

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.



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

1. sum of the square errors.
2. minimize the square of the errors.

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

$$a_0 = \frac{\sum y_i}{n} - a_1 \frac{\sum x_i}{n} \Rightarrow a_0 = 5 - 0.8$$

STANDARD ERROR:

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

STANDARD DEVIATION:

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

$$a_0 = 5 - 0.8x$$

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.

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

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

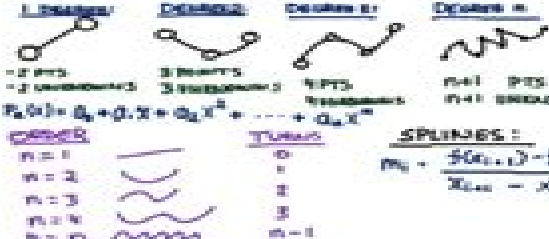
$$\frac{\partial S_r}{\partial a_2} = -2(\sum y_i x_i^2 - \sum a_0 x_i^2 - a_1 \sum x_i^3 - a_2 \sum x_i^4) = 0$$

$$\begin{bmatrix} \sum x_i^0 & \sum x_i^1 & \sum x_i^2 \\ \sum x_i^1 & \sum x_i^2 & \sum x_i^3 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum y_i x_i \\ \sum y_i x_i^2 \end{bmatrix}$$

Matrix method

INTERPOLATION

Use a polynomial $P(x)$



ODE'S

Euler's Method

$$\frac{dy}{dx} = f(x,y) \quad y_{n+1} = y_n + f(x_n, y_n) \Delta x$$

Runge-Kutta Method

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

$$y' = \frac{y^2 + 2x}{2} = f(x,y)$$

$$y_1 = y_0 + \frac{f(x_0, y_0) + f(x_1, y_1)}{2} \Delta x$$

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

$$y_{n+1} = y_n + \Delta x \frac{k_1 + 2k_2 + 2k_3 + k_4}{4}$$

$$k_1 = f(x_n, y_n)$$

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

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

$$k_4 = f(x_n + \Delta x, y_n + \Delta x k_1)$$

PDE'S

Finite Difference Method



EIGEN VALUES

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

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

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

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

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

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

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

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

RIGHT BOUNDARY B.C.

Top boundary: $T = 0$

Bottom boundary: $T = 100$

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Right boundary: $T_{i,N} = T_{i,N-1}$

LEFT BOUNDARY B.C.

Top boundary: $T = 0$

Bottom boundary: $T = 100$

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Left boundary: $T_{1,j} = T_{2,j}$

TOP BOUNDARY B.C.

Top boundary: $T = 0$

Bottom boundary: $T = 100$

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Top boundary: $T_{i,0} = T_{i,1}$

BOTTOM BOUNDARY B.C.

Top boundary: $T = 0$

Bottom boundary: $T = 100$

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Bottom boundary: $T_{i,M} = T_{i,M-1}$

5th row of a matrix

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

[A] MATRIX:

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Right boundary: $T_{i,N} = T_{i,N-1}$

Left boundary: $T_{1,j} = T_{2,j}$

Top boundary: $T_{i,0} = T_{i,1}$

Bottom boundary: $T_{i,M} = T_{i,M-1}$

FINITE DIFFERENCE

Central difference: $T_{i,j} = \frac{T_{i,j-1} + T_{i,j+1} + T_{i-1,j} + T_{i+1,j}}{4}$

Right boundary: $T_{i,N} = T_{i,N-1}$

Left boundary: $T_{1,j} = T_{2,j}$

Top boundary: $T_{i,0} = T_{i,1}$

Bottom boundary: $T_{i,M} = T_{i,M-1}$

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