A Model Refinement Framework for Statistical Model Validation

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Abstract

As the importance of virtual testing has been increased for cost-effective product design and design evaluation, researchers focus on studying verification and validation (V&V) to increase the computational model predictability. Model validation process can make the computational model accurately through the model calibration and validity check process; however, in some cases, unacknowledged uncertainties such as lack of knowledge and human mistakes still exist and decrease the predictability of the model. To overcome this challenge, this thesis presents a model refinement framework for statistical model validation which method finds and removes unacknowledged uncertainties by adding knowledge. This framework consists of the three steps; 1) invalidity analysis, 2) invalidity reasoning tree (IRT) and 3) invalidity sensitivity study. First, the invalidity analysis process identifies possible causes for model invalidity and supplements the deficient knowledge through two comparative studies; i) comparative study of simulation and experiment and ii) comparative study of calibration and validation domains. In the first comparative study, the simulation and experimental results used in the validity check basically contains much information and shows how the physical phenomena of two results work differently. In the second comparative study, model invalidities can be possibly caused by improperly setting calibration and validation domains. Then, the IRT determines a parametric form of refinement candidates from the possible causes with a systematic approach. This process helps select the model refinement candidates by sequentially screening the conceptual, mathematical, and computational models. The IRT begins with changing conceptual models which are related with the 'possible causes of invalidity' selected from the previous step. Then, mathematical models, such as governing equations, geometric representation, and constitutive equations are carefully selected to be changed. Lastly, each mathematical model must be implemented with a special care in terms of spatial discretization, temporal discretization, solution algorithms, and iterative convergence criteria. The IRT will not only help reduce the blunders but also enable time reduction for the model refinement. The invalidity sensitivity analysis finally analyzes the degree of importance of the invalidity causes that are identified in IRT method. The degree of importance of the causes is quantitatively indicated by sensitivity analysis. Once the model refinement step is complete, the model calibration and validity check should continue to improve the prediction capability of the computational model. Model calibration and validity check are followed to ensure good model predictability. The proposed method is demonstrated with the TFT-LCD fracture of a smartphone case study.

keywords : validation and verification (V&V), validity check, virtual product testing, model refinement

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