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Numerical Studies for Standard Bi-Conjugate Gradient Stabilized Method and the Parallel Variants for Solving Linear Equations

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Abstract : Bi-conjugate gradient (Bi-CG) is a well-known method for solving linear equations Ax = b, for x, where A is a given n-by-n matrix, and b is a given n-vector. Typically, the dimension of the linear equation is high and the matrix is sparse. A number of hybrid Bi-CG methods such as conjugate gradient squared (CGS), Bi-CG stabilized (Bi-CGSTAB), BiCGStab2, and BiCGstab(l) have been developed to improve the convergence of Bi-CG. Bi-CGSTAB has been most often used for efficiently solving the linear equation, but we have seen the convergence behavior with a long stagnation phase. In such cases, it is important to have Bi-CG coefficients that are as accurate as possible, and the stabilization strategy, which stabilizes the computation of the Bi-CG coefficients, has been proposed. It may avoid stagnation and lead to faster computation. Motivated by a large number of processors in present petascale high-performance computing hardware, the scalability of Krylov subspace methods on parallel computers has recently become increasingly prominent. The main bottleneck for efficient parallelization is the inner products which require a global reduction. The resulting global synchronization phases cause communication overhead on parallel computers. The parallel variants of Krylov subspace methods reducing the number of global communication phases and hiding the communication latency have been proposed. However, the numerical stability, specifically, the convergence speed of the parallel variants of Bi-CGSTAB may become worse than that of the standard Bi-CGSTAB. In this paper, therefore, we compare the convergence speed between the standard Bi-CGSTAB and the parallel variants by numerical experiments and show that the convergence speed of the standard Bi-CGSTAB is faster than the parallel variants. Moreover, we propose the stabilization strategy for the parallel variants.

Keywords : bi-conjugate gradient stabilized method, convergence speed, Krylov subspace methods, linear equations, parallel variant
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