Preface to the Series

Contributions to Mathematical and Computational Sciences

Mathematical theories and methods and effective computational algorithms are crucial in coping with the challenges arising in the sciences and in many areas of their application. New concepts and approaches are necessary in order to overcome the complexity barriers particularly created by nonlinearity, high-dimensionality, multiple scales and uncertainty. Combining advanced mathematical and computational methods and computer technology is an essential key to achieving progress, often even in purely theoretical research.

The term mathematical sciences refers to mathematics and its genuine sub-fields, as well as to scientific disciplines that are based on mathematical concepts and methods, including sub-fields of the natural and life sciences, the engineering and social sciences and recently also of the humanities. It is a major aim of this series to integrate the different sub-fields within mathematics and the computational sciences and to build bridges to all academic disciplines, to industry and to other fields of society, where mathematical and computational methods are necessary tools for progress. Fundamental and application-oriented research will be covered in proper balance.

The series will further offer contributions on areas at the frontier of research, providing both detailed information on topical research and surveys of the state of the art in a manner not usually possible in standard journal publications. Its volumes are intended to cover themes involving more than just a single "spectral line" of the rich spectrum of mathematical and computational research.

The Mathematics Center Heidelberg (MATCH) and the Interdisciplinary Center for Scientific Computing (IWR) with its Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences (HGS) are in charge of providing and preparing the material for publication. A substantial part of the material will be acquired in workshops and symposia organized by these institutions in topical areas of research. The resulting volumes should be more than just proceedings collecting papers submitted in advance. The exchange of information and the discussions during the meetings should also have a substantial influence on the contributions.

Starting this series is a venture posing challenges to all partners involved. A unique style attracting a larger audience beyond the group experts in the subject areas of specific volumes will have to be developed.

The first volume covers the mathematics of knots in theory and application, a field that appears excellently suited for the start of the series. Furthermore, due to the role that famous mathematicians in Heidelberg like Herbert Seifert (1907–1996) played in the development of topology in general and knot theory in particular, Heidelberg seemed a fitting place to host the special activities underlying this volume.

Springer Verlag deserves our special appreciation for its most efficient support in structuring and initiating this series.

Heidelberg, Germany

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Preface

The point of origin of this book was an international workshop with the same title (*Multiple Shooting and Time Domain Decomposition Methods—MuSTDD 2013*) that took place at the Interdisciplinary Center of Scientific Computing (IWR) at Heidelberg University in late spring 2013. Most of the chapters presented here are based on topics exposed in the talks given during this workshop.

The leading motivation for realizing this book project was its potential to fill a gap in the existing literature on time domain decomposition methods. So far, in contrast to domain decomposition methods for the spatial variables, which have found broad interest in the past two decades, the decomposition of the time domain still constitutes a niche. There is no comparable compendium on this subject, although an increasing amount of journal articles proves a growing need for these methods. Therefore, we firmly believe that this volume provides a useful overview over the state-of-the-art knowledge on the subject and offers a strong incentive for further research.

The book at hand is divided into two parts, which roughly reflect a classification of the articles into theoretical and application-oriented contributions:

- The first part comprises methodical, algorithmic, and implementational aspects of time domain decomposition methods. Although the context is often given by optimization problems (optimal control and parameter estimation with nonstationary differential equations), the covered topics are also accessible and crucial for researchers who intend to utilize time decomposition in a modeling and simulation framework. The topics covered in this theoretical part range from a historical survey of time domain decomposition methods via state-of-the-art environments for multiple shooting (such as ODE parameter estimation or DAE problems) up to recent research results, e.g. on different multiple shooting approaches for PDE, on multiple shooting in the optimal experimental design (OED) or the nonlinear model predictive control (NMPC) frameworks or on parareal methods as preconditioners.
- The second part is concerned with applications in different scientific areas that can potentially benefit from multiple shooting schemes and the related

parareal methods. In the application fields covered in this volume (amongst them fluid dynamics, data compression, image processing, computational biology, and fluid structure interaction problems), the two essential features of time domain decomposition methods, namely the stabilization of the solution process and its parallelizability, display their full potential.

Overall, we are convinced that this volume constitutes a unique compilation of methodical and application-oriented aspects of time domain decomposition useful for mathematicians, computer scientists, and researchers working in different application areas. Although it does not claim to be exhaustive, it provides a comprehensive accumulation of material that can both serve as a starting point for researchers who are interested in the subject and extend the horizon of experienced scientists who intend to deepen their knowledge.

We would like to acknowledge the support of several sponsors who made the MuSTDD workshop possible: the Priority Program 1253 of the German Research Association (DFG), the Mathematics Center Heidelberg (MATCH), and the Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences (HGS MathComp). Furthermore, we thank all the authors for their precious contributions. The cooperation with Springer, MATCH, and IWR should not be left unmentioned: it was a pleasure to work with them, and we thank all the people who rendered this 9th volume of *Contributions in Mathematical and Computational Sciences* possible by quietly and efficiently acting behind the scenes.

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