

# Introduction To Inverse Problems In Imaging

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*Introduction to Inverse Problems for Differential Equations* Alemdar Hasanov Hasanoğlu 2021-08-02 This book presents a systematic exposition of the main ideas and methods in treating inverse problems for PDEs arising in basic mathematical models, though it makes no claim to being exhaustive. Mathematical models of most physical phenomena are governed by initial and boundary value problems for PDEs, and inverse problems governed by these equations arise naturally in nearly all branches of science and engineering. The book's content, especially in the Introduction and Part I, is self-contained and is intended to also be accessible for beginning graduate students, whose mathematical background includes only basic courses in advanced calculus, PDEs and functional analysis. Further, the book can be used as the backbone for a lecture course on inverse and ill-posed problems for partial differential equations. In turn, the second part of the book consists of six nearly-independent chapters. The choice of these chapters was motivated by the fact that the inverse coefficient and source problems considered here are based on the basic and commonly used mathematical models governed by PDEs. These chapters describe not only these inverse problems, but also main inversion methods and techniques. Since the most distinctive features of any inverse problems related to PDEs are hidden in the properties of the corresponding solutions to direct problems, special attention is paid to the investigation of these properties. For the second edition, the authors have added two new chapters focusing on real-world applications of inverse problems arising in wave and vibration phenomena. They have also revised the whole text of the first edition.

Regularized Image Reconstruction in Parallel MRI with MATLAB Joseph Suresh Paul 2019-11-05 Regularization becomes an integral part of the reconstruction process in accelerated parallel magnetic resonance imaging (pMRI) due to the need for utilizing the most discriminative information in the form of parsimonious models to generate high quality images with reduced noise and artifacts. Apart from providing a detailed overview and implementation details of various pMRI reconstruction methods, Regularized image reconstruction in parallel MRI with MATLAB examples interprets regularized image reconstruction in pMRI as a means to effectively control the balance between two specific types of error signals to either improve the accuracy in estimation of missing samples, or speed up the estimation process. The first type corresponds to the modeling error between acquired and their estimated values. The second type arises due to the perturbation of k-space values in autocalibration methods or sparse approximation in the compressed sensing based reconstruction model. Features: Provides details for optimizing regularization parameters in each type of reconstruction. Presents comparison of regularization approaches for each type of pMRI reconstruction. Includes discussion of case studies using clinically acquired data. MATLAB codes are provided for each reconstruction type. Contains method-wise description of adapting regularization to optimize speed and accuracy. This book serves as a reference material for researchers and students involved in development of pMRI reconstruction methods. Industry practitioners concerned with how to apply regularization in pMRI reconstruction will find this book most useful.

Discrete Geometry for Computer Imagery Nicolas Normand 2016-04-08 This book constitutes the refereed proceedings of the 19th IAPR International Conference on Discrete Geometry for Computer Imagery, DGCI 2016, held in Nantes, France, in April 2016. The 32 revised full papers presented together with 2 invited talks were carefully selected from 51 submissions. The papers are organized in topical sections on combinatorial tools; discretization; discrete tomography; discrete and combinatorial topology; shape descriptors; models for discrete geometry; circle drawing; morphological analysis; geometric transforms; and discrete shape representation, recognition and analysis.

Introduction to Inverse Problems in Imaging, Mario Bertero 1998-01-01 This is a graduate textbook on the principles of linear inverse problems, methods of their approximate solution and practical application in imaging. The level of mathematical treatment is kept as low as possible to make the book suitable for a wide range of readers from different backgrounds in science and engineering. Mathematical prerequisites are first courses in analysis, geometry, linear algebra, probability theory and Fourier analysis. The authors concentrate on presenting easily implementable and fast solution algorithms. The book will provide the reader with the appropriate background for a clear understanding of the essence of inverse problems (ill-posedness and its cure) and, consequently, for an intelligent assessment of the rapidly growing literature on these problems.

Geophysical Inverse Theory and Regularization Problems Michael S. Zhdanov 2002-04-24 This book presents

state-of-the-art geophysical inverse theory developed in modern mathematical terminology. The book brings together fundamental results developed by the Russian mathematical school in regularization theory and combines them with the related research in geophysical inversion carried out in the West. It presents a detailed exposition of the methods of regularized solution of inverse problems based on the ideas of Tikhonov regularization, and shows the different forms of their applications in both linear and nonlinear methods of geophysical inversion. This text is the first to treat many kinds of inversion and imaging techniques in a unified mathematical manner. The book is divided in five parts covering the foundations of the inversion theory and its applications to the solution of different geophysical inverse problems, including potential field, electromagnetic, and seismic methods. The first part is an introduction to inversion theory. The second part contains a description of the basic methods of solution of the linear and nonlinear inverse problems using regularization. The following parts treat the application of regularization methods in gravity and magnetic, electromagnetic, and seismic inverse problems. The key connecting idea of these applied parts of the book is the analogy between the solutions of the forward and inverse problems in different geophysical methods. The book also includes chapters related to the modern technology of geophysical imaging, based on seismic and electromagnetic migration. This volume is unique in its focus on providing a link between the methods used in gravity, electromagnetic, and seismic imaging and inversion, and represents an exhaustive treatise on inversion theory.

