Title:

Techniques for Sensitivity Analyses on Non-Monotonic Functions

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Abstract:
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Complex stochastic models and accompanying sensitivity analyses are being increasingly employed to support business, regulatory, and environmental decisions and to manage programs. Sensitivity analyses are commonly used to identify aspects that strongly influence a system performance metric. Investigations of several efficient techniques to identify non-monotonic dependencies between input and output are discussed in this paper. For complex models, efficient methods are needed to highlight parameters contributing to the uncertainty in a system output from relatively few Monte Carlo realizations (e.g., less than 1,000 realizations). Linear regression is an efficient sensitivity analysis technique that produces reliable results if the dependence between model inputs and output is monotonic; however, linear regression can overlook important non-monotonic dependencies. In this paper, we explore the capability of the parameter tree,[1] the mean-based sensitivity,[2,3] and the partitioning[4,5] methods to identify sensitivities of non-monotonic functions. Simple non-monotonic functions (e.g., quadratic functions) are used to compare the methods to the linear regression method. The partitioning method fails to recognize a sensitive parameter if the performance metric reaches an extreme at the median value of the input parameter range. Otherwise, the partitioning method is, in general, capable of identifying sensitive input parameters. The limitation in the partitioning method can be addressed by applying a transformation to the input parameter distributions by folding them along the median values and performing a sensitivity analysis with the transformed input parameter values. A hypothetical example is used in this paper to illustrate the techniques. The example problem comprises a model to track contaminants in soil that may be released to groundwater. Non-monotonic trends are introduced by hypothetical relationships that control contaminant release rates and contaminant travel time.

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