AUTOMATION OF MULTI-DISCIPLINARY ANALYSIS PROCESSES WITH ANSA/META AND OPTISLANG

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Despite the huge success in reducing time to market due to the progress and installation of software solutions for virtual product development, the automotive industry has to face increasing demands from multiple disciplines, e.g. related to the boost in electrification and autonomous driving. The fusion of various different disciplines towards a holistic design approach will be crucial in order to raise or maintain a high level of efficiency in the future. Multi-disciplinary design optimization (MDO) characterizes different attempts in the field of system engineering to offer optimization processes and methods that incorporate diverse fields of technical expertise. While it is expected that the technical system optimized with an MDO approach is superior to the optimization with individual disciplines, an efficient integration of a multitude of disciplines bears a number of challenges. Most of them are linked to the exchange of information between engineering teams associated to different technical fields. Enterprise software solutions for the automation of MDO related applications are required to not only support individual CAE processes but to encourage and foster cooperation among teams.
Together with engineers from BETA CAE, a show case based on the analysis of crash worthiness and durability of a double rail structure has been developed. Given the plugins for ANSA and META post, optiSLang is used to rapidly construct workflows for the design analysis that comprise steps for geometry variation (including shape morphing), finite-element analysis as well as the post-processing and parsing of the simulation results. The scenario at hand acts as demonstrator for different aspects of MDO process automation, coupling ANSA/META and optiSLang. With this demonstrator we like to emphasize the benefit of using meta-modelling techniques as vehicle for information exchange between disciplines and groups. As an example, exploiting meta-models for sensitivity analysis allows to communicate information about the relevance of design parameters for different performance indicators, which can be a key factor to avoid conflicts in the overall MDO process.

1. MULTI-DISCIPLINARY OPTIMIZATION AND DESIGN OF A CRASH BOX

Together with engineers from BETA CAE[1] a MDO show case has been developed that acts as demonstrator for different aspects of MDO process automation. In this setup a double rail structure of a BIW is modelled and optimized for crash worthiness and durability based on the results from finite element simulations. Besides meshing capabilities, ANSA provides morphing techniques that implement a compact parameterization for the study of different geometrical variations. The feature to apply smooth global and local deformations to the geometry with a limited number of design parameters makes this representation particular

[1] https://www.beta-cae.com

useful for computer aided optimization tasks. The morphing boxes are defined in a way that the size of the cross-section at the front and the rear can be controlled independently. Crumple zones for the control of the crash behaviour are introduced and parameterized to apply deformation directly to the surface. Besides setting up and parameterizing the deformation representations, ANSA is used to setup the load cases for dynamic and static loads, too. All post-processing of the simulation data and the calculation of the optimization criteria like maximum force, maximum intrusion dynamic loads are finally done with META post. Given the integrations for ANSA and META post optiSLang is used to rapidly construct different workflows for that comprise steps for geometry variation, finite element analysis as well as the post-processing and parsing of the simulation results. Fig. 1 depicts an overview of the baseline workflow for concurrently analysing the double rail for dynamic and static loads, integrating two different disciplines and simulation tools.

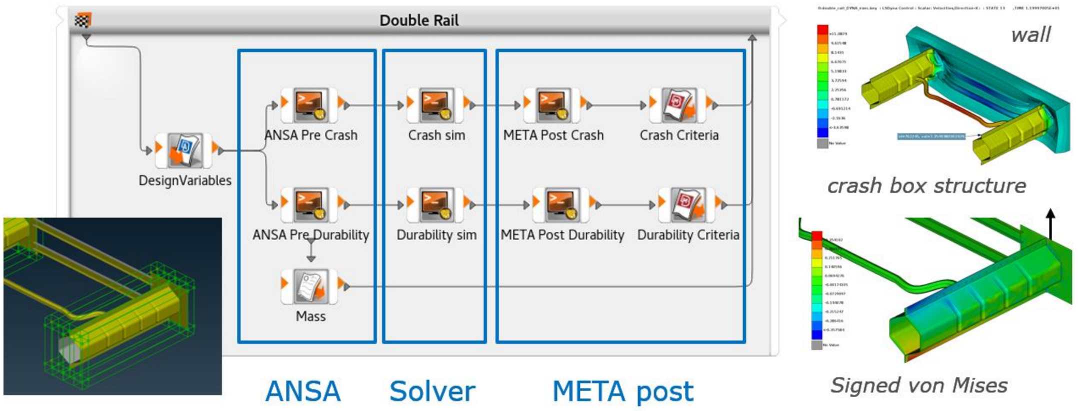

Figure 1 – MDO workflow for direct optimization, illustrating the coupling of two disciplines covering individual integrations for pre-processing, simulation and post-processing.

2. PROCESS INTEGRATION AND AUTOMATION WITH OPTISLANG

Given the double rail crash box structure as an example, we demonstrate in the presentation how optiSLang can be utilized to overcome a number of challenges in the area of MDO.

Customization

In larger companies we often observe a heterogenous software landscape among engineering disciplines and people. Different teams or even engineers within one team are using diverse tools for simulation, pre- and post-processing. In order to combine engineering tools from different disciplines into individual workflows or to adapt to changes in the software landscape it is required that new customized integrations can be build and used rapidly in order to assemble MDO related workflows. The installation of OptiSLang comes already with a large number of customized integrations and provides scripting capabilities using Python to rapidly build new ones. Those integrations can easily be shared among engineers and teams.