Mathematical Modelling, Optimization, Analytic and Numerical Solutions Pammy Manchanda 2020-02-04 This book discusses a variety of topics related to industrial and applied mathematics, focusing on wavelet theory, sampling theorems, inverse problems and their applications, partial differential equations as a model of real-world problems, computational linguistics, mathematical models and methods for meteorology, earth systems, environmental and medical science, and the oil industry. It features papers presented at the International Conference in Conjunction with 14th Biennial Conference of ISIAM, held at Guru Nanak Dev University, Amritsar, India, on 2-4 February 2018. The conference has emerged as an influential forum, bringing together prominent academic scientists, experts from industry, and researchers. The topics discussed include Schrodinger operators, quantum kinetic equations and their application, extensions of fractional integral transforms, electrical impedance tomography, diffuse optical tomography, Galerkin method by using wavelets, a Cauchy problem associated with Korteweg-de Vries equation, and entropy solution for scalar conservation laws. This book motivates and inspires young researchers in the fields of industrial and applied mathematics.

Frontiers in PDE-Constrained Optimization Harbir Antil 2018-10-12 This volume provides a broad and uniform introduction of PDE-constrained optimization as well as to document a number of interesting and challenging applications. Many science and engineering applications necessitate the solution of optimization problems constrained by physical laws that are described by systems of partial differential equations (PDEs). As a result, PDE-constrained optimization problems arise in a variety of disciplines including geophysics, earth and climate science, material science, chemical and mechanical engineering, medical imaging and physics. This volume is divided into two parts. The first part provides a comprehensive treatment of PDE-constrained optimization including discussions of problems constrained by PDEs with uncertain inputs and problems constrained by variational inequalities. Special emphasis is placed on algorithm development and numerical computation. In addition, a comprehensive treatment of inverse problems arising in the oil and gas industry is provided. The second part of this volume focuses on the application of PDE-constrained optimization, including problems in optimal control, optimal design, and inverse problems, among other topics.

Modeling and Inverse Problems in Imaging Analysis Bernard Chalmoud 2012-12-06 More mathematicians have been taking part in the development of digital image processing as a science and the contributions are reflected in the increasingly important role modeling has played solving complex problems. This book is mostly concerned with energy-based models. Most of these models come from industrial projects in which the author was involved in robot vision and radiography: tracking 3D lines, radiographic image processing, 3D reconstruction and tomography, matching, deformation learning. Numerous graphical illustrations accompany the text.

The Radon Transform, Inverse Problems, and Tomography Gestur Ólafsson 2006 Since their emergence in 1917, tomography and inverse problems remain active and important fields that combine pure and applied mathematics and provide strong interplay between diverse mathematical problems and applications. The applied side is best known for medical and scientific use, in particular, medical imaging, radiotherapy, and industrial non-destructive testing. Doctors use tomography to see the internal structure of the body or to find functional information, such as metabolic processes, noninvasively. Scientists discover defects in objects, the topography of the ocean floor, and geological information using X-rays, geophysical measurements, sonar, or other data. This volume, based on the lectures in the Short Course The Radon Transform and Applications to Inverse Problems at the American Mathematical Society meeting in Atlanta, GA, January 3-4, 2005, brings together articles on mathematical aspects of tomography and related inverse problems. The articles cover introductory material, theoretical problems, and practical issues in 3-D tomography, impedance imaging, local tomography, wavelet methods, regularization and approximate inverse, sampling, and emission tomography. All contributions are written for a general audience, and the authors have included references for further reading.

Control And Inverse Problems For Partial Differential Equations Bao Gang 2019-04-08 This book is a collection of lecture notes for the LIASFMA Hangzhou Autumn School on 'Control and Inverse Problems for Partial Differential Equations' which was held during October 17-22, 2016 at Zhejiang University, Hangzhou, China. This autumn school is one of the activities organized by Sino-French International Associate Laboratory in Applied Mathematics (LIASFMA). Established jointly by eight institutions in China

and France in 2014, LIASFMA aims at providing a platform for many leading French and Chinese mathematicians to conduct in-depth researches, extensive exchanges, and student training in broad areas of applied mathematics. The book provides the readers with a unique and valuable opportunity to learn from and communicate with leading experts in control and inverse problems. And the readers are exposed not only to the basic theories and methods but also to the forefront of research directions in both fields.

