# Introduction To Inverse Problems In Imaging

**An Introduction to the Mathematical Theory of Inverse Problems** **Inverse Problems** Inverse Problems in the Mathematical Sciences Inverse Problems in the Mathematical Sciences **Inverse Problems in Quantum Scattering Theory** *An Introduction to Inverse Problems with Applications* **Introduction to Inverse Problems in Imaging** Inverse Problems *Inverse Problems with Applications in Science and Engineering* **Inverse problems in vibration** Statistical and Computational Inverse Problems **Inverse Problems in Engineering Mechanics** **Introduction to Inverse Problems for Differential Equations** Methods for Solving Inverse Problems in Mathematical Physics *Surveys on Solution Methods for Inverse Problems* **Modeling and Inverse Problems in the Presence of Uncertainty** Inverse Problem Theory and Methods for Model Parameter Estimation *Inverse Problems for Partial Differential Equations* **Inverse Problems and High-Dimensional Estimation** **Inverse Problems** *Computational Methods for Inverse Problems* **Inverse Problems in Engineering Mechanics** *Numerical Methods for Inverse Problems* **Discrete Inverse Problems** Modeling and Inverse Problems in Imaging Analysis Computational Methods for Inverse Problems in Imaging **Inverse Problems and Related Topics** Parameter Estimation and Inverse Problems An Introduction to the Mathematical Theory of Inverse Problems **Elements of the Theory of Inverse Problems** *Nonlinear Least Squares for Inverse Problems* **Inverse Problems in Differential Equations** **Inverse Problems and Related Topics** *Regularization of Inverse Problems* *Introduction to Inverse Problems in Imaging* **Modeling and Inverse Problems in Imaging Analysis** *Iterative Optimization in Inverse Problems* *Inverse Problems in Partial Differential Equations* *Inverse Problems for Electrical Networks* **Modeling and Inverse Problems in the Presence of Uncertainty**

