Evendetection
Detect and Search Deformation Patterns.

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Abstract

To cope up with the ever growing amount of simulation runs being performed, tools and techniques are needed to make use of the huge amount of simulation data being stored. While current Simulation Data Management systems and the IT infrastructure already allow storing and accessing huge datasets and would facilitate putting this into action for analysis, the users usually only have tools and the time to make rather straight forward model to model comparisons, between current model versions and their immediate predecessors. To take analysis capabilities and model development a leap forward, it is necessary to also make use of whole model development branches to learn from the gathered simulation information.

Making use of the Principal Component Analysis, a dimension reduction algorithm out of the unsupervised learning techniques, a new database was developed. Continuously being fed with new simulation runs, this database now enables us to automatically detect unknown behaviour in the most recent simulation runs compared to all predecessors at a time. To achieve this, the database does not only need to store and detect every new deformation pattern, but in addition several obstacles like a mapping between different simulation models, a performance efficient database format and a technique to also detect local effects had to be addressed. All these developments now make it possible to automatically detect anomalies/outliers within the crash deformation behaviour, pinpointing exactly to the location in space and time where the model is showing unknown or unwanted deformation patterns. While in daily work the engineer often only has time to compare single simulations with each other, this approach shows how to compare the current simulation with hundreds of predecessors at a time.

In addition to this automatic detection of new crash patterns a second application becomes possible: The search for deformation patterns. Thus the engineer can interactively ask the database, whether or not the behaviour of certain parts has already shown up in any of the simulations in the database before. As an outcome he will also see which of the runs have a rather similar behaviour and which are different. Also time-shifted events can be seen, as the search does not only compare deformation patterns of a single time step, but instead does a comparison of all states among all simulation runs to give the engineer the best insights possible. Thus we are able to incorporate complete

development branches into the daily engineering process and provide a tool to the engineer, to exploit all related simulations.

1. Compressed Analysis Database

In order to make use of all simulation results during model development a compressed database has to be deployed which grants access to every result also at a later stage of development.

We investigate a set of 50 LS-DYNA simulations of a sensitivity analysis for the model “Chrysler Silverado” [1], with 152 timesteps each. The original size is 452.7 GB. With our compression tool FEMZIP-L [2] applied on each simulation result individually, we can reduce the data size to 7.1 GB. Considering also dependencies between simulation results, we achieve with our compression tool SDMZIP-L [3] a compressed size of 1.4 GB. Exploiting the similarities between simulation results improves the compression efficiency by a factor of 5.1.

Making use of the similarities between the simulation results during the development phase therefore allows for a higher compression, which was the initial enabler for the development of Eventdetection.

2. Mapping

One of the biggest challenges next to compressing data is the actual mapping between simulations to make analysis possible over the whole development branch. Some of the challenges to cope with during the model development process are e.g. PID changes, altered parts, different meshes, additional parts and many other part changes, without losing relationship between predecessor parts.

To do so a sophisticated mapping approach between the simulations has been developed, in which groups of parts are treated together. These form components to be used for the mapping procedure. Compared to single PID mapping this allows to cope with the above mentioned challenges.

3. Eventdetection

The tool Eventdetection was developed with the emphasis to automatically spot unknown behaviour in new simulation runs. It allows detecting new behaviour/events within the current simulation compared to all predecessors and automatically raises this to the engineer.

4. Eventscore

The before mentioned detection of new events is based on a PCA related outlier score computation. This results in an event score in the range from [0:2] for every part and time-step, defining how much of an unknown behaviour this event represents. This also gives feedback to the engineer right away about how strong the outlier is, depending on the value of the event score. A score below 1 represents known behaviour, while scores above 1 represents unknown behaviour. The higher the score, the stronger the outlier.

With respect to the challenge of analysing crash structures it is mandatory to not only highlight complete parts which are conspicuous, but also the local segment of the part which showed the behaviour, which is why internally Eventdetection splits parts into fragments to also support a high geometrical resolution and detect local events. Additionally, next to the geometry also all post-values, as e.g. strains and stresses, as well as failure are being analysed.

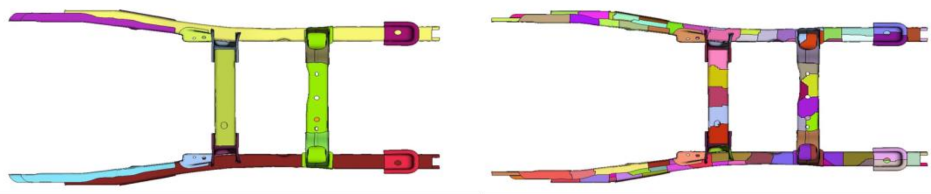

Figure 1: Part decomposition to detect local events. Geometry taken from the example case: Chevrolet Silverado [1]

To not only detect single part differences the event computation incorporates an event clustering. Based on the neighbourhood and the propagation of the deformation, parts are clustered together, forming Events which also represent the propagation over time and space.

5. Example Case

A detailed robustness analysis [4] with our tool DIFFCRASH [5] of a set of simulation runs from the Chevrolet Silverado [1], based up on thickness variations in the range of [-3;3] % , showed a clear bifurcation. While for some simulation runs the break-booster hooked up to the suspension, being pushed into the firewall, for others there was no such hook-up. Therefore the test scenario shown here consists of a set of simulation runs with similar behavior of no hook-up and a newly analyzed simulation containing the hook-up.

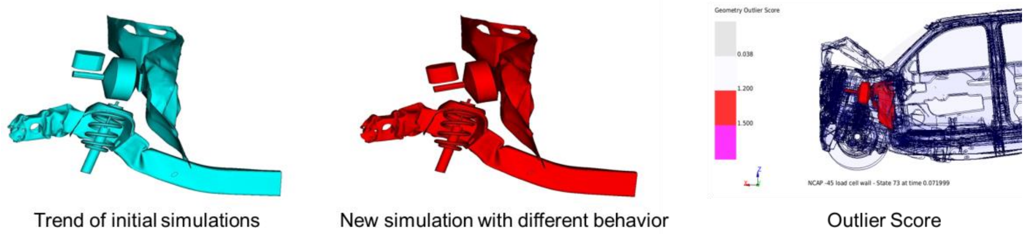

Figure 2: Detection of different deformation patterns in a crash scenario.The outlier score automatically detects and highlights the arae with new behaviour

6. Summary

In this abstract we illustrated how the tool Eventdetection can automatically spot and highlight new behaviour. A compressed database with a sophisticated mapping approach is the enabler to analyse new simulation runs against all predecessors and highlight unknown behaviour to the engineer automatically.

7. References

[1] NHTSA, *Chevrolet Silverado*, https://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/Mass-Reduction-Feasibility-2014-Silverado.zip (accessed 01/25/2023).

[2] SIDACT GmbH, *FEMZIP*, https://www.sidact.com/femzip (accessed Jan. 25, 2023).

[3] SIDACT GmbH, *SDMZIP*, https://www.sidact.com/sdmzip (accessed Jan. 25, 2023

[4] D. Borsotto, R. Strickstrock, C. A. Thole, *Robustness analysis - Significant reduction of scatter occurrence*, presented at NAFEMS Seminar: Optimization and Robust Design, *March 23-24, 2015*

[5] SIDACT GmbH, *DIFFCRASH*, https://www.sidact.com/diffcrash (accessed Jan. 25, 2023