Mathan

COLLABORATORS			
	TITLE : Mathan		
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Mathan

1.1 Mathan V1.0

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                          Mathan V1.0
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                     1996  Enrique Jimenez

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1.2 Introduction

```
INTRODUCTION

(Sorry for my bad english)

       Did  you ever  need  inverting  a  5x5 matrix, a  calculator with
complex numbers, or solving (x+3)^4+2x+3=0?...

       The Amiga  has  plenty  of  killer  applications related to music,
graphics, word proccesors, databases, etc..., but it lacks of engineering
software (CAD/CAM, etc... ) and math programs like Mathemathica or MatLab
for the IBM PC and Macintosh.

       Mathan  isn't  close  to these programs (yet), but it has a lot of
advanced  features: You can plot a 3D  surface and then save it as an IFF
```

ILBM picture , solve a linear simultaneous equation system or find the eigenvalues of a square matrix.

The program is not finished, but the final version is intended to be used primarily for egineers and students in engineering or maths, so some users will not know anything about many concepts developed in this document. Although you can use Mathan as a calculator you should understand that Mathan is not only a simple calculator with plotting capabilities.

There are plenty of public domain calculators with nice graphic user interfaces... Mathan hasn't a very smart look, but it is not a toy. It runs from a console window (CLI/Shell) where you type the operations. Mathan can also run with any text editor or word processor with ARexx, inserting the results in your document.

1.3 Disclaimer

DISCLAIMER

This software and information is provided "as is". You use it at your own risk. No representations or warranties are made with respect to the accuracy, reliability, performance, currentness or operation of this software and information. The autor will not be liable for any damages resulting from the use of this software.

1.4 Distribution

DISTRIBUTION

Mathan V1.0ß - by Enrique Jimenez - 17-4-96

This software and information is Cardware. I ask you to send me a postcard or a message by E-Mail, so I know how many people is using my program and where my program is used. I have no intention of stopping development, but I would like to know whether the time I am investing is worth it. Donations are welcome.

You may freely copy and distribute it as often you like, with the following limitations:

- The package must remain complete and unchanged.
- The package may be included on CD-ROMs, BBS, magazines, but I ask you to inform the Author.

1.5 Requirements

REQUIREMENTS

Mathan requires the following system to run:

* Workbench 3.0 or above.

* 68020 or better.

1.6 Starting

STARTING THE PROGRAM.

There are two ways to start Mathan: from CLI or from Workbench.

When started from the Shell without parameters, Mathan shows a prompt where you can enter the operations. If the parameter is a file name, then Mathan reads the operations from the file. To quit Mathan you may write the command 'Exit' or 'Quit' (NOTE the Upper case).

When started from the Workbench, or when the parameter from the Shell is -rexx, Mathan runs in the background, and accepts commands through an ARexx port called 'Mathan'. Mathan terminates when you send the command 'Exit' or 'Quit'.

Mathan may be used with any text editor or word processor with ARexx support. You can find some excelent shareware text editors in the public domain, like Blacks Editor by Marco Negri, or you can use the AmigaDos text editor, Ed.

There are supplied ARexx scripts for Blacks Editor, ProWrite and Ed. If you use one of these programs, then you can try opening the file examples/demo.mth (for example), put the cursor in the line you want to evaluate and execute the ARexx macro for your editor (with Blacks Editor and ProWrite you can assign the ARexx macro to a keyboard short cut, but with Ed you can use FKey).

Otherwise you need to write an ARexx script for your text editor, then assign the ARexx script to any menu item or keystroke, like CTRL-RETURN, to invoke Mathan to insert a result. SEE THE SUPPLIED SCRIPTS.
The configuration can be a bit complicated for a novice user, so I hope to include more ARexx scripts in further versions. If you have any trouble, don't hesitate to contact me.

