

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.



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

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

$$a_0 = \frac{\sum y_i}{n} \quad a_1 = \frac{\sum x_i y_i - \frac{(\sum x_i)(\sum y_i)}{n}}{\sum x_i^2 - \frac{(\sum x_i)^2}{n}}$$

STANDARD ERROR:

$$S_{y_1} = \sqrt{\frac{S_r}{n-2}} \quad S_{y_2} = \sqrt{\frac{S_r(y_2 - \bar{y})^2}{n-2}}$$

STANDARD DEVIATION:

$$S_y = \sqrt{\frac{S_r}{n-1}} \quad S_x = \sqrt{\frac{2(y_2 - \bar{y})^2}{n-1}}$$

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

POLYNOMIAL QUADRATIC REGRESSION:



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

Take derivatives of S_r to find the error.

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

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

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

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

Use Gauss-Jordan elimination.

INTERPOLATION

Use a polynomial $P(x)$.

| LAGRANGE | HERMITE | LAGRANGE | LAGRANGE |
|--|-------------------------------------|----------------------------------|---|
| 2 pts 1 interval 1 degree | 3 points 2 intervals 2 degree | 4 pts 3 intervals 3 degree | 5 pts 4 intervals 4 degree |
| $P(x) = a_0 + a_1 x + a_2 x^2 + \dots + a_n x^n$ | | | |
| ORDER | | TURNS | SPLINES: |
| $n=1$ | — | 0 | $P_1 = \frac{f(x_{i+1}) - f(x_i)}{x_{i+1} - x_i}$ |
| $n=2$ | — | 1 | |
| $n=3$ | — | 2 | |
| $n=4$ | — | 3 | |
| $n=5$ | — | 4 | |

ODE'S

EULER METHOD

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

HEUN'S METHOD

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

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

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

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

CLASSIC 4th ORDER RUNGE-KUTTA:

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

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

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

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

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

PDE'S

FINITE DIFFERENCE METHOD:



EIGEN VALUES

$\lambda = \text{eigen value}$

Example:

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

The solution:

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

Single 2x2:

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

$$D(x) = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

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

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

Full matrix with given:

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

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

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

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

$[A - \lambda I] \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

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

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

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

$$D(x) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

1D Heat Conduction



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

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

$$-u_{i+1} - u_i + 9u_{i+1} - 2u_{i-1} = -2\Delta x \bar{u}_i$$

$$-u_{i+1} - u_i + 9u_{i+1} - 2u_{i-1} = -2\Delta x \bar{u}_i$$

2D Heat Conduction



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

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

$$-u_{i+1,j} - u_{i,j} + 9u_{i+1,j} - 2u_{i-1,j} = -2\Delta x \bar{u}_i$$

$$-u_{i+1,j} - u_{i,j} + 9u_{i+1,j} - 2u_{i-1,j} = -2\Delta x \bar{u}_i$$

1D Heat Conduction



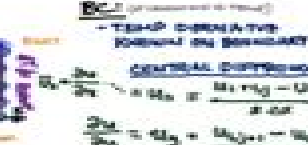
$$\frac{\partial u}{\partial x} = u_x = \frac{u_{i+1} - u_{i-1}}{2\Delta x}$$

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

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

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

2D Heat Conduction



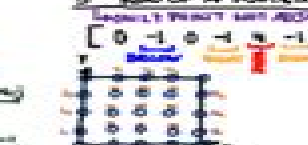
$$\frac{\partial u}{\partial x} = u_x = \frac{u_{i+1,j} - u_{i-1,j}}{2\Delta x}$$

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

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

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

5th Rank of a Matrix



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

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

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

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

Left Boundary B.C.

$$u_{i-1,j} = u_{i,j} - 2\Delta x u_x$$

$$u_{i-1,j} = u_{i,j} - 2\Delta x u_x$$

$$u_{i-1,j} = u_{i,j} - 2\Delta x u_x$$

$$u_{i-1,j} = u_{i,j} - 2\Delta x u_x$$

$$u_{i-1,j} = u_{i,j} - 2\Delta x u_x$$

5th Rank of a Matrix

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

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

Numerical Methods Unit Guide

Gleb Beliakov



Numerical Methods Unit Guide:

Numerical Methods School Mathematics Project, John Higgs, 1992 The aim of 16 19 Mathematics has been to produce a course which while challenging is accessible and enjoyable to all students The course develops ability and confidence in mathematics and its applications together with an appreciation of how mathematical ideas help in the understanding of the world and society in which we live The unit guide contains an introduction to the unit stating the objectives advice on teaching and working through the unit commentaries on the discussion points and task sheets in the student's text

Numerical Methods Gleb Beliakov, 2004 Produced for unit SCM319 Advanced mathematical methods offered by the Faculty of Science and Technology's School of Information Technology in Deakin University's Open Campus Program [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

