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HOW TO CALCULATE OPERATIONS ON MATRICES USING EXCEL

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Abstract:
In the field of medicine: genetic data analysis, radiological image processing, statistical analysis, clinical research and biometric analysis, modeling of biological networks and systems, metabolic analysis and modeling, matrix insertion, matrix addition and subtraction, statistical analysis of matrix operations and mathematical methods, writing matrices in Excel and computing technologies are discussed.

Keywords: Genetic data, radiological imaging, statistical analysis, clinical research, biometric analysis, biological network, modeling, metabolic analysis, matrix, Excel program.

Introduction

In the field of medicine, operations on matrices are widely used in various types of statistical and mathematical analyses. These include the analysis of medical data, image processing, genetics, and biometric data evaluation. Matrices often serve to organize datasets, manipulate them, and perform different operations. Below are several examples of how matrices are applied in medicine:

Genetic data analysis. Matrices are used in genomics and biotechnology to analyze genetic data. For instance, a gene expression matrix contains the expression levels of genes across different samples. Each row corresponds to a

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gene, and each column represents a sample. Matrix operations (such as normalization and clustering) help analyze gene activity patterns.

Radiological image processing. Medical images such as X-rays, CT scans, and MRIs are processed using matrices. Each pixel (or voxel in 3D images) corresponds to an element in a matrix.
Matrix-based operations include:
Filtering: Using a matrix filter to smooth, sharpen, or denoise an image.
Convolution: Performing matrix multiplication between the image and a smaller filter matrix to apply various effects or extract features.
Statistical analysis. Large datasets in medical research are often processed using matrices. Examples include:
Correlation Matrix: Used to examine relationships between various medical variables (e.g., age, blood pressure, cholesterol levels). Each cell shows the correlation coefficient between a pair of variables.
Regression Analysis: In logistic regression and other models, matrices are used to calculate and interpret relationships between independent and dependent variables.
Clinical and biometric data analysis. Matrices are applied in clinical studies and the analysis of biometric data:
Prediction and reconstruction: Patient data collected at various time points can be organized into matrices to build predictive or reconstructive models.
Health statistics: Data such as patient age, sex, and medical history can be organized and analyzed using matrix operations.
Biological networks and systems modeling. Matrices are used to model biological systems such as cellular networks and protein-protein interactions. These interaction matrices help analyze the system's dynamics, for instance in the study of genetic or protein networks.
Metabolic analysis and modeling. Matrices are used to model interactions among metabolites, enzymes, and other molecules in metabolic processes. These interactions form the basis for system models built using mathematical and statistical methods.

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Example: correlation matrix in excel. To analyze relationships between multiple medical variables (e.g., cholesterol level, blood pressure, heart rate), you can create a correlation matrix in Excel. Each column represents a variable, and Excel's =CORREL function is used to calculate the correlation coefficient between them.

Working with matrices in excel. Several Excel functions and methods support matrix operations. Some of the key tools include:

=MMULT: for matrix multiplication.

=TRANSPOSE: to switch rows and columns.

=MINVERSE: to compute the inverse of a matrix.

=MDETERM: to calculate the determinant of a matrix.

These tools make it possible to handle medical data efficiently using Excel.

Working with Matrices in Excel: Step-by-Step Guide.

Matrices are an essential part of many mathematical and data analysis tasks. Microsoft Excel provides several built-in functions to perform operations on matrices. Below is a comprehensive guide on how to input, manipulate, and calculate matrix-based operations using Excel.

1. Entering a matrix in excel. To enter a matrix, select a group of cells corresponding to the matrix's dimensions and fill in the values.

For example, to enter a 2x3 matrix, select 2 rows and 3 columns (e.g., cells A1:C2), and input the numbers directly.

2. Matrix addition and subtraction. Matrices can only be added or subtracted if they have the same dimensions. To perform addition or subtraction in Excel:

Add or subtract each element individually.

