Machine Learning Tools for accelerating CAE and unleashing Design Exploration

physics on screen

Challenges

more complex phenomena, more physics, more Optimization, more design iterations

costly FE Analysis of multi million element models

complicated Data Management and design exploration

Benefits

speeding up CAE simulation through simulation results prediction

speeding up Optimization through machine learning Response Surface Models

benefit from history data using them for ML training

speeding up CAE modeling through ML assisted clips recognition

streamlined data handling

ML solutions

Optimization Tool DOE in DM

KOMVOS Data management and design exploration

easy to use Machine learning tools

coupled Data Analytics Technics and Simulation Data Management

API for customization and automation

Remote ML training and prediction

ML solutions

a unique Feature Based ML for elastic and local modes prediction

a unique mode classification ML for mode shape type prediction

data driven ML for key values, curves and 3d simulation results prediction

Feature Based

General information

A unique "cross-model" approach (i.e. not parametric) that can generalize

Inputs:

- Geometric and engineering features extracted from CAE data.
- Labeled responses

Supports only scalar / 1d outputs (e.g):

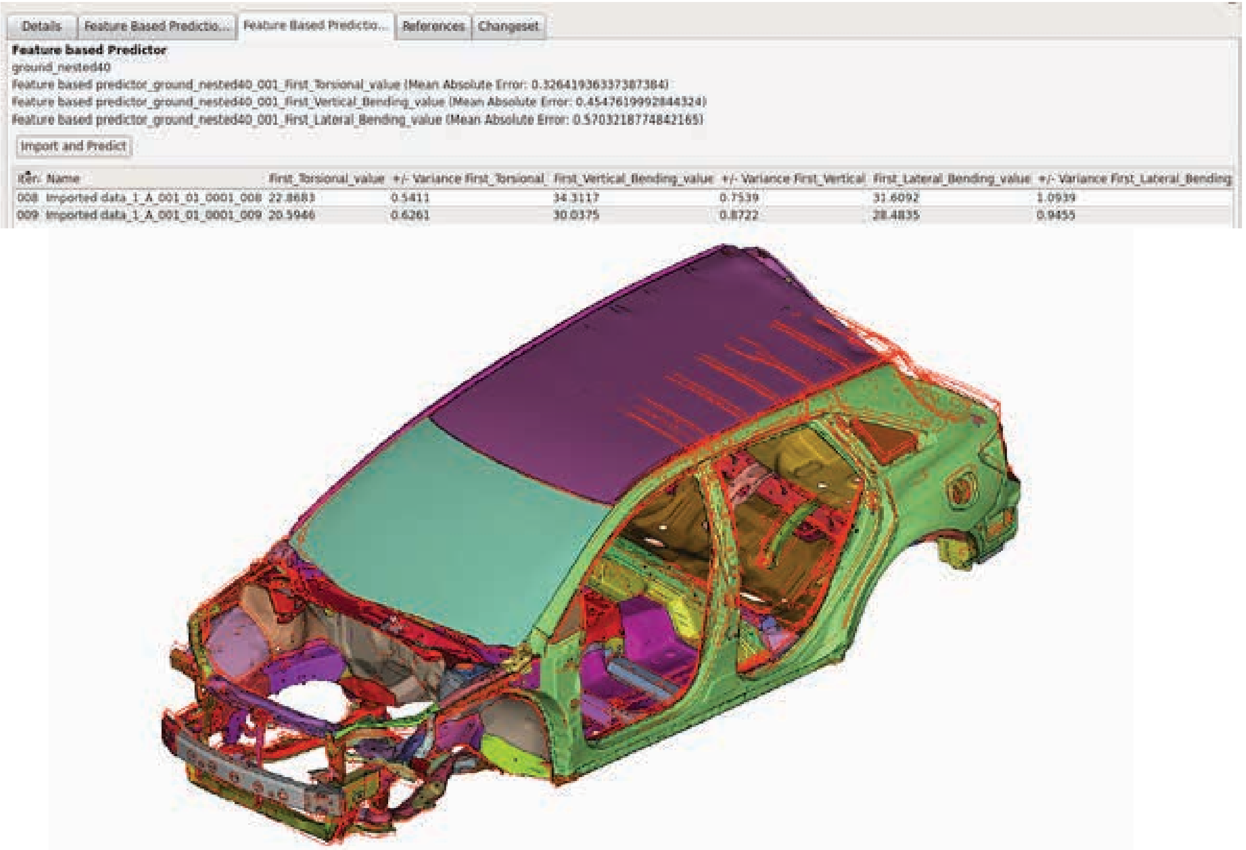
- First torsional mode
- First Vertical Bending mode
- First lateral Bending mode
- Local modes

