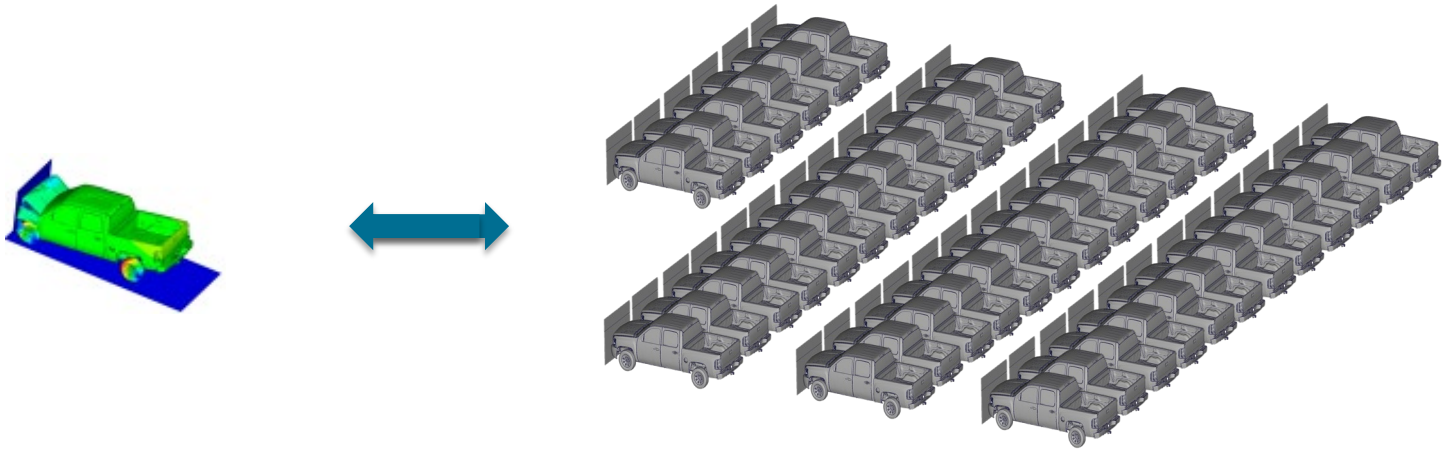
Application of Machine Learning to Automatically Compare Sets of Crash Simulation Results



N. Abdelhady, D. Borsotto, V. Krishnappa, S. Müller, K. Schreiner, C.-A. Thole, T. Weinert

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Simulation Data Analysis and Compression Techniques

FEMZIP – Compression of simulation results: CFD, CRASH, NVH

SDMZIP – Compression of sets of simulation results

DIFFCrash – Robust Design: Identification of areas in geometry causing scatter of simulation results

FemAIyst – Applications of AI in Crash

- Fraunhofer SCAI Spin-off starting January 1st 2013
- 10 full time, 5 part time

Bonn

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Introduction

FemAlyst

DiffCrash

Workflow

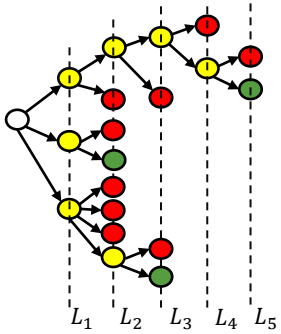
Use case

Event search

Introduction

Development Tree

- Contains Several branches
- Includes dead nodes
- Intermediate design changes
- Branches run several levels deep

