NeXTstep®: An Ideal Platform for *Mathematica*® Studies

In the fields of education and research *Mathematica*'s value and promise is well known. At NeXT™, we understand and appreciate this potential; in fact, *Mathematica* comes bundled with every NeXT computer delivered to users in higher education.

NeXT engineers and scientists have explored dozens of research problems via *Mathematica* on NeXT computers. The global reason for the superiority of the NeXT platform is that in NeXTstep—the graphical user interface and associated development tools bundled with all NeXT computers—*Mathematica* runs with unprecedented efficiency and flexibility. Here is a list of NeXTstep advantages for the *Mathematica* user:

• **Concurrent window interface:** *Mathematica* runs elegantly alongside other applications.
• **High-resolution graphics:** certain studies require the MegaPixel resolution.
• **Superior speed and memory:** many problems previously unassailable can now be resolved on NeXT computers.
• **Testing, prototyping, and porting:** *Mathematica* can be the starting point for algorithms that are later ported for great speed in the C or Objective-C languages.
• **Media processing:** sounds and images may be acquired via NeXT computers and further analyzed via *Mathematica.*
• **Interprocess communication:** other programs may message *Mathematica* to obtain answers in an automated way.
• **Parallelization:** multiple *Mathematica* sessions may be invoked on networks of NeXT machines to allow the simultaneous solution of different parts of a problem.

This paper describes these features and benefits enjoyed by users who run *Mathematica* on NeXT computers. For more information on NeXTstep, please consult companion papers, *The NeXTstep User Interface,* which describes the features and benefits of NeXTstep from the user's perspective, and *The NeXTstep Development Environment*, which presents NeXTstep from the developer's point of view.

Concurrent Window Interface

The user running *Mathematica* starts out with the considerable advantage of a standard NeXTstep application. Not only are the menus, multiple windows, and dialog panels extensive and complete, but all text and graphics follow the standard PostScript® imaging model. This means you may cut and paste information readily between *Mathematica* windows and other application windows. For example, a NeXTstep demonstration application called CircuitBuilder generates explicit circuit equations into one of its windows. These often formidable equations can be immediately pasted into the window of a concurrently executing *Mathematica* application. When the equations are solved via *Mathematica,* you then confront a host of options shared by all PostScript-supporting applications. You may graph frequency response curves, or work out circuit parameters numerically and generate tables, or perform statistical analyses.

In addition, the NeXT *Mathematica* user may keep *Mathematica* active—but "hidden"—in the application dock, ready for recall at any time. Because of the refined and well-tested efficiency of the Mach UNIX® operating system, *Mathematica* causes virtually no overhead until you call for it; you can launch *Mathematica* once in a great while, and always have it in a state of readiness.

High-resolution Graphics

The NeXT MegaPixel Display affords a distinct advantage in areas such as modern studies of chaotic phenomena. Whether the problem involves bifurcation, fractals, or phase transitions, you generally confront tremendous complexity. This complexity often manifests itself as a fine graphical detail, hence the advantage of the high resolution display.

Color graphics are just as natural as gray-scale graphics, since the color paradigm is an integral part of the PostScript model. As described in the previous section, graphics, both color and monochrome, may also be pasted back and forth between applications.

Superior Speed and Memory

The claim of superior speed is by no means artificial. NeXT has found that the 68040-based NeXTstation™, for example, tends to run *Mathematica* calculations about an order of magnitude faster than, say, a Macintosh® IIci. Perhaps equally important for the physical sciences, where huge data storage is often the rule, all NeXT computers enjoy superior virtual memory performance. Here is why: First, when you obtain *Mathematica* with your NeXT computer, you do not have to buy more memory to get the application to run. Second, virtual memory management is so seamless that, depending on your disk configuration, you can run sessions that require tens, or even hundreds of megabytes of storage. Third, if you write an erudite *Mathematica* recursion for which storage runs on to infinity, you will not hurt your computer. NeXT computers are uniquely graceful in the way they handle the exhaustion of resources.

Here is an example of the joys of speed-with-memory. A problem was presented to NeXT's Scientific Computation Group by a NeXT Campus Consultant. Evidently, various alternative computer systems had failed to solve a horrendous nonlinear system in ten unknowns, arising from a chromatographic model. We solved this problem symbolically on a NeXTstation running *Mathematica.* During the successful computations, it was observed that virtual memory ranged up to 20 megabytes. Most other computers would not have provided the required, accurate disk thrashing or the computation speed required for this problem.

