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Variational Method for Least Squares Solutions of Linear and Non-linear Equations Preconditioning and Variational Methods for Solving Linear Equations __________ Computational Aspects of Linear Control Introduction to the Mathematical Theory of Control Processes: Nonlinear Processes Variational Methods for Least Squares Solutions of Linear and Non-linear Equations Convex Variational Problems Variational Methods for Boundary Value Problems for Systems of Elliptic Equations A Generalized Variational Formulation for Non-linear Equations An Introduction to Linear Ordinary Differential Equations Using the Impulsive Response Method and Factorization Introduction to Variational Methods in Control Engineering Regular Variation and Differential Equations An Introduction to Second Order Partial Differential Equations Nonlinear Equations: Methods, Models and Applications Linear System Theory Partial Differential Equations Numerical Methods for Nonlinear Variational Problems Variational iterative methods for nonsymmetric systems of linear equations Linear Prediction Theory Splines and Variational Methods Direct Methods in the Theory of Elliptic Equations Variational Methods for Eigenvalue Approximation Infinite Dimensional Linear Control Systems Differential Equations and the Calculus of Variations Hans Lewy Selecta Mathematical Control Theory The Linearization Method for Constrained Optimization Variational Methods in Nonlinear Analysis Global Bifurcation in Variational Inequalities Mathematical Control Theory Representation and Control of Infinite Dimensional Systems Optimal Control of Nonlinear Parabolic Systems An Invitation to Variational Methods in Differential Equations Variational Equations For Certain Homogeneous and Inhomogeneous Linear Systems An Introduction to Variational Inequalities and Their Applications Mathematical Control Theory Parabolic Quasilinear Equations Minimizing Linear Growth Functionals On Solutions of Linear Fractional Differential Equations of a Variational Type Variational and Extremum Principles in Macroscopic Systems Mathematical Methods in Physics

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A collection of research articles originating from the Workshop on Nonlinear Analysis and Applications held in Bergamo in July 2001. Classical topics of nonlinear analysis were considered, such as calculus of variations, variational inequalities, critical point theory and their use in various aspects of the study of elliptic differential equations and systems, equations of Hamilton-Jacobi, Schrödinger and Navier-Stokes, and free boundary problems. Moreover, various models were focused upon: travelling waves in supported beams and plates, vortex condensation in electroweak theory, information theory, non-geometrical optics, and Dirac-Fock models for heavy atoms. The book extensively introduces classical and variational partial differential equations (PDEs) to graduate and post-graduate students in Mathematics. The topics, even the most delicate, are presented in a detailed way. The book consists of two parts which focus on second order linear PDEs. Part I gives an overview of classical PDEs, that is, equations which admit strong solutions, verifying the equations pointwise. Classical solutions of the Laplace, heat, and wave equations are provided. Part II deals with variational PDEs, where weak (variational) solutions are considered. They are defined by variational formulations of the equations, based on Sobolev spaces. A comprehensive and detailed presentation of these spaces is given. Examples of variational elliptic, parabolic, and hyperbolic problems with different boundary conditions are discussed. An up-to-date and unified treatment of bifurcation theory for variational inequalities in reflexive spaces and the use of the theory in a variety of applications, such as: obstacle problems from elasticity theory, unilateral problems; torsion problems; equations from fluid mechanics and quasilinear elliptic partial differential equations. The tools employed are those of modern nonlinear analysis. Accessible to graduate students and researchers who work in nonlinear analysis, nonlinear partial differential equations, and additional research disciplines that use nonlinear mathematics. This well-thought-out book covers the fundamentals of nonlinear analysis, with a particular focus on variational methods and their applications. Starting from preliminaries in functional analysis, it expands in several directions such as Banach spaces, fixed point theory, nonsmooth analysis, minimax theory, variational calculus and inequalities, critical point theory, monotone, maximal monotone and pseudomonotone operators, and evolution problems. Ne?as' book Direct Methods in the Theory of Elliptic Equations, published 1967 in French, has become a standard reference for the mathematical theory of linear elliptic equations and systems. This English edition, translated by G. Tronel and A. Kufner, presents Ne?as' work essentially in the form it was published in 1967. It gives a timeless and in some sense definitive treatment of a number issues in variational methods for elliptic systems and higher order equations. The text is recommended to graduate students of partial differential equations, postdoctoral associates in Analysis, and scientists working with linear elliptic systems. In fact, any researcher using the theory of elliptic systems will benefit from having the book in his library. The volume gives a self-contained presentation of the elliptic theory based on the "direct method", also known as the variational method. Due to its universality and close connections to numerical approximations, the variational method has become one of the most important approaches to the elliptic theory. The method does not rely on the maximum principle or other special properties of the scalar second order elliptic equations, and it is ideally suited for handling