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Research Article

Matrices And Its Various Applications

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ABSTRACT

Matrices & Determinants, vector algebra, differential calculus, integration, discrete mathematics and more areas of applied mathematics will be categorized in the future. It is generally interesting among numerous topic matrices. Matrices have been used to solve linear equations for a long time. Matrices are extremely helpful tools that can be found in a wide range of applications.

Matrix mathematics is applied to a wide range of scientific and mathematical disciplines. Engineering mathematics is used in our daily lives. The effects of matrix can be seen in any computer-generated image with a reflection or distortion effect, such as light moving across rippling water. Prior to computer graphics, the science of optics used matrices to account for reflection and refraction. In mathematics, matrix notation is used to support graph theory. The number of connections a single node has, is determined by the integer value of each element in an adjacency matrix.

KEYWORDS: Matrices, Vector algebra, calculus, distortion, reflection, refraction, cryptography.

INTRODUCTION:

Matrices are a two-dimensional organization of numbers in row and column enclosed by a pair of square brackets, or, to put it another way, matrices are the rectangular arrangement of numbers, expressions, and symbols arranged in column and rows. In general, a matrix over a field F is a rectangular array of scalars, each of which is a member of F. The individual components that make up a matrix are known as its elements or entries. If two matrices are of the same size, that is, if they have the same number of rows and columns, they can be added or removed element by element. The rule for matrix multiplication, on the other hand, states that two matrices can only be multiplied if the first matrix's number of columns equals the second matrix's number of columns. Matrices are commonly used to describe linear transformations, or generalizations of linear functions like $f(x) = 2x$. If v is a column vector (a matrix with only one column) representing the position of a point in space, the product Rv is a column vector describing the position of that point after a rotation. A matrix that represents the composition of two linear transformations is the product of two transformation matrices. The solution of systems of linear equations is another application of matrices. By determining the determinant of a square matrix, several of its properties can be deduced. A square matrix, for example, has an inverse if and only if its determinant is not zero. The Eigen values and Eigen vectors of a matrix provide insight into the geometry of a linear transformation.

The creation of efficient methods for matrix calculations, a centuries-old subject that is now an emerging area of research, is a prominent branch of numerical analysis. Theoretically and practically, matrix decomposition methods make computations easier. Algorithms designed for specific matrix structures, such as sparse matrices and near-diagonal matrices, speed up finite element method and other computations. Planetary theory and atomic theory both contain infinite matrices. The matrix encoding the derivative operator, which acts on the Taylor series of a function, is a simple example of an infinite matrix.

Matrices have several uses in scientific domains and can also be used to practical real-life difficulties, making them a vital notion for resolving a wide range of practical issues. Matrices are used to represent real-world data such as demographic traits, habits, and so on. Matrices can be used to solve physical problems, such as in the study of electrical circuits, quantum physics, and optics. Matrices can also be used to calculate battery power outputs, resistor conversion of electrical energy into another useful energy, and so on. Matrix mathematics simplifies linear algebra, at least in terms of dealing with large numbers.

Applications of Matrices

Matrices have many applications in diverse fields of science, commerce and social science.

Matrices are used in:

1) Computer Graphics
2) Optics
3) Cryptography
4) Economics
5) Chemistry
6) Geology
7) Robotics and animation
8) Wireless communication and signal processing
9) Finance
10) Mathematics
11) Fourier analysis
12) Gauss theorem
13) Finding electric currents using matrix equations
14) Finding forces in the bridge

Uses of Matrices in Real Life: Matrix or matrices are often used in mathematics, but have you considered how significant they are or where they might be employed? Have you ever wondered from where the word matrix originated? Matrix is a Latin word that refers to the womb, but it also refers to something that is developed or generated. Matrices are frequently employed in everyday life, yet their applications are rarely explored in class. As a result, we've simplified the importance and application of maths by using matrices.

Real-world Applications of Matrices

Encryption

In encryption, we use matrices to scramble data for security purposes to encode and to decode this data. There is a key that helps encode and decode data which is generated by matrices.

Games especially 3D

They use it to alter the object, in 3d space. They use the 3d matrix to 2d matrix to convert it into the different objects as per requirement.

Economics and business

To study the trends of a business, shares, and more. To create business models etc.

Construction

Have you ever seen a building that is straight on the outside but the architects try to vary the outward structure, such as the famous Burj Khalifa? Matrixes can be used to do this.

A matrix is made up of rows and columns, and the number of rows and columns in a matrix can be changed.

Matrices can assist in the support of a variety of historical structures.

Animation:

Matrices helps in making animations more precise.

