A LINEAR APPROXIMATION FOR GRAPH-BASED SIMULTANEOUS LOCALIZATION AND MAPPING

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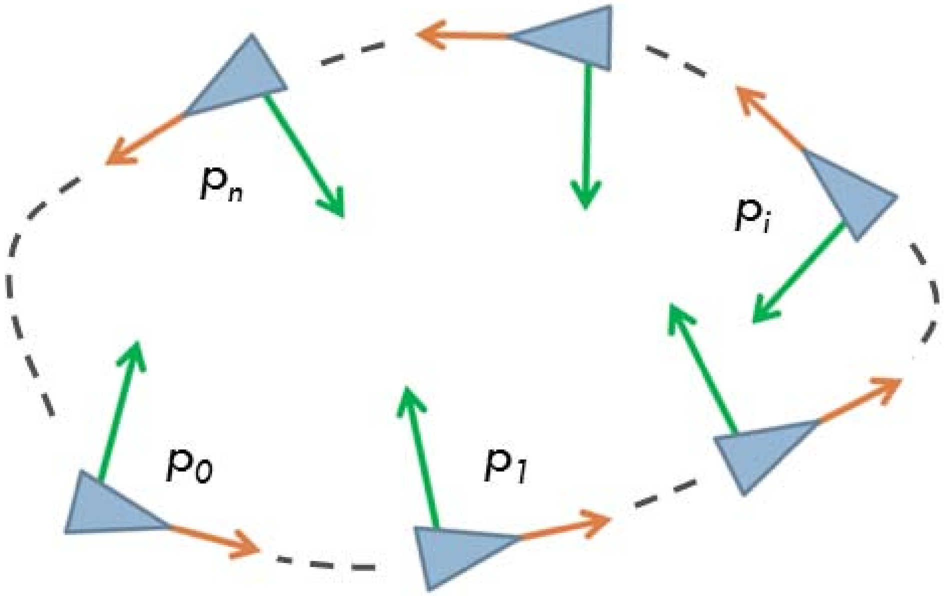
Full SLAM



PROBLEM: estimate the trajectory of a mobile robot (poses from time *0* to time *n*) from relative pose information

input: relative pose measurements $\xi_{ij} = p_j \ominus p_i + \xi_{ij}$, and the corresponding uncertainty $\xi_{ij} \sim N(0, P_{ij})$

output: maximum likelihood configuration $P^* = \{p_0^*, \ldots, p_n^*\}$

A nonlinear non-convex optimization problem: $P^* = argmin\, f(P)$

$$f(\mathcal{P}) = \sum_{(i,j)\in\mathcal{E}} (p_j \ominus p_i - \xi_{ij})^\top P_{ij}^{-1} (p_j \ominus p_i - \xi_{ij})$$

A Linear Framework

Assumption: for each relative pose measurement $\xi_{ij} = [\Delta^l_{ij}\ \delta_{ij}]^T$ the relative position Δ^l_{ij} and the relative orientation δ_{ij} are independent, i.e., $P_{ij} = \mathrm{diag}(P_{\Delta^l_{ij}}, P_{\delta_{ij}})$.

In a planar setup:

- **the relative orientation measurements are linear**
- **the relative position measurements are also linear once robot orientations are known**

Therefore our simple approach proceeds in three phases:

1. **Compute an estimate of robot orientations from the relative orientation measurements (a *linear estimation problem!*)**
2. **Transform the relative position measurements in a common global reference frame, preserving the correlation (a *matrix-vector multiplication!*)**
3. **Solve the problem with the relative measurements expressed in the global frame, obtaining an approximation for P^* (a *linear estimation problem!*)**

A Linear Framework

We **prove** that:

The outcome of the three-phases procedure approximates the solution of the nonlinear maximum likelihood problem: the third phase produces a local correction of a sub-optimal configuration estimate computed in the first phase, leading it towards a minimum of the cost function.

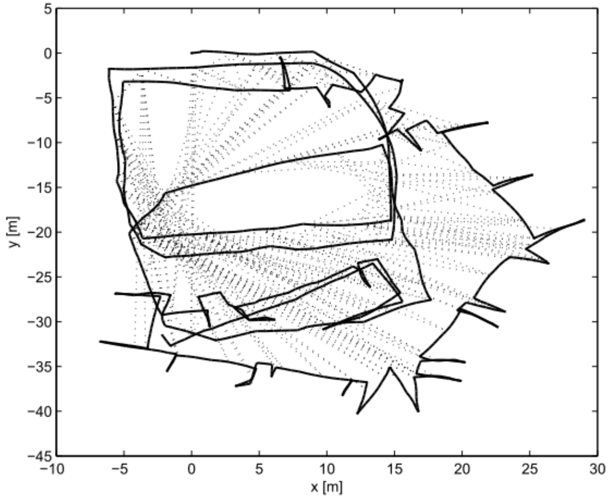
But there is a **trick**:

We are estimating angles in a linear framework: what about the 2π periodicity?

