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INTELLIGENT ENGINEERING WITH UNCERTAIN DATA

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A major task in the engineering sciences is the numerical design of structures for the entire life cycle [1]. The current state of technology is characterized by deterministic thinking and practices. The representation of the reality with deterministic models suggests accuracy and precision. Fact is that all available data and information are characterized by fuzziness, incompleteness, uncertainty, and inaccuracy. An adequate consideration is necessary and cannot be neglected. Intelligent Engineering is defined as generalized development of methods and their application to the numerical design of structures based on uncertain data and information. Advanced numerical concepts are necessary to design efficient structures and systems.

In the contribution approaches and methods for the structural design are presented, which consider the uncertainty of the data in all phases of design problem-oriented, process it in numerical models to gain a new design quality. As the basis of the uncertainty modeling, the definition of the polymorphic uncertainty modeling [2] is proposed, to take all real-world scenarios into account.

Polymorphic uncertainty models allow the incorporation of the uncertainty characteristics variability, imprecision and incompleteness simultaneously. This generalized description reflects the underlying database representatively. The direct consideration of uncertainty in design tasks is for optimization and the solution of the inverse problem not possible, due to the missing of rules for comparing uncertain quantities.

Therefore it is necessary to formulate surrogate models, which allow the application of an appropriate uncertainty model. In general, it is possible to formulate two surrogate models, the passive and active approach [3].

The rapid development of numerical concepts in the context of imprecise probability is taken with [4]. In addition to modeling, acquisition and assimilation of data, numerical structural analysis, interaction questions, assessments, validations, replacement models and reduction methods with uncertain data are outlined, leading to an efficient numerical design [5].

Suitable approaches are reduction methods and replacement models among others. Reduction methods include model reduction, reducing the number of function calls and the complexity (e.g., the dimensionality with sensitivities). Replacement models are, for example, physically motivated and analytical meta-models.

In the selection of analytical meta-model approximations and classification methods can be distinguished. Numerically efficient classification algorithms are e.g. Support Vector Machines (SVM) or Self-Organizing Maps (SOM). Efficient approximate meta-models are, for example, Artificial Neural Networks (ANN), Radial Basis Function Networks (RBFN), Kriging and Extreme Learning Machines (ELM) [6].

In addition to different optimization problems with uncertain data also solutions of the inverse problem are presented, lead to practical engineering solutions.

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