NUMERICAL METHODS

LEAST SQUARES REGRESSION:

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

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

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

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

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

POLYNOMIAL (QUADRATIC) REGRESSION:

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

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

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

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

$$\sum_{i} a_i = a_0 n$$

$$[A][X] = [B]$$

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

COEFFICIENT OF DETERMINATION

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

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

STAND. DEVIATION:

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

INTERPOLATION

USE A POLYNOMIAL FIT:

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

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

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

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:
$$y_{i+1} = y_i + \Delta x \sum a_i k_i$$
$$y_{i+1} = y_i + \Delta x \sum a_i k_i$$

EIGEN VALUES

λ = EIGEN VALUE

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{ad-bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$[X] = \frac{1}{ad-bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

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

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

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

PDE'S

FINITE DIFFERENCE METHOD:

TEMPERATURE

DIRICHLET:

BC:
- TEMP GIVEN @ BOUNDARY

COUPLED HEAT EQN:
$$u_t = k(u_{xx} + u_{yy} + u_{zz}) + q$$

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 (NORMAL) ON BOUNDARY

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

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

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

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

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

MISC EQN'S:

CENTERED FINITE DIVIDED DIFF FORMULAS:

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

Methods In Numerical Analysis

James P Howard, II

Methods In Numerical Analysis:

An Introduction to Numerical Methods and Analysis James F. Epperson,2007-09-17 Praise for the First Edition outstandingly appealing with regard to its style contents considerations of requirements of practice choice of examples and exercises Zentrablatt Math carefully structured with many detailed worked examples The Mathematical Gazette an up to date and user friendly account Mathematika An Introduction to Numerical Methods and Analysis addresses the mathematics underlying approximation and scientific computing and successfully explains where approximation methods come from why they sometimes work or don t work and when to use one of the many techniques that are available Written in a style that emphasizes readability and usefulness for the numerical methods novice the book begins with basic elementary material and gradually builds up to more advanced topics A selection of concepts required for the study of computational mathematics is introduced and simple approximations using Taylor s Theorem are also treated in some depth The text includes exercises that run the gamut from simple hand computations to challenging derivations and minor proofs to programming exercises A greater emphasis on applied exercises as well as the cause and effect associated with numerical mathematics is featured throughout the book An Introduction to Numerical Methods and Analysis is the ideal text for students in advanced undergraduate mathematics and engineering courses who are interested in gaining an understanding of numerical methods and numerical analysis **Computational Methods for Numerical Analysis with R** James P Howard, II,2017-07-12 Computational Methods for Numerical Analysis with R is an overview of traditional numerical analysis topics presented using R This guide shows how common functions from linear algebra interpolation numerical integration optimization and differential equations can be implemented in pure R code Every algorithm described is given with a complete function implementation in R along with examples to demonstrate the function and its use Computational Methods for Numerical Analysis with R is intended for those who already know R but are interested in learning more about how the underlying algorithms work As such it is suitable for statisticians economists and engineers and others with a computational and numerical background *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 **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

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Numerical Methods J. Douglas Faires,Richard L. Burden,1998 This text emphasizes the intelligent application of approximation techniques to the type of problems that commonly occur in engineering and the physical sciences The authors provide a sophisticated introduction to various appropriate approximation techniques they show students why the methods work what type of errors to expect and when an application might lead to difficulties and they provide information about the availability of high quality software for numerical approximation routines The techniques covered in this text are essentially the same as those covered in the Sixth Edition of these authors top selling Numerical Analysis text but the emphasis is much different In Numerical Methods Second Edition full mathematical justifications are provided only if they are concise and add to the understanding of the methods The emphasis is placed on describing each technique from an implementation standpoint and on convincing the student that the method is reasonable both mathematically and computationally

Introduction to Numerical Methods Peter Stark,1970 This text is for an introductory course in what is commonly called numerical analysis numerical methods or even numerical calculus While it parallels the development in Course B4 on Numerical Calculus in the proposed Curriculum in Computer Science issued by the Association for Computing Machinery this book is designed for any science or engineering student who has completed his first course in calculus and who has at least a passing knowledge of elementary computer programming in FORTRAN This is a practical book for the student who in addition to seeing the theory of numerical methods also likes to see the results the predominant emphasis is on specific methods and computer solutions It often points out where the theory departs from practice and it illustrates each method of computer solution by an actual computer program and its results   **Numerical Methods in Economics** Kenneth L. Judd,2023-04-04 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 Analysis M. Schatzman,2002 Numerical analysis explains why numerical computations work or fail This book is divided into four parts Part I starts 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   **Analysis of Numerical Methods** Eugene Isaacson,Herbert Bishop Keller,1994-06-07 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   **Numerical Methods for Mathematics, Science, and Engineering** John H. Mathews,1992 A modern computer oriented approach to numerical analysis that shows how the mathematics of calculus and linear algebra are implemented in computer algorithms Computer output is displayed in tables and used to develop topics of computer accuracy pitfalls in computational methods and error estimation   **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   **An Introduction to Numerical Analysis** Endre Süli,David F. Mayers,2003-08-28 Numerical analysis provides the theoretical foundation for the numerical algorithms we rely on to solve a multitude of computational problems in science Based on a successful course at Oxford University this book covers a wide range of such problems ranging from the approximation of functions and integrals to the approximate solution of algebraic transcendental differential and integral equations Throughout the book particular attention is paid to the essential qualities of a numerical algorithm stability accuracy reliability and efficiency The authors go further than simply providing recipes for solving computational problems They carefully analyse the reasons why methods might fail to give accurate answers or why one method might return an

answer in seconds while another would take billions of years This book is ideal as a text for students in the second year of a university mathematics course It combines practicality regarding applications with consistently high standards of rigour

