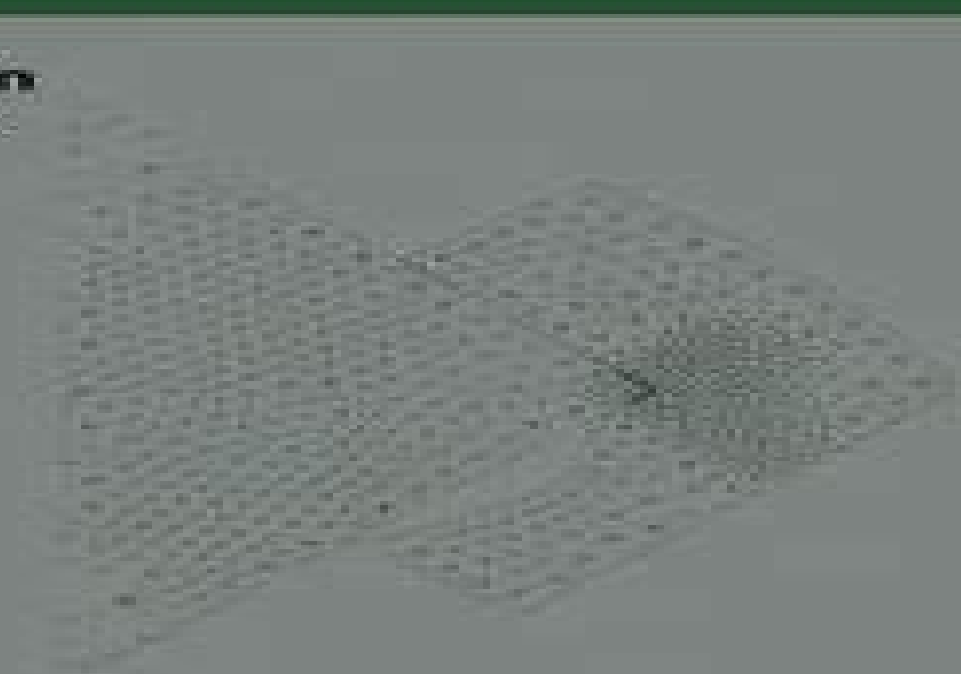# Fast Solution of Discretized Optimization Problems

Karl-Heinz Hoffmann
Ronald H.W. Hoppe
Volker Schulz
Editors

Fast Solution Of Discretized Optimization Problems

Andreas Potschka

Fast Solution Of Discretized Optimization Problems:

Fast Solution of Discretized Optimization Problems Karl-Heinz Hoffmann,Ronald W. Hoppe,Volker Schulz,2012-12-06 Differential equations partial as well as ordinary are one of the main tools for the modeling of real world application problems Pursuing the ultimate aim of influencing these systems in a desired way one is confronted with the task of optimizing discretized models This volume contains selected papers presented at the International Work shop on Fast Solution of Discretized Optimization Problems which took place at the Weierstrass Institute for Applied Analysis and Stochastics in Berlin from May 08 until May 12 2000 The conference was attended by 59 scientists from 10 countries The scientific program consisted of 8 invited lectures presented by H G Bock IWR Heidelberg M Heinkenschloss Rice University Houston K Kunisch University of Graz U Langer University Linz B Mohammadi University of Montpellier J Petersson University of Linkoping E Sachs University of Trier F Troltzsch Technical University of Chemnitz and 28 contributed talks The aim of this workshop was to foster the exchange of ideas between the still comparatively separated disciplines of nonlinear optimiza tion on the one side and numerical methods for differential equations on the other side This is necessary for the successful solution of various current optimization problems in practical applications shape optimization topology optimization pro cess optimization Therefore the organizing committee as well as the speakers have come from both these communities   Fast Solution of Discretized Optimization Problems Karl-Heinz Hoffmann,Ronald W. Hoppe,Volker Schulz,2001-09-01 A collection of articles summarizing the state of knowledge in a large portion of modern homotopy theory This welcome reference for many new results and recent methods is addressed to all mathematicians interested in homotopy theory and in geometric aspects of group theory   , *Constrained Optimization and Optimal Control for Partial Differential Equations* Günter Leugering,Sebastian Engell,Andreas Griewank,Michael Hinze,Rolf Rannacher,Volker Schulz,Michael Ulbrich,Stefan Ulbrich,2012-01-03 This special volume focuses on optimization and control of processes governed by partial differential equations The contributors are mostly participants of the DFG priority program 1253 Optimization with PDE constraints which is active since 2006 The book is organized in sections which cover almost the entire spectrum of modern research in this emerging field Indeed even though the field of optimal control and optimization for PDE constrained problems has undergone a dramatic increase of interest during the last four decades a full theory for nonlinear problems is still lacking The contributions of this volume some of which have the character of survey articles therefore aim at creating and developing further new ideas for optimization control and corresponding numerical simulations of systems of possibly coupled nonlinear partial differential equations The research conducted within this unique network of groups in more than fifteen German universities focuses on novel methods of optimization control and identification for problems in infinite dimensional spaces shape and topology problems model reduction and adaptivity discretization concepts and important applications Besides the theoretical interest the most prominent question is about the effectiveness of model based

