Mathematica on SCD's IBM rs6000 platform

Mark Serda

Richard Valent, supervisor
1992 Summer Employment Program
Scientific Computing Division
National Center for Atmospheric Research
Boulder, Colorado 80307

The National Center for Atmospheric Research is sponsored by the National Science Foundation.
Introduction

The focus of my project is to document a mathematical software package, called Mathematica, for the SCD (Scientific Computing Division) User Documentation Catalog for the National Center for Atmospheric Research (NCAR). Mathematica is a software package that has recently arrived at NCAR. No one has experimented much with the package itself, so it was my obligation to research Mathematica and then give NCAR users a brief, but informative introduction to Mathematica through the use of the User Documentation at SCD.
About Mathematica

Mathematica is a mathematical and symbolic computational software package that belongs to a class of applications software known as Technical Calculation Software. This package provides users with more than 800 built-in mathematical objects capable of performing numerical, symbolic, and graphic computations. Mathematica functions are labeled built-in objects rather than functions in order to distinguish from mathematical functions like those taught in school. The notation of these objects often compares to functions of mathematical and scientific textbooks used by college students.

Not many users at NCAR had experimented with Mathematica, so as the initial stage of my project, I researched some of Mathematica's expanded capabilities. I also used the descriptive textbook, Mathematica: a system for doing mathematics by computer, by Stephen Wolfram, 2nd edition, Redwood City, Ca.: Addison-Wesley, 1991, as a resource on Mathematica. These are some of the computational properties that I researched.

Numerical Computation

The range of numerical computations in Mathematica covers basic arithmetic to advanced math concepts such as differential equations, integration, and Fourier transforms.

Among the basic mathematical functions Mathematica provides are the often-used trigonometric functions, logarithms, and hyperbolic functions as well as other functions usually found on a basic scientific calculator. The notation is much like a calculator or a mathematics book.

Mathematica also provides built-in constants that would be used for many of these calculations, such as $\pi$ (Pi) or the exponential, $e$ (E). Mathematica keeps track of all types of numbers (rational, real, etc.) in your numerical computation.

Some of the higher-math capabilities of Mathematica in numerical computation include solving initial value problems in differential equations, taking definite integrals, taking numerical summations, solving systems of equations numerically, and of course numerical matrix operations, which are common in most mathematical software packages.

Symbolic Computation

Like numerical computations, the symbolic computations of Mathematica span basic to advanced mathematical concepts. In this span, Mathematica covers almost all calculus concepts, such as summations, series, indefinite integration, derivatives, anti-derivatives, and differential equations. Such topics covered in
With the solution, this is the input and output given in Mathematica:

\[
\text{In[2]} := \text{Plot}[1 - \text{Csc}[2] \sin[2 \, x], \{x, -3 \pi, 3 \pi\}]
\]

\[
\text{Out[2]} := \text{-Graphics-}
\]

The actual graphic appears in another window due to the fact that I operated Mathematica under the X-Windows System. The graphic appears as follows:

![Graph](image)

Figure 1. Two-dimensional graph of the solution, \(y(x) = 1 - \csc(2\sin(2x))\).

**3-D Graphic displays**

Now let’s produce a three-dimensional graph using the same solution, \(y(x) = 1 - \csc(2\sin(2x))\).

To produce a three-dimensional graph, the built-in object `Plot3D[f, \{x, xmin, xmax\}, \{y, ymin, ymax\}]` is used. The equation is input and then output in Mathematica as follows:

\[
\text{In[3]} := \text{Plot3D}[1 - \text{Csc}[2] \sin[2 \, x], \{x, -3 \pi, 3 \pi\}, \{y, -3 \pi, 3 \pi\}]
\]

\[
\text{Out[3]} := \text{-SurfaceGraphics-}
\]
Again, the graphic displayed on the window is:

![Graphic of a smooth curve of the 'saddle' equation, \(y^2-x^2\).](image)

Figure 3. A smooth curve of the 'saddle' equation, \(y^2-x^2\).

Mathematica provides many other built-in objects that are graphically oriented. Some of these objects have the ability to produce graphics without entering equations. A few of these built-in objects will be discussed later.

**Extra Features of Mathematica**

**Sound**

In their recent upgrade, Version 2.0 (Version 2.1 coming soon), Mathematica has added a unique feature to its increasing list, sound. The focus of the sound feature is the built-in object, `Play[\(f, \{t, 0, t_{max}\}\]`, where \(f\) is the function that is to be given a waveform plot and \(t\) is the time that the sound spans from 0 to \(t_{max}\). With this object, Mathematica will plot a waveform and actually produce the sound of the wave.

To give an example of the `Play` object, I will use the wave function, \(\cos(300t) - \sin(130t)\). In Mathematica this is what is input and then output:

```
In[5]:= Play[\cos[300t] \- \sin[130t], \{t, 0, 1\}]
```

```
Out[5]= \-Sound\-
```

Like Mathematica’s graphic objects, the built-in sound object, Play, allows the user to visualize the graph itself. So not only does Play produce sound, but it also displays a separate graphic window to display the waveform.

Since sound is a relatively new feature in Mathematica there are not many built-in objects available at this point, although it can be expanded in future versions of Mathematica.
Figure 6. 3-D graphic of a dodecahedron called from the package Graphics 'Polyhedra'.

Of course, there are other auxiliary packages that provide specific areas in mathematics, such as vector analysis, statistics, discrete mathematics, and Laplace transforms. So the features of Mathematica are becoming limitless.

This research set the stage for planning what material I would include in my documentation for Mathematica as well as increase of my knowledge of Mathematica for a possible future reference in my remaining years in college.
Included in the setup section were providing the requirements for running Mathematica on your server and instructions for setting certain environment variables in your UNIX-based computer account. From my research into Mathematica, I found that Mathematica could only be run on X-Window or OpenLook for a UNIX-based server.

The main section of the UserDoc stepped through a simple session of Mathematica that included examples of how to do a symbolic computation and how to produce graphic displays in 2-D and 3-D.

The final section explains the process of getting a hardycopy output out of Mathematica and how to import PostScript files from Mathematica to FrameMaker.

The UserDoc that I developed is quite brief. Its goal is to introduce NCAR users to Mathematica and not in any way to replace such references as the much-acclaimed and informative Mathematica: a system for doing mathematics by computer, by Stephen Wolfram, 2nd edition. Redwood City, Ca.: Addison-Wesley, 1991.
Conclusions

As a result of my project at NCAR for the summer, NCAR users now can become more familiar with this mathematical software package. With the combined efforts of my research into Mathematica and the documentation of it in the UserDoc, users at NCAR can now have a brief but informative introduction to Mathematica. The distribution alone will make users aware of the software package's availability and potential uses.