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ONE GOOD REASON FOR EARLY TERMINATION OF KRYLOV SOLVERS IN TOPOLOGY OPTIMIZATION

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Abstract: In topology optimization, and structural optimization in general, a common methodology is to perform the optimization on design variables only, treating the solution of the underlying PDE constraints as a function call. With this approach, often referred to as the nested approach, the process of repeatedly solving the state and adjoint equations will dominate the computational effort. One attempt to reduce this effort, is to solve the state and adjoint systems less accurately. Previous work on such approximate approaches is based on early termination of an iterative solver. It demonstrates that seemingly rough approximate solutions obtained after few iterations of a Krylov solver are often sufficient for solving the topology optimization problem. In this work we develop on this idea by looking at the problem from a PDE-based angle. Namely we utilize a posteriori FEM error estimates to give a quantitative measure of when to terminate the iterative solver. We illustrate the proposed method with benchmark examples from linear elasticity. Our main observation is that the discretization error dominates the residual after few iterations. Utilizing this observation for an approximate approach, we find that the optimization algorithm behaves similarly to what one expects from ``exact'' solves. But the number of iterations is significantly reduced, even compared to previously suggested heuristics for approximate solves. The proposed method requires estimation of the residual during the iterations. Hence for large problems the method is impractical to utilize as it is presented in this work. Nevertheless we believe that it provides valuable insight into why approximate approaches yield accurate results. Additionally it provides quantitative guidelines for premature termination of iterative solvers and our experiments suggest that when combined with an efficient error estimate, a lot of computational effort can be saved, by solving the discrete problem just accurately enough.