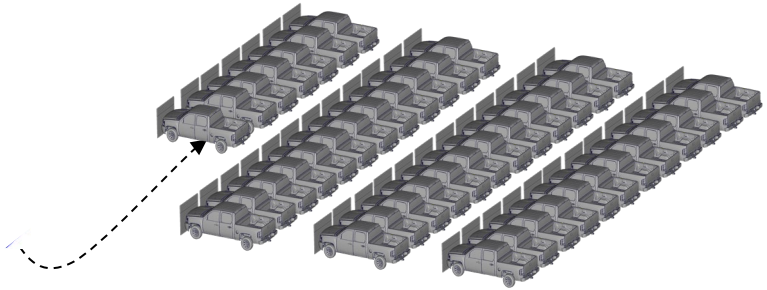


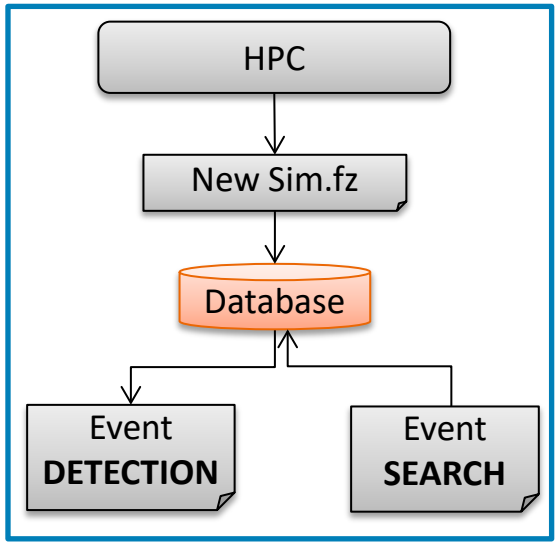
- ➢ Predecessor/Pair-wise comparison – Insufficient
- ➢ Carry forward insights

Our Solution: FemAIyst + DIFFCRASH

Introduction

Database





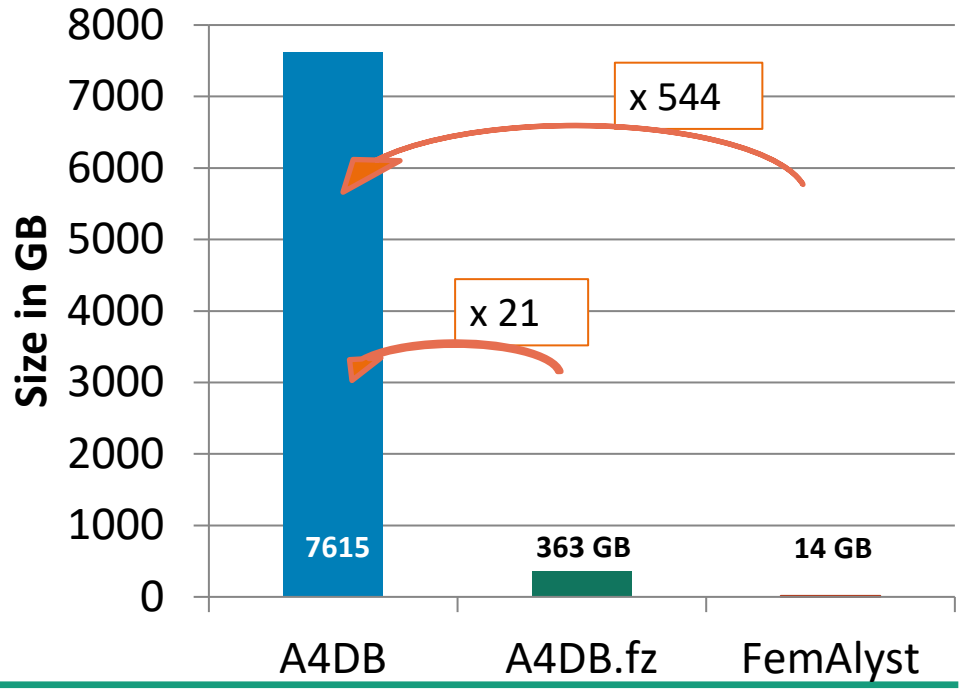
- Incremental
- Compact
- Scalable
- Shared

FemAlyst → Event Detection

Introduction

Database: OEM data set

- 518 A4DB full-vehicle crash runs
- 352 Side crash cases
- 166 Pole crash cases
- ~ 5 Million nodes per model
- 64 variables
- 14 variables analysed



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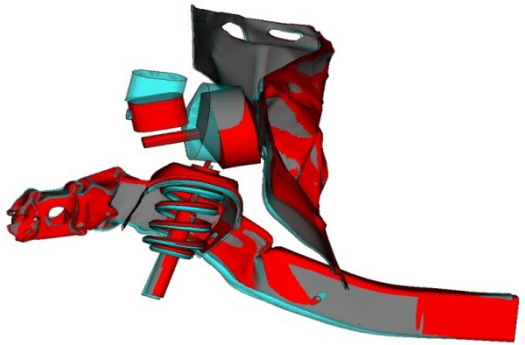
Event Detection

Definition

- What is an Event
    - Unknown/Unwanted behaviour

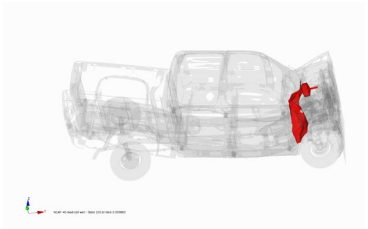
- An Event mainly consists of:
    - Location
        - List of involved parts and time steps
    - Outlier Score
    - History
        - List of previous simulations
    - Event type (Geometry or Post-Value)