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Parameter Estimation and Inverse Problems Jun 30 2020 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 -- IndexLinear 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.
**Inverse Problems and Related Topics** Aug 01 2020 Inverse problems arise in many disciplines and hold great importance to practical applications. However, sound new methods are needed to solve these problems. Over the past few years, Japanese and Korean mathematicians have obtained a number of very interesting and unique results in inverse problems. Inverse Problems and Related Topics compiles papers authored by some of the top researchers in Korea and Japan. It presents a number of original and useful results and offers a unique opportunity to explore the current trends of research in inverse problems in these countries. Highlighting the existence and active work of several Japanese and Korean groups, it also serves as a guide to those seeking future scientific exchange with researchers in these countries.
*Surveys on Solution Methods for Inverse Problems* Aug 13 2021 Inverse problems are concerned with determining causes for observed or desired effects. Problems of this type appear in many application fields both in science and in engineering. The mathematical modelling of inverse problems usually leads to ill-posed problems, i.e., problems where solutions need not exist, need not be unique or may depend discontinuously on the data. For this reason, numerical methods for solving inverse problems are especially difficult, special methods have to be developed which are known under the term "regularization methods". This volume contains twelve survey papers about solution methods for inverse and ill-posed problems and about their application to specific types of inverse problems, e.g., in scattering theory, in tomography and medical applications, in geophysics and in image processing. The papers have been written by leading experts in the field and provide an up-to-date account of solution methods for inverse problems.
**Inverse Problems in Quantum Scattering Theory** Jun 23 2022
**Inverse Problems and Related Topics** Jan 26 2020 This volume contains 13 chapters, which are extended versions of the presentations at International Conference on Inverse Problems at Fudan University, Shanghai, China, October 12-14, 2018, in honor of Masahiro Yamamoto on the occasion of his 60th anniversary. The chapters are authored by world-renowned researchers and rising young talents, and are updated accounts of various aspects of the researches on inverse problems. The volume covers theories of inverse problems for partial differential equations, regularization methods, and related topics from control theory. This book addresses a wide audience of researchers and young post-docs and graduate students who are interested in mathematical sciences as well as mathematics.
Inverse Problems in the Mathematical Sciences Aug 25 2022 Inverse problems are immensely important in modern science and technology. However, the broad mathematical issues raised by inverse problems receive scant attention in the university curriculum. This book aims to remedy this state of affairs by supplying an accessible introduction, at a modest mathematical level, to the alluring field of inverse problems. Many models of inverse problems from science and engineering are dealt with and nearly a hundred exercises, of varying difficulty, involving mathematical analysis, numerical treatment, or modelling of inverse problems, are provided. The main themes of the book are: causation problem modeled as integral equations; model identification problems, posed as coefficient determination problems in differential equations; the functional analytic framework for inverse problems; and a survey of the principal numerical methods for inverse problems. An extensive annotated bibliography furnishes leads on the history of inverse problems and a guide to the frontiers of current research.
Inverse Problem Theory and Methods for Model Parameter Estimation Jun 11 2021 While the prediction of observations is a forward problem, the use of actual observations to infer the properties of a model is an inverse problem. Inverse problems are difficult because they may not have a unique solution. The description of uncertainties plays a central role in the theory, which is based on probability theory. This book proposes a general approach that is valid for linear as well as for nonlinear problems. The philosophy is essentially probabilistic and allows the reader to understand the basic difficulties appearing in the resolution of inverse problems. The book attempts to explain how a method of acquisition of information can be applied to actual real-world problems, and many of the arguments are heuristic.
**Modeling and Inverse Problems in Imaging Analysis** Oct 23 2019 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.
*Inverse Problems for Electrical Networks* Jul 20 2019 Annotation This book is a very timely exposition of part of an important subject which goes under the general name of "inverse problems". The analogous problem for continuous media has been very much studied, with a great deal of difficult mathematics involved, especially partial differential equations. Some of the researchers working on the inverse conductivity problem for continuous media (the problem of recovering the conductivity inside from measurements on the outside) have taken an interest in the authors' analysis of this similar problem for resistor networks. The authors' treatment of inverse problems for electrical networks is at a fairly elementary level. It is accessible to advanced undergraduates, and mathematics students at the graduate level. The topics are of interest to mathematicians working on inverse problems, and possibly to electrical engineers. A few techniques from other areas of mathematics have been brought together in the treatment. It is this amalgamation of such topics as graphtheory, medial graphs and matrix algebra, as well as the analogy to inverse problems for partial differential equations, that makes the book both original and interesting.
**Discrete Inverse Problems** Nov 04 2020 This book gives an introduction to the practical treatment of inverse problems by means of numerical methods, with a focus on basic mathematical and computational aspects. To solve inverse problems, we demonstrate that insight about them goes hand in hand with algorithms.
**Inverse problems in vibration** Jan 18 2022 The last thing one settles in writing a book is what one should put in first. Pascal's Pensees Classical vibration theory is concerned, in large part, with the infinitesimal (i. e. , linear) undamped free vibration of various discrete or continuous bodies. One of the basic problems in this theory is the determination of the natural frequencies (eigen frequencies or simply eigenvalues) and normal modes of the vibrating body. A body which is modelled as a discrete system' of rigid masses, rigid rods, massless springs, etc. , will be governed by an ordinary matrix differential equation in time t. It will have a finite number of eigenvalues, and the normal modes will be vectors, called eigenvectors. A body which is modelled as a continuous system will be governed by a partial differential equation in time and one or more spatial variables. It will have an infinite number of eigenvalues, and the normal modes will be functions (eigen functions) of the space variables. In the context of this classical theory, inverse problems are concerned with the construction of a model of a given type; e. g. , a mass-spring system, a string, etc. , which has given eigenvalues and/or eigenvectors or eigenfunctions; i. e. , given spec tral data. In general, if some such spectral data is given, there can be no system, a unique system, or many systems, having these properties.
**Inverse Problems and High-Dimensional Estimation** Apr 09 2021 The “Stats in the Château” summer school was held at the CRC château on the campus of HEC Paris, Jouy-en-Josas, France, from August 31 to September 4, 2009. This event was organized jointly by faculty members of three French academic institutions ? ENSAE ParisTech, the Ecole Polytechnique ParisTech, and HEC Paris ? which cooperate through a scientific foundation devoted to the decision sciences. The scientific content of the summer school was conveyed in two courses, one by Laurent Cavalier (Université Aix-Marseille I) on "Ill-posed Inverse Problems", and one by Victor Chernozhukov (Massachusetts Institute of Technology) on "High-dimensional Estimation with Applications to Economics". Ten invited researchers also presented either reviews of the state of the art in the field or of applications, or original research contributions. This volume contains the lecture notes of the two courses. Original research articles and a survey complement these lecture notes. Applications to economics are discussed in various contributions.
*Iterative Optimization in Inverse Problems* Sep 21 2019 Iterative Optimization in Inverse Problems brings together a number of important iterative algorithms for medical imaging, optimization, and statistical estimation. It incorporates recent work that has not appeared in other books and draws on the author’s considerable research in the field, including his recently developed class of SUMMA algorithms. Related to sequential unconstrained minimization methods, the SUMMA class includes a wide range of iterative algorithms well known to researchers in various