1.7 Functions

FUNCTIONS

Mathan supports standard built-in functions and user~functions.

```
Built-in functions:


Trigonometric (angular measurement unit = radians)

Cos()~          cosine
Sin()~          sine
Tan()~          tangent
ArcCos()~       arc cosine
ArcSin()~       arc sine
ArcTan()~       arc tangent
Cosh()~         hyperbolic cosine
Sinh()~         hyperbolic sine
Tanh()~         hyperbolic tangent
Sec()           1/Cos()
Cosec()         1/Sec()
Sinc()          Sin(x)/x
Cosc()          Cos(x)/x

Logarithmic and exponential

Exp()~          e to the exponent
Ln()~           base e logarithm
Log()~          base 10 logarithm

Other scientific calculations

Abs()~          absolute value
Sgn()           sign
Int()           interger
Sqrt()~         square root

Complex related functions

Mod()~          magnitude of a complex number
Arg()~          phase of a complex number
Re()~           real part of a complex number
Im()~           imaginay part of a complex number

Matrix related functions

Inverse()~      inverse of a matrix
Transpose()~    transpose of a matrix
EigenValues()~  eigenvalues of a matrix
Det()~          determinant of a matrix
Pol()~          characteristic polynomial of a matrix
LU()~           LU decomposition of a matrix
QR()~           QR decomposition of a matrix
LES()~          linear equation solver

Polynomial related funtions

Roots()~        polynomial roots

Special~functions
```

```
Sum()~          number addition
Prod()~         number multiplication
u()             unit step

Graphics functions

Draw()~         draw a function
Plot()          draw a implicit function

Special commands

Exit            quit Mathan
Quit            quit Mathan

Predefined constants

pi              pi=3.14159...
i               i=Sqrt(-1)
j               j=Sqrt(-1)
```

1.8 User functions

```
USER FUNCTIONS


    You can define functions of eight parameters. The format is:

      <function name>(<parameter1,parameter2,...>)=<expresion>

     * The function name can be up to 255 characters.
     * The expresion may be any object: number, matrix, etc...
     * Everything is case dependent.

  Some examples:

      /* Constants */

      a=3

      /* A function of three variables */

      f(x,y,z)=Sin(x)*Cos(y)+z

      /* You can use long names */

      abcdefghij(var)=Sqrt(var+1)

      /* A matrix function of two parameters */

      W(q,r)={{1,Sin(r),Cos(q)},{Sin(r),r,6},{Cos(q),6,q}}
```

1.9 Inverse

```
Inverse()

        Inverse of a matrix.
        Example:

        >a={{1,2,3,4},{2,3,4,1},{3,4,1,2},{4,1,2,3}}
                1        2        3        4
                2        3        4        1
                3        4        1        2
                4        1        2        3
        >b=Inverse(a)
               -0.225    0.025    0.025    0.275
                0.025    0.025    0.275   -0.225
                0.025    0.275   -0.225    0.025
                0.275   -0.225    0.025    0.025

        You can verify the result calculating a*b. The result is the
        identity matrix, but due to the number precision there are some
        rounding errors, so you can get numbers like 1e-16. You can
        assume these numbers to be 0.
```

1.10 Transpose

```
Transpose()

        Transpose of a matrix.
        Example:

        >c={{1,8,4},{2,3,1}}
                1        8        4
                2        3        1
        >Transpose(c)
                1        2
                8        3
                4        1
```

1.11 LU

```
LU()

         LU decomposition of a matrix. The format is:
         LU(<A matrix>,"<P name>","<L name>","<U name>")

         The function returns three matrices, P is a permutation matrix,
         L a low triangular and U an upper triangular matrix, and

                 A=P*L*U

          Example:
```

```
 >a={{1,2,3,4},{2,3,4,1},{3,4,1,2},{4,1,2,3}}
       1        2        3        4
       2        3        4        1
       3        4        1        2
       4        1        2        3
 >LU(a,"p","l","u")
 >p
      0       0       0       1
      0       0       1       0
      0       1       0       0
      1       0       0       0
>l
      1       0               0               0
      0.75    1               0               0
      0.5     0.769231        1               0
      0.25    0.538462        0.818182        1
>u
      4       1       2         3
      0       3.25    -0.5      -0.25
      0       0       3.384615  -0.307692
      0       0       0         3.636364

You can verify that a=p*l*u.

>p*l*u
      1       2       3       4
      2       3       4       1
      3       4       1       2
      4       1       2       3
```