systems of equations of arbitrary order. The prototypical examples of equations covered by the theory are, in addition to the standard Laplace equation, Lame's system of linear elasticity and the biharmonic equation (both with variable coefficients, of course). General ellipticity conditions are discussed and most of the natural boundary condition is covered. The necessary foundations of the function space theory are explained along the way, in an arguably optimal manner. The standard boundary regularity requirement on the domains is the Lipschitz continuity of the boundary, which "when going beyond the scalar equations of second order" turns out to be a very natural class. These choices reflect the author's opinion that the Lame system and the biharmonic equations are just as important as the Laplace equation, and that the class of the domains with the Lipschitz continuous boundary (as opposed to smooth domains) is the most natural class of domains to consider in connection with these equations and their applications. This book presents a method for solving linear ordinary differential equations based on the factorization of the differential operator. The approach for the case of constant coefficients is elementary, and only requires a basic knowledge of calculus and linear algebra. In particular, the book avoids the use of distribution theory, as well as the other more advanced approaches: Laplace transform, linear systems, the general theory of linear equations with variable coefficients and variation of parameters. The case of variable coefficients is addressed using Mammana's result for the factorization of a real linear ordinary differential operator into a product of first-order (complex) factors, as well as a recent generalization of this result to the case of complex-valued coefficients. Lnear prediction theory and the related algorithms have matured to the point where they now form an integral part of many real-world adaptive systems. When it is necessary to extract information from a random process, we are frequently faced with the problem of analyzing and solving special systems of linear equations. In the general case these systems are overdetermined and may be characterized by additional properties, such as update and shift-invariance properties. Usually, one employs exact or approximate least-squares methods to solve the resulting class of linear equations. Mainly during the last decade, researchers in various fields have contributed techniques and nomenclature for this type of least-squares problem. This body of methods now constitutes what we call the theory of linear prediction. The immense interest that it has aroused clearly emerges from recent advances in processor technology, which provide the means to implement linear prediction algorithms, and to operate them in real time. The practical effect is the occurrence of a new class of high-performance adaptive systems for control, communications and system identification applications. This monograph presumes a background in discrete-time digital signal processing, including Z-transforms, and a basic knowledge of discrete-time random processes. One of the difficulties I have en countered while writing this book is that many engineers and computer scientists lack knowledge of fundamental mathematics and geometry. Many devices (we say dynamical systems or simply systems) behave like black boxes: they receive an input, this input is transformed following some laws (usually a differential equation) and an output is observed. The problem is to regulate the input in order to control the output, that is for obtaining a desired output. Such a mechanism, where the input is modified according to the output measured, is called feedback. The study and design of such automatic processes is called control theory. As we will see, the term system embraces any device and control theory has a wide variety of applications in the real world. Control theory is an interdisci plinary domain at the junction of differential and difference equations, system theory and statistics. Moreover, the solution of a control problem involves many topics of numerical analysis and leads to many interesting computational problems: linear algebra (QR, SVD, projections, Schur complement, structured matrices, localization of eigenvalues, computation of the rank, Jordan normal form, Sylvester and other equations, systems of linear equations, regulariza tion, etc), root localization for polynomials, inversion of the Laplace transform, computation of the matrix exponential, approximation theory (orthogonal poly nomials, Pad6 approximation, continued fractions and linear fractional transfor mations), optimization, least squares, dynamic programming, etc. So, control theory is also a. good excuse for presenting various (sometimes unrelated) issues of numerical analysis and the procedures for their solution. This book is not a book on control. Introduction to the Mathematical Theory of Control Processes: Nonlinear Processes v. 2 This book describes the mathematical background and reviews the techniques for solving problems, including those that require large computations such as transonic flows for compressible fluids and the Navier-Stokes equations for incompressible viscous fluids. Finite element approximations and non-linear relaxation, and nonlinear least square methods are all covered in detail, as are many applications. This volume is a classic in a long-awaited softcover re-edition. This is the first book offering an application of regular variation to the qualitative theory of differential equations. The notion of regular variation, introduced by Karamata (1930), extended by several scientists, most significantly de Haan (1970), is a powerful tool in studying asymptotics in various branches of analysis and in probability theory. Here, some asymptotic properties (including non-oscillation) of solutions of second order linear and of some non-linear equations are proved by means