Bayesian (finite element) model updating

Webinar

Dates: September 25 (Friday) 9:00-13:00
September 28 (Monday) 9:00-11:40
September 29 (Tuesday) 9:00-13:00
September 30 (Wednesday) 9:00-13:00

Lecturers: Prof. Hermann G. Matthies (TU Braunschweig)
Dr. Noémi Friedman (Computer Science and Automation Research Institute, Budapest)

Registration: By e-mail to prof. Boštjan Brank (U Ljubljana) bbrank@fgg.uni-lj.si

Fees: Free for U Ljubljana students and stuff
50 eur for others

Schedule:

Friday 25 September 2020

9:00 -- 10:00 Hermann G. Matthies

Basics: basic tasks, representing uncertain knowledge, uncertainty quantification (UQ) outlook, updating uncertain knowledge, identification outlook, decisions under uncertainty, random variables (RVs), basic operations, mean/expectation, probability, variance, moments, co-variance etc., distributions, densities

10:20 -- 11:20 Hermann G. Matthies

Basic computational methods: functions of other RVs, parametric problems, proxy-models, computational UQ, integration methods in high dimensions (tensor-rules, Monte Carlo methods (MC), quasi Monte Carlo methods (QMC), Smolyak sparse grid), polynomial chaos expansion (PCE), interpolation / collocation, regression / pseudo spectral projection

11:40 -- 13:00 Noémi Friedmann

Working with RVs in practice: introduction to the MATLAB library package SGLIB, UQ in practice: integration rules, convergence of MC methods, proxy modelling by PCE for a small engineering example using SGLIB (interpolation, regression, pseudo spectral projection)

Monday 28 September 2020

9:00 -- 10:10 Hermann G. Matthies

Multi-dimensional RVs, processes, fields: random vectors, stochastic processes, random fields (RFs), joint densities, characteristic functions, simplest case covariance decompositions, spectral decomposition, separated (tensor) expansion, Cholesky and singular value decomposition (SVD), Karhunen-Loève expansion (KLE)

10:30 -- 11:40 Hermann G. Matthies

Basic inverse problems: motivation and explanation, stochastic identification, Bayes' theorem, interpretation (aleatoric, epistemic), conditioning, conditional expectation (CE) / probability, computing conditional distributions (posterior PDFs), MCMC, CE filter based on orthogonal decomposition, approximating the CE, linear approximations, Gauss-Markov theorem

Tuesday 29 September 2020

9:00 -- 9:55 Hermann G. Matthies

Inverse Problems / Identification in a Bayesian setting: filtering, approximations, CE-filter, classical Kalman filter, Kriging, Gauss-Markov-Kalman (GMK) filter, spectral GMK filter (PCEKF or SPKF), MC implementation of GMK filters

(EnKF), nonlinear CE based filters, approximation of the CE by Kriging and (deep) artificial neural networks (ANNs), particle filters

10:15 -- 11:10 Hermann G. Matthies

A few advanced topics: stochastic processes and random fields, covariance, invariance, spectrum, Fourier transform covariance - spectrum, densities - characteristic functions, covariance decompositions, separated and spectral decompositions, SVD, Karhunen-Loève expansion (KLE), high-dimensional functions, low-rank tensor decomposition, deep ANNs

11:30 -- 13:00 Noémi Friedmann

UQ of displacements due to uncertain fields (e.g. due to uncertainties of the constitutive model of inhomogeneous materials) in practice using SGLIB presented on a small engineering example. Practical introduction to inverse problems and Bayesian identification, reason to use proxy modelling (see UQ part) for the identification.

Wednesday 30 September 2020

9:00 -- 9:55 Hermann G. Matthies

Consolidation: parametrising problems, transformation of parameters, choice of RVs, discrete, categorical, and ordinal RVs, analysis of parametric problems, tensor representations, functional approximation, non-intrusive Galerkin, PGD, low-rank tensor methods, other proxy-models like Kriging and (deep) ANNs, Bayesian regression

10:15 -- 11:10 Hermann G. Matthies

Wrap-up and Outlook: preparatory work / input representation, uncertainty quantification (UQ) computational pathways, interpretation of epistemic and aleatoric uncertainty, what and why are we identifying, decisions under uncertainty (loss-functions)

11:30 -- 13:00 Noémi Friedmann

Inverse problems presented on small engineering examples: Bayesian parameter and field identification using SGLIB with different techniques (MCMC, EnKF, PCEKF, nonlinear filtering).

Hermann G. Matthies has obtained his degree from the TU Berlin, Germany; and his doctoral degree in mathematics at MIT, Cambridge, USA in 1978, working on FEM and plasticity. Subsequently he has worked in Research Division of Germanischer Lloyd, Hamburg, Germany, dealing with industrial research and engineering in diverse fields such as wind, offshore, and ice engineering. Since 1995 he joined academia as the Head of the Institute of Scientific Computing at the TU Braunschweig, Germany; and from 1996 to 2006 he was additionally the director of the University Computing Centre. His current research is oriented towards the uncertainty quantification, Bayesian identification and updating, coupled and interaction problems, plasticity and scientific computing. He has received several international distinctions, among them the Fellowship Award of the IACM. Since 2013, he has been appointed Full Member of the "Braunschweigische Wissenschafliche Gesellschaft" (BWG). He has published over 100 papers in scientific journals, as well as over 220 conference publications and topical special issues.

Noémi Friedman is researcher at the Informatics Laboratory at Computer Science and Automation Research Institute, Budapest, Hungary. She is a civil engineer, gained her expertise in stochastic engineering computations, uncertainty quantification and Bayesian update in the Institute of Scientific Computing of TU Braunschweig (2013-19). She received her PhD on the numerical analysis of adaptive, deployable structures from a parallel PhD program of ENS de Cachan in France and the Budapest University of Technology and Economics. She was the main organizer of the summer school "Parametric Uncertainties 2017" held in Budapest (https://www.wire.tu-bs.de/paramunc). She is a member of the German Research Training Group 2075 "Modelling the constitutive evolution of building materials and structures with respect to aging". She held keynote talks (e.g. U Ljubljana, DLR -German Aerospace Center, IACM 2017) on using advanced stochastic computations for different engineering problems.