

NUMERICAL METHODS

C / KAPPA EXAM 12 / 11/19 / 2022 / 20.000

LEAST SQUARES REGRESSION

Goal: minimize the sum of the squares of the residual errors.



$$S_r = \sum_{i=1}^n d_i = \sum_{i=1}^n (y_i - a_0 - a_1 x_i)$$

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

$$a_0 = \frac{\sum y_i - a_1 \sum x_i}{n}$$

$$a_0 = \frac{\sum y_i}{n} - a_1 \frac{\sum x_i}{n}$$

STANDARD ERROR:

$$S_{y_1} = \sqrt{\frac{\sum y_i^2}{n-2}} \quad S_{y_2} = \sqrt{\frac{\sum (y_i - \hat{y}_i)^2}{n-2}}$$

STANDARD DEVIATION:

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

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

POLYNOMIAL QUADRATIC REGRESSION:



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

Take derivative of S_r to find minimum

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

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

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

$$\begin{bmatrix} \sum x_i^0 & \sum x_i^1 & \sum x_i^2 \\ \sum x_i^1 & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum y_i x_i \\ \sum y_i x_i^2 \end{bmatrix}$$

Use Gauss-Jordan elimination

INTERPOLATION

Use a polynomial $P(x)$



ODE'S

Euler's Method

$$\frac{dy}{dx} = f(x,y) \quad y_{i+1} = y_i + f(x_i, y_i) \Delta x$$

Runge-Kutta Method

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

$$y' = \frac{y^2 + 2x}{2} = f(x,y)$$

$$y_1 = 1, y_2 = 2$$

$$y_3 = \frac{y_1^2 + 2x_1}{2} = \frac{1 + 2(1)}{2} = 1.5$$

Taylor Series:
 $y(x+\Delta x) = y(x) + \Delta x y'(x) + \frac{\Delta x^2}{2} y''(x) + \dots$
 $y(x+\Delta x) = y(x) + f(x,y) \Delta x$

Classic 4th order Runge-Kutta

$$y_{i+1} = y_i + \frac{\Delta x}{4} (k_1 + 2k_2 + 2k_3 + k_4)$$

$$k_1 = f(x_i, y_i)$$

$$k_2 = f(x_i + \frac{1}{2}\Delta x, y_i + \frac{1}{2}k_1 \Delta x)$$

$$k_3 = f(x_i + \frac{1}{2}\Delta x, y_i + k_2 \Delta x)$$

$$k_4 = f(x_i + \Delta x, y_i + k_3 \Delta x)$$

PDE'S

Finite Difference Method



EIGEN VALUES

$\lambda = \text{Eigen Value}$

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

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$\Delta(x) = \det(A - \lambda I) = \det \begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}$$

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

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

$$x_1 + x_2 = 0 \Rightarrow x_1 = -x_2$$

$$x_1 + x_2 = 0 \Rightarrow x_1 = -x_2$$

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

$$-x_1 + x_2 = 0 \Rightarrow x_1 = x_2$$

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

RIGHT BOUNDARY BC

Top boundary: $T = T_{top}$

Bottom boundary: $T = T_{bottom}$

Central difference: $\frac{\partial^2 T}{\partial x^2} = \frac{T_{i+1} - 2T_i + T_{i-1}}{\Delta x^2}$

Right boundary BC: $\frac{\partial T}{\partial x} = 0 \Rightarrow \frac{T_{i+1} - T_i}{\Delta x} = 0 \Rightarrow T_{i+1} = T_i$

LEFT BOUNDARY BC

Central difference: $\frac{\partial^2 T}{\partial x^2} = \frac{T_{i+1} - 2T_i + T_{i-1}}{\Delta x^2}$

Left boundary BC: $\frac{\partial T}{\partial x} = 0 \Rightarrow \frac{T_i - T_{i-1}}{\Delta x} = 0 \Rightarrow T_i = T_{i-1}$

TOP BOUNDARY BC

Central difference: $\frac{\partial^2 T}{\partial x^2} = \frac{T_{i+1} - 2T_i + T_{i-1}}{\Delta x^2}$

Top boundary BC: $T = T_{top} \Rightarrow T_i = T_{top}$

RIGHT BOUNDARY BC

Central difference: $\frac{\partial^2 T}{\partial x^2} = \frac{T_{i+1} - 2T_i + T_{i-1}}{\Delta x^2}$

