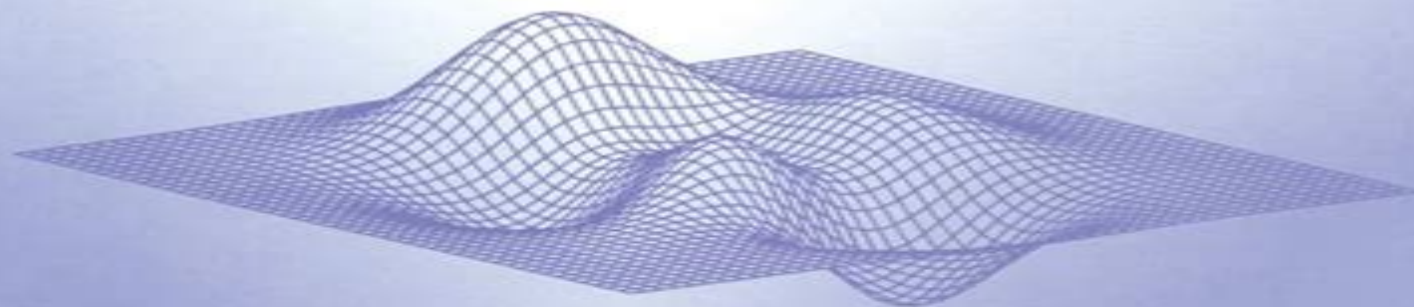


NONCONVEX OPTIMIZATION AND ITS APPLICATIONS

Duality Principles in Nonconvex Systems

Theory, Methods and Applications

David Yang Gao



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Duality Principles In Nonconvex Systems Theory Methods And Applications

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Tyrrell Rockafellar**



Duality Principles In Nonconvex Systems Theory Methods And Applications:

Duality Principles in Nonconvex Systems David Yang Gao, 2000-01-31 Motivated by practical problems in engineering and physics drawing on a wide range of applied mathematical disciplines this book is the first to provide within a unified framework a self contained comprehensive mathematical theory of duality for general non convex non smooth systems with emphasis on methods and applications in engineering mechanics Topics covered include the classical minimax mono duality of convex static equilibria the beautiful bi duality in dynamical systems the interesting tri duality in non convex problems and the complicated multi duality in general canonical systems A potentially powerful sequential canonical dual transformation method for solving fully nonlinear problems is developed heuristically and illustrated by use of many interesting examples as well as extensive applications in a wide variety of nonlinear systems including differential equations variational problems and inequalities constrained global optimization multi well phase transitions non smooth post bifurcation large deformation mechanics structural limit analysis differential geometry and non convex dynamical systems With exceptionally coherent and lucid exposition the work fills a big gap between the mathematical and engineering sciences It shows how to use formal language and duality methods to model natural phenomena to construct intrinsic frameworks in different fields and to provide ideas concepts and powerful methods for solving non convex non smooth problems arising naturally in engineering and science Much of the book contains material that is new both in its manner of presentation and in its research development A self contained appendix provides some necessary background from elementary functional analysis Audience The book will be a valuable resource for students and researchers in applied mathematics physics mechanics and engineering The whole volume or selected chapters can also be recommended as a text for both senior undergraduate and graduate courses in applied mathematics mechanics general engineering science and other areas in which the notions of optimization and variational methods are employed

Duality Principles in Nonconvex Systems David Yang Gao, 2013-03-09 Motivated by practical problems in engineering and physics drawing on a wide range of applied mathematical disciplines this book is the first to provide within a unified framework a self contained comprehensive mathematical theory of duality for general non convex non smooth systems with emphasis on methods and applications in engineering mechanics Topics covered include the classical minimax mono duality of convex static equilibria the beautiful bi duality in dynamical systems the interesting tri duality in non convex problems and the complicated multi duality in general canonical systems A potentially powerful sequential canonical dual transformation method for solving fully nonlinear problems is developed heuristically and illustrated by use of many interesting examples as well as extensive applications in a wide variety of nonlinear systems including differential equations variational problems and inequalities constrained global optimization multi well phase transitions non smooth post bifurcation large deformation mechanics structural limit analysis differential geometry and non convex dynamical systems With exceptionally coherent and lucid exposition the work fills a big

gap between the mathematical and engineering sciences It shows how to use formal language and duality methods to model natural phenomena to construct intrinsic frameworks in different fields and to provide ideas concepts and powerful methods for solving non convex non smooth problems arising naturally in engineering and science Much of the book contains material that is new both in its manner of presentation and in its research development A self contained appendix provides some necessary background from elementary functional analysis Audience The book will be a valuable resource for students and researchers in applied mathematics physics mechanics and engineering The whole volume or selected chapters can also be recommended as a text for both senior undergraduate and graduate courses in applied mathematics mechanics general engineering science and other areas in which the notions of optimization and variational methods are employed **MEAN**

