Learning Theory An Approximation Theory Viewpoint Cambridge Monographs On Applied And Computational Mathematics

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Learning Theory

Sure to be influential, Watanabe's book lays the foundations for the use of algebraic geometry in statistical learning theory. Many models/machines are singular: mixture models, neural networks, HMMs, Bayesian networks, stochastic context-free grammars are major examples. The theory achieved here underpins accurate estimation techniques in the presence of singularities.

Chebyshev Polynomials

Learning Theory

This volume contains all the papers presented at the Ninth International Con- rence on Algorithmic Learning Theory (ALT'98), held at the European education centre Europ¨aisches Bildungszentrum (ebz) Otzenhausen, Germany, October 8{ 10, 1998. The Conference was sponsored by the Japanese Society for Arti cial Intelligence (JSAI) and the University of Kaiserslautern. Thirty-four papers on all aspects of algorithmic learning theory and related areas were submitted, all electronically. Twenty-six papers were accepted by the program committee based on originality, quality, and relevance to the theory of machine learning. Additionally, three invited talks presented by Akira Maruoka of Tohoku University, Arun Sharma of the University of New South Wales, and Stefan Wrobel from GMD,

respectively, were featured at the conference. We would like to express our sincere gratitude to our invited speakers for sharing with us their insights on new and exciting developments in their areas of research. This conference is the ninth in a series of annual meetings established in 1990. The ALT series focuses on all areas related to algorithmic learning theory including (but not limited to): the theory of machine learning, the design and analysis of learning algorithms, computational logic of/for machine discovery, inductive inference of recursive functions and recursively enumerable languages, learning via queries, learning by arti cial and biological neural networks, pattern recognition, learning by analogy, statistical learning, Bayesian/MDL estimation, inductive logic programming, robotics, application of learning to databases, and gene analyses.

Interpolation and Extrapolation Optimal Designs V1

The aim of this book is to discuss the fundamental ideas which lie behind the statistical theory of learning and generalization. It considers learning from the general point of view of function estimation based on empirical data. Omitting proofs and technical details, the author concentrates on discussing the main results of learning theory and their connections to fundamental problems in statistics. These include: - the general setting of learning problems and the general model of minimizing the risk functional from empirical data - a comprehensive analysis of the empirical risk minimization principle and shows how this allows for the construction of necessary and sufficient conditions for consistency - non-asymptotic bounds for the risk achieved using the empirical risk minimization principle - principles for controlling the generalization ability of learning machines using small sample sizes - introducing a new type of universal learning machine that controls the generalization ability.

Model Reduction and Approximation

This volume contains the papers presented at the 18th International Conf- ence on Algorithmic Learning Theory (ALT 2007), which was held in Sendai (Japan) during October 1–4, 2007. The main objective of the conference was to provide an interdisciplinary forum for high-quality talks with a strong theore- cal background and scienti?c interchange in areas such as query models, on-line learning, inductive inference, algorithmic forecasting, boosting, support vector machines, kernel methods, complexity and learning, reinforcement learning, - supervised learning and grammatical inference. The conference was co-located with the Tenth International Conference on Discovery Science (DS 2007). This volume includes 25 technical contributions that were selected from 50 submissions by the ProgramCommittee. It also contains descriptions of the ?ve invited talks of ALT and DS; longer versions of the DS papers are available in the proceedings of DS 2007. These invited talks were presented to the audience of both conferences in joint sessions.

Approximation Theory and Algorithms for Data Analysis

Deterministic Learning Theory for Identification, Recognition, and Control presents a unified conceptual framework for knowledge acquisition, representation, and

knowledge utilization in uncertain dynamic environments. It provides systematic design approaches for identification, recognition, and control of linear uncertain systems. Unlike many books currently available that focus on statistical principles, this book stresses learning through closed-loop neural control, effective representation and recognition of temporal patterns in a deterministic way. A Deterministic View of Learning in Dynamic Environments The authors begin with an introduction to the concepts of deterministic learning theory, followed by a discussion of the persistent excitation property of RBF networks. They describe the elements of deterministic learning, and address dynamical pattern recognition and pattern-based control processes. The results are applicable to areas such as detection and isolation of oscillation faults, ECG/EEG pattern recognition, robot learning and control, and security analysis and control of power systems. A New Model of Information Processing This book elucidates a learning theory which is developed using concepts and tools from the discipline of systems and control. Fundamental knowledge about system dynamics is obtained from dynamical processes, and is then utilized to achieve rapid recognition of dynamical patterns and pattern-based closed-loop control via the so-called internal and dynamical matching of system dynamics. This actually represents a new model of information processing, i.e. a model of dynamical parallel distributed processing (DPDP).

