Overlapping Schwarz Preconditioners for Pose Graph SLAM in Robotics

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We investigate scalable two-level overlapping Schwarz domain decomposition methods with energy-minimizing coarse spaces of GDSW type (Generalized Dryja–Smith–Widlund type) as preconditioners for the sparse linear systems arising in graph-based nonlinear least-squares problems, specifically the pose graph optimization back-end in Simultaneous Localization and Mapping (SLAM). After a brief introduction to SLAM and domain decomposition preconditioners, we describe the nonlinear least-squares formulation, its linearization, and the resulting matrix structure, to facilitate access for readers without prior knowledge of either field. Numerical experiments demonstrate the numerical scalability of the preconditioned conjugate gradient method (CG): Using the two-level overlapping Schwarz preconditioner, the number of CG iterations remains bounded independently of the problem size, overcoming the typical limitations of simple preconditioners, including one-level Schwarz approaches. We also consider two variants of Manhattan-world benchmark problems in SLAM.

References:

[1] https://doi.org/10.48550/arXiv.2603.08975

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