

An Introduction To The Mathematical Theory Of Inverse Problems Applied

About Inverse Problems

An inverse problem is a mathematical problem where the goal is to find the unknown cause or inputs from the observed outputs. It is the reverse process of a direct problem, where the inputs are known, and the goal is to find the resulting outputs. In various fields such as physics, engineering, and medical imaging, inverse problems play a key role in understanding and analyzing real-world phenomena.

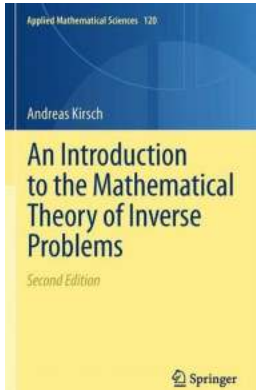
Understanding the Mathematical Theory of Inverse Problems

The mathematical theory of inverse problems provides a framework for tackling these challenging scenarios. It involves formulating the problem mathematically, constructing appropriate models, and utilizing various mathematical techniques to solve them. Inverse problems can be broadly categorized into two types: deterministic and stochastic.

Deterministic Inverse Problems

Deterministic inverse problems deal with situations where the relationship between inputs and outputs is completely defined and lacks any randomness. The goal is to find the exact values of the inputs that lead to the observed outputs. Deterministic inverse problems often involve solving ill-posed problems, where small changes in the data can lead to significant variations in the solution.

An Introduction to the Mathematical Theory of Inverse Problems (Applied Mathematical Sciences Book 120) by Andreas Kirsch (2nd Edition, Kindle Edition)



★★★★☆ 4.8 out of 5

Language : English

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Text-to-Speech: Enabled

Screen Reader: Supported

Print length : 324 pages



Stochastic Inverse Problems

Stochastic inverse problems are concerned with scenarios where randomness is present in the relationship between inputs and outputs. This randomness can arise due to the inherent uncertainty in measurements or the presence of external factors that affect the system. Stochastic inverse problems require probabilistic models and statistical methods to estimate the unknown inputs.

Applications of the Mathematical Theory of Inverse Problems

The mathematical theory of inverse problems finds applications in a wide range of fields, including:

Medical Imaging

Inverse problems are extensively utilized in medical imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET). These techniques involve reconstructing internal structures and functions of the human body from observed measurements. The mathematical theory of inverse problems enables the accurate reconstruction of images from limited and noisy imaging data.

Geophysical Exploration

Inverse problems are instrumental in geophysical exploration, where they are used to infer the properties of subsurface structures. Techniques like seismic imaging, electrical resistivity tomography, and gravitational anomaly inversion rely on solving inverse problems to interpret geophysical data and gain insights into the Earth's composition and resources.

Signal Processing

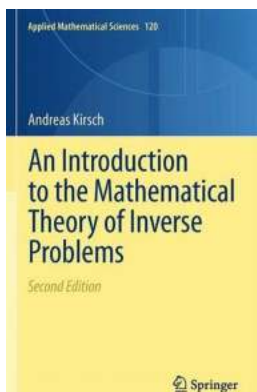
Inverse problems are prevalent in signal processing applications such as image and audio restoration, deconvolution, and source localization. By leveraging the mathematical theory of inverse problems, signal processors can extract meaningful information from noisy or degraded signals and enhance the quality of the processed data.

Non-Destructive Testing

The mathematical theory of inverse problems is deployed in non-destructive testing methods to evaluate the internal properties and defects of materials without causing any damage. Ultrasonic testing, eddy current testing, and X-ray computed tomography rely on solving inverse problems to detect cracks, voids, or structural irregularities in various materials, including metals, composites, and concrete.

The mathematical theory of inverse problems is a powerful tool for understanding and solving real-world problems that involve finding unknown inputs from observed outputs. With applications ranging from medical imaging to geophysical exploration and signal processing, this field plays a crucial role in advancing various scientific and technological domains. By utilizing mathematical models, algorithms, and statistical methods, researchers and practitioners can unravel the

mysteries hidden within complex systems and make accurate predictions and inferences.



