

NUMERICAL METHODS

C / KAPPA EXAM 12 / 11/14 / 1002 / 20, 20M

LEAST SQUARES REGRESSION

Goal: minimize the sum of the square of the residual (error)

Residual = $y_i - \hat{y}_i$

$S_y = \sum_{i=1}^n y_i$, $S_x = \sum_{i=1}^n x_i$, $S_{xy} = \sum_{i=1}^n x_i y_i$

$a_0 = \frac{S_y}{n}$, $a_1 = \frac{S_{xy} - \frac{S_x S_y}{n}}{S_x - \frac{S_x^2}{n}}$

$a_0 = \frac{\sum y_i}{n}$, $a_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$

POLYNOMIAL QUADRATIC REGRESSION

Goal: minimize the sum of the square of the residual (error)

$S_y = \sum_{i=1}^n (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$

$\frac{\partial S_y}{\partial a_0} = -2(\sum y_i - \sum a_0 - \sum a_1 x_i - \sum a_2 x_i^2) = 0$

$\frac{\partial S_y}{\partial a_1} = -2(\sum x_i y_i - \sum a_0 x_i - \sum a_1 x_i^2 - \sum a_2 x_i^3) = 0$

$\frac{\partial S_y}{\partial a_2} = -2(\sum x_i^2 y_i - \sum a_0 x_i^2 - \sum a_1 x_i^3 - \sum a_2 x_i^4) = 0$

$\begin{bmatrix} \sum 1 & \sum x_i & \sum x_i^2 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum x_i y_i \\ \sum x_i^2 y_i \end{bmatrix}$

$C(A) = \begin{bmatrix} \sum 1 & \sum x_i & \sum x_i^2 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix}$

$S_y = \sum_{i=1}^n (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$

STANDARD ERROR

$$S_y = \sqrt{\frac{\sum y_i^2}{n-2}}, S_x = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-2}}$$

STANDARD DEVIATION

$$S_y = \sqrt{\frac{\sum y_i^2}{n-1}}, S_x = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

$$a_0 = \bar{y} - a_1 \bar{x}$$

$$y = a_0 + a_1 x$$

INTERPOLATION

Use a polynomial fit

Linear: $y = a_0 + a_1 x$

Quadratic: $y = a_0 + a_1 x + a_2 x^2$

Cubic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

Quartic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$

Quintic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 + a_5 x^5$

Splines: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 + a_5 x^5$

Order: $n = 1, 2, 3, 4, 5$

Turns: $n = 1, 2, 3, 4, 5$

Nodes: $n = 1, 2, 3, 4, 5$

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DEGREE 1

Linear: $y = a_0 + a_1 x$

Quadratic: $y = a_0 + a_1 x + a_2 x^2$

Cubic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

Quartic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$

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DEGREE 2

Linear: $y = a_0 + a_1 x$

Quadratic: $y = a_0 + a_1 x + a_2 x^2$

Cubic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

Quartic: $y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$

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DEGREE 3

Linear: $y = a_0 + a_1 x$

Quadratic: $y = a_0 + a_1 x + a_2 x^2$

Numerical Methods And Analysis

Eugene Isaacson, Herbert Bishop Keller

Numerical Methods And Analysis:

Analysis of Numerical Methods Eugene Isaacson, Herbert Bishop Keller, 2012-04-26 This excellent text for advanced undergraduate and graduate students covers norms numerical solutions of linear systems and matrix factoring eigenvalues and eigenvectors polynomial approximation and more Many examples and problems 1966 edition **An Introduction to Numerical Methods and Analysis** James F. Epperson, 2021-07-21 The new edition of the popular introductory textbook on numerical approximation methods and mathematical analysis with a unique emphasis on real world application An Introduction to Numerical Methods and Analysis helps students gain a solid understanding of a wide range of numerical approximation methods for solving problems of mathematical analysis Designed for entry level courses on the subject this popular textbook maximizes teaching flexibility by first covering basic topics before gradually moving to more advanced material in each chapter and section Throughout the text students are provided clear and accessible guidance on a wide range of numerical methods and analysis techniques including root finding numerical integration interpolation solution of systems of equations and many others This fully revised third edition contains new sections on higher order difference methods the bisection and inertia method for computing eigenvalues of a symmetric matrix a completely re written section on different methods for Poisson equations and spectral methods for higher dimensional problems New problem sets ranging in difficulty from simple computations to challenging derivations and proofs are complemented by computer programming exercises illustrative examples and sample code This acclaimed textbook Explains how to both construct and evaluate approximations for accuracy and performance Covers both elementary concepts and tools and higher level methods and solutions Features new and updated material reflecting new trends and applications in the field Contains an introduction to key concepts a calculus review an updated primer on computer arithmetic a brief history of scientific computing a survey of computer languages and software and a revised literature review Includes an appendix of proofs of selected theorems and a companion website with additional exercises application models and supplemental resources An Introduction to Numerical Methods and Analysis Third Edition is the perfect textbook for upper level undergraduate students in mathematics science and engineering courses as well as for courses in the social sciences medicine and business with numerical methods and analysis components Numerical Methods and Analysis James L. Buchanan, Peter R. Turner, 1992 Intended for a first course in numerical methods or numerical analysis taken by junior and senior level students this book assumes a knowledge of calculus linear algebra and differential equations It covers numerical approximation interpolation graphics and parallel computing The interplay between hardware and software considerations in numerical algorithm design recurs throughout A portion of the programs in the book are written in Turbo Pascal the remainder are pseudocode or generalized algorithms Programs used in the text will be available on a disk for instructors to use and copy Numerical Methods in Software and Analysis John R. Rice, 2014-05-19 Numerical Methods Software and Analysis Second Edition introduces science and

