Surrogate techniques for matrix-free sparse linear solvers

Ulrich Rüde*[1]

[1]CERFACS, VSB-Technical University of Ostrava, FAU Erlangen-Nürnberg – Germany

Abstract

For large scale finite element problems, storing and accessing the matrix can become a critical bottleneck, even when classical sparse matrix data structures are used. Matrix-free methods thus do not store the matrix, but compute and re-compute its elements on-the-fly. Naturally, this can become costly, e.g., when the matrix coefficients are defined by expensive quadrature rules. These must then be executed many times in each step of an iterative solver. Matrix surrogate techniques therefore go one step further, replacing the costly computation of the matrix elements by cheap approximations, such as moderate order polynomials. Here the matrix elements can be evaluated efficiently, but of course the effect on the accuracy of the final solution of the linear system must be analyzed carefully. Such techniques can become especially effective when combined with special features of the iterative solver, such as the double discretization technique in a multigrid method. Additionally, this opens further algorithmic possibilities, such as using reduced floating point precision in the multigrid smoother.

*Speaker