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A comparative study on the effect of the ordering schemes for solving sparse linear systems, based on factored approximate sparse inverse matrix methods

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Abstract

Preconditioned iterative schemes have been used extensively in many scientific disciplines, during the last decades for solving sparse linear systems. The effectiveness of the Preconditioning methods relies on the construction and use of efficient preconditioners, in the sense that are close approximants to the coefficient matrix of the linear system, suitable for modern computer systems.

Recently, a class of Generic Approximate Inverses has been proposed that can handle any sparsity pattern of the coefficient matrix. A class of Generic Approximate Sparse Inverse matrix in conjunction with approximate inverse sparsity patterns, based on powers of sparsified matrices, has been proposed, that presented improved convergence behavior than existing Generic Approximate Banded Inverses schemes. Moreover, a factored approach, namely Generic Factored Approximate Sparse Inverse has been proposed, that further improved the convergence rate and further reduces the computational complexity and memory requirements. The Modified Generic Factored Approximate Sparse Inverse is a column wise variant that increases the performance by reducing the searches for nonzero elements required in the row-wise approach. The reordering schemes have been used to reduce fill-in for computing the decomposition factors of the coefficient matrix. Additionally, the reordering schemes have been used to increase the quality of incomplete factorization used in conjunction with preconditioned iterative methods. The various reordering schemes, namely Approximate Minimum Degree, the Reverse Cuthill-McKee and the Block Breadth First Search, affect the number of nonzeros and the quality of Modified Generic Factored Approximate Sparse Inverse. Moreover, the reordering schemes affect the sparsity pattern of the resulting approximate sparse inverse preconditioners and the convergence behavior of the proposed schemes.

Finally, we examine the effectiveness and applicability of the various ordering schemes on the computation of the Modified Generic Factored Approximate Sparse Inverse (MGenFAspI) matrix in conjunction with the preconditioned Bi-Conjugate Gradient STABilized method for solving various problems from Matrix Market collection and numerical results are given, which are comparatively better than existing ones.

Key words: Modified Generic Factored Approximate Sparse Inverses, Reordering schemes, Preconditioned iterative methods, Sparsity patterns.