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Theory and Applications of Numerical Analysis G. M. Phillips, Peter J. Taylor, 1996-07-05 Theory and Applications of Numerical Analysis is a self contained Second Edition providing an introductory account of the main topics in numerical analysis The book emphasizes both the theorems which show the underlying rigorous mathematics and the algorithms which define precisely how to program the numerical methods Both theoretical and practical examples are included a unique blend of theory and applications two brand new chapters on eigenvalues and splines inclusion of formal algorithms numerous fully worked examples a large number of problems many with solutions

Numerical Methods and Analysis of Multiscale Problems Alexandre L. Madureira, 2017-02-15 This book is about numerical modeling of multiscale problems and introduces several asymptotic analysis and numerical techniques which are necessary for a proper approximation of equations that depend on different physical scales Aimed at advanced undergraduate and graduate students in mathematics engineering and physics or researchers seeking a no nonsense approach it discusses examples in their simplest possible settings removing mathematical hurdles that might hinder a clear understanding of the methods The problems considered are given by singular perturbed reaction advection diffusion equations in one and two dimensional domains partial differential equations in domains with rough boundaries and equations with oscillatory coefficients This work shows how asymptotic analysis can be used to develop and analyze models and numerical methods that are robust and work well for a wide range of parameters

Introduction to Numerical Analysis Devi Prasad, 2003 An Introduction to Numerical Analysis is designed for a first course on numerical analysis for students of Science and Engineering including Computer Science The book contains derivation of algorithms for solving engineering and science problems and also deals with error analysis It has numerical examples suitable for solving through computers The special features are comparative efficiency and accuracy of various algorithms due to finite digit arithmetic used by the computers

Numerical Analysis M. Schatzman, 2002 Numerical

analysis explains why numerical computations work or fail This book is divided into four parts Part I starts with a guided tour of floating number systems and machine arithmetic The exponential and the logarithm are constructed from scratch to present a new point of view on questions well known to the reader and the needed knowledge of linear algebra is summarized Part II starts with polynomial approximation polynomial interpolation mean square approximation splines It then deals with Fourier series providing the trigonometric version of least square approximations and one of the most important numerical algorithms the fast Fourier transform Any scientific computation program spends most of its time solving linear systems or approximating the solution of linear systems even when trying to solve non linear systems Part III is therefore about numerical linear algebra while Part IV treats a selection of non linear or complex problems resolution of linear equations and systems ordinary differential equations single step and multi step schemes and an introduction to partial differential equations The book has been written having in mind the advanced undergraduate students in mathematics who are interested in the spice and spirit of numerical analysis The book does not assume previous knowledge of numerical methods It will also be useful to scientists and engineers wishing to learn what mathematics has to say about the reason why their numerical methods work or fail

Numerical Methods for Ordinary Differential Equations J. C. Butcher, 2008-04-15 In recent years the study of numerical methods for solving ordinary differential equations has seen many new developments This second edition of the author's pioneering text is fully revised and updated to acknowledge many of these developments It includes a complete treatment of linear multistep methods whilst maintaining its unique and comprehensive emphasis on Runge Kutta methods and general linear methods Although the specialist topics are taken to an advanced level the entry point to the volume as a whole is not especially demanding Early chapters provide a wide ranging introduction to differential equations and difference equations together with a survey of numerical differential equation methods based on the fundamental Euler method with more sophisticated methods presented as generalizations of Euler Features of the book include Introductory work on differential and difference equations A comprehensive introduction to the theory and practice of solving ordinary differential equations numerically A detailed analysis of Runge Kutta methods and of linear multistep methods A complete study of general linear methods from both theoretical and practical points of view The latest results on practical general linear methods and their implementation A balance between informal discussion and rigorous mathematical style Examples and exercises integrated into each chapter enhancing the suitability of the book as a course text or a self study treatise Written in a lucid style by one of the worlds leading authorities on numerical methods for ordinary differential equations and drawing upon his vast experience this new edition provides an accessible and self contained introduction ideal for researchers and students following courses on numerical methods engineering and other sciences

Numerical Analysis or Numerical Method in Symmetry Clemente Cesarano, 2020-02-21 This Special Issue focuses mainly on techniques and the relative formalism typical of numerical methods and therefore of numerical analysis more generally These

fields of study of mathematics represent an important field of investigation both in the field of applied mathematics and even more exquisitely in the pure research of the theory of approximation and the study of polynomial relations as well as in the analysis of the solutions of the differential equations both ordinary and partial derivatives Therefore a substantial part of research on the topic of numerical analysis cannot exclude the fundamental role played by approximation theory and some of the tools used to develop this research In this Special Issue we want to draw attention to the mathematical methods used in numerical analysis such as special functions orthogonal polynomials and their theoretical tools such as Lie algebra to study the concepts and properties of some special and advanced methods which are useful in the description of solutions of linear and nonlinear differential equations A further field of investigation is dedicated to the theory and related properties of fractional calculus with its adequate application to numerical methods

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