

NUMERICAL METHODS

C / RAPPY 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 $d_i = y_i - \hat{y}_i$

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

$$Q_0 = \sum_{i=1}^n y_i^2, \quad Q_1 = \sum_{i=1}^n x_i y_i \Rightarrow a_0 = \frac{Q_0}{n} - a_1 \bar{x}$$

STANDARD ERROR:

$$S_{y_1} = \sqrt{\frac{\sum_{i=1}^n y_i^2}{n-2}}, \quad S_{y_2} = \sqrt{\frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n-2}}$$

STANDARD DEVIATION:

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

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

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 the error.

$$\frac{\partial S_r}{\partial a_0} = -2 \left(\sum_{i=1}^n y_i - \sum_{i=1}^n a_0 - a_1 \sum_{i=1}^n x_i - a_2 \sum_{i=1}^n x_i^2 \right) = 0$$

$$\frac{\partial S_r}{\partial a_1} = -2 \left(\sum_{i=1}^n y_i x_i - \sum_{i=1}^n a_0 x_i - a_1 \sum_{i=1}^n x_i^2 - a_2 \sum_{i=1}^n x_i^3 \right) = 0$$

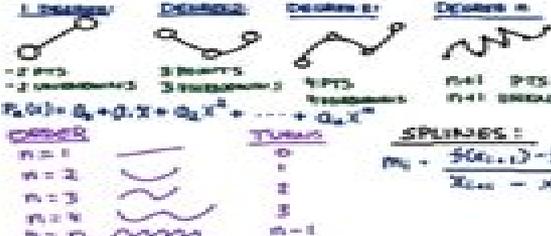
$$\frac{\partial S_r}{\partial a_2} = -2 \left(\sum_{i=1}^n y_i x_i^2 - \sum_{i=1}^n a_0 x_i^2 - a_1 \sum_{i=1}^n x_i^3 - a_2 \sum_{i=1}^n x_i^4 \right) = 0$$

$$\begin{bmatrix} \sum x_i^0 & \sum x_i^1 & \sum x_i^2 \\ \sum x_i^1 & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum y_i x_i \\ \sum y_i x_i^2 \end{bmatrix} \Rightarrow [A][X] = [B]$$

Use Gauss-Jordan elimination to solve for a_0, a_1, a_2 .

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

$$y' = f(x,y)$$

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

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

$$k_3 = f(x_i + \Delta x, y_i + \Delta x k_2)$$

$$y_{i+1} = y_i + \Delta x \left(\frac{k_1 + 2k_2 + k_3}{6} \right)$$

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

$$y_{i+1} = y_i + \Delta x \left(\frac{k_1 + 2k_2 + 2k_3 + k_4}{6} \right)$$

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

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

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

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

PDE'S

Finite Difference Method



EIGEN VALUES

$\lambda = \text{Eigen Value}$

Example: 2×2

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

The determinant:

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

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \quad [A - \lambda I] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$[A - \lambda I] = \begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}$$

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

Find Eigen Value with given

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

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

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

$$x_1 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

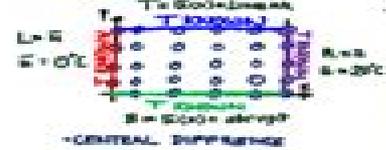
$$\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

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

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

$$x_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

1D Heat Conduction



$$u_{i+1}(t) = u_i(t) - \alpha \Delta x \frac{u_i(t) - u_{i-1}(t)}{\Delta x} + \alpha \Delta x \frac{u_i(t) - u_{i+1}(t)}{\Delta x}$$

$$u_{i+1}(t) = u_i(t) - \alpha \Delta x \frac{u_i(t) - u_{i-1}(t)}{\Delta x} + \alpha \Delta x \frac{u_i(t) - u_{i+1}(t)}{\Delta x}$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

2D Heat Conduction



$$u_{i+1,j} = u_{i,j} - \alpha \Delta x \frac{u_{i,j} - u_{i-1,j}}{\Delta x} + \alpha \Delta x \frac{u_{i,j} - u_{i+1,j}}{\Delta x} + \alpha \Delta y \frac{u_{i,j} - u_{i,j-1}}{\Delta y} + \alpha \Delta y \frac{u_{i,j} - u_{i,j+1}}{\Delta y}$$

$$u_{i+1,j} = u_{i,j} - \alpha \Delta x \frac{u_{i,j} - u_{i-1,j}}{\Delta x} + \alpha \Delta x \frac{u_{i,j} - u_{i+1,j}}{\Delta x} + \alpha \Delta y \frac{u_{i,j} - u_{i,j-1}}{\Delta y} + \alpha \Delta y \frac{u_{i,j} - u_{i,j+1}}{\Delta y}$$