Feature Based

Predict Elastic modes for Simulation Runs

KPIs

- Accuracy vs Datasize
- Target vs Prediction
- Residuals
- Confidence



Feature Based

Predict Elastic modes for Simulation Runs

Elastic and local mode values prediction

Load case

✓ 103 Normal modes Analysis

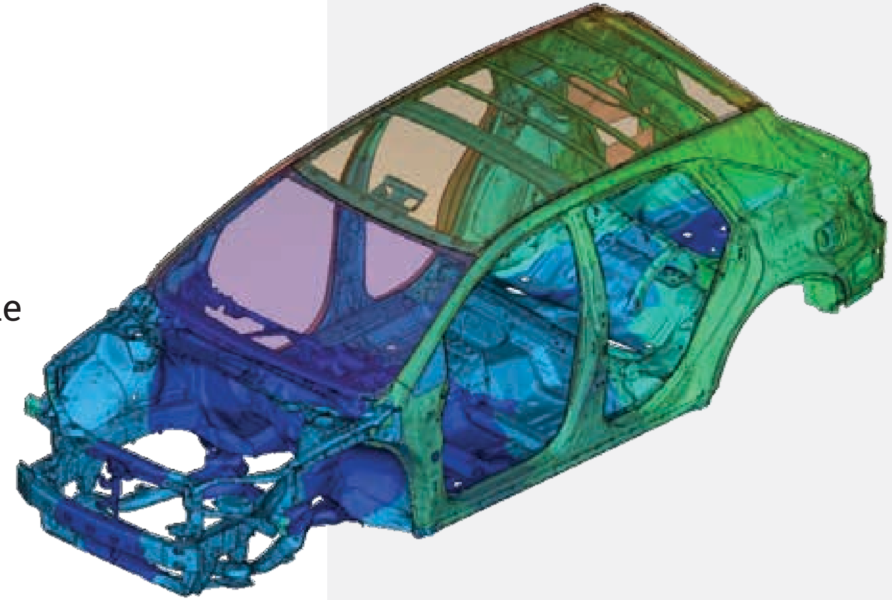
Modes

- 7 • 30.321 Hz
- 8 • 32.411 Hz
- 9 • 33.595 Hz
- 10 • 34.096 Hz

First Torsional mode

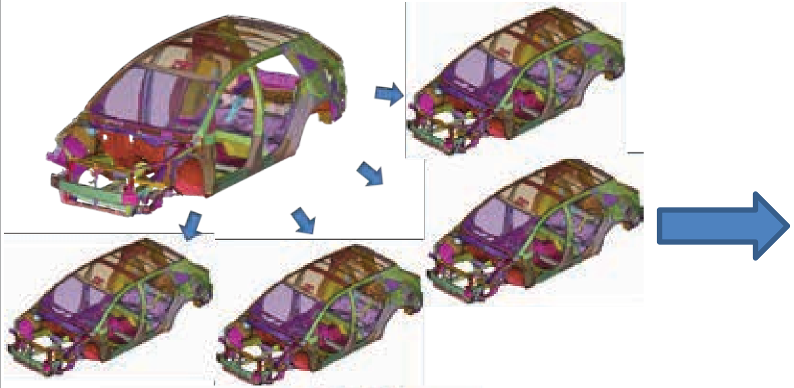
Vertical Bending mode

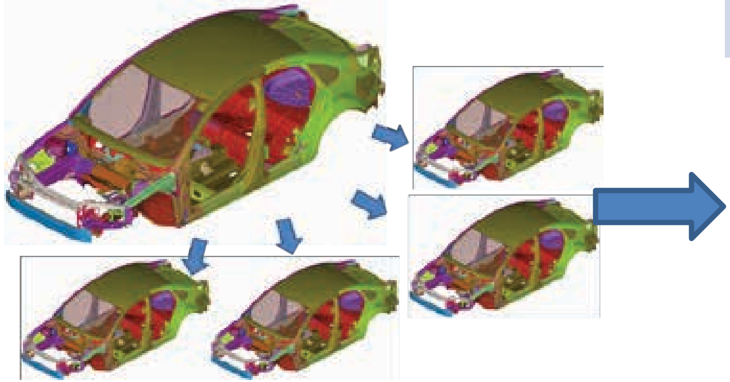
Feature Based Application



Elastic and local mode values prediction

Dataset Creation with ANSA Optimization Tool





Feature Based Application

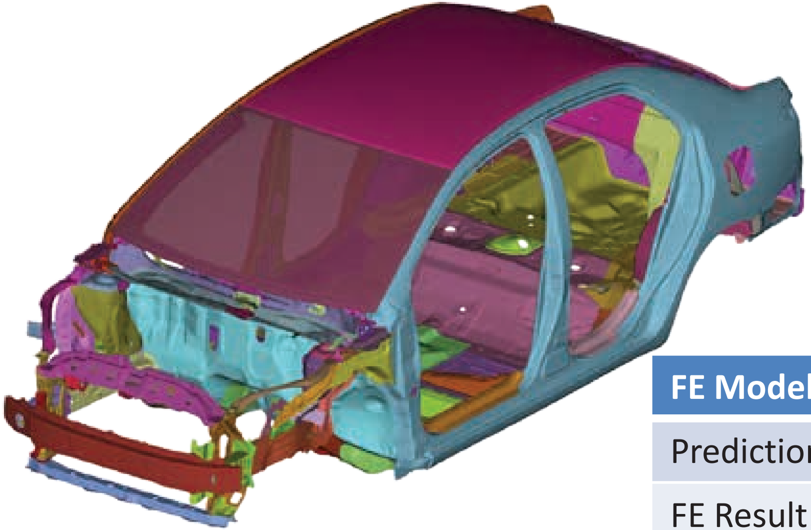
ML Training Dataset

FE Model	First torsional value (Hz)	Vertical bending (Hz)
Sim Run 1	32.411	38.492
Sim Run 2	34.096	39.123
…	…	…

FE Model	First torsional value (Hz)	Vertical bending (Hz)
Sim Run 1	30.123	36.893
Sim Run 2	32.321	37.923
…	…	…

Elastic and local mode values prediction

“Unseen” data elastic mode prediction



Feature Based Application

FE Model	First torsional value (Hz)	Vertical bending (Hz)
Prediction	39.74	40.88
FE Result	39.73	40.78
Abs Error	0.01	0.1

Mode Classifier

General information

“Cross-Model" approach (i.e. not parametric) that can generalize. This classifier is able to Predict the mode-shape types of FE models

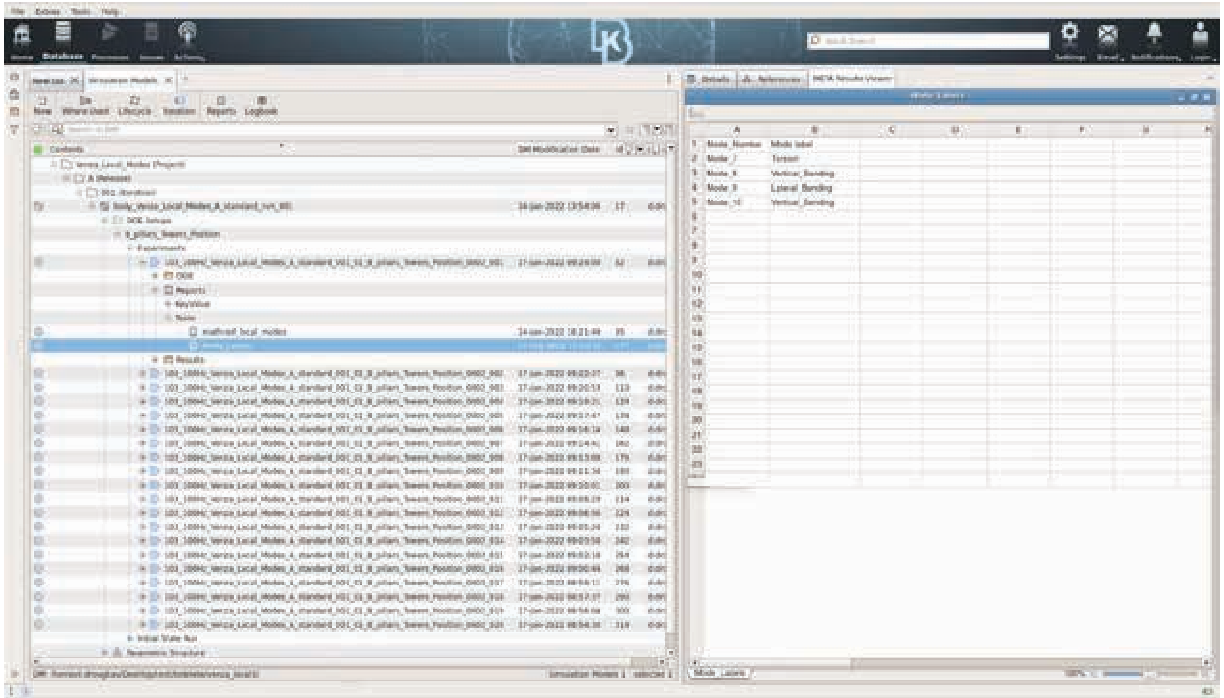
Inputs:

- Normal modes result files of FE models
- Classification

Supports 1d outputs (e.g):

- Mode shape types like Torsional, Bending, Lateral, etc.

