Preface

The optimist proclaims that we live in the best of all possible worlds;
and the pessimist fears this is true.

James Branch Cabell, The Silver Stallion

Over the last century, our information society has witnessed the emergence of a new method of scientific inquiry underpinned by Applied Mathematics. Our understanding of complex systems such as the Earth's weather, the financial market, or social networks, to name a few, is based around mathematical modeling, simulation, and optimization. Modeling and simulation deal with an accurate identification and replication of the underlying processes. Optimization addresses the characterization and computation of actions to achieve a best possible outcome.

Mathematical optimization has been present throughout the history of humankind. From Queen Dido's legend and the isoperimetric problem, going through Fermat's principle of least time in 1662, until the 20th century development of optimal control theory by Bellman and Pontryagin, the synthesis of optimal actions has been a formidable mathematical challenge. The present volume is a nonexhaustive, albeit sufficiently broad, timely account of some of the most prominent current research directions in optimization and optimal control.

This volume features contributions presented at the Special Semester on Optimization, organized by Karl Kunisch and Ekkehard Sachs, held from 14th October until 11th December 2019 at the Johann Radon Institute for Computational and Applied Mathematics (RICAM) in Linz, Austria. Over 140 speakers from all parts of the globe presented their latest research, showcased around five thematic workshops:

New Trends in PDE-Constrained Optimization (organizers: Roland Herzog and Emmanuel Trélat)

This workshop focused on recent advances in the wide and growing field of PDE-constrained optimization. Participants discussed recent developments in modeling, theory, and numerical techniques. Challenging applications ranged over a broad variety of fields, including additive manufacturing, biology, geophysics, fluid flow, medical imaging, solid mechanics, and natural hazards.

Optimal Control and Optimization for Nonlocal Models (organizers: Max Gunzburger and Marta D'Elia)

Participants at this workshop discussed a broad range of models, analytical and numerical techniques, and applications involving nonlocal models, with an emphasis on control and optimization. Examples included fractional differential equations, learning problems for nonlocal models, and nonlocal inverse problems.

Optimization and Inversion Under Uncertainty (organizers: Matthias Heinkenschloss and Georg Stadler)

This workshop showcased theoretical and algorithmic advances in the areas of optimization under uncertainty and Bayesian inversion governed by complex physi-

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cal systems. Problems in these areas arise in many science and engineering applications where we need to make decisions, compute designs, or specify controls under uncertainty, or where we need to infer parameters such as spatially distributed conductivities or permeabilities from measurements. Participants in this workshop presented advances in the development and integration of mathematical and computational tools from uncertainty quantification, optimization, control, and PDEs to solve these challenging problems.

Nonsmooth Optimization (organizer: Christian Clason)

This workshop focused on generalized calculus, optimality conditions, and algorithms for various classes of nonsmooth optimization problems. A variety of examples were discussed, including Nash equilibria, bilevel and multiobjective optimization, and quasi-variational inequalities.

Feedback Control (organizers: Dante Kalise and Karl Kunisch)

The focus of this workshop comprised theoretical and numerical aspects of feedback control. Topics discussed included feedback control and controllability of systems governed by PDEs, optimal feedback control, agent-based models, and computational methods for high-dimensional feedback synthesis.

Conic and Copositive Optimization (organizer: Mirjam Dür)

Conic optimization studies optimization problems where the decision variable is required to lie in some closed convex cone. Notable examples include the nonnegative orthant, the second-order cone, the cone of positive semidefinite matrices, and the cone of copositive matrices. At the workshop, participants presented analytical results and algorithmic advances.

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