Optimization of simulation and test tasks by integrating AI/ML into SPDM

Alexander Köppe (PDTec AG) &

Simon Mayer (sustainedBIZZ GmbH)

PDTec AG – who we are.

- The name PDTec is derived from Product Data Technology
- Owner-managed software company, founded in 1999 in Karlsruhe

- PDTec Group consists of:
  - HQ in Karlsruhe
  - Development Center in Poland
  - International memberships: INCOSE, NAFEMS, Prostep iViP, GFSE e.V., CyberForum e.V.

- Our focus:
  - Engineering Collaboration
  - Simulation Management
  - Data Exchange & Supplier Integration
  - Technology Data Management

SustainedBIZZ GmbH

Founded as a **German-Austrian company** in 2018 we contribute to our future and sustainability by supporting our customers in the innovation of products, services and processes. In doing so, we attach great importance to ensuring that the use of resources and technological development are in harmony.
As a **provider of AI solutions** for engineers and as service provider in the field of **engineering services**, we offer a holistic approach to innovation and development tasks.

Driving Digital Transformation with AI

ENGINEERING SERVICES

- Concept & Product Development
- FEA and CFD Simulation
- AI supported CAE

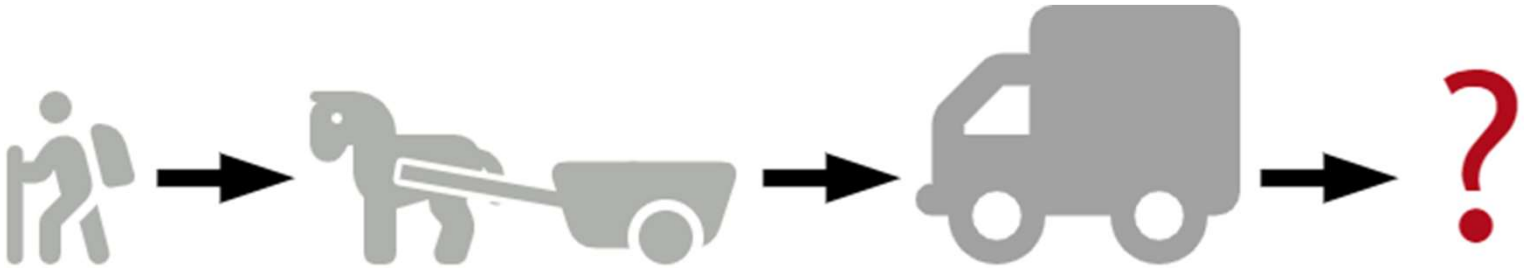
KI LÖSUNGEN

- Non-code AI Tool dAIve
- AI consulting
- AI training & services

The Scenario

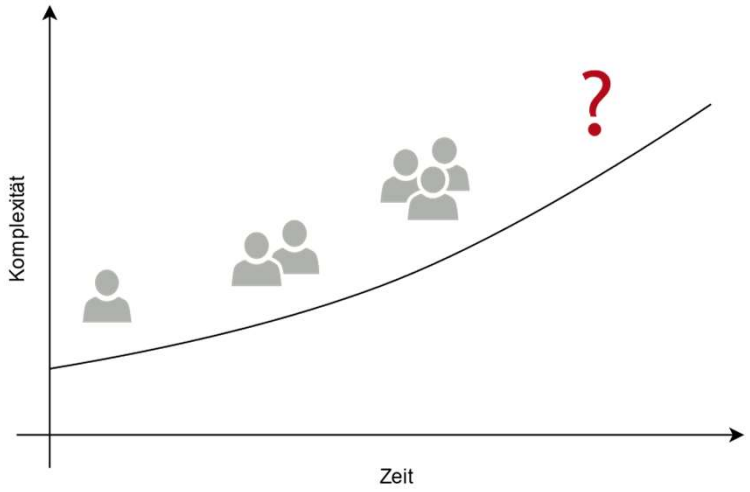
- We want to improve a product
- all simple optimizations have already been implemented
- further optimizations are needed

- The problem: Increasing complexity as the difficult optimization options now have to be implemented



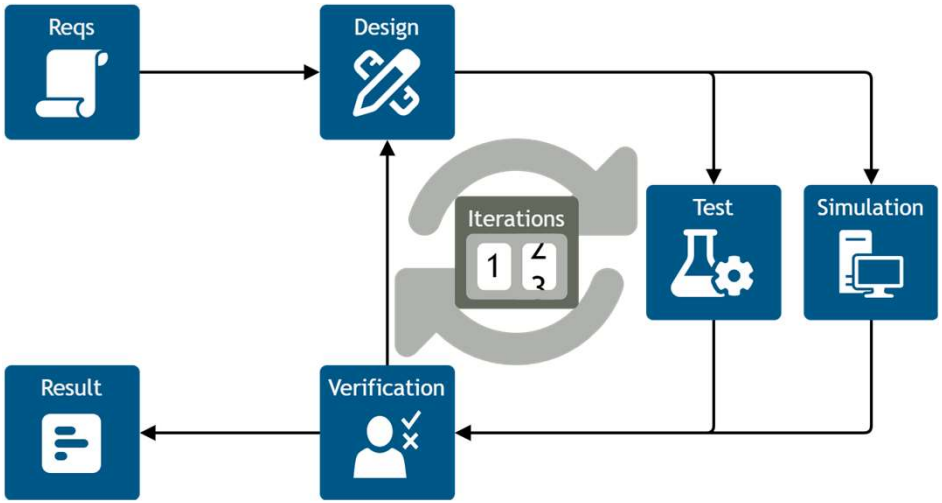
Possible solutions

- Put more developers on the problem
  - Higher costs
  - Decreasing efficiency
- Longer development times
  - Higher costs
  - Increasing time to market
- Increasing the efficiency of the development process
  - Reduced or no cost increase