Physics: Electrical circuits, quantum physics, and optics are all studied using matrices. It aids in the estimation of battery power outputs and the conversion of electrical energy into another useable form through resistors. As a result, matrices play a significant part in calculations. Especially when applying Kirchhoff's voltage and current rules to solve difficulties. It aids in the study and application of quantum physics.

Geology:

Matrices are also used for taking seismic surveys in geology.

Use of Matrices in Computer Graphics

Earlier architecture, cartoons, automation were done by hand drawings but nowadays they are done by using computer graphics. Square matrices very easily represent linear transformation of objects. They are used to project three dimensional images into two dimensional planes in the field of graphics. In Graphics, digital image is treated as a matrix to start with. The rows and columns of the matrix correspond to rows and columns of pixels and the numerical entries correspond to the pixels' colour values. Using matrices to manipulate a point is a common mathematical approach in video game graphics Matrices are also used to express graphs. Every graph can be represented as a matrix, each column and each row of a matrix is a node and the value of their intersection is the strength of the connection between them. Matrix operations such as translation, rotation and scaling are used in graphics. For transformation of a point, we use the equation

Use of Matrices for Financial Records

Matrices allow you to represent a collection of numerous integers as a single item signified by a single symbol, and then execute calculations on these symbols in a very compact manner. The matrix method of calculating opening and closing balances for every accounting period is extremely efficient, accurate, and time-saving.

Use of Matrices in Wireless Communication

Matrices are used to model the wireless signals and to optimize them. For detection, extractions and processing of the information embedded in signals ,matrices are used. Matrices play a key role in signal estimation and detection problems. They are used in sensor array signal processing and design of adaptive filters. Matrices help in processing and representing digital images. We know that wireless and communication is an important part of the telecommunication industry. Sensor array signal processing focuses on signal enumeration and source location applications and presents a huge importance in many domains such as radar signals and underwater surveillance. Main problem in sensor array signal processing is to detect and locate the radiating sources given the temporal and spatial information collected from the sensors.

Use of Matrices in Science

Matrices are used in science of optics to account for reflection and for refraction. Matrices are also useful in electrical circuits and quantum mechanics and resistor conversion of electrical energy. Matrices are used to solve AC network equations in electric circuits.

Application of Matrices in Mathematics

Application of matrices in mathematics have an extended history of application in solving linear equations. Matrices are incredibly useful things that happen in many various applied areas. Application of matrices in mathematics applies to many branches of science, also as different mathematical disciplines. Engineering Mathematics is applied in our daily life.

Matrices for finding area of triangle

Matrices can be used to calculate the area of any triangle with known vertices. Assume the triangle's vertices are A (a, b), B (c, d), and C. (e, f). The following determinant then gives the area of ABC.

Area of Triangle ABC= $\frac{1}{2}\begin{bmatrix} a & b & 1 \\ c & d & 1 \\ \mathrm{e} & f & 1 \end{bmatrix}$

Matrices for collinear points

Matrices are used to see if the three points given are collinear. If A (a, b), B (c, d), and C (e, f) are three plane points. If these points are unable to form a triangle, they are collinear. In other words, the area of the triangle formed by A, B, and C should be zero.

Therefore A, B, C are collinear if $\begin{bmatrix} a & b & 1 \\ c & d & 1 \\ e & f & 1 \end{bmatrix}$ vanishes

Stress Distribution in A Tower Bridge

Matrices are used to calculate stress distribution in a bridge principal stresses for a three-dimensional simply supported beam by finding the eigenvalues of the stress matrix with variable components. The principal stresses are the eigenvalues of the stress matrix. The 3x3 stress matrix is given by

$$\boldsymbol{\sigma} = \begin{bmatrix} \sigma_x & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z \end{bmatrix}$$

Since the shearing stresses have the equalities

$$\tau_{xy} = \tau_{yx}, \tau_{yz} = \tau_{zy}, \tau_{zx} = \tau_{xz}$$

The stress matrix is symmetric.

If we change the orientation of a particular plane the normal stress component $\boldsymbol{\sigma_x}$ will vary, there exists a special orientation where the normal stress will be a maximum, and these are called principal planes and the normal stresses acting on them are called the principal stresses

The general three-dimensional case, the theory to determine principal stresses and the planes on which they act is formulated by the eigenvalue problem

$$[\sigma]\{n\} = \lambda\{n\}$$

where $\boldsymbol{\sigma}$ is the stress matrix, {n} is the principal direction vector and λ (the eigenvalue) is the principal stress. Thus, solving the eigenvalue problem will determine up to three distinct principal stresses and the corresponding three principal directions. It turns out for this application (3x3, symmetric real matrix) the principal directions are mutually orthogonal. • The shear stress components will vanish on these three principal planes and so for a coordinate system that is aligned with the principal directions the stress matrix takes on the simplified diagonal form.

$$\boldsymbol{\sigma} = \begin{bmatrix} \sigma_x & 0 & 0 \\ 0 & \sigma_y & 0 \\ 0 & 0 & \sigma_z \end{bmatrix}$$

Where $\boldsymbol{\sigma_x, \sigma_y, \sigma_z}$ are the problem's eigenvalues (roots of the characteristic equation) and are generally referred to as the principal stresses.

