Technische Universität Braunschweig

MUSEN

From Advanced Simulation Models to Industrial Applications

Lecture of

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The integration of advanced simulation models into industrial applications, especially in civil engineering, is a challenge that requires to develop new concepts. In particular, this is related to the validation of models using open access and FAIR data as well as objective methods for identifying model parameters and model comparison with the integration of both the models and their calibration into reproducible workflow systems.

The challenges are illustratively discussed for a variety of applications ranging from bridge monitoring over the structural behavior under blast loading up to the additive manufacturing of concrete. An important basis for model validation is the existence of machine-readable data structures for experimental data, e.g. based on semantic representations. In addition, platforms to share this structured data in a searchable format in addition with reproducible scientific workflows must be established.

Based on these tools, objective methods for model parameter estimation and validation of the models are a critical step in ensuring their accuracy and usefulness in industrial applications. Bayesian inference is one approach that can be used to optimize simulation parameters, improving the accuracy of the model while being able to estimate the uncertainty. Integrating these procedures in a real-time application with a bidirectional information exchange between the physical systems and the virtual simulation model leads to the concept of digital twins.

For complex simulation models, the computational efficiency is a significant barrier both for real-time applications and in the context of model calibration with potentially millions of required forward-model evaluations. As a consequence, reduced order modeling approaches such as the proper generalized decomposition method can be used to build an efficient to evaluate model - speeding up the online computation but requiring a precomputation in an offline phase.

Finally, a perspective for integrating material and structural design into a joint design optimization is given. The integration of advanced simulation models into industrial applications is a rapidly evolving field with significant potential for innovation and progress. From additive manufacturing of concrete to digital twins and reduced order modeling, there are many tools and approaches that can be used to improve industrial processes and drive progress in a variety of industries.