

Part V

Applications

Introduction to Part V Applications

In this part we focus on a variety of highly challenging applications. These range from the nano-scale to macroscopic problems, and from electrical and chemical engineering to biology and medicine.

Inga Altrogge, Christof Büskens, Tim Kröger, Heinz-Otto Peitgen, Tobias Preusser and Hanne Tiesler summarize, in *Modeling, Simulation and Optimization of Radio Frequency Ablation*, their results on modeling the patient specific treatment of hepatic lesions, the multi-level gradient descent optimization of the probe placement under the corresponding PDE system and the identification of material parameters from temperature measurements. The focus lies on the uncertainties in the patient specific tissue properties that are represented by a stochastic PDE model. The applicability of the models and algorithms is validated against data from real patients' CT scans.

Eberhard Bänsch, Manfred Kaltenbacher, Günter Leugering, Fabian Schury and Fabian Wein present, in *Optimization of Electro-mechanical Smart Structures*, the most recent progress in topology optimization of piezoelectric loudspeakers using the SIMP method and topology gradient based methods along with analytical and numerical results.

Nikolai Botkin, Karl-Heinz Hoffmann and Varvara Turova present, in *Freezing of Living Cells: Mathematical Models and Design of Optimal Cooling Protocols*, the state of the art in optimal cryopreservation of living cells. Two main injuring effects are modeled and controlled using stable algorithms. Additionally, an optimal shape of cells under shrinkage and swelling during freezing and thawing is computed as a level set of a function that satisfies a Hamilton-Jacobi equation resulting from a Stefan-type condition for the normal velocity of the cell boundary. Examples of the shape evolution computed in two and three dimensions are presented.

Michael Gröschel, Günter Leugering and Wolfgang Peukert consider *Model Reduction, Structure-property Relations and Optimization Techniques for the Production of Nanoscale Particles* within a joint project of the faculties of mathematics and engineering. Parameter identification and optimal control techniques are presented for a precipitation process and an innovative aerosol forming process allowing for a precise control of residence time and temperature.

Frank Haußer, Sandra Janssen and Axel Voigt, in *Control of Nanostructures through Electric Fields and Related Free Boundary Problems*, consider geometric evolution equations to control the evolution of the surface or of the interface using the bulk contribution as a distributed control. The applicability of a phase-field approximation and the corresponding control problem are demonstrated in various numerical examples.

Achim Küpper and Sebastian Engell consider, in *Optimization of Simulated Moving Bed Processes*, periodic chromatographic simulated moving bed SMB processes incorporating rigorous models of the chromatographic columns and the discrete shifts of the inlet and outlet ports. The potential of optimization using a

rigorous model and multiple shooting is demonstrated by the ModiCon process where 40% to 50% savings in solvent consumption can be achieved, outperforming other well-established methods.

René Pinnau and Norbert Siedow, in *Optimization and Inverse Problems in Radiative Heat Transfer*, summarize their results on the derivation and investigation of efficient mathematical methods for the solution of optimization and identification problems for radiation dominated processes, which are described by a nonlinear integro-differential system and diffusive type approximations.

Markus Probst, Michael Lulfesmann, Mike Nicolai, H. Martin Bucker, Marek Behr and Christian H. Bischof report *On the Influence of Constitutive Models on Shape Optimization for Artificial Blood Pumps*, presenting a shape optimization framework that couples a highly parallel finite element solver with a geometric kernel and different optimization algorithms. The entire optimization framework is transformed using automatic differentiation techniques and successfully applied in designing bypass geometries in 2D/3D and ventricular assist devices.

Sebastian Engell and Günter Leugering