of a new method that the well-developed theory of regular variation has yielded. A good graduate course both in real analysis and in differential equations suffices for understanding the book. Introduction to Variational Methods in Control Engineering focuses on the design of automatic controls. The monograph first discusses the application of classical calculus of variations, including a generalization of the Euler-Lagrange equations, limitation of classical variational calculus, and solution of the control problem. The book also describes dynamic programming. Topics include the limitations of dynamic programming; general formulation of dynamic programming; and application to linear multivariable digital control systems. The text also underscores the continuous form of dynamic programming; Pontryagin's principle; and the two-point boundary problem. The book also touches on inaccessible state variables. Topics include the optimum realizable control law; observed data and vector spaces; design of the optimum estimator; and extension to the continuous systems. The book also presents a summary of potential applications, including complex control systems and on-line computer control. The text is recommended to readers and students wanting to explore the design of automatic controls. This volume on mathematical control theory contains high quality articles covering the broad range of this field. The internationally renowned authors provide an overview of many different aspects of control theory, offering a historical perspective while bringing the reader up to the very forefront of current research. This book develops a variational method for solving linear equations with $B$-symmetric and $B$-positive operators and generalizes the method to nonlinear equations with nonpotential operators. The author carries out a constructive extension of the variational method to ``nonvariational'' equations (including parabolic equations) in classes of functionals which differ from the Euler-Lagrange functionals. In this connection, some new functions spaces are considered. Intended for mathematicians working in the areas of functional analysis and differential equations, this book would also prove useful for researchers in other areas and students in advanced courses who use variational methods in solving linear and nonlinear boundary value problems in continuum mechanics and theoretical physics. Unabridged republication is a resource for topics in elliptic equations and systems and free boundary problems. The work of Hans Lewy (1904--1988) has had a profound influence in the direction of applied mathematics and partial differential equations, in particular, from the late 1920s. Two of the particulars are well known. The Courant--Friedrichs--Lewy condition (1928), or CFL condition, was devised to obtain existence and approximation results. This condition, relating the time and spatial discretizations for finite difference schemes, is now universally employed in the simulation of solutions of equations describing propagation phenomena. Lewy's example of a linear equation with no solution (1957), with its attendant consequence that most equations have no solution, was not merely an unexpected fact, but changed the viewpoint of the entire field. Lewy made pivotal contributions in many other areas, for example, the regularity theory of elliptic equations and systems, the Monge-- AmpSre Equation, the Minkowski Problem, the asymptotic analysis of boundary value problems, and several complex variables. He was among the first to study variational inequalities. In much of his work, his underlying philosophy was that simple tools of function theory could help one understand the essential concepts embedded in an issue, although at a cost in generality. This approach was extremely successful. In this two-volume work, most all of Lewy's papers are presented, in chronological order. They are preceded by several short essays about Lewy himself, prepared by Helen Lewy, Constance Reid, and David Kinderlehrer, and commentaries on his work by Erhard Heinz, Peter Lax, Jean Leray, Richard MacCamy, Fran?ois Treves, and Louis Nirenberg. Additionally, there are Lewy's own remarks on the occasion of his honorary degree from the University of Bonn. Techniques of optimization are applied in many problems in economics, automatic control, engineering, etc. and a wealth of literature is devoted to this subject. The first computer applications involved linear programming problems with simp- le structure and comparatively uncomplicated nonlinear pro- blems: These could be solved readily with the computational power of existing machines, more than 20 years ago. Problems of increasing size and nonlinear complexity made it necessa- ry to develop a complete new arsenal of methods for obtai- ning numerical results in a reasonable time. The lineariza- tion method is one of the fruits of this research of the last 20 years. It is closely related to Newton's method for solving systems of linear equations, to penalty function me- thods and to methods of nondifferentiable optimization. It requires the efficient solution of quadratic programming problems and this leads to a connection with conjugate gra- dient methods and variable metrics. This book, written by one of the leading specialists of optimization theory, sets out to provide - for a wide readership including engineers, economists and optimization specialists, from graduate student level on - a brief yet quite complete exposition of this most effective method of solution of optimization problems. This book discusses theoretical approaches to the study of optimal control problems governed by non-linear evolutions - including semi-linear equations, variational inequalities and systems with phase transitions. It also provides algorithms for solving non-linear parabolic systems and multiphase Stefan-like systems. Provides a common setting for various methods of bounding the eigenvalues of a self-adjoint