Memoirs of the Scientific Sections of the Romanian Academy
Tome XXXVII, 2014

BOOK REVIEWS

JESÚS A. De LOERA, RAYMOND HEMMECKE, MATTHIAS KÖPPE, *Algebraic and Geometric Ideas in the Theory of Discrete Optimization*, MOS-SIAM Series on Optimization, SIAM & MOS, 2013, xix + 322 p., ISBN: 978-1-611972-43-6.

This is a well-written book that presents recent advances in the mathematical theory of discrete optimization, particularly those supported by methods from algebraic geometry, commutative algebra, convex and discrete geometry, generating functions, and other tools normally considered outside the standard curriculum in optimization.

It is not surprising the usage of geometric ideas in optimization, since it is well-known that they have been very important to the foundations of modern discrete optimization. In the last years, there have been new developments in the understanding of the structure of polyhedra, convex sets, and their lattice points, that have produced new algorithmic ideas for solving integer programs. Since these powerful tools do not make part of standard curriculum of students in optimization, many of them are not yet widely known or applied.

The present book is meant to be used in a quick, intense course. Its aim is to popularize these new ideas among workers in optimization. Its structure, roughly, is as follows: the first part is a short summary of tools usually employed in optimization; the second part presents the idea of test sets and Graver bases; the third part introduces the usage of generating functions in order to deal with integer programs; the fourth part discusses the notion of Grobner bases; and finally, the fifth part presents the solution of global optimization problems with polynomial constraints via linear algebra.

This book is highly recommended as a textbook for both advanced undergraduates and beginning graduate students in mathematics, computer science; or as a tutorial for mathematicians, engineers that whish to know deeply how algorithms work. It should be also emphasized that the present book contains lots of exercises for the students, meant to illustrate the theory.

Ionuț Munteanu

FRED BRAUER, CARLOS CASTILLO-CHAVEZ, *Mathematical Models for Communicable Diseases*, SIAM, Philadelphia, 2013, XVIII + 270 p., ISBN 978-1-611972-41-2.

This book contains the material used for the talks delivered by the authors in the CBMS workshop Mathematical Epidemiology with Applications, funded by the National Science Foundation and held at ETSU between July 25–29, 2011.

The book contains ten lectures, each of them describing models of mathematical epidemiology. The authors considered mainly simple models in order to establish broad principles. These simple models can be considered as the building blocks of other models with more detailed structure.

The first four lectures focus on general classes of models that should be viewed as templates to use in modelling specific diseases, with the incorporation of properties of the disease (compartmental epidemic models, models for endemic diseases, heterogeneity in epidemic models, models structured by age).

Lecture 5 deals with the role of mobility of the individuals in transmission dynamics of communicable diseases, like smallpox. There are two chapters (chapter 6 and chapter 7) discuss influenza, the first one concerned with the basic structure of a single outbreak and the second considering influenza in a broader context. The last three lectures contain mathematical models for the transmission dynamics of HIV, for the dynamics of tuberculosis and for sexually transmitted diseases, respectively.

These lecture notes are intended for graduate-level courses in epidemiology for students in mathematics and also for students imployed in epidemiology programs with a strong background in mathematics. They are also of interest to researchers with backgrounds in the mathematical, epidemiological and medical sciences.

Gabriela Lițcanu

LEE A. SEGEL, LEAH EDELSTEIN-KESHET, *A Primer on Mathematical Models in Biology*, SIAM, Philadelphia, 2013, XVIII + 270 p., ISBN 978-1-611972-49-8.

This book deals with mathematical models in biology. The first two chapters are devoted to a general introduction in mathematical biology. In the second chapter there are several examples that illustrate ways of describing rates of simple chemical reactions and also how to formulate a differential equation model.

The next four chapters provide reference material and ample mathematical tools for the study of models. After a review of linear differential equations (chapter 3), in chapter 4 an introduction to nondimensionalization and scaling is given. A presentation of the geometric methods used for analysis of models is provided in chapters 5 and 7. Chapter 6 deals with a basic disease dynamics model written to illustrate the usefulness of mathematical techniques and concepts.

