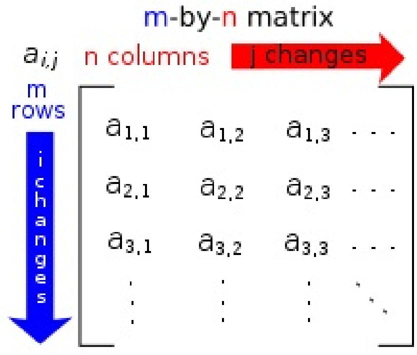
Practical Uses of Matrix Mathematics

December 17, 2013 by Mike DeHaan — 14 Comments

My thanks to an alert reader for asking, "*What are the practical use of matrices in day to day life?*" The most direct answer is, "*It depends on your own day to day life.*" Let's consider some practical uses of matrix mathematics in a variety of settings, along with a brief introduction to matrices.



What are the practical use of matrices in day to day life? Image by Lakeworks.

Applications of Matrix Mathematics

Matrix mathematics applies to several branches of science, as well as different mathematical disciplines. Let's start with computer graphics, then touch on science, and return to mathematics.

We see the results of matrix mathematics in every computer-generated image that has a reflection, or distortion effects such as light passing through rippling water.

Before computer graphics, the science of optics used matrix mathematics to account for reflection and for refraction.

Matrix arithmetic helps us calculate the electrical properties of a circuit, with voltage, amperage, resistance, etc.

In mathematics, one application of matrix notation supports graph theory. In an adjacency matrix, the integer values of each element indicates how many connections a particular node has.

The field of probability and statistics may use matrix representations. A probability vector lists the probabilities of different outcomes of one trial. A stochastic matrix is a square matrix whose rows are probability vectors. Computers run Markov simulations based on stochastic matrices in order to model events ranging from gambling through weather forecasting to quantum mechanics.

Matrix mathematics simplifies linear algebra, at least in providing a more compact way to deal with groups of equations in linear algebra.

Introduction to Matrix Arithmetic

A matrix organizes a group of numbers, or variables, with specific rules of arithmetic. It is represented as a rectangular group of rows and columns, such as $\begin{bmatrix} 11 & 12 & 13 \\ 21 & 22 & 23 \end{bmatrix}$. This "2X3" matrix has two rows and three columns; the number '23' is in the second row of the third column.

An example of a square matrix with variables, rather than numbers, is $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$. This is a square matrix because the number of rows equals the number of columns.

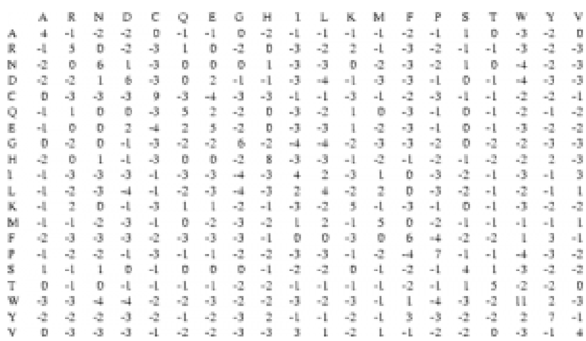
We can only add matrices of the same dimensions, because we add the corresponding elements.
$\begin{bmatrix} a & b \\ c & d \end{bmatrix} + \begin{bmatrix} e & f \\ g & h \end{bmatrix} = \begin{bmatrix} a+e & b+f \\ c+g & d+h \end{bmatrix}$.

Matrix multiplication is another matter entirely. Let's multiply matrices MP=R. M is an mXn matrix; P is nXp; and the result R will have dimension mXp. Note that the number of columns of the left-hand matrix, M, must equal the number of rows of the right hand matrix, P. For example:

$$\begin{bmatrix} a & b & c \\ d & e & f \end{bmatrix} * \begin{bmatrix} g & h \\ i & j \\ k & l \end{bmatrix} = \begin{bmatrix} a*g+b*i+c*k & a*h+b*j+c*l \\ d*g+e*i+f*k & d*h+e*j+f*l \end{bmatrix}.$$

A matrix can also multiply, or be multiplied by, a vector.