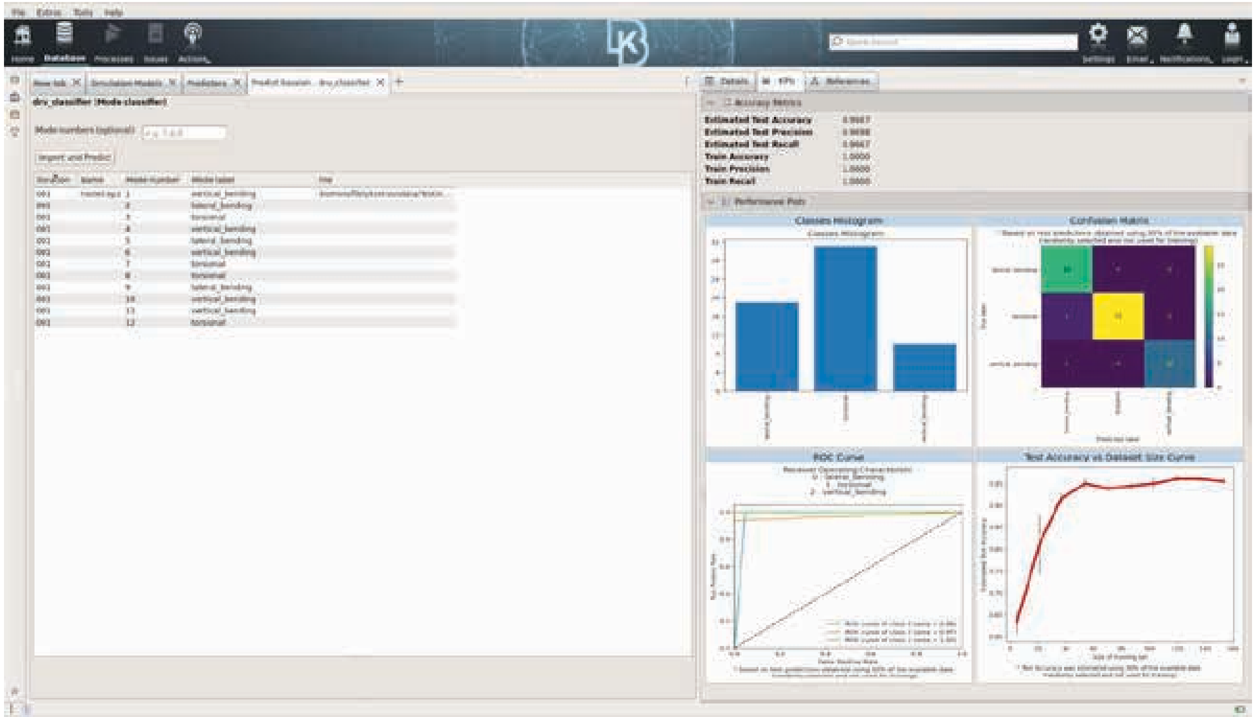
Mode-shape type classification training



Mode Classifier

Imported data with labeling

Mode-shape type classification prediction



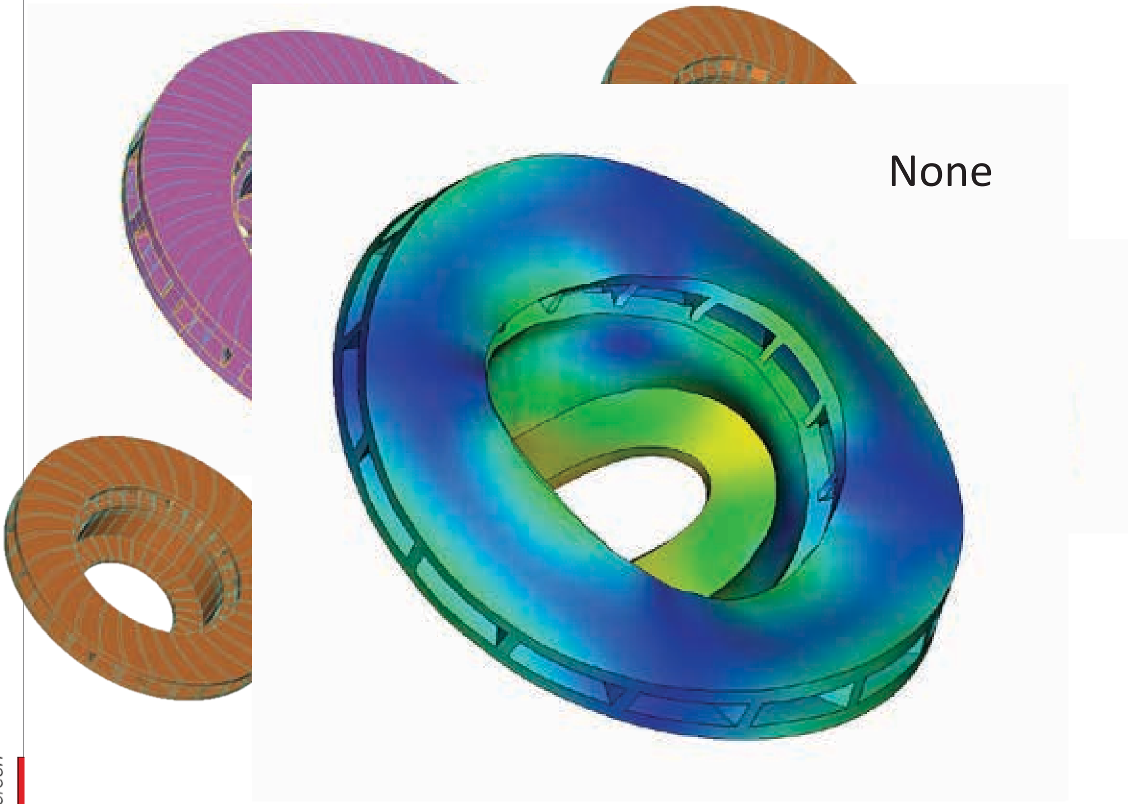
Mode Classifier

Mode shape type
Prediction

KPIs

- Classes Histogram
- Confusion Matrix
- ROC Curve
- Accuracy curve

Disk Brakes mode classification

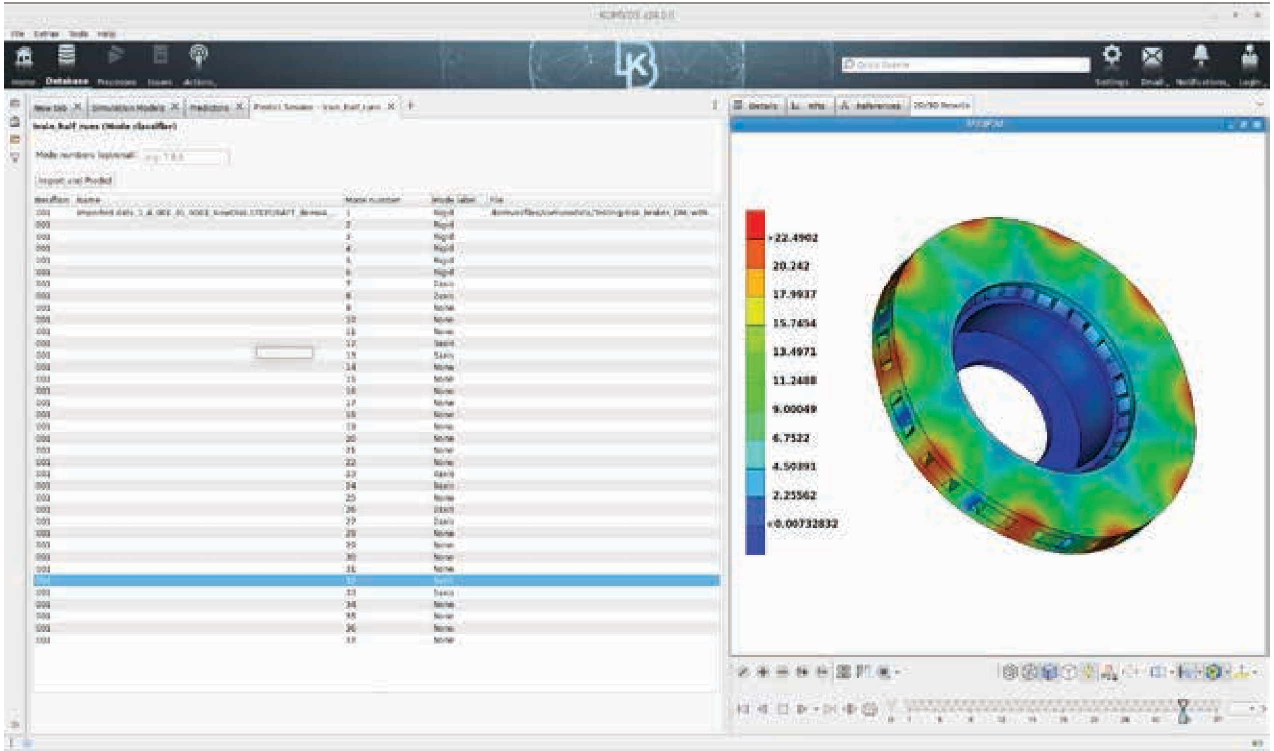


Mode Classification Application

Data set creation

Mode shape labeling

Disk Brakes mode classification



Mode Classification Application

KOMVOS Data view

Mode classifier with KPIs

Prediction

Design Variable Based

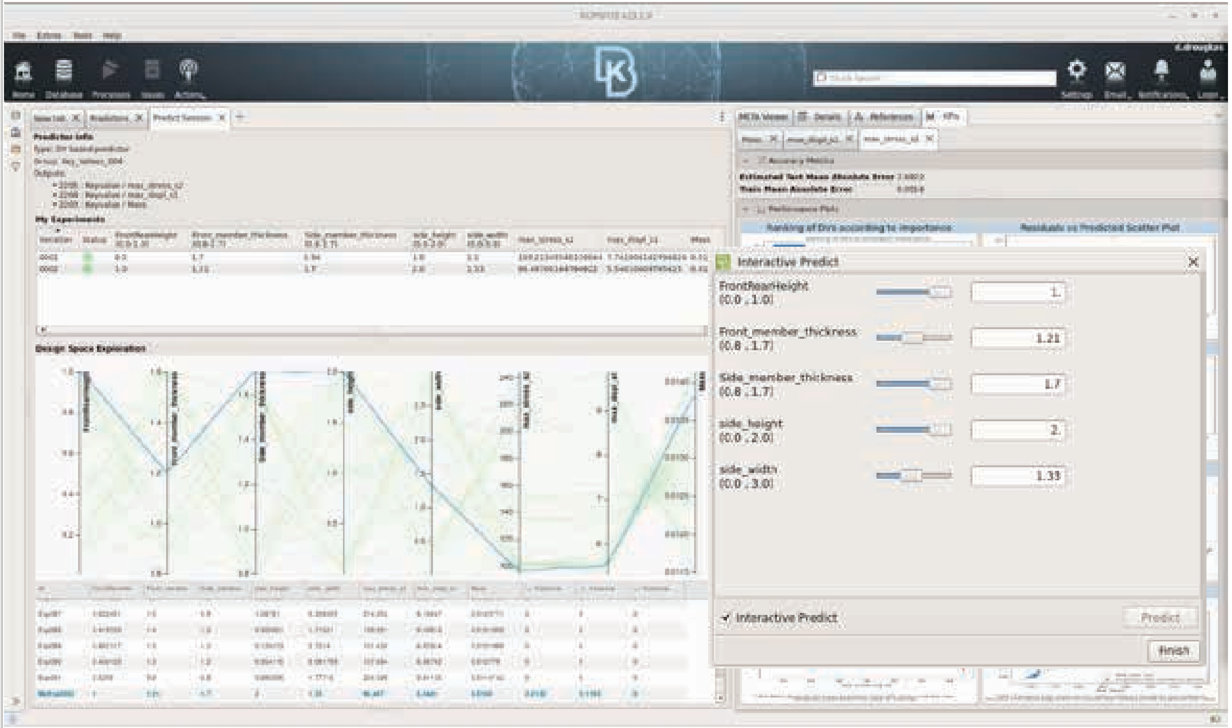
General information

Data driven machine learning for keyvalue, curves and 3d simulation results prediction (parametric)

