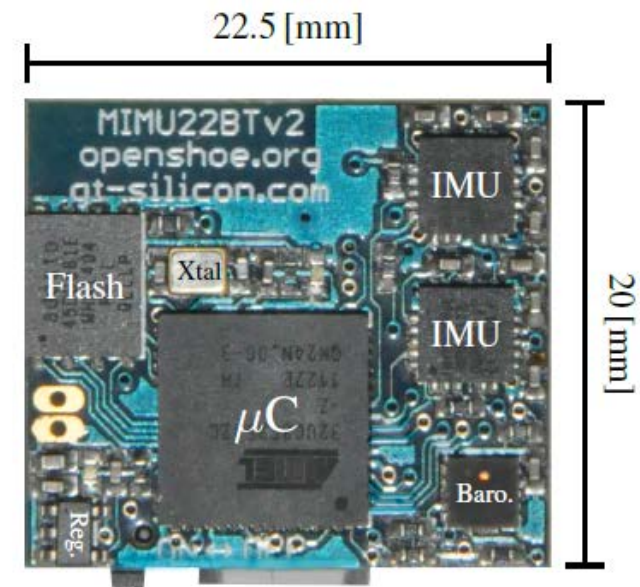
Step-wise aided inertial navigation
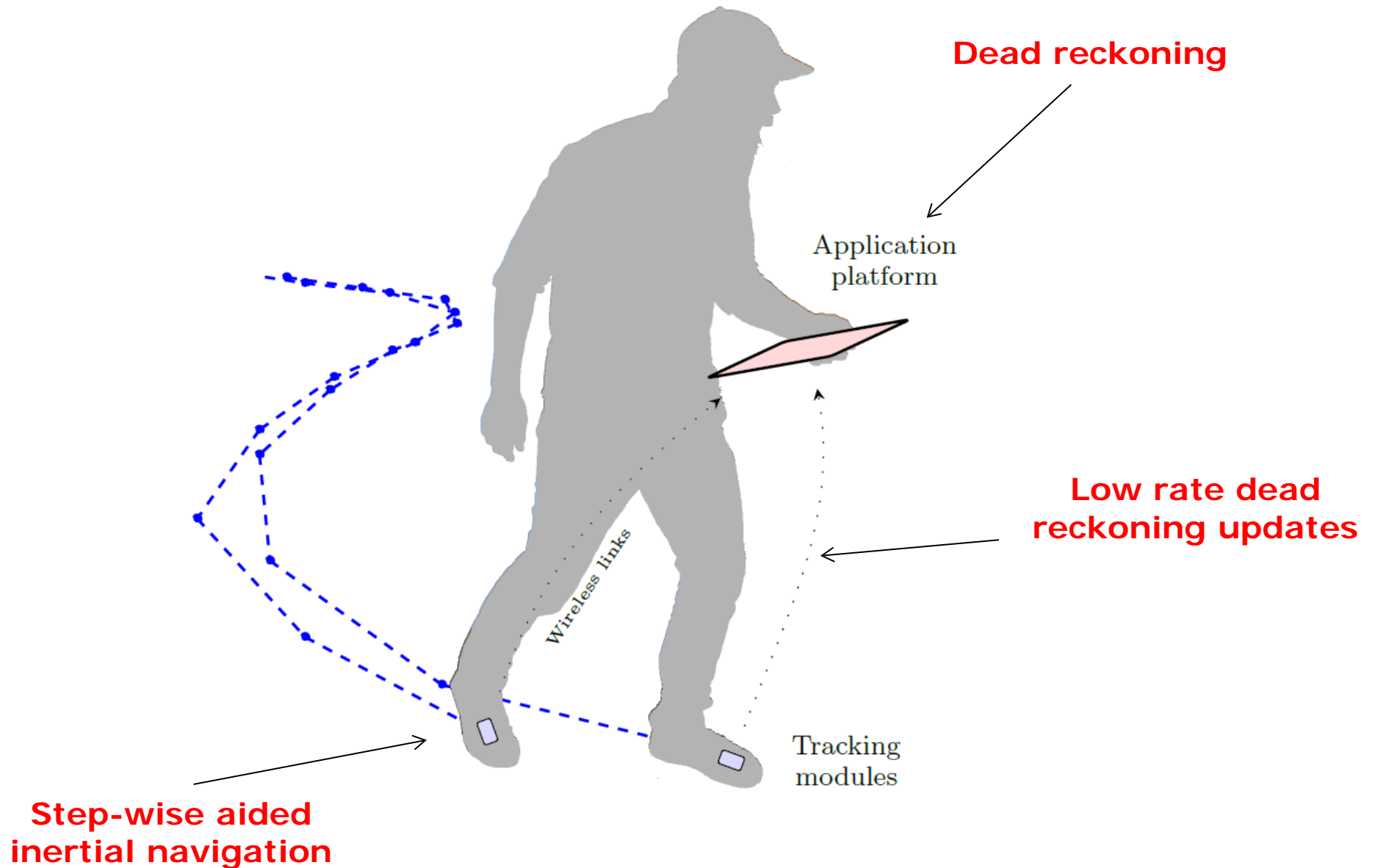
Supporting hardware and software
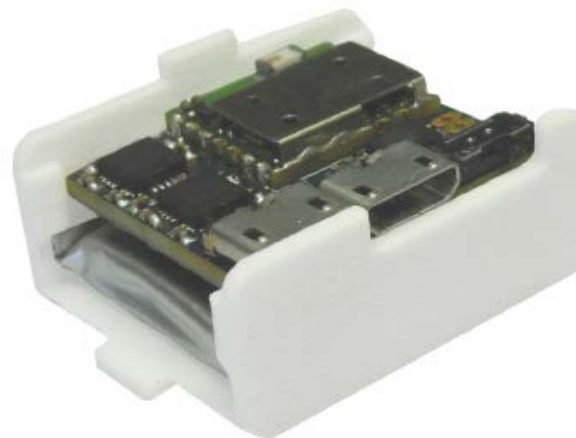
- **Key features**
  - Multiple single-chip IMUs
  - Floating point uC
  - Wireless link (Bluetooth)
  - Low form-factor
  - Open