numerical optimization methods for PDEs versus a black box approach that uses existing codes often heuristic based for optimization   Real-time PDE-constrained Optimization Lorenz T. Biegler,Omar Ghattas,Matthias Heinkenschloss,David Keyes,Bart van Bloemen Waanders,2007-01-01 Many engineering and scientific problems in design control and parameter estimation can be formulated as optimization problems that are governed by partial differential equations PDEs The complexities of the PDEs and the requirement for rapid solution pose significant difficulties A particularly challenging class of PDE constrained optimization problems is characterized by the need for real time solution i e in time scales that are sufficiently rapid to support simulation based decision making Real Time PDE Constrained Optimization the first book devoted to real time optimization for systems governed by PDEs focuses on new formulations methods and algorithms needed to facilitate real time PDE constrained optimization In addition to presenting state of the art algorithms and formulations the text illustrates these algorithms with a diverse set of applications that includes problems in the areas of aerodynamics biology fluid dynamics medicine chemical processes homeland security and structural dynamics Audience readers who have expertise in simulation and are interested in incorporating optimization into their simulations who have expertise in numerical optimization and are interested in adapting optimization methods to the class of infinite dimensional simulation problems or who have worked in offline optimization contexts and are interested in moving to online optimization

Computational Optimization of Systems Governed by Partial Differential Equations Alfio Borzi,Volker Schulz,2012-01-26 This book provides a bridge between continuous optimization and PDE modelling and focuses on the numerical solution of the corresponding problems Intended for graduate students in PDE constrained optimization it is also suitable as an introduction for researchers in scientific computing or optimization   Lagrange Multiplier Approach to Variational Problems and Applications Kazufumi Ito,Karl Kunisch,2008-01-01 Lagrange multiplier theory provides a tool for the analysis of a general class of nonlinear variational problems and is the basis for developing efficient and powerful iterative methods for solving these problems This comprehensive monograph analyzes Lagrange multiplier theory and shows its impact on the development of numerical algorithms for problems posed in a function space setting The authors develop and analyze efficient algorithms for constrained optimization and convex optimization problems based on the augumented Lagrangian concept and cover such topics as sensitivity analysis convex optimization second order methods and shape sensitivity calculus General theory is applied to challenging problems in optimal control of partial differential equations image analysis mechanical contact and friction problems and American options for the Black Scholes model   **Online Optimization of Large Scale Systems** Martin Grötschel,Sven O. Krumke,Joerg Rambau,2013-03-14 In its thousands of years of history mathematics has made an extraordinary ca reer It started from rules for bookkeeping and computation of areas to become the language of science Its potential for decision support was fully recognized in the twentieth century only vitally aided by the evolution of computing and communi cation technology Mathematical optimization in particular has

