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An accelerated deflation preconditioner for parametric systems based on subspace recycling

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Krylov subspace recycling [1] is often deployed to accelerate the iterative solution of sequences of linear systems. Such approaches reuse a continuously updated deflation subspace to reach a converged solution within a low number of iterations. This procedure is justified for problems that describe gradually evolving phenomena, such as crack propagation, and thus involve a sequence of systems that are not simultaneously available. However considering parametric systems, these techniques might induce an unnecessary overhead cost. Specifically, by constantly updating the recycled subspace a new projection on the newly constructed subspace needs to be operated for each new system, inducing a cost that scales with $\mathcal{O}(\ell \times N^2)$ for dense systems, where N is the size of the system and ℓ is the size of the employed recycled basis.

In that context, this work proposes an accelerated recycling procedure for parametric systems that is inspired by the Galerkin Model Order Reduction strategy and employs an offline – online operation splitting. In the offline part, the subspace to be recycled is constructed via an Automatic Krylov subspaces Recycling algorithm (AKR)[2] and the parametric system is projected on the subspace to yield a Reduced Order Model (ROM). Then, in the online part the construction of the deflation preconditioner only requires employing the ROM and as a result the cost of constructing the preconditioner is reduced to $\mathcal{O}(\ell^2)$.

The proposed procedure is tested on a randomly parametrized linear system and is compared to existing recycling approaches. Due to the offline – online splitting of operations it achieves greater accelerations for the iterative solution of the sequence of systems than the competitive approaches and thus it essentially enables the efficient subspace recycling for dense parametric systems.

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