Modeling Tools, Techniques, and Standards

Title: **The Effect of Model Conservatism on Identifying Influential Parameters**

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The risk-informed, performance-based approach is increasingly being adopted by nuclear and non-nuclear industries (e.g., waste disposal, facility decommissioning, chemical process plant safety, and food safety) as a model for safety evaluation and licensing. Quantitative risk assessment, which permits systematic investigation, quantification, and explanation of system safety, is essential to implementing these risk-informed, performance-based approaches. Assessments are carried out probabilistically when uncertainty is associated with the system. Sensitivity analysis (also referred to as uncertainty importance analysis in some contexts) is an important component of the probabilistic risk assessment (PRA) methodology. Results from sensitivity analyses typically are used to derive the risk significance of various aspects of the system as represented through parameters, conceptual models, and assumptions.

In the literature, parametric sensitivity analysis typically refers to the sensitivity of model outputs to various model parameters. Hundreds of parametric sensitivity analysis methods have been published (see Saltelli, et al.[1] for a recent review article), and many off-the-shelf software packages are available for conducting sensitivity analysis. An assumption that is implicit to conducting sensitivity analysis is that the underlying model is realistic (i.e., neither overly pessimistic or optimistic). It is a common knowledge, however, that making conservative assumptions is unavoidable when assessing large and complex systems such as the disposal of high-level radioactive waste, when the system has a significant level of uncertainty.

In this paper, we use three example problems to illustrate the effect of this expected conservatism in model parameters on the identification and ranking of influential parameters. Simple example problems are used so the impact of conservatism can be clearly demonstrated. The first example is a generic four-parameter, nonlinear analytic function that permits computation of the exact sensitivity analytically. The other two examples are simple but practical problems. One illustrates the effect of conservatism when the model output is inversely proportional to the parameter of interest, and the other illustrates the effects of conservatism when the model output is directly proportional to the parameter of interest. In all three cases, the parameters are sampled from assigned distributions.

The sensitivity cases were obtained by changing the probability distribution function of the parameter of interest in the nominal case to a spike function with different means and a small but fixed variance. The mean was allowed to vary only within range of the nominal case parameter values.

Abstract:
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Our analyses to date show that the ranking of influential parameters clearly changes non-monotonically with the degree of assumed conservatism, depending on the model structure. Such changes could lead the analyst to conclude spuriously that other parameters are more influential. Because conservatism in safety analysis models with large uncertainties is unavoidable, analysts may consider using alternative methods (e.g., Mohanty, 2003) to ensure that all influential parameters are correctly identified.

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