NUMERICAL METHODS

LEAST SQUARES (SCORE)

$$S_r = \sum e_i^2 = \sum (z_i - a_o - a_1 x_i)^2$$

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

$$a_o = \frac{\sum y_i}{n}, \quad a_1 = \frac{\sum x_i}{n} \Rightarrow a_o = \bar{y} - a_1 \bar{x}$$

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

$$y = a_o + a_1 x$$

POLYNOMIAL / QUADRATIC REGRESSION:

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

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

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

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

$$\sum_{i=0}^{} a_i = a_o n$$

$$[A][x] = [B]$$

$$x = A \backslash B$$

$$S_{y/x} = \sqrt{\frac{S_r}{n-2}}$$

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

STANDARD ERROR:

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

STAND. DEVIATION:

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

INTERPOLATION

USE A POLYNOMIAL FIT:

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

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

ORDER / TURNS
- n=1 : 0
- n=2 : 1
- n=3 : 2
- 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:
$$\frac{dy}{dx} = f(x,y) \qquad y_{i+1} = y_i + f(x_i, y_i)h$$

HEUN'S METHOD:
$$\frac{dy}{dx} = f(x,y)$$
$$x_{i+1} = y_i + f(x_i, y_i)\Delta x$$
$$\frac{dy}{dx} = y_i^o = f(x_i, y_i)$$
$$\frac{dy}{dx} = y_i^o = f(x_i, y_i)$$
$$y_i^o = \frac{y_i^o + y_{i+1}}{2}, \quad \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^o)}{2}$$
$$y_{i+1} = y_i + \frac{f(x_i, y_i) + f(x_{i+1}, y_{i+1}^o)}{2}\Delta x$$

TAYLOR SERIES:

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

CLASSIC 4TH ORDER RUNGE-KUTTA:

$$y_{i+1} = y_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)\Delta x$$
$$k_1 = f(x_i, y_i)$$
$$k_2 = f\left(x_i + \tfrac{1}{2}\Delta x, \ y_i + \tfrac{1}{2}k_1 \Delta x\right)$$
$$k_3 = f\left(x_i + \tfrac{1}{2}\Delta x, \ y_i + \tfrac{1}{2}k_2 \Delta x\right)$$
$$k_4 = f\left(x_i + \Delta x, \ y_i + k_3 \Delta x\right)$$

DORMAND PRINCE RUNGE-KUTTA:

$$y_{i+1} = y_i + \Delta x \sum_{i=1}^{} a_i k_i$$
$$y_{i+1} = y_i + \Delta x \sum_{i=1}^{} a_i k_i$$

EIGEN VALUES

λ = EIGEN VALUE

SIMPLE 2×2:
$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \quad [A]^{-1} = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$
$$[x] = \frac{1}{\det(A)}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}[B]$$
$$\begin{bmatrix} a-\lambda & b \\ c & d-\lambda \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$
$$\lambda = \frac{(a+d) \pm \sqrt{(a+d)^2 - 4(ad - bc)}}{2}$$

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

PDE'S

FINITE DIFFERENCE METHOD:

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

TEMPERATURE

DIRICHLET:

BC:
- TEMP KNOWN @ BOUNDARY

GOVERNING HEAT EQN:
$$u_t = k(u_{xx} + u_{yy}) + q$$
$$u_{xx} + u_{yy} = 0$$

NEUMANN:

BC:
- TEMP DERIVATIVE KNOWN ON BOUNDARY

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

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

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

[A] MATRIX:

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

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

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

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

MISC EQN'S:

CENTERED FINITE DIVIDED DIFF FORMULAS:
$$f'(x_i) = \frac{f(x_{i+1}) - f(x_{i-1})}{2h}$$
$$f'(x_i) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h}$$

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