Complex Systems in Biomedicine A. Quarteroni 2007-03-20  
Mathematical modeling of human physiopathology is a tremendously ambitious task. It encompasses the modeling of most diverse compartments such as the cardiovascular, respiratory, skeletal and nervous systems, as well as the mechanical and biochemical interaction between blood flow and arterial walls, and electrocardiac processes and electric conduction in biological tissues. Mathematical models can be set up to simulate both vasculogenesis (the aggregation and organization of endothelial cells dispersed in a given environment) and angiogenesis (the formation of new vessels sprouting from an existing vessel) that are relevant to the formation of vascular networks, and in particular to the description of tumor growth. The integration of models aimed at simulating the cooperation and interrelation of different systems is an even more difficult task. It calls for the setting up of, for instance, interaction models for the integrated cardio-vascular system and the interplay between the central circulation and peripheral compartments, models for the mid-to-long range cardiovascular adjustments to pathological conditions (e.g., to account for surgical interventions, congenital malformations, or tumor growth), models for integration among circulation, tissue perfusion, biochemical and thermal regulation, models for parameter identification and sensitivity analysis to parameter changes or data uncertainty - and many others.

Encyclopedia of Nonlinear Science Alwyn Scott 2006-05-17 In 438 alphabetically-arranged essays, this work provides a useful overview of the core mathematical background for nonlinear science, as well as its applications to key problems in ecology and biological systems, chemical reaction-diffusion problems, geophysics, economics, electrical and mechanical oscillations in engineering systems, lasers and nonlinear optics, fluid mechanics and turbulence, and condensed matter physics, among others.

Introduction to Inverse Problems in Imaging M. BOCCACCI BERTERO (P. DE MOL, CHRISTINE.) 2021-12-21 Fully updated throughout, with several new chapters, this second edition of Introduction to Inverse Problems in Imaging guides advanced undergraduate and graduate students in physics, computer science, mathematics and engineering through the principles of linear inverse problems, in addition to methods of their approximate solution and their practical applications in imaging. The level of mathematical treatment is kept as low as possible to make the book suitable for a wide range of readers from different backgrounds, with readers needing just a rudimentary understanding of analysis, geometry, linear algebra, probability theory, and Fourier analysis. This second edition contains new chapters on quadratic, iterative, and sparsity-enforcing tikhonov regularizations in addition to maximum likelihood methods and bayesian regularization. The authors concentrate on presenting easily implementable and fast solution algorithms. With examples and exercises throughout, the book will provide the reader with the appropriate background for a clear understanding of the essence of inverse problems (ill-posedness and its cure) and, consequently, for an intelligent assessment of the rapidly growing literature on these problems. Key features: - Provides an accessible introduction to the topic, whilst keeping mathematics to a minimum - Interdisciplinary topic with growing relevance and wide-ranging applications - Accompanied by numerical examples throughout Author bios Mario Bertero is a Professor Emeritus at the Università di Genova. Patrizia Boccacci is a Professor at the Università di Genova. Christine De Mol is a Professor at the Université libre de Bruxelles.

*Advances in Imaging and Electron Physics* Peter W. Hawkes 2003-12-02 The subjects reviewed in the 'Advances' series cover a broad range of themes including microscopy, electromagnetic fields and image coding. Volume 128 concentrates on regularization, a vital aspect of restoration on low voltage scanning electron microscopy. This book looks at theory and its application in a practical sense, with a full account of the methods used and realistic detailed application. The authors do this by examining the latest developments, historic illustrations and mathematical fundamentals of the exciting developments in imaging and applying them to realistic practical situations. The text bridges the gap between academic researchers and R&D designers by addressing and solving daily issues, which makes this book essential reading. · Emphasizes broad and in depth article collaborations between world-renowned scientists in the field of image and electron physics · Presents theory and its application in a practical sense, providing long awaited solutions and new findings · Bridges the gap between academic researchers and practitioners in industry

*Numerical Methods for Inverse Problems* Michel Kern 2016-03-31 This book studies methods to concretely address inverse problems. An inverse problem arises when the causes that produced a given effect must be determined or when one seeks to indirectly estimate the parameters of a physical system. The author uses practical examples to illustrate inverse problems in physical sciences. He presents the techniques and specific methods chosen to solve inverse problems in a general domain of application, choosing to focus on a small number of methods that can be used in most applications. This book is aimed at readers with a mathematical and scientific computing background. Despite this, it is a book with a practical perspective. The methods described are applicable, have been applied, and are often illustrated by numerical examples.

