Seminar

HPC Lab · CDS

Wednesday, December 7, 2022
4–5:30 p.m.
Room 1.03, RRZK
University of Cologne
Weyertal 121

Center for Data and Simulation Science

Speaker:

Prof. Dr. Martin Kronbichler

University of Augsburg

EFFICIENT IMPLEMENTATIONS OF HIGH-ORDER FINITE-ELEMENT METHODS

The talk focuses on the efficient implementation of high-order methods in the context of continuous and discontinuous finite elements applied to linear and nonlinear partial differential equations on complex geometries. The core algorithmic ingredient is the matrix-free operator evaluation (matrix-vector product), for which fast quadrature schemes for cell and face integrals based on a technique called sum factorization are employed. The algorithm selection for achieving a high throughput is demonstrated, guided by performance analysis, as well as the scalability to large-scale parallel machines. The best algorithms come with an arithmetic intensity of one to five flop/byte, with memory transfer primarily due to the access into input and output vectors as well as some geometry or variable coefficient data. As a result of our optimizations, many downstream solvers, such as explicit time stepping, smoothers in multigrid methods, or conjugate gradient solvers, are now no longer dominated by the matrix-vector product but by vector operations instead. To overcome this limitation, we consider the whole solution chain and fuse the memory access between different stages of an algorithm. The effect of these optimizations on the performance on contemporary CPU and GPU architectures are illustrated and results are shown of fluid dynamics simulations implemented with computational kernels from the deal.II finite element library.

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