Leveraging Collaborative Algorithms for Improved Indoor Localization with Ultra-Wideband (UWB) Technology

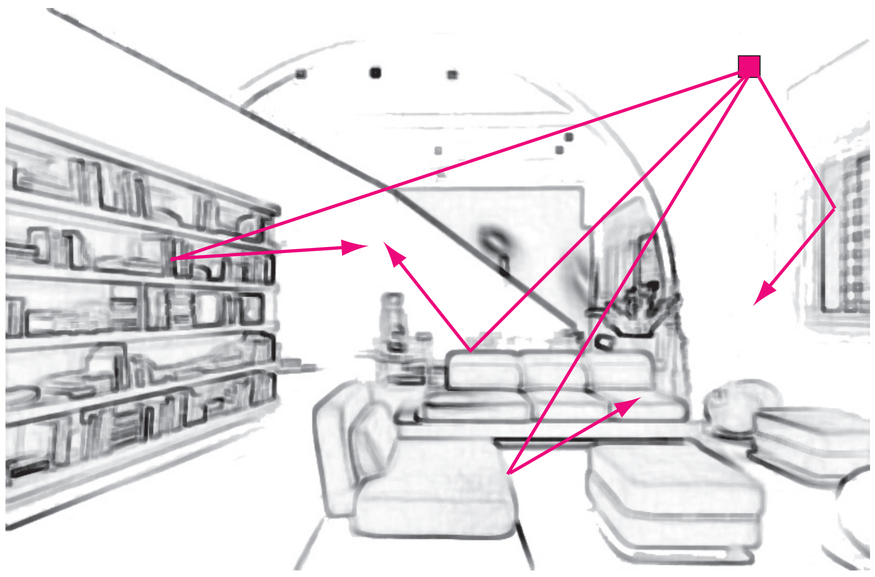
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ENAC /EDIC 2011

Author Amanda Prorok

Supervisor Alcherio Martinoli

Both author and supervisor are with the Distributed Intelligent Systems and Algorithms Laboratory (DISAL)



An indoor home scenario. The highly cluttered space creates non-line-of-sight situations. Each location is associated with a localization bias.

Motivation

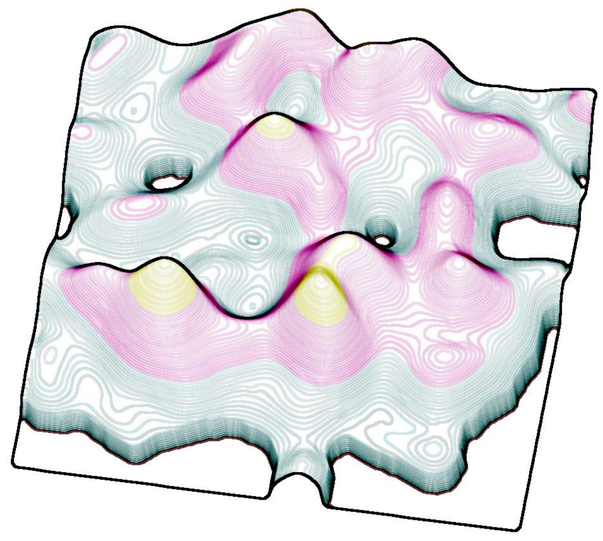
- Accurate localization for GPS-denied, indoor environments
- Power- and cost-efficiency

Potential of UWB

- Very high time resolution
- Penetration through obstacles

Challenges

- Cluttered environments
- Non-line-of-sight (NLOS)
- Biased time-of-flight signal



A bias field associated to a specific indoor environment.

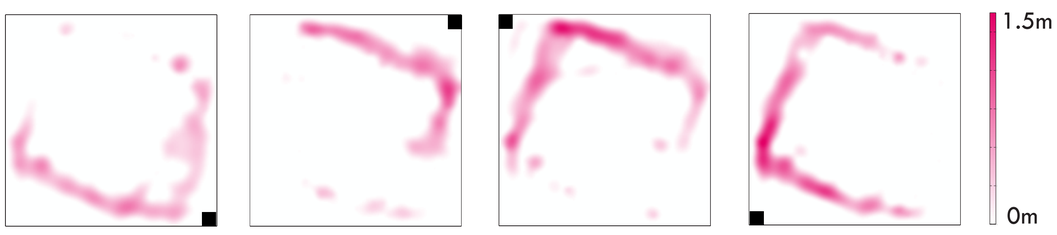
Setup

KheperaIII robots

- Mobile robots: Khepera III (400MHz CPU)
- Range & bearing module (Relative positioning)
- UWB: Ubisense (Absolute positioning)
- Communication: WiFi (802.11.b)
- Experimental area: 3 x 3 m^2

