DATA BASED NON-LINEAR DYNAMIC COMPONENT MODELS FOR VIRTUAL PROTOTYPING

**Problem**

The standard way to accurately model complex non-linear dynamic behavior of car components is via physical or “White-Box” models. These models rely on detailed information about the geometry, physical properties, and physical laws of a component. The drawbacks of these approaches are excessive computation time, the high complexity, or uncertainties due to not fully understood underlying physics. In effect, these drawbacks represent one of the current bottlenecks in virtual prototyping for vehicle design.

Our approach of modeling of a non-linear dynamical system with hysteretic behavior is a data based hybrid approach. Especially on one side, the development of customized, case sensitive, Preisach theory based models and its couplings with, on the other side recurrent neural network based dynamic models.

Our models allow high accuracy data based system identification with the possibility of a-priori system knowledge integration into the model structure (Grey-Box models). Moreover they guarantee fast simulation.

**Application areas**

Examples of problems for which the appropriate models have been identified are:

- Car rubber bearing hysteretic behavior
- Hysteretic system identification of two objects in frictional contact (brakes, clutches, bearings, joins)
- Prognosis of a car spring damper hysteretic behavior under high loading scenarios
- Prognosis of hysteretic behavior of electromagnetic valves in hydraulic car systems
**Data based modelling of strain/stress behaviour of casted magnesium component**

---

**Modeling and Simulation**
- Consulting and support by planning and implementation of series of measurements (design of experiments)
- Development of data based models
- Accomplishment of simulations and evaluation of results
- Decision support by the optimization of control parameters on the basis of identified models

**Software development**
- Development and implementation of individual software modules for data based modeling of non-linear dynamic component behaviors and decision support instruments
- Integration of developed modules into existing simulation and analysis tools
- Allocation of possibilities for reidentification and adaptation of developed models

**Development of new solutions**
- Collaboration in national and international donor projects in a network with industrial partners
- Development of new approaches for data based system identification, simulation, prognosis and optimization of control and process parameters

---

**Our competencies**
- Data based modelling and system identification
- Identification of static and dynamic non-linear systems
- Analysis and validation of series of measurements
- Estimation and optimization of process parameters

Used programming languages and simulation instruments:
- MATLAB, R, C++, Java, ABAQUS, etc.

**Methods**
- System theory (non-linear dynamic models, hysteresis models)
- Machine learning (Feed-Forward and recurrent Neural Networks)
- Approximation theory (Wavelets)
- Mathematical Statistics (Maximum Likelihood, Bayesian Approach)
- Data Mining (Classification, Clustering, Significance analysis)
- Monte Carlo Methods (Markov Chain Monte Carlo, Sequential Monte Carlo)