A Robust and Parallel Approximate Factorization Preconditioner using Hierarchical Matrices and Randomized Sampling

Pieter Ghysels [1]

We present a parallel and fully algebraic preconditioner based on an approximate sparse factorization using low-rank matrix compression. The sparse factorization uses a multifrontal algorithm with fill-in occurring in dense frontal matrices. These frontal matrices are approximated as hierarchically semi-separable matrices, which are constructed using a randomized sampling technique. The resulting approximate solver has (close to) optimal complexity in terms of flops and memory usage for many discretized partial differential equations. We illustrate the robustness and performance of this new preconditioner for a number of unstructured grid problems. Initial results show that the rank-structured preconditioner could be a viable alternative to algebraic multigrid and incomplete LU, for instance. Our implementation uses MPI and OpenMP and supports real and complex arithmetic. We present a detailed performance analysis. The code is released as the STRUMPACK library with a BSD license.

[1]Lawrence Berkeley National Laboratory, USA (pghysels@lbl.gov)