FIELD THEORIES AND DUAL VARIATION Takashi Suzuki, 2009-01-01 A mathematical theory is introduced in this book to unify a large class of nonlinear partial differential equation PDE models for better understanding and analysis of the physical and biological phenomena they represent The so called mean field approximation approach is adopted to describe the macroscopic phenomena from certain microscopic principles for this unified mathematical formulation Two key ingredients for this approach are the notions of duality according to the PDE weak solutions and hierarchy for revealing the details of the otherwise hidden secrets such as physical mystery hidden between particle density and field concentration quantized blow up biological mechanism sealed in chemotaxis systems as well as multi scale mathematical explanations of the Smoluchowski Poisson model in non equilibrium thermodynamics two dimensional turbulence theory self dual gauge theory and so forth This book shows how and why many different nonlinear problems are inter connected in terms of the properties of duality and scaling and the way to analyze them mathematically **Stochastic Approximation and Its Applications** Han-Fu

Chen, 2005-12-30 Estimating unknown parameters based on observation data containing information about the parameters is ubiquitous in diverse areas of both theory and application For example in system identification the unknown system coefficients are estimated on the basis of input output data of the control system in adaptive control systems the adaptive control gain should be defined based on observation data in such a way that the gain asymptotically tends to the optimal one in blind channel identification the channel coefficients are estimated using the output data obtained at the receiver in signal processing the optimal weighting matrix is estimated on the basis of observations in pattern classification the parameters specifying the partition hyperplane are searched by learning and more examples may be added to this list All these parameter estimation problems can be transformed to a root seeking problem for an unknown function To see this let note the observation at time i i.e the information available about the unknown parameters at time i It can be assumed that the parameter under estimation denoted by θ is a root of some unknown function This is not a restriction because for example may serve as such a function Advances in Applied Mathematics and Global Optimization David Y. Gao, Hanif D.

Sherali, 2009-04-09 The articles that comprise this distinguished annual volume for the Advances in Mechanics and

Mathematics series have been written in honor of Gilbert Strang a world renowned mathematician and exceptional person

Written by leading experts in complementarity duality global optimization and quantum computations this collection reveals the beauty of these mathematical disciplines and investigates recent developments in global optimization nonconvex and nonsmooth analysis nonlinear programming theoretical and engineering mechanics large scale computation quantum algorithms and computation and information theory

Encyclopedia of Optimization Christodoulos A. Floudas, Panos M. Pardalos, 2008-09-04 The goal of the Encyclopedia of Optimization is to introduce the reader to a complete set of topics that show the spectrum of research the richness of ideas and the breadth of applications that has come from this field The second edition builds on the success of the former edition with more than 150 completely new entries designed to ensure that the reference addresses recent areas where optimization theories and techniques have advanced Particularly heavy attention resulted in health science and transportation with entries such as Algorithms for Genomics Optimization and Radiotherapy Treatment Design and Crew Scheduling

Optimum Design 2000 Anthony Atkinson, Barbara Bogacka, Anatoly A. Zhigljavsky, 2013-03-09 This volume contains many of the papers presented at the conference Optimum Design 2000 Prospects for the New Millennium held in Cardiff UK on April 12th 14th 2000 The majority of the papers consider aspects of optimum experimental design from the theoretical to applications Many of the optimisation problems arising in the optimum design theory in general and the articles in this volume in particular fall into the category of nonconvex including global optimization The papers are organised in two sections Since we are at the beginning of a new millennium the first paper starts by looking back at the beginnings of optimum experimental design in 1917 and sketches the development up to Kiefer's paper read to the Royal Statistical Society in 1959 This is the first in a group of papers which we have labelled Theory which cover the more general aspects such as the properties and methods of construction of designs In the Applications section there are papers on sequential design problems arising in the pharmaceutical industry and on the designs with discrete factors which occur in agriculture There are also papers on training neural networks on the efficient design of sampling methods on design problems in mixtures arising from a study of glass manufacturing and on the resistance of Brazilian weeds to herbicides The number attending the meeting was deliberately limited to 50 in order to encourage a workshop atmosphere and the exchange of ideas

