FAST AND SCALABLE SOLVERS IN PDE APPROXIMATION OF COMPLEX PHYSICS

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ABSTRACT

Multiscale forward and inverse PDE systems, characterized by interactions between different scales in space and time, as well as the requirement to assimilate data coming from real-world measurements offer valuable insights into diverse scientific disciplines, including physics, biology, materials science, and engineering. With advances in hardware technologies enabling simulations of larger and more complex systems, the development of robust and scalable numerical methods becomes crucial to fully unlock the potential of modern supercomputers. This Invited Session aims to address key topics in this field, including multilevel solvers for partial differential equations, nonlinear optimization, and multi-fidelity techniques.

Multilevel solvers and preconditioners: Techniques such as multigrid and domain decomposition methods have emerged as powerful techniques to handle large-scale problems involving high numbers of unknowns. These methods alleviate the computational bottleneck in numerical simulations and improve the efficiency of solving algebraic systems consisting of several millions of unknowns.

Nonlinear optimization: Real-world phenomena often exhibit complex behavior, which translates into nonlinearities in their objective function and/or constraints. Nonlinear optimization methods can further leverage the power of multilevel techniques and combine them with nonlinear optimization algorithms and nonlinear preconditioners, providing effective solutions to tackle these challenges. This integration enables more efficient optimization of complex systems.

The Invited Session emphasizes the importance of fast and scalable numerical methods, preconditioned solvers, and high-performance algorithms in modern supercomputing practices.