NUMERICAL METHODS

LEAST SQUARES REGRESSION:

$$S_r = \sum e_i^2 = \sum (z_i - a_o - a_1 x_i)^2$$

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

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

STANDARD ERROR:

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

STAND. DEVIATION:

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

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

$$y = a_o + a_1 x$$

POLYNOMIAL (QUADRATIC) REGRESSION:

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

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

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

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

$$\sum_{i} a_i = a_o n$$

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

$$x = A \backslash B$$

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

COEFFICIENT OF DETERMINATION:

$$r^2 = \frac{S_t - S_r}{S_t}$$

INTERPOLATION

USE A POLYNOMIAL FIT:

DEGREE 1	DEGREE 2	DEGREE 3	DEGREE n
2 PTS	3 POINTS	4 PTS	n+1 PTS

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

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:

$$\frac{dy}{dx} = f(x,y)$$

$$x_{i+1} = y_i + f(x_i, y_i) \Delta x$$

$$\frac{dy}{dx} = y_i = f(x_i, y_i)$$

$$\frac{dy}{dx} = y_i = f(x_i, y_i)$$

$$y_i = \frac{y_i + y_{i+1}}{2}, \quad \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^o)}{2}$$

$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^o)}{2} \Delta x$$

TAYLOR SERIES:

$$y(x + \Delta x) = y(x) + \frac{dy}{dx}(x_o) \Delta x$$

$$y(x + \Delta x) = y(x) + f(x, y) \Delta x$$

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:

$$y_{i+1} = y_i + \Delta x \sum_{i=1}^{7} a_i k_i$$

$$y_{i+1} = y_i + \Delta x \sum_{i=1}^{7} a_i k_i$$

EIGEN VALUES

$$\lambda = \text{EIGEN VALUE}$$

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

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

SIMPLE 2x2:

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$[x] = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}[B]$$

$$\begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$\lambda = \frac{(a+d) \pm \sqrt{(a+d)^2 - 4(ad - bc)}}{2}$$

EIGENVECTORS:

$$X_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$1x_1 + 1x_2 = 0 \quad x_1 = -x_2$$

$$1x_1 + 1x_2 = 0 \quad x_2 = -x_1$$

$$X_1 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} -1 & 1 \\ 1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$-1x_1 + 1x_2 = 0 \quad y_1 = x_2$$

$$1x_1 - 1x_2 = 0$$

$$X_2 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

PDE'S

FINITE DIFFERENCE METHOD:

TEMPERATURE

$$L = 6$$
$$T = 0^\circ C$$

BC:
- TEMP KNOWN @ BOUNDARY

COUPLED HEAT EQN:

$$u_t = k(u_{xx} + u_{yy} + u_{zz}) + q$$

$$q = 0, \quad k = 1$$

$$u_{xx} + u_{yy} = 0$$

CENTRAL DIFFERENCE:

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

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

NEUMANN:

BC:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

CENTRAL DIFFERENCE:

$$\frac{\partial u}{\partial x} = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$

$$\frac{\partial u}{\partial y} = a_{ij} = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$

RIGHT NEUMANN B.C.:

$$\frac{\partial u}{\partial x} = a_{ij} = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$

$$u_{i+1,j} = u_{i-1,j} + 2\Delta x\, a_{ij}$$

BOTTOM NEUMANN B.C.:

$$\frac{\partial u}{\partial y} = a_{ij} = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$

$$u_{i,j-1} = u_{i,j+1} - 2\Delta y\, a_{ij}$$

TOP NEUMANN BC:

$$\frac{\partial u}{\partial y} = a_{ij} = \frac{u_{i,j+1} - u_{i,j-1}}{2\Delta y}$$

$$u_{i,j+1} = u_{i,j-1} + 2\Delta y\, a_{ij}$$

LEFT NEUMANN B.C.:

$$u_{i-1,j} = u_{i+1,j} - 2\Delta x\, a_{ij}$$

5TH ROW OF A MATRIX:

$$\begin{bmatrix} 0 & -1 & 0 & -1 & 4 & -1 & 0 & -1 & 0 \end{bmatrix}[u] = 0$$

[A] MATRIX:

LEFT:

$$-2u_{i-1,j} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x\, a_{ij}$$

RIGHT:

$$-2u_{i+1,j} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x\, a_{ij}$$

BOTTOM:

$$-2u_{i,j+1} - u_{i-1,j} + 4u_{i,j} = -2\Delta y\, a_{ij}$$

TOP:

$$-2u_{i,j-1} - u_{i-1,j} + 4u_{i,j} - u_{i+1,j} = -2\Delta y\, a_{ij}$$

MISC EQN'S:

CENTERED FINITE DIVIDED-DIFFERENCE FORMULA:

$$f'(x) = \frac{f(x_{i+1}) - f(x_{i-1})}{2h}$$

$$f'(x) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h}$$

Numerical Methods And Analysis

Petre Teodorescu,Nicolae-Doru Stanescu,Nicolae Pandrea

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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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   An Introduction to Numerical Analysis Kendall Atkinson,1989-01-17 This edition of the standard introductory textbook on numerical analysis has been revised and updated to include optimization trigonometric interpolation and the fast Fourier transform numerical differentiation the method of lines and boundary value problems   *Solutions Manual to accompany An Introduction to Numerical Methods and Analysis* James F. Epperson,2013-10-21 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 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

     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   **Numerical Methods in Economics** Kenneth L. Judd,1998-09-28 To harness the full power of computer technology economists need to use a broad range of mathematical techniques In this book Kenneth Judd presents techniques from the numerical analysis and applied mathematics literatures and shows how to use them in economic analyses The book is divided into five parts Part I provides a general introduction

Part II presents basics from numerical analysis on R n including linear equations iterative methods optimization nonlinear equations approximation methods numerical integration and differentiation and Monte Carlo methods Part III covers methods for dynamic problems including finite difference methods projection methods and numerical dynamic programming Part IV covers perturbation and asymptotic solution methods Finally Part V covers applications to dynamic equilibrium analysis including solution methods for perfect foresight models and rational expectation models A website contains supplementary material including programs and answers to exercises   **Numerical Methods in Finite Element Analysis** Klaus-Jürgen Bathe,Edward L. Wilson,1976   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 real world problems in mechanics physics and civil and mechanical engineering Unlike most books on numerical analysis this outstanding work links theory and application explains the mathematics in simple engineering terms and clearly demonstrates how to use numerical methods to obtain solutions and interpret results Each chapter is devoted to a unique analytical methodology including a detailed theoretical presentation and emphasis on practical computation Ample numerical examples and applications round out the discussion illustrating how to work out specific problems of mechanics physics or engineering Readers will learn the core purpose of each technique develop hands on problem solving skills and get a complete picture of the studied phenomenon Coverage includes How to deal with errors in numerical analysis Approaches for solving problems in linear and nonlinear systems Methods of interpolation and approximation of functions Formulas and calculations for numerical differentiation and integration Integration of ordinary and partial differential equations Optimization methods and solutions for programming problems Numerical Analysis with Applications in Mechanics and Engineering is a one of a kind guide for engineers using mathematical models and methods as well as for physicists and mathematicians interested in engineering problems

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