Inputs:
- Design Variables and their values
- Responses extracted from FE Analysis

Supports:
- 1d results (Scalar Key Values)
- 2d results (Any available curve results)
- 3d results (Any available field results. Scalar, Deformation, Vector)

Key values prediction



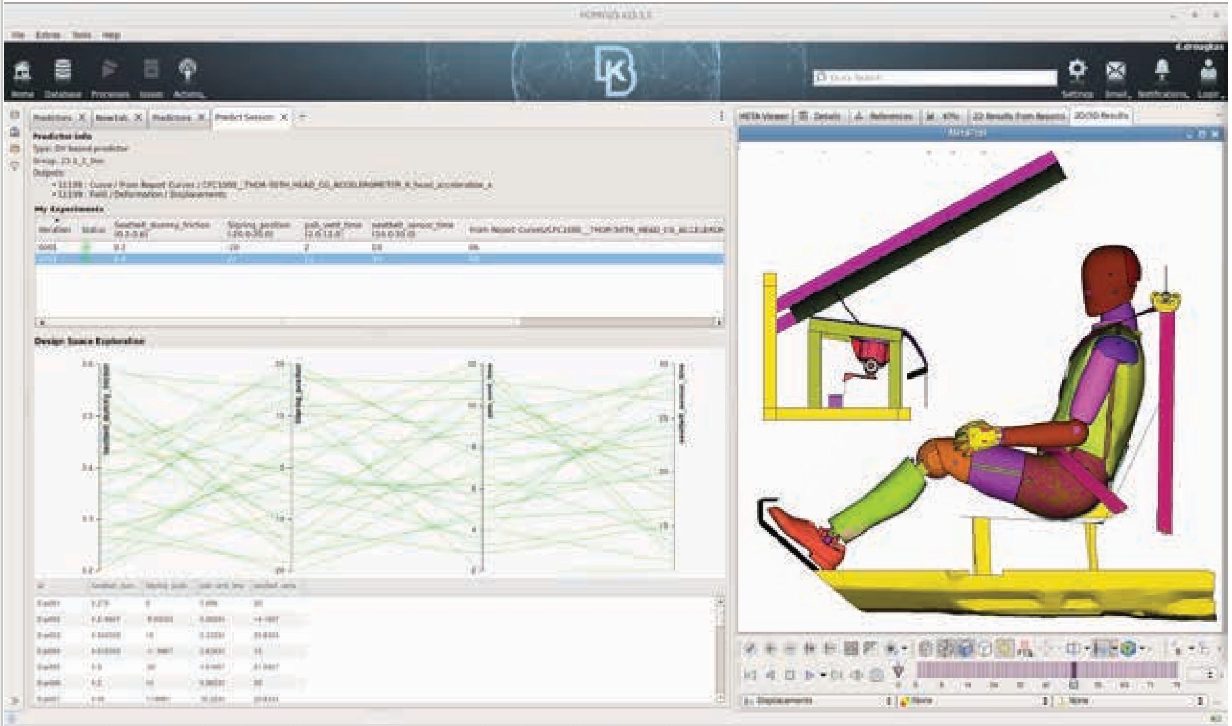
Design Variable Based

Predict Key Values, Curves and 3D Field results on theoretical designs

KPIs

- Ranking of DVs with Importance
- Accuracy vs Datasize
- Target vs Prediction
- Residuals
- Confidence

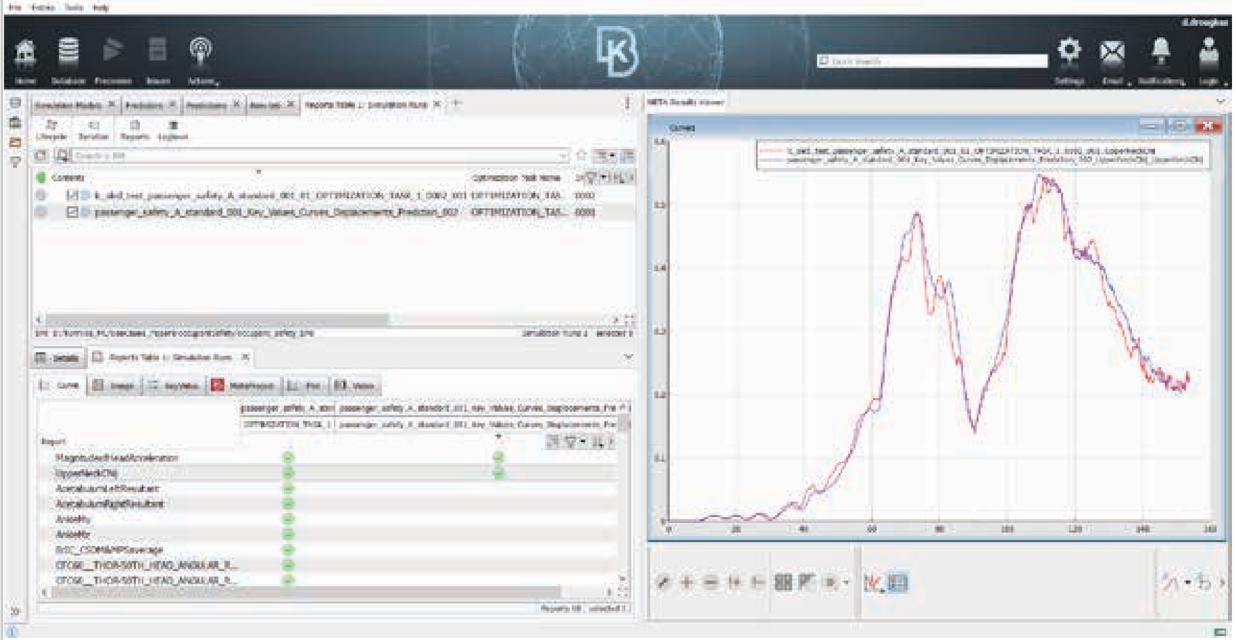
3D Results prediction



Design Variable Based

Predict Key Values, Curves and 3D Field results on theoretical designs

2D Results prediction and comparison

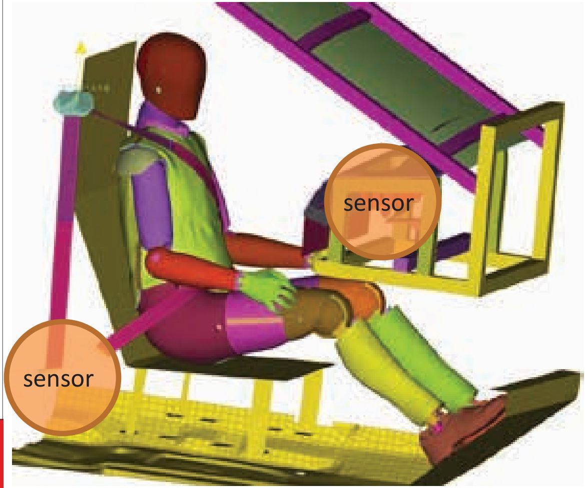


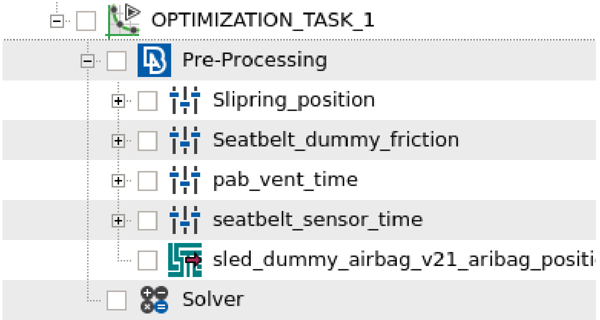
Design Variable Based

Predict Key Values, Curves and 3D Field results on theoretical designs

Occupant safety prediction

- Slip ring position (Z axis).
- Friction coefficient between seat belt and ATD
- Airbag venting trigger time
- Seatbelt sensor trigger time



