Distance Measurement for Relative Localization

PhD Student Valerio Brunacci – Advisor Prof Alessio De Angelis

EMERLab

Scenarios

Indoor Localization

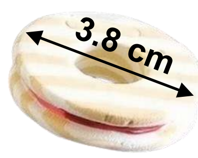
Relative Localization

Sensors

Ultra Wide Band (UWB) Ranging sensors

6.5 GHz (5 channels)

Ranging accuracy 5 cm



Custom developed AC magnetic ranging sensors

Resonance Frequency 175 KHz

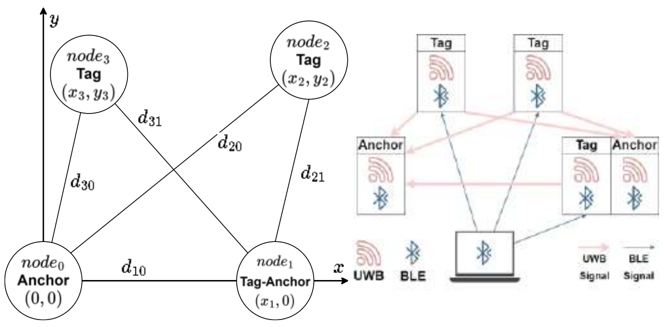
Inductance 2.5 μH - 5 windings

Ranging accuracy up to 1 cm

1. Development a Relative Localization System and Analysis of the Theoretical Limits

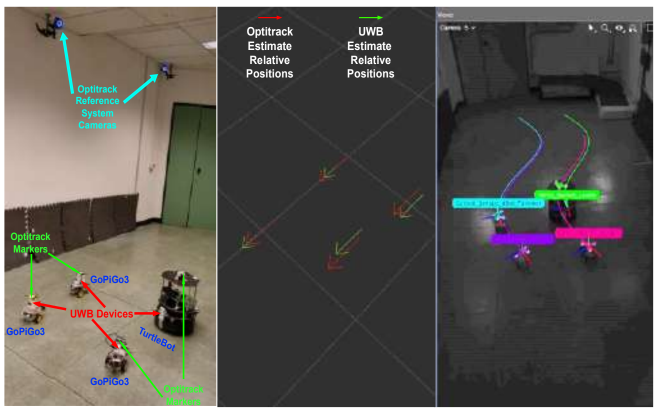
Motivation:

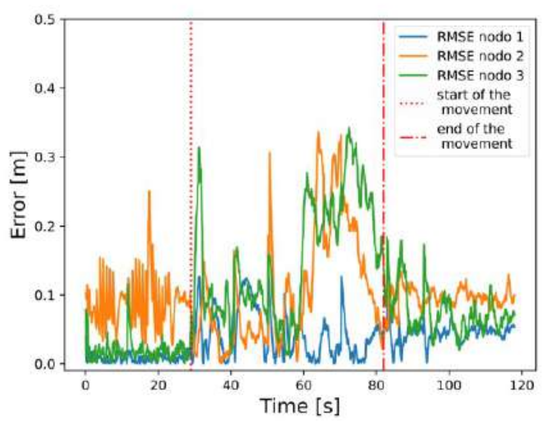
SoA characterization of an RLS is computationally inefficient. Therefore, they are not suitable for live execution, e.g., online optimal geometric configuration..



Idea:

Develop an RLS based on distance measurements only. Analyze the performance in a dynamic scenario. Define a Monte Carlo Simulation based on that estimator and compute the Cramer Rao Lower Bound. Propose a fast method for the characterization analysis.





Method:

Avoid inverting the Fisher matrix in the CRLB computation. Instead, derive bounds on the diagonal elements of the Fisher matrix.