Testing, Prototyping, and Porting

Say you have an algebraic problem whose solution will necessitate an eventual expense of billions of floating point operations. You may fear that if a mistake is present in your code (which could be C or Objective-C), then at least the first pass at calculation will amount to "wasted billions." Often you can test the problem in *Mathematica* first. If everything checks out, you can transfer the calculation to the C or Objective-C programming environments available on all NeXT computers.

Here is an example of *Mathematica* playing an important role as a prototyping tool. A recent research project involved a computation of gigantic polynomials. These were to be finite series approximations to the function:

$$f(t) = \sin(t)\ \sin(\omega t)\ \sin(\omega^2 t)\ \sin(\omega^3 t)\ \sin(\omega^4 t)\ \sin(\omega^5 t)\ \sin(\omega^6 t)\ \sin(\omega^7 t)$$

where ω is an eighth root of unity, $\omega = e^{i\pi/4}$. But *Mathematica* investigation showed that the first few terms of f(t) are:

$$-t^8 + \frac{t^{16}}{4725} - \frac{1838\ t^{24}}{162820783125} + \frac{29039641\ t^{32}}{3028793579456347828125}$$

This suggests that the function f(t) might be, in reality, a series in powers of t^8. Indeed, this is so, and the testing exercise saved a factor of 8 when the problem was ported over to C routines running on a network of NeXT computers.

Media Processing

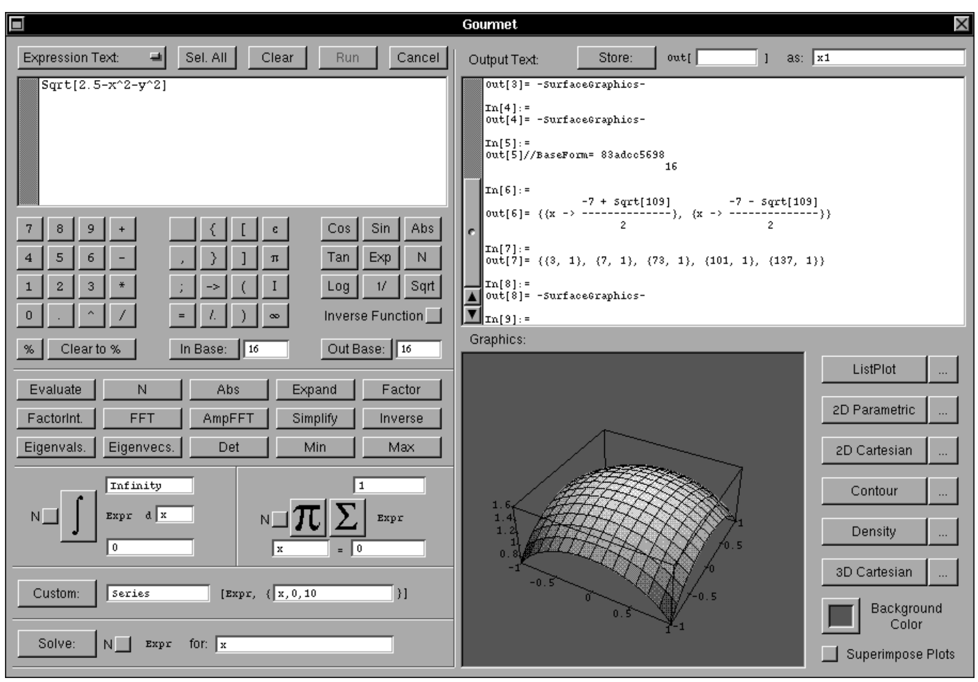
A feature of NeXT computers is that they may acquire sounds and images, in some instances on a real-time basis. *Mathematica* provides a good way to experiment with media processing. Here is an example: Say that you have a sound file and want to create a spectrogram or a sonogram. Read the sound file into *Mathematica,* perform the requisite Fast Fourier Transforms (FFTs) using built-in functions `Fourier[]` and `InverseFourier[]`, then graph the results in meaningful format. For image processing, you can read in an image file, and easily apply two-dimensional FFTs, or antialiasing, or de-blurring routines via *Mathematica.*

The educational potential for such media-oriented transformations is profound. Imagine a student's term project involving optical character recognition proceeding on the basis of files of text images on which the student learns to perform two-dimensional transforms. The key benefit is NeXT computers allow virtually all these operations to proceed in a self-contained, concurrent manner.