linear operator and emphasizes their relationships. A mapping principle is presented to connect many of the methods. The eigenvalue problems studied are linear, and linearization is shown to give important information about nonlinear problems. Linear vector spaces and their properties are used to uniformly describe the eigenvalue problems presented that involve matrices, ordinary or partial differential operators, and integro-differential operators. This book offers a self-contained introduction to partial differential equations (PDEs), primarily focusing on linear equations, and also providing perspective on nonlinear equations. The treatment is mathematically rigorous with a generally theoretical layout, with indications to some of the physical origins of PDEs. The Second Edition is rewritten to incorporate years of classroom feedback, to correct errors and to improve clarity. The exposition offers many examples, problems and solutions to enhance understanding. Requiring only advanced differential calculus and some basic Lp theory, the book will appeal to advanced undergraduates and graduate students, and to applied mathematicians and mathematical physicists. The author emphasizes a non-uniform ellipticity condition as the main approach to regularity theory for solutions of convex variational problems with different types of non-standard growth conditions. This volume first focuses on elliptic variational problems with linear growth conditions. Here the notion of a "solution" is not obvious and the point of view has to be changed several times in order to get some deeper insight. Then the smoothness properties of solutions to convex anisotropic variational problems with superlinear growth are studied. In spite of the fundamental differences, a non-uniform ellipticity condition serves as the main tool towards a unified view of the regularity theory for both kinds of problems. Geared primarily to an audience consisting of mathematically advanced undergraduate or beginning graduate students, this text may additionally be used by engineering students interested in a rigorous, proof-oriented systems course that goes beyond the classical frequency-domain material and more applied courses. The minimal mathematical background required is a working knowledge of linear algebra and differential equations. The book covers what constitutes the common core of control theory and is unique in its emphasis on foundational aspects. While covering a wide range of topics written in a standard theorem/proof style, it also develops the necessary techniques from scratch. In this second edition, new chapters and sections have been added, dealing with time optimal control of linear systems, variational and numerical approaches to nonlinear control, nonlinear controllability via Lie-algebraic methods, and controllability of recurrent nets and of linear systems with bounded controls. This book is the result of our teaching over the years an undergraduate course on Linear Optimal Systems to applied mathematicians and a first-year graduate course on Linear Systems to engineers. The contents of the book bear the strong influence of the great advances in the field and of its enormous literature. However, we made no attempt to have a complete coverage. Our motivation was to write a book on linear systems that covers finite dimensional linear systems, always keeping in mind the main purpose of engineering and applied science, which is to analyze, design, and improve the performance of phy sical systems. Hence we discuss the effect of small nonlinearities, and of perturbations of feedback. It is our on the data; we face robustness issues and discuss the properties hope that the book will be a useful reference for a first-year graduate student. We assume that a typical reader with an engineering background will have gone through the conventional undergraduate single-input single-output linear systems course; an elementary course in control is not indispensable but may be useful for motivation. For readers from a mathematical curriculum we require only familiarity with techniques of linear algebra and of ordinary differential equations. Physics has long been regarded as a wellspring of mathematical problems. Mathematical Methods in Physics is a self-contained presentation, driven by historic motivations, excellent examples, detailed proofs, and a focus on those parts of mathematics that are needed in more ambitious courses on quantum mechanics and classical and quantum field theory. Aimed primarily at a broad community of graduate students in mathematics, mathematical physics, physics and engineering, as well as researchers in these disciplines. Mathematical Control Theory: An Introduction presents, in a mathematically precise manner, a unified introduction to deterministic control theory. In addition to classical concepts and ideas, the author covers the stabilization of nonlinear systems using topological methods, realization theory for nonlinear systems, impulsive control and positive systems, the control of rigid bodies, the stabilization of infinite dimensional systems, and the solution of minimum energy problems. "Covers a remarkable number of topics....The book presents a large amount of material very well, and its use is highly recommended." --Bulletin of the AMS For more than forty years, the equation $y'(t) = Ay(t) + u(t)$ in Banach spaces has been used as model for optimal control processes described by partial differential equations, in particular heat and diffusion processes. Many of the outstanding open problems, however, have remained open until recently, and some have never been solved. This book is a survey of all results know to the author, with emphasis on very recent results (1999 to date). The book is restricted to linear equations and two particular problems (the time optimal problem, the norm optimal problem) which results in a more focused and concrete treatment. As experience shows, results on linear equations