Inverse Problem with Solution Using Data Mining

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Abstract: ***An inverse problem in science is the process of calculating from a set of observations the causal factors that produced them. It is called an inverse problem because it starts with the results and then calculates the causes. This is the inverse of a forward problem, which starts with the causes and then calculates the results.***

Keywords: Inverse Problem, Decomposition, Clustering, Simple Modeling

1. Introduction

Inverse Problems is a research area dealing with inversion of models or data. An inverse problem is a mathematical framework that is used to obtain information about a physical object or system from observed measurements. ***The solution to this problem is useful because it generally provides information about a physical parameter that we cannot directly observe***. Thus, inverse problems are some of the most important and well-studied mathematical problems in science and mathematics.

Inverse problems are some of the most important mathematical problems in science and mathematics because they tell us about parameters that we cannot directly observe. They have wide application in optics, radar, acoustics, communication theory, signal processing, medical imaging, computer vision, geophysics, oceanography, astronomy, remote sensing, natural language processing, machine learning, nondestructive testing, and many other fields.

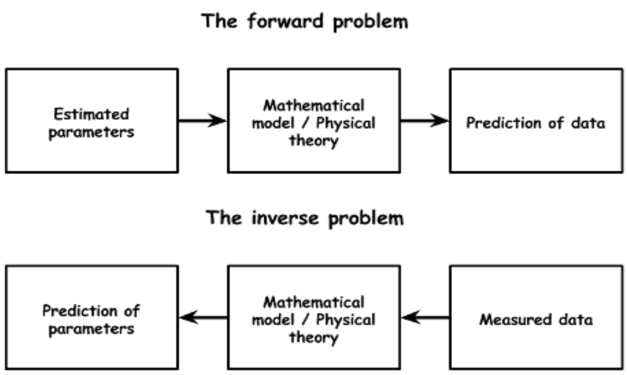

Figure 1: Forward Problem Vs Inverse Problem

1.1 Real Life Examples and Applications

Inverse problems are some of the most important mathematical problems in science and mathematics because they tell us about parameters that we cannot directly observe.

- **Forward Problem**: As per the corruption rate, government decides to demonetization of currency.
  Inverse Problem: Many people suffers from issues due to the lake of new currency – which produced by demonetization of currency.

In IT industry,

- **Forward Problem**: To increase security of WordPress site, we are going to update the latest version of WordPress and plugins of the website.
  Inverse Problems: The whole layout of website may get disturbed due to some not compatible updates of latest version.

2. Existing Methods and Their Limitations

2.1 Tikhonov Regularization

The numerical solution of linear discrete ill-posed problems typically requires regularization, i.e., replacement of the available ill-conditioned problem by a nearby better conditioned one.

The most popular regularization methods for problems of small to moderate size, which allow evaluation of the singular value decomposition of the matrix defining the problem, are the truncated singular value decomposition and Tikhonov regularization.

2.2 Neural Network

A neural network is a machine that is designed to model the way in which the brain performs a particular task or function of interest. To achieve good performance, they employ a massive interconnection of simple computing cells referred to as 'Neurons' or 'processing units'. Hence Neural networks are composed of simple elements operating in parallel.

A typical multi-layer network consists of an input, hidden and output layer, each fully connected to the next, with activation feeding forward.

2.3 Genetic Algorithm

The principle of this method is to model the studied system with a network of problems i.e, electric dipoles, magnetic dipoles or both of them. The procedure of modeling is made in three stages.

- First, measurements of the near electric or magnetic field is made at a height h which is very lower than $\frac{\lambda}{2\pi}$
- Secondly, from the cartography of the measured field, an optimization algorithm proceeds to look for optimal parameters of dipoles (position, orientations and moments) that will give a calculated field which gets closer for the best of the measured near field.

- Thirdly, identified parameters are used to estimate the electromagnetic field in all points of the space. The most popular optimization method used based on genetic algorithm.

2.4 Limitations

- Tikhonov regularization method is limited for single variable output and particular for linear and non-complex problems.
- The Neural network solutions to the inverse problem in specific and often simple cases and thus are not generally applicable to situations and applications other than those they are developed for.
- Genetic algorithms are generally unsuitable for real-time applications and also the accuracy of the solution is not sufficient for some applications, e.g. robotics.

In fact when solutions exist, they are generally non-unique and in some cases many. Even if the solution is unique, the routine to find it sometimes become unstable to minute perturbation of the data due to singularities. The existence, uniqueness and stability are necessary conditions to ensure well-posedness of the problem, which is not generally guaranteed in inverse problems.