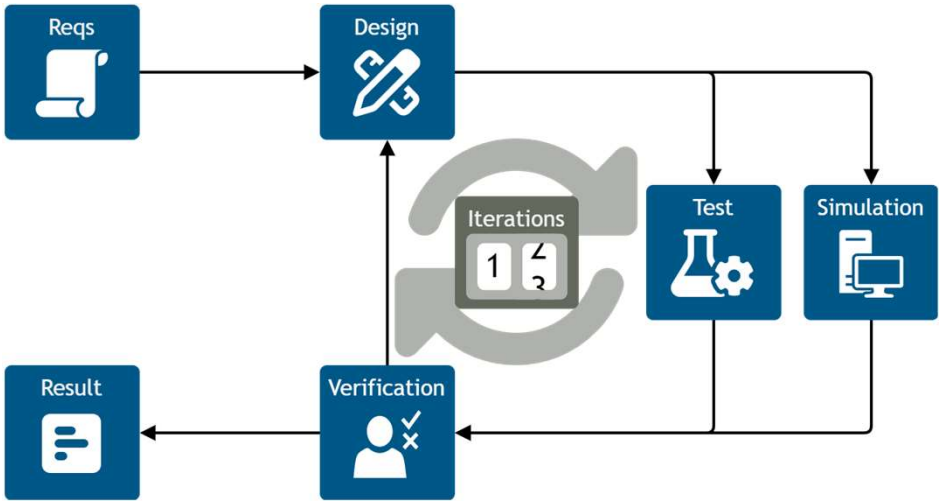
Efficiency Increase

- Exemplary process
- CAD → FEA / Test
- Iterative goal achievement
- Many iterations necessary in complex cases



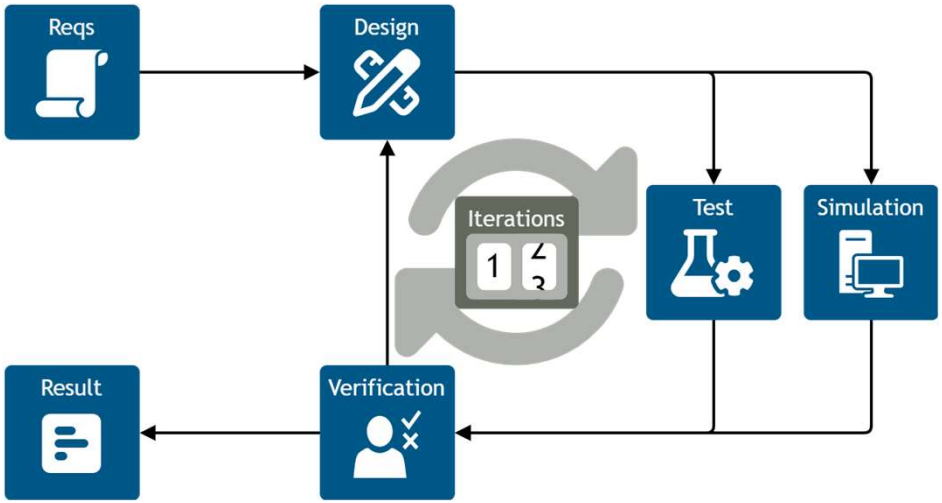
Efficiency Increase

- Every change to the design must be verified by a test or simulation
- Depending on the effort, a simulation can take minutes to days.
- Tests often take much longer



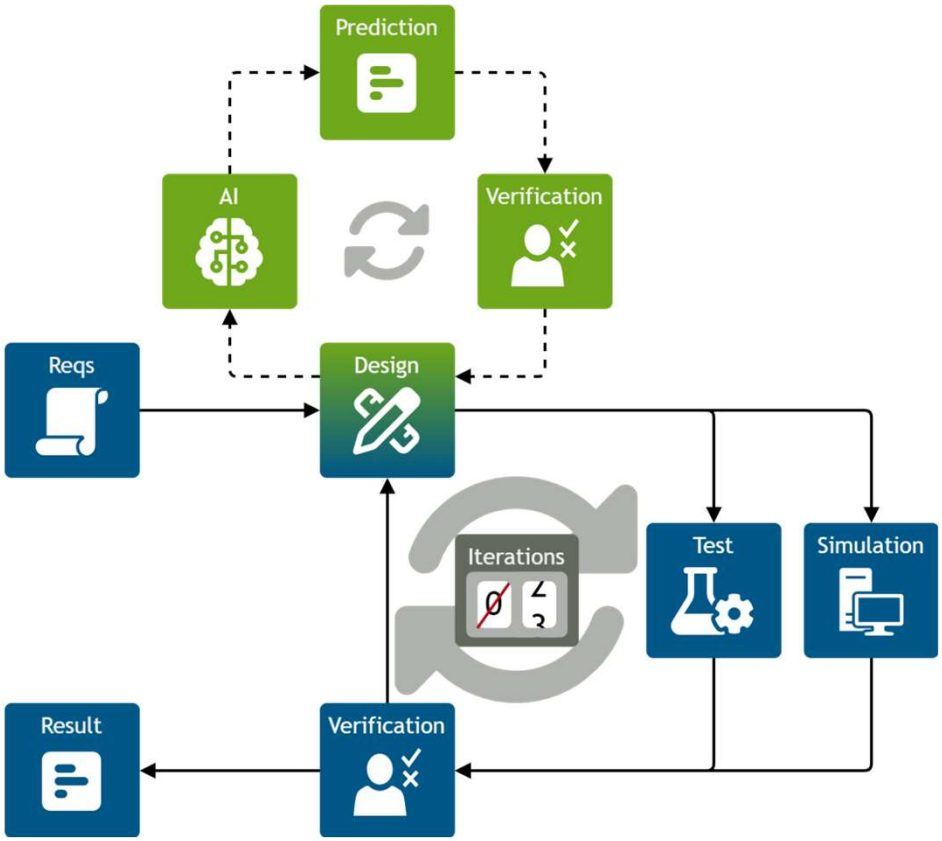
Efficiency Increase

- Potential to increase efficiency:
  - Reduction of simulations or tests
  - Reduction of total iterations
  - Automation
  - and others