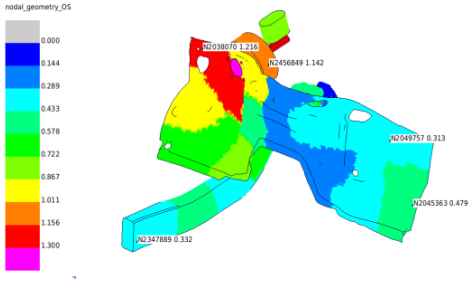


Event Detection

Functionality

- Automatic Event Detection
- Spot behavioural anomalies
- Highlights unseen behaviours – Events
- Precise location & timespan
- Magnitude of „outlierness“
- Rank Events



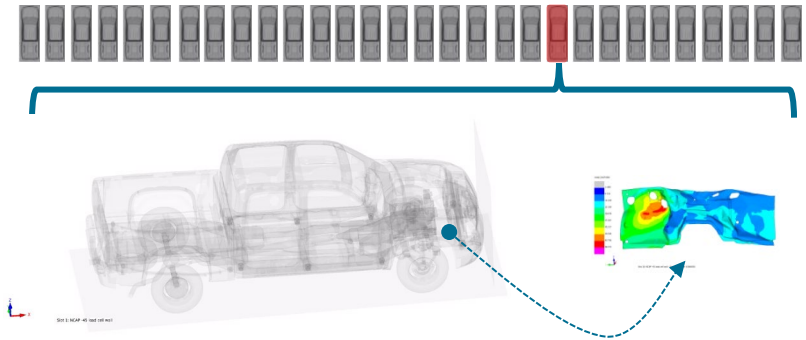


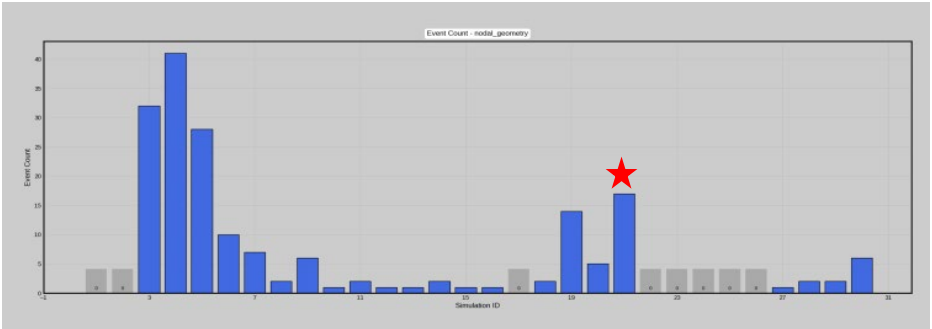
Event Detection

Functionality

FemAIyst

- Event propagation
- Distance to reference
- Comparison to all predecessors
- Analysis on all post values





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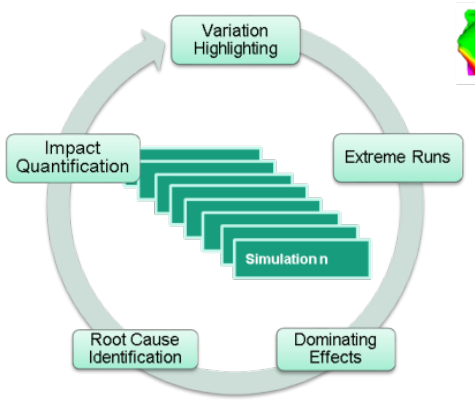
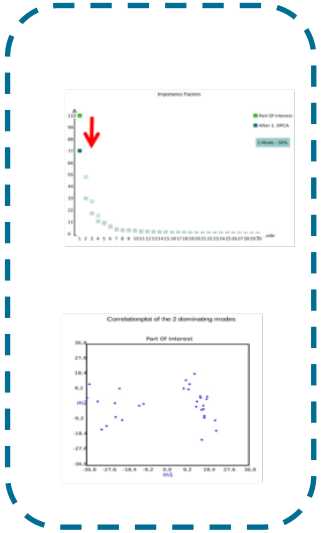
DIFFCRASH