Chapters 8 and 9 present the concept of the quasi steady-state approximation. This will be used in the context of enzyme-substrate reactions and Michaelis-Menten kinetics.

Chapters 10 and 11 are an introduction to excitable systems (FitzHugh-Nagumo equations) and neurophysiology.

Chapter 12 contains a variety of relatively elementary models. The authors construct here a bridge between the mathematical methods presented in chapter 5 and 7 and the ODE models for small functional circuits of molecules or genes.

Chapter 13 provides an alternative perspective using discrete networks.

In Chapter 14 a material about further exploration of several topics is included.

The last chapter deals with problems and exercises related to the material covered in the book.

The book includes also five appendices. The first four review some definitions and basic concepts used in this textbook. The last one contains many sample codes for XPP, together with basic instructions on how to run them. Each of them is linked the equations and figures appearing in the text.

This book is appropriate for upper-level undergraduates in mathematics, graduate students in biology, and lower-level graduate students in mathematics who would like some exposure to biological applications.

Gabriela Lițcanu

HARRY DANKOWICZ, FRANK SCHILDER, *Recipes for Continuation*, Computational Science & Engineering Series, SIAM, Philadelphia, 2013, xvi + 584 p., ISBN: 978-1-611972-56-6.

This book provides a comprehensive introduction to the mathematical methodology of parameter continuation, the computational analysis of families of solutions to nonlinear mathematical equations.

The aim of this book is to present the theoretical concept of parameter continuation, based on the fact that solutions to parameterized mathematical equations often belong to solution families. In order to apply this method it is important to translate problems formulations into algorithms suitable for parameter continuation. And this book is meant to help students to do that. Beyond the promulgation of a fundamental paradigm of applied mathematics and computational science and engineering, this text seeks to enable and stimulate its reader, whether novice or adept.

The structure of the book is as follows: in the first part it is introduced a fundamental mathematical paradigm within which the subsequent tool development is framed. An illustration of the utility of parameter continuation in the context of optimization problem from the calculus of variations, is provided. The second part of the text presents a sequence of toolbox templates that build on the task-embedding paradigm. The third part discusses the development of atlas algorithms, implementations of a finite-state machine for generating a collection of charts, covering a portion of the solution manifold of the continuation problem. The fourth part has as topic the event handling, an essential ingredient in parameter continuation. Finally, the fifth part provides an introductory treatment to the problem of adaptive changes for the discretization of a continuation problem during parameter continuation.

This book is recommended for students and teachers of nonlinear dynamics and engineering, as well as engineers and scientists engaged in modeling and simulation, and it is valuable to potential developers of computational tools for analysis of nonlinear dynamical systems. It should be emphasized the large number of the exercises at the end of each chapter that are intended to be helpful for the reader in the well understanding of the theoretical presentation.

Ionuţ Munteanu

JENNIFER L. MUELLER, SAMULI SILTANEN, *Linear and Nonlinear Inverse Problems with Practical Applications*, Computational Science & Engineering, SIAM, 2012, xiii + 351 p., ISBN: 978-1-611972-33-7.

Linear and Nonlinear Inverse Problems with Practical Applications provides a practical introduction to inverse problems from both a computational and theoretical perspective. Inverse problems arise from the need to interpret indirect and incomplete measurements, which is a very frequent issue when appling the theory in practice. The theory of inverse problems is a quite recent one, but strongly growing thanks to advances in computation, theoretical breakthroughs, and modern digital sensors that provide vast amounts of data. Its applications areas include engineering, geophysics, medicine, biology, chemistry, and finance. Therefore, an well-written introduction book on this subject, as the present one, is welcome and very useful.

The book is organized into two parts. The first part treats the case of linear inverse problems, in both continuous and discrete forms. This is because the authors wanted to instruct the reader on how ill-posedness is inherent in the idealized problem and how it shows up in the real life problem and in its discretization. Many examples and figures are provided, as-well.

The second part is for advanced researchers and addresses nonlinear inversions. It should be emphasized that this part presents, with full details and explanation, the so-called D-bar method, that would be very interesting for the researchers in electrical impendance tomography.

