GEOPHYSICAL INVERSE THEORY AND REGULARIZATION PROBLEMS

M. S. ZHDANOV

Geophysical Inverse Theory And Regularization Problems

Hwee-San Lim

Geophysical Inverse Theory And Regularization 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

Inverse Theory and Applications in Geophysics Michael S. Zhdanov,2015-07-15 Geophysical Inverse Theory and Applications Second Edition 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 It s the first book of its kind 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 Unique in its focus on providing a link between the methods used in gravity electromagnetic and seismic imaging and inversion it represents an exhaustive treatise on inversion theory Written by one of the world s foremost experts this work is widely recognized as the ultimate researcher s reference on geophysical inverse theory and its practical scientific applications Presents state of the art geophysical inverse theory developed in modern mathematical terminology the first to treat many kinds of inversion and imaging techniques in a unified mathematical way Provides a critical link between the methods used in gravity electromagnetic and seismic imaging and inversion and represents an exhaustive treatise on geophysical inversion theory

Features more than 300 illustrations figures charts and graphs to underscore key concepts Reflects the latest developments in inversion theory and applications and captures the most significant changes in the field over the past decade

Geophysical Inversion Theory and Global Optimization Methods Caiyun Liu,Jie Xiong,2018-04-01 Geophysical inversion is an ill posed problem Classical local search method for inversion is depend on initial guess and easy to be trapped in local optimum The global optimization is a group of novel methods to deal with the problems mentioned above The book introduces the geophysical inversion theory including the classical solving approaches firstly Then it introduces several typical global inversion approaches including particle swarm optimization PSO differential evolution DE and multiobjective optimization methods as well as some examples to inverse the geophysical data such as gravity MT sounding well logging self potential seismic data using these global optimization approaches *V Hotine-Marussi Symposium on Mathematical Geodesy* Fernando Sansò,2013-03-09 Just as in the era of great achievements by scientists such as Newton and Gauss the mathematical theory of geodesy is continuing the tradition of producing exciting theoretical results but today the advances are due to the great technological push in the era of satellites for earth observations and large computers for calculations Every four years a symposium on methodological matters documents this ongoing development in many related underlying areas such as estimation theory stochastic modelling inverse problems and satellite positioning global reference systems This book presents developments in geodesy and related sciences including applied mathematics among which are many new results of high intellectual value to help readers stay on top of the latest happenings in the field **Applications of Linear and Nonlinear Models** Erik W. Grafarend,Silvelyn Zwanzig,Joseph L. Awange,2022-10-01 This book provides numerous examples of linear and nonlinear model applications Here we present a nearly complete treatment of the Grand Universe of linear and weakly nonlinear regression models within the first 8 chapters Our point of view is both an algebraic view and a stochastic one For example there is an equivalent lemma between a best linear uniformly unbiased estimation BLUUE in a Gauss Markov model and a least squares solution LESS in a system of linear equations While BLUUE is a stochastic regression model LESS is an algebraic solution In the first six chapters we concentrate on underdetermined and overdetermined linear systems as well as systems with a datum defect We review estimators algebraic solutions of type MINOLESS BLIMBE BLUMBE BLUUE BIQUE BLE BIQUE and total least squares The highlight is the simultaneous determination of the first moment and the second central moment of a probability distribution in an inhomogeneous multilinear estimation by the so called E D correspondence as well as its Bayes design In addition we discuss continuous networks versus discrete networks use of Grassmann Plucker coordinates criterion matrices of type Taylor Karman as well as FUZZY sets Chapter seven is a speciality in the treatment of an overjet This second edition adds three new chapters 1 Chapter on integer least squares that covers i model for positioning as a mixed integer linear model which includes integer parameters ii The general integer least squares problem is formulated and the optimality of the least squares solution is

