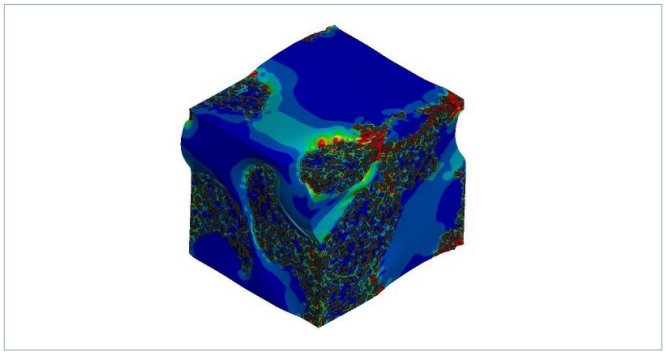
Fraunhofer SCAI

SAMG-Elasticity: fast solution of large-scale elasticity models

The idea of AMG extended to elasticity

To perform numerical simulations of 3D elasticity problems in (industrially-) sufficient computing time, robust and efficient solution methods are required for the large linear systems involved.

Hierarchical solution approaches such as the algebraic multigrid (AMG) method have proved to be highly efficient for diffusion-like problems. With the methods from SAMG-Elasticity, the same advantages are delivered to the solution of coupled 3D elasticity problems.



Visualization of a tire cube where SAMG-Elasticity has been applied to compute physical stresses.

[…] By using SAMG, it is now possible to obtain calculation results that took several months within two days. SAMG is an indispensable tool in our research on materials informatics.“

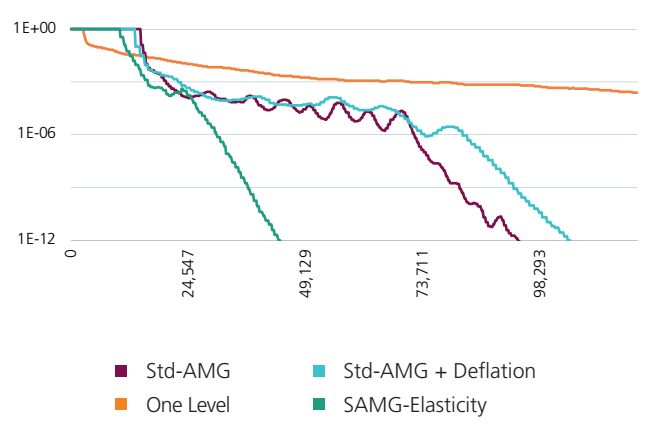
Yokohama Rubber

The best solution for your elasticity problem

SAMG-Elasticity (which automatically comprises the module **SAMG-Coupled**) contains two state-of-the-art AMG approaches that are relevant and applicable for linear elasticity applications. It allows the user to find the one that best suits a particular problem.

The underlying solver approaches are designed to handle different model formulations and material parameters. SAMG-Elasticity methods are particularly robust when strong contrasts in material properties or network distortions are present.

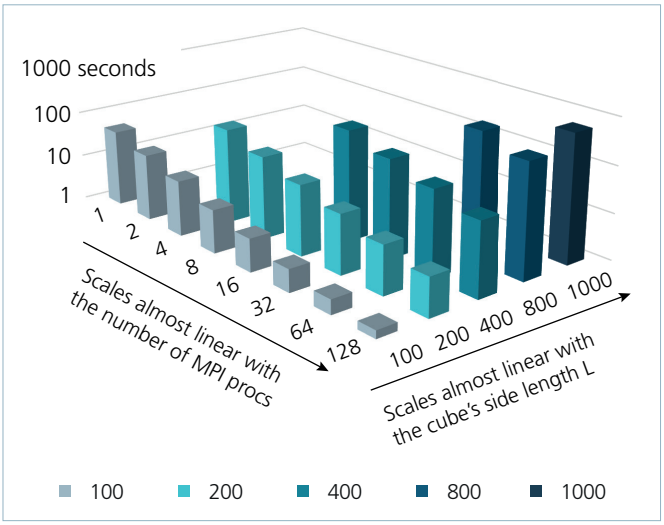
Typically, SAMG-Elasticity handles problematic properties such as rigid-body-mode freedoms of a mechanical structure. It also enables the user to approach the non-compressible limit case considerably.



Time for different solver approaches from SAMG-Core and the default method from SAMG-Elasticity to reach a sure accuracy for an exemplary 3D elasticity problem with 1 million DOF (including setup time).

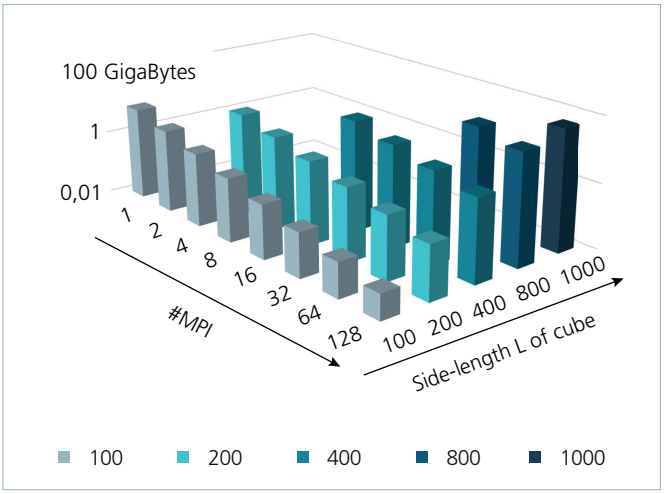
Efficient use of computing resources

SAMG-Elasticity can be executed on systems with multiple computing nodes (e.g., clusters or HPC systems) since it is MPI parallelized. In fact, hybrid parallelization means that SAMG-Elasticity can also exploit parallelism through multi-threading automatically to ensure the most efficient use of the computing hardware.



Runtime for solving elasticity problems with different numbers of MPI processes and problem sizes. Considered is a 3D cube domain L^3 with different side lengths L, but fixed grid spacing.

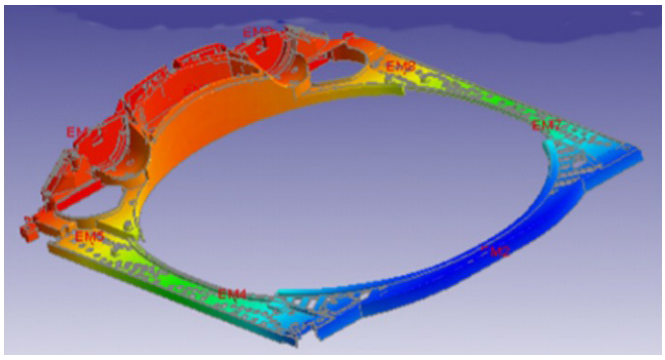
In addition to its computational efficiency, SAMG-Elasticity also is extremely memory efficient: Memory requirements scale only linearly with the problem size. This pushes the limits of what is practically computable on given hardware, especially compared to direct solvers.



Memory requirements for solving elasticity problems in the cube domain with side-length L from above.

Easy access – minimal user-interaction

SAMG-Elasticity provides the user with a variety of powerful linear solver approaches. For the ease-of-use, however, different profiles are available: This auto-adjusts a variety of settings based on minimal user input. While these typically fit well for most problems, further adjustment of individual parameters is still possible.



Example of a complex domain to which SAMG-Elasticity has been successfully applied.

In addition, along with SAMG-ASC, the software can use advanced machine learning tools to choose between standard and aggregation-based AMG approaches and adjust parameters. This approach allows the software adapt autonomously to the specific application characteristics.

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