Computed Radiation Imaging Esam M A Hussein 2011-05-27 Computer-assisted imaging with radiation (x- and gamma rays) is an integral part of modern medical-diagnostic practice. This imaging technology is also slowly finding its way into industrial applications. Although the technology is well developed, there is a need for further improvement to enhance image quality, reduce artifacts, minimize patient radiation

exposure, compete with and complement other imaging methods (such as magnetic resonance imaging and ultrasonics), and accommodate dense and large objects encountered in industrial applications. Scientists and engineers, attempting to progress this technology, are faced with an enormous amount of literature, addressing the imaging problem from various view points. This book provides a single source that addresses both the physical and mathematical aspects of the imaging problem in a consistent and comprehensive manner. Discusses the inherent physical and numerical capabilities and limitations of the methods presented for both the forward and inverse problems Provides information on available Internet resources and software Written in a manner that makes it readable by physicists, mathematicians, engineers and computer scientists - avoids, as much as possible, the use of specialized terminology without clear introduction and definition

*Computational Methods for Applied Inverse Problems* Yanfei Wang 2012-10-30 This monograph reports recent advances of inversion theory and recent developments with practical applications in frontiers of sciences, especially inverse design and novel computational methods for inverse problems. Readers who do research in applied mathematics, engineering, geophysics, biomedicine, image processing, remote sensing, and environmental science will benefit from the contents since the book incorporates a background of using statistical and non-statistical methods, e.g., regularization and optimization techniques for solving practical inverse problems.

*Experimental Stress Analysis for Materials and Structures* Alessandro Freddi 2015-03-19 This book summarizes the main methods of experimental stress analysis and examines their application to various states of stress of major technical interest, highlighting aspects not always covered in the classic literature. It is explained how experimental stress analysis assists in the verification and completion of analytical and numerical models, the development of phenomenological theories, the measurement and control of system parameters under operating conditions, and identification of causes of failure or malfunction. Cases addressed include measurement of the state of stress in models, measurement of actual loads on structures, verification of stress states in circumstances of complex numerical modeling, assessment of stress-related material damage, and reliability analysis of artifacts (e.g. prostheses) that interact with biological systems. The book will serve graduate students and professionals as a valuable tool for finding solutions when analytical solutions do not exist.

*Inverse Problems and Applications* Plamen Stefanov 2014-05-05 This volume contains the proceedings of two conferences on Inverse Problems and Applications, held in 2012, to celebrate the work of Gunther Uhlmann. The first conference was held at the University of California, Irvine, from June 18-22, 2012, and the second was held at Zhejiang University, Hangzhou, China, from September 17-21, 2012. The topics covered include inverse problems in medical imaging, scattering theory, geometry and image processing, and the mathematical theory of cloaking, as well as methods related to inverse problems.

*An Introduction to Mathematics of Emerging Biomedical Imaging* Habib Ammari 2008-05-21 Biomedical imaging is a fascinating research area to applied mathematicians. Challenging imaging problems arise and they often trigger the investigation of fundamental problems in various branches of mathematics. This is the first book to highlight the most recent mathematical developments in emerging biomedical imaging techniques. The main focus is on emerging multi-physics and multi-scales imaging approaches. For such promising techniques, it provides the basic mathematical concepts and tools for image reconstruction. Further improvements in these exciting imaging techniques require continued research in the mathematical sciences, a field that has contributed greatly to biomedical imaging and will continue to do so. The volume is suitable for a graduate-level course in applied mathematics and helps prepare the reader for a deeper understanding of research areas in biomedical imaging.

*Integrated Imaging of the Earth* Max Moorkamp 2016-03-23 Reliable and detailed information about the Earth's subsurface is of crucial importance throughout the geosciences. Quantitative integration of all available geophysical and geological data helps to make Earth models more robust and reliable. The aim of this book is to summarize and synthesize the growing literature on combining various types of geophysical and other geoscientific data. The approaches that have been developed to date encompass joint inversion, cooperative inversion, and statistical post-inversion analysis methods, each with different benefits and assumptions. Starting with the foundations of inverse theory, this book systematically describes the mathematical and theoretical aspects of how to best integrate different geophysical datasets with geological prior understanding and other complimentary data. This foundational basis is followed by chapters that demonstrate the diverse range of applications for which integrated methods have been used to date. These range from imaging the hydrogeological properties of the near-surface to natural resource exploration and probing the composition of the lithosphere and the deep Earth. Each chapter is written by leading experts in the field, which makes this book the definitive reference on integrated imaging of the Earth. Highlights of this volume include: Complete coverage of the theoretical foundations of integrated imaging approaches from inverse theory to different coupling methods and quantitative evaluation of the resulting models Comprehensive overview of current applications of integrated imaging including hydrological investigations, natural resource exploration, and imaging the deep Earth Detailed case studies of integrated approaches providing valuable guidance for both experienced users and researchers new to joint inversion. This volume will be a valuable resource for graduate students, academics, industry practitioners, and researchers who are interested in using or developing integrated imaging approaches.

