Info-Gap Analysis and Design of Structures: A Tutorial

Session on

Robustness to Lack of Knowledge in Design

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Abstract

Reliability analysis is challenged in three ways by uncertainty. Our understanding of the world and its uncertainties is evolving; indeterminism is an inherent part of the open universe in which we live; and learning from experience involves untestable assumptions. We discuss several concepts of robustness as tools for responding to these challenges. Using concepts from info-gap theory, we emphasize the non-probabilistic nature of major uncertainties facing the reliability engineer.

These uncertainties in the analysis and design of structures arise in material properties, geometry, loads, and operational conditions. In this tutorial we explore several aspects of this problem from the perspective of info-gap decision theory.

We consider the updating a dynamic model from measurements, when the structure of the model is uncertain. We formulate the info-gap robustness and discuss its two basic properties: zeroing and trade-off. Zeroing is the property that the estimated fidelity between model and measurement has no robustness to uncertainty in the model structure. The trade off property is that poorer fidelity has greater robustness to model uncertainty.

We then consider the probabilistic design of a structure when the relevant probability distributions are imperfectly known. We are particularly interested in severe uncertainty in the pdf's such as uncertain fat tails or uncertain mixtures of populations. In addition to the zeroing and trade off properties we also illustrate the potential for reversal of preference between design alternatives, depending on the designer's performance requirements.

Finally, we discuss the relation between optimizing and satisficing, and demonstrate how the robustness function is used in determining the degree of performance-sub-optimality that is required in order to manage the ambient uncertainty.

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