Right boundary BC: $T = T_{right} \Rightarrow T_i = T_{right}$

[A] MATRIX:

$$-2u_{i,j} + u_{i+1,j} + u_{i-1,j} = -2\Delta x^2 \bar{u}_{i,j}$$

$$-2u_{i,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = -2\Delta x^2 \bar{u}_{i,j}$$

$$-2u_{i,j} + 4u_{i,j} - u_{i,j} - u_{i,j+1} = -2\Delta x^2 \bar{u}_{i,j}$$

$$-2u_{i,j} - u_{i,j} + 4u_{i,j} - 2u_{i,j+1} = -2\Delta x^2 \bar{u}_{i,j}$$

$$-2u_{i,j} - u_{i,j} + 4u_{i,j} - 2u_{i,j-1} = -2\Delta x^2 \bar{u}_{i,j}$$

FINITE DIFFERENCE:

Centered finite-difference approximation:

$$f'(x) = \frac{f(x+\Delta x) - f(x-\Delta x)}{2\Delta x}$$

$$f''(x) = \frac{f(x+\Delta x) - 2f(x) + f(x-\Delta x))}{\Delta x^2}$$

Guide To Numerical Analysis

Baraka Handal



Guide To Numerical Analysis:

Guide to Numerical Analysis Peter R. Turner, 1989 This book considers some of the most fundamental ideas of mathematical and in particular numerical computing These in turn form the basis of most of the techniques of scientific computing which are widely used in almost every branch of scientific work and in business and economic applications **A Student's Guide to Numerical Methods** Ian H. Hutchinson, 2015-04-30 The plain language style worked examples and exercises in this book help students to understand the foundations of computational physics and engineering **Study Guide for Numerical Analysis** Richard L. Burden, J. Douglas Faires, 1997 *The Graduate Student's Guide to Numerical Analysis '98* Mark Ainsworth, Jeremy Levesley, Marco Marletta, 2012-12-06 The Eighth EPSRC Numerical Analysis Summer School was held at the University of Leicester from the 5th to the 17th of July 1998 This was the third Numerical Analysis Summer School to be held in Leicester The previous meetings in 1992 and 1994 had been carefully structured to ensure that each week had a coherent theme For the 1998 meeting in order to widen the audience we decided to relax this constraint Speakers were chosen to cover what may appear at first sight to be quite diverse areas of numerical analysis However we were pleased with the extent to which the ideas cohered and particularly enjoyed the discussions which arose from differing interpretations of those ideas We would like to thank all six of our main speakers for the care which they took in the preparation and delivery of their lectures In this volume we present their lecture notes in alphabetical rather than chronological order Nick Higham Alastair Spence and Nick Trefethen were the speakers in week 1 while Bernardo Cockburn Stig Larsson and Bob Skeel were the speakers in week 2 Another new feature of this meeting compared to its predecessors was that we had invited seminars A number of established academics based in the UK were asked to participate in the afternoon seminar program *Student Solutions Manual and Study Guide for Numerical Analysis* Richard L. Burden, J. Douglas Faires, 2004-12-01 The Student Solutions Manual contains worked out solutions to many of the problems It also illustrates the calls required for the programs using the algorithms in the text which is especially useful for those with limited programming experience *Numerical Analysis* Richard L. Burden, J. Douglas Faires, 1997 Includes solutions to representative exercises including a large number of the type students will find on the actuarial exam [An Introduction to Numerical Methods and Analysis](#) James F. Epperson, 2013 The objective of this book is for readers to learn where approximation methods come from why they work why they sometimes don't work and when to use which of the many techniques that are available and to do all this in an environment that emphasizes readability and usefulness to the numerical methods novice Each chapter and each section begins with the basic elementary material and gradually builds up to more advanced topics The text begins with a review of the important calculus results and why and where these ideas play an important role throughout the book Some of the concepts required for the study of computational mathematics are introduced and simple approximations using Taylor's Theorem are treated in some depth The exposition is intended to be

lively and student friendly Exercises run the gamut from simple hand computations that might be characterized as starter exercises to challenging derivations and minor proofs to programming exercises Eleven new exercises have been added throughout including Basins of Attraction 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 Various sections have been revised to reflect recent trends and updates in the field [Study guide for numerical analysis](#) Richard L. Burden,1997 *The Numerical Analysis Problem Solver* Research and Education Association,1993