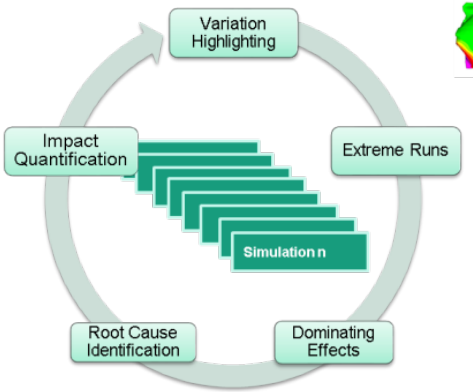
- DOE based subset
- Robustness Analysis
    - Variation
    - Extreme runs
    - Dominating Effects

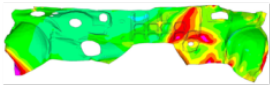


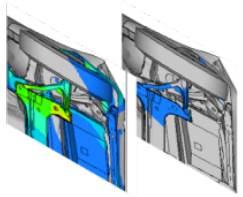
DIFFCRASH

- DOE based subset
- Robustness Analysis
    - Variation
    - Extreme runs
    - Dominating Effects
    - Root cause
    - Impact Quantification



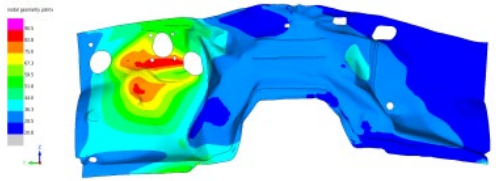


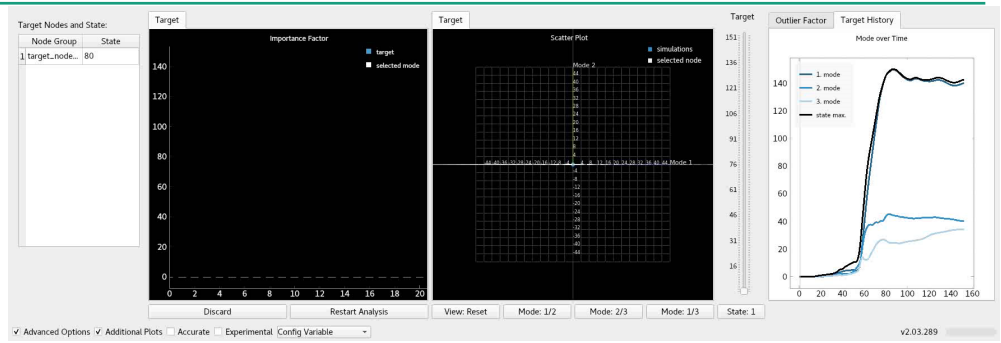




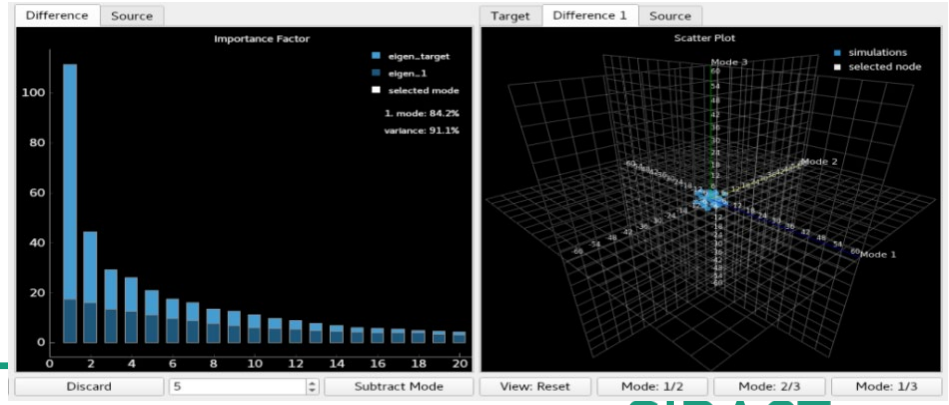
DIFFCRASH

Impact Quantification (PCA)





Cause correlation (DPCA)



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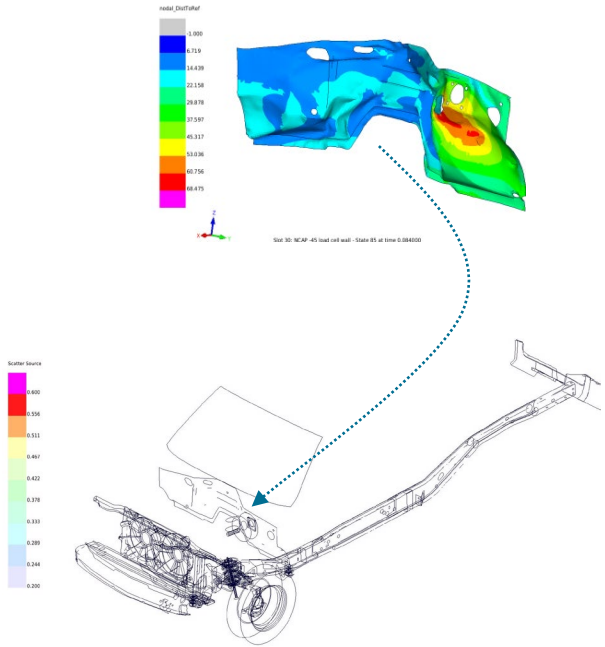
DIFFCRASH