Graphic Uses of Matrix Mathematics



	A	R	N	D	C	Q	E	G	H	I	L	K	M	F	P	S	T	W	Y	V
A	4	-1	-2	-2	0	-1	-1	0	-2	-1	-1	-1	-1	-2	-1	1	0	-3	-2	0
R	-1	5	0	-2	-3	1	0	-2	0	-3	-2	2	-1	-3	-2	-1	-1	-3	-2	-3
N	-2	0	6	1	-3	0	0	0	1	-3	-3	0	-2	-3	-2	1	0	-4	-2	-3
D	-2	-2	1	6	-3	0	2	-1	-1	-3	-4	-1	-3	-3	-1	0	-1	-4	-3	-3
C	0	-3	-3	-3	9	-3	-4	-3	-3	-1	-1	-3	-1	-2	-3	-1	-1	-2	-2	-1
Q	-1	1	0	0	-3	5	2	-2	0	-3	-2	1	0	-3	-1	0	-1	-2	-1	-2
E	-1	0	0	2	-4	2	5	-2	0	-3	-3	1	-2	-3	-1	0	-1	-3	-2	-2
G	0	-2	0	-1	-3	-2	-2	6	-2	-4	-4	-2	-3	-3	-2	0	-2	-2	-3	-3
H	-2	0	1	-1	-3	0	0	-2	8	-3	-3	-1	-2	-1	-2	-1	-2	-2	2	-3
I	-1	-3	-3	-3	-1	-3	-3	-4	-3	4	2	-3	1	0	-3	-2	-1	-3	-1	3
L	-1	-2	-3	-4	-1	-2	-3	-4	-3	2	4	-2	2	0	-3	-2	-1	-2	-1	1
K	-1	2	0	-1	-3	1	1	-2	-1	-3	-2	5	-1	-3	-1	0	-1	-3	-2	-2
M	-1	-1	-2	-3	-1	0	-2	-3	-2	1	2	-1	5	0	-2	-1	-1	-1	-1	1
F	-2	-3	-3	-3	-2	-3	-3	-3	-1	0	0	-3	0	6	-4	-2	-2	1	3	-1
P	-1	-2	-2	-1	-3	-1	-1	-2	-2	-3	-3	-1	-2	-4	7	-1	-1	-4	-3	-2
S	1	-1	1	0	-1	0	0	0	-1	-2	-2	0	-1	-2	-1	4	1	-3	-2	-2
T	0	-1	0	-1	-1	-1	-1	-2	-2	-1	-1	-1	-1	-2	-1	1	5	-2	-2	0
W	-3	-3	-4	-4	-2	-2	-3	-2	-2	-3	-2	-3	-1	1	-4	-3	-2	11	2	-3
Y	-2	-2	-2	-3	-2	-1	-2	-3	2	-1	-1	-2	-1	3	-3	-2	-2	2	7	-1
V	0	-3	-3	-3	-1	-2	-2	-3	-3	3	1	-2	1	-1	-2	-2	0	-3	-1	4

Surprisingly, we all use matrix in our daily lives. Image by Kkmann.

Graphic software uses matrix mathematics to process linear transformations to render images. A square matrix, one with exactly as many rows as columns, can represent a linear transformation of a geometric object. For example, in the Cartesian X-Y plane, the matrix $\begin{matrix} 0 & -1 \\ 1 & 0 \end{matrix}$ reflects an object in the vertical Y axis. In a video game, this would render the upside-down mirror image of a castle reflected in a lake.

If the video game has curved reflecting surfaces, such as a shiny silver goblet, the linear transformation matrix would be more complicated, to stretch or shrink the reflection.

The Identity Matrix and the Inverse Matrix

The Identity matrix is an nXn square matrix with ones on the diagonal and zeroes elsewhere. It causes absolutely no change as a linear transformation; much like multiplying an ordinary number by one. The dimension of an Identity matrix is shown by a subscript, so $I_2 = \begin{matrix} 1 & 0 \\ 0 & 1 \end{matrix}$ is the 2X2 Identity matrix.

Suppose we have two square nXn matrices, A and B, such that $AB=I_n$. Then we call B the inverse matrix of A, and show it as A^{-1}. The first practical point is that the inverse matrix A^{-1} reverses the changes made by the original linear transformation matrix A.

The Determinant

Another important task in matrix arithmetic is to calculate the determinant of a 2X2 square matrix. For matrix $M=\begin{bmatrix} a & b \\ c & d \end{bmatrix}$, the determinant is $|M| = a*d - b*c$.

If the determinant of M is zero, then *no* inverse matrix M^{-1} exists.

