A Data Assimilation Approach to Solving Nonlinear Partial Differential Equations

Xuejian Li

Data assimilation (DA) is a technique that integrates observational data with the output of a physical model to estimate key unknowns, such as the physical state or crucial parameters. DA is grounded in a solid mathematical framework that includes numerical methods, optimization, and Bayesian inference. In this presentation, we introduce a continuous data assimilation (CDA) approach aimed at solving nonlinear partial differential equations where data measurements or solution observations are available. Specifically, this approach enhances the iterative methods of Picard and Newton. We demonstrate that CDA-Picard not only converges more quickly than the standard Picard method, but also handles more challenging problems, such as large Reynolds-number Navier-Stokes equations. Furthermore, for CDA-Newton, we prove that the domain of convergence with repect to initial guess expands as the amount of measurement data increases. Several numerical results from common benchmark Navier-Stokes tests will highlight the effectiveness of the proposed methods.