To conclude, this book represents a great instrument for the researchers, begginers or advanced in the subject of inverse problems, that will develop a deeper understanding of the connections between the mathematical theory, the computational model, and the practical problem arising from the application.

Ionuţ Munteanu

SEÁN DINEEN, *Probability Theory in Finance. A Mathematical Guide to the Black-Scholes Formula* (Second Edition), Graduate Studies in Mathematics, vol. 70, American Mathematical Society, 2013, XIV + 305 p., ISBN 978-30-8218-9490-3.

The book representing an undergraduate course in probability and stochastic methods for option pricing, starts with an introduction in Probability Theory and builds up to the Black-Scholes formula for pricing the European options. It is structured into 12 chapters. It starts with a preface and ends with solutions to the exercises proposed at the end of each chapter. Also, a short list of references is given.

The first chapter deals with interest rates, offering a short introduction to financial markets. Chapter two discusses the topics of fair games, hedging and arbitrage. In the third chapter, the notions of sigma-fields, partitions and filtrations are introduced and discussed through exercises. Chapter four is devoted to measurable functions and their properties.

In Chapter five, the author presents a short introduction in probability spaces, random variables, independence of events and random variables and stochastic processes. Also, the binomial model for pricing a call option is discussed.

Chapter six is devoted to the expected value of a random variable. Similar to the Lebesque integral, the expectation of a random variable is defined successively, starting from the expected value of a simple random variable, to the expected value of arbitrary random variables. Some important results concerning convergence of random variables are also presented.

Chapter seven starts with basic results concerning continuous and convex real-valued functions. The famous Jensen and Chebyshev inequalities are discussed here. The chapter ends with the Central Limit Theorem and the convergence in distribution of a sequence of random variables.

The notion of conditional expectation and its properties is introduced in Chapter eight. Then, the problem of pricing a call option is expressed in terms of conditional expectation.

Chapter nine is devoted to the Lebesque measure and to its relationship with the Riemann integral. Based on the Radon-Nicodym theorem, density functions for a random variable are introduced here.

Chapter ten introduces the notions of discrete-time and continuous-time martingales.

The famous Black-Scholes formula for pricing European call options is the topic of Chapter eleven.

The last chapter of the book is dedicated to the stochastic integral. The stochastic Riemann integral and the Itô integral for almost surely continuous processes are analyzed. Moreover, it is shown how a call option could be hedged using a stochastic differential equation.

Iulian Stoleriu

PHILIPPE G. CIARLET, *Linear and Nonlinear Functional Analysis with Applications*, SIAM, 2013, xiv + 832 p., ISBN 978-1-611972-58-0.

When studying Partial Differential Equations, aiming to model some phenomena, in order to better understand them, the first step should be a heavy learning of both linear and nonlinear Functional Analysis. The present book assembles in a single volume the most basic theorems of linear and nonlinear functional analysis. This may be considered the main originality of this text, since, the existing literature, provides plenty of textbooks on this subject. Besides this, in order to illustrate the wide applicability of the presented theorems, a lot of applications are treated.

The book contains nine chapters, each of them presenting main results in functional analysis. The fist chapter is essentially a review of results from real analysis and theory of functions that will be applied throughout the text, with self-contained and complete proofs for most of the theorems. This is a gain for a student, because these proofs are not always easy to locate in the literature, or difficult to reconstruct without an extended knowledge of collateral topics.

The next three chapters include details about the main three types of the most frequently used function spaces, namely normed vector spaces, Bancah spaces and inner-product spaces, in particular Hilbert spaces. Chapter five collects the the "Great Theorems" of linear functional analysis, like Baire's theorem, Banach-Steinhaus theorem, Hanh-Banach theorem and Banach-Saks-Mazur theorem. Of course, for each of them, lots of applications are presented. Chapter six introduces linear partial differential equations, while the next two chapters deal with differential calculus. Finally, the last chapter presents the "Great Theorems" of nonlinear functional analysis, like Ekeland's Principle, Brower fixed point theorem, Galerkin method, monotone operators.