The Theory of Approximation

This book constitutes the strictly refereed post-workshop proceedings of the Second International Workshop on Database Issues for Data Visualization, held in conjunction with the IEEE Visualization '95 conference in Atlanta, Georgia, in October 1995. Besides 13 revised full papers, the book presents three workshop subgroup reports summarizing the contents of the book as well as the state-of-the-art in the areas of scientific data modelling, supporting interactive database exploration, and visualization related metadata. The volume provides a snapshop of current research in the area and surveys the problems that must be addressed now and in the future towards the integration of database management systems and data visualization.

Pade and Rational Approximation

This book constitutes the refereed proceedings of the 17th Annual Conference on Learning Theory, COLT 2004, held in Banff, Canada in July 2004. The 46 revised full papers presented were carefully reviewed and selected from a total of 113 submissions. The papers are organized in topical sections on economics and game theory, online learning, inductive inference, probabilistic models, Boolean function learning, empirical processes, MDL, generalisation, clustering and distributed learning, boosting, kernels and probabilities, kernels and kernel matrices, and open problems.

Algebraic Geometry and Statistical Learning Theory

Most functions that occur in mathematics cannot be used directly in computer calculations. Instead they are approximated by manageable functions such as polynomials and piecewise polynomials. The general theory of the subject and its

application to polynomial approximation are classical, but piecewise polynomials have become far more useful during the last twenty years. Thus many important theoretical properties have been found recently and many new techniques for the automatic calculation of approximations to prescribed accuracy have been developed. This book gives a thorough and coherent introduction to the theory that is the basis of current approximation methods. Professor Powell describes and analyses the main techniques of calculation supplying sufficient motivation throughout the book to make it accessible to scientists and engineers who require approximation methods for practical needs. Because the book is based on a course of lectures to third-year undergraduates in mathematics at Cambridge University, sufficient attention is given to theory to make it highly suitable as a mathematical textbook at undergraduate or postgraduate level.

Manifold Learning Theory and Applications

This concisely written book gives an elementary introduction to a classical area of mathematics – approximation theory – in a way that naturally leads to the modern field of wavelets. The exposition, driven by ideas rather than technical details and proofs, demonstrates the dynamic nature of mathematics and the influence of classical disciplines on many areas of modern mathematics and applications. Featuring classical, illustrative examples and constructions, exercises, and a discussion of the role of wavelets to areas such as digital signal processing and data compression, the book is one of the few to describe wavelets in words rather than mathematical symbols.

The Nature of Statistical Learning Theory

This is a textbook on classical polynomial and rational approximation theory for the twenty-first century. Aimed at advanced undergraduates and graduate students across all of applied mathematics, it uses MATLAB to teach the field□s most important ideas and results. Approximation Theory and Approximation Practice, Extended Edition differs fundamentally from other works on approximation theory in a number of ways: its emphasis is on topics close to numerical algorithms; concepts are illustrated with Chebfun; and each chapter is a PUBLISHable MATLAB M-file, available online. The book centers on theorems and methods for analytic functions, which appear so often in applications, rather than on functions at the edge of discontinuity with their seductive theoretical challenges. Original sources are cited rather than textbooks, and each item in the bibliography is accompanied by an editorial comment. In addition, each chapter has a collection of exercises, which span a wide range from mathematical theory to Chebfun-based numerical experimentation. This textbook is appropriate for advanced undergraduate or graduate students who have an understanding of numerical analysis and complex analysis. It is also appropriate for seasoned mathematicians who use MATLAB.

