UNIVERSITY of HOUSTON
CULLEN COLLEGE of ENGINEERING
Department of Electrical & Computer Engineering

PhD Dissertation Announcement

Stochastic Methods and Their Applications in Statistical Electromagnetic Modeling

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The stochastic computation of electromagnetic problems is a relatively new topic, yet very important to understand the true physics due to uncertainties associated with them. To deal with these uncertainties, the traditional Monte Carlo method can be applied. However, it requires a very large number of simulations to reach convergence, which makes it very computationally expensive.

This dissertation discusses alternative stochastic methods which are more efficiently than Monte Carlo method and their applications in EM modeling. The first part presents the use of generalized polynomial chaos method for stochastic computation. In this method, the stochastic solutions we are interested in are approximated by polynomial expansion in terms of input random variables, truncated at a finite order. Based on the distribution of random inputs, there is an optimal choice for polynomial basis to achieve fastest convergence. By taking inner product of the testing basis, we are seeking to solve the Maxwell equations in a weak form. The second part focuses on applying Stochastic Collocation method for stochastic computation. In this method, the solution is constructed via polynomial interpolation. Only a small number of repeated simulations are needed to get accurate statistics, which makes it computationally favorable. The selection of collocation points is of greatest importance in collocation method, especially in the multi-dimensional problems, since the total simulation cost is proportional to the number of collocation points. A sparse grid technique can be used for generating collocation points much less than tensor product rule in the multi-dimensional problems. The third part emphasizes on analyzing uncertainty problems with correlations. Most of the stochastic methods are based on the assumption that the probability space can be characterized by a set of independent random variables. However, this requirement may not be met in some cases. For example, the random process is a function of spatial coordinates or random variables are correlated in the probability space. To deal with spatial correlation, the Karhunen-Loeve expansion technique can be applied. For correlated Gaussian random variables, a linear mapping technique can transform them into uncorrelated random variables.

Numerical examples demonstrate the effectiveness and efficiency of these methods.

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