NUMERICAL METHODS

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LEAST SQUARES REGRESSION

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

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

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

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

STANDARD ERROR:

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

STND DEVIATION:

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

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

$y = a_0 + a_1 x$

INTERPOLATION

- USE A POLYNOMIAL FIT!

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

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

ORDER	TURNS
n=1	0
n=2	1
n=3	2
n=4	3
n=n	n-1

SPLINES:

$m_i = \frac{f(x_{i+1}) - f(x_i)}{x_{i+1} - x_i}$

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 MIN ERROR

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

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

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

$\sum a_0 = a_0 n$

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

[A] [X] [B]

$S_{y/x} = \sqrt{\frac{S_r}{n-(m+1)}}$ — data points; m = order of polynomial

$r^2 = \frac{S_t - S_r}{S_t}$ — coefficient of determination

ODE'S

- EULER'S METHOD (FORWARD EULER)

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

- HEUN'S METHOD:

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

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

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

$\frac{dy_{i+1}}{dx} = y'_{i+1} = f(x_{i+1}, y_{i+1}^0)$

$\frac{dy_i}{dx} = y'_i = f(x_i, y_i)$

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

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

- TAYLOR SERIES:

$y(x+\Delta x) = y(x) + \sum_{n=1}^{\infty} \frac{f^n(x)}{n!}(\Delta x)^n$

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

CLASSIC 1ST ORDER RUNGE-KUTTA:

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

$k_1 = f(x_i, y_i)$

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

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

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

DORMAND-PRINCE RUNGE-KUTTA:

$y_{n+1} = y_n + \Delta x \sum_{i=1}^{s} b_i k_i$ (ORDER 5 METHOD)

$y_{n+1} = y_n + \Delta x \sum_{i=1}^{s} a_i k_i$ (ORDER 4 METHOD)

PDE'S

- FINITE DIFFERENCE METHOD:

DIRICHLET BOUNDARY CONDITIONS

INSULATED OR CONVECTIVE THERMOCOUPLE

TEMPERATURE

EIGEN VALUES

λ = 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 SAME!

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

SIMPLE 2x2:

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

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

NOTE: $\det(A) \neq 0$

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

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

FIND EIGEN VALUES FIRST

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

$1x_1 + 1x_2 = 0$

$1x_1 + 1x_2 = 0$

$x_1 = -x_2$

$x_2 = -x_1$

$x_1 = x_2$

- EIGEN VECTOR

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

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

$-1x_1 + 1x_2 = 0$

$1x_1 + -1x_2 = 0$

$x_1 = x_2$

$x_2 = x_1$

- ZERO EQUATION

$[x_1] = \begin{bmatrix} : \\ : \end{bmatrix}$

PROJECT:

THE SOLID + LIQUID

T_{BOTTOM}

T_{TOP}

$L = 5$

$T = 0°C$

$R_{in} = 2$

$R_{out} = 3°C$

$k = 500 \frac{W}{m \cdot K}$ (STEEL)

- CENTRAL DIFFERENCE

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

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

BC:

- TEMP KNOWN AT BOUNDARY

SIMPLIFIED HEAT EQN:

$0 = k(u_{xx} + u_{yy} + u_{zz}) + q$

IF $q = 0$ & $k = 1$

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

NEUMANN:

BC:

- TEMP DERIVATIVE KNOWN AT BOUNDARY

CENTRAL DIFFERENCE:

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

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

RIGHT NEUMANN B.C.

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

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

BOTTOM NEUMANN B.C.

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

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

TOP NEUMANN BC

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

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

LEFT NEUMANN B.C.

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

5TH ROW OF A MATRIX

- RESULT MUST BE EQUAL TO ZERO!

