NUMERICAL METHODS

LEAST SQUARES REGRESSION:

GOAL: MINIMIZE THE SUM OF THE SQUARE OF THE RESIDUAL ERRORS

$$S_r = \sum e_i^2 = \sum (y_i - a_0 - a_1 x_i)^2$$

$$a_1 = \frac{n\sum (x_i y_i) - \sum x_i \sum y_i}{n\sum (x_i^2) - (\sum x_i)^2}$$

$$a_0 = \frac{\sum y_i}{n}, \quad a_1 \qquad \frac{\sum x_i}{n} \Rightarrow a_0 = \bar{y} - a_1 \bar{x}$$

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

$$y = a_0 + a_1 x$$

POLYNOMIAL (QUADRATIC) REGRESSION:

$$S_r = \sum (y_i - a_0 - a_1 x_i - a_2 x_i^2)^2$$

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

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

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

$$[A][x] = [B]$$

$$S_{y/x} = \sqrt{\frac{S_r}{n-(m+1)}}$$

COEFFICIENT OF DETERMINATION:
$$r^2 = \frac{S_t - S_r}{S_t}$$

STANDARD ERROR:

$$S_y = \sqrt{\frac{S_t}{n-1}} \qquad S_{y/x} = \sqrt{\frac{\sum (y_i - y_i^{fit})^2}{n-2}}$$

STANDARD DEVIATION:

$$S_y = \sqrt{\frac{S_t}{n-1}} \qquad S_y = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}}$$

INTERPOLATION

USE A POLYNOMIAL FIT:

1. LINEAR	DEGREE 2	DEGREE 3	DEGREE n
2 PTS	3 PTS	4 PTS	n+1 PTS

$$f_n(x) = a_0 + a_1 x + a_2 x^2 + \cdots + a_n x^n$$

ORDER	TURNS
n=1	0
n=2	1
n=3	2
n=n	n-1

SPLINES:
$$m_i = \frac{f(x_{i+1}) - f(x_i)}{x_{i+1} - x_i}$$

ODE'S

EULER'S METHOD:
$$\frac{dy}{dx} = f(x,y) \qquad y_{i+1} = y_i + f(x_i, y_i)h$$

HEUN'S METHOD:
$$\frac{dy}{dx} = f(x,y)$$
$$x_{i+1} - y_i = f(x_i, y_i) \Delta x$$
$$\frac{dy}{dx} = y_i' = f(x_i, y_i)$$
$$y' = \frac{y_i' + y_{i+1}'}{2} = \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^*)}{2}$$
$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^*)}{2}\Delta x$$

- TAYLOR SERIES
$$y(x+\Delta x) = y(x) + \frac{dy}{dx}(x_0)\Delta x$$
$$y(x+\Delta x) = y(x) + f(x,y)\Delta x$$

CLASSIC 4TH ORDER RUNGE-KUTTA:
$$y_{i+1} = y_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)\Delta x$$
$$k_1 = f(x_i, y_i)$$
$$k_2 = f(x_i + \tfrac{1}{2}\Delta x, \; y_i + \tfrac{1}{2}k_1 \Delta x)$$
$$k_3 = f(x_i + \tfrac{1}{2}\Delta x, \; y_i + \tfrac{1}{2}k_2 \Delta x)$$
$$k_4 = f(x_i + \Delta x, \; y_i + k_3 \Delta x)$$

DORMAND-PRINCE RUNGE-KUTTA:
$$y_{i+1} = y_i + \Delta x \sum_{i} a_i k_i$$
$$y_{i+1} = y_i + \Delta x \sum_{i} a_i k_i$$

EIGEN VALUES

λ = EIGEN VALUE

SIMPLE 2x2:
$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \quad [A]^{-1} = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$
$$[x] = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}[B]$$
$$\begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$\lambda = \frac{(a+d) \pm \sqrt{(a+d)^2 - 4(ad-bc)}}{2}$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} a_{11}-\lambda & a_{12} & a_{13} \\ a_{21} & a_{22}-\lambda & a_{23} \\ a_{31} & a_{32} & a_{33}-\lambda \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$x_1 + 1x_2 = 0 \qquad x_1 = -x_2$$
$$1x_1 + 1x_2 = 0 \qquad x_1 = -x_2$$
- EIGENVECTOR
$$X_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$-1x_2 + 1x_2 = 0 \qquad x_1 = x_2$$
$$1x_1 + -1x_2 = 0 \qquad x_1 = x_2$$
- 2ND EIGENVECTOR
$$[X_2] = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