areas, such as statistics and image processing. Organizing the topics from general to more specific, the book first gives an overview of sequential optimization, the subclasses of auxiliary-function methods, and the SUMMA algorithms. The next three chapters present particular examples in more detail, including barrier- and penalty-function methods, proximal minimization, and forward-backward splitting. The author also focuses on fixed-point algorithms for operators on Euclidean space and then extends the discussion to include distance measures other than the usual Euclidean distance. In the final chapters, specific problems illustrate the use of iterative methods previously discussed. Most chapters contain exercises that introduce new ideas and make the book suitable for self-study. Unifying a variety of seemingly disparate algorithms, the book shows how to derive new properties of algorithms by comparing known properties of other algorithms. This unifying approach also helps researchers—from statisticians working on parameter estimation to image scientists processing scanning data to mathematicians involved in theoretical and applied optimization—discover useful related algorithms in areas outside of their expertise.

*Regularization of Inverse Problems* Dec 25 2019 This book is devoted to the mathematical theory of regularization methods and gives an account of the currently available results about regularization methods for linear and nonlinear ill-posed problems. Both continuous and iterative regularization methods are considered in detail with special emphasis on the development of parameter choice and stopping rules which lead to optimal convergence rates.

*Numerical Methods for Inverse Problems* Dec 05 2020 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.

**Inverse Problems in Engineering Mechanics** Nov 16 2021 Inverse problems can be found in many topics of engineering mechanics. There are many successful applications in the fields of inverse problems (non-destructive testing and characterization of material properties by ultrasonic or X-ray techniques, thermography, etc.). Generally speaking, the inverse problems are concerned with the determination of the input and the characteristics of a mechanical system from some of the output from the system. Mathematically, such problems are ill-posed and have to be overcome through development of new computational schemes, regularization techniques, objective functionals, and experimental procedures. Seventy-two papers were presented at the International Symposium on Inverse Problems in Mechanics (ISIP '98) held in March of 1998 in Nagano, where recent developments in the inverse problems in engineering mechanics and related topics were discussed. The main themes were: mathematical and computational aspects of the inverse problems, parameter or system identification, shape determination, sensitivity analysis, optimization, material property characterization, ultrasonic non-destructive testing, elastodynamic inverse problems, thermal inverse problems, and other engineering applications.

**Modeling and Inverse Problems in the Presence of Uncertainty** Jul 12 2021 Modeling and Inverse Problems in the Presence of Uncertainty collects recent research—including the authors' own substantial projects—on uncertainty propagation and quantification. It covers two sources of uncertainty: where uncertainty is present primarily due to measurement errors and where uncertainty is present due to the modeling formulation itself. After a useful review of relevant probability and statistical concepts, the book summarizes mathematical and statistical aspects of inverse problem methodology, including ordinary, weighted, and generalized least-squares formulations. It then discusses asymptotic theories, bootstrapping, and issues related to the evaluation of correctness of assumed form of statistical models. The authors go on to present methods for evaluating and comparing the validity of appropriateness of a collection of models for describing a given data set, including statistically based model selection and comparison techniques. They also explore recent results on the estimation of probability distributions when they are embedded in complex mathematical models and only aggregate (not individual) data are available. In addition, they briefly discuss the optimal design of experiments in support of inverse problems for given models. The book concludes with a focus on uncertainty in model formulation itself, covering the general relationship of differential equations driven by white noise and the ones driven by colored noise in terms of their resulting probability density functions. It also deals with questions related to the appropriateness of discrete versus continuum models in transitions from small to large numbers of individuals. With many examples throughout addressing problems in physics, biology, and other areas, this book is intended for applied mathematicians interested in deterministic and/or stochastic models and their interactions. It is also suitable for scientists in biology, medicine, engineering, and physics working on basic modeling and inverse problems, uncertainty in modeling, propagation of uncertainty, and statistical modeling.