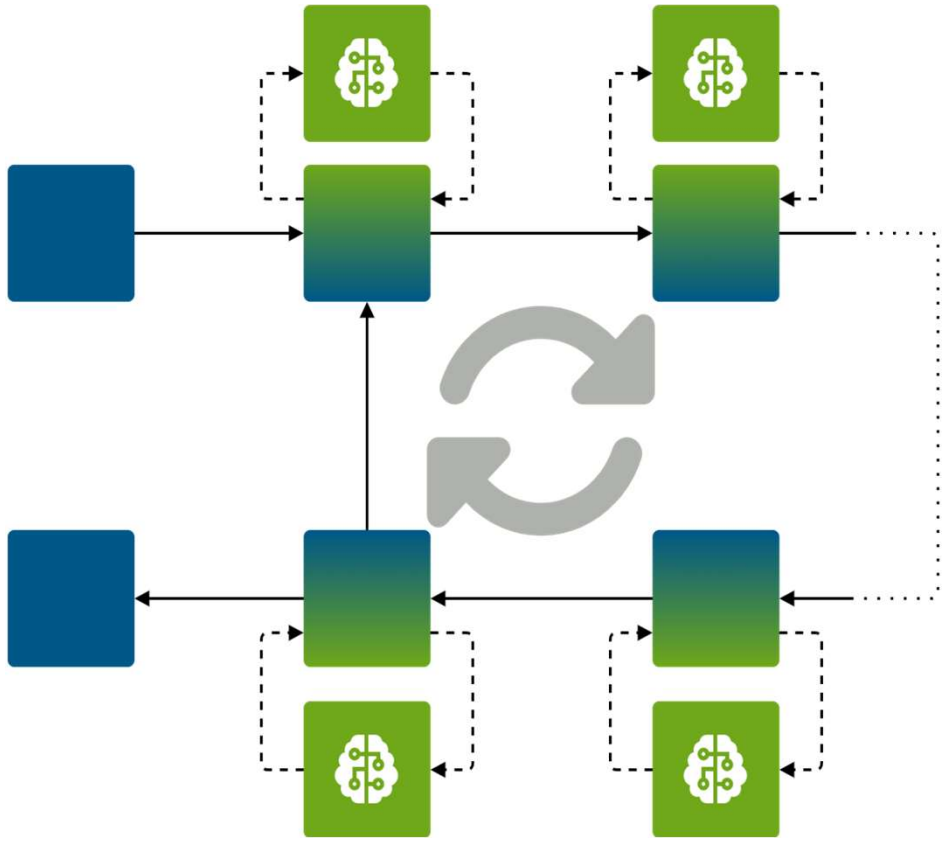
Reduction of Simulations or Tests

- Evaluate designs at an early stage by integrating an AI-based tool
- Avoid unnecessary simulations and tests by omitting hopeless candidates
- Quickly compare multiple candidates to prioritize the most promising ones



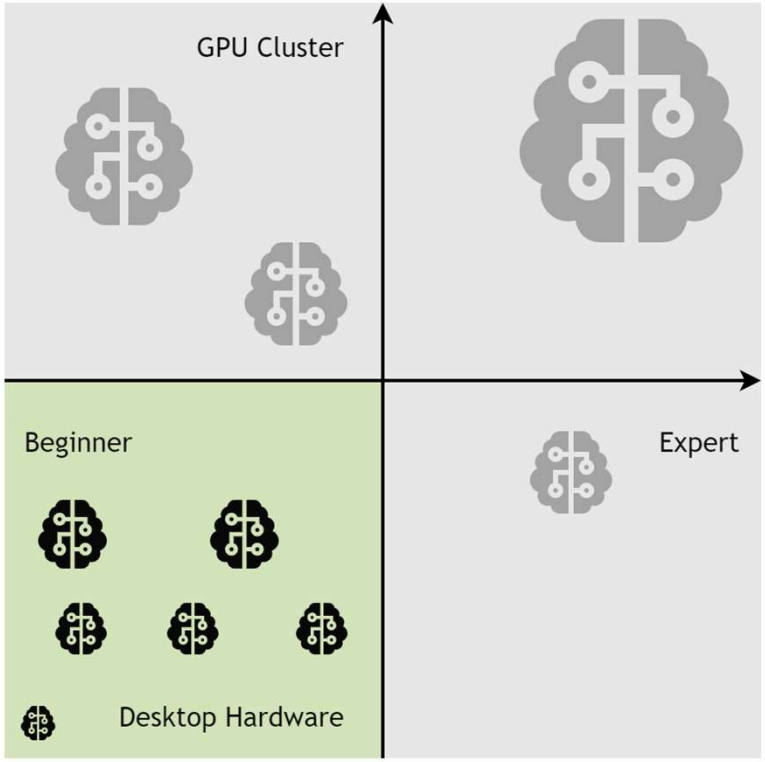
Reduction der Simulations or Tests

- The larger and longer the process chain, the more worthwhile the approach
- Saving on voting rounds
- Greater independence of employees
- Reduction of waiting times for decision-making processes
- Up to 80%-time savings compared to classic processes in practice



Requirements

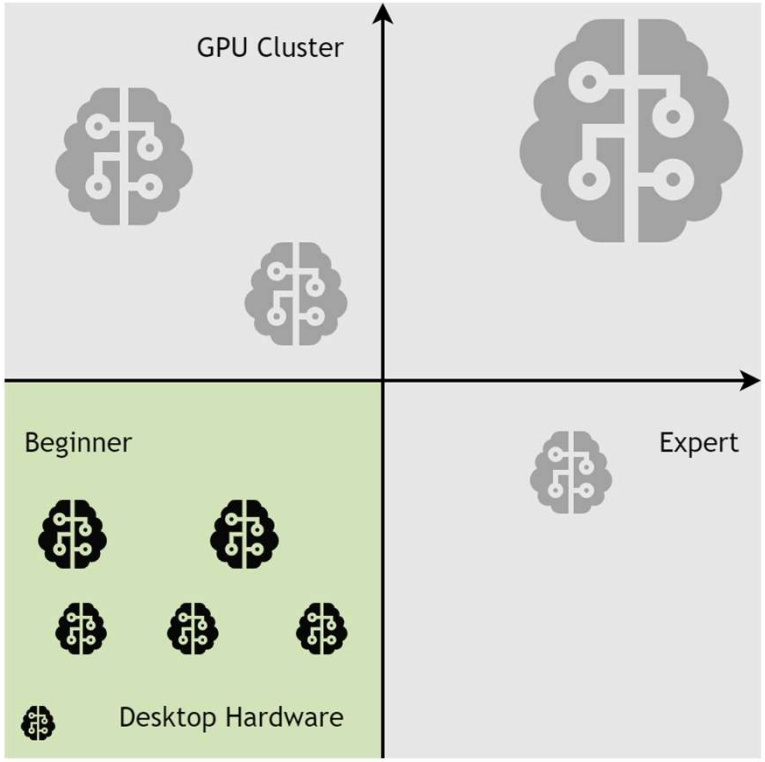
- User-friendly and easy to learn
- Fast training process
- Low hardware requirements



