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CPU-GPU computations for MultiGrid techniques coupled with Fourth-Order Compact Discretizations for Isotropic and Anisotropic Poisson problems

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Abstract

A CPU-GPU parallel algorithm for a fourth-order compact finite difference scheme with unequal mesh size in different coordinate directions, is designed to discretize a two dimensional isotropic or anisotropic Poisson equation in a rectangular domain. A multigrid technique with partial semi-coarsening strategy is used to iteratively solve the sparse linear system derived. Numbering the unknowns and equations according to the line red-black fashion, the coefficient matrix obtains a block structure suitable for parallel computations. These blocks consist of Toeplitz matrices with known inverses, allowing the efficient solution of inner linear systems on parallel computing environments with accelerators. The realization of the algorithm takes place on a HP SL390s G7 multicore system with Tesla M2070 GPUs and the application is developed in double precision Fortran code using the OpenACC standard with PGI's compilers. The performance investigation reveals that the solution of fine discretization problems can be accelerated, although multigrid techniques usually yield poor efficiency on parallel computing architectures due to solution approximations of decreased size problems.

Key words: Multigrid techniques, Compact finite difference schemes, GPU computations, OpenACC