shown iii The relation to the closest vector problem is considered and the notion of reduced lattice basis is introduced iv The famous LLL algorithm for generating a Lovasz reduced basis is explained 2 Bayes methods that covers i general principle of Bayesian modeling Explain the notion of prior distribution and posterior distribution Choose the pragmatic approach for exploring the advantages of iterative Bayesian calculations and hierarchical modeling ii Present the Bayes methods for linear models with normal distributed errors including noninformative priors conjugate priors normal gamma distributions and iii short outview to modern application of Bayesian modeling Useful in case of nonlinear models or linear models with no normal distribution Monte Carlo MC Markov chain Monte Carlo MCMC approximative Bayesian computation ABC methods 3 Error in variables models which cover i Introduce the error in variables EIV model discuss the difference to least squares estimators LSE ii calculate the total least squares TLS estimator Summarize the properties of TLS iii explain the idea of simulation extrapolation SIMEX estimators iv introduce the symmetrized SIMEX SYMEX estimator and its relation to TLS and v short outview to nonlinear EIV models The chapter on algebraic solution of nonlinear system of equations has also been updated in line with the new emerging field of hybrid numeric symbolic solutions to systems of nonlinear equations ermined system of nonlinear equations on curved manifolds The von Mises Fisher distribution is characteristic for circular or hyper spherical data Our last chapter is devoted to probabilistic regression the special Gauss Markov model with random effects leading to estimators of type BLIP and VIP including Bayesian estimation A great part of the work is presented in four appendices Appendix A is a treatment of tensor algebra namely linear algebra matrix algebra and multilinear algebra Appendix B is devoted to sampling distributions and their use in terms of confidence intervals and confidence regions Appendix C reviews the elementary notions of statistics namely random events and stochastic processes Appendix D introduces the basics of Groebner basis algebra its careful definition the Buchberger algorithm especially the C F Gauss combinatorial algorithm   New Achievements in Geoscience Hwee-San Lim,2012-03-23 New Achievements in Geoscience is a comprehensive up to date resource for academic researchers in geophysics environmental science earth science natural resource managements and their related support fields This book attempts to highlight issues dealing with geophysical and earth sciences It describes the research carried out by world class scientists in the fields of geoscience The content of the book includes selected chapters covering seismic interpretation potential field data interpretation and also several chapters on earth science   **Decorrelative Mollifier Gravimetry** Willi Freeden,2021-05-12 This monograph presents the geoscientific context arising in decorrelative gravitational exploration to determine the mass density distribution inside the Earth First an insight into the current state of research is given by reducing gravimetry to mathematically accessible and thus calculable decorrelated models In this way the various unresolved questions and problems of gravimetry are made available to a broad scientific audience and the exploration industry New theoretical developments will be given and innovative ways of modeling geologic layers and faults by mollifier regularization techniques are shown This book is

dedicated to surface as well as volume geology with potential data primarily of terrestrial origin For deep geology the geomathematical decorrelation methods are to be designed in such a way that depth information e g in boreholes may be canonically entered Bridging several different geo disciplines this book leads in a cycle from the potential measurements made by geoengineers to the cleansing of data by geophysicists and geoengineers to the subsequent theory and model formation computer based implementation and numerical calculation and simulations made by geomathematicians to interpretation by geologists and if necessary back It therefore spans the spectrum from geoengineering especially geodesy via geophysics to geomathematics and geology and back Using the German Saarland area for methodological tests important new fields of application are opened particularly for regions with mining related cavities or dense development in today s geo exploration **Practical and Theoretical Aspects of Geological Interpretation of Gravitational, Magnetic and Electric Fields** Danis Nurgaliev,Natalia Khairullina,2019-02-01 This volume offers an overview of the state of the art theoretical and practical approaches currently used for geophysical data interpretation It includes new methods and techniques for solving data processing problems and an analysis of geopotential fields by international researchers It discusses topics such as 1 Theoretical issues of interpretation of gravitational magnetic and electric fields including general methods of interpreting potential fields and other geophysical data 2 Modern algorithms and computer technologies for interpretating geophysical fields 3 The study of Earth deep structure using terrestrial and satellite potential field anomalies 4 Geological interpretation of gravitational magnetic and electric fields This proceedings book is of interest to all geophysical researchers Advanced Methods of Joint Inversion and Fusion of Multiphysics Data Michael S. Zhdanov,2023-12-28 Different physical or geophysical methods provide information about distinctive physical properties of the objects e g rock formations and mineralization In many cases this information is mutually complementary which makes it natural for consideration in a joint inversion of the multiphysics data Inversion of the observed data for a particular experiment is subject to considerable uncertainty and ambiguity One productive approach to reducing uncertainty is to invert several types of data jointly Nonuniqueness can also be reduced by incorporating additional information derived from available a priori knowledge about the target to reduce the search space for the solution This additional information can be incorporated in the form of a joint inversion of multiphysics data Generally established joint inversion methods however are inadequate for incorporating typical physical or geological complexity For example analytic empirical or statistical correlations between different physical properties may exist for only part of the model and their specific form may be unknown Features or structures that are present in the data of one physical method may not be present in the data generated by another physical method or may not be equally resolvable This book presents and illustrates several advanced new approaches to joint inversion and data fusion which do not require a priori knowledge of specific empirical or statistical relationships between the different model parameters or their attributes These approaches include the following novel methods among others 1 the

