

# NUMERICAL METHODS

C / KAPPA EXAM 12 / 11/14 / 2022 / 20.00%

### LEAST SQUARES REGRESSION

Goal: minimize the sum of the square of the residual (error).

Residual =  $y_i - \hat{y}_i$

Sum of Squares (SS):  $S_y = \sum_{i=1}^n y_i^2$ ,  $S_{xy} = \sum_{i=1}^n x_i y_i$

Standard Error:  $S_y = \sum_{i=1}^n (y_i - \bar{y})^2$

Standard Deviation:  $S_y = \sqrt{\frac{S_y}{n-1}}$

Regression Line:  $\hat{y} = a_0 + a_1 x$

Formulas:

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

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

### POLYNOMIAL QUADRATIC REGRESSION

Goal: minimize the sum of the square of the residual (error).

Residual =  $y_i - \hat{y}_i$

Sum of Squares (SS):  $S_y = \sum_{i=1}^n y_i^2$ ,  $S_{xy} = \sum_{i=1}^n x_i y_i$

Standard Error:  $S_y = \sum_{i=1}^n (y_i - \bar{y})^2$

Standard Deviation:  $S_y = \sqrt{\frac{S_y}{n-1}}$

Regression Line:  $\hat{y} = a_0 + a_1 x + a_2 x^2$

Formulas:

$$a_2 = \frac{n \sum x_i^2 y_i - \sum x_i^2 \sum y_i - 2 \sum x_i \sum x_i y_i + (\sum x_i)^2 \sum y_i}{n \sum x_i^4 - (\sum x_i^2)^2 - 2 \sum x_i \sum x_i^3 + (\sum x_i^2)^2}$$

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

$$a_0 = \bar{y} - a_1 \bar{x} - a_2 \bar{x}^2$$

### PDE'S

#### FINITE DIFFERENCE METHOD

Grid points:  $x_i, y_j$

Central Difference:

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

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

Boundary Conditions:

- Dirichlet:  $u = g(x, y)$
- Neumann:  $\frac{\partial u}{\partial n} = h(x, y)$
- Robin:  $\alpha u + \beta \frac{\partial u}{\partial n} = \gamma(x, y)$

### EIGEN VALUES

Example:  $A = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$

Characteristic Equation:  $\det(A - \lambda I) = 0$

$(1-\lambda)(1-\lambda) - 4 = 0$

$\lambda^2 - 2\lambda - 3 = 0$

$\lambda = 3, -1$

### INTERPOLATION

Linear:  $P_1(x) = a_0 + a_1 x$

Quadratic:  $P_2(x) = a_0 + a_1 x + a_2 x^2$

Cubic:  $P_3(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

Newton's Method:

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

### ODE'S

#### Runge-Kutta

Order 4:

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

Order 2:

$$y_{n+1} = y_n + \Delta x f(x_n, y_n)$$

### Taylor Series

Example:  $e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots$

Maclaurin Series:

$$f(x) = f(0) + f'(0)x + \frac{f''(0)}{2!}x^2 + \dots$$

### FINITE DIFFERENCE METHOD (Continued)

Grid points:  $x_i, y_j$

Central Difference:

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

Boundary Conditions:

- Dirichlet:  $u = g(x, y)$
- Neumann:  $\frac{\partial u}{\partial n} = h(x, y)$
- Robin:  $\alpha u + \beta \frac{\partial u}{\partial n} = \gamma(x, y)$

### [A] MATRIX

Example:  $A = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 1 & 4 \\ 3 & 4 & 1 \end{bmatrix}$

Row 1:  $1u_1 + 2u_2 + 3u_3 = 10$

Row 2:  $2u_1 + 1u_2 + 4u_3 = 12$

Row 3:  $3u_1 + 4u_2 + 1u_3 = 14$

# Numerical Methods Ssm 3rd

**Michael Brown**



## **Numerical Methods Ssm 3rd:**

## **Numerical Methods Ssm 3rd** Book Review: Unveiling the Magic of Language

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