developed into a powerful machinery to help planners Whether costs are to be reduced profits to be maximized or scarce resources to be used wisely optimization methods are available to guide decision making Opti mization is particularly strong if precise models of real phenomena and data of high quality are at hand often yielding reliable automated control and decision proce dures But what if the models are soft and not all data are around Can mathematics help as well This book addresses such issues e g problems of the following type An elevator cannot know all transportation requests in advance In which order should it serve the passengers Wing profiles of aircrafts influence the fuel consumption Is it possible to con tinuously adapt the shape of a wing during the flight under rapidly changing conditions Robots are designed to accomplish specific tasks as efficiently as possible But what if a robot navigates in an unknown environment Energy demand changes quickly and is not easily predictable over time Some types of power plants can only react slowly **A Direct Method for Parabolic PDE Constrained Optimization Problems** Andreas Potschka,2013-11-29 Andreas Potschka discusses a direct multiple shooting method for dynamic optimization problems constrained by nonlinear possibly time periodic parabolic partial differential equations In contrast to indirect methods this approach automatically computes adjoint derivatives without requiring the user to formulate adjoint equations which can be time consuming and error prone The author describes and analyzes in detail a globalized inexact Sequential Quadratic Programming method that exploits the mathematical structures of this approach and problem class for fast numerical performance The book features applications including results for a real world chemical engineering separation problem Scalable Algorithms for Contact Problems Zdeněk Dostál,Tomáš Kozubek,Marie Sadowská,Vít Vondrák,2023-10-28 This book presents a comprehensive treatment of recently developed scalable algorithms for solving multibody contact problems of linear elasticity The brand new feature of these algorithms is their theoretically supported numerical scalability i e asymptotically linear complexity and parallel scalability demonstrated in solving problems discretized by billions of degrees of freedom The theory covers solving multibody frictionless contact problems contact problems with possibly orthotropic Tresca s friction and transient contact problems In addition it also covers BEM discretization treating jumping coefficients floating bodies mortar non penetration conditions etc This second edition includes updated content including a new chapter on hybrid domain decomposition methods for huge contact problems Furthermore new sections describe the latest algorithm improvements e g the fast reconstruction of displacements the adaptive reorthogonalization of dual constraints and an updated chapter on parallel implementation Several chapters are extended to give an independent exposition of classical bounds on the spectrum of mass and dual stiffness matrices a benchmark for Coulomb orthotropic friction details of discretization etc The exposition is divided into four parts the first of which reviews auxiliary linear algebra optimization and analysis The most important algorithms and optimality results are presented in the third chapter The presentation includes continuous formulation discretization domain decomposition optimality results and numerical experiments The final part contains extensions to contact shape optimization

plasticity and HPC implementation Graduate students and researchers in mechanical engineering computational engineering and applied mathematics will find this book of great value and interest **Modeling, Simulation, and Optimization of Integrated Circuits** K. Antreich,R. Bulirsch,A. Gilg,P. Rentrop,2012-12-06 In November 2001 the Mathematical Research Center at Oberwolfach Germany hosted the third Conference on Mathematical Models and Numerical Simulation in Electronic Industry It brought together researchers in mathematics electrical engineering and scientists working in industry The contributions to this volume try to bridge the gap between basic and applied mathematics research in electrical engineering and the needs of industry **Fast Solution of Discretized Optimization Problems** Karl-Heinz Hoffmann,Ronald H. W. Hoppe,Volker Schulz,2001-01-01 This book contains a collection of articles summarizing the state of knowledge in a large portion of modern homotopy theory A call for articles was made on the occasion of an emphasis semester organized by the Centre de Recerca MatemA tica in Bellaterra Barcelona in 1998 The main topics treated in the book include abstract features of stable and unstable homotopy homotopical localizations p compact groups H spaces classifying spaces for proper actions cohomology of discrete groups K theory and other generalized cohomology theories configuration spaces and Lusternik Schnirelmann category The book is addressed to all mathematicians interested in homotopy theory and in geometric aspects of group theory New research directions in topology are highlighted Moreover this informative and educational book serves as a welcome reference for many new results and recent methods

