A NEAR-FIELD PRECONDITIONER FOR FAST METHODS

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Approaches such as Fast Multipole Method (FMM) and Adaptive Integral Method (AIM) use specialized matrix vector products (MVP) in conjunction with iterative solvers to reduce the complexity of solving an electromagnetic problem directly. As a result, computational complexity is often reduced from the **O**(N^3) associated with direct LU factorization to as low as **O**(N log N) while memory requirements are reduced from **O**(N^2) to **O**(N). The MVPs associated with fast methods, however, are non-trivial and can require significantly more time to compute when compared to traditional Method of Moments (MoM). Since electromagnetic problems typically result in poorly conditioned systems and require solution of many right-hand-sides (RHS), any reduction in the number of MVPs significantly decreases the total computation time required.

In the past, standard preconditioning techniques such as the Incomplete LU (ILU) and Approximate Inverse Preconditioner (AIPC) (Y. Saad. *Iterative Solutions for Sparse Linear Systems*. PWS Publishing Company, Boston. 1996.) have been used to improve the condition of the system matrix and reduce the overall number of MVPs required. While some improvement can be observed with these techniques, neither is specially tailored specifically for electromagnetic problems. Specifically, the ILU suffers from an uncontrollable non-zero pattern while the AIPC requires careful hand tuning for optimum performance. This paper proposes a new approach that uses the physics contained within the near-field (NF) terms of the system matrix to generate a preconditioner that has low computational complexity, requires little storage, and significantly reduces the total of MVPs required for convergence. Several typical electromagnetic examples are shown to validate the performance of the approach and demonstrate how computation of the NF preconditioner can achieve near-linear speedup in either shared- or distributed-memory parallel computing environments.

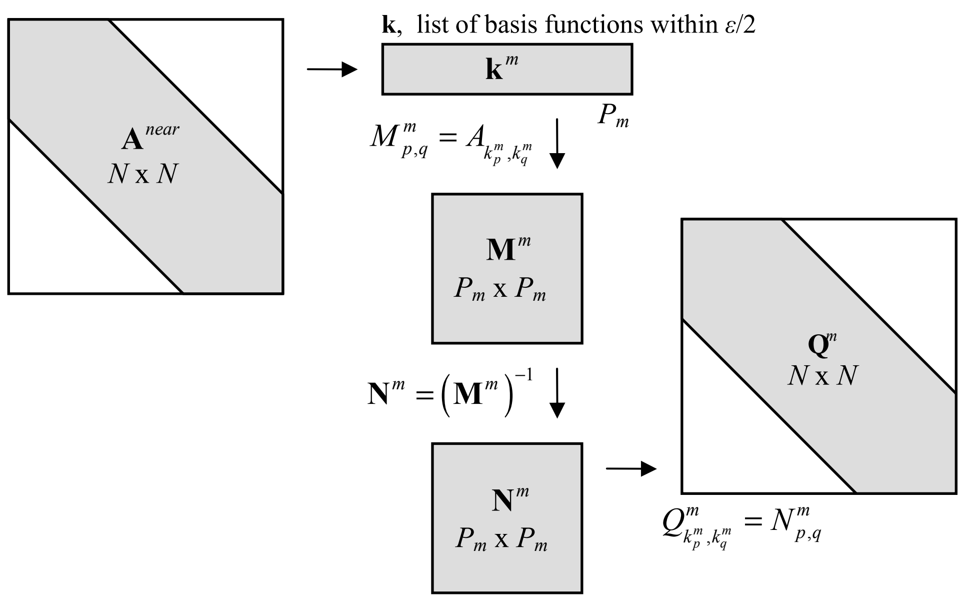

Figure 1. Assembling the Near-Field Preconditioner Q from the system matrix A