- We aim at the lower left quadrant →

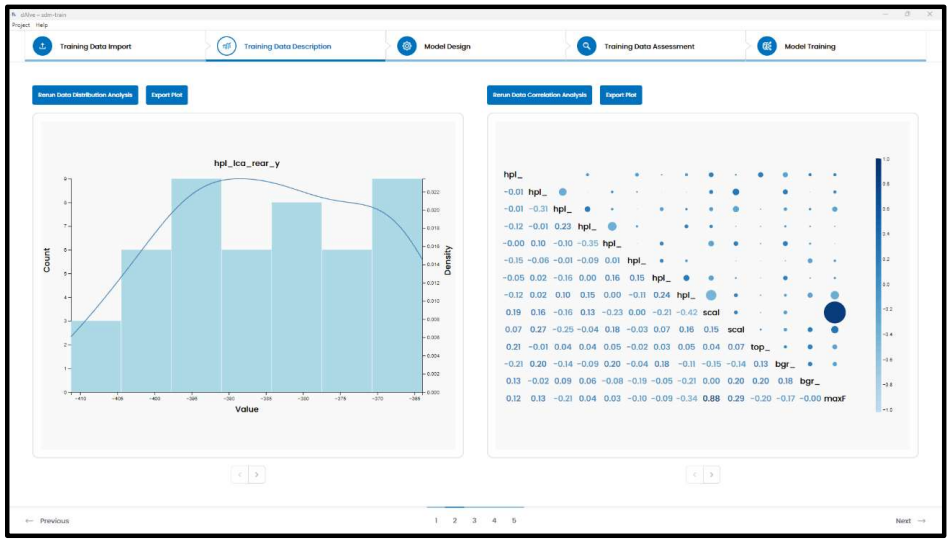
Resulting Boundary Conditions

- Use only small to very small neural networks
- No generic, only specific use cases
- Short model lifetime and frequent retraining
- No-code approach for minimal barriers to entry
- Optimal provision of training data for minimal training effort



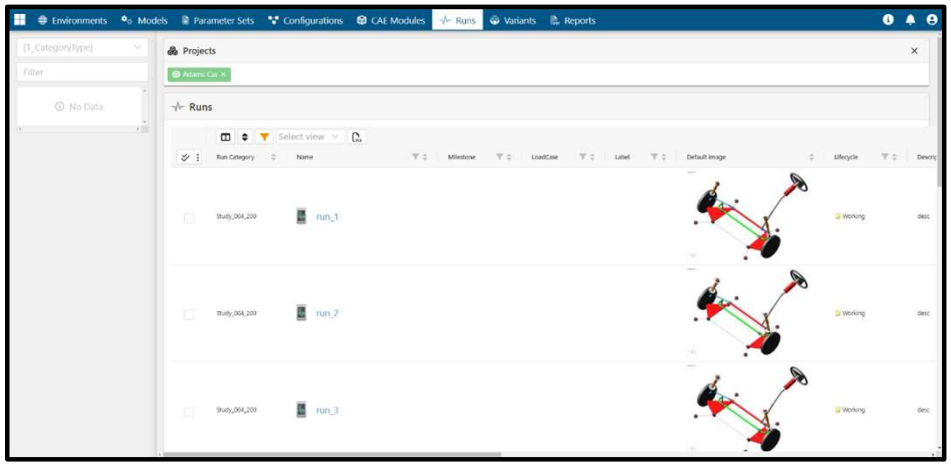
Usability

- Graphical user interface of the machine learning software
- Extensive to complete automation of the training process
- Easy sharing of models
- Easy prediction by models



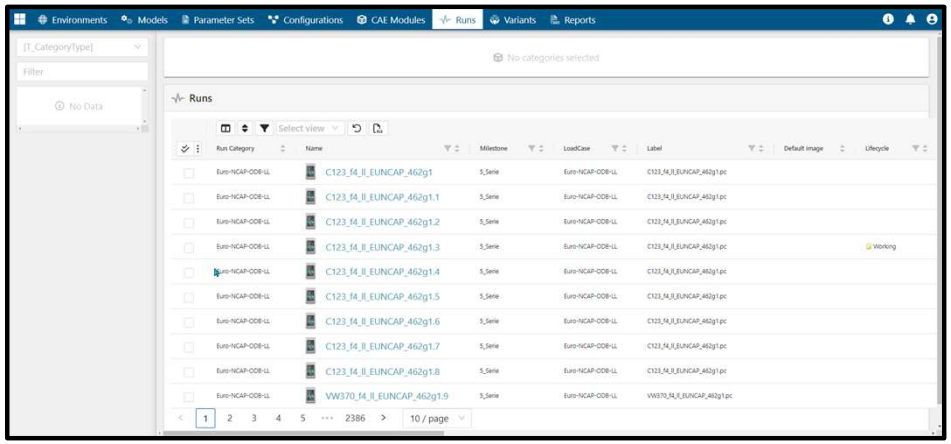
Training Data

- The provision of training data must be as automatic and consistent as possible
- Minimal user time
- Simple call of the ML application from data management



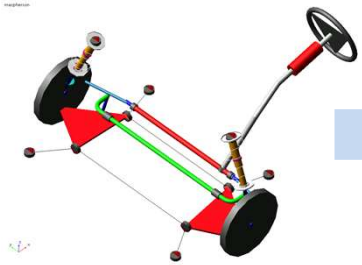
Data Management

- Training should be frequent
- Models to be shared
- The documentation of the models is essential in order to be able to reuse them
- Traceability of the relationship between training data and model to prediction

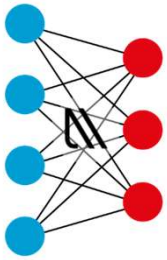


The AI Approach - Training

Geometry
Shock absorber characteristics

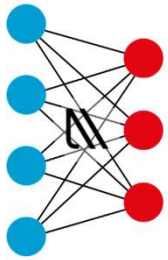


$F_{z,\,max}$ Top mount left
$F_{z,\,max}$ Top mount right
M_{max} Steering column



The AI Approach - Prediction

Geometry
Shock absorber characteristics



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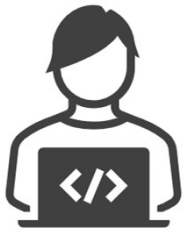
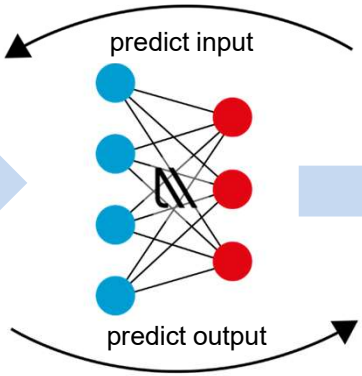