On the other hand, if we apply M as the linear transformation of a unit square U into U_M, then the determinant |M| is the area of that transformed square. In a sense, the determinant is the size, or "norm", of a square matrix.

Daily Matrix Applications

Matrix mathematics has many applications. Mathematicians, scientists and engineers represent groups of equations as matrices; then they have a systematic way of doing the math. Computers have embedded matrix arithmetic in graphic processing algorithms, especially to render reflection and refraction. Some properties of matrix mathematics are important in math theory.

However, few of us are likely to consciously apply matrix mathematics in our day to day lives.

Readers, please leave a comment: how do you use matrices on a daily basis?

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Comments

Chris says

February 26, 2015 at 9:17 am

I would say the best use for matrices are by setting up experimental test sequences using orthogonal matrices, also know as Design of Expirements. If you have to setup a machine for instance for resistance welding and you want to establish the best parameters for optimizing multiple answers you can drastically reduce the ammount of tests that you need to run while at the same time getting good statistical evidence that the tests are valid.

For instance for resistance welding, I might decide on 3 variables to change. Current, Force, and Time. I then vary the current at two levels 3 kAmps and 5kAmps, force at 2 levels and 2 different times.

Instead of having to run 8 tests imperically, I can setup my test matrix and run 4 tests. With more variables and levels the time and cost savings increase. You also get a statistical understanding of how each variable actually changes the results helping to eliminate variables that dont really have an effect. When imperically testing you always have the question in the back of your mind. Are my results really valid? Did I do enough tests to rely on the result?

You can then optimize different the results for instance to get the strongest weld, the largest welding area, and for the lifetime of the welding electrodes.

I have sometime seen people trying to optimize certain processes where the desired results work counter to each other. With the Matrix data you can quickly see what is possible and what is not possible in a matter of hours instead of days, weeks, or months.

Reply

Guest says
December 26, 2014 at 3:33 pm

Twitter and Facebook, as well as any social network are just huge matrices

Reply

divya hassani says
October 26, 2014 at 11:10 pm

Cryptogram is awesome application of matrix

Reply

Md Matin says
October 23, 2014 at 2:02 pm

Thankx… this is realy helpfull for my project..

Reply

prem says
October 12, 2014 at 7:10 am

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Reply

Shouryodeep Chakraborty says
October 6, 2014 at 12:28 am

thank you , it has helped me in my project

Reply

ravindra kumar prajapati says
September 30, 2014 at 2:15 am

in the real life no real use of matrix if have then prove it .most respect………………

Reply

Ronald says
September 25, 2014 at 5:35 am

This helps me to calculate the number of points that a particular football team has, when goin to shop different locations you can compare prices this can be done by forming array of prices and then prices, do the multiplication.

Reply

mahesh says
August 4, 2014 at 11:21 pm

nice

Reply

veronica ni ni win says
July 7, 2014 at 1:58 am

Thank you very much. It helps me for my papers.

Reply

Shouryodeep Chakraborty says
October 6, 2014 at 12:41 am

me too

Reply

kavya says
July 3, 2014 at 7:12 am

i find interesting solving matrices problems and therefore i use it in my school........

Reply

BinaryStar34 says
January 7, 2014 at 3:18 am

I have no idea what this was supposed to be about and why it needed to be published.

For those who know and use linear algebra, this was an unnecessary article, and for those who don't, it was a useless article, because they can not possibly understand how one can use matrices for circuit simulation.

That would require about one semester of university level math and one semester of university level circuit theory, just to explain the methods.

It's even worse for group theory, 99.9% of which has absolutely nothing to do with matrices.

Reply

Guest says
March 19, 2014 at 3:09 pm

shut up. this helped me loads.

Reply

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About the Author

Mike DeHaan

Mike DeHaan applies his Bachelor of Math in Computer Sciences degree, years of Cobol programming and quality assurance (including testing credit card interest calculations) to research and present mathematical theory for the ... *Read Full Profile*

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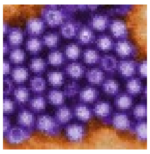

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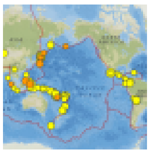

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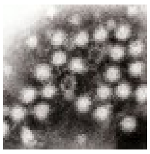

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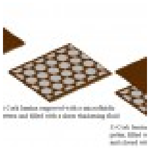

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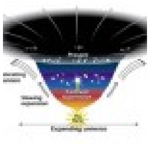

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