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Alternatives to Smoothed Aggregation Multigrid Prolongators for Anisotropic Problems

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We consider alternatives to the traditional methods in smoothed aggregation for generating prolongator operators. The goal is to produce prolongators that are appropriate for anisotropic operators.

Consider the linear problem $Ax = b$. In the first approach, smoothed aggregation with basis function shifting, we begin with the standard smoothed prolongator, $P^{(sm)} = (I - \omega D^{-1} A)P^{(t)}$, where $P^{(t)}$ is the tentative prolongator. Given a prescribed prolongator sparsity pattern, this method moves basis function support (columns of $P^{(sm)}$) from one aggregate to another to produce a new prologator, $P^{(shift)}$. The shifting is done in such a way that null space interpolation is maintained.

In the second approach, we consider extensions to building prolongator operators via energy optimization (Vanek, Mandel, Brezina). In this method, the sum of the energies of the prolongator basis functions is minimized, subject to a fixed prolongator nonzero pattern and interpolation of low-energy modes. We consider modifications such as filtering A to account for anisotropies and applying a modified CG method to solve the optimization problem.

We present numerical experiments that compare the two methods to traditional smoothed aggregation on a variety of model problems.