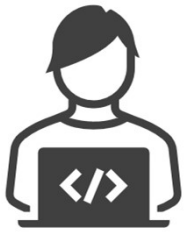
➔ Investigations and optimizations without additional simulations within seconds

Der KI-Ansatz – Invertierung

$F_{z,\,max}$ Top mount left
$F_{z,\,max}$ Top mount right
M_{max} Steering column

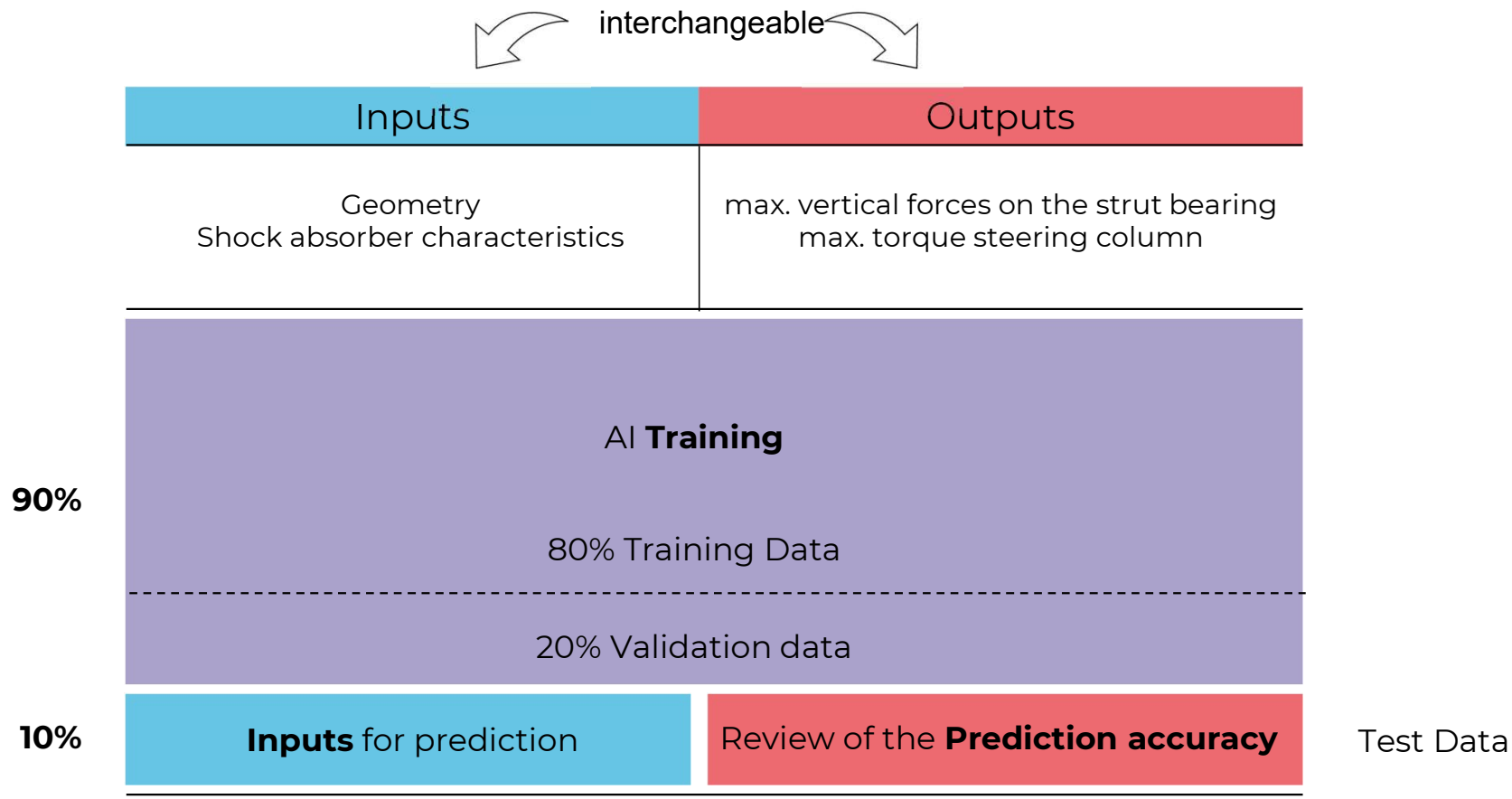


Geometry
Shock absorber characteristics



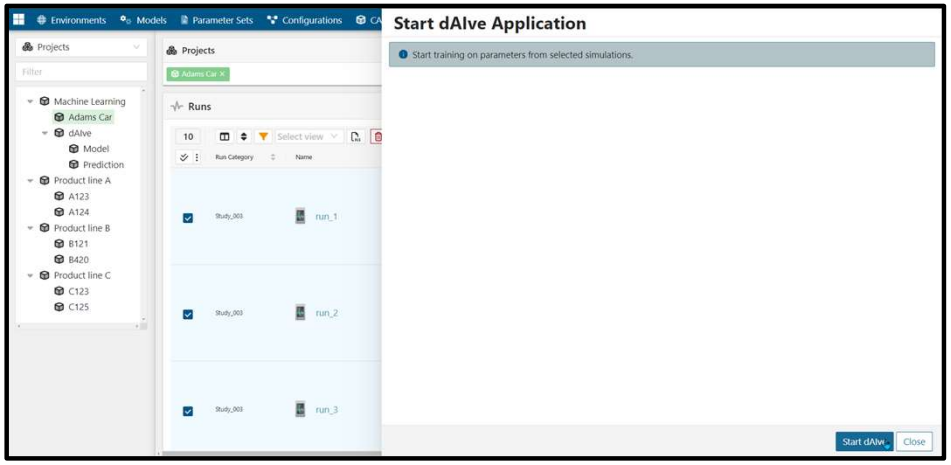
➔ Solution of optimization problems by inverting the question