Algorithmic Learning Theory

Approximation Theory, Wavelets and Applications draws together the latest developments in the subject, provides directions for future research, and paves the way for collaborative research. The main topics covered include constructive

multivariate approximation, theory of splines, spline wavelets, polynomial and trigonometric wavelets, interpolation theory, polynomial and rational approximation. Among the scientific applications were de-noising using wavelets, including the de-noising of speech and images, and signal and digital image processing. In the area of the approximation of functions the main topics include multivariate interpolation, quasi-interpolation, polynomial approximation with weights, knot removal for scattered data, convergence theorems in Padé theory, Lyapunov theory in approximation, Neville elimination as applied to shape preserving presentation of curves, interpolating positive linear operators, interpolation from a convex subset of Hilbert space, and interpolation on the triangle and simplex. Wavelet theory is growing extremely rapidly and has applications which will interest readers in the physical, medical, engineering and social sciences.

Algorithmic Learning Theory

This textbook is designed for graduate students in mathematics, physics, engineering, and computer science. Its purpose is to guide the reader in exploring contemporary approximation theory. The emphasis is on multi-variable approximation theory, i.e., the approximation of functions in several variables, as opposed to the classical theory of functions in one variable. Most of the topics in the book, heretofore accessible only through research papers, are treated here from the basics to the currently active research, often motivated by practical problems arising in diverse applications such as science, engineering, geophysics, and business and economics. Among these topics are projections, interpolation paradigms, positive definite functions, interpolation theorems of Schoenberg and Micchelli, tomography, artificial neural networks, wavelets, thin-plate splines, box splines, ridge functions, and convolutions. An important and valuable feature of the book is the bibliography of almost 600 items directing the reader to important books and research papers. There are 438 problems and exercises scattered through the book allowing the student reader to get a better understanding of the subject.

Learning Theory

The goal of learning theory is to approximate a function from sample values. To attain this goal learning theory draws on a variety of diverse subjects, specifically statistics, approximation theory, and algorithmics. Ideas from all these areas blended to form a subject whose many successful applications have triggered a rapid growth during the last two decades. This is the first book to give a general overview of the theoretical foundations of the subject emphasizing the approximation theory, while still giving a balanced overview. It is based on courses taught by the authors, and is reasonably self-contained so will appeal to a broad spectrum of researchers in learning theory and adjacent fields. It will also serve as an introduction for graduate students and others entering the field, who wish to see how the problems raised in learning theory relate to other disciplines.

Approximation Theory, Wavelets and Applications

Trained to extract actionable information from large volumes of high-dimensional data, engineers and scientists often have trouble isolating meaningful low-dimensional structures hidden in their high-dimensional observations. Manifold learning, a groundbreaking technique designed to tackle these issues of dimensionality reduction, finds widespread

Advances in Learning Theory

Statistical Learning Theory

A rigorous mathematical treatment of the technique for studying the properties of an experimental situation.

Artificial Neural Networks

This self-contained, systematic treatment of multivariate approximation begins with classical linear approximation, and moves on to contemporary nonlinear approximation. It covers substantial new developments in the linear approximation theory of classes with mixed smoothness, and shows how it is directly related to deep problems in other areas of mathematics. For example, numerical integration of these classes is closely related to discrepancy theory and to nonlinear approximation with respect to special redundant dictionaries, and estimates of the entropy numbers of classes with mixed smoothness are closely related to (in some cases equivalent to) the Small Ball Problem from probability theory. The useful background material included in the book makes it accessible to graduate students. Researchers will find that the many open problems in the theory outlined in the book provide helpful directions and guidance for their own research in this exciting and active area.

Greedy Approximation

This brief monograph is the first one to deal exclusively with the quantitative approximation by artificial neural networks to the identity-unit operator. Here we study with rates the approximation properties of the "right" sigmoidal and hyperbolic tangent artificial neural network positive linear operators. In particular we study the degree of approximation of these operators to the unit operator in the univariate and multivariate cases over bounded or unbounded domains. This is given via inequalities and with the use of modulus of continuity of the involved function or its higher order derivative. We examine the real and complex cases. For the convenience of the reader, the chapters of this book are written in a self-contained style. This treatise relies on author's last two years of related research work. Advanced courses and seminars can be taught out of this brief book. All necessary background and motivations are given per chapter. A related list of references is given also per chapter. The exposed results are expected to find applications in many areas of computer science and applied mathematics, such as neural networks, intelligent systems, complexity theory, learning theory, vision and approximation theory, etc. As such this monograph is suitable for researchers, graduate students, and seminars of the above subjects, also for all science

libraries.