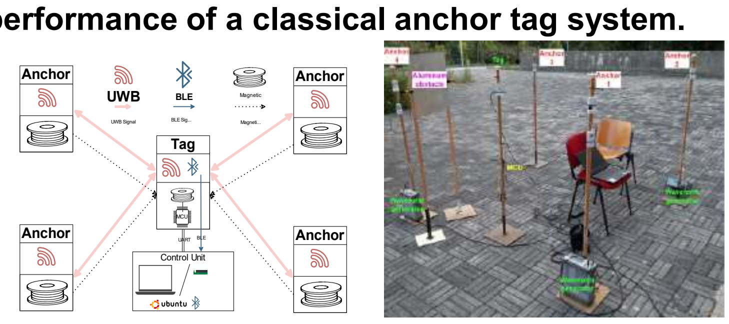
Param.	Std. Dev. of estimates (numerical simulation) [m]	CRLB [m]	Bound on CRLB [m]	Bias of estimates (numerical simulation) [m]
x_1	0.0184	0.0182	0.039	-2.1E-04
x_2	0.0306	0.0306	0.055	1.8E-04
y_2	0.0203	0.0203	0.037	-1.7E-04
x_3	0.0562	0.0555	0.087	-3.4E-04
y_3	0.0386	0.0383	0.064	-9.2E-04

2. Robust Localization in Non-Line-of-Sight conditions

A. Fusion UWB and Magnetic ranging systems

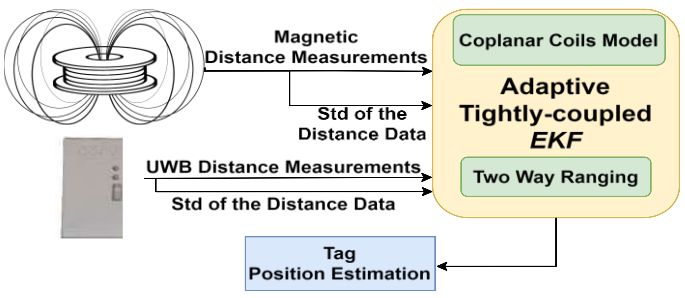
Motivation:

In a real world scenario, it is common to have conditions (NLOS) that deeply affect the performance of a classical anchor tag system.



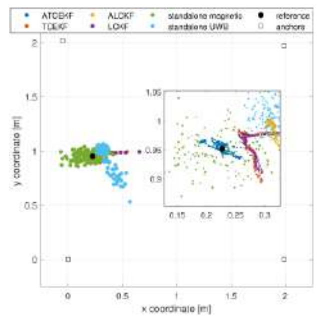
Idea:

Analyze the complementary characteristics of UWB and magnetic distance measurements. Propose a method for the fusion of the magnetic RS and the UWB RS.



Method:

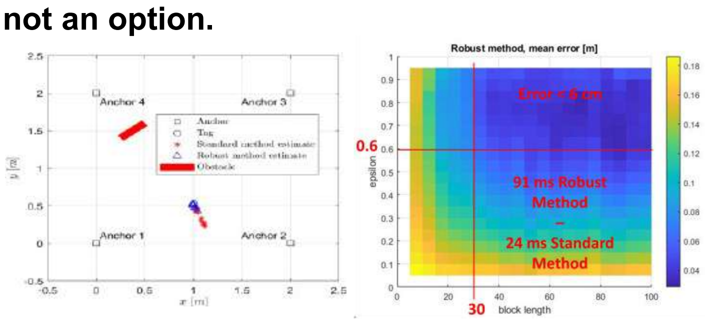
Use the complementary characteristics of the standard deviation of the 2 RS and the raw distance measurement as input for a tightly-coupled EKF.



B. Robust Localization: statistical Approaches

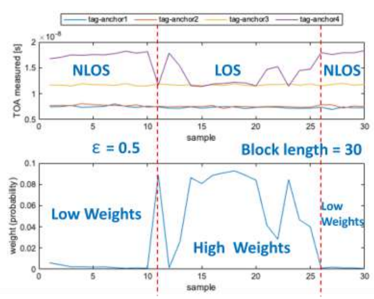
Motivation:

It is complex to estimate the PDF of the corrupted measurements. Also, brute force is not an option.



