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Preface

The papers, composing this Special Section of an issue of the quarterly journal *Control and Cybernetics*, come from a workshop, devoted to optimization with PDE constraints. This OPTPDE2008 workshop took place at the Polish Academy of Sciences in Warsaw on December 11-13, 2008. It was organized within the framework of the "Optimization with PDE Constraints" programme, financed by the European Science Foundation. The Scientific Committee included Ronald W. Hoppe (Chairman), Karl Kunisch, Jan Sokołowski and Antoni Żochowski. The members of the local organizing committee were Piotr Nowak, Jan Sokołowski and Antoni Żochowski.

The scope of the workshop included:

- Mathematical foundations of PDE constrained optimization and control,
- Numerical methods in PDE constrained optimization,
- Applications to real-world and real-time process control problems.

The workshop was attended by 52 scientists from Austria (4), Brazil (1), Czech Republic (7), Denmark (4), France (6), Germany (8), United Kingdom (5), Luxembourg (1), Italy (2), Poland (7), Russia (1), Spain (2), Switzerland (2) and Turkey (2). During the workshop, 42 talks were presented, exactly according to the schedule published before the conference. More detailed information can be obtained on line under www.ibspan.waw.pl/OPTPDE2008, together with full versions of some of the presentations.

The main goal of this first workshop within the framework of the OPTPDE programme was to create a network of leading European research teams in the area of PDE constrained optimization and its applications. Upon having a look at the list of participants, it appears that the meeting gathered representatives of most advanced and active research groups working in the domain considered. The list includes also scientists from countries, which formally do not participate in the programme, like Denmark - with a very important group working in the area of shape and topology optimization, as well as France, traditionally very strong in all subjects concerning applied analysis of partial differential equations.

The leading theme, to which the most numerous group of presentations was devoted concerned shape and topology optimization (17 out of 42). The subject is on the one hand well established, and on the other hand it is a source of new difficult and unsolved problems. It also has many interesting applications, which were discussed as well (e.g. aeronautics, structural optimization, design

of microstructures, layout design). It should be noted that there were many young researchers, including PhD students, who also attended the workshop.

Shape and topology optimization generates also difficult and interesting problems for discrete and continuous optimization theory, and it sets high demands on the accuracy and speed of PDE solvers. Several talks on development of fast and accurate numerical methods, waveform relaxation, model reduction and regularization, were delivered.

One of the interesting applications of PDE optimization theory, discussed during the workshop, was the data assimilation problem for very large systems related to weather modelling. Other applications concerned financial mathematics and the problem of option pricing and volatility.

There were also several talks about methodological aspects of optimization in general, with emphasis on an infinite-dimensional setting.

A very important feature of the workshop was that the many young researchers present could see the wide picture of subjects treated by means of PDE control methodology. As an important result, it is hoped that there will be an increased number of short scientific visits of students and young researchers among the groups working in different countries, facilitated by the OPTPDE programme.

The following papers were presented during the workshop

Samuel Amstutz, France, *Topology optimization with constraints*

Martin Philip Bendsoe, Denmark, *PLATO-N: Developing Specialized Methods for Aeronautics Structural Optimization*

Coralia Cartis, United Kingdom, *Adaptive regularization methods for nonlinear problems*

Christian Clason, Austria, *A predual formulation for PDE constrained optimization with total variation regularization*

Yves Courvoisier, Switzerland, *Schwarz waveform relaxation methods*

Luca Dede', Italy, *Reduced basis method for parameterized optimal control problems*

Sue Dollar, United Kingdom, *Optimal solvers for PDE-constrained optimization*

Allan Roulund Gersborg, Denmark, *Maximizing opto-elastic interaction by topology optimization*

Marta Grzanek, Poland, *Uniqueness of identification of a hole for the inverse problem of eigenvalues*

Jaroslav Haslinger, Tomas Ligursky, Czech Republic, *3D discrete contact problems with Coulomb friction and a solution-dependent coefficient of friction: analysis and numerical realization*

Michael Hintermüller, Germany, *Mathematical programs with elliptic complementarity constraints in function space: stationarity concepts, path-following and multilevel algorithms*