Gramian method which enforces the correlation between different parameters 2 joint total variation functional or joint focusing stabilizers e g minimum support and minimum gradient support constraints 3 data fusion employing a joint minimum entropy stabilizer which yields the simplest multiphysics solution that fits the multi modal data In addition the book describes the principles of using artificial intelligence AI in solving multiphysics inverse problems The book also presents in detail both the mathematical principles of these advanced approaches to joint inversion of multiphysics data and successful case histories of regional scale and deposit scale geophysical studies to illustrate their indicated advantages   <u>Geophysical Electromagnetic Theory and Methods</u> Michael S. Zhdanov,2009-06-12 In this book the author presents the state of the art electromagnetic EM theories and methods employed in EM geophysical exploration The book brings together the fundamental theory of EM fields and the practicalaspects of EM exploration for mineral and energy resources This text is unique in its breadth and completeness in providing anoverview of EM geophysical exploration technology The book is divided into four parts covering the foundations of EMfield theory and its applications and emerging geophysical methods Part I is an introduction to the field theory required for baselineunderstanding Part II is an overview of all the basic elements ofgeophysical EM theory from Maxwell s fundamental equations to modernmethods of modeling the EM field in complex 3 D geoelectrical formations Part III deals with the regularized solution of ill posedinverse electromagnetic problems the multidimensional migration and imaging ofelectromagnetic data and general interpretation techniques Part IV describes major geophysical electromagnetic methods direct current DC induced polarization IP magnetotelluric MT and controlled source electromagnetic CSEM methods and covers different applications of EM methods in exploration geophysics includingminerals and HC exploration environmental study and crustal study Presents theoretical and methodological findings as well as examples of applications of recently developed algorithms and software in solving practical problems Describes the practical importance of electromagnetic data through enabling discussions on a construction of a closed technological cycle processing analysis and three dimensional interpretation Updates current findings in the field especially with MT magnetovariational and seismo electrical methods and the practice of 3D interpretations   *Applications of Linear and Nonlinear Models* Erik Grafarend,Joseph L. Awange,2012-08-15 Here we present a nearly complete treatment of the Grand Universe of linear and weakly nonlinear regression models within the first 8 chapters Our point of view is both an algebraic view as well as a stochastic one For example there is an equivalent lemma between a best linear uniformly unbiased estimation BLUUE in a Gauss Markov model and a least squares solution LESS in a system of linear equations While BLUUE is a stochastic regression model LESS is an algebraic solution In the first six chapters we concentrate on underdetermined and overdeterimined linear systems as well as systems with a datum defect We review estimators algebraic solutions of type MINOLESS BLIMBE BLUMBE BLUUE BIQUE BLE BIQUE and Total Least Squares The highlight is the simultaneous determination of the first moment and the second central moment of a probability distribution in an

inhomogeneous multilinear estimation by the so called E D correspondence as well as its Bayes design In addition we discuss continuous networks versus discrete networks use of Grassmann Pluecker coordinates criterion matrices of type Taylor Karman as well as FUZZY sets Chapter seven is a speciality in the treatment of an overdetermined system of nonlinear equations on curved manifolds The von Mises Fisher distribution is characteristic for circular or hyper spherical data Our last chapter eight is devoted to probabilistic regression the special Gauss Markov model with random effects leading to estimators of type BLIP and VIP including Bayesian estimation A great part of the work is presented in four Appendices Appendix A is a treatment of tensor algebra namely linear algebra matrix algebra and multilinear algebra Appendix B is devoted to sampling distributions and their use in terms of confidence intervals and confidence regions Appendix C reviews the elementary notions of statistics namely random events and stochastic processes Appendix D introduces the basics of Groebner basis algebra its careful definition the Buchberger Algorithm especially the C F Gauss combinatorial algorithm

