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Regularization and Adaptivity for Nonlinear Elliptic PDE Solvers

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In this talk I will introduce an adaptive framework developed to solve nonlinear elliptic partial differential equations (PDE) starting from a coarse mesh. The target problem class includes quasi-linear problems with steep internal layers in the solution-dependent diffusion coefficients, for which standard methods such as Newton or Picard iterations are known to fail. The method is designed to start with a discretization that does not resolve the problem coefficients. The discrete problem on the initial sequence of meshes is not assumed to inherit the stability, coercivity, monotonicity or solvability properties of the continuous system; essentially, the initial sequence of discrete problems is assumed ill-posed.

A sequence of partial solves of regularized problems is used to refine the discretization where necessary to resolve the problem coefficients and data. Adaptivity is used both for mesh refinement and automatic control of the regularization parameters to ultimately solve the discrete problem without regularization. I will discuss improving stability of the method with different pseudo-time integrators. The method will be demonstrated with numerical examples using an underlying linear finite element discretization.