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The Convergence of Krylov Subspaces Methods with Recycling

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Many problems in science and engineering require the solution of a long sequence of linear systems, with small changes from one matrix to the next but substantial changes over multiple systems. We are particularly interested in cases where both the matrix and the right hand side change and systems are not available simultaneously. Such sequences arise in time-dependent iterations, nonlinear systems of equations and optimization, (distributed) parameter identification and inverse problems, and many other problems.

In recent papers [1,2,3] we have proposed methods to recycle selected subspaces from the Krylov spaces generated for previous linear systems to improve the convergence of subsequent linear systems. In this presentation, we discuss several important convergence issues:

- the convergence of Krylov methods that recycle approximate solution spaces, approximate invariant subspaces, and other relevant spaces,
- the relevant perturbation theory for the spaces mentioned above for sequences of matrices arising in a range of applications,
- how fast our proposed methods learn to adapt to a changing problem.

We provide experimental results for a range of problems from tomography, nonlinear mechanics, large-scale design optimization, and statistical mechanics.

References

1. Michael L. Parks, Eric de Sturler, Greg Mackey, Duane D. Johnson, and Spandan Maiti, *Recycling Krylov Subspaces for Sequences of Linear Systems*, SIAM Journal on Scientific Computing (accepted with minor revisions), 2006, available as Tech. Report UIUCDCS-R-2004-2421, March 2004, from http://www-faculty.cs.uiuc.edu/~sturler ,

2. Misha Kilmer and Eric de Sturler, *Recycling Subspace Information for Diffuse Optical Tomography*, SIAM Journal on Scientific Computing (accepted for publication), 2006, available from
http://www-faculty.cs.uiuc.edu/~sturler ,

3. Shun Wang, Eric de Sturler, and Glaucio H. Paulino, *Large-Scale Topology Optimization using Preconditioned Krylov Subspace Methods with Recycling*, International Journal for Numerical Methods in Engineering (submitted), 2006, available as Technical Report UIUCDCS-R-2006-2678 from
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