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

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

1D Heat Conduction



$$u_{i+1} = u_i - \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i-1}) + \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i+1})$$

$$u_{i+1} = u_i - \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i-1}) + \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i+1})$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

2D Heat Conduction



$$u_{i+1,j} = u_{i,j} - \frac{\alpha \Delta x}{2\Delta x} (u_{i,j} - u_{i-1,j}) + \frac{\alpha \Delta x}{2\Delta x} (u_{i,j} - u_{i+1,j}) + \frac{\alpha \Delta y}{2\Delta y} (u_{i,j} - u_{i,j-1}) + \frac{\alpha \Delta y}{2\Delta y} (u_{i,j} - u_{i,j+1})$$

$$u_{i+1,j} = u_{i,j} - \frac{\alpha \Delta x}{2\Delta x} (u_{i,j} - u_{i-1,j}) + \frac{\alpha \Delta x}{2\Delta x} (u_{i,j} - u_{i+1,j}) + \frac{\alpha \Delta y}{2\Delta y} (u_{i,j} - u_{i,j-1}) + \frac{\alpha \Delta y}{2\Delta y} (u_{i,j} - u_{i,j+1})$$

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

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

5th Rank of A Matrix



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

$$u_{i+1} = u_i - \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i-1}) + \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i+1})$$

$$u_{i+1} = u_i - \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i-1}) + \frac{\alpha \Delta x}{2\Delta x} (u_i - u_{i+1})$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

Left Boundary B.C.



$$u_{i-1} = u_{i+1} - 2\alpha \Delta x u_i$$

$$u_{i-1} = u_{i+1} - 2\alpha \Delta x u_i$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

$$-u_{i-1} - u_{i+1} + 4u_i - 2u_{i-1} = -2\alpha \Delta x u_i$$

5th Rank of A Matrix

Centered Finite-Difference Formula

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

$$f(x) = \frac{f(x+\Delta x) + 3f(x) - 3f(x-\Delta x) + f(x+\Delta x))}{12\Delta x}$$

Numerical Methods For Engineers

Bilal Ayyub, Richard H. McCuen



Numerical Methods For Engineers:

Numerical Methods for Engineers and Scientists Using MATLAB® Ramin S. Esfandiari, 2013-06-04 Designed to benefit scientific and engineering applications Numerical Methods for Engineers and Scientists Using MATLAB focuses on the fundamentals of numerical methods while making use of MATLAB software The book introduces MATLAB early on and incorporates it throughout the chapters to perform symbolic graphical and numerical tasks The text covers a variety of methods from curve fitting to solving ordinary and partial differential equations Provides fully worked out examples showing all details Confirms results through the execution of the user defined function or the script file Executes built in functions for re confirmation when available Generates plots regularly to shed light on the soundness and significance of the numerical results Created to be user friendly and easily understandable Numerical Methods for Engineers and Scientists Using MATLAB provides background material and a broad introduction to the essentials of MATLAB specifically its use with numerical methods Building on this foundation it introduces techniques for solving equations and focuses on curve fitting and interpolation techniques It addresses numerical differentiation and integration methods presents numerical methods for solving initial value and boundary value problems and discusses the matrix eigenvalue problem which entails numerical methods to approximate a few or all eigenvalues of a matrix The book then deals with the numerical solution of partial differential equations specifically those that frequently arise in engineering and science The book presents a user defined function or a MATLAB script file for each method followed by at least one fully worked out example When available MATLAB built in functions are executed for confirmation of the results A large set of exercises of varying levels of difficulty appears at the end of each chapter The concise approach with strong up to date MATLAB integration provided by this book affords readers a thorough knowledge of the fundamentals of numerical methods utilized in various disciplines