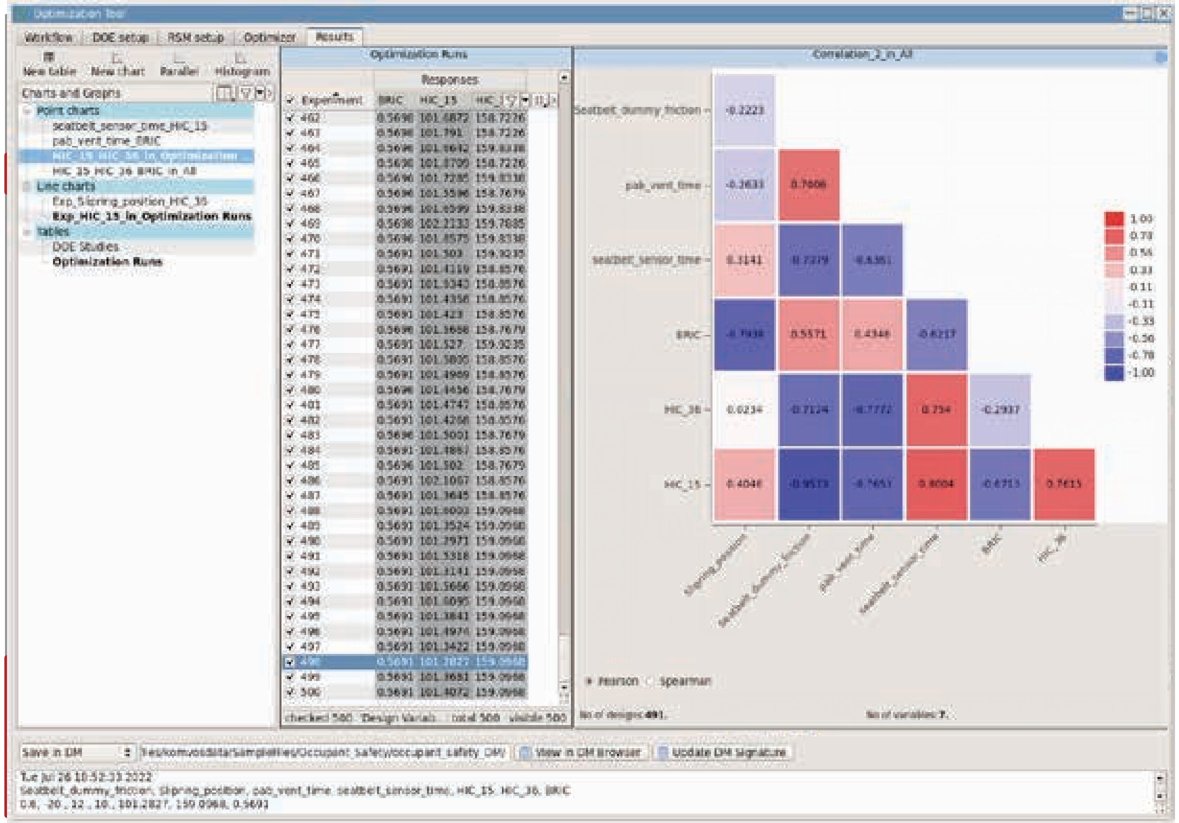


Design Variable Based Application

Design Variables

Optimization task

Occupant safety prediction



Design Variable Based Application

Response Surface Method Optimization - Predictor

Objective

Constraints

Correlation

physics on screen

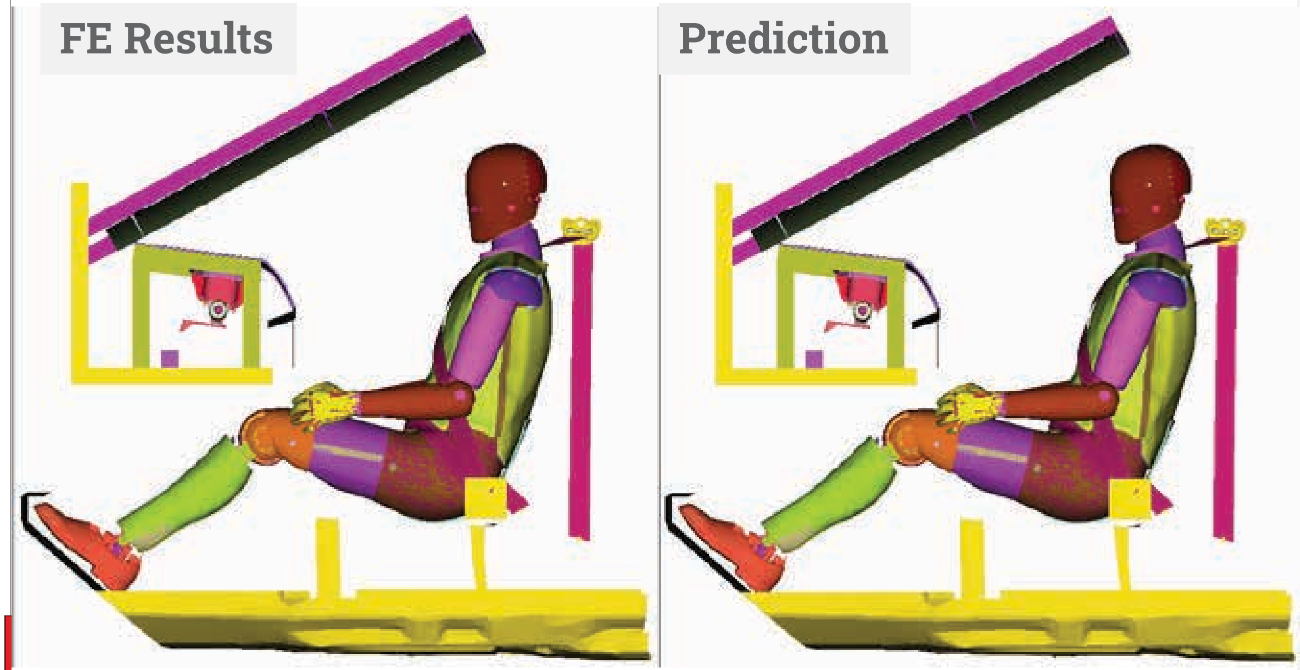
Occupant safety prediction

Design Variable Based Application

	Initial	Optimum	Reduction
HIC_15	132.365	102.026	22.92%
HIC_36	165.047	158.489	3.97%
BRIC	0.534	0.5297	0.8%

Response	Analysis result	Prediction	Error (%)
HIC_15	102.026	101.541	0.47%
HIC_36	158.489	159.096	0.38%
BRIC	0.5297	0.5674	6.87%
ATD measurements			
Head acceleration (mm)	38.905	38.5627	0.88%
Left clavicle inboard load cell(kN)	1.3762	1.3916	1.11%
Upper neck nij	0.3988	0.4022	0.84%
Thorax rib UL(mm)	65.597	66.321	1.09%
Thorax rib UR(mm)	43.722	43.421	0.69%

