

MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

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Numerical Methods for PDE Constrained Optimization with Uncertain Data

Organised by
Matthias Heinkenschloss, Houston
Volker Schulz, Trier

27 January – 2 February 2013

ABSTRACT. Optimization problems governed by partial differential equations (PDEs) arise in many applications in the form of optimal control, optimal design, or parameter identification problems. In most applications, parameters in the governing PDEs are not deterministic, but rather have to be modeled as random variables or, more generally, as random fields. It is crucial to capture and quantify the uncertainty in such problems rather than to simply replace the uncertain coefficients with their mean values. However, treating the uncertainty adequately and in a computationally tractable manner poses many mathematical challenges. The numerical solution of optimization problems governed by stochastic PDEs builds on mathematical subareas, which so far have been largely investigated in separate communities: Stochastic Programming, Numerical Solution of Stochastic PDEs, and PDE Constrained Optimization.

The workshop achieved an impulse towards cross-fertilization of those disciplines which also was the subject of several scientific discussions. It is to be expected that future exchange of ideas between these areas will give rise to new insights and powerful new numerical methods.

Mathematics Subject Classification (2010): 35xx, 49xx, 60xx, 65xx, 90xx, 93xx.

Introduction by the Organisers

The workshop *Numerical Methods for PDE Constrained Optimization with Uncertain Data*, organized by Matthias Heinkenschloss (Houston) and Volker Schulz (Trier) was held 27 January – 2 February 2013. One of the main objectives of this meeting was to bring together leading experts from the fields of stochastic

programming, numerical solution of stochastic PDEs, and PDE constrained optimization in order to encourage and foster new approaches by the exchange of state-of-the-art methods and fresh ideas. The achievement of this goal was well reflected by this workshop which was attended by almost fifty active researchers from seven countries including a few students and postdoctoral fellows. A total of thirty presentations was given at the workshop covering a wide spectrum of issues ranging from the analysis of specific theoretical problems to more algorithmic aspects of computational schemes and various applications.

A particular area of active research is the topic of

Optimization methods

This topic was one of the central themes of the workshop addressed in several talks including optimization with probability constraints (Henrion), optimal experimental design (Herzog), preconditioning of full-space SQP methods (Ridzal), finite dimensional stochastic programming (Schultz), robust optimization based on lower order approximations (Ulbrich) and in several application oriented talks.

Another central theme of the workshop was concerned with

Adaptive methods

This topic included the aspects of high order spatial discretizations (Gittelsohn), adaptive solution of PDE constrained optimization problems (Kouri), low-rank tensor approximations (Litvinenko), accurate discretization schemes (Mohammadi), collocation approaches (Nobile), adaptive quadrature rules (Ritter), and adaptive Smolyak-type approaches (Schillings).

Furthermore, the powerful methodology of

Model reduction and model predictive control

played an important role. Researchers in these areas reported on the usage of Fokker-Planck approaches (Borzi), nonstationary nonlinear model predictive control (Kostina), real-time optimization (Potschka) and approximation of stochastic optimization problems (Römisch).

The important aspect of

Applications

was the subject of ten talks concerned with Pareto-front identification in aerodynamic optimization (Desideri), oil and gas exploration (El-Bakry), groundwater flow (Ernst), optimal experimental design (Herzog), cardiovascular applications (Kunisch), inverse identification (Matthies), radio frequency ablation (Preusser), large scale shape optimization (Schmidt), topology optimization (Stoffel) and thermoelastic shape optimization (Zorn).

Furthermore several talks addressed interesting side aspects not covered within the clusters above, like piecewise deterministic processes (Annunziato), random domains (Harbrecht), and the tractability of multivariate problems (Novak),

It was noticeable in several presentations that the idea of bringing the so far separated disciplines of stochastic programming, numerical solution of stochastic PDEs, and PDE constrained optimization together is timely and very relevant for

applications. However, it has become also clear that this workshop has been just the first step giving an impulse towards cross-fertilization of those fields and that further similar efforts are necessary to unravel the full potential for future joint research.

Workshop: Numerical Methods for PDE Constrained Optimization with Uncertain Data

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