*Parameter Estimation and Inverse Problems* Richard C. Aster 2013 Preface -- 1. Introduction -- 2. Linear Regression -- 3. Discretizing Continuous Inverse Problems -- 4. Rank Deficiency and Ill-Conditioning -- 5. Tikhonov Regularization -- 6. Iterative Methods -- 7. Other Regularization Techniques -- 8. Fourier Techniques -- 9. Nonlinear Regression -- 10. Nonlinear Inverse Problems -- 11. Bayesian Methods --

Appendix A: Review of Linear Algebra -- Appendix B: Review of Probability and Statistics -- Appendix C: Glossary of Notation -- Bibliography -- Index  
Linear Regression -- Discretizing Continuous Inverse Problems -- Rank Deficiency and Ill-Conditioning -- Tikhonov Regularization -- Iterative Methods -- Other Regularization Techniques -- Fourier Techniques -- Nonlinear Regression -- Nonlinear Inverse Problems -- Bayesian Methods.

*The Radon Transform and Medical Imaging* Peter Kuchment 2014-03-20 This book surveys the main mathematical ideas and techniques behind some well-established imaging modalities such as X-ray CT and emission tomography, as well as a variety of newly developing coupled-physics or hybrid techniques, including thermoacoustic tomography. The Radon Transform and Medical Imaging emphasizes mathematical techniques and ideas arising across the spectrum of medical imaging modalities and explains important concepts concerning inversion, stability, incomplete data effects, the role of interior information, and other issues critical to all medical imaging methods. For nonexperts, the author provides appendices that cover background information on notation, Fourier analysis, geometric rays, and linear operators. The vast bibliography, with over 825 entries, directs readers to a wide array of additional information sources on medical imaging for further study.

*Microwave Imaging and Electromagnetic Inverse Scattering Problems* Loreto Di Donato 2020-05-20 Microwave imaging techniques allow for the development of systems that are able to inspect, identify, and characterize in a noninvasive fashion under different scenarios, ranging from biomedical to subsurface diagnostics as well as from surveillance and security applications to nondestructive evaluation. Such great opportunities, though, are actually severely limited by difficulties arising from the solution of the underlying inverse scattering problem. As a result, ongoing research efforts in this area are devoted to developing inversion strategies and experimental apparatus so that they are as reliable and accurate as possible with respect to reconstruction capabilities and resolution performance, respectively. The intent of this Special Issue is to present the experiences of leading scientists in the electromagnetic inverse scattering community, as well as to serve as an assessment tool for people who are new to the area of microwave imaging and electromagnetic inverse scattering problems.

*Introduction to Imaging from Scattered Fields* Michael A Fiddy 2014-11-10 Obtain the Best Estimate of a Strongly Scattering Object from Limited Scattered Field Data Introduction to Imaging from Scattered Fields presents an overview of the challenging problem of determining information about an object from measurements of the field scattered from that object. It covers widely used approaches to recover information about the objects and examines the assumptions made a priori about the object and the consequences of recovering object information from limited numbers of noisy measurements of the scattered fields. The book explores the strengths and weaknesses of using inverse methods for weak scattering. These methods, including Fourier-based signal and image processing techniques, allow more straightforward inverse algorithms to be exploited based on a simple mapping of scattered field data. The authors also discuss their recent approach based on a nonlinear filtering step in the inverse algorithm. They illustrate how to use this algorithm through numerous two-dimensional electromagnetic scattering examples. MATLAB® code is provided to help readers quickly apply the approach to a wide variety of inverse scattering problems. In later chapters of the book, the authors focus on important and often forgotten overarching constraints associated with exploiting inverse scattering algorithms. They explain how the number of degrees of freedom associated with any given scattering experiment can be found and how this allows one to specify a minimum number of data that should be measured. They also describe how the prior discrete Fourier transform (PDFT) algorithm helps in estimating the properties of an object from scattered field measurements. The PDFT restores stability and improves estimates of the object even with severely limited data (provided it is sufficient to meet a criterion based on the number of degrees of freedom). Suitable for graduate students and researchers working on medical, geophysical, defense, and industrial inspection inverse problems, this self-contained book provides the necessary details for readers to design improved experiments and process measured data more effectively. It shows how to obtain the best estimate of a strongly scattering object from limited scattered field data.

