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Book review:

Control and Estimation of Distributed Parameter Systems

by

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The volume here presented contains the Proceedings of the International Conference on Control of Distributed Parameter Systems, held in Graz (Austria) from July 15–21, 2001. It was the one eighth in a series of conferences that began in 1982. The book includes are a broad variety of topics related to partial differential equations, ranging from abstract functional analytic framework to aspects of modelling, with the main emphasis, however, on theory and numerics of optimal control for nonlinear distributed parameter systems.

The proceedings contain 16 articles written by 27 authors, each of the papers containing new research results, not published before. They give a very useful overview to many of the current theoretical and industrial problems. The up-to-date references at the end of the articles are also very helpful, and the nice, uniform TeX style of the book will be appreciated by the readers.

In what follows, I describe briefly the papers contained in this collection. [1]

H.T. Banks, S.C. Beeler and H.T. Tran, *State estimations and tracking control of nonlinear dynamical systems*. Based on the "state-dependent Riccati equation", nonlinear estimators and nonlinear feedback tracking controls are constructed for a wide class of systems. An application to a flight dynamics simulation shows that the corresponding computational methods are easily implementable and efficient.

H.T. Banks, H. Tran and S. Wynne, *The well-posedness results for a shear wave propagation model*. Existence and uniqueness results are established for a nonlinear model for propagation of shear waves in viscoelastic tissue.

R. Becker and B. Wexler, *Mesh adaptation for parameter identification problems*. The authors consider automatic mesh refinement for parameter identification problems involving PDEs. The idea is to solve the inverse problem on a "cheap" discrete model, which still captures the "essential" features of the physical model. To this end, a posteriori error estimator is used to successively

[1] In case of reviews provided by the authors it is customary to refrain from any evaluation of the respective books (editors).

improve the accuracy by appropriate mesh refinement. The performance of the method is demonstrated on two examples of convection-diffusion equations.

M. Bergounioux and M. Haddou, *An SQP-augmented Lagrangian method for optimal control of semilinear elliptic variational inequalities.* Since Lagrange multipliers do not always exist for the problems under consideration in this paper, a close relaxed problem is solved by coupling the augmented Lagrangian method with a Gauss-Seidel splitting.

J.A. Burns and J.R. Singler, *On the long time behavior of approximating dynamical systems.* The authors show that a convergent numerical method on a finite precision machine can produce false steady state solutions even for "simple" nonlinear boundary value problems. Moreover, this problem cannot be eliminated by using a time stepper that preserves a side condition. Problems of this type are infinitely sensitive to small parameter changes and can have a dramatic impact on the convergence of optimal control and design algorithms.

K. Deckelnick and M. Hinze, *Error estimates in space and time for tracking-type control of the instationary Stokes system.* An optimal control problem of tracking type is considered for Stokes flows in two and three space dimensions. Based on the first order optimality conditions, the solution is approximated by finite elements in space and implicitly in time. Error estimates are also given and the results are confirmed by numerical examples.

M.C. Delfour, *Modeling and control of asymptotic shells.* In the first part of the paper the author improves his earlier treatment of an asymptotic model of thin shells: thanks to the use of a new projection a coupling term disappears. This leads to the complete decoupling of the membrane and bending equations. In the second part of the paper a dynamical thin shell model is studied for small vibrations.

W. Desch, E. Favsanga and J. Milota, *Unbounded observers and Riccati operators in nonreflexive spaces.* An infinite horizon linear quadratic optimal control problem is considered in a nonreflexive Banach space. The authors prove the existence of the Riccati operator synthesising the optimal solution in the feedback form, and they identify it with the minimal positive solution of the Riccati equation.

Q. Du and M. Gunzburger, *Centroidal Voronoi tessellation based proper orthogonal decomposition analysis.* In the study of turbulent and chaotic systems and in the real-time feedback control of complex systems, model reduction plays a very important role. Proper orthogonal decompositions have been used to extract the most energetic modes, while the centroidal Voronoi tessellations have been used to extract the best representatives. In this paper the two ideas are combined. The optimality of this approach and its implementability are also discussed.

H.O. Fattorini, *Time and norm optimal controls for linear parabolic equations: necessary and sufficient conditions*. The author proves a sufficient condition for time and norm optimality of controls for linear parabolic equations with a pointwise bound on the controls, and explores its interplay with the existing necessary conditions. Simple examples show the usefulness of the new condition.

A. Fursikov, *Feedback stabilization for the 2D Oseen equations: additional remarks*. In a recent paper, Fursikov (2001), the author proposed a new approach to the feedback stabilization. It was based on the construction of a suitable extension operator. Because of space limitation a unique continuation property was admitted without proof. The present paper contains its proof for an adjoint steady-state Oseen operator.

G. Grammel, *Pontryagin's maximum principle via singular perturbations*. Necessary optimality conditions are proved for a system consisting of a parabolic equation coupled with an ordinary differential equation in a Banach space. Such systems typically arise in the modelling of population dynamics in a contaminated environment.

K. Ito, *Level set methods for variational problems and applications*. The author discusses the application of the level set method for the inverse interface problems and shape optimization. The versatility of this approach is demonstrated by examples in inverse scattering, electrical impedance tomography, shape optimization, free boundary problems and obstacle problems. Numerical results are also presented.

V. Komornik and P. Loreti, *Boundary observability of compactly perturbed systems*. In an earlier work the authors introduced a constructive method for the proof of observability of compactly perturbed linear distributed systems. This allows one to avoid indirect compactness-uniqueness arguments. In the present paper this method is applied for systems of coupled wave and plate equations.

S. Manservisi, *Some shape optimal control computations for Navier-Stokes flows*. An incompressible, viscous flow is studied in a two-dimensional square to determine the shape of part of the boundary that minimizes the tracking velocity functional. The optimality system is derived by using an adjoint method and the Lagrange multipliers.

R.C. Smith and M.V. Salapaka, *Model development for the positioning mechanisms in an atomic force microscope*. This paper addresses the development of distributed models for the piezoceramic positioning mechanisms employed in current atomic force microscope designs. An abstract formulation encompassing two common models is developed and used to establish the well-posedness criteria. Numerical approximation techniques are also summarised and the accuracy of the models is demonstrated through comparison with experimental data.

References

FURSIKOV, A. (2001) Stabilizability of two-dimensional Navier-Stokes equations with help of boundary feedback control. *J. of Math. Fluid Mech.* **3**, 259–301.

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