*An Introduction to Inverse Problems with Applications* May 22 2022 Computational engineering/science uses a blend of applications, mathematical models and computations. Mathematical models require accurate approximations of their parameters, which are often viewed as solutions to inverse problems. Thus, the study of inverse problems is an integral part of computational engineering/science. This book presents several aspects of inverse problems along with needed prerequisite topics in numerical analysis and matrix algebra. If the reader has previously studied these prerequisites, then one can rapidly move to the inverse problems in chapters 4-8 on image restoration, thermal radiation, thermal characterization and heat transfer. "This text does provide a comprehensive introduction to inverse problems and fills a void in the literature". Robert E White, Professor of Mathematics, North Carolina State University

**Elements of the Theory of Inverse Problems** Apr 28 2020 The Inverse and Ill-Posed Problems Series is a series of monographs publishing postgraduate level information on inverse and ill-posed problems for an international readership of professional scientists and researchers. The series aims to publish works which involve both theory and applications in, e.g., physics, medicine, geophysics, acoustics, electrodynamics, tomography, and ecology.

Inverse Problems in the Mathematical Sciences Jul 24 2022 Inverse problems are immensely important in modern science and technology. However, the broad mathematical issues raised by inverse problems receive scant attention in the university curriculum. This book aims to remedy this state of affairs by supplying an accessible introduction, at a modest mathematical level, to the alluring field of inverse problems. Many models of inverse problems from science and engineering are dealt with and nearly a hundred exercises, of varying difficulty, involving mathematical analysis, numerical treatment, or modelling of inverse problems, are provided. The main themes of the book are: causation problem modeled as integral equations; model identification problems, posed as coefficient determination problems in differential equations; the functional analytic framework for inverse problems; and a survey of the principal numerical methods for inverse problems. An extensive annotated bibliography furnishes leads on the history of inverse problems and a guide to the frontiers of current research.

*Inverse Problems in Partial Differential Equations* Aug 21 2019

**Inverse Problems in Differential Equations** Feb 25 2020 Elucidates the fundamental mathematical structures of inverse problems, analyzing both the information content and the solution of some inverse problems in which the information content of the coefficients and the source term of a given differential equation is not too large. In order to be accessib

*Inverse Problems for Partial Differential Equations* May 10 2021 A comprehensive description of the current theoretical and numerical aspects of inverse problems in partial differential equations. Applications include recovery of inclusions from anomalies of their gravity fields, reconstruction of the interior of the human body from exterior electrical, ultrasonic, and magnetic measurement. By presenting the data in a readable and informative manner, the book introduces both scientific and engineering researchers as well as graduate students to the significant work done in this area in recent years, relating it to broader themes in mathematical analysis.

*Computational Methods for Inverse Problems* Feb 07 2021 Provides a basic understanding of both the underlying mathematics and the computational methods used to solve inverse problems.

*Nonlinear Least Squares for Inverse Problems* Mar 28 2020 The domain of inverse problems has experienced a rapid expansion, driven by the increase in computing power and the progress in numerical modeling. When I started working on this domain years ago, I became somehow fr-tratedtoseethatmyfriendsworkingonmodelingwhereproducingexistence, uniqueness, and stability results for the solution of their equations, but that I was most of the time limited, because of the nonlinearity of the problem, to provethatmyleastsquaresobjectivefunctionwasdi?erentiable....Butwith my experience growing, I became convinced that, after the inverse problem has been properly trimmed, the ?nal least squares problem, the one solved on the computer, should be Quadratically (Q)-wellposed,thatis,both we- posed and optimizable: optimizability ensures that a global minimizer of the least squares function can actually be found using e?cient local optimization algorithms, and wellposedness that this minimizer is stable with respect to perturbation of the data. But the vast majority of inverse problems are nonlinear, and the clas- cal mathematical tools available for their analysis fail to bring answers to these crucial questions: for example, compactness will ensure existence, but provides no uniqueness results, and brings no information on the presence or absenceofparasiticlocalminimaorstationarypoints....

*Introduction to Inverse Problems in Imaging* Nov 23 2019 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.