Advances in Electromagnetics Empowered by Artificial Intelligence and Deep Learning Sawyer D. Campbell,Douglas H. Werner,2023-09-26 Authoritative reference on the state of the art in the field with additional coverage of important foundational concepts Advances in Electromagnetics Empowered by Artificial Intelligence and Deep Learning presents cutting edge research advances in the rapidly growing areas in optical and RF electromagnetic device modeling simulation and inverse design The text provides a comprehensive treatment of the field on subjects ranging from fundamental theoretical principles and new technological developments to state of the art device design as well as examples encompassing a wide range of related sub areas The content of the book covers all dielectric and metallodielectric optical metasurface deep learning accelerated inverse design deep neural networks for inverse scattering applications of deep learning for advanced antenna design and other related topics To aid in reader comprehension each chapter contains 10 15 illustrations including prototype photos line graphs and electric field plots Contributed to by leading research groups in the field sample topics covered in Advances in Electromagnetics Empowered by Artificial Intelligence and Deep Learning include Optical and photonic design including generative machine learning for photonic design and inverse design of electromagnetic systems RF and antenna design including artificial neural networks for parametric electromagnetic modeling and optimization and analysis of uniform and non uniform antenna arrays Inverse scattering target classification and other applications including deep learning for high contrast inverse scattering of electrically large structures Advances in Electromagnetics Empowered by Artificial Intelligence and Deep Learning is a must have resource on the topic for university faculty graduate students and engineers within the fields of electromagnetics wireless communications antenna RF design and photonics as well as researchers at large defense contractors and government laboratories   **Metal, Ceramic and Polymeric Composites for Various Uses** John Cuppoletti,2011-07-20 Composite materials often shortened to composites are engineered or naturally occurring materials made from two or more constituent materials with significantly different

physical or chemical properties which remain separate and distinct at the macroscopic or microscopic scale within the finished structure The aim of this book is to provide comprehensive reference and text on composite materials and structures This book will cover aspects of design production manufacturing exploitation and maintenance of composite materials The scope of the book covers scientific technological and practical concepts concerning research development and realization of composites **Brain Source Localization Using EEG Signal Analysis** Munsif Ali Jatoi,Nidal Kamel,2017-12-14 Of the research areas devoted to biomedical sciences the study of the brain remains a field that continually attracts interest due to the vast range of people afflicted with debilitating brain disorders and those interested in ameliorating its effects To discover the roots of maladies and grasp the dynamics of brain functions researchers and practitioners often turn to a process known as brain source localization which assists in determining the source of electromagnetic signals from the brain Aiming to promote both treatments and understanding of brain ailments ranging from epilepsy and depression to schizophrenia and Parkinson s disease the authors of this book provide a comprehensive account of current developments in the use of neuroimaging techniques for brain analysis Their book addresses a wide array of topics including EEG forward and inverse problems the application of classical MNE LORETA Bayesian based MSP and its modified version M MSP Within the ten chapters that comprise this book clinicians researchers and field experts concerned with the state of brain source localization will find a store of information that can assist them in the quest to enhance the quality of life for people living with brain disorders Effective Surveillance for Homeland Security Francesco Flammini,Roberto Setola,Giorgio Franceschetti,2013-06-10 Effective Surveillance for Homeland Security Balancing Technology and Social Issues provides a comprehensive survey of state of the art methods and tools for the surveillance and protection of citizens and critical infrastructures against natural and deliberate threats Focusing on current technological challenges involving multi disciplinary prob **Smart Modeling for Engineering Systems** Alena V. Favorskaya,Margarita N. Favorskaya,Sergey S. Simakov,Lakhmi C. Jain,2019-01-08 This book highlights the work of several world class researchers on smart modeling of complex systems The contributions are grouped into the four main categories listed below Numerical schemes construction for the solution of partial differential equations Numerical methods in continuum media mechanics problems Mathematical modeling in aerodynamics plasma physics deformable body mechanics and geological hydrocarbon exploration Mathematical modeling in medical applications The book offers a valuable resource for theoreticians and application scientists and engineers as well as postgraduate students in the fields of computational methods numerical experiments parallel algorithms deformable solid bodies seismic stability seismic prospecting migration elastic and acoustic wave investigation gas dynamics astrophysics aerodynamics fluid dynamics turbulent flows hypersonic flows detonation waves composite materials fracture mechanics melting of metals mathematical economics medicine and biology *Advances in Modeling and Interpretation in Near Surface Geophysics* Arkoprovo Biswas,Shashi Prakash Sharma,2020-01-01 This book deals primarily with the aspects of