Cause correlation

- Interactive Analysis possible
- Automatically identify root cause
    - Pair-wise correlation computation
    - Empirical
- Correlation Quantification – Scatter score



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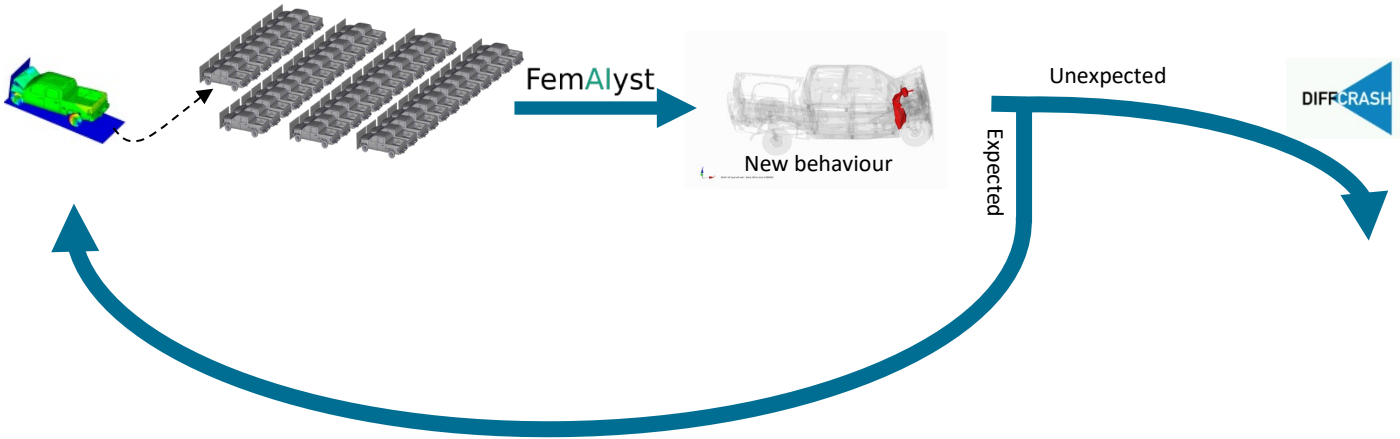
Workflow



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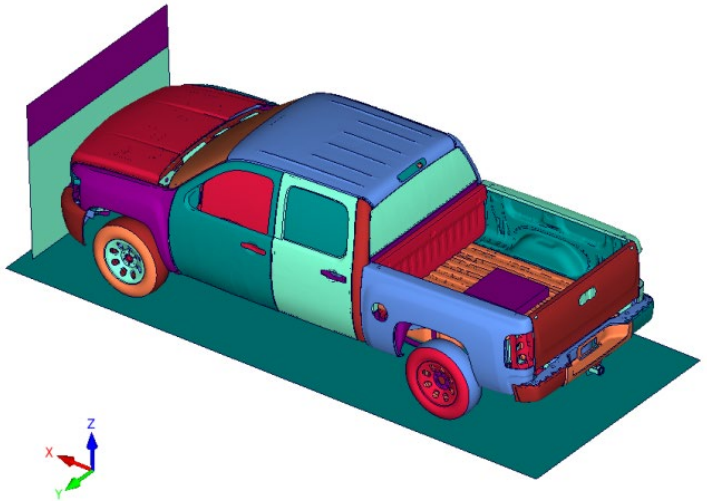
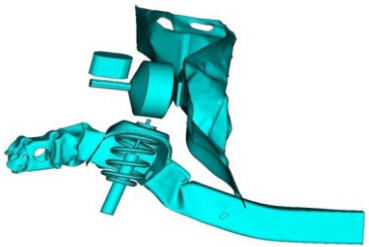
Evaluation Case