For example, if you have two matrices A and B, and you want to compute C = A + B, type the formula in each cell of the resulting matrix like this:

=A1 + B1 (in cell C1), then apply the formula to the remaining elements accordingly.

3. Matrix multiplication. To multiply two matrices, use the MMULT function in Excel. Suppose you have:

Matrix A of size $m \times n$

Matrix B of size $n \times p$

Then the resulting product matrix will be of size $m \times p$.

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Example formula:
=MMULT(A1:B2, C1:D2)
This multiplies the matrix in cells A1:B2 with the matrix in C1:D2.
Note: Press Ctrl + Shift + Enter (if using older versions of Excel) to execute the array formula.
4. Matrix transposition. To transpose a matrix (swap rows with columns), use the TRANSPOSE function.
Example: excel
=TRANSPOSE(A1:B2)
This formula returns the transpose of the 2×2 matrix in A1:B2.
5. Calculating the determinant. The MDETERM function is used to calculate the determinant of a square matrix (e.g., 2x2, 3x3).
Example: excel
=MDETERM(A1:B2)
This returns the determinant of the matrix in cells A1:B2.
6. Finding the inverse of a matrix. To compute the inverse of a square matrix, use the MINVERSE function.
Example: excel
=MINVERSE(A1:B2)
This function returns the inverse of the matrix in A1:B2.
Note: As with multiplication, select the appropriate output range and use Ctrl + Shift + Enter if needed.
7. Sorting matrix elements. To sort a row or column matrix, use the SORT function.
This works well for one-dimensional arrays.
Example: excel
=SORT(A1:A5)
This sorts the values in the range A1 to A5 in ascending order.
8. Performing operations on matrix elements. If you want to apply an arithmetic operation to every matrix element-such as multiplying by a constant or adding a number-you can do so directly.
Examples: excel
=A1 * 2   (doubles the value in A1)

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=A1 + 5   (adds 5 to the value in A1)

Apply similar formulas across the matrix using copy-paste or autofill.

9. Example: adding two matrices. Let's say we are given the following matrices:

Matrix A =

1	-3	5
2	3	2

Matrix B =

0	4	3
2	-2	3

To add these matrices in excel: Enter each matrix into a separate cell range.

In a third range, type a formula in each cell to add corresponding elements.

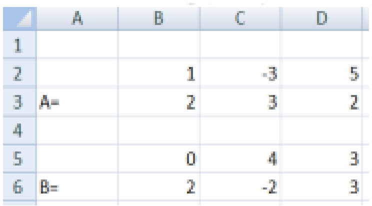
For example, in cell C1 of the result matrix, type: excel

=A1 + B1

Repeat this for each corresponding element.

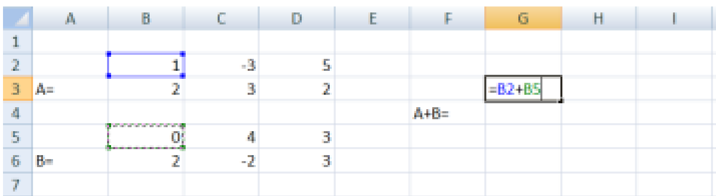
This will generate the resulting matrix:

1	1	8
4	1	5



	A	B	C	D
1				
2		1	-3	5
3	A=	2	3	2
4				
5		0	4	3
6	B=	2	-2	3

II) We enter a formula in a cell to find the sum of the 1st elements of the matrices.



	A	B	C	D	E	F	G	H	I
1									
2		1	-3	5					
3	A=	2	3	2			=B2+B5		
4						A+B=			
5		0	4	3					
6	B=	2	-2	3					
7									

III) We will fill the 2x3 table with the formula in this cell by automatically copying it. To do this, move the mouse to the lower right corner of this cell. When