$\begin{bmatrix} 0 & -1 & 0 & -1 & 4 & -1 & 0 & -1 & 0 \end{bmatrix} [u] = 0$

LEFT | BELOW | MIDDLE | ABOVE | RIGHT

[A] MATRIX:

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

LEFT:

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

THIS CHANGED

RIGHT:

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

THIS CHANGED

BOTTOM:

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

THIS CHANGED

TOP:

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

THIS CHANGED

FDC EQNS:

CENTERED FINITE-DIFFERENCE APPROXIMATION

FIRST:

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

$f'(x_i) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12\Delta x}$

Numerical Analysis Notes Bca

S Ben Porath

Numerical Analysis Notes Bca:

Deep Excavations in Soil John Endicott,2020-08-04 The book describes the theory and current practices for design of earth lateral support for deep excavations in soil It addresses basic principles of soil mechanics and explains how these principles are embodied in design methods including hand calculations It then introduces the use of numerical methods including the fundamental beam on springs models and then more sophisticated computer programmes which can model soil as a continuum in two or three dimensions Constitutive relationships are introduced that are in use for representing the behaviour of soil including a strain hardening model and a Cam Clay model including groundwater flow and coupled consolidation These methods are illustrated by reference to practical applications and case histories from the author s direct experience and some of the pitfalls that can occur are discussed Theory and design are strongly tied to construction practice with emphasis on monitoring the retaining structures and movement of surrounding ground and structures in the context of safety and the Observational Method Examples are presented for conventional Bottom up and Top down sequences along with hybrid sequences giving tips on how to optimise the design and effect economies of cost and time for construction It is written for practising geotechnical civil and structural engineers and especially for senior and MSc students Advances in Computational Mechanics Manolis Papadrakakis,B. H. V. Topping,1994 Includes a selection of papers that were presented at the Second International Conference on Computational Structures Technology held in Athens Greece from 30 August 1 September 1994 **Reflections on the Foundations of Mathematics: Essays in Honor of Solomon Feferman** Wilfried Sieg,Richard Sommer,Carolyn Talcott,2002-08-16 Solomon Feferman has shaped the field of foundational research for nearly half a century These papers most of which were presented at the symposium honoring him at his 70th birthday reflect his broad interests as well as his approach to foundational research which places the solution of mathematical and philosophical problems at the top of his **British Reports, Translations and Theses** British Library. Document Supply Centre,British Library. Lending Division,1994 Issue for Mar 1981 contains index for Jan Mar 1981 in microfiche form *Board of Contract Appeals Decisions* United States. Armed Services Board of Contract Appeals,2002 Taking Stock of Environmental Assessment Jane Holder,Donald McGillivray,2007-11-13 Examining the relationship between law environmental governance and the regulation of decision making this volume both reflective and contextual in approach uses a wide range of theories to explore the key features of modern environmental assessment **American Book Publishing Record** ,2003 **Human and Ecological Risk Assessment** Dennis J. Paustenbach,2024-04-15 Understand the fundamentals of human risk assessment with this introduction and reference Human risk assessments are a precondition for virtually all industrial action or environmental regulation all the more essential in a world where chemical and environmental hazards are becoming more abundant These documents catalog potential environmental toxicological ecological or other harms resulting from a particular hazard from chemical spills to construction projects to dangerous workplaces They turn on a number of variables

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Freedom's Port Christopher Phillips,1997 Baltimore s African American population nearly 27 000 strong and more than 90 percent free in 1860 was the largest in the nation at that time Christopher Phillips s Freedom s Port the first book length study of an urban black population in the antebellum Upper South chronicles the growth and development of that community He shows how it grew from a transient aggregate of individuals many fresh from slavery to a strong overwhelmingly free community less wracked by class and intraracial divisions than were other cities Almost from the start Phillips states Baltimore s African Americans forged their own freedom and actively defended it in a state that maintained slavery and whose white leadership came to resent the liberties the city s black people had achieved **Vortex Flow Aerodynamics** North Atlantic Treaty Organization. Advisory Group for Aerospace Research and Development. Fluid Dynamics Panel. Symposium,1991 **The SAE Journal** Society of Automotive Engineers,1931 1938 1946 include as a separate section the Society s Transactions **Applied Mechanics Reviews** ,1974 British Books ,1965 **The Standard Periodical Directory** ,2003 *Mathematical Reviews* ,2008 **Social Science Abstracts** ,1932 *Bookseller and Stationery Trades' Journal* ,1966 Vols for 1871 76 1913 14 include an extra number The Christmas bookseller separately paged and not included in the consecutive numbering of the regular series **Electrical & Electronics Abstracts** ,1997 **Publisher's Monthly** ,2001 Statistics Catalog 2005 Neil Thomson,2004-09

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