Algorithmic Learning Theory

Introduction: The Problem of Induction and Statistical Inference. Two Approaches to the Learning Problem. Appendix to Chapter1: Methods for Solving III-Posed Problems. Estimation of the Probability Measure and Problem of Learning. Conditions for Consistency of Empirical Risk Minimization Principle. Bounds on the Risk for Indicator Loss Functions. Appendix to Chapter 4: Lower Bounds on the Risk of the ERM Principle. Bounds on the Risk for Real-Valued Loss Functions. The Structural Risk Minimization Principle. Appendix to Chapter 6: Estimating Functions on the Basis of Indirect Measurements. Stochastic III-Posed Problems. Estimating the Values of Function at Given Points. Perceptrons and Their Generalizations. The Support Vector Method for Estimating Indicator Functions. The Support Vector Method for Estimating Real-Valued Functions. SV Machines for Pattern Recognition. SV Machines for Function Approximations, Regression Estimation, and Signal Processing. Necessary and Sufficient Conditions for Uniform Convergence of Frequencies to Their Probabilities. Necessary and Sufficient Conditions for Uniform Convergence of Means to Their Expectations. Necessary and Sufficient Conditions for Uniform One-Sided Convergence of Means to Their Expectations.

Mathematical Foundations of Infinite-Dimensional Statistical Models

A Course in Approximation Theory

This first book on greedy approximation gives a systematic presentation of the fundamental results. It also contains an introduction to two hot topics in numerical mathematics: learning theory and compressed sensing. Nonlinear approximation is becoming increasingly important, especially since two types are frequently employed in applications: adaptive methods are used in PDE solvers, while m-term approximation is used in image/signal/data processing, as well as in the design of neural networks. The fundamental question of nonlinear approximation is how to devise good constructive methods (algorithms) and recent results have established that greedy type algorithms may be the solution. The author has drawn on his own teaching experience to write a book ideally suited to graduate courses. The reader does not require a broad background to understand the material. Important open problems are included to give students and professionals alike ideas for further research.

Intelligent Systems: Approximation by Artificial Neural Networks

Interpolation and Approximation

Approximation Theory and Approximation Practice, Extended

Edition

The fundamental mathematical tools needed to understand machine learning include linear algebra, analytic geometry, matrix decompositions, vector calculus, optimization, probability and statistics. These topics are traditionally taught in disparate courses, making it hard for data science or computer science students, or professionals, to efficiently learn the mathematics. This self-contained textbook bridges the gap between mathematical and machine learning texts, introducing the mathematical concepts with a minimum of prerequisites. It uses these concepts to derive four central machine learning methods: linear regression, principal component analysis, Gaussian mixture models and support vector machines. For students and others with a mathematical background, these derivations provide a starting point to machine learning texts. For those learning the mathematics for the first time, the methods help build intuition and practical experience with applying mathematical concepts. Every chapter includes worked examples and exercises to test understanding. Programming tutorials are offered on the book's web site.

Algorithmic Learning Theory

The goal of learning theory is to approximate a function from sample values. To attain this goal learning theory draws on a variety of diverse subjects, specifically statistics, approximation theory, and algorithmics. Ideas from all these areas blended to form a subject whose many successful applications have triggered a rapid growth during the last two decades. This is the first book to give a general overview of the theoretical foundations of the subject emphasizing the approximation theory, while still giving a balanced overview. It is based on courses taught by the authors, and is reasonably self-contained so will appeal to a broad spectrum of researchers in learning theory and adjacent fields. It will also serve as an introduction for graduate students and others entering the field, who wish to see how the problems raised in learning theory relate to other disciplines.

Stochastic Approximation

Intermediate-level survey covers remainder theory, convergence theorems, and uniform and best approximation. Other topics include least square approximation, Hilbert space, orthogonal polynomials, theory of closure and completeness, and more. 1963 edition.

Computational Learning Theory

This book is the first of a series which focuses on the interpolation and extrapolation of optimal designs, an area with significant applications in engineering, physics, chemistry and most experimental fields. In this volume, the authors emphasize the importance of problems associated with the construction of design. After a brief introduction on how the theory of optimal designs meets the theory of the uniform approximation of functions, the authors introduce the basic elements to design planning and link the statistical theory of optimal design and the theory of the uniform approximation of functions. The appendices provide the

reader with material to accompany the proofs discussed throughout the book.

