Data-driven computational statistics and stochastic techniques for the robust design of continuum systems

Nicholas Zabaras

Materials Process Design and Control Laboratory, Sibley School of Mechanical and Aerospace Engineering, Cornell University, 188 Frank H.T. Rhodes Hall, Ithaca, NY, 14853-3801, USA

Email: zabaras@cornell.edu URL: http://www.mae.cornell.edu/zabaras/

A stochastic modeling and statistical inference approach will be presented for the solution of inverse problems in thermal transport systems (the presentation is available online at [1]). We will demonstrate these techniques using as an example the inverse heat conduction problem (IHCP) of estimating an unknown boundary heat flux in a conducting solid given temperature data within the domain [2,3]. Even though deterministic sequential and whole time domain estimation methods have been applied with success over the years for the solution of such problems, we herein introduce stochastic approaches to representing and solving the IHCP. As most engineering systems and processes operate in an uncertain environment, it becomes increasingly important to address their analysis and inverse design in a stochastic manner using statistical data-driven prior and concurrent information on the system response. Recent advances in spectral stochastic modeling, computational Bayesian and spatial statistics enable statistically complete and efficient solution procedures to such problems. Two distinct approaches to the IHCP will be presented one based on spectral stochastic modeling [3] and the other on Bayesian inference [2,4]. Although these techniques are discussed in the context of the IHCP, the methodology presented is general and applicable to design and estimation problems in other more complex problems in thermal transport systems including problems in the presence of convection, radiation and conduction [4,5].

REFERENCES

[1] http://www.mae.cornell.edu/zabaras/Publications/PDFiles/PRESENTATIONS/IPDO04.ppt

[2] J. Wang, N. Zabaras, A Bayesian inference approach to the stochastic inverse heat conduction problem, Int. J. Heat Mass Trans., in press.
Available online at: http://www.mae.cornell.edu/zabaras/Publications/PDFiles/Paper56.pdf

[3] V. A. Badri Narayanan and N. Zabaras, Stochastic inverse heat conduction using a spectral approach, Int. J. Num. Meth. Engrg, in press.
Available online at: http://www.mae.cornell.edu/zabaras/Publications/PDFiles/Paper54.pdf

[4] J. Wang, N. Zabaras, Using Bayesian statistics in the estimation of heat sources in radiation, Int. J. Heat Mass Trans., submitted for publication.
Available online at: http://www.mae.cornell.edu/zabaras/Publications/PDFiles/Paper60.pdf

[5] V.A. Badri Narayanan and N. Zabaras, Variational multiscale stabilized FEM formulations for transport equations: stochastic advection-diffusion and incompressible stochastic Navier-Stokes equations, J. Comp. Physics, submitted for publication.
Available online at: http://www.mae.cornell.edu/zabaras/Publications/PDFiles/Paper62.pdf