Computational Enhancements for Certifiably Correct SLAM

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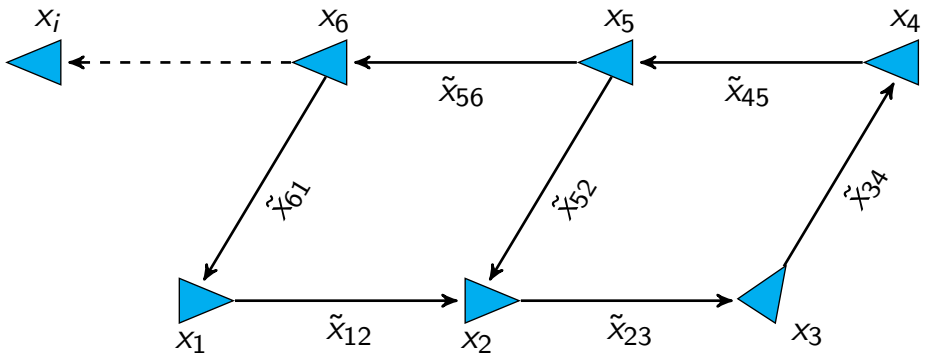
A lightning review of pose-graph SLAM

Given:

- Unknown *poses* $x_1, \ldots, x_n \in \mathrm{SE}(d)$
- A network of *noisy relative measurements* $\tilde{x}_{ij} \sim p_{ij}(\cdot | x_i^{-1} x_j)$:



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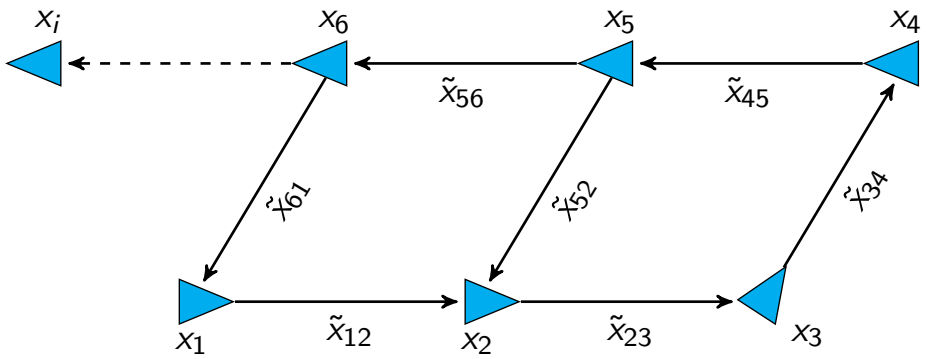

Find: The *maximum-likelihood estimate* $\hat{x} = (\hat{x}_1, \ldots, \hat{x}_n) \in \mathrm{SE}(d)$:

$$\hat{x} \triangleq \underset{x_1,\ldots,x_n \in \mathrm{SE}(d)}{\operatorname{argmin}} \sum_{(i,j)\in\vec{\mathcal{E}}} -\log p_{ij}\left(\tilde{x}_{ij} | x_i^{-1} x_j\right)$$

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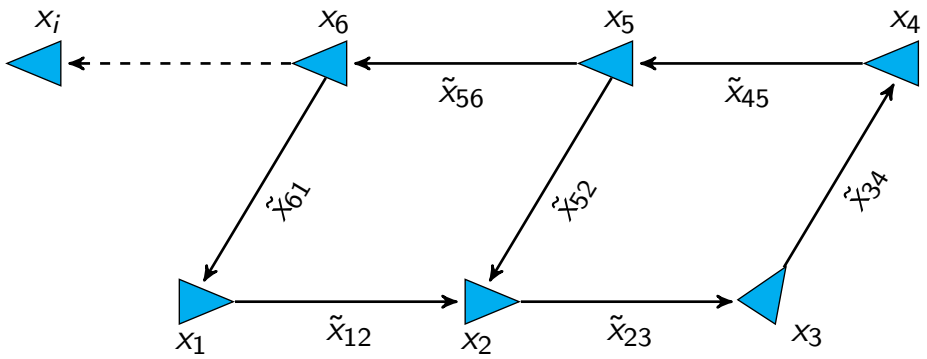

