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Certified Reduced Basis Methods for Parametrized Partial Differential Equations

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Jörg Fehr, Bernard Haasdonk



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Certified Reduced Basis Methods for Parametrized Partial Differential Equations Jan S Hesthaven, Gianluigi Rozza, Benjamin Stamm, 2015-08-20 This book provides a thorough introduction to the mathematical and algorithmic aspects of certified reduced basis methods for parametrized partial differential equations Central aspects ranging from model construction error estimation and computational efficiency to empirical interpolation methods are discussed in detail for coercive problems More advanced aspects associated with time dependent problems non compliant and non coercive problems and applications with geometric variation are also discussed as examples **Optimization and Control for Partial Differential Equations** Roland Herzog, Matthias Heinkenschloss, Dante Kalise, Georg Stadler, Emmanuel Trélat, 2022-03-07 This book highlights new developments in the wide and growing field of partial differential equations PDE constrained optimization Optimization problems where the dynamics evolve according to a system of PDEs arise in science engineering and economic applications and they can take the form of inverse problems optimal control problems or optimal design problems This book covers new theoretical computational as well as implementation aspects for PDE constrained optimization problems under uncertainty in shape optimization and in feedback control and it illustrates the new developments on representative problems from a variety of applications **Model Reduction of Parametrized Systems** Peter Benner, Mario Ohlberger, Anthony Patera, Gianluigi Rozza, Karsten Urban, 2017-09-05 The special volume offers a global guide to new concepts and approaches concerning the following topics reduced basis methods proper orthogonal decomposition proper generalized decomposition approximation theory related to model reduction learning theory and compressed sensing stochastic and high dimensional problems system theoretic methods nonlinear model reduction reduction of coupled problems multiphysics optimization and optimal control state estimation and control reduced order models and domain decomposition methods Krylov subspace and interpolatory methods and applications to real industrial and complex problems The book represents the state of the art in the development of reduced order methods It contains contributions from internationally respected experts guaranteeing a wide range of expertise and topics Further it reflects an important effort carried out over the last 12 years to build a growing research community in this field Though not a textbook some of the chapters can be used as reference materials or lecture notes for classes and tutorials doctoral schools master classes Numerical Methods for PDEs Daniele Antonio Di Pietro, Alexandre Ern, Luca Formaggia, 2018-10-12 This volume gathers contributions from participants of the Introductory School and the IHP thematic quarter on Numerical Methods for PDE held in 2016 in Cargèse Corsica and Paris providing an opportunity to disseminate the latest results and envisage fresh challenges in traditional and new application fields Numerical analysis applied to the approximate solution of PDEs is a key discipline in applied mathematics and over the last few years several new paradigms have appeared leading to entire new families of discretization methods and solution algorithms This book is intended for researchers in the field Spectral and

High Order Methods for Partial Differential Equations ICOSAHOM 2016 Marco L. Bittencourt, Ney A. Dumont, Jan S. Hesthaven, 2017-11-07 This book features a selection of high quality papers chosen from the best presentations at the International Conference on Spectral and High Order Methods 2016 offering an overview of the depth and breadth of the activities within this important research area The carefully reviewed papers provide a snapshot of the state of the art while the extensive bibliography helps initiate new research directions

IUTAM Symposium on Model Order Reduction of Coupled Systems, Stuttgart, Germany, May 22-25, 2018 Jörg Fehr, Bernard Haasdonk, 2019-07-19 This volume contains the proceedings of the IUTAM Symposium on Model Order Reduction of Coupled System held in Stuttgart Germany May 22 25 2018 For the understanding and development of complex technical systems such as the human body or mechatronic systems an integrated multiphysics and multidisciplinary view is essential Many problems can be solved within one physical domain For the simulation and optimization of the combined system the different domains are connected with each other Very often the combination is only possible by using reduced order models such that the large scale dynamical system is approximated with a system of much smaller dimension where the most dominant features of the large scale system are retained as much as possible The field of model order reduction MOR is interdisciplinary Researchers from Engineering Mathematics and Computer Science identify explore and compare the potentials challenges and limitations of recent and new advances

Spectral and High Order Methods for Partial Differential Equations ICOSAHOM 2018 Spencer J. Sherwin, David Moxey, Joaquim Peiró, Peter E. Vincent, Christoph Schwab, 2020-08-11 This open access book features a selection of high quality papers from the presentations at the International Conference on Spectral and High Order Methods 2018 offering an overview of the depth and breadth of the activities within this important research area The carefully reviewed papers provide a snapshot of the state of the art while the extensive bibliography helps initiate new research directions

Model Predictive Control Aris Daniilidis, Lars Grüne, Josef Haunschmied, Gernot Tragler, 2025-06-07 The book explores the field of model predictive control MPC It reports on the latest developments in MPC current applications and presents various subfields of MPC The book features topics such as uncertain and stochastic MPC variants learning and neural network approaches easy to use numerical implementations as well as multi agent systems and scheduling and coordination tasks While MPC is rooted in engineering science this book illustrates the potential of using MPC theory and methods in non engineering sciences and applications such as economics finance and environmental sciences