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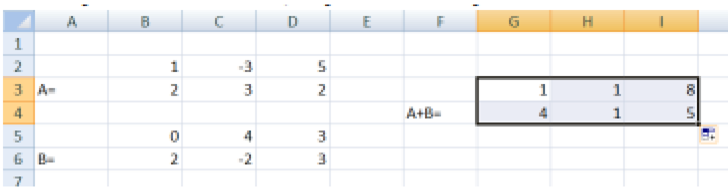
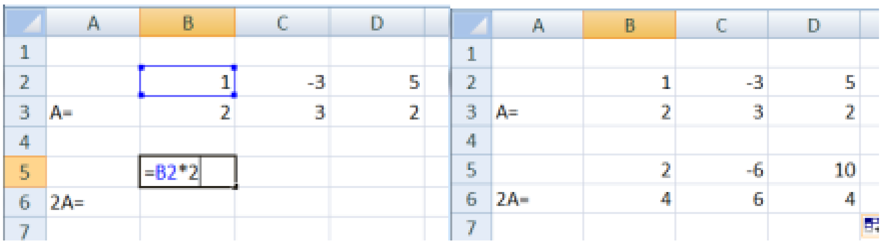
a thick black cursor (cross) appears, click the left mouse button and drag it first three cells in the row, then two cells in the column.



	A	B	C	D	E	F	G	H	I
1									
2		1	-3	5					
3	A=	2	3	2			1	1	8
4						A+B=	4	1	5
5		0	4	3					
6	B=	2	-2	3					
7									

The result is the sum of the matrices.

2) We multiply the matrix A above by 2. To do this, we enter the formula for multiplying the matrix A by 2 in a cell. We automatically fill in the formula in this cell in the way explained above.

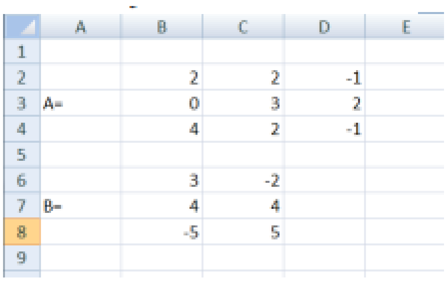


	A	B	C	D
1				
2		1	-3	5
3	A=	2	3	2
4				
5		=B2*2		
6	2A=			
7				

	A	B	C	D
1				
2		1	-3	5
3	A=	2	3	2
4				
5		2	-6	10
6	2A=	4	6	4
7				

3) $A = \begin{pmatrix} 2 & 2 & -1 \\ 0 & 3 & 2 \\ 4 & 2 & -1 \end{pmatrix}$, $B = \begin{pmatrix} 3 & -2 \\ 4 & 4 \\ -5 & 5 \end{pmatrix}$ Let AB be the product. Since the dimensions of matrix A are 3x3 and the dimensions of matrix B are 3x2, the dimensions of the product are 3x2.

I) We enter matrices A and B in a table in Excel.