*An Introduction to Data Analysis and Uncertainty Quantification for Inverse Problems* Luis Tenorio 2017-07-06 Inverse problems are found in many applications, such as medical imaging, engineering, astronomy, and geophysics, among others. To solve an inverse problem is to recover an object from noisy, usually indirect observations. Solutions to inverse problems are subject to many potential sources of error introduced by approximate mathematical models, regularization methods, numerical approximations for efficient computations, noisy data, and limitations in the number of observations; thus it is important to include an assessment of the uncertainties as part of the solution. Such assessment is interdisciplinary by nature, as it requires, in addition to knowledge of the particular application, methods from applied mathematics, probability, and statistics. This book bridges applied mathematics and statistics by providing a basic introduction to probability and statistics for uncertainty quantification in the context of inverse problems, as well as an introduction to statistical regularization of inverse problems. The author covers basic statistical inference, introduces the framework of ill-posed inverse problems, and explains statistical questions that arise in their applications. An Introduction to Data Analysis and Uncertainty Quantification for Inverse Problems includes many examples that explain techniques which are useful to address general problems arising in uncertainty quantification, Bayesian and non-Bayesian statistical methods and discussions of their complementary roles, and analysis of a real data set to illustrate the methodology covered throughout the book.

*Inverse Problems* C. W. Groetsch 1999-12-02 Discusses the direction in which the field of differential equations, and its teaching, is going.

*Inverse Problems in Vision and 3D Tomography* Ali Mohamad-Djafari 2013-01-29 The concept of an inverse

problem is a familiar one to most scientists and engineers, particularly in the field of signal and image processing, imaging systems (medical, geophysical, industrial non-destructive testing, etc.) and computer vision. In imaging systems, the aim is not just to estimate unobserved images, but also their geometric characteristics from observed quantities that are linked to these unobserved quantities through the forward problem. This book focuses on imagery and vision problems that can be clearly written in terms of an inverse problem where an estimate for the image and its geometrical attributes (contours and regions) is sought. The chapters of this book use a consistent methodology to examine inverse problems such as: noise removal; restoration by deconvolution; 2D or 3D reconstruction in X-ray, tomography or microwave imaging; reconstruction of the surface of a 3D object using X-ray tomography or making use of its shading; reconstruction of the surface of a 3D landscape based on several satellite photos; super-resolution; motion estimation in a sequence of images; separation of several images mixed using instruments with different sensitivities or transfer functions; and more.

An Introduction to Data Analysis and Uncertainty Quantification for Inverse Problems Luis Tenorio 2017-07-06 Inverse problems are found in many applications, such as medical imaging, engineering, astronomy, and geophysics, among others. To solve an inverse problem is to recover an object from noisy, usually indirect observations. Solutions to inverse problems are subject to many potential sources of error introduced by approximate mathematical models, regularization methods, numerical approximations for efficient computations, noisy data, and limitations in the number of observations; thus it is important to include an assessment of the uncertainties as part of the solution. Such assessment is interdisciplinary by nature, as it requires, in addition to knowledge of the particular application, methods from applied mathematics, probability, and statistics. This book bridges applied mathematics and statistics by providing a basic introduction to probability and statistics for uncertainty quantification in the context of inverse problems, as well as an introduction to statistical regularization of inverse problems. The author covers basic statistical inference, introduces the framework of ill-posed inverse problems, and explains statistical questions that arise in their applications. An Introduction to Data Analysis and Uncertainty Quantification for Inverse Problems?includes many examples that explain techniques which are useful to address general problems arising in uncertainty quantification, Bayesian and non-Bayesian statistical methods and discussions of their complementary roles, and analysis of a real data set to illustrate the methodology covered throughout the book.

Discrete Signals and Inverse Problems J. Carlos Santamarina 2005-12-13 Discrete Signals and Inverse Problems examines fundamental concepts necessary to engineers and scientists working with discrete signal processing and inverse problem solving, and places emphasis on the clear understanding of algorithms within the context of application needs. Based on the original 'Introduction to Discrete Signals and Inverse Problems in Civil Engineering', this expanded and enriched version: combines discrete signal processing and inverse problem solving in one book covers the most versatile tools that are needed to process engineering and scientific data presents step-by-step 'implementation procedures' for the most relevant algorithms provides instructive figures, solved examples and insightful exercises Discrete Signals and Inverse Problems is essential reading for experimental researchers and practicing engineers in civil, mechanical and electrical engineering, non-destructive testing and instrumentation. This book is also an excellent reference for advanced undergraduate students and graduate students in engineering and science.