1.12 QR

```
QR()

        QR decomposition of a matrix. The format is:
        QR(<A matrix>,"<Q name>","<R name>")

                A=Q*R

        Q is ortogonal and R triangular.

        Example:

        >a={{1,2,3,4},{2,3,4,1},{3,4,1,2},{4,1,2,3}}
               1        2        3        4
               2        3        4        1
               3        4        1        2
               4        1        2        3
        >QR(a,"q","r")
        >q
        0.182574        0.365148        0.490098        0.770154
        0.365148        0.426006        0.536774       -0.630126
        0.547723        0.486864       -0.676802        0.070014
        0.730297       -0.669439        0.11669         0.070014
        >r
```

```
5.477226        4.38178          4.016632        4.38178
0               3.286335         1.947458        0.852013
0               0                3.173968        1.493632
0               0                0               2.80056
>q*r
1       2       3       4
2       3       4       1
3       4       1       2
4       1       2       3
```

1.13 Det

```
Det()
```

Determinant of a matrix.

Example:

```
>a={{1,2,3,4},{2,3,4,1},{3,4,1,2},{4,1,2,3}}
        1       2       3       4
        2       3       4       1
        3       4       1       2
        4       1       2       3
>Det(a)
        160
```

1.14 LES

```
LES()
```

Linear equation system solver. Format:

LES(<A matrix>,<b matrix>)

The function returns the x solution of: A*x=b

Example 1:

Imagine the system:

```
 2u +  v + w =  1
 4u +  v     = -2
-2u + 2v + w =  7
```

In the matrix notation:

```
 2         1        1         u        1
 4         1        0   *     v   =   -2
-2         2        1         w        7
```

```
>A={{2,1,1},{4,1,0},{-2,2,1}}
>b={1,-2,7}
```

```
>LES(A,b)
        -1
         2
         1

Then the solution is
        u = -1
        v =  2
        w =  1

Example 2:

We don't know the function f(x,y,z), but we have the
experimental data:

 x    y     z     f

 2    1     1     2
 4    1     0    -1
-2    2     1     8
 1    1     1     5
 4    2     2     3

We think that f(x,y,z) is like

        f(x,y,z)=ax+by+cz+d

So we have the system:

 2a+ b+ c+d= 2
 4a+ b+  +d=-1
-2a+2b+ c+d= 8
  a+ b+ c+d= 5
 4a+2b+2c+d= 3

Without the last equation we get a=-3,b=-6,c=-3,d=17.

>A={{2,1,1,1},{4,1,0,1},{-2,2,1,1},{1,1,1,1}}
>b={2,-1,8,5}
>LES(A,b)
         -3
         -6
         -3
         17

But the last equation shows that the system is incompatible:

>g(x,y,z)=-3x-6y-3z+17
>g(4,2,2)=-13

We can find the best function using the less squares method:

>A={{2,1,1,1},{4,1,0,1},{-2,2,1,1},{1,1,1,1},{4,2,2,1}}
>b={2,-1,8,5,3}
>AA=Transpose(A)*A
>bb=Transpose(A)*b
>LES(AA,bb)
```

```
        -1.162162
         0.486486
         1.756757
         3.054054

Then the best approximation is:
        a=-1.162162
        b=0.486486
        c=1.756757
        d=3.054054
```

1.15 Pol

```
Pol()

        Characteristic polynomial of a matrix.

              Det(A-xI)

        Example:

        >mat={{1,0,3},{3,-1,2},{4,1,2}}
        >Pol(mat)
                (x)^3-2*(x)^2-15*x-17
```

1.16 EigenValues

```
EigenValues()

        Eigenvalues of a matrix.

                Det(A-xI)=0

        Example:

        >mat={{1,0,3},{3,-1,2},{4,1,2}}
        >EigenValues(mat)
                 5.377185         0
                -1.688687        -0.556536
                -1.688687         0.556536

        The first column is the real part, and the second the imaginary
        part, so the eigenvalues are:

                 5.377185
                -1.688687 - 0.556536*j
                -1.688687 + 0.556536*j

        You can get the same result with

        >Roots(Pol(mat))
```

1.17 Roots

POLYNOMIAL ROOTS

The Roots() function calculates the polynomial roots, but this will not work with multivariable polynomials.