- **Software**
  - C (no OS)
  - Framework + algorithms

22.5 [mm]
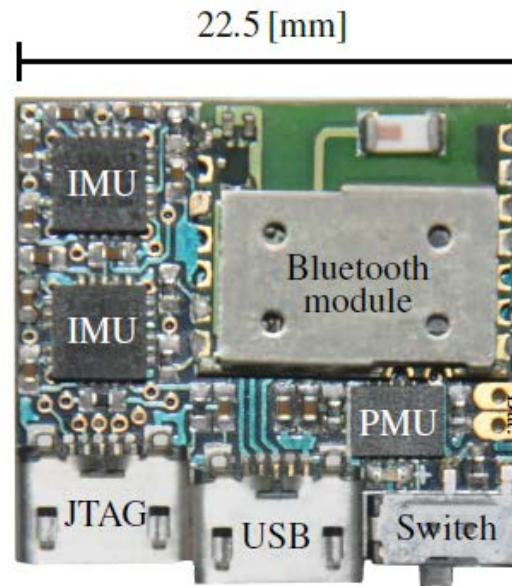
(a) Top side of the PCB.

22.5 [mm]

MIMU22BTv2
openshoe.org
gt-silicon.com

20 [mm]
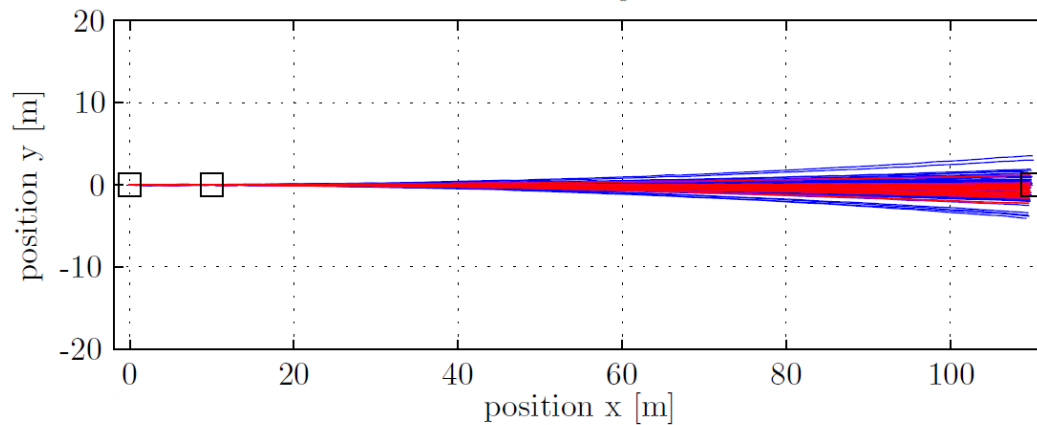
(b) Bottom side of the PCB.