This book can be successfully used by both students and experimented researchers in any field that requires knowledge on functional analysis. Moreover, the numerous examples provided make the reading more accesible and interesting.

Ionuţ Munteanu

SIMEON REICH, ALEXANDER J. ZASLAVSKI (editors), *Optimization Theory and Related Topics*, A Workshop in Memory of Dan Butnariu, January 11–14, 2010, Haifa, Israel; Contemporary Mathematics, 568, AMS/Bar, 2012, xx + 271 p., ISBN: 978-0-8218-6908-6.

This book reunites a series of 17 papers presented by renowned specialists in the field of Optimization Theory, at a workshop held in memory of Dan Butnariu, in Haifa, Israel, on January 11–14, 2010. The texts cover a broad variety of subjects concerning Optimization Theory and its applications.

The first article, written by Zvi Artstein, provides error estimates for fixed points and for trajectories of perturbations from contraction-like mappings, using Lyapunov metrics. A maximal monotonicity result for the sum of a maximal monotone linear relation and the subdifferential operator of a proper, lower semicontinuous, sublinear function is established in a joint work of Heinz H. Bauschke, Xianfu Wang, and Liangjin Yao. The paper of Adi Ben-Israel studies some properties of the inverse Newton transform and the relation between its zeros and the fixed points of the original function. Various examples are also provided. In his work, Joël Blot derives new infinite-horizon discrete-time strong and weak Pontryagin principles for optimal control problems. Each problem is reduced to a sequence of finite-horizon problems, for which the results of Phillipe Michel in Optimization Theory are applied.

Sjur Didrik Flåm discusses efficient sharing and Pareto efficient allocations, as well as risk sharing. Manal Gabour and Simeon Reich provide weak and strong convergence theorems for the Stochastic Convex Feasibility Problem in Banach spaces, by means of the Expected Retraction Method. In his article, Valery Y. Glizer considers an optimal control problem with quadratic cost functional, not containing a control cost, for a linear system with point-wise and distributed time delays in state variables. He associates a cheap control problem and constructs for it a state-feedback control, which is a minimizing sequence for the first problem. I. Ioslovich, P.-O. Gutman, and A. Lichtsinder propose presolving procedures that reduce the dimension of a linear programming problem with box-constrained uncertainty in coefficients; the preprocessing algorithm here presented is a robust one.

The paper of Igor V. Konnov studies descent methods with respect to a merit function for a mixed variational inequality involving a general non-smooth mapping and a convex function, possibly nondifferentiable. The methods use exact and inexact linesearch procedures. Tomáš Kroupa presents a generalization for games on MV-algebras of the Möbius transform of games with a finite number of players; it is applied to a Cimmino-type algorithm for the core solution. After reviewing their previous results concerning the generation of ergodic sequences of subgradients generated within a subgradient scheme, Torbjörn Larsson, Michael Patriksson, and Ann-Brith Strömberg apply them to a simplicial decomposition algorithm for convex and non-smooth optimization problems.

Oren Mangoubi considers a Kannai-Rosenmüller model of a strategic financial market game, with a finite number of players, that can save or spend money over multiple trading periods, and proves the existence of a subgame-perfect pure-strategy Nash equilibrium when the game is played in series over three trading periods. The article of Daniel Reem is a sequel of a previous work, where the Bregman distance has been generalized by removing the Bregman function from its definition. In the present paper, the author generalizes the Bregman distance to weak-strong spaces, and gives a generalization of a theorem of S. Reich about weak convergence, to a common asymptotic fixed point, of an infinite product of strongly nonexpansive mappings.

Simeon Reich and Shoham Sabach prove three strong convergence theorems on iterative methods for solving equilibrium problems corresponding to finitely many bifunctions in reflexive Banach spaces. In her paper, Elena Resmerita suggests using coderivatives in sufficient conditions for error estimation of the variational regularization of inverse problems involving non-linear ill-posed nonsmooth operators.

The volume ends with two articles of Alexander J. Zaslavski. In the first one, the author uses the penalty approach in the study of two constrained minimization problems in finite-dimensional spaces; using the Mordukhovich basic subdifferential, he obtains a simple sufficient condition for the exact penalty property. The second work considers the Robinson-Solow-Srinivasan model with a nonconcave utility function, and proves the existence of weakly agreeable programs.