Numerical Data Fitting in Dynamical Systems Klaus Schittkowski,2013-06-05 Real life phenomena in engineering natural or medical sciences are often described by a mathematical model with the goal to analyze numerically the behaviour of the system Advantages of mathematical models are their cheap availability the possibility of studying extreme situations that cannot be handled by experiments or of simulating real systems during the design phase before constructing a first prototype Moreover they serve to verify decisions to avoid expensive and time consuming experimental tests to analyze understand and explain the behaviour of systems or to optimize design and production As soon as a mathematical model contains differential dependencies from an additional parameter typically the time we call it a dynamical model There are two key questions always arising in a practical environment 1 Is the mathematical model correct 2 How can I quantify model parameters that cannot be measured directly In principle both questions are easily answered as soon as some experimental data are available The idea is to compare measured data with predicted model function values and to minimize the differences over the whole parameter space We have to reject a model if we are unable to find a reasonably accurate fit To summarize parameter estimation or data fitting respectively is extremely important in all practical situations where a mathematical model and corresponding experimental data are available to describe the behaviour of a dynamical system **Relaxation in Optimization Theory and Variational Calculus** Tomáš Roubíček,2020-11-09 The relaxation method has enjoyed an intensive development during many decades and this new edition of this comprehensive text reflects in particular the main

achievements in the past 20 years Moreover many further improvements and extensions are included both in the direction of optimal control and optimal design as well as in numerics and applications in materials science along with an updated treatment of the abstract parts of the theory **Iterative Methods and Preconditioners for Systems of Linear Equations** Gabriele Ciaramella,Martin J. Gander,2022-02-08 Iterative methods use successive approximations to obtain more accurate solutions This book gives an introduction to iterative methods and preconditioning for solving discretized elliptic partial differential equations and optimal control problems governed by the Laplace equation for which the use of matrix free procedures is crucial All methods are explained and analyzed starting from the historical ideas of the inventors which are often quoted from their seminal works Iterative Methods and Preconditioners for Systems of Linear Equations grew out of a set of lecture notes that were improved and enriched over time resulting in a clear focus for the teaching methodology which derives complete convergence estimates for all methods illustrates and provides MATLAB codes for all methods and studies and tests all preconditioners first as stationary iterative solvers This textbook is appropriate for undergraduate and graduate students who want an overview or deeper understanding of iterative methods Its focus on both analysis and numerical experiments allows the material to be taught with very little preparation since all the arguments are self contained and makes it appropriate for self study as well It can be used in courses on iterative methods Krylov methods and preconditioners and numerical optimal control Scientists and engineers interested in new topics and applications will also find the text useful

    Theory and Numerics of Differential Equations James Blowey,John P. Coleman,Alan W. Craig,2013-03-09 The Ninth EPSRC Numerical Analysis Summer School was held at the Uni versity of Durharn UK from the 10th to the 21st of July 2000 This was the first of these schools to be held in Durharn having previously been hosted initially by the University of Lancaster and latterly by the University of Leicester The purpose of the summer school was to present high quality in structional courses on topics at the forefront of numerical analysis research to postgraduate students Eminent figures in numerical analysis presented lectures and provided high quality lecture notes At the time of writing it is now more than two years since we first con tacted the guest speakers and during that period they have given significant portions of their time to making the summer school and this volume a suc cess We would like to thank all six of them for the care which they took in the preparation and delivery of their lectures The speakers were Christine Bernardi Petter Bj0rstad Carsten Carstensen Peter Kloeden Ralf Kornhu ber and Anders Szepessy This volume presents written contributions from five of the six speakers In all cases except one these contributions are more comprehensive versions of the lecture not es which were distributed to participants during the meeting Peter Kloeden s contribution is intended to be complementary to his lecture course and numerous references are given therein to sources of the lecture material *Control and Estimation of Distributed Parameter Systems* Wolfgang Desch,Franz Kappel,Karl Kunisch,2012-12-06 Consisting of 16 refereed original contributions this volume presents a diversified collection of recent results in control of distributed parameter systems Topics addressed

