AMG accelerated elasticity solver on GPU-clusters

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Recent developments in graphics hardware by NVidia and ATI, and associated software development tools as CUDA (and OpenACC recently) enable us to transfer numerical solver components on the recent generation of graphics processing units (GPUs).

Originating from potential problems we solve systems of linear equations with sparse unstructured system matrices derived from f.e. discretizations of PDEs and we present the adaption of an algebraic multigrid solver (AMG) used as preconditioner in a conjugate gradient solver on these GPUs. We achieve an accelerations of 10 wrt. to one CPU core in various practical applications ranging from engineering to medical technology based on fully unstructured discretizations.

The step from the potential problem to elasticity seems to be quite straight forward. But as always, the challenges are hidden in the details. Applying the AMG for the potential problems works in the first place at the cost of high iteration counts. Replacing the inappropriate potential solver components in smoother and intergrid transfer operations by appropriate 3×3 block components, i.e., taking into account the underlying energy norm/physics, reduces the number of iterations significantly.

Stepping forward from one GPU to clusters of GPUs is non-trivial even with a fast interconnect between the compute nodes. Here, even minor imbalances in a small subset of the code cause dramatic efficiency losses. A rescheduling of communication and operations on the boundary nodes was necessary to improve the efficiency of the parallel solver. Together with the new extension of all solver components to blocks systems, e.g., elasticity, we are able to run most parts of the CARP simulation software on clusters of GPUs now [1]. The Cardiac Arrhythmia Research Package (CARP) simulation software is used worldwide for the simulation of cardiovascular phenomena, see http://carp.medunigraz.at .

References:

[1] A. Neic, M. Liebmann, E. Hötzl, L. Mitchell, E. Vigmond, G. Plank, G. Haase, *Accelerating cardiac bidomain simulations using Graphics Processing Units*, IEEE Transactions on Biomedical Ingineering, 2012, accepted for publication

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