are the basis for the treatment of their semilinear counterparts, and techniques for the time and norm optimal problems can often be generalized to more general cost functionals. The main object of this book is to be a state-of-the-art monograph on the theory of the time and norm optimal controls for $y'(t) = Ay(t) + u(t)$ that ends at the very latest frontier of research, with open problems and indications for future research. Key features: · Applications to optimal diffusion processes. · Applications to optimal heat propagation processes. · Modelling of optimal processes governed by partial differential equations. · Complete bibliography. · Includes the latest research on the subject. · Does not assume anything from the reader except basic functional analysis. · Accessible to researchers and advanced graduate students alike · Applications to optimal diffusion processes. · Applications to optimal heat propagation processes. · Modelling of optimal processes governed by partial differential equations. · Complete bibliography. · Includes the latest research on the subject. · Does not assume anything from the reader except basic functional analysis. · Accessible to researchers and advanced graduate students alike This textbook introduces variational methods and their applications to differential equations to graduate students and researchers interested in differential equations and nonlinear analysis. It serves as a sampling of topics in critical point theory. Coverage includes: minimizations, deformations results, the mountain-pass and saddle-point theorems, critical points under constraints, and issues of compactness. Applications immediately follow each result for easy assimilation by the reader. This straightforward and systematic presentation includes many exercises and examples to motivate the study of variational methods. This unified, revised second edition of a two-volume set is a self-contained account of quadratic cost optimal control for a large class of infinite-dimensional systems. The original editions received outstanding reviews, yet this new edition is more concise and self-contained. New material has been added to reflect the growth in the field over the past decade. There is a unique chapter on semigroup theory of linear operators that brings together advanced concepts and techniques which are usually treated independently. The material on delay systems and structural operators has not yet appeared anywhere in book form. Famous monograph by a distinguished mathematician presents an innovative approach to classical boundary value problems. The treatment employs the basic scheme first suggested by Hilbert and developed by Tonnelli. 1963 edition. We consider a class of interative algorithms for solving systems of linear equations where the coefficient matrix is nonsymmetric with positive-definite symmetric part. The algorithms are modelled after the conjugate gradient method, and are well-suited for large sparse systems. They do not make use of any associated symmetric problems. Convergence results and error bounds are presented. (Author). This book details the mathematical developments in total variation based image restauration. From the reviews: "This book is devoted to PDE's of elliptic and parabolic type associated to functionals having a linear growth in the gradient, with a special emphasis on the applications related to image restoration and nonlinear filters....The book is written with great care, paying also a lot of attention to the bibliographical and historical notes."-- ZENTRALBLATT MATH Recent years have seen a growing trend to derive models of macroscopic phenomena encountered in the fields of engineering, physics, chemistry, ecology, self-organisation theory and econophysics from various variational or extremum principles. Through the link between the integral extremum of a functional and the local extremum of a function (explicit, for example, in the Pontryagin’s maximum principle variational and extremum principles are mutually related. Thus it makes sense to consider them within a common context. The main goal of Variational and Extremum Principles in Macroscopic Systems is to collect various mathematical formulations and examples of physical reasoning that involve both basic theoretical aspects and applications of variational and extremum approaches to systems of the macroscopic world. The first part of the book is focused on the theory, whereas the second focuses on applications. The unifying variational approach is used to derive the balance or conservation equations, phenomenological equations linking fluxes and forces, equations of change for processes with coupled transfer of energy and substance, and optimal conditions for energy management. A unique multidisciplinary synthesis of variational and extremum principles in theory and application A comprehensive review of current and past achievements in variational formulations for macroscopic processes Uses Lagrangian and Hamiltonian formalisms as a basis for the exposition of novel approaches to transfer and conversion of thermal, solar and chemical energy One of the clearest available introductions to variational methods, this text requires only a minimal background in calculus and linear algebra. Its self-contained treatment explains the application of theoretic notions to the kinds of physical problems that engineers regularly encounter. The text’s first half concerns approximation theoretic notions, exploring the theory and computation of one- and two-dimensional polynomial and other spline functions. Later chapters examine variational methods in the solution of operator equations, focusing on boundary value problems in one and two dimensions. Additional topics include least squares and other Galerkin methods. Many helpful definitions, examples, and exercises appear throughout the book. A classic reference in spline theory, this volume will benefit experts as well as students of engineering and mathematics.