Dissertation Defense

Inner-Product Free Krylov Methods for Inverse Problems

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Abstract: Iterative Krylov projection methods have become widely used for solving largescale linear inverse problems. Certain methods that rely on orthogonality require inner-products, which create a bottleneck for parallelization and causes the algorithms to fail in low-precision. As a result, there is a need for more effective iterative methods to alleviate this computational burden. This study presents new Krylov projection methods that do not require inner products to solve large-scale linear inverse problems.

The first iterative solver is known as the Changing Minimal Residual Hessenberg method (CMRH). The second is a new extension of CMRH to rectangular systems which we call the least squares LU method (LSLU). We further adapt both approaches to efficiently incorporate Tikhonov regularization. These methods are labeled as Hybrid CMRH and Hybrid LSLU. Each of these techniques are known as quasi-minimal residual methods rather than minimal residual methods. Still, these methods do not offer a way to control how closely the quasi-norm approximates the desired norm. In this work, we also propose a new Krylov method that is both inner-product free and minimizes a functional that is theoretically closer to the residual norm. The new scheme combines the conventional CMRH method and the newly proposed LSLU method with a randomized sketch-and-solve technique to solve the strongly overdetermined projected least-squares problem. Extensive numerical examples illustrate the effectiveness of all methods in this dissertation.

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