Sparse Polynomial Approximation of High-Dimensional Functions Ben Adcock, Simone Brugiapaglia, Clayton G. Webster, 2022-02-16 Over seventy years ago Richard Bellman coined the term the curse of dimensionality to describe phenomena and computational challenges that arise in high dimensions These challenges in tandem with the ubiquity of high dimensional functions in real world applications have led to a lengthy focused research effort on high dimensional approximation that is the development of methods for approximating functions of many variables accurately and efficiently from data This book provides an in depth treatment of

one of the latest installments in this long and ongoing story sparse polynomial approximation methods These methods have emerged as useful tools for various high dimensional approximation tasks arising in a range of applications in computational science and engineering It begins with a comprehensive overview of best s term polynomial approximation theory for holomorphic high dimensional functions as well as a detailed survey of applications to parametric differential equations It then describes methods for computing sparse polynomial approximations focusing on least squares and compressed sensing techniques Sparse Polynomial Approximation of High Dimensional Functions presents the first comprehensive and unified treatment of polynomial approximation techniques that can mitigate the curse of dimensionality in high dimensional approximation including least squares and compressed sensing It develops main concepts in a mathematically rigorous manner with full proofs given wherever possible and it contains many numerical examples each accompanied by downloadable code The authors provide an extensive bibliography of over 350 relevant references with an additional annotated bibliography available on the book s companion website www.sparse-hd-book.com This text is aimed at graduate students postdoctoral fellows and researchers in mathematics computer science and engineering who are interested in high dimensional polynomial approximation techniques

Mathematical Modelling of the Human Cardiovascular System Alfio Quarteroni, Luca Dede', Andrea Manzoni, Christian Vergara, 2019-05-09 Addresses the mathematical and numerical modelling of the human cardiovascular system from patient data to clinical applications

Data-Driven Science and Engineering Steven L. Brunton, J. Nathan Kutz, 2022-05-05 Data driven discovery is revolutionizing how we model predict and control complex systems Now with Python and MATLAB this textbook trains mathematical scientists and engineers for the next generation of scientific discovery by offering a broad overview of the growing intersection of data driven methods machine learning applied optimization and classical fields of engineering mathematics and mathematical physics With a focus on integrating dynamical systems modeling and control with modern methods in applied machine learning this text includes methods that were chosen for their relevance simplicity and generality Topics range from introductory to research level material making it accessible to advanced undergraduate and beginning graduate students from the engineering and physical sciences The second edition features new chapters on reinforcement learning and physics informed machine learning significant new sections throughout and chapter exercises Online supplementary material including lecture videos per section homeworks data and code in MATLAB Python Julia and R available on databookuw.com

Cardiovascular Mechanics Michel Labrosse, 2018-09-13 The objective of this book is to illustrate in specific detail how cardiovascular mechanics stands as a common pillar supporting such different clinical successes as drugs for high blood pressure prosthetic heart valves and coronary artery bypass grafting among others This information is conveyed through a comprehensive treatment of the overarching principles and theories that are behind mechanobiological processes aortic and arterial mechanics atherosclerosis blood and microcirculation hear valve mechanics as well as medical devices and drugs Examines

all major theoretical and practical aspects of mechanical forces related to the cardiovascular system Discusses a unique coverage of mechanical changes related to an aging cardiovascular system Provides an overview of experimental methods in cardiovascular mechanics Written by world class researchers from Canada the US and EU Extensive references are provided at the end of each chapter to enhance further study Michel R Labrosse is the founder of the Cardiovascular Mechanics Laboratory at the University of Ottawa where he is a full professor within the Department of Mechanical Engineering He has been an active researcher in academia along with being heavily associated with the University of Ottawa Heart Institute He has authored or co authored over 90 refereed communications and supervised or co supervised over 40 graduate students and post docs

Real Time Reduced Order Computational Mechanics Gianluigi Rozza, Francesco Ballarin, Leonardo Scandurra, Federico Pichi, 2024-05-23 The book is made up by several worked out problems concerning the application of reduced order modeling to different parametric partial differential equations problems with an increasing degree of complexity This work is based on some experience acquired during lectures and exercises in classes taught at SISSA Mathematics Area in the Doctoral Programme Mathematical Analysis Modelling and Applications especially in computational mechanics classes as well as regular courses previously taught at EPF Lausanne and during several summer and winter schools The book is a companion for master and doctoral degree classes by allowing to go more deeply inside some partial differential equations worked out problems examples and even exercises but it is also addressed for researchers who are newcomers in computational mechanics with reduced order modeling In order to discuss computational results for the worked out problems presented in this booklet we will rely on the RBniCS Project The RBniCS Project contains an implementation in FEniCS of the reduced order modeling techniques such as certified reduced basis method and Proper Orthogonal Decomposition Galerkin methods for parametric problems that will be introduced in this booklet Spectral and

