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Preconditioned iterative methods for a class of nonlinear eigenvalue problems☆

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Abstract

This paper proposes new iterative methods for the efficient computation of the smallest eigenvalue of symmetric nonlinear matrix eigenvalue problems of large order with a monotone dependence on the spectral parameter. Monotone nonlinear eigenvalue problems for differential equations have important applications in mechanics and physics. The discretization of these eigenvalue problems leads to nonlinear eigenvalue problems with very large sparse ill-conditioned matrices monotonically depending on the spectral parameter. To compute the smallest eigenvalue of large-scale matrix nonlinear eigenvalue problems, we suggest preconditioned iterative methods: preconditioned simple iteration method, preconditioned steepest descent method, and preconditioned conjugate gradient method. These methods use only matrix–vector multiplications, preconditioner-vector multiplications, linear operations with vectors, and inner products of vectors. We investigate the convergence and derive grid-independent error estimates for these methods. Numerical experiments demonstrate the practical effectiveness of the proposed methods for a model problem.

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