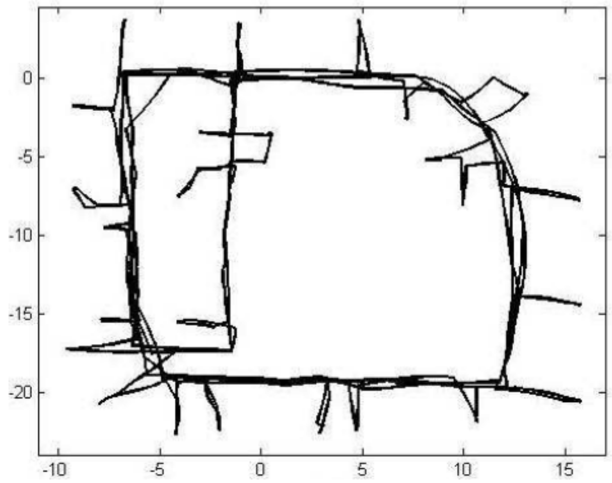
We show that a simple "regularization" of the orientation measurements allows to properly estimate the orientation of the robot and that this regularization can be performed in every SLAM problem!

Impact

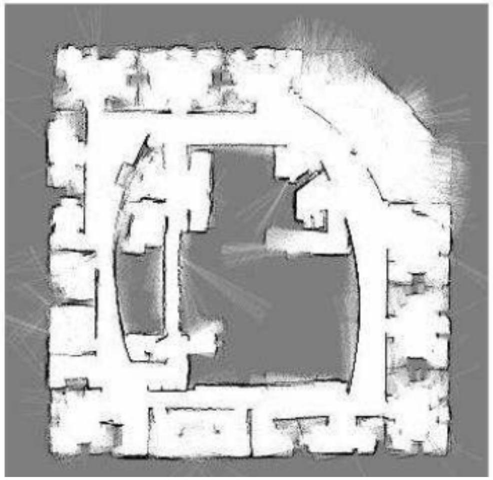
INPUT



OUTPUT

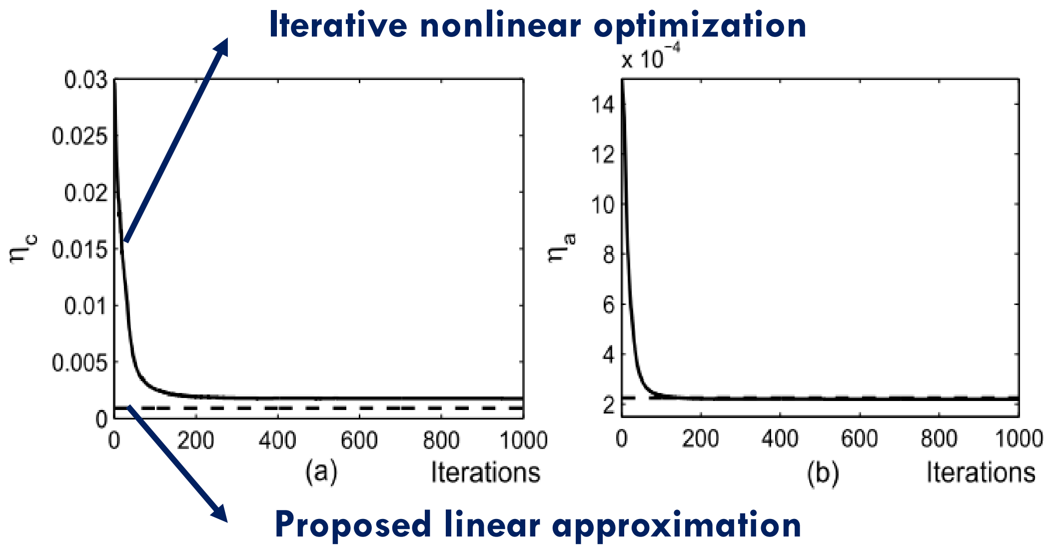


MAP



ADVANTAGES

1. Closed-form linear solution
2. Needs no initial guess
3. Can be used for bootstrapping other iterative approaches
4. Already accurate in practice



Thank you for the attention

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