# **MATRIX MIX**

# Introduction

Matrices are rectangular arrays of numbers, symbols, or expressions arranged in rows and columns. Each value in a matrix is called an element. Matrices are typically used to organize data or to solve systems of equations. They can be added, subtracted, and multiplied, and there are special types of matrices like identity matrices, zero matrices, and square matrices. Matrices are a foundational concept in linear algebra and are widely used in computer science, engineering, economics, and more. Understanding how to read, interpret, and manipulate matrices opens the door to solving complex real-world problems.



# **Image Processing & Digital Filters**

Matrices are used in image processing to manipulate and enhance digital images. Each pixel in a grayscale image can be represented as a number, and an image itself becomes a matrix of these numbers. Filters, such as those used to sharpen, blur, or detect edges in an image, use matrices that are applied across the image to transform it.

For example, when applying a blur filter to a photograph, a matrix called a kernel is multiplied with small regions of the image matrix. This changes the values of the pixels based on the neighbors, resulting in a softened image. This matrix-based method is behind many photo editing tools and even facial recognition systems.

Reference:

Nag, H. (2020, June 21). Applications of linear algebra in image filters [part I]- operations. Medium. <u>https://medium.com/swlh/applications-of-linear-algebra-in-image-filters-part-i-operations-aeb64f236845</u>



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# **Computer Graphics & Animation**

Matrices are essential in computer graphics, where they are used to perform transformations such as rotations, translations, and scaling of objects in 2D and 3D space. Every object or scene can be transformed using matrix multiplication.

For example, in a 3D video game, when a character moves or the camera changes perspective, the position and orientation of the character are recalculated using transformation matrices. This makes animations smooth and realistic, and it's all powered by matrix math running behind the scenes.

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Reference:
Gao's blog. (2020, May 31). Matrix transformations. <u>https://vitaminac.github.io/Matrices-in-Computer-Graphics/</u>
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# **Electrical Circuits & Engineering**

Matrices are widely used in electrical engineering to analyze complex circuits. Engineers use a technique called mesh analysis, where a matrix represents the relationships between voltages, currents, and resistances.

For instance, in a circuit with multiple loops and components, the equations derived from Kirchhoff's laws are organized into a matrix format. Solving the matrix helps determine how much current flows through each component. This allows engineers to design efficient, safe, and effective electronic systems in devices from smartphones to spacecraft.

Reference:

Bazzi, A. (2020, May 24). *Electrical circuit analysis: Application of linear systems | Linear algebra #13.* YouTube [Video]. https://www.youtube.com/watch?v=wqq21mWH\_S4&t=5s



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# **Ecology & Population Modeling**

Matrices help ecologists model the population dynamics of species. These are known as Leslie matrices, used to predict how populations grow, decline, or stabilize over time, based on age-specific birth and survival rates.

For example, a conservationist might use a matrix to track a bird species with three age groups: juvenile, sub-adult, and adult. The matrix helps project future population sizes, assess the impact of environmental changes, and inform decisions for habitat protection and biodiversity preservation.

Reference:

Value Virtual Labs. (2025). Stage structured Leslie matrix. Value Virtual Labs, Amrita University, India. https://vlab.amrita.edu/?sub=3&brch=65&sim=771&cnt=1



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# **Weather Forecasting & Climate Models**

Meteorologists use matrices to analyze and simulate complex weather systems. Matrices allow them to organize massive datasets temperature, pressure, humidity, and wind speeds, from multiple sources across regions.

For example, a matrix might represent temperature readings from dozens of weather stations over time. Using matrix-based simulations, computers can model how storms develop and move, improving the accuracy of forecasts and preparing communities for extreme weather events.

Reference:

National Weather Service. (n.d.). Decoding the area forecast matrices. NWS Birmingham, Alabama. https://www.weather.gov/bmx/afm



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# **Sports Analytics & Performance**

In sports analytics, matrices are used to track and analyze player and team performance. Statistics from games are organized in matrices to help coaches and analysts make strategic decisions.

For instance, a basketball coach might use a matrix showing player shooting accuracy from different court zones. By analyzing this matrix, the coach can adjust plays to increase scoring efficiency. Math also helps in player scouting, game strategy, and injury prevention.

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Adapted from:
Google. (2025). Gemini (Flash 2.0) [Large language model].9 <u>https://gemini.google.com/</u>
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# Cryptography & Data Security

Matrices are used in cryptography to encode and decode messages. In particular, they can be used in algorithms that scramble data into unreadable formats, which can then only be decoded with the correct key or matrix operation.

For example, a message can be converted into a matrix of numbers using a coding system. This matrix can then be multiplied by another matrix (the encryption key) to produce a new matrix that hides the original message. The recipient can decrypt it using the inverse of the key matrix, ensuring secure communication in areas like online banking and digital messaging.

Reference:

Marshematics. (2015, Jun 21). Cryptography with matrices. YouTube [Video]. https://www.youtube.com/watch?v=hIYACo8c4bc



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# **Traffic Flow & Urban Planning**

Matrices are used in modeling and analyzing traffic flow in cities. Traffic engineers use matrices to represent how vehicles move between intersections, streets, and regions.

For example, a city might use a matrix to track how many cars travel from neighborhood A to neighborhood B during rush hour. This helps urban planners optimize traffic-light timings, redesign roads, and predict the impact of new infrastructure, reducing congestion and improving public transportation systems.

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