Michael Hinze, Germany, *Optimization with PDEs in the presence of constraints; tailored discrete concepts and error analysis*
Jakob Sondergaard Jensen, Denmark, *Space-time topology optimization*
François Jouve, France, *Damage evolution and shape optimization*
Anna Kaźmierczak, Poland, *Dynamic programming approach to shape optimization for Navier-Stokes equations*
Tomas Kozubek, Czech Republic, *Practical aspects of the scalable total FETI based algorithms for numerical solution of contact problems*
Felix Kwok, Switzerland, *An algebraic optimized Schwarz method that converges in finitely many steps*
Antoine Laurain, Austria, *Shape optimization for variational inequalities*
Amos S. Lawless, United Kingdom, *Imposing physical constraints through variable transformations in variational data assimilation*
Günter Leugering, Germany, *Constrained optimization of processes and topologies for coupled PDEs*
Tomasz Lewiński, Poland, *Optimal layout of two-materials within core layers of sandwich plates*
Andrea Marson, Italy, *Control problems in hyperbolic balance laws*
Bijan Mohammadi, France, *Reduced-order modelling in applied shape optimization*
Andrzej Myśliński, Poland, *Radial basis function level set method in structural optimization*
Sergey Nazarov, Russia, *The spectral problems for scalar and vector (elastic) fields*
Nancy K. Nichols, United Kingdom, *Optimal state estimation for very large dynamical systems using reduced order models*
André Novotny, Brasil, *Sensitivity of the macroscopic constitutive tensor to topological microstructural changes*
Hans Josef Pesch, Germany, *New necessary conditions for a type of ODE-PDE constrained optimal control problem*
Jean-Pierre Puel, France, *Relations between controllability questions and some inverse problems for evolution equations*
Gast Rauchs, Luxembourg, *Material parameter identification using finite element modelling and numerical optimization*
Eduard Rohan, Czech Republic, *On sensitivity analysis for shape and topology optimization of phononic band gap structures*
Ekkehard Sachs, Germany, *Optimization of partial integrodifferential equations in finance*
Volker Schulz, Germany, *Fast methods for certain and uncertain aerodynamic shape optimization*
Maria Specovius-Neugebauer, Germany, *Asymptotic analysis and polarization matrices in elasticity*
Jan Stebel, Czech Republic, *Shape optimization for non-Newtonian incompressible fluids*

Mathias Stolpe, Denmark, *On solving discrete topology optimization problems in the PLATO-N project*

Katarzyna Szulc, France, *Asymptotic analysis and topological derivatives for semilinear problems*

Philippe Toint, Belgium, *Multilevel optimization using trust-regions and line searches*

Fredi Troeltzsch, Germany, *On a-posteriori error estimates for proper orthogonal decomposition*

Gabriel Turinici, France, *Deriving volatility surfaces for illiquid currency pairs in the local volatility framework*

Daniel Wachsmuth, Austria, *How to check numerically the sufficient optimality conditions for infinite-dimensional optimization problems*

Enrique Zuazua, Spain, *Wave propagation and discontinuous Galerkin approximations.*

Thus, altogether, the scientific scope of the workshop contained the following topics:

1) Mathematical foundations of PDE constrained optimization and control, in particular:
   - approximation and shape parameterization
   - convergence analysis
   - model reduction
   - parallel and grid computing.
2) Numerical methods in PDE constrained optimization, in particular:
   - treatment of control and state constraints
   - fast iterative solution of particular problems
   - adaptive methods.
3) Application to real-world and real-time process control problems, in particular:
   - engineering optimal design
   - mathematical finance.

The most numerous thread of the workshop may be placed at the intersection of topics 1 and 3. It concerned topology optimization for PDEs. In this group, we find the presentations of S. Amstutz, M.P. Bendsoe, A.R. Gersbourg, M. Grzanek, J.S. Jensen, F. Jouve, T. Lewinski, A. Kaźmierczak, M. Stolpe, F. Kwok, G. Leugering, A. Myśliński, A. Novotny, E. Rohan and K. Szulc. The subject seems indeed to enjoy a growing popularity.

Related to the above is shape optimization represented by talks of V. Schulz, M. Specovius-Neugebauer and J. Strebel. They dealt with algorithmic and theoretical aspects of some particular problems.

The talks by A. Marson, S. Nazarov, H.J. Pesch and J-P. Puel were concerned with the general theory of optimal control for PDEs with emphasis on the treatment of constraints and inverse problems.

The other dominant subjects were numerical methods used in PDE control with applications to real world problems. The speakers were C. Curtis, L. Dede, S. Dollar, J. Haslinger, T. Ligurski, E. Zuazua, A.S. Lawless, B. Mohammadi, C. Clason, N.K. Nichols, G. Rauchs, D. Wachsmuth, F. Troeltzsch, M. Hinde. The main themes were concerned with regularization, model reduction, data assimilation, and fast solvers.

The last subject, namely financial applications, was represented by C. Turinici and E. Sachs.

All the talks were presented as planned. Despite a busy schedule (42 talks in two days), the participants found time for discussions and the planning of future activities in the framework of the OPTPDE programme. The meeting of the Steering Committee during the workshop also served this purpose.

Several presentations may be found in their full form on the website of the workshop, www.ibspan.waw.pl/OPTPDE2008.

We are certain that also the papers, contained in this Special Section, constitute a significant contribution to the domain.

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