include optimal control in fluid mechanics numerical methods for optimal control of partial differential equations modeling and control of shells level set methods mesh adaptation for parameter estimation problems shape optimization Advanced graduate students and researchers will find the book an excellent guide to the forefront of control and estimation of distributed parameter systems   *Relaxation and Decomposition Methods for Mixed Integer Nonlinear Programming* Ivo Nowak,2005-08-15 Nonlinearoptimizationproblemscontainingbothcontinuousanddiscretevariables are called mixed integer nonlinear programs MINLP Such problems arise in many elds such as process industry engineering design communications and nance There is currently a huge gap between MINLP and mixed integer linear programming MIP solvertechnology With a modernstate of the artMIP solver itispossibletosolvemodelswithmillionsofvariablesandconstraints whereasthe dimensionofsolvableMINLPsisoftenlimitedbyanumberthatissmallerbythree or four orders of magnitude It is theoretically possible to approximate a general MINLP by a MIP with arbitrary precision However good MIP approximations are usually much larger than the original problem Moreover the approximation of nonlinear functions by piecewise linear functions can be di cult and ti consuming In this book relaxation and decomposition methods for solving nonconvex structured MINLPs are proposed In particular a generic branch cut and price BCP framework for MINLP is presented BCP is the underlying concept in almost all modern MIP solvers Providing a powerful decomposition framework for both sequential and parallel solvers it made the success of the current MIP technology possible So far generic BCP frameworks have been developed only for MIP for example COIN BCP IBM 2003 andABACUS OREAS GmbH 1999 In order to generalize MIP BCP to MINLP BCP the following points have to be taken into account A given sparse MINLP is reformulated as a block separable program with linear coupling constraints The block structure makes it possible to generate Lagrangian cuts and to apply Lagrangian heuristics In order to facilitate the generation of polyhedral relaxations nonlinear c vex relaxations are constructed The MINLP separation and pricing subproblems for generating cuts and columns are solved with specialized MINLP solvers

Nonlinear Smoothing and Multiresolution Analysis Carl Rohwer,2005-06-16 This monograph presents a new theory for analysis comparison and design of nonlinear smoothers linking to established practices Although a part of mathematical morphology the special properties yield many simple powerful and illuminating results leading to a novel nonlinear multiresolution analysis with pulses that may be as natural to vision as wavelet analysis is to acoustics Similar to median transforms they have the advantages of a supporting theory computational simplicity remarkable consistency full trend preservation and a Parceval type identity Although the perspective is new and unfamiliar to most the reader can verify all the ideas and results with simple simulations on a computer at each stage The framework developed turns out to be a part of mathematical morphology but the additional specific structures and properties yield a heuristic understanding that is easy to absorb for practitioners in the fields like signal and image processing The book targets mathematicians scientists and engineers with interest in concepts like trend pulse smoothness and resolution in sequences   **Optimal Quadratic**

Programming Algorithms Zdenek Dostál,2009-04-03 Solving optimization problems in complex systems often requires the implementation of advanced mathematical techniques Quadratic programming QP is one technique that allows for the optimization of a quadratic function in several variables in the presence of linear constraints QP problems arise in fields as diverse as electrical engineering agricultural planning and optics Given its broad applicability a comprehensive understanding of quadratic programming is a valuable resource in nearly every scientific field Optimal Quadratic Programming Algorithms presents recently developed algorithms for solving large QP problems The presentation focuses on algorithms which are in a sense optimal i e they can solve important classes of problems at a cost proportional to the number of unknowns For each algorithm presented the book details its classical predecessor describes its drawbacks introduces modifications that improve its performance and demonstrates these improvements through numerical experiments This self contained monograph can serve as an introductory text on quadratic programming for graduate students and researchers Additionally since the solution of many nonlinear problems can be reduced to the solution of a sequence of QP problems it can also be used as a convenient introduction to nonlinear programming The reader is required to have a basic knowledge of calculus in several variables and linear algebra

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