Occupant safety prediction

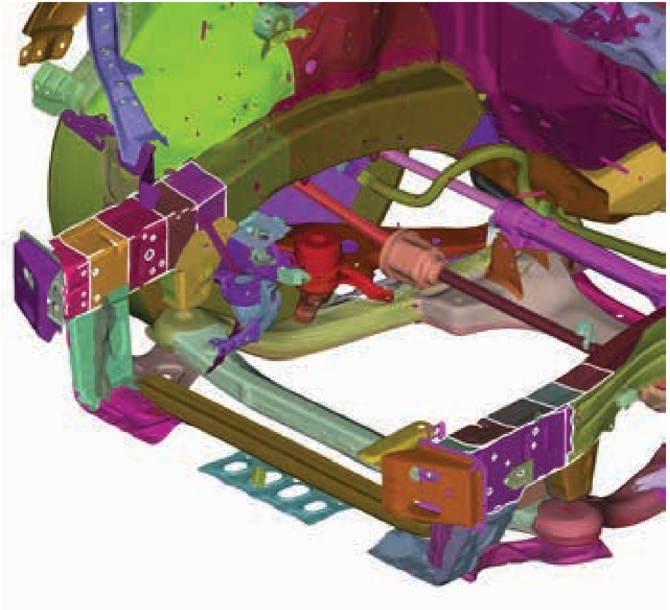


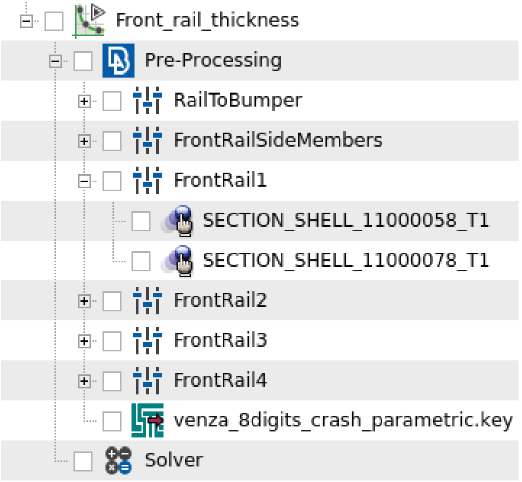
Design Variable Based Application

ML Prediction vs FE Results

physics on screen

Front crash accelerations & intrusions prediction



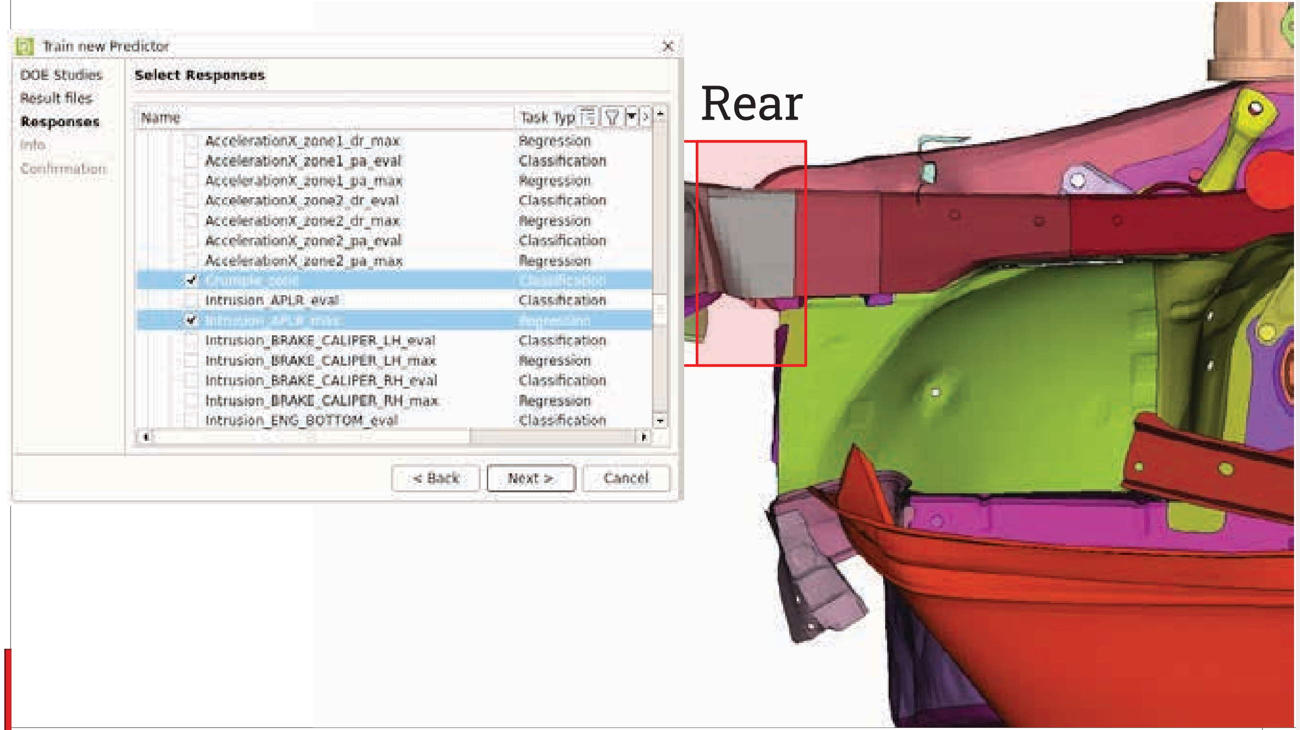


Design Variable Based Application

Design Variables

Optimization task

Front crash accelerations & intrusions prediction

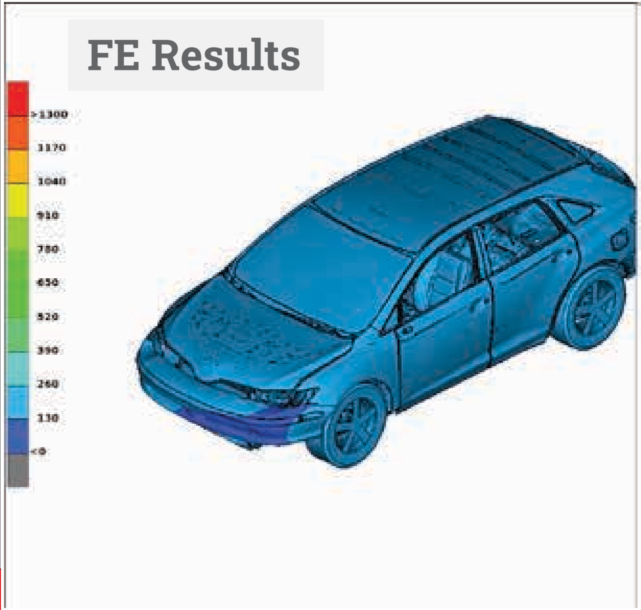


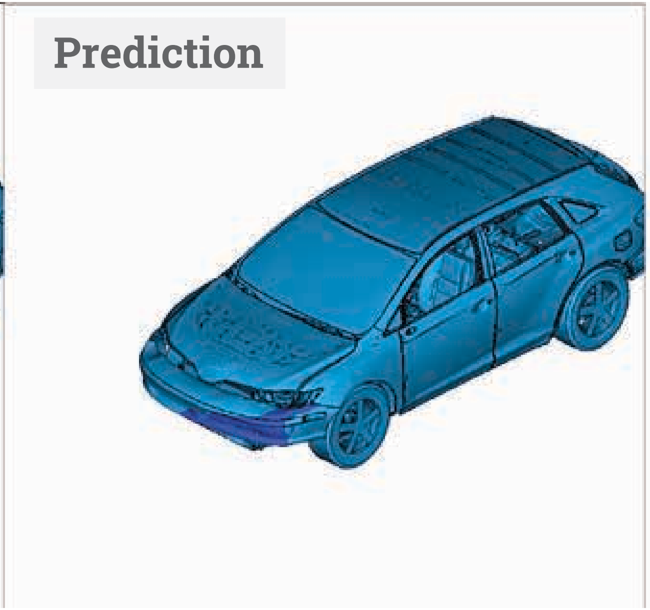
Design Variable Based Application

Key Value Predictors

Classification type predictors

Front crash accelerations & intrusions prediction

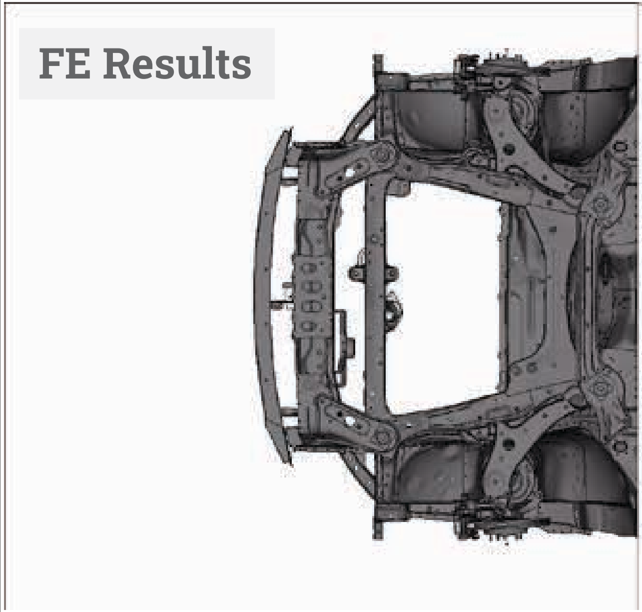


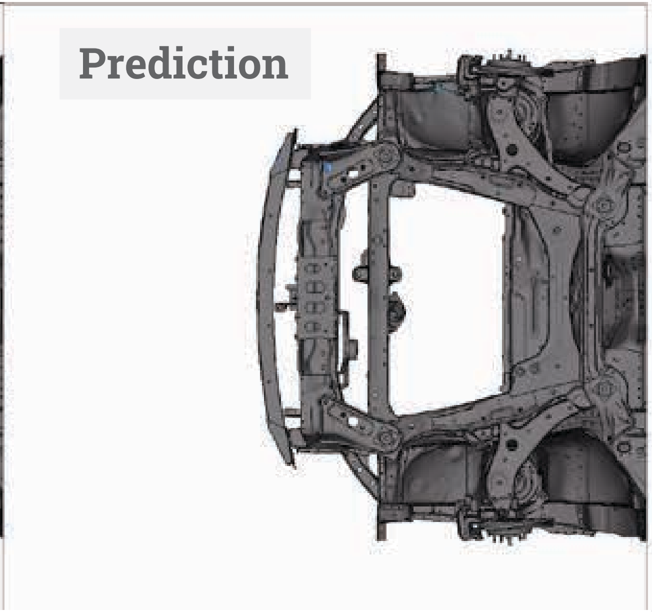


Design Variable Based Application

ML Prediction vs FE Results

Front crash accelerations & intrusions prediction





Design Variable Based Application

ML Prediction vs FE Results

DOE Studies

Doe studies dedicated tab for design exploration

- Parallel Coordinates filtering
- 2^{nd} level filtering checkbox
- 2D,3D charts
- Reports table