(c) PCB, casing bottom, battery.
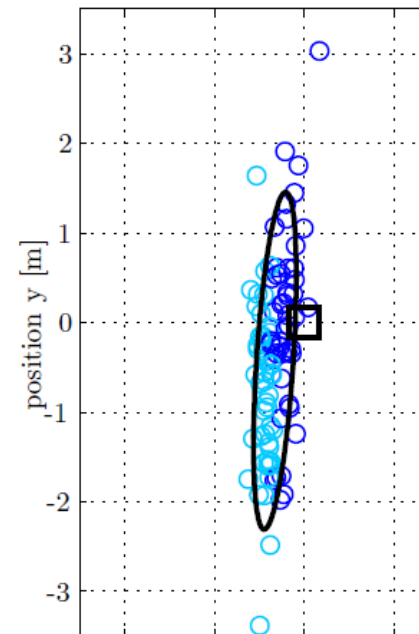
(d) The complete tracking module.

Performance results
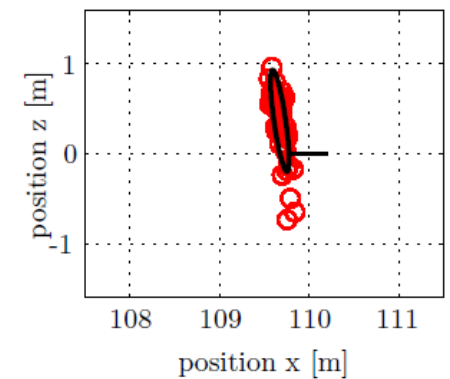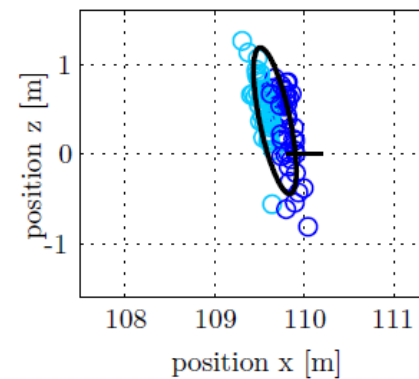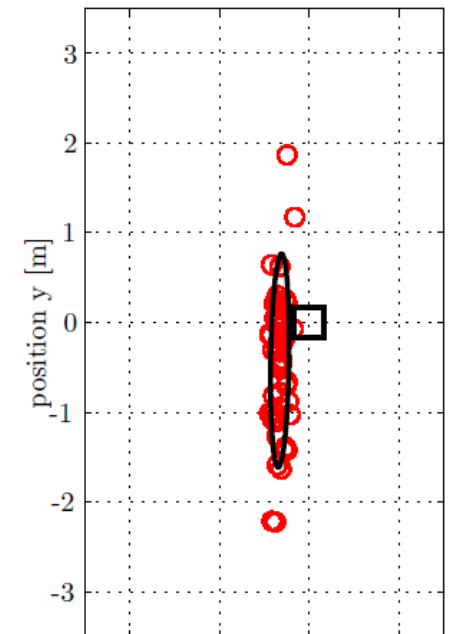