The History of Approximation Theory

This book constitutes the refereed proceedings of the 18th Annual Conference on Learning Theory, COLT 2005, held in Bertinoro, Italy in June 2005. The 45 revised full papers together with three articles on open problems presented were carefully reviewed and selected from a total of 120 submissions. The papers are organized in topical sections on: learning to rank, boosting, unlabeled data, multiclass classification, online learning, support vector machines, kernels and embeddings, inductive inference, unsupervised learning, generalization bounds, query learning, attribute efficiency, compression schemes, economics and game theory, separation results for learning models, and survey and prospects on open problems.

Learning Theory

Sure to be influential, this book lays the foundations for the use of algebraic geometry in statistical learning theory. Many widely used statistical models and learning machines applied to information science have a parameter space that is singular: mixture models, neural networks, HMMs, Bayesian networks, and stochastic context-free grammars are major examples. Algebraic geometry and singularity theory provide the necessary tools for studying such non-smooth models. Four main formulas are established: 1. the log likelihood function can be given a common standard form using resolution of singularities, even applied to more complex models; 2. the asymptotic behaviour of the marginal likelihood or 'the evidence' is derived based on zeta function theory; 3. new methods are derived to estimate the generalization errors in Bayes and Gibbs estimations from training errors; 4. the generalization errors of maximum likelihood and a posteriori methods are clarified by empirical process theory on algebraic varieties.

Approximation Theory and Methods

This book constitutes the refereed proceedings of the 11th International Conference on Algorithmic Learning Theory, ALT 2000, held in Sydney, Australia in December 2000. The 22 revised full papers presented together with three invited papers were carefully reviewed and selected from 39 submissions. The papers are organized in topical sections on statistical learning, inductive logic programming, inductive inference, complexity, neural networks and other paradigms, support vector machines.

Function Spaces, Approximation Theory, and Nonlinear Analysis

* Exciting exposition integrates history, philosophy, and mathematics * Combines a mathematical analysis of approximation theory with an engaging discussion of the differing philosophical underpinnings behind its development * Appendices containing biographical data on numerous eminent mathematicians, explanations of Russian nomenclature and academic degrees, and an excellent index round out

the presentation

Mathematics for Machine Learning

This survey of the most important properties of Chebyshev polynomials encompasses several areas of mathematical analysis: - Interpolation theory - Orthogonal polynomials - Approximation theory - Numerical integration - Numerical analysis - Ergodic theory Starting with some definitions and descriptions of elementary properties, the treatment advances to examinations of extremal properties, the expansion of functions in a series of Chebyshev polynomials, and iterative properties. The final chapter explores selected algebraic and number theoretic properties of the Chebyshev polynomials. For advanced undergraduates and graduate students in mathematics Originally published in 1974, the text was updated in 1990; this reprint of the second edition corrects various errors and features new material.

Deterministic Learning Theory for Identification, Recognition, and Control

Padé and Rational Approximation: Theory and Applications presents the proceedings of the Conference on Rational Approximation with Emphasis on Applications of Padé Approximants, held in Tampa, Florida on December 15-17, 1976. The contributors focus on the interplay of theory, computation, and physical applications. This book is composed of six parts encompassing 44 chapters. The introductory part discusses the general theory of orthogonal polynomials that is the mathematical basis of Padé approximants and related matters evaluation. This text also examines the connection between approximants on a stepline in the ordinary Padé table and certain continued fractions and the convergence of diagonal Padé approximants to a class of functions with an even number of branch points. The following parts deal with the special functions and continued fractions of Padé approximation and the theory of rational approximations. These parts also investigate the geometric convergence of Chebyshev rational approximation on the half line, the optimal approximation by “Almost Classical interpolation, and the incomplete polynomials approximation. The discussion then shifts to the physical applications and computations of the Padé approximants. The concluding part presents the applications of rational approximation to gun fire control and to the White Sands Missile Range Computer Facility. This part also provides a list of some open problems and conjectures concerning polynomials and rational functions. This book is of great benefit to mathematicians, physicists, and laboratory workers.