Regularization and Bayesian Methods for Inverse Problems in Signal and Image Processing Jean-Francois Giovannelli 2015-02-02 The focus of this book is on "ill-posed inverse problems". These problems cannot be solved only on the basis of observed data. The building of solutions involves the recognition of other pieces of a priori information. These solutions are then specific to the pieces of information taken into account. Clarifying and taking these pieces of information into account is necessary for grasping the domain of validity and the field of application for the solutions built. For too long, the interest in these problems has remained very limited in the signal-image community. However, the community has since recognized that these matters are more interesting and they have become the subject of much greater enthusiasm. From the application field's point of view, a significant part of the book is devoted to conventional subjects in the field of inversion: biological and medical imaging, astronomy, non-destructive evaluation, processing of video sequences, target tracking, sensor networks and digital communications. The variety of chapters is also clear, when we examine the acquisition modalities at stake: conventional modalities, such as tomography and NMR, visible or infrared optical imaging, or more recent modalities such as atomic force imaging and polarized light imaging.

An Introduction to the Mathematical Theory of Inverse Problems Andreas Kirsch 2011-03-24 This book introduces the reader to the area of inverse problems. The study of inverse problems is of vital interest to many areas of science and technology such as geophysical exploration, system identification, nondestructive testing and ultrasonic tomography. The aim of this book is twofold: in the first part, the reader is exposed to the basic notions and difficulties encountered with ill-posed problems. Basic properties of regularization methods for linear ill-posed problems are studied by means of several simple analytical and numerical examples. The second part of the book presents two special nonlinear inverse problems in detail - the inverse spectral problem and the inverse scattering problem. The corresponding direct problems are studied with respect to existence, uniqueness and continuous dependence on parameters. Then some theoretical results as well as numerical procedures for the inverse problems are discussed. The choice of material and its presentation in the book are new, thus making it particularly suitable for graduate students. Basic knowledge of real analysis is assumed. In this new edition, the Factorization Method is included as one of the prominent members in this monograph. Since the Factorization Method is particularly simple for the problem of EIT and this field has attracted a lot of

attention during the past decade a chapter on EIT has been added in this monograph as Chapter 5 while the chapter on inverse scattering theory is now Chapter 6. The main changes of this second edition compared to the first edition concern only Chapters 5 and 6 and the Appendix A. Chapter 5 introduces the reader to the inverse problem of electrical impedance tomography.

*Introduction to Inverse Problems in Imaging* M. Bertero 1998-01-01 This is a graduate textbook on the principles of linear inverse problems, methods of their approximate solution, and practical application in imaging. The level of mathematical treatment is kept as low as possible to make the book suitable for a wide range of readers from different backgrounds in science and engineering. Mathematical prerequisites are first courses in analysis, geometry, linear algebra, probability theory, and Fourier analysis. The authors concentrate on presenting easily implementable and fast solution algorithms. With examples and exercised throughout, the book will provide the reader with the appropriate background for a clear understanding of the essence of inverse problems (ill-posedness and its cure) and, consequently, for an intelligent assessment of the rapidly growing literature on these problems.

*Optimization Techniques in Computer Vision* Mongi A. Abidi 2016-12-06 This book presents practical optimization techniques used in image processing and computer vision problems. Ill-posed problems are introduced and used as examples to show how each type of problem is related to typical image processing and computer vision problems. Unconstrained optimization gives the best solution based on numerical minimization of a single, scalar-valued objective function or cost function. Unconstrained optimization problems have been intensively studied, and many algorithms and tools have been developed to solve them. Most practical optimization problems, however, arise with a set of constraints. Typical examples of constraints include: (i) pre-specified pixel intensity range, (ii) smoothness or correlation with neighboring information, (iii) existence on a certain contour of lines or curves, and (iv) given statistical or spectral characteristics of the solution. Regularized optimization is a special method used to solve a class of constrained optimization problems. The term regularization refers to the transformation of an objective function with constraints into a different objective function, automatically reflecting constraints in the unconstrained minimization process. Because of its simplicity and efficiency, regularized optimization has many application areas, such as image restoration, image reconstruction, optical flow estimation, etc. Optimization plays a major role in a wide variety of theories for image processing and computer vision. Various optimization techniques are used at different levels for these problems, and this volume summarizes and explains these techniques as applied to image processing and computer vision.

*Inverse Problems in Scattering and Imaging* Bertero 1992-02-27 *Inverse Problems in Scattering and Imaging* is a collection of lectures from a NATO Advanced Research Workshop that integrates the expertise of physicists and mathematicians in different areas with a common interest in inverse problems. Covering a range of subjects from new developments on the applied mathematics/mathematical physics side to many areas of application, the book achieves a blend of research, review, and tutorial contributions. It is of interest to researchers in the areas of applied mathematics and mathematical physics as well as those working in areas where inverse problems can be applied.

