MAXIMA FOR UNIVERSITY STUDENTS:
MATRICES AND LINEAR ALGEBRA

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ABSTRACT

This paper intends to give a short information about a computer algebra system "Maxima", to emphasize the importance of Maxima facilitation for university students as a book, to deal with the applications of matrices and linear algebra, and to demonstrate privileges of this study.

INTRODUCTION

What is "Maxima"? Maxima is a system for the manipulation of symbolic and numerical expressions, including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, and sets, lists, vectors, matrices, and tensors. Maxima yields high precision numeric results by using exact fractions, arbitrary precision integers, and variable precision floating point numbers. Maxima can plot functions and data in two and three dimensions.

Because of Maxima's open source advantage, I intended to make a contributions to this formation. After some studies I recognized that the program Maxima is very essential for university students and it needs to be summarized and presented in an effective manner. Only then, the university students can easily understand important topics and use the program efficiently. Also, one of the incomplete sides of the Maxima program is that there are not corresponding examples and applications for many functions. So, I want to complete this part of program by applying the functions.

In this paper, I am going to present matrices and linear algebra applications with several examples for each. Firstly, we will learn about functions of matrices. There are short and easy understandable definitions of functions besides their examples.

APPLICATION

This part gives us opportunity to understand functions of matrices, vectors , eigenvalues and eigenvectors. There are short and easy understandable definitions of functions. After table contents, we will solve some problems for more interesting functions.

Table-1: Corresponding Functions for Matrices and Linear Algebra

#	Function	Short Definition
1	addcol	Appends the column(s) given by the one or more lists (or matrices) onto the matrix *M*
2	addrow	Appends the row(s) given by the one or more lists (or matrices) onto the matrix *M*
3	adjoint	Returns the adjoint of the matrix *M*
4	augcoefmatrix	Returns the augmented coefficient matrix
5	charpoly	Returns the characteristic polynomial for the matrix *M* with respect to variable *x*
6	coefmatrix	Returns the coefficient matrix
7	col	Returns the column of the matrix
8	columnvector	Returns a matrix of one column and length (*L*) rows
9	covect	Synonym to columnvector
10	conjugate	Returns the complex conjugate of *x*
11	copymatrix	Returns a copy of the matrix
12	determinant	Calculates the determinant of matrix
13	diagmatrix	Returns diagonal matrix
14	echelon	Returns the echelon form of a matrix
15	eigenvalues	Takes a list of two lists containing eigenvalues of the matrix
16	eigenvectors	Gives lists of eigenvalues and corresponding eigenvectors
17	ident	Returns an *n* by *n* identity matrix
18	invert	Returns the inverse of the matrix *M*. The inverse is computed by the adjoint method
19	minor	Returns the *i*, *j* minor of the matrix *M*. That is, *M* with row *i* and column *j* removed
20	transpose	Returns the transpose of *M*
21	triangulariz	Returns the upper triangular form of the matrix M, as produced by Gaussian

	e	elimination
22	zeromatrix	Returns an *m* by *n* matrix, all elements of which are zero

Table-2: Option Variables

#	Option	Short Definition
1	**detout**	Default value: false When detout is true, the determinant of a matrix whose inverse is computed is factored out of the inverse. For this switch to have an effect doallmxops and doscmxops should be false (see their descriptions). Alternatively this switch can be given to ev which causes the other two to be set correctly
2	**dontfactor**	Default value: [] dontfactor may be set to a list of variables with respect to which factoring is not to occur. (The list is initially empty.) Factoring also will not take place with respect to any variables which are less important, according the variable ordering assumed for canonical rational expression (CRE) form, than those on the dontfactor list
3	**dotdistrib**	Default value: false When dotdistrib is true, an expression A.(B + C) simplifies to A.B + A.C
4	**ratmx**	Default value: false When ratmx is false, determinant and matrix addition, subtraction, and multiplication are performed in the representation of the matrix elements and cause the result of matrix inversion to be left in general representation
6	**vect_cross**	Default value: false When vect_cross is true, it allows DIFF(X~Y,T) to work where ~ is defined in SHARE;VECT (where VECT_CROSS is set to true, anyway.)

Examples with solutions

1. addcol(M,list_1,list_2,…,list_n)

```
(%i1) M:matrix([1,1,1],[2,2,2]);
```

(%o1) $\begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 2 \end{bmatrix}$

```
(%i2) addcol(M,[0,0]);
```

(%o2) $\begin{bmatrix} 1 & 1 & 1 & 0 \\ 2 & 2 & 2 & 0 \end{bmatrix}$

2. adjoint(M)

```
(%i4) M:matrix([1,2,3],[4,5,6],[7,8,9]);
```

(%o4) $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

```
(%i5) adjoint(M);
```

(%o5) $\begin{bmatrix} -3 & 6 & -3 \\ 6 & -12 & 6 \\ -3 & 6 & -3 \end{bmatrix}$

3. augcoefmatrix(eq_1,[x,y])

```
(%i1) eqsys:[5*x+y=2,x-4*y=0]$

(%i2) augcoefmatrix(eqsys,[x,y]);
```

(%o2) $\begin{bmatrix} 5 & 1 & -2 \\ 1 & -4 & 0 \end{bmatrix}$

4. coefmatrix([equation],[x,y])

```
(%i1) coefmatrix([a*x+b*y=0,c*x-d*y=0],[x,y]);
```

(%o1) $\begin{bmatrix} a & b \\ c & -d \end{bmatrix}$

5. (%i6) determinant(matrix([a,b],[c,d]));

(%o6) a d - b c

6. (%i20) eigenvalues(matrix([1,2],[2,1]));

(%o20) [[3, - 1], [1, 1]]

CONCLUSION

As a result, I would like to specify that I am glad to contribute to the computer algebra system Maxima, which is in open source nature and needs to be developed more and more. Moreover, I think that university administration should help for developing this program and prepare wide opportunity for researchers. Thus, every study about Maxima would be supplementation for mathematics area. Finally, I wish university students to use advantages of this simple application.

REFERENCES

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