Example:

```
>Roots(x^4+5x^3+7x^2-3x-10)
 -2    0
  1    0
 -2   -1
 -2    1
```

The roots are -2,1,-2+i and -2-i. You can verify the result:

```
>(x+2)(x-1)(x+2-i)(x+2+i)
 (x)^4+5*(x)^3+7*(x)^2-3*x-10+0*i
```

NOTES:

* Mathan can't calculate the roots of multivariable polynomials like x^2+2y-3z+1.

* For polynomials like Sin(x)*Sin(x)-1, the roots are for the polynomial variable Sin(x), not x. Example:

```
>f(x)=Sin(x)*Sin(x)-1
>Roots(f(x))
 -1   0
  1   0
```

Then the roots are in Sin(x)=-1, Sin(x)=1. The solutions are

$$x=\pi/2+k*\pi \quad (k=0,1,2,...)$$

1.18 Special

SPECIAL FUNCTIONS

Sum()

Format:

Sum("<expresion>",<range>)

<range>={"<var name>",<start>,<stop>}

Example:

```
>Sum("x^2",{"x",0,5})
 55
```

```
       (0^2+1^2+2^2+3^2+4^2+5^2 = 55)

 Prod()

         Format:
                 Prod("<expresion>",<range>)

                 <range>={"<var name>",<start>,<stop>}

         Example:

         >Prod("x^2",{"x",1,5})
          14400

         (1^2*2^2*3^2*4^2*5^2 = 14400)

 u()
         Unit step, or Heaviside function:

         u(x)=0 if x<0
         u(x)=1 if x>=0

            Example:

            >Draw("{x,1+(x^2-x)*u(x-1)}",{"x",-2,2,100})
```

1.19 Graphics

```
 GRAPHICS

 Drawing functions.

       Draw("<point>",<range>,[<range>])

       <point> = {x,y,z} or {x,y}

       <range> = {"name",start,stop,[count]}

 Examples.

   *   Drawing 2D functions.

         This example draws the Sin() function calculating 30 points
         between 0 and 2pi. The more points (count parameter), the
         more accurate plot.

         Draw("{x,Sin(x)}",{"x",0,2pi,30})

    *  Drawing 3D functions.

         Try the next line (draws a cube):

         Draw("{Cos(x),Sin(x),y}",{"x",-pi,pi,4},{"y",0,Sqrt(2),1})

         This example draws the function f(x,y)=x*x-y*y in the range
```

-2<x<2 and -3<y<3, calculating 20*20=400 points.

Draw("{x,y,x*x-y*y}",{"x",-2,2,20},{"y",-3,3,20})

* NOTES

-The observer point can be rotated with the keyboard cursor.

-You can print or save (IFF ILBM) the image in the Project menu.

-If you save the graphic as a Mathan gfx, then you can display the graphic with the program DisplayM.

-If you save the graphic as ASCII, then you can import the data from any program like Excel and add axis labels and so on.

-The graphic window multitasks with Mathan. You can have several windows at once.

-You have these examples and more in the file examples/demo.mth, so you can execute them with the command (from the Shell):

>mathan examples/demo.mth

1.20 Objects

OBJECTS

Mathan works with several types of objects. Some functions only deal with certain objects types, and some operations are not allowed.

List of objects types:

Real
Complex
Matrix
Polynomial
String

1.21 Real

REAL NUMBERS

Real numbers are C-style signed double precision floating point numbers. The range depends of the implementation, in the Amiga the range is from 2.222E-308 to 1.797E+308. I'd have no problem changing the real type to long double in the source code, but this is planed for further versions.

Internally mathan uses integer numbers for some operations. For

example, type in a normal calculator:

```
(2/15)*3
```

You will get the reply 0.39999999, because the floating point format used by computers is not exact. You can see that:

```
(2/15)*3 = 2/5 = 4/10 = 0.4
```

Mathan will try to avoid using the floating point format. Mathan knows that (2/15)*3 is not (0.13333333)*3, but the fraction 2/5.

1.22 complex

COMPLEX NUMBERS

Entering complex numbers is simple. Some examples:

```
3+2i
3+2j
(2+2i)*(4+i)/(2-i)
```

Mathan accepts "j" and "i" as constant functions with the value Sqrt(-1). Note that (2+3)i is 5*i, but i(2+3) is i(5), and i(5) is i, because "i" is constant. I recommend using the "*" symbol to prevent errors (see also multiplicaton~notes).