PDE'S

FINITE DIFFERENCE METHOD:

- ONE DIMENSIONAL
- DIVIDED EVENLY THROUGHOUT
- CONSTANT HEAT

TEMPERATURE:

- CENTRAL DIFFERENCE
$$u_{xx}(x,y) = \frac{u(x-\Delta x, y) - 2u(x,y) + u(x+\Delta x, y)}{\Delta x^2}$$
$$u_{yy}(x,y) = \frac{u(x, y-\Delta y) - 2u(x,y) + u(x, y+\Delta y)}{\Delta y^2}$$

BC:
- TEMP GRADIENT @ BOUNDARY

GOVERNING HEAT EQN:
$$u_t = k(u_{xx} + u_{yy}) + q$$
$$u_t = q = 0, \; k = 1$$
$$u_{xx} + u_{yy} = 0$$

NEUMANN:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

CENTRAL DIFFERENCE:
$$\frac{\partial u}{\partial x} = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$
$$\frac{\partial u}{\partial y} = q_y = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$

BC:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

5TH ROW OF A MATRIX:
ADJACENT, POINT NOT ADJACENT TO BOUNDARY
$$\begin{bmatrix} 0 & -1 & 0 & -1 & 4 & -1 & 0 & -1 & 0 \end{bmatrix}[u] = 0$$

RIGHT NEUMANN B.C.:
$$\frac{\partial u}{\partial x} = q_x = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$
$$u_{i+1,j} = u_{i-1,j} + 2\Delta x q_x$$

BOTTOM NEUMANN B.C.:
$$\frac{\partial u}{\partial y} = q_y = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$
$$u_{i,j-1} = u_{i,j+1} - 2\Delta y q_y$$

TOP NEUMANN BC:
$$\frac{\partial u}{\partial y} = q_y = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$
$$u_{i,j+1} = u_{i,j-1} + 2\Delta y q_y$$

LEFT NEUMANN B.C.:
$$u_{i-1,j} = u_{i+1,j} - 2\Delta x q_x$$

[A] MATRIX:

LEFT:
$$u_{i-1,j} + 4u_{i,j} - u_{i,j} - u_{i,j+1} = 2\Delta x q_x$$

THIS CHANGED
$$-2u_{i+1,j} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x q_x$$

BOTTOM:
$$-2u_{i,j-1} + 4u_{i,j} - u_{i-1,j} - u_{i+1,j} = -2\Delta x q_y$$

THIS CHANGED
$$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} - 2u_{i,j+1} = -2\Delta x q_y$$

TOP:
$$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} - 2u_{i,j-1} = -2\Delta x q_y$$

THIS CHANGED

MISC EQN'S:

CENTERED FINITE DIVIDED DIFFERENCE:
FIRST:
$$f'(x_i) = \frac{f(x_{i+1}) - f(x_{i-1})}{2h}$$
$$f'(x_i) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h}$$

Numerical Methods And Analysis

James F. Epperson

Numerical Methods And Analysis:

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 **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, Solutions Manual James F. Epperson,2014-08-28 A solutions manual to accompany An Introduction to Numerical Methods and Analysis Second Edition An Introduction to Numerical Methods and Analysis Second Edition reflects the latest trends in the field includes new material and revised exercises and offers a unique emphasis on applications The author clearly explains how to both construct and evaluate approximations for accuracy and performance which are key skills in a variety of fields A wide range of higher level methods and solutions including new topics such as the roots of polynomials spectral collocation finite element ideas and Clenshaw Curtis quadrature are presented from an introductory perspective and the Second Edition also features Chapters and sections that

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An Introduction to Numerical Analysis, 2nd Ed Kendall E. Atkinson,2008-09 Market_Desc Mathematics Students Instructors About The Book This Second Edition of a standard numerical analysis text retains organization of the original edition but all sections have been revised some extensively and bibliographies have been updated New topics covered include optimization trigonometric interpolation and the fast Fourier transform numerical differentiation the method of lines boundary value problems the conjugate gradient method and the least squares solutions of systems of linear equations