Linear Operators and Approximation Theory

Multivariate Approximation

Many physical, chemical, biomedical, and technical processes can be described by partial differential equations or dynamical systems. In spite of increasing computational capacities, many problems are of such high complexity that they are solvable only with severe simplifications, and the design of efficient numerical

schemes remains a central research challenge. This book presents a tutorial introduction to recent developments in mathematical methods for model reduction and approximation of complex systems. Model Reduction and Approximation: Theory and Algorithms contains three parts that cover (I) sampling-based methods, such as the reduced basis method and proper orthogonal decomposition, (II) approximation of high-dimensional problems by low-rank tensor techniques, and (III) system-theoretic methods, such as balanced truncation, interpolatory methods, and the Loewner framework. It is tutorial in nature, giving an accessible introduction to state-of-the-art model reduction and approximation methods. It also covers a wide range of methods drawn from typically distinct communities (sampling based, tensor based, system-theoretic).?? This book is intended for researchers interested in model reduction and approximation, particularly graduate students and young researchers.

Algebraic Geometry and Statistical Learning Theory

The field of approximation theory has become so vast that it intersects with every other branch of analysis and plays an increasingly important role in applications in the applied sciences and engineering. Fundamentals of Approximation Theory presents a systematic, in-depth treatment of some basic topics in approximation theory designed to emphasize the rich connections of the subject with other areas of study. With an approach that moves smoothly from the very concrete to more and more abstract levels, this text provides an outstanding blend of classical and abstract topics. The first five chapters present the core of information that readers need to begin research in this domain. The final three chapters the authors devote to special topics-splined functions, orthogonal polynomials, and best approximation in normed linear spaces- that illustrate how the core material applies in other contexts and expose readers to the use of complex analytic methods in approximation theory. Each chapter contains problems of varying difficulty, including some drawn from contemporary research. Perfect for an introductory graduate-level class, Fundamentals of Approximation Theory also contains enough advanced material to serve more specialized courses at the doctoral level and to interest scientists and engineers.

Fundamentals of Approximation Theory

A highly accessible and unified approach to the design and analysisof intelligent control systems Adaptive Approximation Based Control is a tool every controldesigner should have in his or her control toolbox. Mixing approximation theory, parameter estimation, and feedbackcontrol, this book presents a unified approach designed to enablereaders to apply adaptive approximation based control to existingsystems, and, more importantly, to gain enough intuition andunderstanding to manipulate and combine it with other control toolsfor applications that have not been encountered before. The authors provide readers with a thought-provoking framework forrigorously considering such questions as: * What properties should the function approximator have? * Are certain families of approximators superior to others? * Can the stability and the convergence of the approximatorparameters be guaranteed? * Can control systems be designed to be robust in the face ofnoise, disturbances, and unmodeled effects? * Can this approach handle significant changes in the dynamics dueto such disruptions as

system failure? * What types of nonlinear dynamic systems are amenable to thisapproach? * What are the limitations of adaptive approximation basedcontrol? Combining theoretical formulation and design techniques withextensive use of simulation examples, this book is a stimulatingtext for researchers and graduate students and a valuable resourcefor practicing engineers.

Adaptive Approximation Based Control

The recent re-emergence of network-based approaches to artificial intelligence has been accomplished by a virtual explosion of research. This research spans a range of disciplines - cognitive science, computer science, biology, neuroscience, electrical engineering, psychology, econometrics, philosophy, etc. - which is, perhaps, wider than any other contemporary endeavor. Of all the contributing disciplines the relatively universal language of mathematics provides some of the most powerful tools for answering fundamental questions about the capabilities and limitations of these 'artificial neural networks'. In this collection, Halbert White and his colleagues present a rigorous mathematical analysis of the approximation and learning capabilities of the leading class of single hidden layer feedforward networks. Drawing together work previously scattered in space and time, the book gives a unified view of network learning not available in any other single location, and forges fundamental links between network learning and modern mathematical statistics.

Approximation Theory

This textbook offers an accessible introduction to the theory and numerics of approximation methods, combining classical topics of approximation with recent advances in mathematical signal processing, and adopting a constructive approach, in which the development of numerical algorithms for data analysis plays an important role. The following topics are covered: * least-squares approximation and regularization methods * interpolation by algebraic and trigonometric polynomials * basic results on best approximations * Euclidean approximation * Chebyshev approximation * asymptotic concepts: error estimates and convergence rates * signal approximation by Fourier and wavelet methods * kernel-based multivariate approximation * approximation methods in computerized tomography Providing numerous supporting examples, graphical illustrations, and carefully selected exercises, this textbook is suitable for introductory courses, seminars, and distance learning programs on approximation for undergraduate students.