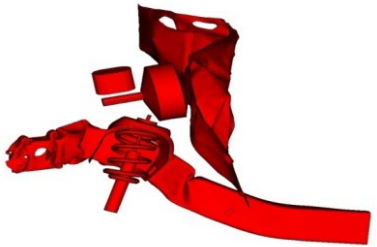
Model	Chevrolet Silverado*
Year	2007
Number of Parts	679
Finite-Elements	929,131

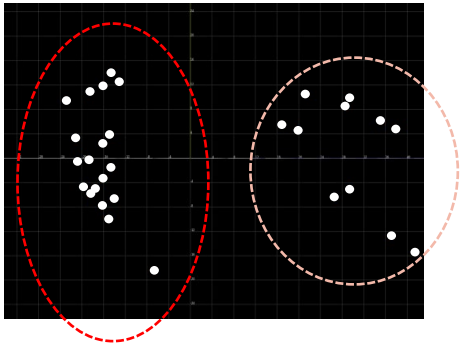


*The model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT“ http://www.ncac.gwu.edu/vml/models.html

Ground Truth



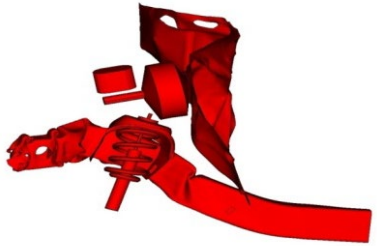




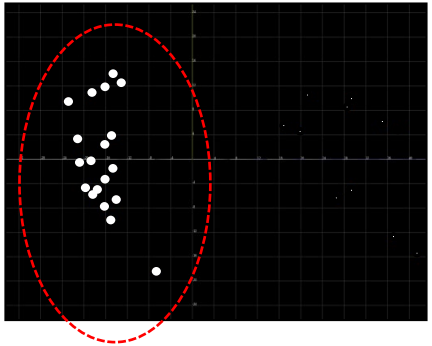
DIFFCRASH - Scatter plot

Bifurcation – Hook Up vs No Hook Up

Test case

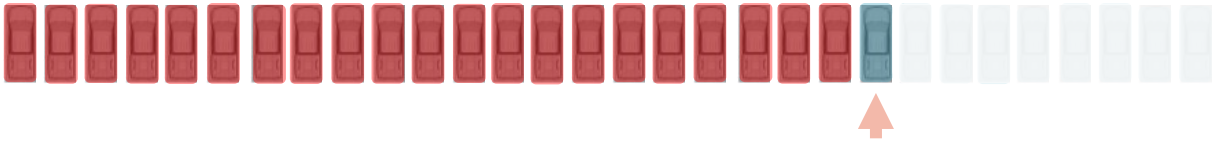


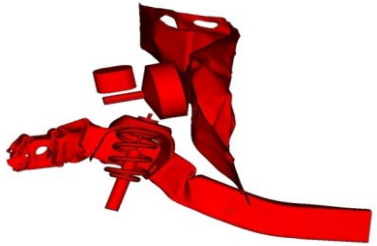
Deformation trend in archived simulations