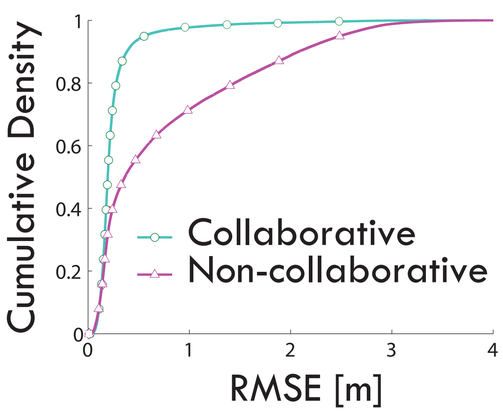
Ubisense tag

Experimental Validation



Bias estimation Robot trajectories show estimated bias values for each base-station. Arena walls create NLOS.

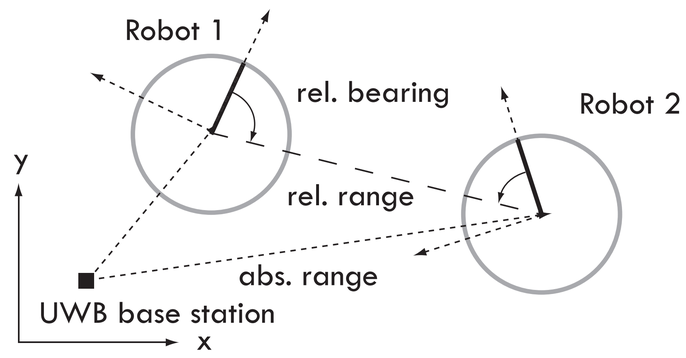
Localization performance

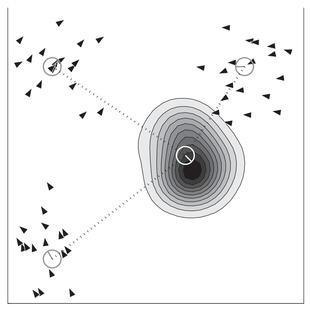


With the knowledge of a bias map, a collaborative team of 4 robots outperforms a non-collaborative team: 80% of the errors are below 0.25m.

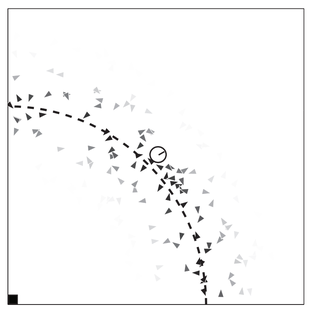
Method

How do we construct bias maps collaboratively and benefit from this knowledge to improve localization accuracy?

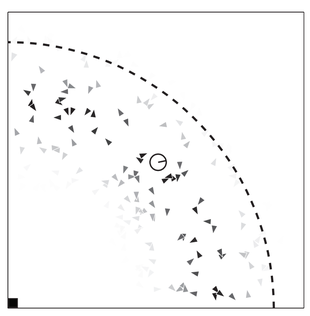




Multi-robot detection model



Non-biased range model



Biased range model

Step 1 Define a collaborative schema based on relative range and bearing measurements.

Step 2 Design a collaborative localization filter. A novel, reciprocal sampling algorithm optimizes efficiency.

Step 3 Define UWB error model. Design UWB measurement models and a fusion algorithm.

$$\hat{\rho}_{sn} = \rho_{sn} + b_{sn} + \varepsilon_{sn}$$

- $\hat{\rho}_{sn}$: biased range between base-station **s** and mobile target **n**
- ρ_{sn}: true range
- b_{sn}: bias
- ε_{sn}: Gaussian noise

Relevant publications

[1] Amanda Prorok, Phillip Tome, Alcherio Martinoli. A Framework for NLOS Ultra-Wideband Ranging in Collaborative Mobile Robot Systems. *International Conference on Indoor Positioning and Indoor Navigation (IPIN)*, 2011. To appear.

[2] Amanda Prorok, Adrian Arfire, Alexander Bahr, John Farserotu, Alcherio Martinoli. Indoor Navigation Research with the Khepera III Mobile Robot: An Experimental Baseline with a Case-study on Ultra-wideband Positioning. *International Conference on Indoor Positioning and Indoor Navigation (IPIN)*, 2010, doi:10.1109/IPIN.2010.5647880

[3] Jim Pugh, Xavier Raemy, Cedric Favre, Riccardo Falconi, Alcherio Martinoli. A Fast On-Board Relative Positioning Module for Multi-Robot Systems. *IEEE/ASME Transactions on Mechatronics, Focused Section on Mechatronics in Multi Robot Systems*, 14:151-162 , 2009

MICS

FNSNF Schweizerischer Nationalfonds / Fonds national suisse / Swiss National Science Foundation

Disal