Editorial

Inverse Problems: Theory and Application to Science and Engineering

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It is a real pleasure to announce the publication of this special issue. Inverse problems arise naturally in many branches of science and engineering where the values of some model parameters must be obtained from the observed data. In recent years, theory and applications of inverse problems have undergone tremendous growth. Inverse problems can be formulated in many mathematical areas and analyzed by different theoretical and computational techniques. This special issue contains 13 papers, and it aims to highlight recent research, development, and applications of inverse problems in science and engineering.

In the paper “*Fractal-based methods and inverse problems for differential equations: current state-of-the-art*” by H. Kunze et al., the authors illustrate the current state-of-the-art of fractal-based techniques and their application to the solution of inverse problems for ordinary and partial differential equations. They review several methods based on the Collage Theorem and its extensions, and they also discuss two innovative applications.

In the paper “*Electromagnetic nondestructive testing by perturbation homotopy method*” by L. Ding and J. Cao, the authors consider an inverse electromagnetic problem which is concerned with the estimation of electric conductivity of Maxwell’s equations (2D and 3D). A perturbation homotopy method combined with damping Gauss-Newton methods is applied to the inverse electromagnetic problem.

In the paper “*A structured approach to solve the inverse eigenvalue problem for a beam with added mass*” by F. M. Hosseini and N. Baddour, the authors investigate a method for imposing two natural frequencies on a dynamical system consisting of an Euler-Bernoulli beam and carrying a single mass attachment.

In the paper “*Reconstruction of shredded paper documents by feature matching*” by P. Li et al., the authors introduce the algorithm of splicing the shredded paper which is based on the matching to texture feature. By means of this algorithm, they model and solve the problem of splicing the shredded paper. They prove the accuracy of the algorithm by applying it to splice both pieces of English shredded paper and Chinese shredded paper.

In the paper “*Estimation of bottom friction coefficients based on an isopycnal-coordinate internal tidal model with adjoint method*” by Y. Gao et al., the authors, using an isopycnal-coordinate internal tidal model with the adjoint method, carry out three groups of ideal experiments in order to investigate the estimation of spatially varying bottom friction coefficients (BFCs). In Group 1, five values of distance between independent points (DIP) are used to invert the BFCs with the distribution of conical surface. In Group 2, five values of interpolation radius (IR) are used to invert the BFCs with the distribution of conical surface. Based on the results of the first two groups, Group 3 adopts the optimal DIP and IR to estimate 4 kinds of spatially varying BFCs.

In the paper “*Two-parameter inversion of fluid-saturated porous medium with niche ant colony algorithm*” by X.-M. Zhang and L.-R. Wang, the authors perform the inversion of reservoir parameters with an improved niche ant colony algorithm (INACA). In order to overcome the premature problem of the inversion process, the improved niche ant colony algorithm is constructed by combining the fitness sharing principle which is one of the niche methods with the ant colony algorithm. The results of numerical simulation demonstrate that the method is an effective convergent optimization method.

In “*Convergence of a generalized USOR iterative method for augmented systems*” by Y.-Q. Bai et al., the authors establish a generalized Uzawa-SOR (GUSOR) method for solving augmented systems. They prove the convergence of the proposed method under suitable restrictions on the iteration parameters and provide some numerical experiments to show that their proposed method has faster convergence rate than other methods in the literature.

In “*A new method for TSVD regularization truncated parameter selection*” by Z. Wu et al., the truncated singular value decomposition (TSVD) regularization applied to ill-posed problems is studied and a new method for truncated parameter selection is proposed. In this new method, all local optimal truncated parameters are first selected by taking into account the interval estimation of the observation noises, and then the optimal truncated parameter is selected from the local optimal ones.

In the paper “*Method to locate contaminant source and estimate emission strength*” by Q. Hongquan et al., a procedure of source identification which is able to locate the position and estimate the emission strength of the contaminant source is developed. The method is based on a discrete concentration stochastic model. With this model, a sensitivity analysis algorithm is induced to locate the source position and a Kalman filter is used to estimate the contaminant emission strength. Simulation results show the virtues of the method.

In the paper “*Effect of rotation for two-temperature generalized thermoelasticity of two-dimensional under thermal shock problem*” by K. Lotfy and W. Hassan, the authors study the influence of rotation on the total deformation of thermoelastic half-space and the interaction with each other under the influence of two temperature theories. The methodology applied in the paper uses normal mode analysis techniques to solve the resulting nondimensional coupled field equations for the two theories. Numerical results for the displacement components, force stresses, and temperature distribution are presented graphically and discussed. The conductive temperature, the dynamical temperature, the stress, and the strain distributions are shown graphically with some comparisons.

In the paper “*Application of the RBF method to the estimation of temperature on the external surface in laminar pipe flow*” by S. Lyu et al., the inverse heat conduction problem on the heat transfer characteristics of cooled/heated laminar flows through a finite length thick-walled circular tube is studied, using temperature measurements taken at several different locations within the fluid. The method of radial basis functions is coupled with the boundary control technique to

estimate the unknown temperature on the external surface of the circular pipe. The main idea of the proposed method is to solve the direct problem instead of solving the inverse problem directly. The final results confirm that the proposed method is capable of yielding accurate results even when errors in the temperature measurements are present.

In the paper “*Inverse diffraction theory and computation of minimum source regions of far fields*” by E. A. Marengo, a methodology based on the multipole expansion is developed to estimate the minimum source region of a given far field. The support of any source that produces the given far field must contain this minimum source region. The results are derived in the framework of the scalar Helmholtz equation in two-dimensional free space, which is relevant to transverse magnetic electromagnetic waves. The derived approach is illustrated with analytical and numerical examples relevant to inverse source and scattering problems.

The paper “*Improved magnetotelluric Zohdy-Oldenburg direct inversion*” by H. Cao et al. proposes an improved 2D MT Zohdy-Oldenburg direct inversion method, in the least-square sense, embodying the features of Zohdy’s ratio method and Oldenburg’s difference method, in the condition of rugged topography, with phase information. It bypasses large calculations of the Jacobian matrix and large sparse linear systems of equations and enables direct modifications and comparisons of the model parameters. According to the calculation and analysis of examples, it shows faster convergence and higher precision. In contrast with the conventional linear inversion, the calculation speed of this new method can show an increase of more than 10 times.

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