The book addresses to researchers in Applied Mathematics, but also to graduate students interested in this field.

Adriana-Ioana Lefter

MARCO LOCATELLI, FABIO SCHOEN, *Global Optimization. Theory, Algorithms, and Applications*, SIAM/MOS, 2013, vii+437 p., ISBN 978-1-611972-66-5.

This volume approaches one of the most interesting and dynamic areas of Applied Mathematics, namely Global Optimization. The authors tried to cover as many subjects as possible, taking account of the rapid development in the field.

The book is divided into 6 chapters, the first of which introduces the basic terminology and overviews the contents of the text.

Chapter 2 is a technical one and presents the theoretical issue of complexity. Indications on the suitability of applying exact methods to a specific problem are given by its difficulty level. Regarding this criterion, global optimization problems can be divided into the following subclasses: problems to which solutions can be obtained in polynomial time, problems for which a fully polynomial time approximation scheme or a polynomial time approximation scheme is available, those for which approximate solutions can be obtained in polynomial time only with low precision, and problems for which even the detection of an approximate solution with an arbitrary low precision is difficult.

Chapter 3 deals with heuristic approaches for global optimization problems and presents a set of methods, to be used according to the characteristics of the problem. The first part of the chapter groups methods presuming that evaluating the objective function is sufficiently cheap, such as clustering methods, basin hopping, particle swarm optimization, differential evolution, continuous Greedy randomized adaptive search, DIRECT, simulated annealing, smoothing methods. The next section treats optimization methods for problems with expensive functions. Surrogate models, radial basis functions, Kriging, regression, merit functions are discussed. The last part presents basic results of convergence for the heuristic methods.

Chapter 4 studies the derivation of lower bounds for minimization problems, highly or mildly structured. After treating the notion of convex envelope, the authors analyse techniques to derive convex relaxations: the reformulation-linearization technique, the α-branch-and-bound approaches, dual Lagrangian bounds, bounds based on interval arithmetic, McCormick relaxations for factorable functions. They also cover relaxation techniques for the particular cases of quadratic programming and quadratically constrained quadratic programming problems, polynomial programming problems, difference-of-convex and difference-of-monotonic problems.

Chapter 5 approaches branch-and-bound methods. It discusses different branching strategies, the convergence and finiteness results for branch-and-bound methods, domain reduction strategies, and fathoming rules.

Chapter 6 presents problems and applications of the algorithms described in the previous chapters. The first section, devoted to benchmark test problems, is intended for researchers interested in developing new algorithms. The second section explains several applications of global optimization, namely finding the lowest energy conformation of a molecule or of an atomic cluster, finding the optimal packing of objects of a given shape in a container, planning an optimal trajectory for an outer space mission. The following part is devoted to two appendices, one on convex sets, convex and concave functions, the other gathering the most frequently used notations in the text.

The book ends with an extensive Bibliography and an Index. Additional information can be found on the book's companion web site, http://www.siam.org/books/mo15.

Global Optimization is a valuable resource for researchers, graduate students, Ph.D. students, and practitioners interested in advanced solution methods to difficult optimization problems.

Adriana-Ioana Lefter

NIKOLAOS BEKIARIS-LIBERIS, MIROSLAV KRSTIC, *Nonlinear Control under Nonconstant Delays*, Advances in Design and Control, SIAM, 2013, xii + 297 p., ISBN 978-1-611973-17-4.

This book is addressed to researchers working on control of delay systems, including engineers, mathematicians, and students. Why are delayed-systems so important? Well, because, when adding a delay to a classical system that models some phenomena, the obtained equations-model becomes closer to the real model. For example, take the Fitzhugh-Nagumo equations that describe the dynamics of electrical potential across cell membrane. It is shown that, since repeated and frequent alcohol use can have serious repercussions on the nervous system, particularly the brain, it is important to consider a delay in the original Fitzhugh-Nagumo equation, in order to have a more realistic model.