Numerical Analysis Burden,Faires,1996-01-01 **Numerical Analysis** Peter R. Turner,1994 [Numerical Methods and Optimization](#) Éric Walter,2014-07-22 Initial training in pure and applied sciences tends to present problem solving as the process of elaborating explicit closed form solutions from basic principles and then using these solutions in numerical applications This approach is only applicable to very limited classes of problems that are simple enough for such closed form solutions to exist Unfortunately most real life problems are too complex to be amenable to this type of treatment Numerical Methods a Consumer Guide presents methods for dealing with them Shifting the paradigm from formal calculus to numerical computation the text makes it possible for the reader to discover how to escape the dictatorship of those particular cases that are simple enough to receive a closed form solution and thus gain the ability to solve complex real life problems understand the principles behind recognized algorithms used in state of the art numerical software learn the advantages and limitations of these algorithms to facilitate the choice of which pre existing bricks to assemble for solving a given problem and acquire methods that allow a critical assessment of numerical results Numerical Methods a Consumer Guide will be of interest to engineers and researchers who solve problems numerically with computers or supervise people doing so and to students of both engineering and applied mathematics **Numerical Analysis Guide** Baraka Handal,2014-11-01 Numerical Analysis is a way to solve the real life mathematical physical and engineering problems Numerical Analysis can be used to answer the problems for which the analytical solution is not available **Computational Mathematics, Numerical Analysis and Applications** Mariano Mateos,Pedro Alonso,2017-08-03 The first part of this volume gathers the lecture notes of the courses of the XVII Escuela Hispano Francesa held in Gijón Spain in June 2016 Each chapter is devoted to an advanced topic and presents state of the art research in a didactic and self contained way Young researchers will find a complete guide to beginning advanced work in fields such as High Performance Computing Numerical Linear Algebra Optimal Control of Partial Differential Equations and Quantum Mechanics Simulation while experts in these areas will find a comprehensive reference guide including some previously unpublished results and teachers may find these chapters useful as textbooks in graduate courses The second part features the extended abstracts of selected research work presented by the students during the School It highlights new results and applications in Computational Algebra Fluid Mechanics Chemical Kinetics

and Biomedicine among others offering interested researchers a convenient reference guide to these latest advances

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 [Student Solutions Manual and Study Guide](#) Richard L. Burden, J. Douglas Faires, 2010-09-22 The Student Solutions Manual and Study Guide contains worked out solutions to selected exercises from the text The solved exercises cover all of the techniques discussed in the text and include step by step instruction on working through the algorithms *Guide to Scientific Computing* Peter R. Turner, 2001 This book introduces the reader to many of the problems of scientific computing and the wide variety of methods used for their solutions It discusses basic approaches and stimulates an appreciation of the need for numerical methods in solving different types of problems For each of the problems presented the author provides some mathematical justification and examples These serve as practical evidence and motivation for the reader to follow Practical justification of the methods is provided through computer examples and exercises The book includes an introduction to MATLAB but the code used is not intended to exemplify sophisticated or robust pieces of software it is purely illustrative of the method under discussion [Numerical Analysis](#) Richard L. Burden, 1993 **Numerical Analysis with Applications in Mechanics and Engineering** Petre Teodorescu, Nicolae-Doru Stanescu, Nicolae Pandrea, 2013-05-07 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 Recent Advances in Material, Manufacturing, and Machine Learning Bjorn Schuller, Rajeew Gupta, Rakesh Mote, Abhishek Sharma, J.P. Giri, R.B. Chadge, 2024-06-17 The main aim of the 2nd international conference on recent advances in materials manufacturing and machine learning processes 2023 RAMMML 23 is to bring together all interested academic researchers scientists engineers and technocrats and provide a platform for continuous improvement of manufacturing machine learning design and materials engineering research RAMMML 2023 received an overwhelming response with more than 530 full paper submissions After due and careful scrutiny about 120 of them have been selected for presentation The papers submitted have been reviewed by experts from renowned institutions and subsequently the authors have revised the papers duly incorporating the suggestions of the reviewers This has led to significant improvement in the quality of the contributions Taylor Francis publications CRC Press have agreed to publish the selected proceedings of the conference in their book series of Advances in Mechanical Engineering and Interdisciplinary Sciences This enables fast dissemination of the papers worldwide and increases the scope of visibility for the research contributions of the authors

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