Matrices for Physics

In the study of optics, matrices are employed to account for reflection and refraction. Electrical circuits, quantum mechanics, and resistor conversion of electrical energy all benefit from matrices. In electric circuits, matrices are utilized to solve AC network equation.

Matrices-Application to Cryptography

Cryptography's core premise is that information may be encoded using an encryption technique and decoded by anybody who understands the system. There are a variety of encryption systems available, ranging from simple to complicated. The majority of them are of a mathematical character.

Credit card numbers, personal information, bank account numbers, letters of credit, passwords for vital databases, and other sensitive information is sent over the Internet every second. That data is frequently encoded or encrypted.

The encoder is a matrix, and the decoder is its inverse. Let A be the encoding matrix, M for the message matrix, and X will be the encrypted matrix (the sizes of A and M will have to be consistent and will determine the size of X). Then, mathematically, the operation is the encoder is a matrix, and the decoder is the inverse of that matrix. The operation is then mathematically completed.

$$AM = X$$

Someone has X and knows A, and wants to recover M, the original message. That would be the same as solving the matrix equation for M. Multiplying both sides of the equation on the left by A^{-1} we have

$$A = \begin{bmatrix} 0 & 2 & 1 & 3 \\ 1 & 1 & -1 & -2 \\ 1 & 2 & 0 & 1 \\ -1 & 1 & 2 & 6 \end{bmatrix}$$

Since this is a 4 x 4 matrix, we can encode only 4 numbers at a time. We break the message into packets of 4 numbers each, adding blanks to the end if necessary. The first group is 4,18,1and 7. The message matrix will be 4 x1.

$$\begin{bmatrix} 0 & 2 & 1 & 3 \\ 1 & 1 & -1 & -2 \\ 1 & 2 & 0 & 1 \\ -1 & 1 & 2 & 6 \end{bmatrix}\begin{bmatrix} 4 \\ 18 \\ 1 \\ 7 \end{bmatrix} = \begin{bmatrix} 58 \\ 7 \\ 47 \\ 58 \end{bmatrix}$$

So, the first 4 encrypted numbers are 58, 7, 47, and 58

Next 4 encrypted numbers are 15, 14, 12, and 1

$$\begin{bmatrix} 0 & 2 & 1 & 3 \\ 1 & 1 & -1 & -2 \\ 1 & 2 & 0 & 1 \\ -1 & 1 & 2 & 6 \end{bmatrix}\begin{bmatrix} 15 \\ 14 \\ 12 \\ 1 \end{bmatrix} = \begin{bmatrix} 43 \\ 15 \\ 44 \\ 29 \end{bmatrix}$$

The second group is 43, 15, 44, and 29. Notice that 1 came out as 47 in the first group, but as 29 in the second group. That's one of the advantages of the matrix scheme. The same data can be encoded different ways making it harder to find a pattern.

Encoding the entire sequence gives us the encrypted message:

58, 7, 47, 58, 43, 15, 44,29,25,5,26,24 Let’s decode it using the inverse matrix

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

Decoding the first 4 numbers, we have

(**Note:** A must have an inverse)

$$\left[\begin{bmatrix} -1 & -3 & 3 & -1 \\ 1 & 1 & -1 & 0 \\ 2 & -5 & 2 & -3 \\ -1 & 1 & 0 & 1 \end{bmatrix}\right]\begin{bmatrix} 58 \\ 7 \\ 47 \\ 58 \end{bmatrix} = \begin{bmatrix} 4 \\ 18 \\ 1 \\ 7 \end{bmatrix}$$

$$M = A^{-1}X$$

Example: Let A=1, B=2, C=3, and so on, let a space be represented by 0.

Let's encode the message "DRAGONLANDED". We need to translate letters into numbers. Using the list above, the message becomes:

4,18,1,7,15,14,12,1,14,4,5,4

Now we need to decide on a coding matrix.
The first 4 numbers decode as the first 4 numbers in the original message.

Matrix encryption is just one of many schemes. Every year, the National Security Agency, the military and private corporations hire hundreds of people to devise new schemes and decode existing ones.

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