Der KI Ansatz

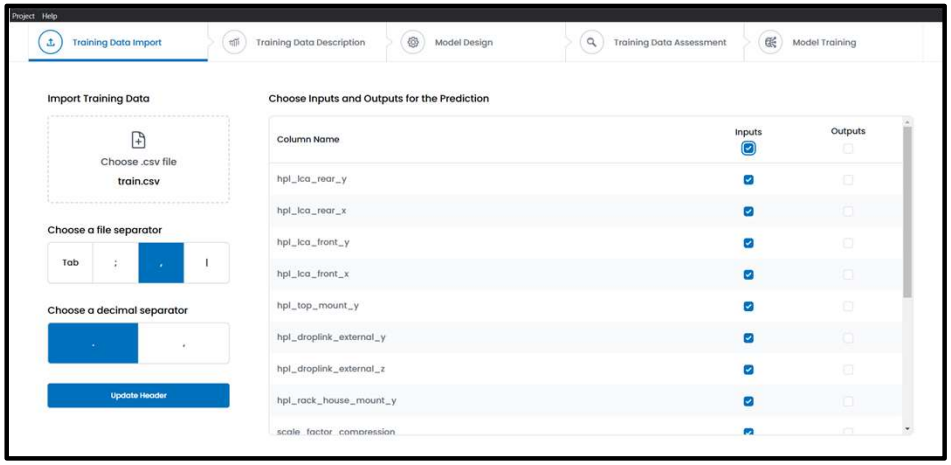


Start Training – via Integration

Data Management

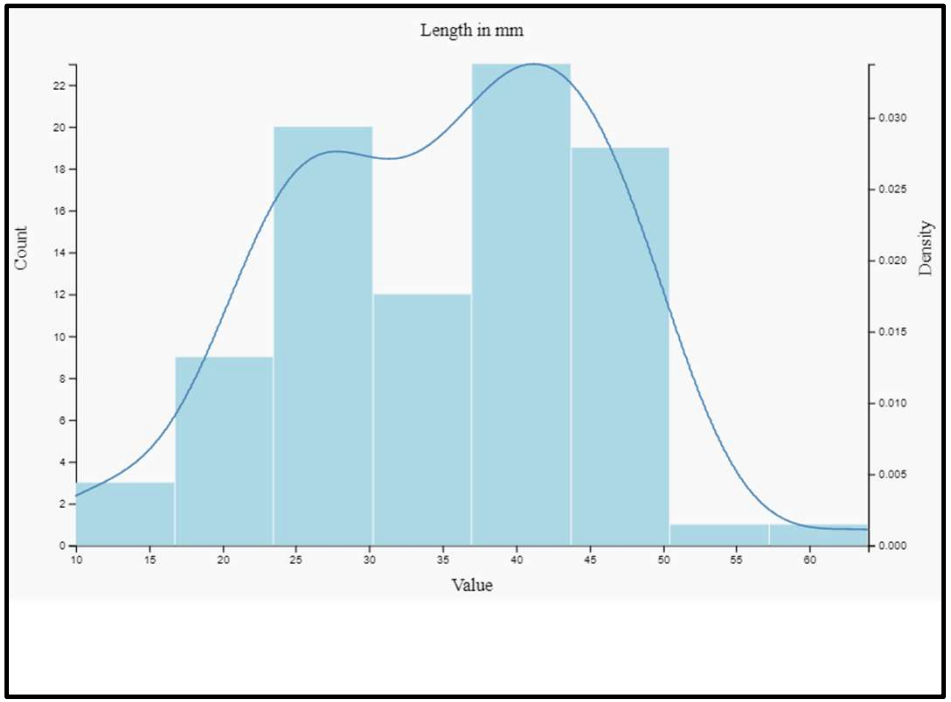


Machine Learning Application

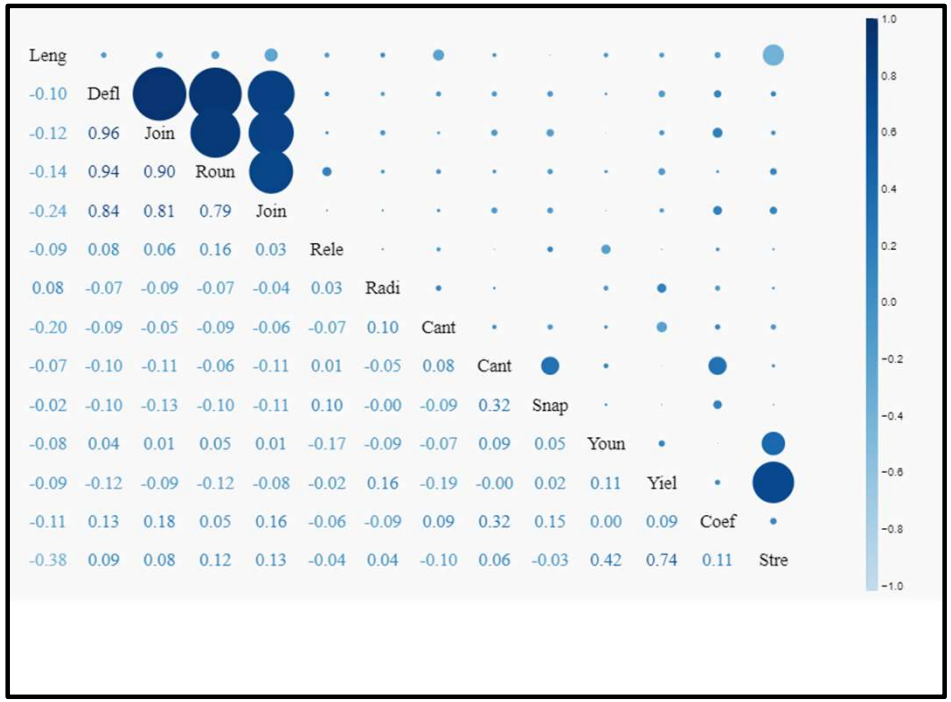


Visualization of the Data

Data Distribution

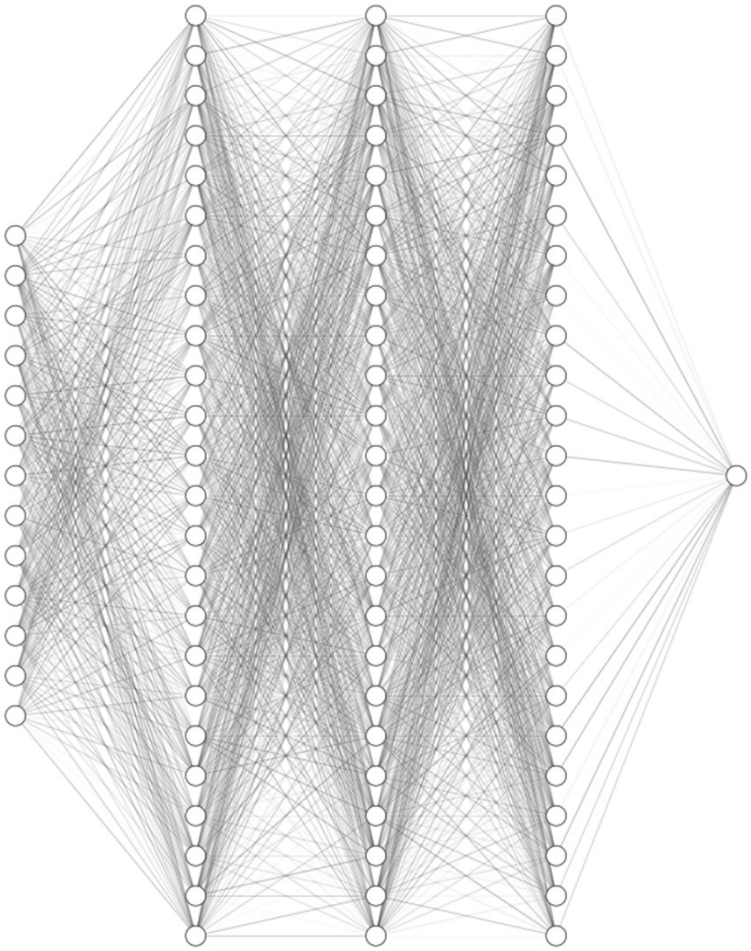


