Fully automated simulation and optimization process for CAE applications

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Agenda

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Motivation

• Reduction of prototypes in development process
• Hardware in early phases of development process not available
• Reduction of measurement time in costly measurement devices (e.g. wind tunnels)
• Deeper insight in physical phenomena
Optimization – Basic Needs

Main Steps of the Optimization Process

1. Fully automated simulation process for every application
2. Parameterized input data
   (numerical values or parameterized geometry)
3. Optimizer or DOE (Design of Experiments)
   (control of parameter variations)
4. Post-processing of Results

The importance of the different steps is decreasing from 1 to 4. For example, it is not necessary to define a DOE when the simulation process at hand is not fully automated.

The most important and most time consuming step is the definition of the parameters including their variation range as well as the target value.
Optimization - Challenges

• Definition of parameter range

• Fully automated simulation process
  • Control of input parameters
  • Automated post-processing of target values

• High robustness of simulation process
  • Huge amount of data (memory requirements, data transfer)
  • Huge amount of simulations (availability of CPUs)
CAE-AutoWorkflow

OptiSlang

Parameter setup → Geometry creation → Meshing → Simulation → Post-processing

Geometry creation → Meshing → Simulation → Post-processing

Sensitivities Optimum

Application: Aerodynamics

Software-Tools:
CAE-AutoWorkflow

workflow = ansa_combine,GenerMesh,sim
casename = Aero_Test
starccm_version = 9.04.009
...
[sim]
type = starccm_generic
input = VolMesh.sim
result_file = VolMesh_Result.sim

Input-File

Daimler AG

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Example: Truck Aerodynamics

- **Computing Mesh:**
  - 100 million computational cells
  - Computational domain: \( l : b : h = 115 : 90 : 36 \text{ m} \)
  - Size of result files: 60 GB

- **Resources:**
  - Pre- / Post Processing: min. 200 GB memory
  - Per simulation about 2 days on 400 cores
  - 9 parameters: 200 CFD runs
  - **Total amount of data per sensitivity analysis:** approximately 8TB
Analysis in Meta-Model

- In the meta-model relationships can be analyzed in real time and discussed in the development team
- Determining optimum

- The above sensitivities are only valid for exactly one parameter combination
- With the postponement of a parameter, all other functional relationships change
Example: Passenger Car Aerodynamics

Sensitivities

Optimal Shapes

Example: Passenger Car Aerodynamics

Morphing

Optimal Shapes

Example: Passenger Car Aerodynamics

Sensitivities
Conclusions and Future Work

• CAE-AutoWorkflow successfully implemented
• High robustness of simulation process
• Highly appreciated insight in parameter sensitivities
• Extension to more applications ongoing