MICHIGAN STATE UNIVERSITY
Department of Statistics and Probability

COLLOQUIUM

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Some Statistical Aspects of Uncertainty Quantification

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10:20 a.m. - 11:10 am
Refreshments 10:00 am
C405 Wells Hall

Abstract

Computer simulations based on computational fluid dynamics, finite element analysis, discrete element models and multi-physics codes are widely used in aerospace, turbomachine, finance, data centers and many other fields. These simulations are necessary for studying complex phenomena such as thermal dynamics, supersonic flows, aircraft-controller interaction, and engine systems. Unfortunately, simulation models are never perfect and various uncertainties, including random initial and boundary conditions, input uncertainty, and model discrepancy, can produce misleading results. Thus, it is necessary to develop a rigorous mathematical framework for uncertainty quantification (UQ). UQ is an emerging field in applied mathematics, statistics and engineering.

This talk consists of three statistical aspects of UQ. The first topic presents a new class of statistical design inspired by the Samurai Sudoku puzzle. These designs have overlapping components and are useful for cross-validating data or models from multiple sources. The second topic discusses UQ for simulations with invariance properties, which appear in materials science, physics and biology. We propose a new statistical framework for building emulators to preserve invariance. The framework uses a weighted complete graph to represent the geometry and introduces a new class of function, called the relabeling symmetric functions, associated with the graph. The effectiveness of the method is illustrated by several examples from materials science. The third topic deals with computer codes with gradients. The gradient-enhanced Gaussian process emulator is widely used to analyze all outputs from a computer model with gradient info. The gradient-enhanced Gaussian process emulator has more numeric problems than in many multivariate cases because of the dependence of the model output and each gradient output. We derive a statistical theory to understand why this problem happens.

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