advances in near surface geophysical data modeling different interpretation techniques new ideas and an integrated study to delineate the subsurface structures It also involves the practical application of different geophysical methods to delineate the subsurface structures associated with mineral groundwater exploration subsurface contamination hot springs coal fire etc This book is specifically aimed with the state of art information regarding research advances and new developments in these areas of study coupled to extensive modeling and field investigations obtained from around the world It is extremely enlightening for the research workers scientists faculty members and students in Applied Geophysics Near Surface Geophysics Potential Field Electrical and Electromagnetic Methods Mathematical Modeling Techniques in Earth Sciences as well as Environmental Geophysics *Computational Geo-Electromagnetics* Viacheslav V. Spichak,2020-02-01 Computational Geo Electromagnetics Methods Models and Forecasts Volume Five in the Computational Geophysics series is devoted to techniques for building of geoelectrical models from electromagnetic data featuring Bayesian statistical analysis and neural network algorithms These models are applied to studying the geoelectrical structure of famous volcanoes i e Vesuvio Kilauea Elbrus Komagatake Hengill and geothermal zones i e Travale Italy Soultz sous Forets Elsace Methodological recommendations are given on electromagnetic sounding of faults as well as geothermal and hydrocarbon reservoirs Techniques for forecasting of petrophysical properties from the electrical resistivity as proxy parameter are also considered Computational Geo Electromagnetics Methods Models and Forecasts offers techniques and algorithms for building geoelectrical models under conditions of rare or irregularly distributed EM data and or lack of prior geological and geophysical information This volume also includes methodological guidelines on interpretation of electromagnetic sounding data depending on goals of the study Finally it details computational algorithms for using electrical resistivity for properties beyond boreholes Provides algorithms for inversion of incomplete rare or irregularly distributed EM data Features methodological issues of building geoelectrical models Offers techniques for retrieving petrophysical properties from EM sounding data and well logs Applied Geothermics Lev Eppelbaum,Izzy Kutasov,Arkady Pilchin,2014-04-29 This book describes origin and characteristics of the Earth s thermal field thermal flow propagation and some thermal phenomena in the Earth Description of thermal properties of rocks and methods of thermal field measurements in boreholes underground at near surface conditions enables to understand the principles of temperature field acquisition and geothermal model development Processing and interpretation of geothermal data are shown on numerous field examples from different regions of the world The book warps for instance such fields as analysis of thermal regime of the Earth s crust evolution and thermodynamic conditions of the magma ocean and early Earth atmosphere thermal properties of permafrost thermal waters geysers and mud volcanoes methods of Curie discontinuity construction quantitative interpretation of thermal anomalies examination of some nonlinear effects and integration of geothermal data with other geophysical methods This book is intended for students and researchers in the field of Earth Sciences and Environment studying thermal processes in the

Earth and in the subsurface It will be useful for specialists applying thermal field analysis in petroleum water and ore geophysics environmental and ecological studies archaeological prospection and climate of the past **Proceedings of the International Field Exploration and Development Conference 2019** Jia'en Lin,2020-07-11 This book gathers selected papers from the 8th International Field Exploration and Development Conference IFEDC 2019 and addresses a broad range of topics including Low Permeability Reservoir Unconventional Tight Shale Oil Reservoir Unconventional Heavy Oil and Coal Bed Gas Digital and Intelligent Oilfield Reservoir Dynamic Analysis Oil and Gas Reservoir Surveillance and Management Oil and Gas Reservoir Evaluation and Modeling Drilling and Production Operation Enhancement of Recovery Oil and Gas Reservoir Exploration The conference not only provided a platform to exchange experiences but also promoted the advancement of scientific research in oil gas exploration and production The book is chiefly intended for industry experts professors researchers senior engineers and enterprise managers

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