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This is a *high-dimensional*, *nonconvex* optimization problem

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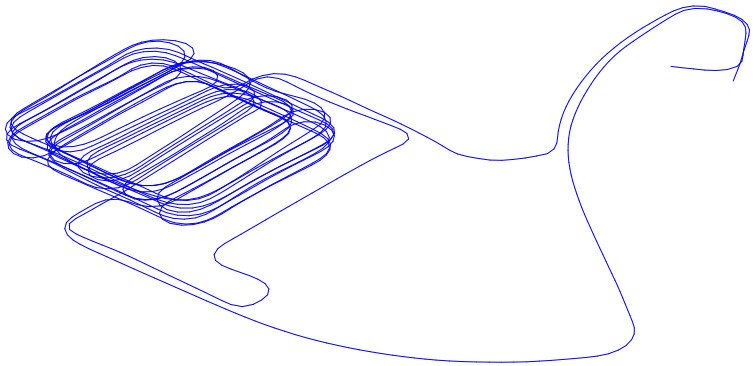

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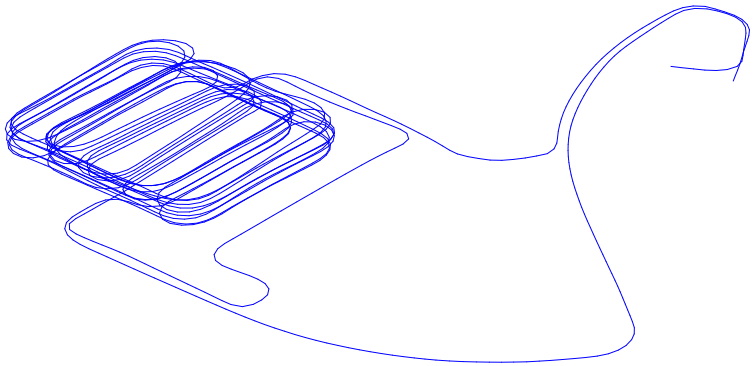

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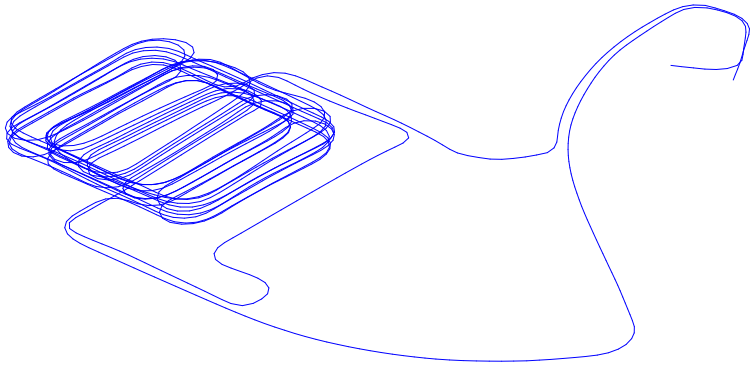

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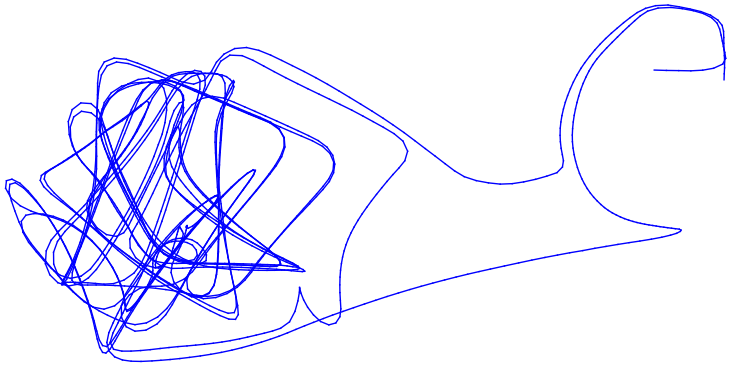