Introduction to Global Optimization R. Horst, Panos M. Pardalos, Nguyen Van Thoai, 2000-12-31 Most of the existing books on optimization focus on the problem of computing locally optimal solutions Global optimization is concerned with the computation and characterization of global optima of nonlinear functions Global optimization problems are widespread in the mathematical modeling of real world systems for a very broad range of applications During the past three decades many new theoretical algorithmic and computational contributions have helped to solve globally multi extreme problems arising from important practical applications Introduction to Global Optimization is the first comprehensive textbook that covers the fundamentals in global optimization The second edition includes algorithms

applications and complexity results for quadratic programming concave minimization DC and Lipschitz problems decomposition algorithms for nonconvex optimization and nonlinear network flow problems Each chapter contains illustrative examples and ends with carefully selected exercises which are designed to help the student to get a grasp of the material and enhance their knowledge of global optimization methods Audience This textbook is addressed not only to students of mathematical programming but to all scientists in various disciplines who need global optimization methods to model and solve problems

Variational and Non-variational Methods in Nonlinear Analysis and Boundary Value Problems Dumitru Motreanu, Vicentiu D. Radulescu, 2013-06-29 This book reflects a significant part of authors research activity during the last ten years The present monograph is constructed on the results obtained by the authors through their direct cooperation or due to the authors separately or in cooperation with other mathematicians All these results fit in a unitary scheme giving the structure of this work The book is mainly addressed to researchers and scholars in Pure and Applied Mathematics Mechanics Physics and Engineering We are greatly indebted to Viorica Venera Motreanu for the careful reading of the manuscript and helpful comments on important issues We are also grateful to our Editors of Kluwer Academic Publishers for their professional assistance Our deepest thanks go to our numerous scientific collaborators and friends whose work was so important for us D Motreanu and V Radulescu IX Introduction The present monograph is based on original results obtained by the authors in the last decade This book provides a comprehensive exposition of some modern topics in nonlinear analysis with applications to the study of several classes of boundary value problems Our framework includes multivalued elliptic problems with discontinuities variational inequalities hemivariational inequalities and evolution problems The treatment relies on variational methods monotonicity principles topological arguments and optimization techniques Excepting Sections 1 and 3 in Chapter 1 and Sections 1 and 3 in Chapter 2 the material is new in comparison with any other book representing research topics where the authors contributed The outline of our work is the following

Duality for Nonconvex Approximation and Optimization Ivan Singer, 2007-03-12 The theory of convex optimization has been constantly developing over the past 30 years Most recently many researchers have been studying more complicated classes of problems that still can be studied by means of convex analysis so called anticonvex and convex anticonvex optimization problems This manuscript contains an exhaustive presentation of the duality for these classes of problems and some of its generalization in the framework of abstract convexity This manuscript will be of great interest for experts in this and related fields

Stabilization, Optimal and Robust Control Aziz Belmiloudi, 2008-08-17 Stabilization Optimal and Robust Control develops robust control of infinite dimensional dynamical systems derived from time dependent coupled PDEs associated with boundary value problems Rigorous analysis takes into account nonlinear system dynamics evolutionary and coupled PDE behaviour and the selection of function spaces in terms of solvability and model quality Mathematical foundations are provided so that the book remains accessible to the non control specialist Following chapters giving a general view of convex

analysis and optimization and robust and optimal control problems arising in fluid mechanical biological and materials scientific systems are laid out in detail The combination of mathematical fundamentals with application of current interest will make this book of much interest to researchers and graduate students looking at complex problems in mathematics physics and biology as well as to control theorists *Nonsmooth Mechanics and Analysis* Pierre Alart,Olivier Maissen,R. Tyrrell Rockafellar,2006-06-26 This book's title Nonsmooth Mechanics and Analysis refers to a major domain of mechanics particularly those initiated by the works of Jean Jacques Moreau Nonsmooth mechanics concerns mechanical situations with possible nondifferentiable relationships eventually discontinuous as unilateral contact dry friction collisions plasticity damage and phase transition The basis of the approach consists in dealing with such problems without resorting to any regularization process Indeed the nonsmoothness is due to simplified mechanical modeling a more sophisticated model would require too large a number of variables and sometimes the mechanical information is not available via experimental investigations Therefore the mathematical formulation becomes nonsmooth regularizing would only be a trick of arithmetic without any physical justification Nonsmooth analysis was developed especially in Montpellier to provide specific theoretical and numerical tools to deal with nonsmoothness It is important not only in mechanics but also in physics robotics and economics Audience This book is intended for researchers in mathematics and mechanics

