SimExplore – a tool developed by Fraunhofer SCAI to support CAE engineers in product development and make their daily work much easier

We employ state-of-the-art machine learning methods adapted to CAE data. The SimExplore workflow consists of two steps, where an offline batch process is followed by interactive exploration and analysis. The approach is available as a standalone tool and is designed for integration with other software clients.

SimExplore provides for a set of simulations

- an automated process to detect the most affected parts,
- an automatic identification of clusters, which are simulations that behave similarly,
- an automatic determination of outliers, which are simulations that behave very differently,
- an interactive visualization for many simulations,
- an interactive inspection of design variations.

Most affected parts

In the SimExplore workflow one can first optionally use SCAI's SimCompare to compare all simulations with a reference simulation. This analysis, which determines changes in the behavior of deformations or other mesh functions, is performed on all the parts. The most affected parts across all the two-sided comparisons can be collected according to a user-defined threshold and then selected for further analysis. Alternatively, user selected parts can be included in the analysis.

Geometry-driven representation

We use our specially developed, patented dimensionality reduction technique to compute geometry-driven features representing displacements or mesh functions of the selected parts. Using these geometric features, a clustering algorithm is applied to identify clusters, and outliers. Since the geometric

features depend only on the geometry, they can be used for comparative analysis starting from two simulations, which is a significant advantage over other machine learning approaches.

Simulations or parts with the largest deviations

To further automate the process of identifying exceptions, an outlier score is calculated for each simulation. The outlier score is mainly based on the distance of the simulation from the cluster mean with respect to the deformations or other selected mesh functions. After an aggregation over all time steps and a normalization, the outlier score allows a ranking of the simulations with respect to their deviations from the other analyzed simulations. In addition to a score per simulation, we developed a component score that helps to find patterns in the deviations per component across all simulations and all time steps.
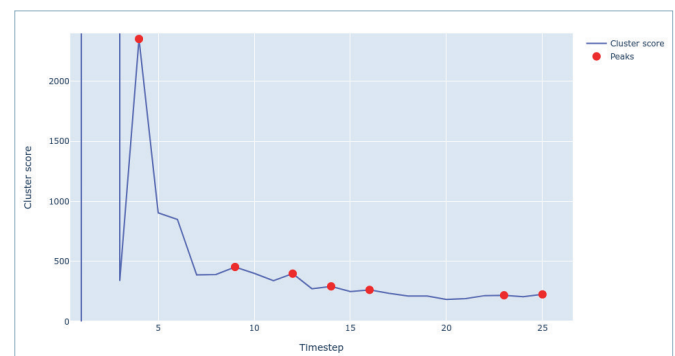
An optimized representation per part and time step that gives the best separation into clusters is automatically determined. Based on this, a score is obtained that highlights to the engineer interesting time steps for similarity analysis.

An exploration of many simulations and a fast 3D preview is possible with our dimensionality reduction methodology. Such a representation assists in clustering many simulations or detecting outliers, allowing a significant speed-up in the CAE post-processing.

Interactive exploration

The interactive SimExplore component allows the user to seamlessly analyze different parts or part combinations. The visual representation of the simulations as points in a scatter plot provides an intuitive overview of the similarities and exceptions with respect to the chosen functions. Users can select any function and parts for detailed interactive analysis. Clicking on a simulation quickly displays the corresponding part and mesh function in a 3D preview, allowing an easy-to-use exploration of the simulation results. Additional information for a given simulation or part can be interactively accessed, including a direct link to the GNS Animator.

Design variations

SCAI's ModelCompare identifies the changes in a given model compared to a pre-selected model, e.g., the reference or the predecessor. These design variations can also be explored in the interactive part of SimExplore, providing a holistic approach for evaluating the consequences of design measures.

Batch data processing and interactive analysis

The workflow is divided into a computationally intensive non-interactive part and an interactive exploration part. The batch processing involves, for example, the determination of the most affected parts, the computation of the geometry-driven data-representation or the pre-computation of additional information for later visual exploration. Additionally, new simulations can be added to an existing explorative analysis with low computational effort. SimExplore's workflow steps can work independently or be integrated into any simulation data-management system.

User benefits

Overall, SimExplore provides an automatic identification of clusters and detection of outliers, combined with a rapid visualization and interactive analysis for many simulations. The ability to interface directly with the preferred post-processor eases the detailed analysis of identified special simulations. The calculated similarity information enables an overview of many simulation results, where the integration of model variations allows the inspection of corresponding design changes - a breakthrough in the way post-processing and simulation analysis can be performed.

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SimExplore