NUMERICAL METHODS

r/KAPPY | EXAM 2 | 11/14/2022 | [illegible]

LEAST SQUARES REGRESSION:

[illegible]

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

[illegible]

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

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

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

$y = a_0 + a_1 x$

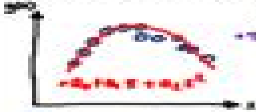
STANDARD ERROR:

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

STAND DEVIATION:

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

POLYNOMIAL QUADRATIC REGRESSION:



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

- TAKE DERIVATIVE OF S_r [illegible]

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

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

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

$\sum_{1}^{n} a_0 = a_0 n$

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

[A] [X] [B]

$x = A \backslash B$

$S_{y/x} = \sqrt{\frac{S_r}{n-(m+1)}}$

data points

[illegible] coefficients

COEFFICIENT OF DETERMINATION:

$r^2 = \frac{S_t - S_r}{S_t}$

INTERPOLATION

- USE A POLYNOMIAL FIT:

- 2 PTS - 2 UNKNOWNS
- 3 POINTS 3 UNKNOWNS
- 4 PTS 4 UNKNOWNS
- n+1 PTS n+1 [illegible]

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

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

SPLINES:

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

ODE'S

- EULER'S METHOD:

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

- TAYLOR SERIES:

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

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

- HEUN'S METHOD:

[illegible]

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

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

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

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

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

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

CLASSIC 4th ORDER RUNGE-KUTTA:

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

$k_1 = f(x_i, y_i)$

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

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

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

DORMAND PRINCE RUNGE-KUTTA

$y_{i+1} = y_i + \Delta x \sum_{j=1}^{n} a_j k_j$ [illegible]

$y_{i+1} = y_i + \Delta x \sum_{j=1}^{n} a_j k_j$ [illegible]

EIGEN VALUES eig()

λ = EIGEN VALUE

EXAMPLE:

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

[illegible]

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

SIMPLE 2×2:

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

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

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

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

[illegible]

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

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

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

[illegible] : $x_2 = 1$, $x_1 = -1$

- EIGEN VECTOR

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

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

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

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

$x_1 = 1$

$x_2 = 1$

- 2nd EIGENVECTOR

$[x_2] = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

PDE'S

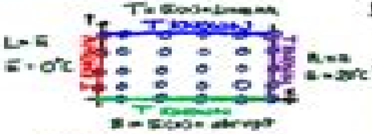
[illegible]

FINITE DIFFERENCE METHOD:

TEMPERATURE

DIRICHLET:

$T = f(x) =$ LINEAR



BC: [illegible]

- TEMP KNOWN @ BOUNDARY

SIMPLIFIED HEAT EQN:

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

if $q = 0$ + $k = 1$

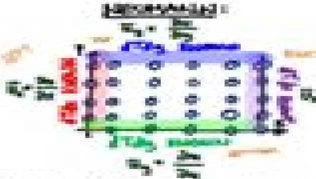
$u_{xx} + u_{yy} = 0$ [illegible]

- CENTRAL DIFFERENCE

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

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

NEUMANN:



BC: [illegible]

- TEMP DERIVATIVE KNOWN ON BOUNDARY

CENTRAL DIFFERENCE:

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

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

5th ROW OF A MATRIX

[illegible]

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

RIGHT NEUMANN B.C.

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

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

BOTTOM NEUMANN B.C.

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

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

TOP NEUMANN BC

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

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

LEFT NEUMANN B.C.

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

[A] MATRIX:

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

LEFT:

$\underbrace{-2u_{i+1,j}}_{\text{THIS CHANGED}} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x G_x$

RIGHT:

$\underbrace{-2u_{i-1,j}}_{\text{THIS CHANGED}} + 4u_{i,j} - u_{i,j-1} - u_{i,j+1} = -2\Delta x G_x$

BOTTOM:

$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} \underbrace{-2u_{i,j+1}}_{\text{THIS CHANGED}} = -2\Delta x G_y$

TOP:

$-u_{i-1,j} - u_{i+1,j} + 4u_{i,j} \underbrace{-2u_{i,j-1}}_{\text{THIS CHANGED}} = -2\Delta x G_y$

MISC EQNS:

CENTERED FINITE-DIVIDED DIFF. FORMULAS:

FIRST:

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

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

Numerical Methods For Engineers

Daniela Niemeyer

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