Avoiding breakdown in incomplete factorizations in low precision arithmetic

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Abstract

The emergence of low precision floating-point arithmetic in computer hardware has led to a resurgence of interest in mixed precision variants of iterative solvers. Our focus is on incomplete factorizations, which have long been popular general-purpose algebraic preconditioners for solving large sparse linear systems of equations. Guaranteeing the factorization is breakdown free while computing a high quality preconditioner is challenging. Even for well-conditioned problems, breakdown can occur when small entries occur on the diagonal during the incomplete factorization. When using half precision arithmetic, overflows are an additional potential source of breakdown. We examine how breakdowns can be avoided and implement our strategies within new half precision Fortran software. Our numerical simulations target highly ill-conditioned sparse systems coming from practical applications with the goal of computing the factors in half precision arithmetic and then achieving double precision accuracy using mixed precision refinement. We also consider the often overlooked issue of growth in the sizes of entries in the factors that can occur when using any precision and can render the computed factors ineffective as preconditioners.

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