Design Representation

In consideration of MDO processes in fact the representation of the product design has rarely been discussed in the literature. Giving the double rail as an example, we are defining a set of design variables that are used to generate variations of the geometry. Under the assumption that we don't have any experience with this particular crash box topology, a priori information on which parameters are important by means of which parameters are sensitive to the simulation outcome is typically not given. In general, parameters that are relevant for one discipline might be completely interconnected with the outcome of simulations in another discipline. Being able to quantify and share information about the relevance of design parameters for each discipline and connected to the respective optimization criteria can be a key factor for an efficient MDO process. Engineers, teams and computer aided optimization algorithms can exploit this information and raise the awareness that for certain variations of the design a close interconnection and information exchange between disciplines is necessary. With optiSLang we are providing the algorithmic base for estimating this information by means of sensitivity studies. Given the results from design of experiments, first, the sensitivity study constructs a meta model, the meta model of optimal prognosis (MOP). Based on the MOP, the influence of each parameter on the modelled response value is quantified using the so-called CoP value (Coefficient of prognosis). The Information of the CoP value provides an objective measure that can be shared among different disciplines.

Management and use of meta-models

Meta-models like Polynomials, Kriging, Artificial Neural Networks or support vector machines define a class of mathematical models that can be tuned to approximate the relation between the design parameters and the responses, which are the outcome of the simulation. In contrast to high fidelity simulations the run-time of meta-models can often be neglected. Therefore, meta-models are often used as surrogates for te computational expensive simulation during the analysis of hundereds and tausends geometrical variations. Even so quantitatively meta-models often lack accuracy with respect to the simulation, meta-models are of high value for decision making in particular in the early stages of the product development process.

OptiSLang implements and provides users the so called "Model of optimal prognosis" (MOP). Depending on the given data and the intrinsic functional relationship between the design variables and simulation responses, the MOP algorithm runs an automatic feature and meta-model selection in the training phase. The objective for the search for an optimal meta-model is to minimze the coefficient of prognosis (CoP), a criteria that quantifies the prognosis quality of different meta-model variants. Depending on the model quality, judged by the CoP value, the meta-model can serve several purposes to speed up the MDO process and to support information exchange between disciplines.

Besides the use of Meta-models as surrogates in computational variation studies for optimization, sensitivity and robustness analysis, meta-models can be used for trade-off studies and for the prediction of potential conflicts between disciplines. As such sharing meta-models among different teams and disciplines can be of high value to support a rapid identification of potential conflicts early on in the development process. In this presentation we demonstrate this concept based on the double rail example, where ANSYS EKM2 (Engineering Knowledge Manager) is used as platform to exchange meta-models and can be used to automatically trigger the execution of optiSLang workflows, e.g. for the prediction of responses of group A, if group B is submitting a new design to EKM, or if running a trade-off study by means of meta-model assist MDO on the server. Given the double rail as an example application, where two different domains are involved, Fig. 2 sketches the concept of sharing meta-models among groups and processes.

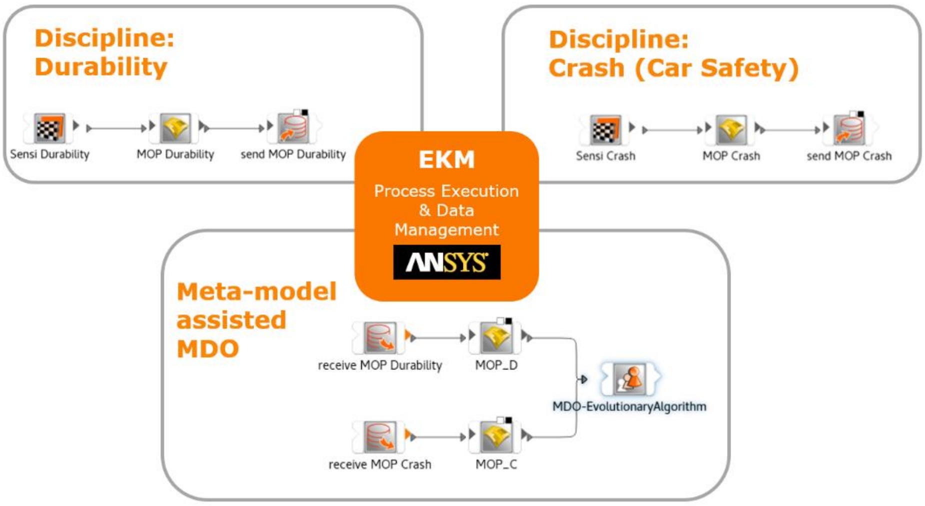

Figure 2 – Conceptual view on the exchange of meta-models via EKM (Simulation Data and Process Management) solution between individual disciplines and the meta-model assisted MDO process.

<u>Knowledge and data exchange</u>

For an efficient MDO, it is not only important to exchange information and data between the teams and disciplines but also avoid redundant work, e.g., regarding the writing of pre-, and post processing scripts as well as the creation and update of workflows for process automation. For this purpose, optiSLang is providing the functionality to store, load and manage the workflow templates. These templates facilitate an easy re-use of existing workflows. With that different groups can construct their workflows mostly independently, e.g., creating workflows for the optimization concerning objectives of individual disciplines, which then can be used to assemble and run workflows for MDO in a rapid manner.

[2] https://www.ansys.com/products/platform/ansys-ekm