High Order Methods for Partial Differential Equations ICOSAHOM 2020+1 Jens M. Melenk, Ilaria Perugia, Joachim Schöberl, Christoph Schwab, 2023-06-30 The volume features high quality papers based on the presentations at the ICOSAHOM 2020 1 on spectral and high order methods The carefully reviewed articles cover state of the art topics in high order discretizations of partial differential equations The volume presents a wide range of topics including the design and analysis of high order methods the development of fast solvers on modern computer architecture and the application of these methods in fluid and structural mechanics computations

Reduction, Approximation, Machine Learning, Surrogates, Emulators and Simulators Gianluigi Rozza, Giovanni Stabile, Max Gunzburger, Marta D'Elia, 2024-06-24 This volume is focused on the review of recent algorithmic and mathematical advances and the development of new research directions for Mathematical Model Approximations via RAMSES Reduced order models Approximation theory Machine learning Surrogates Emulators Simulators in the setting of parametrized partial differential equations also with sparse and noisy data in high dimensional parameter spaces The book is a valuable resource for researchers as well as masters and Ph D students

Optimal Control of PDEs under Uncertainty Jesús Martínez-Frutos, Francisco Periago Esparza, 2018-08-30 This book provides a direct and comprehensive introduction to theoretical and numerical concepts in the emerging field of optimal control of partial differential equations PDEs under uncertainty The main objective of the book is to offer graduate students and researchers a smooth transition from optimal control of deterministic PDEs to optimal control of random PDEs Coverage includes uncertainty modelling in control problems variational formulation of PDEs with random inputs robust and risk averse formulations of optimal control problems existence theory and numerical resolution methods The exposition focusses on the entire path starting from uncertainty modelling and ending in the practical implementation of numerical schemes for the numerical approximation of the considered problems To this end a selected number of illustrative examples are analysed in detail throughout the book Computer codes written in MatLab are provided for all these examples This book is addressed to graduate students and researches in Engineering Physics and Mathematics who are interested in optimal control and optimal design for random partial differential equations

Model Reduction of Complex Dynamical Systems Peter Benner, Tobias Breiten, Heike Faßbender, Michael Hinze, Tatjana Stykel, Ralf Zimmermann, 2021-08-26 This contributed volume presents some of the latest research related to model order reduction of complex dynamical systems with a focus on time dependent problems Chapters are written by leading researchers and users of model order reduction techniques and are based on presentations given at the 2019 edition of the workshop series Model Reduction of Complex Dynamical Systems MODRED held at the University of Graz in Austria The topics considered can be divided into five categories system theoretic methods such as balanced truncation Hankel norm approximation and reduced basis methods data driven methods including Loewner matrix and pencil based approaches dynamic mode decomposition and kernel based methods surrogate modeling for design and optimization with special emphasis on control and data assimilation model reduction methods in applications such as control and network systems computational electromagnetics structural mechanics and fluid dynamics and model order reduction software packages and benchmarks This volume will be an ideal resource for graduate students and researchers in all areas of model reduction as well as those working in applied mathematics and theoretical informatics

Finite Element Approximation of Boundary Value Problems Franz Chouly, 2024-11-06 This textbook provides an accessible introduction to the mathematical foundations of the finite element method for a broad audience The author accomplishes this in part by including numerous exercises and illustrations Each chapter begins with a clear outline to help make complex concepts more approachable without sacrificing depth Structurally the book begins with the simplest type of finite element method low order piecewise continuous Lagrange finite elements With this crucial questions about the stability and approximation errors are answered Of particular note is the author's coverage of two specific topics that often go overlooked in introductory material The first is the numerical treatment of boundary conditions especially the Nitsche technique The second is a detailed explanation of the discretization error using specific techniques of a posteriori error

estimation With the book's compact yet thorough treatment of these areas readers will have a clear understanding of how mathematical analysis tools can be used in practice Finite Element Approximation of Boundary Value Problems will be suitable as a supplementary textbook in applied mathematics courses for graduate students and may also be used for self study

Applications Peter Benner, et al., 2020-12-07 An increasing complexity of models used to predict real world systems leads to the need for algorithms to replace complex models with far simpler ones while preserving the accuracy of the predictions This three volume handbook covers methods as well as applications This third volume focuses on applications in engineering biomedical engineering computational physics and computer science *Recent Advances in PDEs: Analysis, Numerics and Control* Anna Doubova, Manuel González-Burgos, Francisco Guillén-González, Mercedes Marín Beltrán, 2018-11-02 This book contains the main results of the talks given at the workshop Recent Advances in PDEs Analysis Numerics and Control which took place in Sevilla Spain on January 25-27 2017 The work comprises 12 contributions given by high level researchers in the partial differential equation PDE area to celebrate the 60th anniversary of Enrique Fernández-Cara University of Sevilla The main topics covered here are Control and inverse problems Analysis of Fluid mechanics and Numerical Analysis The work is devoted to researchers in these fields

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