	A	B	C	D	E
1					
2		2	2	-1	
3	A=	0	3	2	
4		4	2	-1	
5					
6		3	-2		
7	B=	4	4		
8		-5	5		
9					

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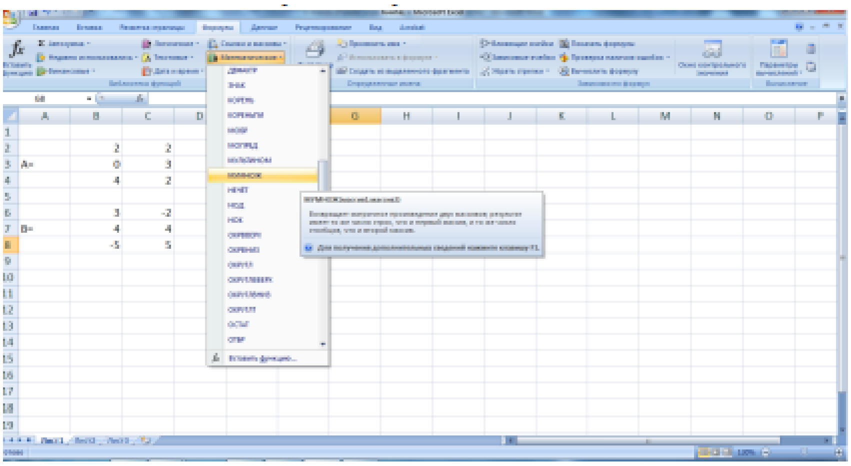
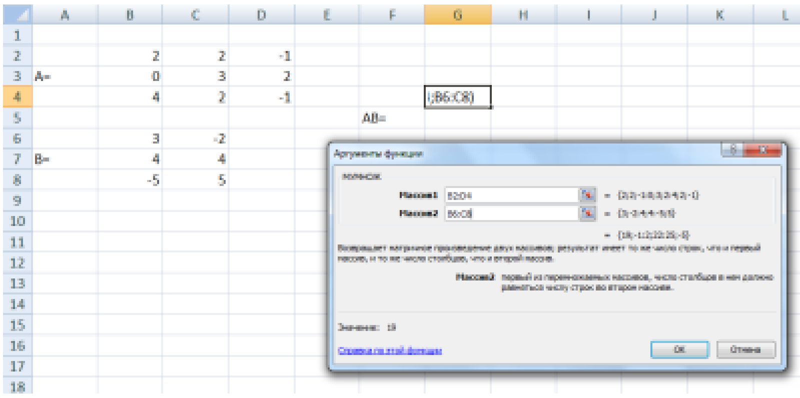
II) From the Excel functions list, find the list of mathematical functions. From this list, select the "МУМНОЖ" function.



III) In the new window that appears, enter the coordinates of matrix A in the "Array1" line, and the coordinates of matrix B in the "Array2" line. Press the Enter button.



IV) In this case, only one element of the product is generated in the cell where the function is entered. To find the other elements, we select a table with three rows and three columns corresponding to the product dimensions as shown in the figure and press the F2 key.

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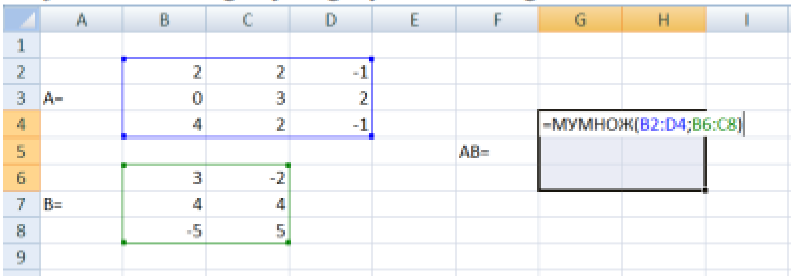
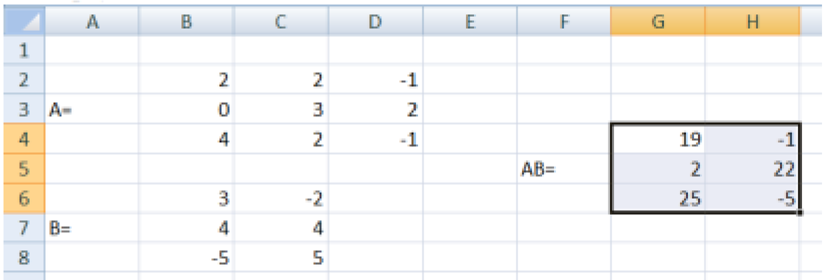


	A	B	C	D	E	F	G	H	I
1									
2		2	2	-1					
3	A=	0	3	2					
4		4	2	-1			=МУМНОЖ(B2:D4;B6:C8)		
5						AB=			
6		3	-2						
7	B=	4	4						
8		-5	5						
9									

V) Press Ctrl+Shift+Enter at the same time. The matrix product will be created in the selected cells.



