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Interactive feasibility evaluation with the help of data driven modeling by the example of forming simulation

Introduction

Development processes of the automotive industry often require a fast and reliable evaluation of the technical feasibility or other characteristics of a design. Usually, this evaluation is based on computer simulations or experiments and is therefore very time consuming so that such an evaluation is not feasible within a meeting, the way it should be to discuss the design variations immediately. A solution for this problem is provided by the latest methods of the so-called data driven modeling method which was developed by divis and is available as our standard software ClearVu Analytics. Due to its functionality BMW established ClearVu Analytics as their standard software for the data driven modeling of experiment or simulation based data.

Task formulation

In this contribution the application is explained by a representative example of forming technology at BMW AG. The relevant design area contains the door opening at the B-post (see fig. 4)

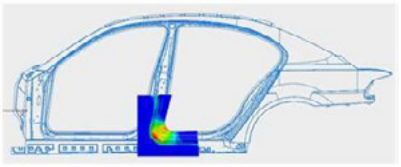

Fig. 4, door opening at the B-post

Concerning the forming technology this area is very challenging because depending on the design (opening angle, entrance radius, depth of the frame) problems like thinning or cracking can occur.

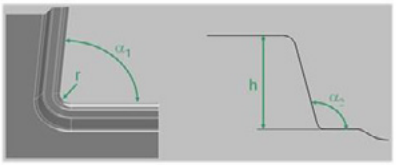

Fig. 5, simplified model of the door opening and its design parameters. Left: side view, right: cross section

To reduce the calculation time for the side frame (10hrs of CPU time using 16 CPUs) a simplified parameterized model is used, as shown in fig. 4. This reduces the calculation time to 15 min. per parameter combination. The relevant design parameters for the door opening are summarized in fig. 5.: r = entrance radius, α1 = opening angle, h = forming depth, α2 = frame opening. Additionally, two more parameters (trimming parameters) are considered so that the model contains six real valued parameters which can be varied within the defined range of values.

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Solution

First, a design of experiments for approximately 2000 simulations was generated with ClearVu Analytics (using Latin Hypercube). The simulations delivered information on the formation of cracks and thinning which occurs during the forming process. Afterwards, these numeric values were divided into three categories:

- Green: faultless design (no cracks, no significant thinning)
- Red: erroneous design (cracks and significant thinning)
- Yellow: intermediate design

These categories exist for both target values (cracks/ thinning), so that all in all there are nine options to choose from.

Based on the 2000 data points and statistical analysis ClearVu Analytics is able to automatically create a generalizing model of the relations between cracks/thinning and geometrical parameters. The modeling method is not predefined but determined by the software. Thus, the user does not need any knowledge about statistical data driven modeling or data mining. The so-called cross-validation ensures that the model is able to predict the producibility also for new combinations of the input parameters.

Contrary to the simulations which need 8-12 hours per calculation, the predictions of such a learned model can be calculated immediately. Thus, new designs can be analyzed and evaluated, for example, during a meeting, a big advantage since it saves a lot of time.

Detailed approach

After the data have been uploaded in ClearVu Analytics, the modeling process can be activated in only a few steps. During the process various modeling methods like linear models, support vector machine, random forest, fuzzy models, kriging, PLS- and RBF-models are applied on the data and optimized automatically so that the best model can be found. The user only has to take a few steps with CVA—the software automatically evaluates the models and eventually shows the best model for the prediction.

The interactive model interface shown in fig. 6 enables the user to vary the model parameters with sliders and get an immediate feedback concerning the suitability of the new parameter combination.

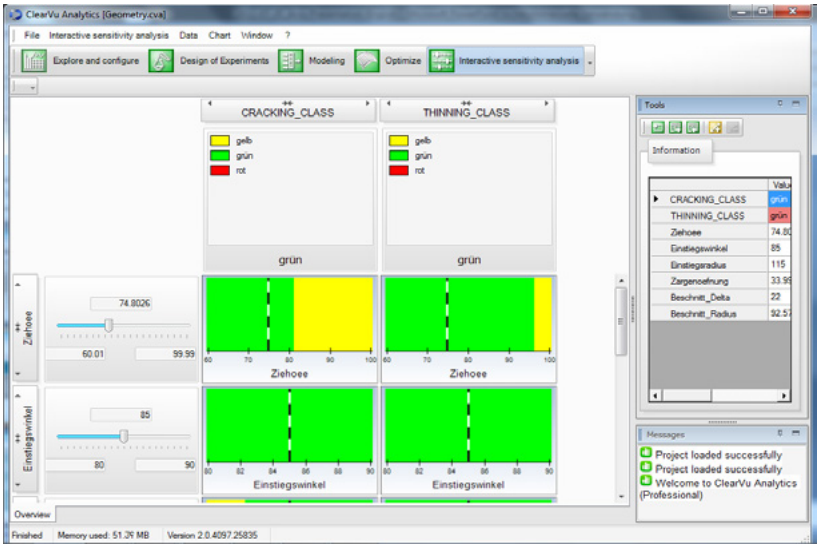

Fig. 6, the interactive model interface helps predict the formability of the door opening. The sliders on the left change the geometry parameters (here: forming depth and opening angle), the columns then show the result by predicting cracking and thinning.

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Further options

The most common case of such a data driven modeling is, however, not the prediction of a class affiliation, but the prediction of one or more numeric input values. There is a wide range of applicability. This system is suitable for all kinds of work in which it is important to get a deeper insight into the relations between the variables and the output values and where reliable predictions for new combinations are necessary.

Due to the efficiency and versatility of our approach BMW has established ClearVu Analytics as their standard tool for meta modeling, and is cooperating with us concerning the development of further releases. A cooperation agreement has been signed in July 2011.

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