Dissertation Defense

Improving Multigrid Methods with Deep Neural Networks

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Abstract: Multigrid methods are one of the most efficient techniques for solving large sparse linear systems arising from Partial Differential Equations (PDEs) and graph Laplacians from machine learning applications. There are two key components of multigrid, smoothing which aims at reducing high-frequency errors on each grid level, and coarse grid correction which interpolates the solution at the coarse grid. However, finding optimal smoothing algorithms is problem-dependent and can impose challenges for many problems. Meanwhile, as the multigrid hierarchy is formed, coarse-grid operators have significantly more nonzeros per row than the original fine-grid operator, which generates high parallel communication costs on coarse-levels. In this talk, I will first talk about my research on developing an efficient adaptive framework for learning optimal smoothers from operator stencils in the form of convolutional neural networks (CNNs). I will also talk about our deep learning framework for sparsifying coarse grid operators. I will demonstrate how these techniques can be used for challenging anisotropic rotated Laplacian problems, variable coefficient diffusion problems, and linear elasticity problems.

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