Preface for Volume I: Applied Inverse Problems

In this volume articles related to the First Annual Workshop on Inverse Problems as well as to the Second Annual Workshop on Inverse Problems organized within the project "Adaptive Finite Element Methods for Solutions of Inverse Problems" are collected. For the full information about the project visit the project site https://sites.google.com/site/visby2010/.

Both workshops were supported by the Swedish Institute, Visby program, and organized by the Department of Mathematical Sciences, Chalmers University of Technology, and University of Gothenburg. The First Annual Workshop on Inverse Problems was held from June 2 to 3, 2011, at the Department of Mathematics, Chalmers University of Technology, and University of Gothenburg, Gothenburg, Sweden. The Second Annual Workshop on Inverse Problems took place from May 1 to 6, 2012, in Sunne, Sweden.

All papers in this volume highlight the most recent research related to the new reliable numerical techniques for the solution of inverse and ill-posed problems. The importance of this topic is due to a wide range of applications of inverse and ill-posed problems, such as many aspects of acoustics, electromagnetics, optics, medical imaging, and geophysics. It is well known that inverse problems are both nonlinear and ill-posed. These two factors cause major challenges for the development of numerical methods for them. The ill-posedness means that small fluctuations of the data can cause large fluctuations of solutions. The ill-posedness can be treated via regularization algorithms, and in this volume we present papers where algorithms have the regularization properties.

An Iteratively Truncated Newton's (ITN) scheme for solution of nonlinear irregular operator equations or unstable minimization problems is proposed in the paper by A. B. Bakushinsky and A. B. Smirnova. Authors present numerical studies of a 2D nonlinear inverse magnetometry problem to illustrate advantages of the proposed algorithm. A new model of an approximately globally convergent method for a hyperbolic coefficient inverse problem in the case of backscattering data is studied in the paper by L. Beilina and M. V. Klibanov. Authors present also numerical examples for reconstruction of land mines from backscattered data. Their tests show that refractive indices and locations of dielectric abnormalities can be accurately

imaged using an approximately globally convergent method. A time-adaptive finite element method for the solution of a parameter identification problem for ODE which describes dynamical systems of biological models is presented in the paper by L. Beilina and I. Gainova. Authors present a time-mesh relaxation property on adaptively refined meshes for the finite element solution of a parameter identification problem for system of ODE, formulate the time-mesh refinement recommendation, and present an adaptive algorithm which can be used to find optimal values of the distributed parameters in biological models. In the paper by L. Beilina, M. P. Hatlo Andresen, and H. E. Krogstad the validity of an adaptive finite element method for reconstruction of dielectrics in a symmetric structure is verified on time-resolved data in two dimensions. Numerical tests of this paper show that an adaptive finite element method allows to accurately reconstruct dielectric permittivity, locations, and shapes of dielectric abnormalities. An alternating method for the stable reconstruction of the solution to the Cauchy problem for the stationary heat equation in a bounded Lipschitz domain is studied in the paper by T. N. Baranger, R. Rischette, and B. T. Johansson. Authors formulate the alternating method as the minimization of a discrepancy functional and show that the original alternating method can be interpreted as a method for the solution of the Euler–Lagrange optimality equations for the discrepancy functional. Numerical examples of this paper show the accurate reconstructions using an alternating method. N. Koshev and L. Beilina present an adaptive finite element method for the solution of a Fredholm integral equation of the first kind and derive a posteriori error estimates both in the Tikhonov functional and in the regularized solution of this functional. Authors present experimental verification of an adaptive algorithm on the backscattered data measured in microtomography to restore blurred images obtained by the electron microscope. Their tests show that the local adaptive mesh refinement can significantly improve contrast of the blurred images using optimized number of nodes in the computational mesh. Stable numerical methods and regularizing algorithms for quantum mechanical molecular force fields in vibrational spectroscopy are proposed in the paper by G. Kuramshina, I. Kochikov, and A. Yagola. Authors present numerical examples where they have implemented different models of molecular force fields in the software package SPECTRUM. The paper by L. A. Nazarova and L. A. Nazarov discusses the solution of coefficient and mixed inverse problems in the modeling of solid mineral mining processes. The relaxation property for the mesh refinements and a posteriori error estimate for the reconstructed coefficient for a hyperbolic CIP are presented in the paper by L. Beilina and M. V. Klibanov. Numerical examples of the paper show performance of the two-step numerical procedure on the computationally simulated data where on the first step a good approximation of the exact coefficient is obtained using an approximate globally convergent method, and on the second step this solution is improved via minimization of the corresponding Tikhonov functional on adaptively refined meshes. A new globally convergent algorithm is proposed in the paper by A. Rhoden, N. Patong, Y. Liu, J. Su, and H. Liu to solve a coefficient inverse problem for an elliptic equation with applications in diffuse optical tomography. Numerical experiments are presented to image tumorlike abnormalities both in human organs and in small animals using near-infrared (NIR)

light. A review of inverse problems on compact sets as well as inverse problems with source-wise represented solutions is presented in the paper by A. G. Yagola and Y. M. Korolev. Authors discussed also a posteriori error estimates for regularized solutions with special regularization properties.

The intended audience of this book is : university students (knowledge of mathematics: bachelor level and higher), PhD students (specializing in applied mathematics, mathematics, electrical engineering, physics), researchers, university teachers, and engineers with deeper knowledge and interest in mathematics.

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