Nonsmooth/Nonconvex Mechanics David Yang Gao,Raymond W. Ogden,Georgios E. Stavroulakis,2013-12-01 Nonsmooth and nonconvex models arise in several important applications of mechanics and engineering The interest in this field is growing from both mathematicians and engineers The study of numerous industrial applications including contact phenomena in statics and dynamics or delamination effects in composites require the consideration of nonsmoothness and nonconvexity The mathematical topics discussed in this book include variational and hemivariational inequalities duality complementarity variational principles sensitivity analysis eigenvalue and resonance problems and minimax problems Applications are considered in the following areas among others nonsmooth statics and dynamics stability of quasi static evolution processes friction problems adhesive contact and debonding inverse problems pseudoelastic modeling of phase transitions chaotic behavior in nonlinear beams and nonholonomic mechanical systems This volume contains 22 chapters written by various leading researchers and presents a cohesive and authoritative overview of recent results and applications in the area of nonsmooth and nonconvex mechanics Audience Faculty graduate students and researchers in applied mathematics optimization control and engineering

Nonlinear Optimization in Finite Dimensions Hubertus Th. Jongen,P. Jonker,F. Twilt,2013-12-11 At the heart of the topology of global optimization lies Morse Theory The study of the behaviour of lower level sets of functions as the level varies Roughly speaking the topology of lower level sets only may change when passing a level which corresponds to a stationary point or Karush Kuhn Tucker point We study elements of Morse Theory both in the unconstrained and constrained case Special attention is paid to the degree of differentiability of the functions under

consideration The reader will become motivated to discuss the possible shapes and forms of functions that may possibly arise within a given problem framework In a separate chapter we show how certain ideas may be carried over to nonsmooth items such as problems of Chebyshev approximation type We made this choice in order to show that a good understanding of regular smooth problems may lead to a straightforward treatment of just continuous problems by means of suitable perturbation techniques taking a priori nonsmoothness into account Moreover we make a focal point analysis in order to emphasize the difference between inner product norms and for example the maximum norm Then specific tools from algebraic topology in particular homology theory are treated in some detail However this development is carried out only as far as it is needed to understand the relation between critical points of a function on a manifold with structured boundary Then we pay attention to three important subjects in nonlinear optimization

Foundations of Bilevel Programming Stephan Dempe, 2005-12-19 Bilevel programming problems are hierarchical optimization problems where the constraints of one problem the so called upper level problem are defined in part by a second parametric optimization problem the lower level problem If the lower level problem has a unique optimal solution for all parameter values this problem is equivalent to a one level optimization problem having an implicitly defined objective function Special emphasis in the book is on problems having non unique lower level optimal solutions the optimistic or weak and the pessimistic or strong approaches are discussed The book starts with the required results in parametric nonlinear optimization This is followed by the main theoretical results including necessary and sufficient optimality conditions and solution algorithms for bilevel problems Stationarity conditions can be applied to the lower level problem to transform the optimistic bilevel programming problem into a one level problem Properties of the resulting problem are highlighted and its relation to the bilevel problem is investigated Stability properties numerical complexity and problems having additional integrality conditions on the variables are also discussed Audience Applied mathematicians and economists working in optimization operations research and economic modelling Students interested in optimization will also find this book useful

Quasidifferentiability and Related Topics Vladimir F. Demyanov, Alexander M. Rubinov, 2013-03-14