Estimated trajectories

Final position individual modules

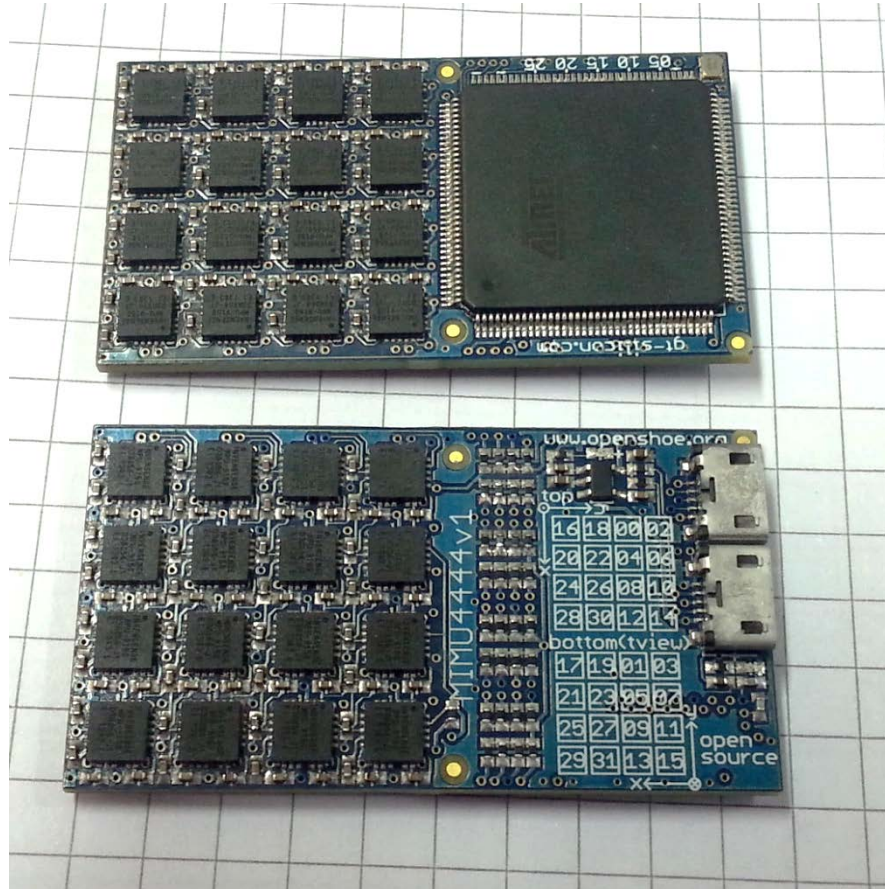Final position combined dual modules

Supporting/supported research

Calibration (supporting)

J.-O. Nilsson, I. Skog, and P. Händel, "Aligning the forces – Eliminating the misalignments in IMU arrays," *IEEE Trans. Instrum. Meas.*, vol. 63, no. 10, pp. 2498–2500, 2014.
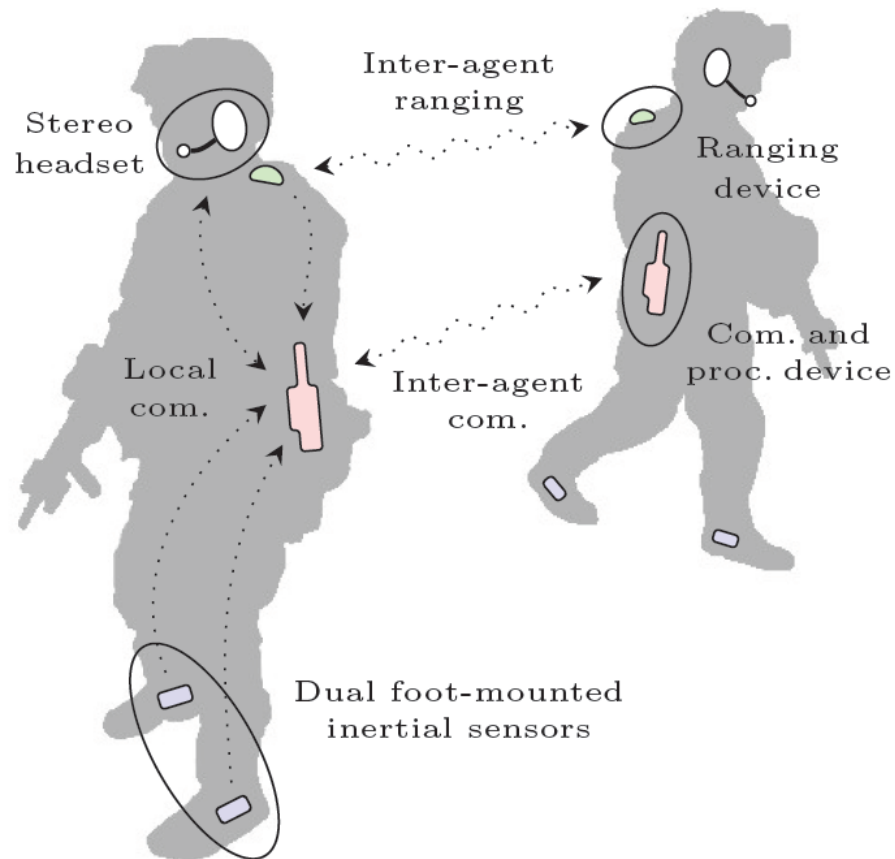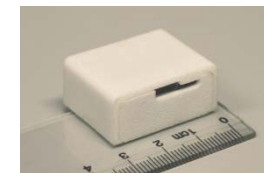
Massive-MIMU (supporting)

I. Skog, J.-O. Nilsson, and P. Händel, "An open-source multi inertial measurement unit (MIMU) platform," in *ISISS2014*, Laguna Beach, CA, USA, 25-26 Feb. 2014.

Tactical locator – TOR (supported)

Setup

Implementation

J.-O. Nilsson, C. Schüldt, and P. Händel, "Voice radio communication, 3D audio and the tactical use of pedestrian localization," in *IPIN2013*, Montbéliard - Belfort, France, 28-31 Oct. 2013.