	A	B	C	D	E	F	G	H
1								
2		2	2	-1				
3	A=	0	3	2				
4		4	2	-1			19	-1
5						AB=	2	22
6		3	-2				25	-5
7	B=	4	4					
8		-5	5					

So, $AB = \begin{pmatrix} 19 & -1 \\ 2 & 22 \\ 25 & -5 \end{pmatrix}$

The Gauss-Jordan method is used to find the inverse of a matrix. This process includes the following steps:

1. Constructing an augmented matrix:

We expand the given non-singular matrix A with the identity matrix E of the same order. This augmented matrix will look like this:

$$(A|E)$$

2. Elementary permutations:

Elementary permutations are performed on the rows of the augmented matrix. The goal is to create an identity matrix in the first part of the augmented matrix

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(i.e., part A). During this process, the following elementary permutations are used:
- Multiply any row by a non-zero number.
- Add one row to another.
- Swap rows.

3. Resulting augmented matrix:
After the process is complete, the augmented matrix will look like this:

$$(E|A^{-1})$$

Here, A^{-1} is the inverse of the given matrix.

Conclusion:
We can write this process in the form of a Gauss-Jordan modification or formula:

$$(A|E) \sim (E|A^{-1})$$

This method performs the necessary elementary manipulations to transform a given matrix into its inverse. If the given matrix is non-singular, then the inverse matrix exists, otherwise it does not.
Example 6. Find the inverse matrix of the given matrix using the Gauss-Jordan method.

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 2 & -1 \\ 2 & 2 & 4 \end{pmatrix}$$

Solution. We write the augmented matrix $\Gamma=(A/E)$ of dimension (3×6). First, we perform elementary permutations on the rows of the matrix to bring it to the echelon form $\Gamma_1=(A_1/B)$, then we bring it to the form $\Gamma_1=(E/A^{-1})$.

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$$\Gamma=\left(\begin{array}{ccc|ccc}1&1&1&1&0&0\\1&2&-1&0&1&0\\2&2&4&0&0&1\end{array}\right)\begin{array}{l}\\II-I\\III-2\cdot I\end{array}\sim$$

$$\sim\Gamma_1=\left(\begin{array}{ccc|ccc}1&1&1&1&0&0\\0&1&-2&-1&1&0\\0&0&2&-2&0&1\end{array}\right)II+III\quad\sim$$

$$\sim\left(\begin{array}{ccc|ccc}1&1&1&1&0&0\\0&1&0&-3&1&1\\0&0&2&-2&0&1\end{array}\right)III\div 2\quad\sim$$

$$\sim\left(\begin{array}{ccc|ccc}1&1&1&1&0&0\\0&1&0&-3&1&1\\0&0&1&-1&0&\frac{1}{2}\end{array}\right)I-II-III\quad\sim$$

$$\sim\left(\begin{array}{ccc|ccc}1&0&0&5&-1&-\frac{3}{2}\\0&1&0&-3&1&1\\0&0&1&-1&0&\frac{1}{2}\end{array}\right)=\Gamma_2$$

So,

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

We check:

$$AA^{-1}=\begin{pmatrix}1&1&1\\1&2&-1\\2&2&4\end{pmatrix}\begin{pmatrix}5&-1&-\frac{3}{2}\\-3&1&1\\-1&0&\frac{1}{2}\end{pmatrix}=\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}.$$

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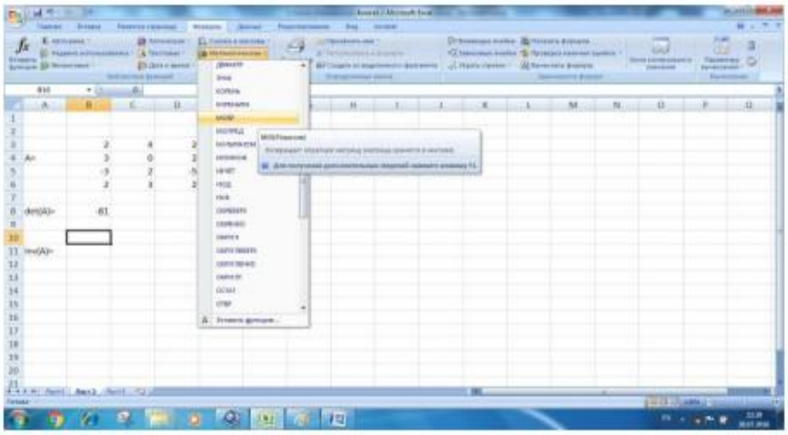
$$A^{-1}A=\begin{pmatrix}5 & -1 & -\frac{3}{2}\\ -3 & 1 & 1\\ -1 & 0 & \frac{1}{2}\end{pmatrix}\begin{pmatrix}1 & 1 & 1\\ 1 & 2 & -1\\ 2 & 2 & 4\end{pmatrix}=\begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix}.$$