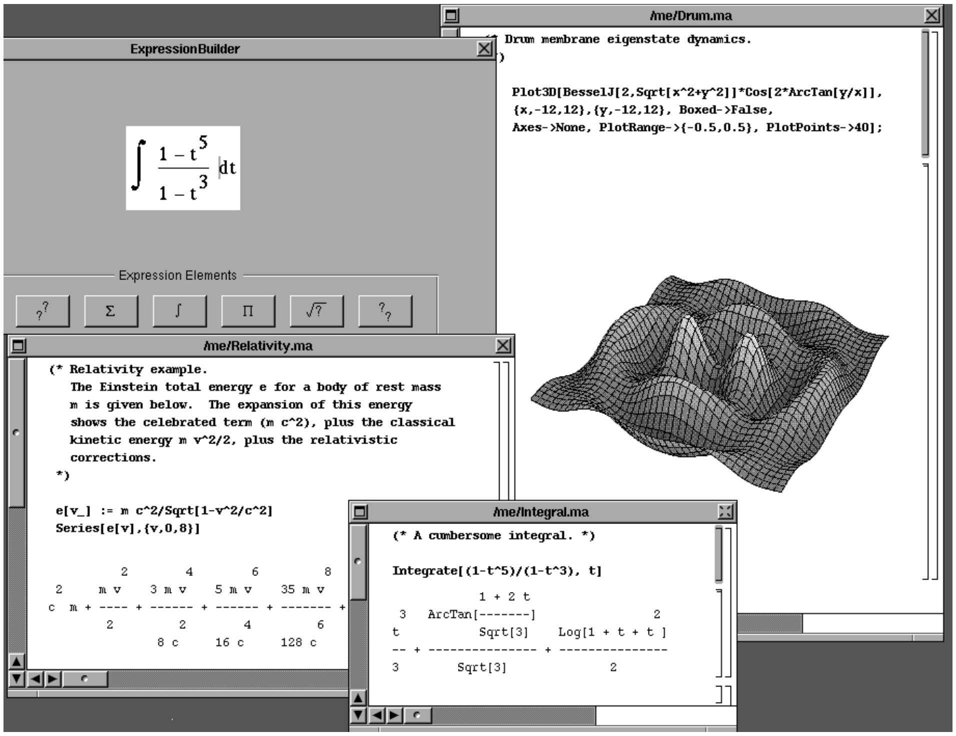
Interprocess Communication

The NeXTstep Application Kit™ allows interprocess communication via NeXT's Speaker/Listener paradigm. This means you can write an application that asks deep questions of *Mathematica.* Furthermore, you have the choice of interrogating the application *Mathematica* itself, or its executable kernel. For example, as described fall 1990 issue of *NeXT on Campus*™ (see "Adventures in supercalculator design"), *Gourmet*—an experimental supercalculator—messages the *Mathematica* kernel, sending problems and displaying the answers in standard ScrollViews. Similarly, *RealTimeAlgebra*—a demonstration application bundled with release 2.0—messages between itself and the *Mathematica* application.

An interprocess example, which signals perhaps a new era in mathematical text processing, is an unreleased application called ExpressionBuilder, written by Josh Doenias of NeXT's Scientific Computation Group. This application allows you to build PostScript expressions, such as those found in professional monographs, and to send these expressions to *Mathematica* in the appropriate format.



Mathematica messaging capability of NeXT computers is exemplified in the application *Gourmet*—a supercalculator demonstration.



Suite of *Mathematica* demonstrations (clockwise from upper right): Bessel membrane, tough integral, relativity example, ExpressionBuilder application for *Mathematica*-compatible typesetting.

Parallelization

In the summer 1990 issue of *NeXT On Campus* we described a supercomputing network comprised of many NeXT computers. There is now a demonstration application called Zilla, which provides a graphical interface for such supercomputing, with available machines appearing as icons within an application window. It is now a straightforward matter to parallelize *Mathematica* problems via the Zilla application. You may, for example, launch *Mathematica* kernels on many computers with Zilla, each kernel being fed some unique set of seed parameters, thereby multiplying the power of *Mathematica* one-hundred-fold.

Conclusion

That *Mathematica* and NeXT products together make a great combination is no accident. As a company, NeXT was founded to provide innovative technology for educators and scholars. Indeed, *Mathematica* was effectively introduced to the world when NeXT announced its first computers in 1988.

Now, NeXT is reaffirming its commitment to educational innovation—by bundling *Mathematica* with every computer sold to education, by collaborating with Wolfram Research, Inc., on an innovative front-end to *Mathematica,* and by optimizing our system's performance to maximize throughput for *Mathematica* users. *Mathematica* is a revolutionary tool that can fundamentally change the way we teach numerically intensive subjects, and the way students visualize mathematical relations.

For Further Reading

For technical details on scientific applications in general, consult the text, *Mathematica for the Sciences,* by Richard Crandall (Addison-Wesley, 1991). This book and its source code examples were developed and typeset entirely on a NeXT computer running *Mathematica* and WriteNow®.

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