NUMERICAL METHODS

LEAST SQUARES REGRESSION:

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

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

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

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

$$y = a_0 + a_1 x$$

STANDARD ERROR:

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

STAND DEVIATION:

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

POLYNOMIAL / QUADRATIC REGRESSION:

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

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

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

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

$$\sum a_i = a_0 n$$

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

$$X = A^{-1} B$$

$$S_y = \sqrt{\frac{S_r}{n-1}}$$

COEFFICIENT OF DETERMINATION:
$$r^2 = \frac{S_t - S_r}{S_t}$$

INTERPOLATION

USE A POLYNOMIAL FIT:

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

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

ORDER
n = 1
n = 2
n = 3
n = n

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

$$y_{i+1}^0 = y_i + f(x_i, y_i) h$$

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

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

$$y_i' = \frac{y_i' + y_{i+1}'}{2} = \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^0)}{2}$$

$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^0)}{2} \Delta x$$

TAYLOR SERIES:
$$y(x + \Delta x) = y(x) + \frac{dy}{dx}(x_0) \Delta x$$

$$y(x + \Delta x) = y(x) + f(x_0, y_0) \Delta x$$

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

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

EIGEN VALUES

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

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

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

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

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

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

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

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

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

2ND EIGENVECTOR:
$$X_2 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

PDE'S

FINITE DIFFERENCE METHOD:

TEMPERATURE:

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

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

DIRICHLET:
$$T = \text{BOUNDARY}$$

BC:
- TEMP KNOWN @ BOUNDARY

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

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

NEUMANN:
BC:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

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

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

5TH ROW OF A MATRIX:
$$\begin{bmatrix} 0 & -1 & 0 & -1 & 4 & -1 & 0 & -1 & 0 \end{bmatrix}[u] = 0$$

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

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

THIS CHANGED

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

THIS CHANGED

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

THIS CHANGED

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

THIS CHANGED

MISC EQN'S:

CENTERED FINITE DIVIDED DIFFERENCE:

FIRST:
$$f'(x) = \frac{f(x+h) - f(x-h)}{2h}$$

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

Numerical Analysis Using R

M Carnoy

Numerical Analysis Using R:

Using R for Numerical Analysis in Science and Engineering Victor A. Bloomfield,2018-09-03 Instead of presenting the standard theoretical treatments that underlie the various numerical methods used by scientists and engineers Using R for Numerical Analysis in Science and Engineering shows how to use R and its add on packages to obtain numerical solutions to the complex mathematical problems commonly faced by scientists and engineers This practical guide to the capabilities of R demonstrates Monte Carlo stochastic deterministic and other numerical methods through an abundance of worked examples and code covering the solution of systems of linear algebraic equations and nonlinear equations as well as ordinary differential equations and partial differential equations It not only shows how to use R s powerful graphic tools to construct the types of plots most useful in scientific and engineering work but also Explains how to statistically analyze and fit data to linear and nonlinear models Explores numerical differentiation integration and optimization Describes how to find eigenvalues and eigenfunctions Discusses interpolation and curve fitting Considers the analysis of time series Using R for Numerical Analysis in Science and Engineering provides a solid introduction to the most useful numerical methods for scientific and engineering data analysis using R   *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   **Numerical Analysis Using R : Solutions to ODEs and PDEs** Graham W Griffiths,2016 This book presents the latest numerical solutions to initial value problems and boundary value problems described by ODEs and PDEs The author offers practical methods that can be adapted to solve wide ranges of problems and illustrates them in the increasingly popular open source computer language R allowing integration with more statistically based methods The book begins with standard techniques followed by an overview of high resolution flux limiters and WENO to solve problems with solutions exhibiting high gradient phenomena Meshless methods using radial basis functions are then discussed in the context of scattered data interpolation and the solution of PDEs on irregular grids Three detailed case studies demonstrate how numerical methods can be used to tackle very different complex problems With its focus on practical solutions to real world problems this book will be useful to students and practitioners in all areas of science and engineering especially those using R   *Numerical Analysis Using R* Graham W. Griffiths,2016-04-26 This book presents the latest numerical solutions to initial value problems and boundary value problems described by ODEs and PDEs The author offers practical methods that

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Rodrigues,Rui Jorge Mendes Robalo,Rui Manuel Pires Almeida,2016-11-30 This book focuses on process simulation in chemical engineering with a numerical algorithm based on the moving finite element method MFEM It offers new tools and approaches for modeling and simulating time dependent problems with moving fronts and with moving boundaries described by time dependent convection reaction diffusion partial differential equations in one or two dimensional space domains It provides a comprehensive account of the development of the moving finite element method describing and analyzing the theoretical and practical aspects of the MFEM for models in 1D 1D 1d and 2D space domains Mathematical models are universal and the book reviews successful applications of MFEM to solve engineering problems It covers a broad range of application algorithm to engineering problems namely on separation and reaction processes presenting and discussing relevant numerical applications of the moving finite element method derived from real world process simulations *Critical Phenomena* F. J. W. Hahne,2005-06-30 Catalogue of the Library of the Surgeon General's Office, U. S. Army ,1873 **Catalogue of the Library of the Surgeon General's Office, United States Army** United States Army. Library of the Surgeon General's Office (Washington).,1873 Who's who in Technology Today ,1981 Scientific and Technical Aerospace Reports ,1985 The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science ,1922 **Account of the Operations of the Great Trigonometrical Survey of India** Survey of India. Trigonometrical Branch,1901 *Periodic orbits and miscellaneous papers. 1911* Sir George Howard Darwin,1911 U.S. Government Research & Development Reports ,1965

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