Data Correlation



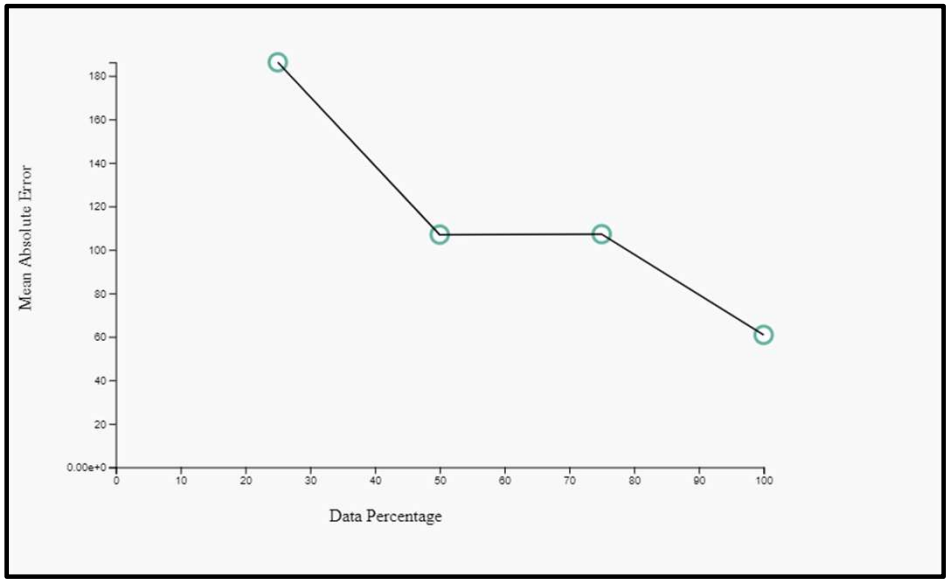
Neural Network Design

Layer 1 - Number of Neurons:	128
Layer 2 - Number of Neurons:	128
Layer 3 - Number of Neurons:	128
Optimizer	Adam
Loss function	Huber
Normalization	False
Batch_Normalization	True
Dropout	0
Learning_rate	0,01
Batch_size	32
Epochs	1000

