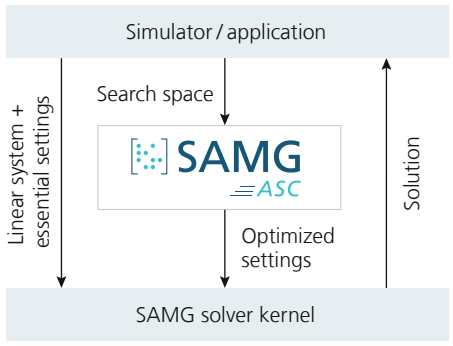
Fraunhofer SCAI

SAMG-ASC: machine learning based run-time optimization for the solver

Automatic setting of optimal parameters

SAMG-ASC extends SAMG with machine learning techniques to find optimal settings for an individual simulation run.

SAMG includes numerous linear solver procedures and algebraic multigrid (AMG) components. Hence, it is applicable to an extensive range of applications. However, an optimal set of parameters may be case-dependent and not straightforward to find.



Control-flow of SAMG-ASC

SAMG's Autonomous Solver Control module allowed us to robustly apply computationally efficient iterative solver methods in our battery aging simulations with our battery simulation studio BaSiS.“

www.battery-simulation-studio.com
Fraunhofer IEE

SAMG-ASC provides answers: needing only a search space for solver parameters for the type of application to be solved, the integrated machine learning techniques then optimize the settings. That optimization also accounts for parallel execution.

A fallback mechanism for robust applications

SAMG-ASC initially employs efficient solver settings that work well in most cases. At the same time, the control ensures that more robust fallback approaches are used if necessary: The solver can work as efficiently as possible while being as robust as necessary.

Controlling setup reuse

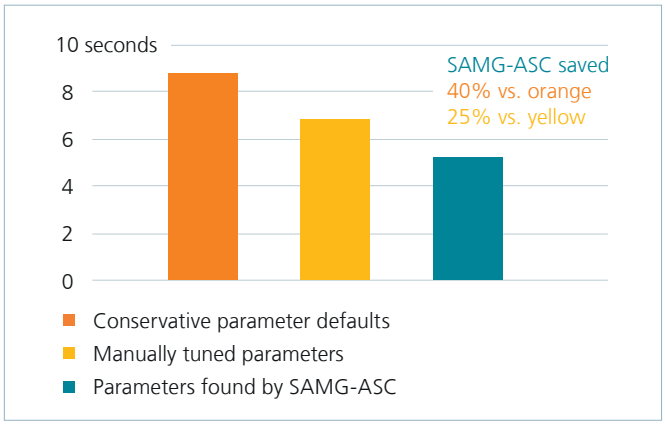
SAMG-ASC investigates whether AMG setups and preparations can be reused beneficially with a series of different but comparable matrices. Machine learning techniques are employed to control recalculations, while permanent monitoring ensures robustness.

Controlling all of SAMG

SAMG-ASC is compatible with the full set of SAMG features and other extension modules. This includes application with OpenMP and MPI.

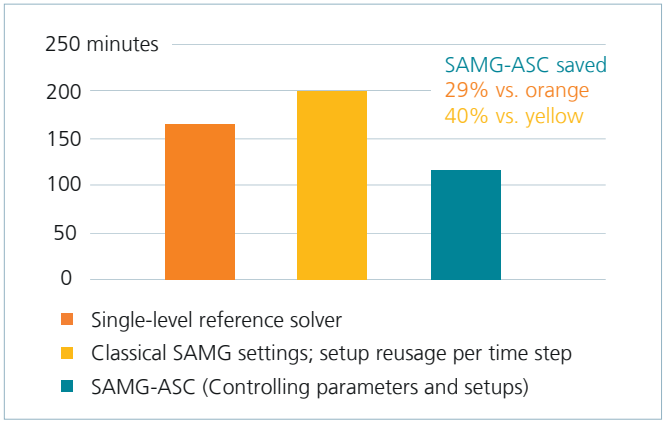
Automatic optimization – easy access

SAMG-ASC allows for an easy definition of a parameter optimization space using standard XML input. The learning machinery in SAMG-ASC then finds the optimal setting for a particular simulation, using online or offline training modes. In addition, the user can choose whether only run times count or reproducibility is an issue. A learning database optionally allows SAMG to exploit previous runs via a surrogate model. Finally, comprehensive convergence monitoring ensures the robustness of the solution.



Performance of different parameter sets with a reservoir simulation problem of 3 Mio DOF

Excluding the SAMG-ASC training time:
SAMG-ASC was rather used to initially parameters.



Full runtime, incl. SAMG-ASC, of a two-phase groundwater simulation with 552,600 cells

```
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   <param name="Smoother" mode=fix>
      <value val="Gauss Seidel">
   </param>
   <param name="ncg" mode=list>
      <value val="5">
      <value val="51">
   </param>
</method>
<method name="ILU(0)" class=ilu signature=202102221529>
   <param name="levelx" mode=fix>
      <value val="1">
   </param>
   <param name="smoother" mode=fix>
      <value val="ILU">
   </param>
   <param name="ilu0_single_prec" mode=list>
      <value val="0">
      <value val="1">
   </param>
</method>
```
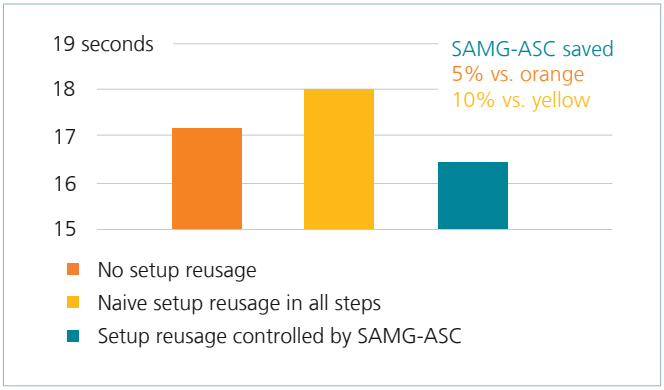

Controlling setup reuse automatically

The additional possibility of reusing solver setups within transient or nonlinear applications – across different time and linearization (Newton) steps – further reduces the computational effort for the linear solver. Similarly, machine learning methods evaluate whether the reuse or recalculation of a setup seems more suitable. Again, a monitoring mechanism ensures robust convergence through a new setup in cases of sudden changes in the application's matrix properties (e.g., arising from the modeled material properties or computational grid).



Cumulated solver runtime, incl. SAMG-ASC, with different setup reusage approaches for a reservoir simulation with 788,000 grid cells

Contact

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