Stochastic Modeling Study at LSU Predicts Refined Algorithms

Although it has long been recognized that many physical systems are fundamentally stochastic, the desired governing equations for applications are usually deterministic. However, as we move toward a more realistic acceptance of probability as an essential component in the analysis of complex phenomena, the role of stochastic modeling is receiving more and more attention. This trend is illustrated, for example, by stochastic simulations to support petroleum reservoir management, probabilistic financial decision making and probabilistic weather forecasts.

LSU Assistant Professor of Mathematics and the Center for Computation & Technology, Xiaoliang Wan, received a $100, 211 award from the National Science Foundation to study the effect of Wick-type stochastic modeling and develop algorithms and applications. "The goal of the proposed research is to understand mathematically the effect of Wick products, as a generalization of Itˆo integral, on stochastic (elliptic) problems and to develop new algorithms to quantify the uncertainty in stochastic mathematical models of complex physical systems," said Wan.

The research will strive to identify the discrepancy between stochastic elliptic models and construct a new stochastic elliptic model based on the Wick product to reduce the discrepancy between the two stochastic modeling strategies produced. The development of more efficient algorithms will be attempted by incorporating the lower-triangular structure induced by the Wick product, as well as the development of a high-order adaptive method to solve the optimization problem given by the large deviation theory for random perturbations of dynamical systems. Lastly, applying the developments discussed, Wan will study some important physical phenomena such as diffusion in porous media, subcritical bifurcation, and exploration of high-dimensional configuration space.

Furthermore, the overall impact of this study will:

- from the theoretical point of view, provide the possibility of establishing a connection between two types of stochastic elliptic modeling strategies, which previously have been studied separately. A new stochastic elliptic model will be proposed and may shed new light on the understanding of the Wick product for physical applications;
- from the numerical point of view, provide the possibility for improving further current state-of-the-art numerical algorithms for stochastic elliptic partial differential equations and transitions in dynamical systems perturbed by small noise; and
- from the application point of view, provide the possibility for engineers to reconsider and examine this stochastic modeling strategy based on the Wick product, which might be more efficient and mathematically tractable for many cases. As a general framework, the developed high-order adaptive minimum action method can be employed to study general dynamical systems perturbed by small noise.

For more information on this or other research being done at the LSU Center for Computation & Technology, visit www.cct.lsu.edu/home.

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