1.23 Matrix

MATRIX OBJECTS

The { and } symbols can be used to enter a matrix. For example:

```
A={{1,2,3},{4,5,6},{3,1,2}}
```

```
     1 2 3
A= 4 5 6
     3 1 2
```

The matrix dimension is limited to 1000 elements in this version, so mathan can handle matrices up to 30x30 or 50x20. In further versions only the amount of free memory will restrict the matrix size.

See Also:

Inverse()
Transpose()
Det()
LU()

```
QR()
LES()
Pol()
EigenValues()
```

1.24 Polynomial

```
POLYNOMIAL

        Mathan can operate with polynomials of order n. For example:

                >(x+2)(x+3)^2
                 (x)^3+8(x)^2+21*x+18

        (if the variable x is defined then the result will be different)

        The polynomial can be composed of several variables:

                >x*(y+z)^2
                 x*(y)^2+x*(z)^2+2*x*y*z


        See Also:

        Roots()
```

1.25 String

```
STRING OBJECT

         Sometimes Mathan needs a variable name, not the current value of
the variable, or needs a expression to evaluate later, not the current
value of the expression. For this reason the string object is used.
Some examples:

         "x"     (the variable x, not the current value)

          Sum("3x+2",{"x",1,3})
          Draw("{x,y,x*x+y*y}",{"x",-2,2},{"y",-2,2})
```

1.26 Configuration

```
CONFIGURATION


Mathan needs some files to run.

config/mathan.dfn

You can edit the file mathan.dfn to translate the error messages
```

to your language.

displaym.thd

Mathan needs the file displaym.thd to draw graphics.

1.27 External Programs

EXTERNAL PROGRAMS

I'm suppling other two programs with Mathan: DisplayM and AdToDat.

DisplayM displays any graphic saved in the Mathan gfx format.

The program AdToDat converts any graphic in the Mathan format to
the ASCII format.

1.28 Bugs

BUGS AND NOTES

Multiplication Notes.

Mathan accepts implicit multiplication. When no operator is found
multiplication is assumed.

```
3x     is 3*x
3(2+3) is 3*(2+3)
```

Sometimes you must write the "*" symbol:

- xy is not x*y, but the function xy().

- (3+2)x is parsed as 5*x, but x(3+2) is parsed as x(5), this is
  the function x with parameter 5. If the function x has no
  parameters (constant), then the parameters are ignored.

- 3e or 3E is not 3*e or 3*E, but 3e0 and 3E0 (i.e. 3*10^0).
  You must write the "*" before any function starting with "E",
  because Mathan reads the numbers in the scientific format.

Bugs

My system hasn't MMU, so I haven't tested Mathan with Enforcer.
However, I have tested Mathan with MungWall, and it reported
no errors.

Bug reports can be sent to:

e-mail: n109701@eicaiii.uc3m.es

or:

Enrique Jimenez
Romero Robledo 20, 3\textdegree{}A
28008 MADRID
SPAIN

1.29 Future

FUTURE

I have no intention of stopping development.
I'm working in:

- Bugs.
- OS-independent source code.
  (I hope to compile an Unix/X Window version.)
- Derivation and integration (Numerical&Symbolic).
- Matrix algebra.
  (EigenVectors,Singular Value Decomposition,...)
- System analysys, control and estability.
  (Simulation, Bode Plots, Root Locus Plots,PID design,...)
- Numerical methods for Ordinary and Partial differential Equations.

- Graphic User Interface for Mathan.
- ARexx macros for all the text editors/word processors.
- Interface with other software.

1.30 Author

AUTHOR

I'm a 21 years old engineering student in Madrid, Spain. Mathan is my first program, and it was written in standard C using the DICE V3.0 compiler on an Amiga 1200 with a 68030/50Mhz, 6 Mb of memory and 430 Mb of HD.

About 90% of the code is ANSI C. There is a IBM PC DOS version of Mathan... but it seems that the whole PC users community is playing Doom...

Queries, comments, bug reports, suggestions or anything are all wellcome, and can be sent to:

Enrique Jimenez
Romero Robledo 20, 3\textdegree{}A
28008 MADRID

SPAIN

e-mail: n109701@eicaiii.uc3m.es