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SpaND: An Algebraic Sparsified Nested Dissection Algorithm Using Low-Rank Approximations

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We propose a new algorithm for the fast solution of large, sparse, symmetric positive-definite linear systems, spaND — sparsified Nested Dissection. It is based on nested dissection, sparsification and low-rank compression. After eliminating all interiors at a given level of the elimination tree, the algorithm sparsifies all separators corresponding to the interiors. This operation reduces the size of the separators by eliminating some degrees of freedom but without introducing any fill-in. This is done at the expense of a small and controllable approximation error. The result is an approximate factorization that can be used as an efficient preconditioner. We then perform several numerical experiments to evaluate this algorithm. We demonstrate that a version using orthogonal factorization and block-diagonal scaling takes less CG iterations to converge than previous similar algorithms on various kinds of problems. Furthermore, this algorithm is provably guaranteed to never break down and the matrix stays symmetric positive-definite throughout the process. We evaluate the algorithm on some large problems show it exhibits near-linear scaling. The factorization time is roughly $O(N)$ and the number of iterations grows slowly with problem size N. SpaND [1] can be viewed as an extension of the HIF method [2].

References

[1] An Algebraic Sparsified Nested Dissection Algorithm Using Low-Rank Approximations, Lopold Cambier, Chao Chen, Erik G Boman, Sivasankaran Rajamanickam, Raymond S. Tuminaro, and Eric Darve, *arXiv:1901.02971*

[2] Hierarchical interpolative factorization for elliptic operators: differential equations, K.L. Ho and L. Ying, *Communications on Pure and Applied Mathematics*, 69:8, 2016.

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