

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.



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

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

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

STANDARD ERROR:

$$S_{y_1} = \sqrt{\frac{S_r}{n-2}} \quad S_{y_2} = \sqrt{\frac{S_r (1-x_i^2)}{n-2}}$$

STANDARD DEVIATION:

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

POLYNOMIAL QUADRATIC REGRESSION:



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

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

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

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

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

INTERPOLATION

Order	Degree	Nodes	Equation
1	0	2	$P_1(x) = a_0 + a_1 x$
2	1	3	$P_2(x) = a_0 + a_1 x + a_2 x^2$
3	2	4	$P_3(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3$
4	3	5	$P_4(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$

ODE'S

Euler's Method:
 $y_{i+1} = y_i + f(x_i, y_i) \Delta x$

Runge-Kutta Method:

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

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

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

CLASSIC 4th ORDER Runge-Kutta:

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

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

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

$$k_3 = f(x_i + \frac{1}{2}\Delta x, y_i + \Delta x k_1)$$

$$k_4 = f(x_i + \Delta x, y_i + \Delta x k_1)$$

PDE'S

FINITE DIFFERENCE METHOD:



EIGEN VALUES

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

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

$$\lambda^2 - (a+d)\lambda + (ad-bc) = 0$$

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

Single 2x2:
 $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$
 $\det(A - \lambda I) = \det \begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix} = (a-\lambda)(d-\lambda) - bc = 0$

Two 2x2 with same eigenvalue:
 $\begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \lambda x_1 \\ \lambda x_2 \end{bmatrix}$
 $(a-\lambda)x_1 + bx_2 = 0$
 $cx_1 + (d-\lambda)x_2 = 0$

Two 2x2 with different eigenvalues:
 $\begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \lambda_1 x_1 \\ \lambda_2 x_2 \end{bmatrix}$
 $(a-\lambda_1)x_1 + bx_2 = 0$
 $cx_1 + (d-\lambda_2)x_2 = 0$

Central Difference:
 $\frac{\partial^2 u}{\partial x^2} = \frac{u_{i-1} - 2u_i + u_{i+1}}{\Delta x^2}$
 $u_{i-1} - 2u_i + u_{i+1} = -\Delta x^2 \frac{\partial^2 u}{\partial x^2}$

Right Neumann B.C.:
 $\frac{\partial u}{\partial x} = 0 \Rightarrow \frac{u_{i+1} - u_{i-1}}{2\Delta x} = 0 \Rightarrow u_{i+1} = u_{i-1}$

Bottom Neumann B.C.:
 $\frac{\partial u}{\partial x} = 0 \Rightarrow \frac{u_{i+1} - u_{i-1}}{2\Delta x} = 0 \Rightarrow u_{i+1} = u_{i-1}$

Top Neumann B.C.:
 $\frac{\partial u}{\partial x} = 0 \Rightarrow \frac{u_{i+1} - u_{i-1}}{2\Delta x} = 0 \Rightarrow u_{i+1} = u_{i-1}$

Left Neumann B.C.:
 $\frac{\partial u}{\partial x} = 0 \Rightarrow \frac{u_{i+1} - u_{i-1}}{2\Delta x} = 0 \Rightarrow u_{i+1} = u_{i-1}$

[A] MATRIX:
 $u_{i-1,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = -2\Delta x^2 \frac{\partial^2 u}{\partial x^2}$
 $-2u_{i-1,j} + 4u_{i,j} - u_{i,j+1} - u_{i,j-1} = -2\Delta x^2 \frac{\partial^2 u}{\partial x^2}$
 $-u_{i-1,j} - u_{i,j} + 4u_{i,j} - 2u_{i,j+1} = -2\Delta x^2 \frac{\partial^2 u}{\partial x^2}$
 $-u_{i-1,j} - u_{i,j} + 4u_{i,j} - 2u_{i,j-1} = -2\Delta x^2 \frac{\partial^2 u}{\partial x^2}$

Finite Elements:
 $f(x) = \frac{f(x_{i+1}) - f(x_i)}{\Delta x}$
 $f(x) = \frac{f(x_{i+1}) + 3f(x_i) - 3f(x_{i-1}) + f(x_{i-2}))}{12\Delta x}$

Numerical Computing With Matlab Solutions

B Lingard



Numerical Computing With Matlab Solutions :

Reviewing **Numerical Computing With Matlab Solutions** : Unlocking the Spellbinding Force of Linguistics

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