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MECHANICAL ENGINEERING COLLOQUIUM SERIES 2011-2012

Mechanical Engineering Lecture in Ocean Engineering

Non-Gaussian Data Assimilation and Uncertainty Prediction with Stochastic PDEs: Bye-Bye Monte-Carlo?

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Friday, Nov. 4th at 3:30pm in 3-370

Data assimilation is the process of quantitatively estimating properties of interest by melding information from observations with that predicted by dynamical models. By definition, for ocean data assimilation, this includes numerical ocean modeling, uncertainty quantification and assimilation schemes, and applications to ocean dynamics. We first highlight recent results by our research group, including multi-scale processes in the Philippines Archipelago, high-order Finite-Element schemes for biogeochemical ocean dynamics, and exact path planning for swarms of ocean vehicles using new level-set equations. We then address a grand challenge in ocean data assimilation: predict the probability density functions (pdfs) of large nonlinear ocean systems using stochastic partial differential equations (PDEs), assimilate data using Bayes' law with these pdfs and predict the future data that optimally reduce uncertainties. Specifically, our stochastic Dynamically Orthogonal (DO) PDEs and their adaptive stochastic subspace are employed to predict prior probabilities for the full dynamical state, effectively approximating the Fokker-Planck equations. At assimilation times, the DO realizations are fit to semi-parametric Gaussian Mixture Models using the Expectation-Maximization algorithm and the Bayesian Information Criterion. Bayes' Law is then efficiently carried out analytically within the evolving stochastic subspace. The advantages of rigorously respecting nonlinear dynamics and preserving non-Gaussian statistics are brought to light. The use of this new data assimilation scheme is illustrated for adaptive sampling, i.e. for predicting the optimal future data. Examples are provided using time-dependent ocean and fluid flows, including cavity, double-gyre and sudden-expansion flows with jets and eddies.

Refreshments will be served before the seminar.
GAME will host student/faculty Wine and Cheese reception after the lecture at the ME Commons 1-114.
Please contact Maggie Sullivan at sullmag@mit.edu with any questions.

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