Numerical Methods for Engineers Steven C. Chapra, Raymond P. Canale, 2002 The Fourth Edition of Numerical Methods for Engineers continues the tradition of excellence it established as the winner of the ASEE Meriam Wiley award for Best Textbook Instructors love it because it is a comprehensive text that is easy to teach from Students love it because it is written for them with great pedagogy and clear explanations and examples throughout This edition features an even broader array of applications including all engineering disciplines The revision retains the successful pedagogy of the prior editions Chapra and Canale s unique approach opens each part of the text with sections called Motivation Mathematical Background and Orientation preparing the student for what is to come in a motivating and engaging manner Each part closes with an Epilogue containing sections called Trade Offs Important Relationships and Formulas and Advanced Methods and Additional References Much more than a summary the Epilogue deepens understanding of what has been learned and provides a peek into more advanced methods What s new in this edition A shift in orientation toward more use of software packages specifically MATLAB and Excel with VBA This includes material on developing MATLAB m files and VBA macros In addition

the text has been updated to reflect improvements in MATLAB and Excel since the last edition. Also many more and more challenging problems are included. The expanded breadth of engineering disciplines covered is especially evident in the problems which now cover such areas as biotechnology and biomedical engineering. Features: The new edition retains the clear explanations and elegantly rendered examples that the book is known for. There are approximately 150 new challenging problems drawn from all engineering disciplines. There are completely new sections on a number of topics including multiple integrals and the modified false position method. The website will provide additional materials such as programs for student and faculty use and will allow users to communicate directly with the authors.

Numerical Methods for Engineers

Steven C. Chapra, Raymond P. Canale, 2006. The fifth edition of *Numerical Methods for Engineers* continues its tradition of excellence. Instructors love this text because it is a comprehensive text that is easy to teach from. Students love it because it is written for them with great pedagogy and clear explanations and examples throughout. The text features a broad array of applications including all engineering disciplines. The revision retains the successful pedagogy of the prior editions. Chapra and Canale's unique approach opens each part of the text with sections called Motivation, Mathematical Background, and Orientation, preparing the student for what is to come in a motivating and engaging manner. Each part closes with an Epilogue containing sections called Trade Offs, Important Relationships, and Formulas, and Advanced Methods and Additional References. Much more than a summary, the Epilogue deepens understanding of what has been learned and provides a peek into more advanced methods. Users will find use of software packages specifically MATLAB and Excel with VBA. This includes material on developing MATLAB m files and VBA macros. Approximately 80% of the problems are new or revised for this edition. The expanded breadth of engineering disciplines covered is especially evident in the problems which now cover such areas as biotechnology and biomedical engineering.

Numerical Methods for Engineers

D. Vaughan Griffiths, I.M. Smith, 2006-06-22. Although pseudocodes in Mathematica and MATLAB illustrate how algorithms work, designers of engineering systems write the vast majority of large computer programs in the Fortran language. Using Fortran 95 to solve a range of practical engineering problems. *Numerical Methods for Engineers*, Second Edition, provides an introduction to numerical methods.

Numerical Methods for Engineers and Scientists Joe D. Hoffman, Steven Frankel, 2018-10-03. Emphasizing the finite difference approach for solving differential equations, the second edition of *Numerical Methods for Engineers and Scientists* presents a methodology for systematically constructing individual computer programs. Providing easy access to accurate solutions to complex scientific and engineering problems, each chapter begins with objectives, a discussion of a representative application, and an outline of special features, summing up with a list of tasks students should be able to complete after reading the chapter. Perfect for use as a study guide or for review. The AIAA Journal calls the book a good, solid instructional text on the basic tools of numerical analysis.

Numerical Methods for Scientists and Engineers Richard Hamming, 2012-04-25. This inexpensive paperback edition of a groundbreaking text stresses frequency approach in coverage.

of algorithms polynomial approximation Fourier approximation exponential approximation and other topics Revised and enlarged 2nd edition *Numerical Methods for Engineers and Scientists* Amos Gilat,Vish Subramaniam,2013-10-22

Numerical Methods for Engineers and Scientists 3rd Edition provides engineers with a more concise treatment of the essential topics of numerical methods while emphasizing MATLAB use The third edition includes a new chapter with all new content on Fourier Transform and a new chapter on Eigenvalues compiled from existing Second Edition content The focus is placed on the use of anonymous functions instead of inline functions and the uses of subfunctions and nested functions This updated edition includes 50% new or updated Homework Problems updated examples helping engineers test their understanding and reinforce key concepts *Numerical Methods for Engineers* Abdulmajeed A Mohamad,Adel M Benselama,2023-03-21