*Sound Visualization and Manipulation* Yang-Hann Kim 2013-08-26 Unique in addressing two different problems - sound visualization and manipulation - in a unified way Advances in signal processing technology are enabling ever more accurate visualization of existing sound fields and precisely defined sound field production. The idea of explaining both the problem of sound visualization and the problem of the manipulation of sound within one book supports this inter-related area of study. With rapid development of array technologies, it is possible to do much in terms of visualization and manipulation, among other technologies involved with the spatial distribution of sound. This book aims to explore various basic functions for the visualization and manipulation and demonstrate to the reader how these properties determine the quality of visualization and manipulation. The first half of the book introduces some basic and general concepts and theories and the second part of the book explains a number of techniques in sound visualization and manipulation. It offers a unified presentation to two very different topics - sound field visualization techniques based on microphone arrays, and techniques for generation of controlled sound fields using loudspeaker arrays. The authors emphasize the similarities between these two physical problems and between the mathematical methods used for solving them. With extensive examples throughout the book, chapters include: Acoustic Wave Equation and its Basic Physical Measures, Acoustic Wave Equation and its Basic Physical Measures, Basic Theory of Sound Visualization, Acoustic Holography, Beamforming, Basic Theory of Sound Manipulation, Sound Focusing, and Sound Field Reproduction. The first book to combine both the visualization and manipulation of sound technologies in one comprehensive volume Presents the basic concepts using simple one dimensional cases and then extends the concept to three dimensional cases, enabling easier understanding of the fundamental concepts through the use of minimum mathematics Provides a solid understanding of associated physics as well as mathematical concepts for understanding the technologies, addressing diffraction problems in an integrated format by using Kirchhoff-Helmholtz integral equation Uses extensive examples demonstrating the benefits and drawbacks of various applications, including beamforming and acoustic holography A valuable resource for post/graduate students, acoustic engineers, audio and noise control system developers

*Qualitative Methods in Inverse Scattering Theory* Fioralba Cakoni 2005-11-03 Inverse scattering theory has been a particularly active and successful field in applied mathematics and engineering for the past twenty years. The increasing demands of imaging and target identification require new powerful and flexible techniques besides the existing weak scattering approximation or nonlinear optimization methods. One class of such methods comes under the general description of qualitative methods in inverse

scattering theory. This textbook is an easily-accessible "class-tested" introduction to the field. It is accessible also to readers who are not professional mathematicians, thus making these new mathematical ideas in inverse scattering theory available to the wider scientific and engineering community.

Computational Uncertainty Quantification for Inverse Problems Johnathan M. Bardsley 2018-08-01 This book is an introduction to both computational inverse problems and uncertainty quantification (UQ) for inverse problems. The book also presents more advanced material on Bayesian methods and UQ, including Markov chain Monte Carlo sampling methods for UQ in inverse problems. Each chapter contains MATLAB® code that implements the algorithms and generates the figures, as well as a large number of exercises accessible to both graduate students and researchers. Computational Uncertainty Quantification for Inverse Problems is intended for graduate students, researchers, and applied scientists. It is appropriate for courses on computational inverse problems, Bayesian methods for inverse problems, and UQ methods for inverse problems.

Introduction to Inverse Problems in Imaging M. Bertero 2020-08-30 This is a graduate textbook on the principles of linear inverse problems, methods of their approximate solution, and practical application in imaging. The level of mathematical treatment is kept as low as possible to make the book suitable for a wide range of readers from different backgrounds in science and engineering. Mathematical prerequisites are first courses in analysis, geometry, linear algebra, probability theory, and Fourier analysis. The authors concentrate on presenting easily implementable and fast solution algorithms. With examples and exercises throughout, the book will provide the reader with the appropriate background for a clear understanding of the essence of inverse problems (ill-posedness and its cure) and, consequently, for an intelligent assessment of the rapidly growing literature on these problems.

Inverse Methods in Action Pierre C. Sabatier 1990-06-20 The basic idea of inverse methods is to extract from the evaluation of measured signals the details of the object emitting them. The applications range from physics and engineering to geology and medicine (tomography). Although most contributions are rather theoretical in nature, this volume is of practical value to experimentalists and engineers and as well of interest to mathematicians. The review lectures and contributed papers are grouped into eight chapters dedicated to tomography, distributed parameter inverse problems, spectral and scattering inverse problems (exact theory), wave propagation and scattering (approximations); miscellaneous inverse problems and applications and inverse methods in nonlinear mathematics.