MAC – Munich Centre of Advanced Computing
Computational Steering with Precomputed Simulation Data
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Abstract
With the ever-increasing complexity, accuracy, dimensionality, and size of numerical simulations, a step in the direction of data-intensive scientific discovery becomes necessary. Parameter-dependent simulations are an example of such a data-intensive task; the researcher changes essential parameters of a simulation and wants to immediately see the effect of these changes in a visual environment. The main goal here is fast exploration. We use the sparse grid method \cite{bun06} to sample such a multi-dimensional parameter space and obtain, by means of interpolation, data for not yet simulated combinations of parameters thus speeding up the exploration process.

Sparse Grids for Multi-dimensional Representation
We consider a parametrized simulation as a multi-variate function in several parameters \cite{but11}. We numerically represent such a multi-dimensional function with the sparse grid method. Once we have such a representation, we can evaluate the function at any point in its parameter space and, by means of interpolation, obtain simulation data for that combination.

ALGORITHM:
- sample: perform only a few simulations
- compress: obtain interpolation ready format
- extract: interpolate (clinearly) the values for unknown parameter combinations

Interpolate More Simulate Less

Interpolated Results

How do parameters influence vortex shape and position?

CFD: A Test Scenario
As a test simulation, we consider a well-known benchmark problem for viscous incompressible fluid flow, the lid-driven cavity. The geometry at stake is a square cavity consisting of three rigid walls with no-slip boundary conditions and a lid moving with a given tangential velocity $u$.

The movement of the lid drives the fluid which is stagnant at the beginning. With time passing by, this results in a series of vortices at several locations and with different rotation directions (center CV, bottom left BLV, etc.).

For the driven cavity scenario we consider three parameters:
- $u$ ... velocity of the moving lid
- $Re$ ... Reynolds’s number, viscosity of the fluid
- $t$ ... time passed in the simulation

Integrated Exploration Workflow
The presented method is integrated in a complete exploration workflow. A simulation can thus be investigated by a combination of precomputed simulation data and live simulation results.

Critical: fast algorithms are required to ensure the interpolation is significantly faster than performing the actual simulation \cite{mur11}.

Outlook
- more complex scenarios
- intuitive user interfaces (3D)
- automated point of interest detection

References
\begin{itemize}
\item \cite{but11} D. Butnaru, D. Pflüger, H.-J. Bungartz, Towards High-Dimensional Computational Steering of Precomputed Simulation Data using Sparse Grids. ICCS2011.
\end{itemize}