The most useful part of the present book is the design of the feedback laws for systems with input delays and certain system structures involving state delays. However, the most interesting part of the present is the analysis of the stability of the considered closed-loop systems.

Mainly, stability analysis is based on the recently introduced techniques involving infinite-dimensional backstepping transformations. As known, the backstepping technique requires lots of complex technical computations, which explains the difficulty of the problem.

The main results are accompanied by constructions of Lyapunov-Krasovskii functionals for each particular problem. The Lyapunov functionals are used to provide, explicitly, the performance measures of the closed-loop systems, such as convergence rate and overshoot.

The book contains three chapters, each of them describing models in which delays occur, an Introduction and an Appendix. The first chapter deals with examples of linear and nonlinear systems containing constant input and state delays. The second chapter studies the case where the delays are time-varying, while the last chapter treats the case where the delays are state-dependent. Finally, the Appendix may be considered useful for beginners, since basic inequalities, input-to-output stability theory and Lyapunov stability theory, are presented, often with proofs,.

This book can be successfully used for both students and experimented researchers in the field of delay systems. Moreover, the numerous examples provided make the reading more accesible and interesting.

Ionuț Munteanu

RICHARD J. HANSON, TIM HOPKINS, *Numerical Computing with Modern Fortran*, SIAM, Philadelphia, 2013, XV + 244 p., ISBN 978-1-611973-11-2.

This book represents an approach toward writing computer software for numerical computing and applications. The here provided software combines ideas with a variety of language constructs. Therefore, the reader-programmer needs to do significant research in integrating these ideas, checking for conformance to the current standard, and recalling the syntax of the language elements.

In the attempt of saving time and money, the authors propose that, if an existing C function or application can provide some required functionality, they will prefer it rather then implementing into Fortran code. Moreover, the same tactic may be used by C programmers when a useful component is available in Fortran, by making an interlanguage call from C to Fortran.

In order to anticipate many of the common questions programmers face as they write codes based on algorithms of numerical analysis and scientific computation, the authors inserted in the text illustrative examples of common interest to both Fortran programmers and those who must maintain or interface to the existing Fortran software.

Most of the chapters in this book make reference to complete program that illustrates the practical use of features of the newer Fortran standards. Each chapter begins with a Synopsis section giving the main features to be covered so that the reader may quickly ascertain the content without further reading.

Ana-Maria Moşneagu

DANIEL J. BATES, JONATHAN D. HAUENSTEIN, ANDREW J. SOMMESE, CHARLES W. WAMPLER, *Numerically Solving Polynomial Systems with Bertini*, SIAM, Philadelphia, 2013, XX + 352, ISBN 978-1-611972-69-6.

Mathematical modelling is one of the powerful tools for understanding the multitude of phenomena that occur around us. To this end, mathematicians developed different kinds of mathematical equations. But, when trying to solve them it turns out that only numerical approximations are available, in general. Systems of polynomial equations are a common occurrence in problem formulations in engineering, science, and mathematics. Effective algorithms have been developed in recent years to numerically compute and manipulate them. One of them is the software Bertini introduced and explained in the present book.

The goals of this book are: to explain sufficiently the background on solutions sets of polynomial systems so that the reader has a basic understanding of the geometry of such sets both data types and breadth of the various computations of numerical algebraic geometry. Another objective is to show the reader how to use Bertini to solve polynomial; systems efficiently and interpret the output correctly, and finally, to provide a detailed manual of commands and settings for Bertini.

In addition to simple introductory problems, the author provides examples of polynomial systems from various applications and treat each as a case study to show that the software can be used to deduce different sorts of information needed by a user.

The present book approaches numeric algebraic geometry from the perspective of user offering numerous examples of how Bertini is applicable to polynomial systems. It treats the fundamental task of solving a given polynomial system and describes the latest advances in the field.

The book is designed to serve scientists and engineers needing to quickly solve systems of polynomial equations; senior undergraduate or beginning graduate students with a computational focus, who have a knowledge of calculus, linear algebra; as weel as, to those with mathematical bent who wish to explore the underpinnings of the methods, delve into the more technical details, and read descriptions of the latest developments.

Ana-Maria Moşneagu