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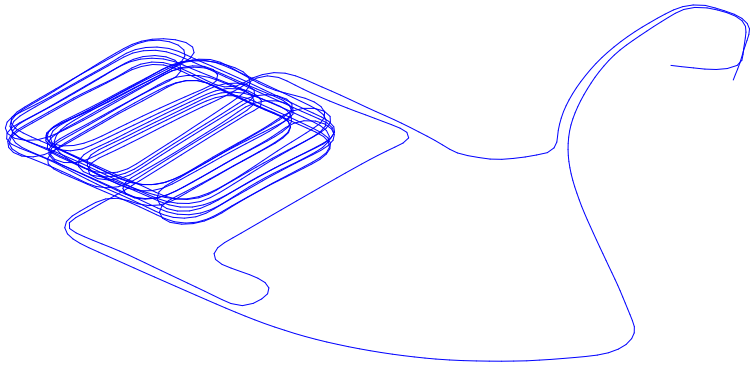

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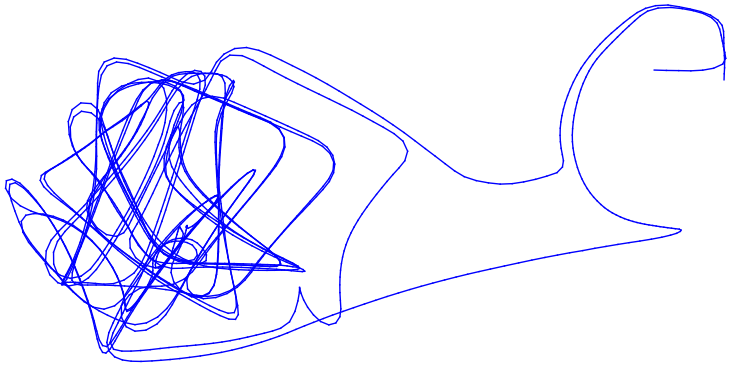

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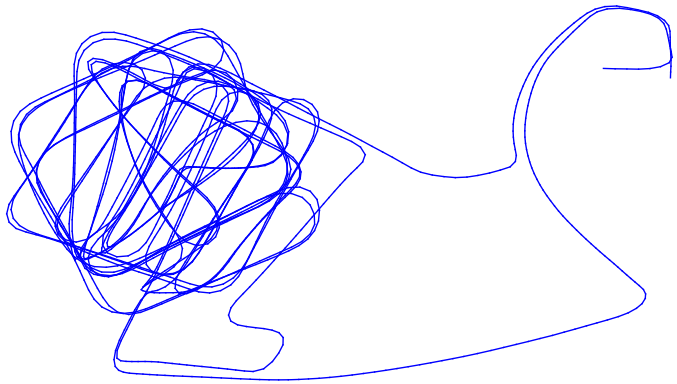

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Certifiably Correct SLAM

Previously: We have developed *SE-Sync*,[1] an algorithm for *certifiably correct SLAM*

- Directly searches for *global optima* via *convex relaxation*
- Generates *certificates of correctness* for global optima

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However: These computations can be expensive

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Contributions

In this work:

- *Computational enhancements* for accelerating SE-Sync:
  - Riemannian optimization
  - Truncated-Newton methods
  - Structure-exploiting matrix decompositions
  - Krylov-subspace linear algebra techniques
- *First C++ implementation* of SE-Sync
- *Experimental evaluation*: SE-Sync $\approx 2\times$ faster than GTSAM

Code: `https://github.com/david-m-rosen/SE-Sync`