Import Parametric Data

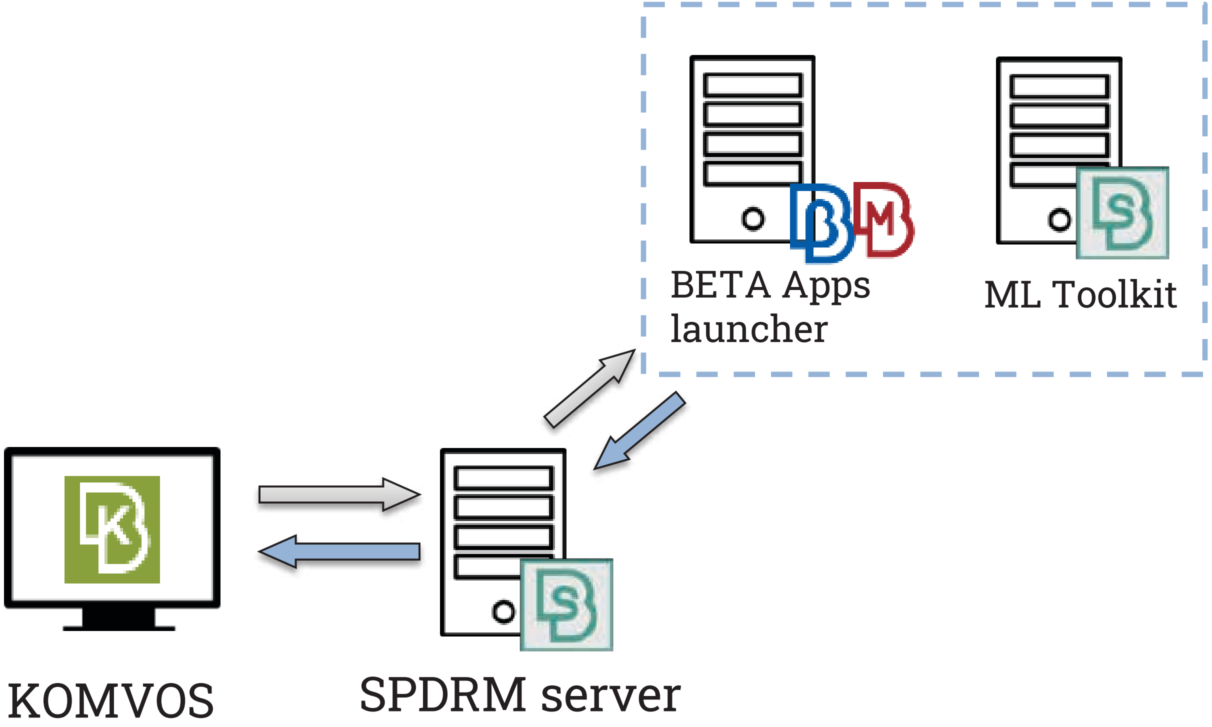
Import existing excel sheet with parametric data

Machine learning API

Direct Access to all aspects of the Machine Learning processes through python script interface

- Data collection
- Training
- Prediction
- Predictor Life Cycle

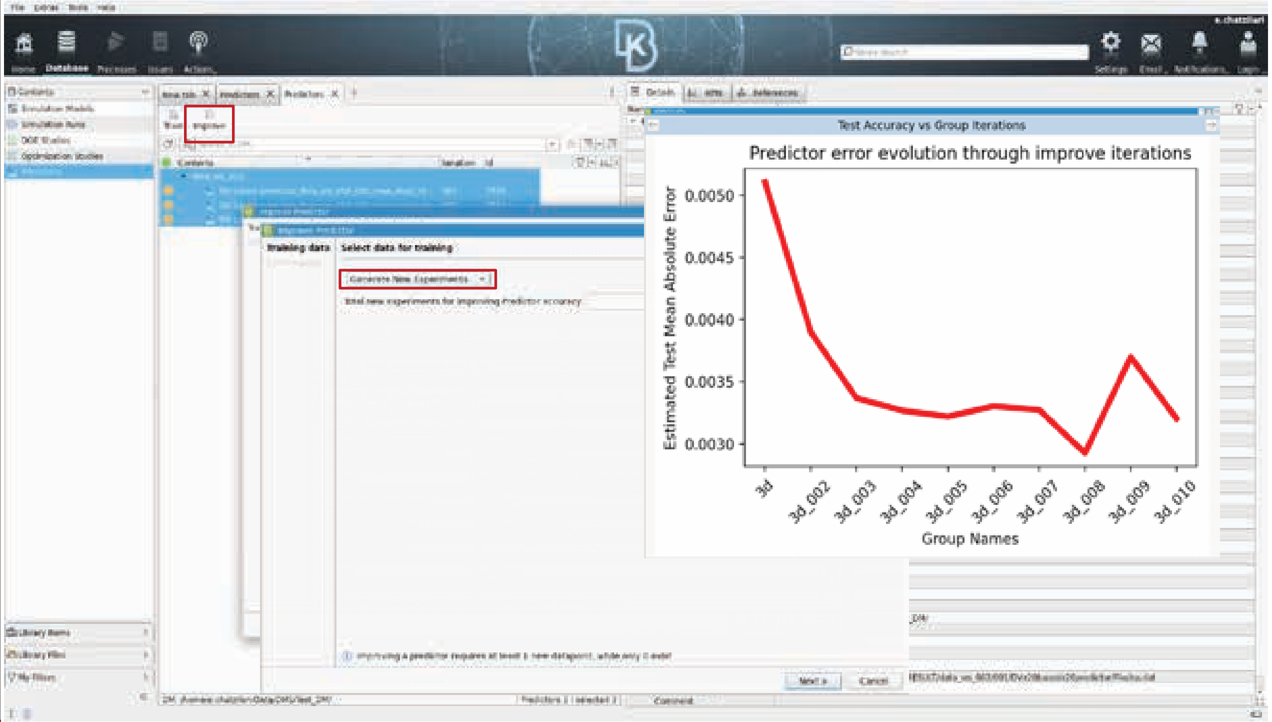
v24.0.0 New Features



Remote Training and Prediction

ML Training and Prediction actions can be performed remotely through SPDRM SERVER