Idea:

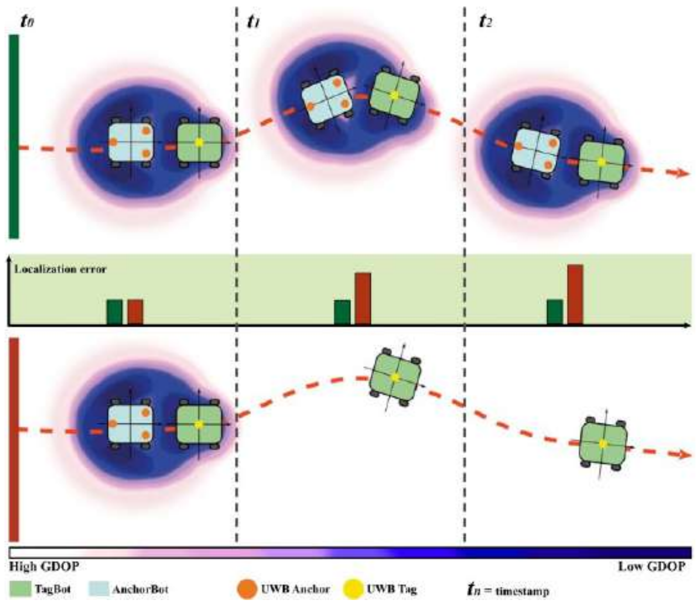
Consider the problem in a statistical setting using an empirical data distribution. The empirical distribution has entropy. Use entropy to "detect" corrupted measurements. This can be solved using coordinate descent.



3. Active Localization (under review)

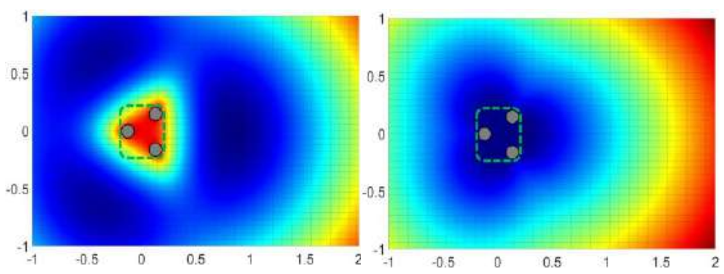
Motivation:

infrastructure-less multi robot localization systems require a static robot.



Idea:

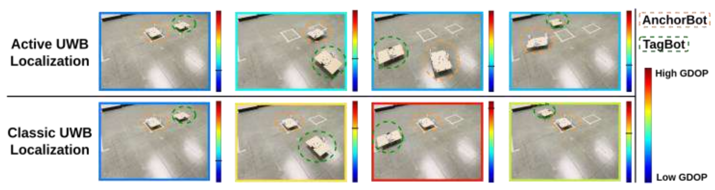
use an active localization approach, i.e. , one robot (TagBot) is free to move, the other (AnchorBot) adjust its position to keep the TagBot in the minimum of UWB Relative Localization Loss.



Method:

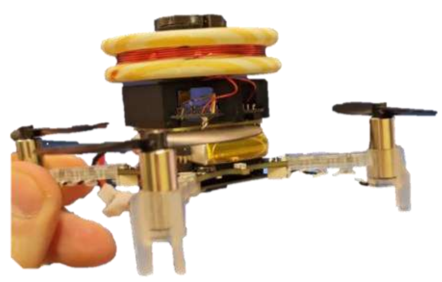
use the Gemoetrical Diliution of Precision to propose a novel UWB Relative Localization Loss.

Train an active Reinforcement Learning-based controller using this loss to adapt the AnchorBot's position to minimize the relative localization error of the TagBot.



3. On going research at ETH:

Low power magnetic localization system for nano-UAV



Motivation:

UWB RS are too noisy for 10 cm diameter drone.