**Modeling and Inverse Problems in the Presence of Uncertainty** Jun 18 2019 Modeling and Inverse Problems in the Presence of Uncertainty collects recent research—including the authors' own substantial projects—on uncertainty propagation and quantification. It covers two sources of uncertainty: where uncertainty is present primarily due to measurement errors and where uncertainty is present due to the modeling formulation itself. After a useful review of relevant probability and statistical concepts, the book summarizes mathematical and statistical aspects of inverse problem methodology, including ordinary, weighted, and generalized least-squares formulations. It then discusses asymptotic theories, bootstrapping, and issues related to the evaluation of correctness of assumed form of statistical models. The authors go on to present methods for evaluating and comparing the validity of appropriateness of a collection of models for describing a given data set, including statistically based model selection and comparison techniques. They also explore recent results on the estimation of probability distributions when they are embedded in complex mathematical models and only aggregate (not individual) data are available. In addition, they briefly discuss the optimal design of experiments in support of inverse problems for given models. The book concludes with a focus on uncertainty in model formulation itself, covering the general relationship of differential equations driven by white noise and the ones driven by colored noise in terms of their resulting probability density functions. It also deals with questions related to the appropriateness of discrete versus continuum models in transitions from small to large numbers of individuals. With many examples throughout addressing problems in physics, biology, and other areas, this book is intended for applied mathematicians interested in deterministic and/or stochastic models and their interactions. It is also suitable for scientists in biology, medicine, engineering, and physics working on basic modeling and inverse problems, uncertainty in modeling, propagation of uncertainty, and statistical modeling.

**Introduction to Inverse Problems for Differential Equations** Oct 15 2021 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.