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construct and evaluate approximations for accuracy and performance which are key skills in a variety of fields A wide range of higher level methods and solutions including new topics such as the roots of polynomials spectral collocation finite element ideas and Clenshaw Curtis quadrature are presented from an introductory perspective and theSecond Edition also features Chapters and sections that begin with basic elementary material followed by gradual coverage of more advanced material Exercises ranging from simple hand computations to challenging derivations and minor proofs to programming exercises Widespread exposure and utilization of MATLAB An appendix that contains proofs of various theorems and other material

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 andthe 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 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   Applied Numerical Analysis Curtis F. Gerald,Patrick O. Wheatley,1984   **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   **Numerical Analysis or Numerical Method in Symmetry** Clemente Cesarano,2020 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   *Introduction to Precise Numerical Methods* Oliver Aberth,2007-04-11 Precise numerical analysis may be defined as the study of computer methods for solving mathematical problems either exactly or to prescribed accuracy This book explains how precise numerical analysis is constructed The book

also provides exercises which illustrate points from the text and references for the methods presented Clearer simpler descriptions and explanations of the various numerical methods Two new types of numerical problems accurately solving partial differential equations with the included software and computing line integrals in the complex plane **Numerical Methods in Finite Element Analysis** Klaus-Jürgen Bathe,Edward L. Wilson,1976 An Introduction to Numerical Methods and Analysis Set James F. Epperson,2013-10-09 This set includes An Introduction to Numerical Methods and Analysis 2nd Edition Roots of Polynomials I Radial Basis Function Interpolation Tension Splines An Introduction to Galerkin Finite Element Ideas for BVPs Broyden s Method Roots of Polynomials II Spectral collocation methods for PDEs Algebraic Multigrid Method Trigonometric interpolation Fourier analysis and Monte Carlo methods **INTRODUCTORY METHODS OF NUMERICAL ANALYSIS, FIFTH EDITION** SASTRY, S. S.,2012-06-12 This thoroughly revised and updated text now in its fifth edition continues to provide a rigorous introduction to the fundamentals of numerical methods required in scientific and technological applications emphasizing on teaching students numerical methods and in helping them to develop problem solving skills While the essential features of the previous editions such as References to MATLAB IMSL Numerical Recipes program libraries for implementing the numerical methods are retained a chapter on Spline Functions has been added in this edition because of their increasing importance in applications This text is designed for undergraduate students of all branches of engineering NEW TO THIS EDITION Includes additional modified illustrative examples and problems in every chapter Provides answers to all chapter end exercises Illustrates algorithms computational steps or flow charts for many numerical methods Contains four model question papers at the end of the text **Numerical Analysis** Brian Sutton,2019-04-18 This textbook develops the fundamental skills of numerical analysis designing numerical methods implementing them in computer code and analyzing their accuracy and efficiency A number of mathematical problems interpolation integration linear systems zero finding and differential equations are considered and some of the most important methods for their solution are demonstrated and analyzed Notable features of this book include the development of Chebyshev methods alongside more classical ones a dual emphasis on theory and experimentation the use of linear algebra to solve problems from analysis which enables students to gain a greater appreciation for both subjects and many examples and exercises Numerical Analysis Theory and Experiments is designed to be the primary text for a junior or senior level undergraduate course in numerical analysis for mathematics majors Scientists and engineers interested in numerical methods particularly those seeking an accessible introduction to Chebyshev methods will also be interested in this book

Numerical Analysis with Applications in Mechanics and Engineering Petre Teodorescu,Nicolae-Doru Stanescu,Nicolae Pandrea,2013-06-04 NUMERICAL ANALYSIS WITH APPLICATIONS IN MECHANICS AND ENGINEERING A much needed guide on how to use numerical methods to solve practical engineering problems Bridging the gap between mathematics and engineering Numerical Analysis with Applications in Mechanics and Engineering arms readers with powerful tools for solving

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This book delves into Numerical Methods And Analysis. Numerical Methods And Analysis is an essential topic that needs to be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Numerical Methods And Analysis, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:

    - Chapter 1: Introduction to Numerical Methods And Analysis
    - Chapter 2: Essential Elements of Numerical Methods And Analysis
    - Chapter 3: Numerical Methods And Analysis in Everyday Life
    - Chapter 4: Numerical Methods And Analysis in Specific Contexts
    - Chapter 5: Conclusion

2. In chapter 1, the author will provide an overview of Numerical Methods And Analysis. The first chapter will explore what Numerical Methods And Analysis is, why Numerical Methods And Analysis is vital, and how to effectively learn about Numerical Methods And Analysis.
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