Classical and Modern Numerical Analysis Azmy S. Ackleh,Edward James Allen,R. Baker Kearfott,Padmanabhan Seshaiyer,2009-07-20 Classical and Modern Numerical Analysis Theory Methods and Practice provides a sound foundation in numerical analysis for more specialized topics such as finite element theory advanced numerical linear algebra and optimization It prepares graduate students for taking doctoral examinations in numerical analysis The text covers the main areas o **Numerical Methods for Equations and its Applications** Ioannis K. Argyros,Yeol J. Cho,Saïd Hilout,2012-06-05 This book introduces advanced numerical functional analysis to beginning computer science researchers The reader is assumed to have had basic courses in numerical analysis computer programming computational linear algebra and an introduction to real complex and functional analysis Although the book is of a theoretical nature each chapter contains several new theoretical results and important applications in engineering in dynamic economics systems in input output system in the solution of nonlinear and linear differential equations and optimization problem **A Friendly Introduction to Numerical Analysis** Brian Bradie,2006 An introduction to the fundamental concepts and techniques of numerical analysis and numerical methods Application problems drawn from many different fields aim to prepare students to use the techniques covered to solve a variety of practical problems **A Theoretical Introduction to Numerical Analysis** Victor S. Ryaben'kii,Semyon V. Tsynkov,2006-11-02 A Theoretical Introduction to Numerical Analysis presents the general methodology and principles of numerical analysis illustrating these concepts using numerical methods from real analysis linear algebra and differential equations The book focuses on how to efficiently represent mathematical models for computer based study An accessible yet rigorous mathematical introduction this book provides a pedagogical account of the fundamentals of numerical analysis The authors thoroughly explain basic concepts such as discretization error efficiency complexity numerical stability consistency and convergence The text also addresses more complex topics like intrinsic error limits and the effect of smoothness on the accuracy of approximation in the context of Chebyshev interpolation Gaussian quadratures and spectral methods for differential equations Another advanced subject discussed the method of difference potentials employs discrete analogues of Calderon s potentials and boundary projection operators The authors often delineate various techniques through exercises that require further theoretical study or computer implementation By lucidly presenting the central mathematical concepts of numerical methods A Theoretical Introduction to Numerical Analysis provides a foundational link to more specialized computational work in fluid dynamics acoustics and electromagnetism

Applied Numerical Analysis Curtis F. Gerald,Patrick O. Wheatley,1984 *Nonlinear Methods in Numerical Analysis* A. Cuyt,L. Wuytack,1987-03-01 While most textbooks on Numerical Analysis discuss linear techniques for the solution of various numerical problems this book introduces and illustrates nonlinear methods It presents several nonlinear techniques

resulting mainly from the use of Pad approximants and rational interpolants   **Numerical Methods** Anne Greenbaum,Tim P. Chartier,2012-04-01 A rigorous and comprehensive introduction to numerical analysis Numerical Methods provides a clear and concise exploration of standard numerical analysis topics as well as nontraditional ones including mathematical modeling Monte Carlo methods Markov chains and fractals Filled with appealing examples that will motivate students the textbook considers modern application areas such as information retrieval and animation and classical topics from physics and engineering Exercises use MATLAB and promote understanding of computational results The book gives instructors the flexibility to emphasize different aspects design analysis or computer implementation of numerical algorithms depending on the background and interests of students Designed for upper division undergraduates in mathematics or computer science classes the textbook assumes that students have prior knowledge of linear algebra and calculus although these topics are reviewed in the text Short discussions of the history of numerical methods are interspersed throughout the chapters The book also includes polynomial interpolation at Chebyshev points use of the MATLAB package Chebfun and a section on the fast Fourier transform Supplementary materials are available online Clear and concise exposition of standard numerical analysis topics Explores nontraditional topics such as mathematical modeling and Monte Carlo methods Covers modern applications including information retrieval and animation and classical applications from physics and engineering Promotes understanding of computational results through MATLAB exercises Provides flexibility so instructors can emphasize mathematical or applied computational aspects of numerical methods or a combination Includes recent results on polynomial interpolation at Chebyshev points and use of the MATLAB package Chebfun Short discussions of the history of numerical methods interspersed throughout Supplementary materials available online   Numerical Analysis for Engineers Bilal Ayyub,Richard H. McCuen,2015-09-18 Numerical Analysis for Engineers Methods and Applications demonstrates the power of numerical methods in the context of solving complex engineering and scientific problems The book helps to prepare future engineers and assists practicing engineers in understanding the fundamentals of numerical methods especially their applications limitations

Unveiling the Magic of Words: A Review of "**Methods In Numerical Analysis**"

In some sort of defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their capability to kindle emotions, provoke contemplation, and ignite transformative change is really awe-inspiring. Enter the realm of "**Methods In Numerical Analysis**," a mesmerizing literary masterpiece penned by way of a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve in to the book is central themes, examine its distinctive writing style, and assess its profound impact on the souls of its readers.

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