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11 DIFFERENCES OF CONVEX COMPACTA AND METRIC SPACES OF CONVEX COMPACTA WITH APPLICATIONS A SURVEY A M Rubinov A A Vladimirov 1 Introduction 264 2 Preliminaries 264 3 Differences of convex compact sets general approach 266 4 Metric projections and corresponding differences one dimensional case 267 5 The difference 269 6 The Demyanov difference 271 7 Geometric and inductive definitions of the D difference 273 8 Applications to DC and quasidifferentiable functions 276 9 Differences of pairs of set valued mappings with applications to quasidifferentiability 278 10 Applications to approximate subdifferentials 280 11 Applications to the approximation of linear set valued mappings 281 12 The Demyanov metric 282 13 The Bartels Pallaschke

metric 284 14 Hierarchy of the three norms on \mathbb{Q}^n 285 15 Derivatives 287 16 Distances from convex polyhedra and convergence of convex polyhedra 289 17 Normality of convex sets 290 18 D regular sets 291 19 Variable D regular sets 292 20 Optimization 293 References 294 12 CONVEX APPROXIMATORS

Advances in Convex Analysis and Global Optimization Nicolas Hadjisavvas, Panos M. Pardalos, 2013-12-01 There has been much recent progress in global optimization algorithms for nonconvex continuous and discrete problems from both a theoretical and a practical perspective. Convex analysis plays a fundamental role in the analysis and development of global optimization algorithms. This is due essentially to the fact that virtually all nonconvex optimization problems can be described using differences of convex functions and differences of convex sets. A conference on Convex Analysis and Global Optimization was held during June 5-9, 2000 at Pythagorion Samos, Greece. The conference was honoring the memory of C. Caratheodory (1873-1950) and was endorsed by the Mathematical Programming Society (MPS) and by the Society for Industrial and Applied Mathematics (SIAM) Activity Group in Optimization. The conference was sponsored by the European Union through the EPEAEK program, the Department of Mathematics of the Aegean University and the Center for Applied Optimization of the University of Florida, by the General Secretariat of Research and Technology of Greece, by the Ministry of Education of Greece and several local Greek government agencies and companies. This volume contains a selective collection of refereed papers based on invited and contributing talks presented at this conference. The two themes of convexity and global optimization pervade this book. The conference provided a forum for researchers working on different aspects of convexity and global optimization to present their recent discoveries and to interact with people working on complementary aspects of mathematical programming.

Multivalued Analysis and Nonlinear Programming Problems with Perturbations B. Luderer, L. Minchenko, T. Satsura, 2013-03-09 The book presents a treatment of topological and differential properties of multivalued mappings and marginal functions. In addition, applications to sensitivity analysis of nonlinear programming problems under perturbations are studied. Properties of marginal functions associated with optimization problems are analyzed under quite general constraints defined by means of multivalued mappings. A unified approach to directional differentiability of functions and multifunctions forms the base of the volume. Nonlinear programming problems involving quasidifferentiable functions are considered as well. A significant part of the results are based on theories and concepts of two former Soviet Union researchers, Demyanov and Rubinov, and have never been published in English before. It contains all the necessary information from multivalued analysis and does not require special knowledge but assumes basic knowledge of calculus at an undergraduate level.

Handbook of Global Optimization Reiner Horst, Panos M. Pardalos, H. Edwin Romeijn, 2002-06-30 Global optimization is concerned with the computation and characterization of global optima of nonlinear functions. During the past three decades, the field of global optimization has been growing at a rapid pace and the number of publications on all aspects of global optimization has been increasing steadily. Many applications as well as new theoretical algorithmic and

computational contributions have resulted The Handbook of Global Optimization is the first comprehensive book to cover recent developments in global optimization Each contribution in the Handbook is essentially expository in nature but scholarly in its treatment The chapters cover optimality conditions complexity results concave minimization DC programming general quadratic programming nonlinear complementarity minimax problems multiplicative programming Lipschitz optimization fractional programming network problems trajectory methods homotopy methods interval methods and stochastic approaches

Abstract Convexity and Global Optimization Alexander M. Rubinov, 2000-05-31 This book consists of two parts Firstly the main notions of abstract convexity and their applications in the study of some classes of functions and sets are presented Secondly both theoretical and numerical aspects of global optimization based on abstract convexity are examined Most of the book does not require knowledge of advanced mathematics Classical methods of nonconvex mathematical programming being based on a local approximation cannot be used to examine and solve many problems of global optimization and so there is a clear need to develop special global tools for solving these problems Some of these tools are based on abstract convexity that is on the representation of a function of a rather complicated nature as the upper envelope of a set of fairly simple functions Audience The book will be of interest to specialists in global optimization mathematical programming and convex analysis as well as engineers using mathematical tools and optimization techniques and specialists in mathematical modelling

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