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Editorial

"Computer experiments and uncertainty quantification" is a rapidly growing area at the interface between statistics and applied mathematics. In fact, the theme reflects its interdisciplinary nature: "computer experiments" is the term used in statistics, and "uncertainty quantification" is the term used in applied mathematics. First, let us briefly review its fascinating historical development. Ever since the pioneering work of R. A. Fisher in experimental design, its original motivation and later applications have been largely in the planning and analysis of *physical* experiments, such as agriculture, chemical and manufacturing engineering, etc. But physical experiments have some shortcomings: they can be costly, time-consuming, or difficult to implement. Additionally, physical observations (e.g., hurricanes or mudslides) can be few and far between and are observed under unexpected or uncontrolled conditions. A convenient alternative is to conduct computer simulations, based on mathematical models that can describe the physical phenomena precisely. As faithful mathematical models, efficient algorithms, and fast computer code have become widely available, the use of computer simulation (e.g., finite element analysis) has become increasingly popular. In some applications, such simulations have replaced physical experiments as the primary *modus operandi.* The planning, analysis and optimization of computer simulation experiments are referred to collectively as *computer experiments* in the statistical literature. Independent of and parallel to the statistical development, applied mathematicians have become interested in the key question of how to quantify the uncertainty of the output obtained from solving, say, partial differential equations, when the input parameters are subject to stochastic variations. Some of the major early work was done by applied mathematicians in the Department of Energy (DOE) laboratories. Naturally, the tools they used are related to function approximation in the classical deterministic case. These mathematicians coined the term "uncertainty quantification" (UQ), which has a much broader meaning than the one described above. In particular, their motivation, mathematical tools, foundational philosophy and primary applications are quite different from what is called computer experiments in statistics. In the first 20 years (1990–2010) of this development, these two communities worked separately and often used different terminologies. Lately, there has been more communication between them, which culminated in the creation of a new journal called "SIAM-ASA Journal of Uncertainty Quantification" (JUQ) in 2013.

The goal of this theme issue is to publish papers primarily on the statistical side of this new area. It encompasses theory, methodology, computations and applications. While papers of this nature can be found in journals like JUQ and *Technometrics*, the collection of papers in this issue gives readers an updated and comprehensive view of the latest development in the research on computer experiments. We sincerely hope that this special issue will inspire new research and stimulate further progress in this important area.

The 18 papers herein cover a broad range of topics in computer experiments. To save space, we use the surname of the first author to refer to a paper. One group deals with stochastic modeling: stable processes in Tuo, and Gaussian Process (GP) in Plumlee and in Tan. Three papers by Sung, by Lee, and by Tajbakhsh address some computational or estimation problems based on GP models. Four papers by P. Chen, Pratola, Brown, and Tuo respectively deal with various aspects of the so-called calibration problem in UQ. This class of calibration problems plays a central role in the research and application of UQ, and the problem formulation is quite different from the classical calibration problem in statistics. A related paper by Jiahong Chen is on software auto-tuning. Two papers by Francom and by Xiong deal with the problem of sensitivity analysis when a computer model/code is used to describe the input-output relationship. Four papers by Jiajie Chen, Labopin-Richard, Ba, Harari are on various aspects of experimental design: Latin hypercubes, sequential design for estimating quantiles, sequential maximum projection design, and sample size choice respectively. Several papers mention applications in engineering or physical sciences. For example, the paper by Hwang focuses on estimation of pollution emission; the proposed methodology in the paper by Tajbakhsh can help handle big data.

Guest Editors
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