

# A Decentralized LiDAR-SLAM System with Certifiably Optimal Pose Graph Optimization

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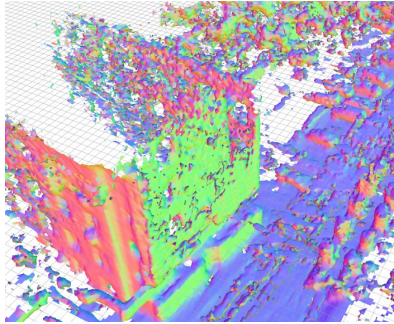
Jun 5, 2026 @ Vienna, Austria

# Background of decentralized mapping

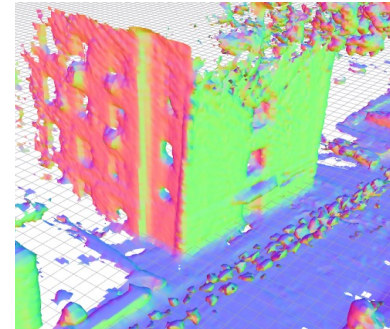
Merge by  
Pose Graph Optimization (PGO)



*Building*



*Before merging*

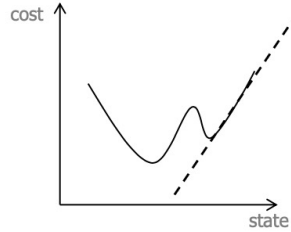


*After merging*

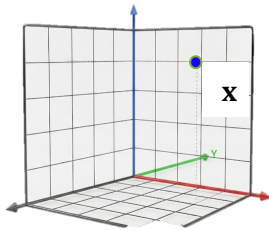
- Should provide states with optimality guarantees (**Optimality**).
- Should be efficient even with large-scale mapping (**Efficiency**).

# Certiably optimal pose graph optimization (PGO)

Traditional linearization



Key insight:  
To derive a linear problem  
with the **same gradient**  
(local descending direction).



$\mathbf{x}$  in real space  $\mathbb{R}^n$

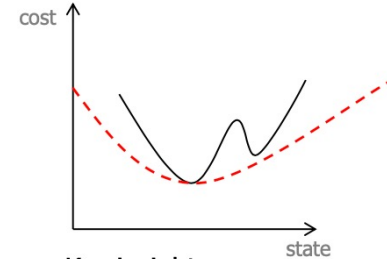
$$\min_{\{\mathbf{R}_i, \mathbf{t}_i\}} \sum_{(i,j) \in \mathcal{E}} \left( \kappa_{ij} \|\mathbf{R}_j - \mathbf{R}_i \tilde{\mathbf{R}}_{ij}\|_F^2 + \sigma_{ij} \|\mathbf{t}_j - \mathbf{t}_i - \mathbf{R}_i \tilde{\mathbf{t}}_{ij}\|_2^2 \right)$$

**relax** using  
 $\mathbf{X} - \mathbf{x}\mathbf{x}^T \succeq \mathbf{0}$ .

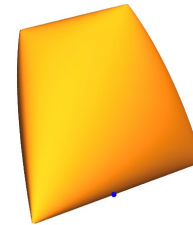


**recover** the  
unique  $\mathbf{x}$

Current convex relaxation



Key insight:  
To reformulate a convex problem  
with the **same optimal cost** value.



$\mathbf{X}$  in convex space  $\mathcal{S}_+^n$   
[Ref. MP22, HY]

$$\min_{\mathbf{X} \in \mathcal{S}_+^n} \langle \mathbf{C}, \mathbf{X} \rangle$$

s. t.  $\text{diag}(\mathbf{X}) = \mathbf{I}$

# Applications: initial positioning

Module    Loop closure    Map fusion    Certifiable PGO

3.13  
(once)

Key insight: Our system can achieve 3D-position of precision **48.9%** higher than DiSCo-SLAM while only costing **3 seconds**.

Future work: certifiably optimal **lightweight** mapping (e.g. object-level)

Paper &  
Poster :



<https://arxiv.org/abs/2605.25051>

Website:



<https://baoshan-song.github.io/>

SDP (Ours): global optimum

Robot	7.01	7.07	3.02
Robot2	4.90	2.73	2.38