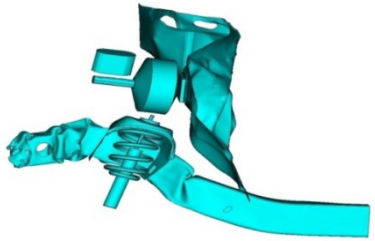
DIFFCRASH - Scatter plot

Test case

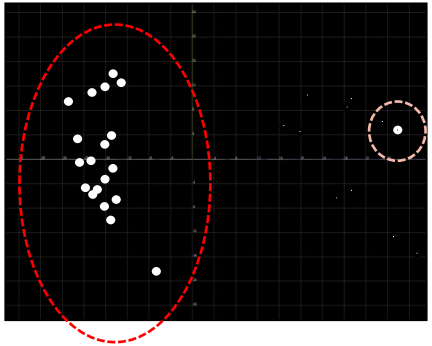




Deformation trend in archived simulations



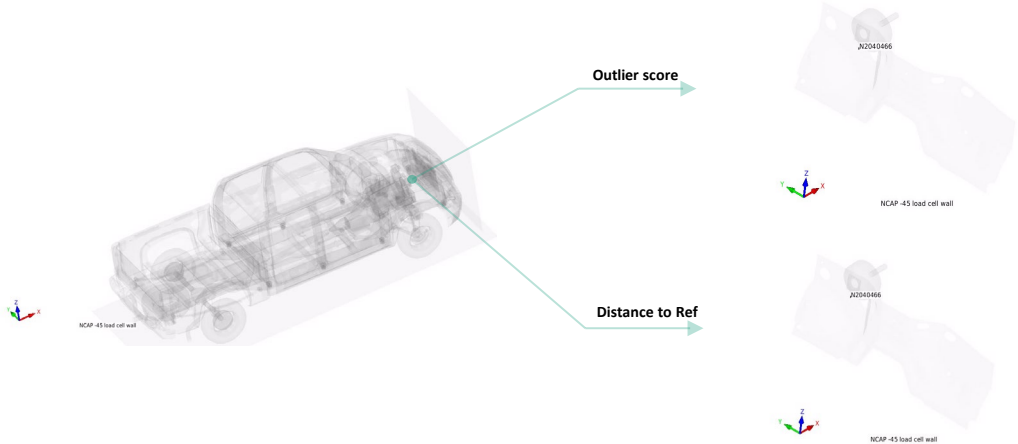
Deformation in the appended simulation

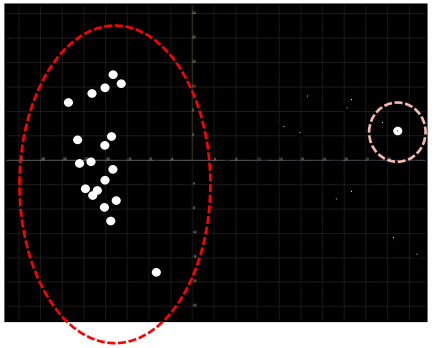


DIFFCRASH - Scatter plot

FemAlyst

FemAlyst





DIFFCRASH - Scatter plot

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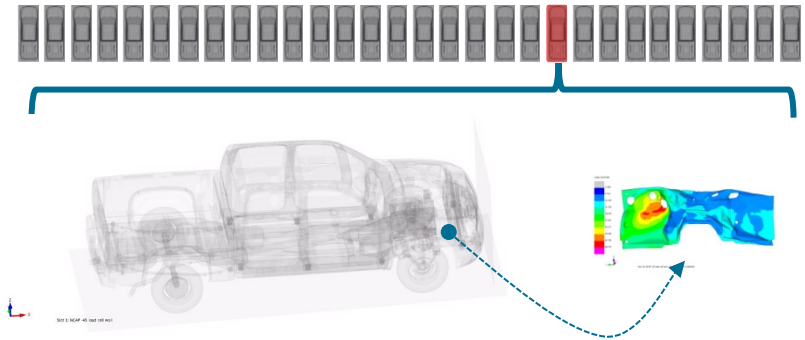
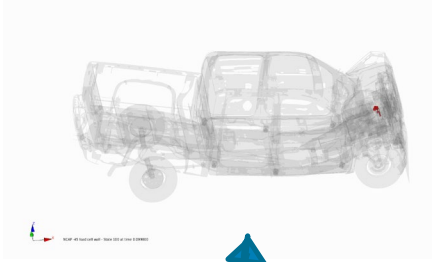
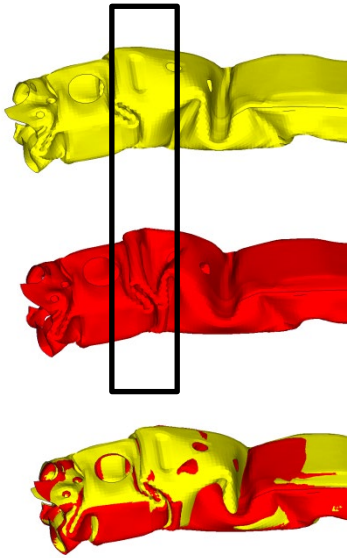
FemAlyst