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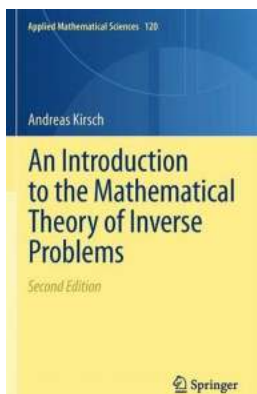


This book introduces the reader to the area of inverse problems. The study of inverse problems is of vital interest to many areas of science and technology such as geophysical exploration, system identification, nondestructive testing and ultrasonic tomography.

The aim of this book is twofold: in the first part, the reader is exposed to the basic notions and difficulties encountered with ill-posed problems. Basic properties of regularization methods for linear ill-posed problems are studied by means of several simple analytical and numerical examples.

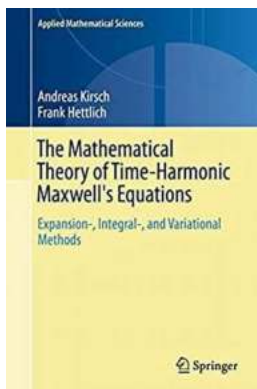
The second part of the book presents two special nonlinear inverse problems in detail - the inverse spectral problem and the inverse scattering problem. The corresponding direct problems are studied with respect to existence, uniqueness and continuous dependence on parameters. Then some theoretical results as well as numerical procedures for the inverse problems are discussed. The choice of material and its presentation in the book are new, thus making it particularly suitable for graduate students. Basic knowledge of real analysis is assumed.

In this new edition, the Factorization Method is included as one of the prominent members in this monograph. Since the Factorization Method is particularly simple for the problem of EIT and this field has attracted a lot of attention during the past decade a chapter on EIT has been added in this monograph as Chapter 5 while the chapter on inverse scattering theory is now Chapter 6. The main changes of this second edition compared to the first edition concern only Chapters 5 and 6 and the Appendix A. Chapter 5 introduces the reader to the inverse problem of electrical impedance tomography.



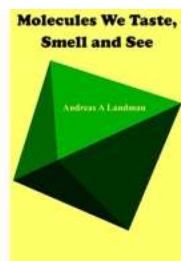
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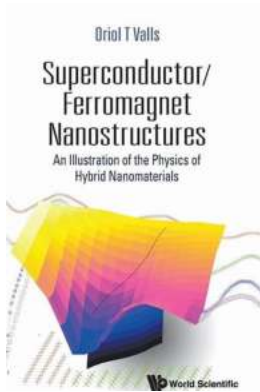
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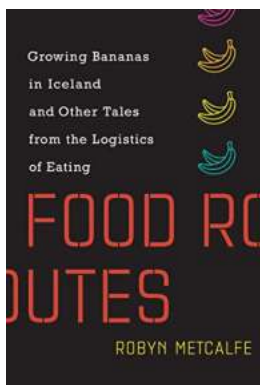
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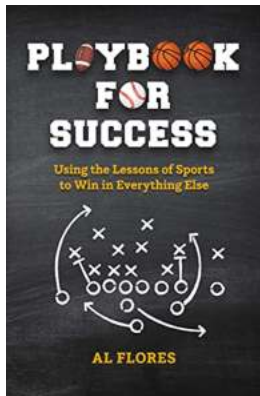
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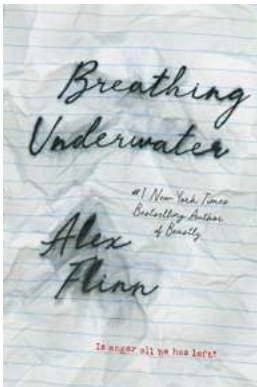
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