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Time Parallel KKT Preconditioners for Transient PDE-Constrained Optimization

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Many physics-informed data integrated modeling approaches require the solution of optimization problems with evolutionary constraints. This talk develops scalable algorithms for transient PDE-constrained optimization. Here, simulation-based optimization repeatedly executes the simulator's forward and adjoint time integration schemes. Consequently, the arrow of time creates a sequential bottleneck in the optimization algorithm. Further, for performance these methods rely strongly on spatial parallelization for the forward and adjoint solves. Thus, when forward and adjoint solvers are already operating at the limit of strong scaling, the arrow-of-time bottleneck cannot be mitigated by adding additional computing resources.

To address this bottleneck we have developed approaches to parallelize over the time domain, alleviating the serialization burden and yielding faster optimization. We propose a domain decomposition and multigrid preconditioner for solving the KKT system arising in sequential quadratic programming. These approaches leverage the observation that the Schur-complement is elliptic in time, and thus our approaches our based on domain decomposition and multigrid techniques. The performance of these preconditioners is examined in an empirical study demonstrating the approach is scalable with respect to the number of time steps and subdomains.

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