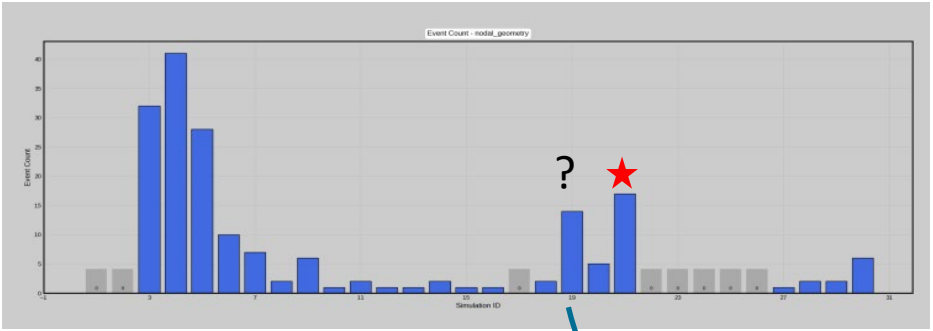
Number of raised events

FemAlyst









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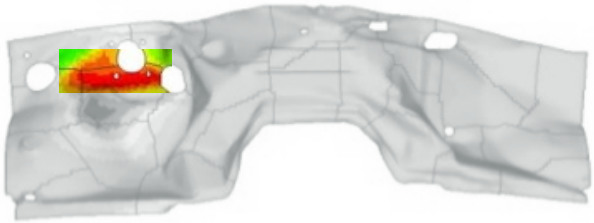
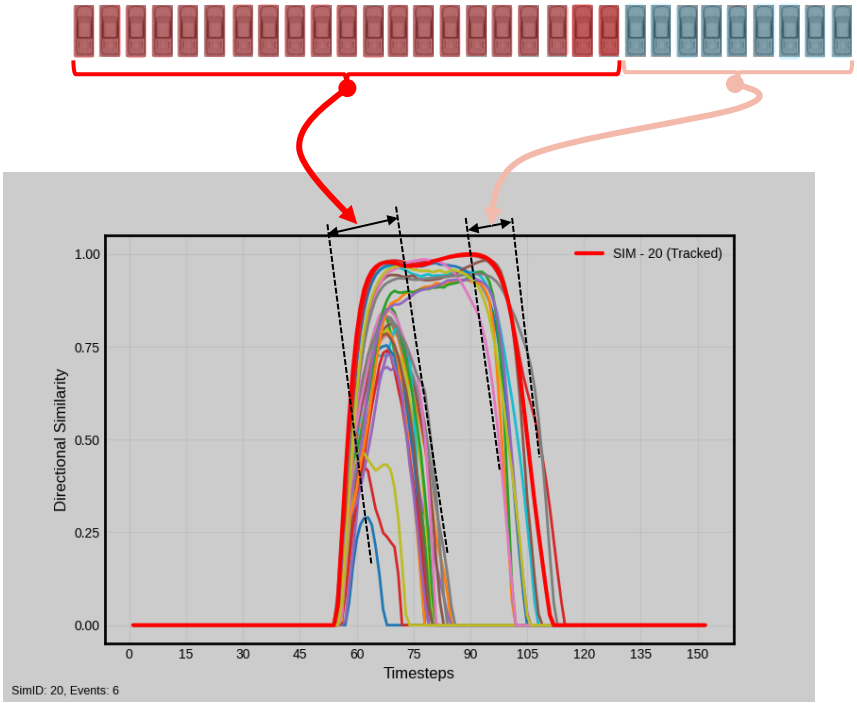
Event Search

FemAIyst

- Search Database for similar behaviours
- Based on a similarity measure
- Interactive search
- Fast





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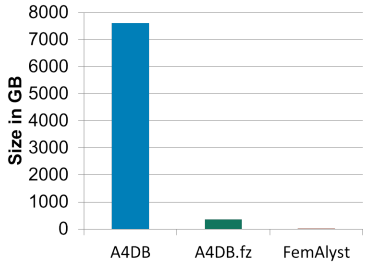
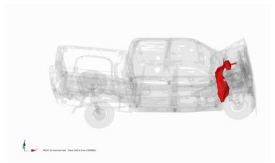
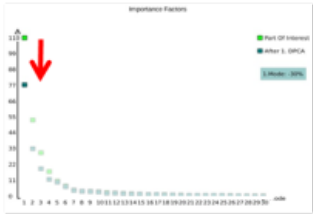
Summary

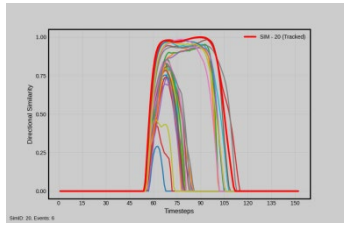
Applied Machine Learning Techniques for:

- Creating a compact database
- Event Detection
- Cause Correlation
- Searching for similar crash patterns

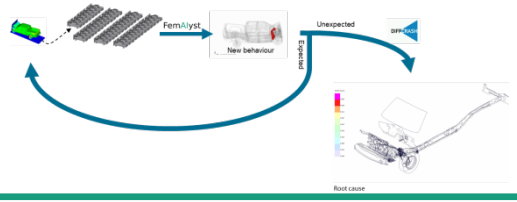








Highly automatized process



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Thank you for your kind attention!

Stefan Müller
Stefan.mueller@sidact.com
www.sidact.com