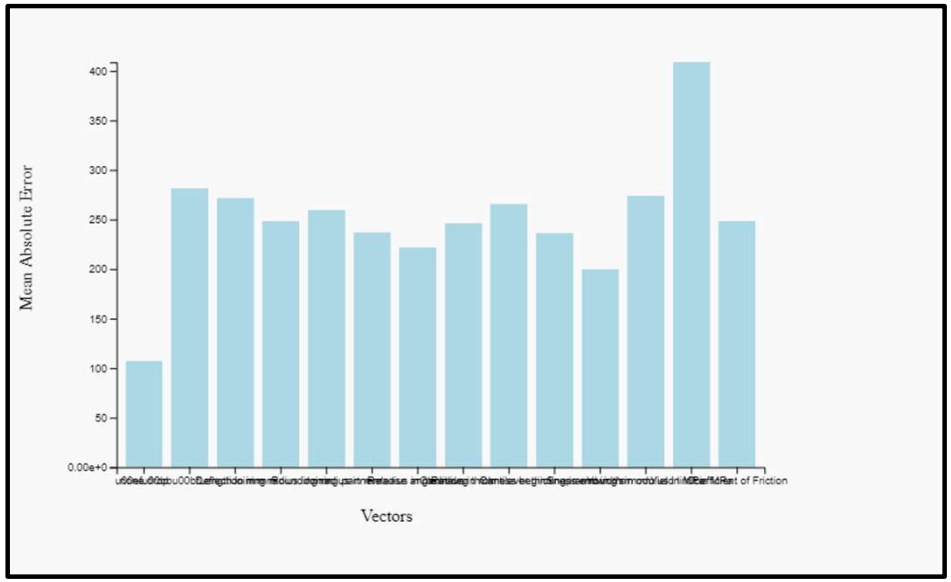


Further analyses

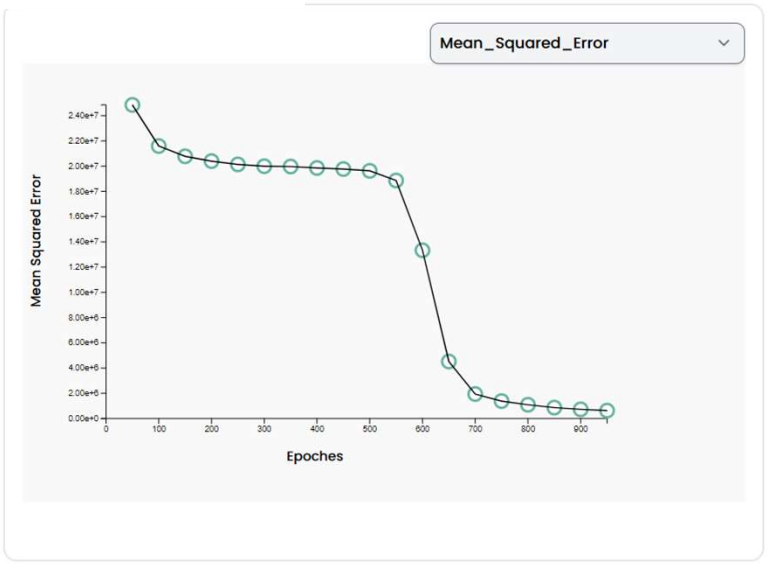
Data Size Analysis



Input Dropout Analysis



Training

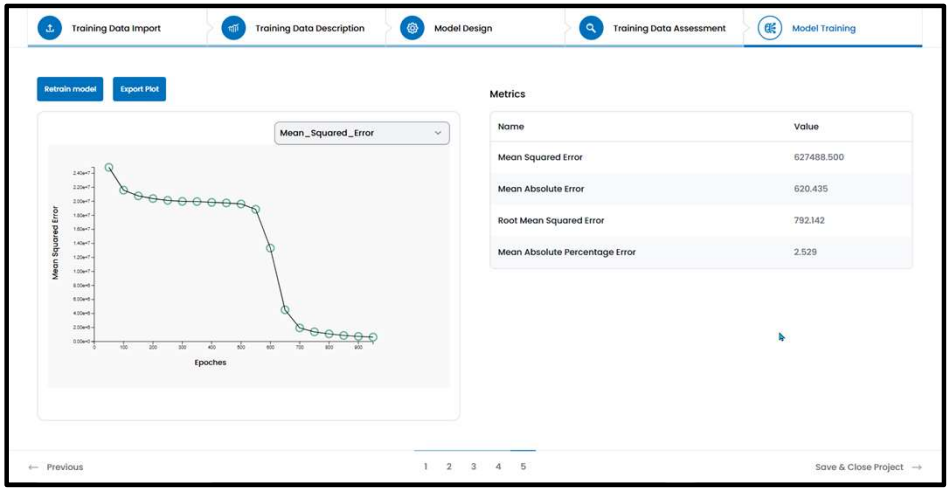


Metrics

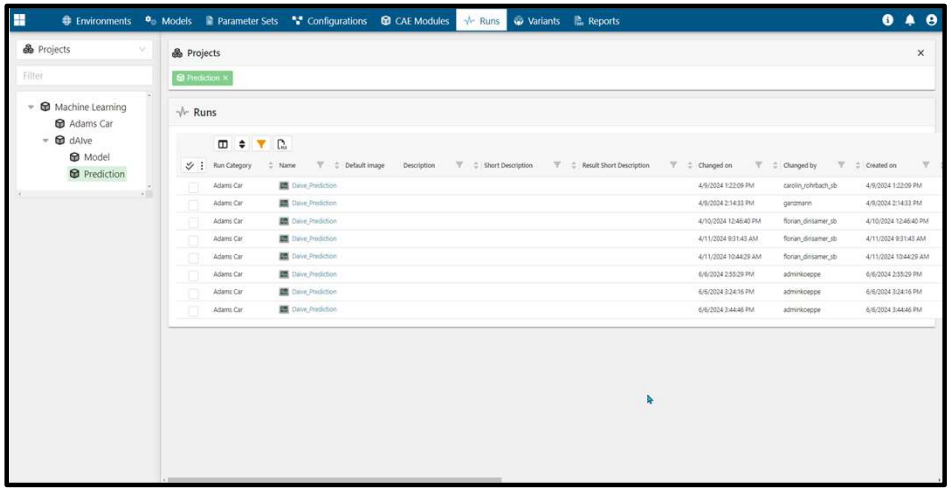
Name	Value
Mean Squared Error	627488.500
Mean Absolute Error	620.435
Root Mean Squared Error	792.142
Mean Absolute Percentage Error	2.529

Data feedback – via integration

Machine Learning Applikation



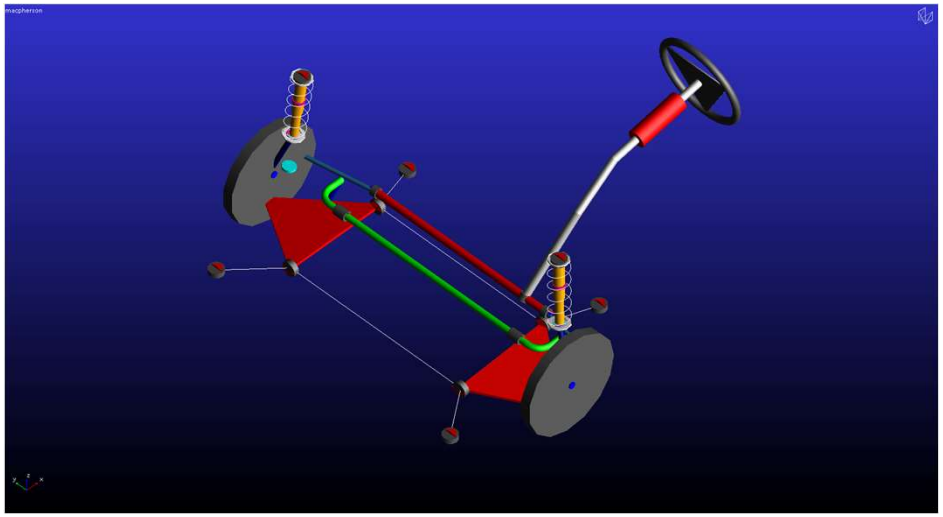
Daten Management



Duration of training on a laptop

Min.	
< 2	• Selection of training data
< 2	• Evaluate training data
< 1	• Configuration of the Neural Network
5,5	• Statistical preliminary examination of the training data
< 1	• Training
< 1	• Storage of data in data management
< 8	• Total

- Multi-body simulation
- 13 Input parameters
- 3 Output parameters



Screen capture of the workflow

View screen recording via the link:

https://pdtec.com/wp-content/uploads/2024/06/daive-demo-2_compressed.mp4

You have questions – we have answers!

Simon Mayer

Alexander Köppe

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P|D|Tec.

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www.daive.de

info@sustainedbizz.com

www.pdtec.de

sales@pdtec.com

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