J.-O. Nilsson, D. Zachariah, I. Skog, and P. Händel, "Cooperative localization by dual foot-mounted inertial sensors and inter-agent ranging," *EURASIP J. Adv. Sig. Pr.*, vol. 2013:164, 2013.

Some field experiments

- Search operation in smokefilled built-up environment

- 15min

- Fully equipped smokedivers

- Walking first part

- Crawling second part
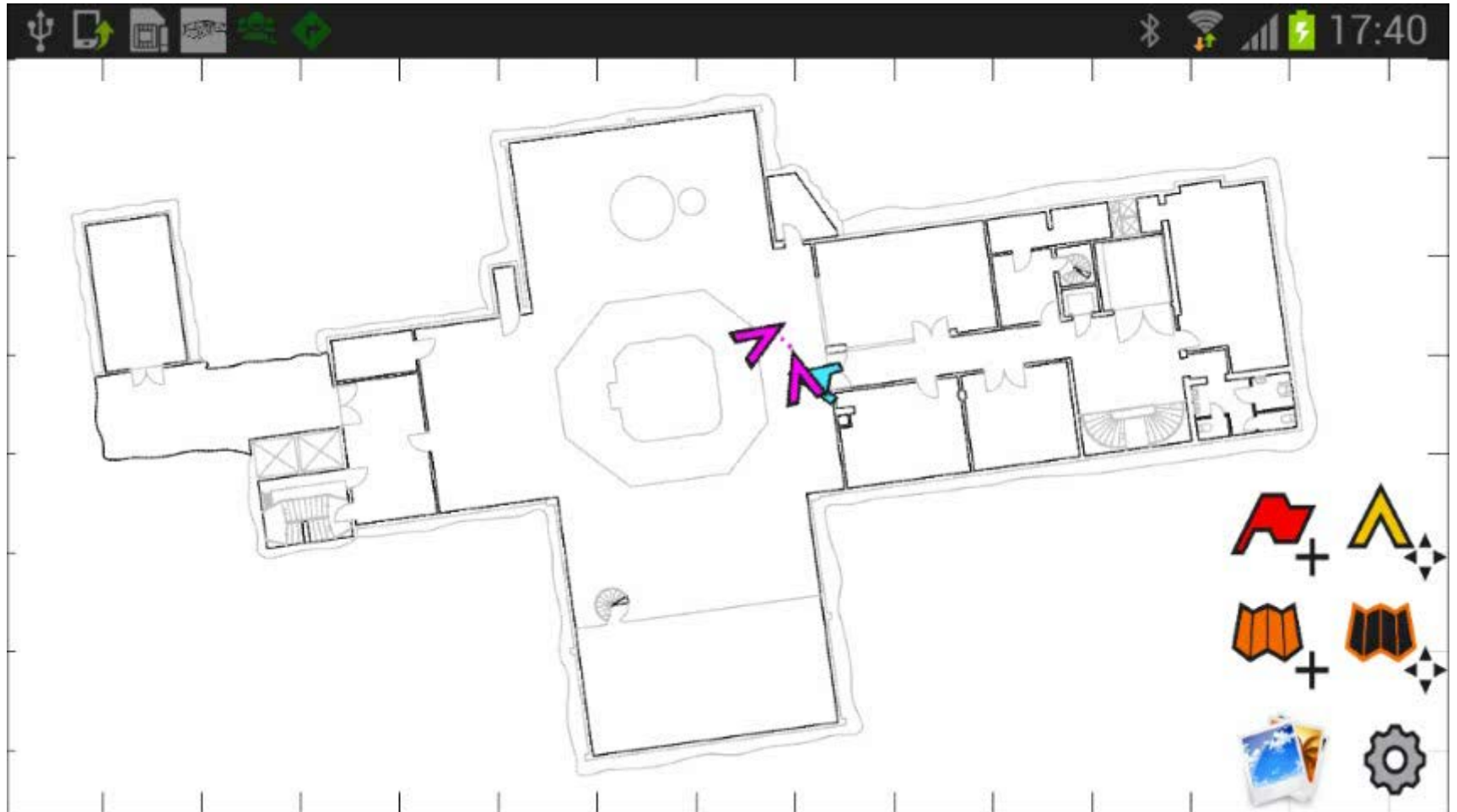
Final remarks

- All resources at www.openshoe.org (calibration and massive-MIMU platform as well)

- Possible to buy modules (www.gt-silicon.com)

- Demo tomorrow