Applications of Matrices in Electronics & Communication Engineering

- What is Matrices ?

Matrices are two dimensional arrangement of numbers in rows and columns. enclosed in square brackets, or you could say matrices are simply a rectangular arrangement of numbers, expression, symbols arranged in rows and columns. Matrices have many uses in science and are also applicable to practical real-life problems making it an important concept to solve many practical problems.

- Applications in EC Engineering

  * Electrical and Electronic circuits
  * Signal processing
  * Wireless communication
  * Cryptography
  * Steganography
  * Computer Graphics (Animation)
  * Machine learning & Artificial Intelligence
  * Quantum Mechanics
  * Wireless communication
  * Robotics - Robot Movements
  * more ...

- Let us see some important applications of Matrices in EC Engineering.

* Electrical and Electronic circuits

- Calculation of battery power outputs
- Resistor conversion of electrical energy into another useful energy
- Node - potential method
- Mesh - current method
- Current in force
- Knowing the Voltage
- To solve AC Network Equation
- When using Kirchoff's laws to create equations and solve, using matrices and Gaussian elimination helps to simplify the solutions.

⇒ Example :

Node method for cultural Interest

In Matrix form

$$\left[\begin{array}{c|c} G_1 + G_2 + G_3 & -G_3 \\ \hline -G_3 & G_3 + G_4 + G_5 \end{array}\right] \left[\begin{array}{c} e_1 \\ \hline e_2 \end{array}\right] = \left[\begin{array}{c} G_1 V_0 \\ \hline G_4 V_0 + I_1 \end{array}\right]$$

Conductivity matrix — Unknown Node Voltages — Sources

$\therefore$ $Ax = b$ (For computation on computer)

* Signal Processing

- Eigen Values and Vectors
- Distance Matrix
- Procrustes Problem
- Neural Nets and the Learning Function
- Finding clusters in Graphs
- Eigen vectors of circulant Matrices: Fourier Matrix
- Stochastic Gradient Descent
- Hermitian Matrix

⇒ Example

$a_{ij} = \bar{a}_{ji}$

That is,

$A = A^{\dagger}$

* Cryptography

⇒ Encryption process

Example:

Let, A=1, B=2, C=3 and so on, let a blank be represented by 0. Let us encode the message "I LOVE MY INDIA". We need to translate letters into numbers.

Using the above list, the message becomes

⇒ 9, 0, 12, 15, 22, 5, 0, 13, 25, 0, 9, 14, 4, 9, 1

Now we need to decide on a coding matrix.

$$A = \begin{bmatrix} 3 & 1 & 2 \\ 2 & 0 & 1 \\ 3 & 4 & 5 \end{bmatrix}$$

By break the message into packets of 3 nos

$$\begin{bmatrix} 3 & 1 & 2 \\ 2 & 0 & 1 \\ 3 & 4 & 5 \end{bmatrix} \begin{bmatrix} 9 \\ 0 \\ 12 \end{bmatrix} = \begin{bmatrix} 51 \\ 30 \\ 87 \end{bmatrix} \quad \ldots$$

Encoding the entire sequence gives us the encrypted message :

51, 30, 87, 77, 35, 158, 63, 23, 177, 37, 14, 106, 23, 9, 53.

* (Signaling) Wireless communication

- SVD for Modeling MIMO channels
- Representing OFDM
- Cholesky Decomposition for whitening the Noise
- SVD for least-squares Based Estimation
- Matrix Inverse Lemma for Derivation of the Recursive least squares Filters
- Matrix theory in sensor array signal Processing

⇒ Example: Image Processing

$$S_{uv} = \begin{bmatrix} s(0,0,u,v) & s(0,1,u,v) & \cdots & s(0,n-1,u,v) \\ s(1,0,u,v) & s(1,1,u,v) & \cdots & s(1,n-1,u,v) \\ \vdots & \vdots & \ddots & \vdots \\ s(n-1,0,u,v) & s(n-1,1,u,v) & \cdots & s(n-1,n-1,u,v) \end{bmatrix}$$

~ THANK YOU ~