An Introduction to the Mathematical Theory of Inverse Problems May 30 2020 This graduate-level textbook introduces the reader to the area of inverse problems, vital to many fields including geophysical exploration, system identification, nondestructive testing, and ultrasonic tomography. It aims to expose the basic notions and difficulties encountered with ill-posed problems, analyzing basic properties of regularization methods for ill-posed problems via several simple analytical and numerical examples. The book also presents three special nonlinear inverse problems in detail: the inverse spectral problem, the inverse problem of electrical impedance tomography (EIT), and the inverse scattering problem. The corresponding direct problems are studied with respect to existence, uniqueness, and continuous dependence on parameters. Ultimately, the text discusses theoretical results as well as numerical procedures for the inverse problems, including many exercises and illustrations to complement coursework in mathematics and engineering. This updated text includes a new chapter on the theory of nonlinear inverse problems in response to the field's growing popularity, as well as a new section on the interior transmission eigenvalue problem which complements the Sturm-Liouville problem and which has received great attention since the previous edition was published.
Modeling and Inverse Problems in Imaging Analysis Oct 03 2020 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.
**Inverse Problems in Engineering Mechanics** Jan 06 2021 Inverse problems occur in a wide variey of fields. In general, the inverse problem can be defined as one where one should estimate the cause from the result, while the direct problem is concerned with how to obtain the result from the cause. The aim of this symposium was to gather scientists and researchers in engineering mechanics concerned with inverse problems in order to exchange research result and develop computational and experimentalapproaches to solve inverse problems. The contributions in this volume cover the following subjects: mathematical and computational aspects of inverse problems, parameter or system identification, shape determination, sensitivity analysis, optimization, material property characterization, ultrasonic nondestructive testing, elastodynamic inverse problems, thermal inverse problems, and other miscellaneous engineering applications.
Statistical and Computational Inverse Problems Dec 17 2021 This book covers the statistical mechanics approach to computational solution of inverse problems, an innovative area of current research with very promising numerical results. The techniques are applied to a number of real world applications such as limited angle tomography, image deblurring, electical impedance tomography, and biomagnetic inverse problems. Contains detailed examples throughout and includes a chapter on case studies where such methods have been implemented in biomedical engineering.
Inverse Problems Mar 20 2022 Problem solving in mathematics is often thought of as a one way process. For example: take two numbers and multiply them together. However for each problem there is also an inverse problem which runs in the opposite direction: now take a number and find a pair of factors. Such problems are considerably more important, in mathematics and throughout science, than they might first appear. This book concentrates on these inverse problems and how they can be usefully introduced to undergraduate students. A historical introduction sets the scene and gives a cultural context for the rest of the book. Chapters dealing with inverse problems in calculus, differential equations and linear algebra then follow and the book concludes with suggestions for further reading. Whatever their own field of expertise, this will be an essential purchase for anyone interested in the teaching of mathematics.
**Inverse Problems** Sep 26 2022 The overall goal of the book is to provide access to the regularized solution of inverse problems relevant in geophysics without requiring more mathematical knowledge than is taught in undergraduate math courses for scientists and engineers. From abstract analysis only the concept of functions as vectors is needed. Function spaces are introduced informally in the course of the text, when needed. Additionally, a more detailed, but still condensed introduction is given in Appendix B. A second goal is to elaborate the single steps to be taken when solving an inverse problem: discretization, regularization and practical solution of the regularized optimization problem. These steps are shown in detail for model problems from the fields of inverse gravimetry and seismic tomography. The intended audience is mathematicians, physicists and engineers having a good working knowledge of linear algebra and analysis at the upper undergraduate level.
**Inverse Problems** Mar 08 2021 Inverse problems arise in practical applications whenever one needs to deduce unknowns from observables. This monograph is a valuable contribution to the highly topical field of computational inverse problems. Both mathematical theory and numerical algorithms for model-based inverse problems are discussed in detail. The mathematical theory focuses on nonsmooth Tikhonov regularization for linear and nonlinear inverse problems. The computational methods include nonsmooth optimization algorithms, direct inversion methods and uncertainty quantification via Bayesian inference. The book offers a comprehensive treatment of modern techniques, and seamlessly blends regularization theory with computational methods, which is essential for developing accurate and efficient inversion algorithms for many practical inverse problems. It demonstrates many current developments in the field of computational inversion, such as value function calculus, augmented Tikhonov regularization, multi-parameter Tikhonov regularization, semismooth Newton method, direct sampling method, uncertainty quantification and approximate Bayesian inference. It is written for graduate students and researchers in mathematics, natural science and engineering.
Computational Methods for Inverse Problems in Imaging Sep 02 2020 This book presents recent mathematical methods in the area of inverse problems in imaging with a particular focus on the computational aspects and applications. The formulation of inverse problems in imaging requires accurate mathematical modeling in order to preserve the significant features of the image. The book describes computational methods to efficiently address these problems based on new optimization algorithms for smooth and nonsmooth convex minimization, on the use of structured (numerical) linear algebra, and on multilevel techniques. It also discusses various current and challenging applications in fields such as astronomy, microscopy, and biomedical imaging. The book is intended for researchers and advanced graduate students interested in inverse problems and imaging.
*Inverse Problems with Applications in Science and Engineering* Feb 19 2022 Driven by the advancement of industrial mathematics and the need for impact case studies, Inverse Problems with Applications in Science and Engineering thoroughly examines the state-of-the-art of some representative classes of inverse and ill-posed problems for partial differential equations (PDEs). The natural practical applications of this examination arise in heat transfer, electrostatics, porous media, acoustics, fluid and solid mechanics – all of which are addressed in this text. Features: Covers all types of PDEs — namely, elliptic (Laplace's, Helmholtz, modified Helmholtz, biharmonic and Stokes), parabolic (heat, convection, reaction and diffusion) and hyperbolic (wave) Excellent reference for post-graduates and researchers in mathematics, engineering and any other scientific discipline that deals with inverse problems Contains both theory and numerical algorithms for solving all types of inverse and ill-posed problems
**An Introduction to the Mathematical Theory of Inverse Problems** Oct 27 2022 Following Keller [119] we call two problems inverse to each other if the for mulation of each of them requires full or partial knowledge of the other. By this definition, it is obviously arbitrary which of the two problems we call the direct and which we call the inverse problem. But usually, one of the problems has been studied earlier and, perhaps, in more detail. This one is usually called the direct problem, whereas the other is the inverse problem. However, there is often another, more important difference between these two problems. Hadamard (see [91]) introduced the concept of a well-posed problem, originating from the philosophy that the mathematical model of a physical problem has to have the properties of uniqueness, existence, and stability of the solution. If one of the properties fails to hold, he called the problem ill-posed. It turns out that many interesting and important inverse in science lead to ill-posed problems, while the corresponding di problems rect problems are well-posed. Often, existence and uniqueness can be forced by enlarging or reducing the solution space (the space of "models"). For restoring stability, however, one has to change the topology of the spaces, which is in many cases impossible because of the presence of measurement errors. At first glance, it seems to be impossible to compute the solution of a problem numerically if the solution of the problem does not depend continuously on the data, i. e. , for the case of ill-posed problems.
Methods for Solving Inverse Problems in Mathematical Physics Sep 14 2021 Developing an approach to the question of existence, uniqueness and stability of solutions, this work presents a systematic elaboration of the theory of inverse problems for all principal types of partial differential equations. It covers up-to-date methods of linear and nonlinear analysis, the theory of differential equations in Banach spaces, applications of functional analysis, and semigroup theory.
**Introduction to Inverse Problems in Imaging** Apr 21 2022 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.