11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Combining state of the art meta-models for predicting the behavior of non-linear crashworthiness structures for shape and sizing optimizations

Axel Schumacher, Christopher Ortmann

University of Wuppertal, Faculty D – Mechanical Engineering, Chair for Optimization of Mechanical Structures, Wuppertal, Germany, schumacher@uni-wuppertal.de, ortmann@uni-wuppertal.de

Abstract

In this contribution, we consider a shape optimization problem of a simple crashworthiness structure. The application example is an aluminum frame clamped on one side and impacted on the other side. The structural analysis is carried out with the finite element method using explicit time integration. Contact phenomena, buckling phenomena und non-linear material data are taken into account. With the aid of this example, a large number of different meta-models using radial basis functions, Kriging (Gaussian processes) and neural networks are generated.

The advantages and disadvantages of these different methods and the problems by relying on the common quality criterions "coefficient of determination R^2" and "leave-one-out-cross-validation R_{press}^2" are shown. The combination and superposition of the different meta-model techniques is investigated in order to enhance the meta-model prediction capability.

In our crash application example with one design variable, 7 sampling points are used, assuming that more sampling points are not available. In order to evaluate the quality criterions and the prediction capabilities of the meta-models, 6 additional validation points are used. For this purpose the regression parameter R_{val}^2 is calculated for the validation points similarly as R^2 is calculated for the sampling points. The quality criterions R^2 and R_{press}^2, the average absolute error at the validation points $|\varepsilon|_{ave}$ and the regression parameter for the validation points R_{val}^2 for each meta-model of the crashworthiness example are discussed.

The superposition of all meta-models has a better $|\varepsilon|_{ave}$ as the average value of all meta-models. This difference is quite surprising, because the superposition is just a simple averaging of the meta-models. Also the R_{val}^2 is significantly better than the average value of all meta-models.

References

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