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

Supplementary List of Publications of the National Bureau of Standards, 1960

Handbook of Numerical Methods for the Solution of Algebraic and Transcendental Equations V. L. Zaguskin, 2014-05-12 Handbook of Numerical Methods for the Solution of Algebraic and Transcendental Equations provides information pertinent to algebraic and transcendental equations This book indicates a well grounded plan for the solution of an approximate equation Organized into six chapters this book begins with an overview of the solution of various equations This text then outlines a non traditional theory of the solution of approximate equations Other chapters consider the approximate methods for the calculation of roots of algebraic equations This book discusses as well the methods for making roots more accurate which are essential in the practical application of Berstov's method The final chapter deals with the methods for the solution of simultaneous linear equations which are divided into direct methods and methods of

successive approximation This book is a valuable resource for students engineers and research workers of institutes and industrial enterprises who are using mathematical methods in the solution of technical problems [Proceedings of the 2023 9th International Conference on Advances in Energy Resources and Environment Engineering \(ICAEESEE 2023\)](#) Abd El-Fatah Abomohra,Rongkui Su,Md Wasikur Rahman,Jiwei Wen,2024-05-13 This is an open access book 2023 9th International Conference on Advances in Energy Resources and Environment Engineering ICAEESEE 2023 will be held on December 29 31 2023 in Sanya China ICAEESEE 2023 is to bring together innovative academics and industrial experts in the field of energy resources and environment engineering to a common forum The primary goal of the conference is to promote research and developmental activities in energy resources and environment engineering and another goal is to promote scientific information interchange between researchers developers engineers students and practitioners working all around the world The conference will be held every year to make it an ideal platform for people to share views and experiences in energy resources and environment engineering and related areas **Mathcad PLUS 5.0 User's Guide** ,1994 *Guidelines for Vapor Cloud Explosion, Pressure Vessel Burst, BLEVE, and Flash Fire Hazards* CCPS (Center for Chemical Process Safety),2011-12-01 This guide provides an overview of methods for estimating the characteristics of vapor cloud explosions flash fires and boiling liquid expanding vapor explosions BLEVEs for practicing engineers It has been updated to include advanced modeling technology especially with respect to vapor cloud modeling and the use of computational fluid dynamics The text also reviews past experimental and theoretical research and methods to estimate consequences Heavily illustrated with photos charts tables and diagrams this manual is an essential tool for safety insurance regulatory and engineering students and professionals **Staff Officers Field Manual Nuclear Weapons Employment** United States. Department of the Army,1963 *Teacher's Guide to Palmer Method Penmanship* Austin Norman Palmer,1923 **Mathcad 3.1 User's Guide** ,1992 Allows user to work with formulas numbers text and graphs *Whitaker's Books in Print* ,1998 **Manual for the ORACLE** Oak Ridge National Laboratory,1953 **Resources in Education** ,1982 *Fundamentals of Business Organization and Management* William Bouck Cornell,John Haskell MacDonald,Frederick George Nichols,1927 **Willing's Press Guide** ,1994 A guide to the press of the United Kingdom and to the principal publications of Europe Australia the Far East Gulf States and the U S A **Whitaker's Five-year Cumulative Book List** ,1968 [Civil Engineering Guidelines for Planning and Designing Hydroelectric Developments: Planning, design of dams, and related topics, and environmental](#) American Society of Civil Engineers,1989 *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

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web jun 23 2023 when immigrants settled in peru they didn t have the usual ingredients they were accustomed to at home so they modified their recipes using local peruvian ingredients this gave rise to newer culinary traditions within peruvian cuisine like creole nikkei and chifa cooking

essential peruvian food 10 must eat dishes to seek out serious eats - May 12 2023

web sep 30 2023 peruvian cuisine has only recently exploded onto the international culinary stage but peruvians have always been crazy about their nation s culinary heritage and they steadfastly cling to the traditional multi culti flavors of home pit roasted feasts and all even in the face of modern gastronomic innovation

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web oct 12 2023 what is the peruvian food staples peruvian cuisine is known for its diverse and delicious food staples below is a list of some of the most popular peruvian food items and their corresponding ingredients 1 cuy a type of roasted guinea pig 2 aji de gallina a peruvian chili sauce 3 queso blanco a fresh cheese 4

8 traditional dishes of peru raising miro on the road of life - Feb 26 2022

web apr 25 2012 8 must try traditional dishes of peru similar to other cultures peruvian dishes are a rich combination of several influences including spanish and chinese cuisine combined with traditional ingredients originating from peru many tourists who visit the nation have the opportunity to try new versions of some old favorites and may just be

the ancient cooking of the peruvian andes foodism - Aug 03 2022

web may 10 2018 the ancient cooking of the peruvian andes the andina food of arequipa is as rich in history as it is in flavour we discover that preserving and celebrating the traditions of this mountainous region is about much more than just nostalgia

amazon com customer reviews the food and cooking of peru traditions - Mar 30 2022

web although the book does has a nice introduction to peruvian cuisine and the classic ingredients it does not describe the main ajies that are used such as aji amarillo aji panca aji mirasol rocoto and aji limo they all have distinctive flavors and can be used fresh dried and in paste the book does not really go into that

30 traditional peru foods you must try dishes drinks desserts - Apr 11 2023

web aug 2 2022 hours 12 pm 3 pm 6 pm 11 pm daily 5 caldo de gallina hen soup caldo de gallina or hen soup is one of the oldest traditional foods in peru the traditional soup consists of hen not chicken noodles hard boiled eggs different types of potatoes peru has over 3 500 types of potatoes and chinese onions

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