3. Literature Review

On the base of all this paper, Analysis for inverse problem solving method is very important. It also needs to be accurate and efficient. The results must be proper and well sorted. The major drawback is that we don't get any proper accurate and one relevant results for all problems.

In paper [5], author introduce a new technique for identification of radiation sources has been presented. The novel algorithm based on coupling the PZMI and Neural Network with the inverse electromagnetic method based on Genetic Algorithms is detailed and tested on a realistic example. The proposed method has the advantage to apply several times the Genetic Algorithm Method with for each time, only 3 parameters to identify. By this way, the convergence of the Genetic Algorithms is assured and the resolution time of the global approach is extremely reduced.

In the paper [4], author applied some methods of artificial neural network for the solution of inverse kinematics of 6-link serial chain manipulator. The methods are multilayer perceptron and polynomial preprocessor neural network has applied. The main objective of this paper is to predict the values of coordinates (inverse kinematics), as there is no unique solution for the inverse kinematics even mathematical formulae are complex and time taking so it is better to find out solution through neural network.

In paper [3], author find the real purpose of choosing membership functions, their choice of range and number has become apparent. Finding a membership function to fit a nonlinear surface is the inverse problem which is solved using Sugeno Model. Now it remains to tune these MFs for a Fuzzy control system to optimize its response. What is apparently a rough conjecture by way of choosing these and defining the rules associated with them has to be applied for control systems for improving system control performance.

In paper [2], author represent the results of analysis demonstrate that solving the inverse scattering problem requires different representation of far-field model that is used to solve direct scattering problem. Hence a new model is proposed to describe distribution of the electromagnetic field caused by scattering of the plane waves on contrast scatters. The model has a form of a set of integral transformations of functions that depend on both the deterministic and random parameters. The form allows to consider initial data for inverse scattering problems as a realization of random processes.

In paper [1], author propose a simple method for solving the inverse problem which is based on decomposition of output space into cells, with the corresponding regions in the input space. Solutions are identified using a clustering method and relationship between data in an output cell and the corresponding input region is modeled by a simple polynomial. The coefficients of the polynomials are stored and are used during inverse function evaluations. It is shown that the proposed method achieves very high accuracy with relatively high input and output dimensions.

4. Conclusion

After analyzing the approaches we conclude that we can have framework proposed for solving inverse problems that are highly nonlinear and extremely complex, have multiple solutions, and possibly require real-time solutions.

The framework consists of search space decomposition, clustering, approximation modeling, and parameters storing/retrieving. Within each of these strategies, any suitable technique can be used. For example, for modeling of data in a region, simple regression, regularization, vector support regression or neural network can be employed, depending on the nature of the data, e.g. noisy, ill conditioned etc.

References

[1] V. S. ABRUKOV, D. A. TROESHESTOVA, R. A. PAVLOV, AND P. V. IVANOV, Artificial neural networks and inverse problems of optical diagnostics, in Sixth International Conference on Intelligent Systems Design and Applications (Proc., Jinan, 2006), vol. 1, IEEE, New Jersey, 2006, pp. 850–855.
[2] A. BECK AND A. BEN-TAL, On the solution of the tikhonov regularization of the total least squares problem, SIAM J. Optim., 17 (2006), pp. 98–118.
[3] A. V. BROVKO, E. K. MURPHY, AND V. V. YAKOVLEV, Waveguide microwave imaging: Neural network reconstruction of functional 2-d permittivity profiles, MTT, 57 (2009), pp. 406–414.
[4] K. A. BUCKLEY, S. H. HOPKINS, AND B. C. H. TURTON, Solution of inverse kinematics problems of a highly kinematically redundant manipulator using genetic algorithms, in Second International Conference On Genetic Algorithms in Engineering Systems:

Innovations and Applications (Proc., Glasgow, 1997), IET, Hertfordshire, 1997, pp. 264–269.
[5] O. CORTES, G. URQUIZA, J. A. HERNANDEZ, AND M. A. CRUZ, Artificial neural networks for inverse heat transfer problems, in Electronics, Robotics and Automotive Mechanics Conference (Proc., Morelos, 2007), IEEE, New Jersey, 2007, pp. 198–201.
[6] I. CRAIG AND J. BROWN, Inverse Problems in Astronomy, Adam Hilger Ltd., Accord, Massachusetts, 1986.
[7] J. J. CRAIG, Introduction to Robotics Mechanics and Control, Pearson Prentice Hall, New Jersey, 2005, ch. 3, pp. 77–83.
[8] J. J. CRAIG, Introduction to Robotics Mechanics and Control, Pearson Prentice Hall,New Jersey, 2005, ch. 4, pp. 117–121.