The unique compendium is an introductory reference to learn the most popular numerical methods cohesively The text focuses on practical applications rather than on abstract and heavy analytical concepts The key elements of the numerical methods are Taylor series and linear algebra Based on the authors years of experience most materials on the text are tied to those elements in a unified manner The useful reference manual benefits professionals researchers academics senior undergraduate and graduate students in chemical engineering civil engineering mechanical engineering and aerospace engineering *Numerical Methods for Engineers and Scientists Using MATLAB* Ramin S. Esfandiari,2017

This book provides a pragmatic methodical and easy to follow presentation of numerical methods and their effective implementation using MATLAB which is introduced at the outset Each method is accompanied by at least one fully worked out example showing essential details involved in preliminary hand calculations as well as computations in MATLAB

Publisher description *Numerical Methods for Engineers and Scientists* J. N. Sharma (M.A.),2004 The desire for numerical answers to applied problems has increased manifold with the advances made in various branches of science and engineering and rapid development of high speed digital computers Although numerical methods have always been useful their role in the present day scientific computations and research is of fundamental importance numerous distinguishing features The contents of the book have been organized in a logical order and the topics are discussed in a systematic manner concepts algorithms and numerous exercises at the end of each chapter helps students in problem solving both manually and through computer programming an exhaustive bibliography and an appendix containing some important and useful iterative methods for the solution of nonlinear complex equations **Numerical Methods for Engineers and Scientists** Joe D. Hoffman,2001

Basic tools of numerical analysis Ordinary differential equations Partial differential equations parabolic partial differential equations [Loose Leaf for Numerical Methods for Engineers](#) Raymond P. Canale,Steven C. Chapra, Dr.,2020-03-03

The eighth edition of Chapra and Canale s *Numerical Methods for Engineers* retains the instructional techniques that have made the text so successful The book covers the standard numerical methods employed by both students and practicing engineers Although relevant theory is covered the primary emphasis is on how the methods are

applied for engineering problem solving Each part of the book includes a chapter devoted to case studies from the major engineering disciplines Numerous new or revised end of chapter problems and case studies are drawn from actual engineering practice This edition also includes several new topics including a new formulation for cubic splines Monte Carlo integration and supplementary material on hyperbolic partial differential equations [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 **Applied Numerical Methods with MATLAB for Engineers and Scientists** Steven C. Chapra, 2022-01-24 [Numerical Methods for Engineers](#) D. V. Griffiths, I. M. Smith, 1993 [Numerical Methods for Engineers and Scientists](#) Avinash Chandra Bajpai, Irene M. Calus, J. Alex Fairley, 1977 Programmed instruction type format [Numerical Methods for Engineers](#) Steven C. Chapra, 2019 [Numerical Methods for Engineers](#) Steven C. Chapra, Raymond P. Canale, 1985 *Numerical Methods for Engineers and Scientists* Avinash C. Bajpai, 1977 **EBOOK: Applied Numerical Methods with MATLAB for Engineers and Scientists** Steven Chapra, 2011-05-16 Steven Chapra's Applied Numerical Methods with MATLAB third edition is written for engineering and science students who need to learn numerical problem solving Theory is introduced to inform key concepts which are framed in applications and demonstrated using MATLAB The book is designed for a one semester or one quarter course in numerical methods typically taken by undergraduates The third edition features new chapters on Eigenvalues and Fourier Analysis and is accompanied by an extensive set of m files and instructor materials

Adopting the Beat of Term: An Emotional Symphony within **Numerical Methods For Engineers**

In a world taken by screens and the ceaseless chatter of immediate interaction, the melodic elegance and mental symphony developed by the published word frequently disappear in to the background, eclipsed by the relentless noise and interruptions that permeate our lives. However, nestled within the pages of **Numerical Methods For Engineers** an enchanting literary prize brimming with fresh feelings, lies an immersive symphony waiting to be embraced. Constructed by an outstanding composer of language, this captivating masterpiece conducts readers on a mental journey, skillfully unraveling the hidden songs and profound influence resonating within each carefully constructed phrase. Within the depths of this moving review, we shall explore the book is main harmonies, analyze their enthralling writing style, and submit ourselves to the profound resonance that echoes in the depths of readers souls.

<https://www.staging.gilderlehrman.org/results/book-search/fetch.php/Complete%20Beginner%20Guide%20To%20Use%20AI%20For%20Ecommerce%20Store%20For%20Content%20Creators%20BATCH48%2026.pdf>

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