Simplified Predictor Improvement interface



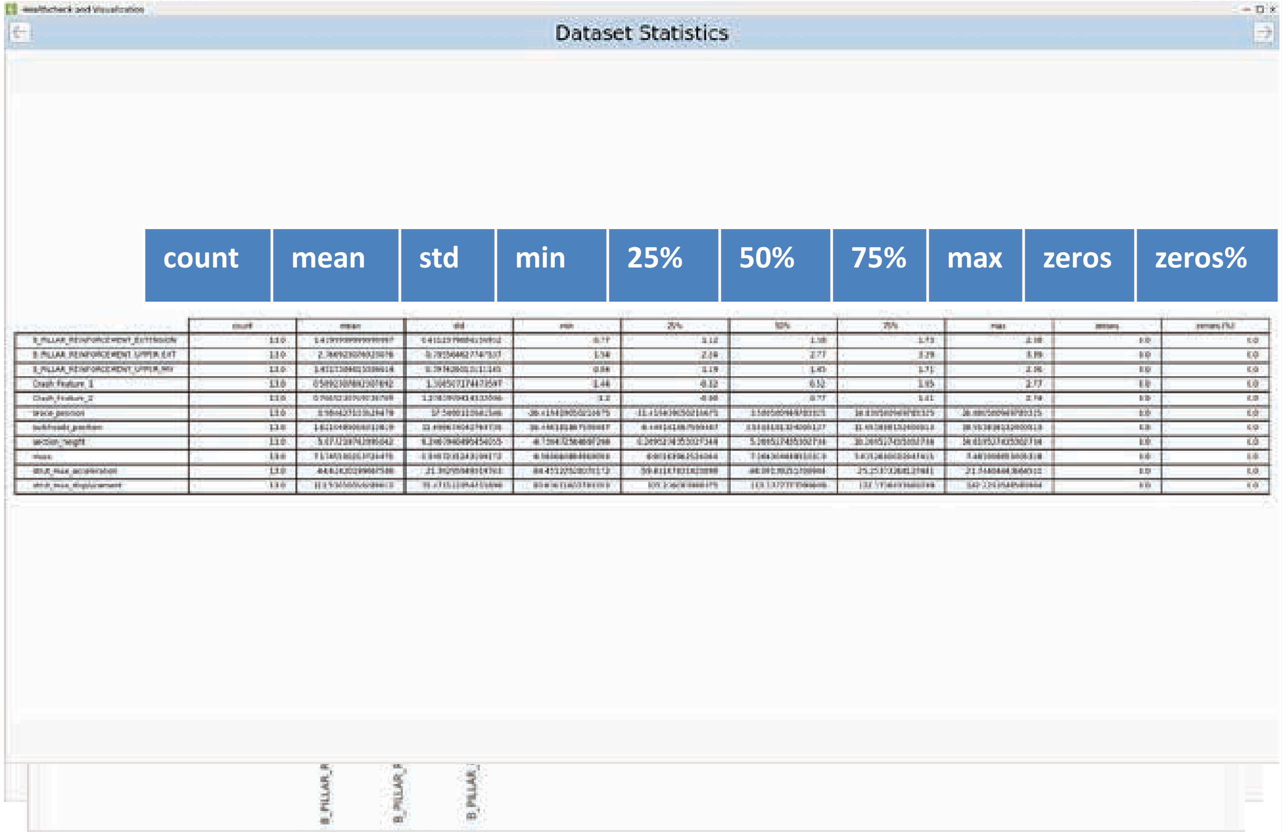
24.0.0

Unified Predictor Improve tool

Incremental
Retrain and
Smart sampling
Now in a simple unified interface

physics on screen

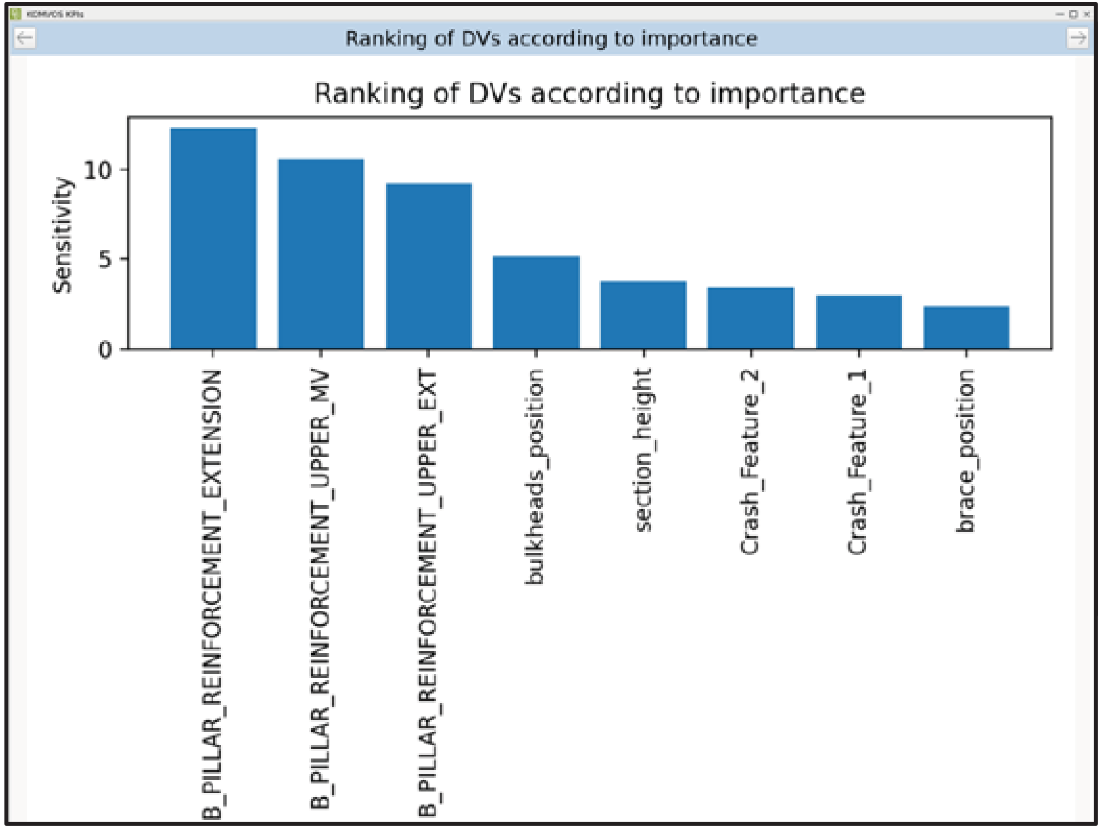
Data visualizations



Data analysis charts

- Pair plots
- Correlation
- Predictive Power Score
- Mutual Information
- Dataset Statistics

Interpretable Machine Learning



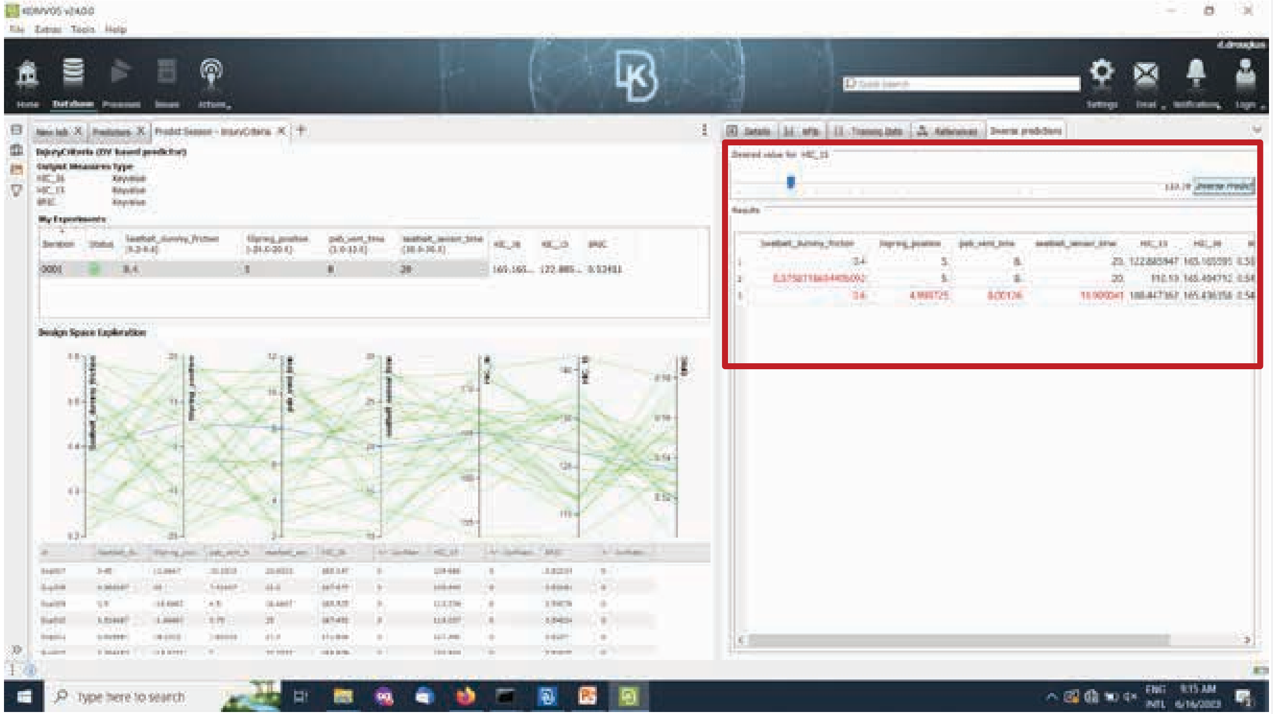
24.0.0

More clarity on a predictors behavior

- Partial dependence
- What-if plots
- Breakdown plots
- SHAP (Shapley) plots
- Permutation Feature Importance

Inverse Prediction

24.0.0



Asking for the best DV values

Inverse predictions show the Design Variable values that would result in the user defined Response value

Future Developments

Control and Transparency

- Tuning ML hyper-parameters
- Specify ML algorithms
- User designed ML modules
- Access through API

Mode classification

- Trim body models
- Modal Map Generation

Physics informed Machine learning

- CFD
- Extend to other disciplines

Future Developments

Smart Sampling

- Better performance with fewer experiments
- More effective exploration of the Design Space during Optimization
- Effective exploration of data coming from real tests

Optimization

- Start and supervise Optimization studies in KOMVOS
- Post process Optimization results

BETA
SIMULATION SOLUTIONS

Stay connected