Now let's get acquainted with constructing the inverse matrix in Excel.

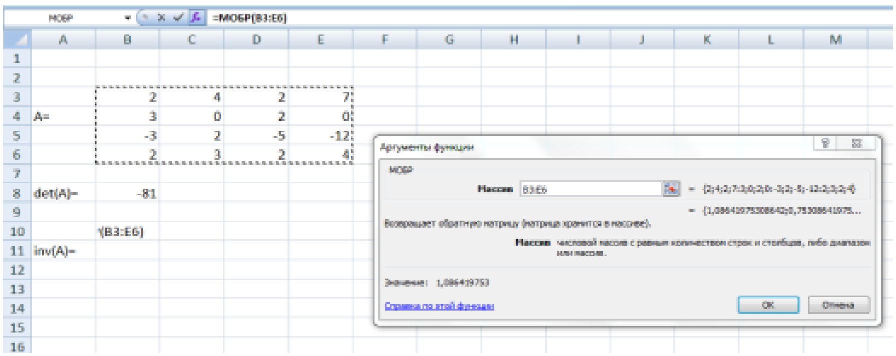
$$A=\begin{pmatrix}2 & 4 & 2 & 7\\ 3 & 0 & 2 & 0\\ -3 & 2 & -5 & -12\\ 2 & 3 & 2 & 4\end{pmatrix}$$

We find the inverse of a matrix. First, we calculate the determinant of the matrix. $det(A)=-81\neq 0$. So, there is an inverse matrix.

I. Select an empty cell. Select the 'MOBR' function from the mathematical functions.



II. In the dialog box, enter the coordinates of the location of matrix A.



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III. Press Enter. The first element of the inverse matrix appears in the selected cell. To create other elements, select a 4 by 4 table starting from this cell and press F2. Then press Ctrl+Shift+Enter together. This will create the inverse matrix.

B10 {=МОБР(B3:E6)}

	A	B	C	D	E	F	G
1							
2							
3		2	4	2	7		
4	A=	3	0	2	0		
5		-3	2	-5	-12		
6		2	3	2	4		
7							
8	det(A)=	-81					
9							
10		1,08642	0,75309	0,12346	-1,53086		
11	inv(A)=	-0,14815	-0,14815	0,07407	0,48148		
12		-1,62963	-0,62963	-0,18519	2,2963		
13		0,38272	0,04938	-0,02469	-0,49383		
14							

We can verify the correctness of the result by checking the matrix multiplication method.

G6

	A	B	C	D	E	F	G	H	I	J	K
1											
2											
3		2	4	2	7						
4	A=	3	0	2	0						
5		-3	2	-5	-12						
6		2	3	2	4			1	0	0	0
7								0	1	0	0
8	det(A)=	-81					A*inv(A)=	0	0	1	0
9								0	0	0	1
10		1,08642	0,75309	0,12346	-1,53086						
11	inv(A)=	-0,14815	-0,14815	0,07407	0,48148						
12		-1,62963	-0,62963	-0,18519	2,2963						
13		0,38272	0,04938	-0,02469	-0,49383						
14											

In conclusion, matrix operations in medicine are important not only in statistical analysis, but also in image processing, genetics, biotechnology, etc. Excel and

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other software are very useful tools for matrix analysis and calculation, allowing you to work with big data in medicine.

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