requires an IBM PC, XT, AT, PS/2, or compatible; a hard disk; at least CGA-compatible graphics; 512-kilobyte memory; PC-DOS; and a Fortran compiler. The math coprocessor for the PC is recommended, although it is not required. The cost of the system is $495.00 (7).

The program is delivered on four floppy disks. It comes with a PC-size binder for the 160-page user's manual. System installation is handled automatically through a .BAT batch file and is quite simple. Telephone consultation is provided for registered users.

The AUTOMATED PROGRAMMER generates Fortran code that is compatible with three Fortran compilers. The user must supply either the Ryan-McFarland Fortran (version 2.10), Lahey Fortran (version 2.22), or Microsoft Fortran (version 4.01). There are some very minor differences in the way each compiler translates the code produced by the AUTOMATED PROGRAMMER, and these differences are explained in the documentation that accompanies the AUTOMATED PROGRAMMER.

Conclusion

As a tool for mathematically sophisticated users in the scientific-engineering-mathematical domain, the AUTOMATED PROGRAMMER is unlike any other product that I have seen. It approaches the ideal of the executable specification, yet is simple and easy to use. Although the developers themselves state that the AUTOMATED PROGRAMMER is not an automatic numerical analyst or an automated problem solver, if a problem can be posed in the standard symbols and technical English of the mathematical domain then it can be solved by the AUTOMATED PROGRAMMER with considerably less effort on the part of the user. The low purchase price of this system is easily recovered by the benefits which it provides. Among these benefits are:

- Increased reliability, attributed to increased readability and understandability.
- Increased maintainability due to the lack of necessity of hand translation from the problem-domain formulation to the solution-domain formulation.
- Increased productivity without the need to become a computer professional as well as a domain expert.
- Savings in time due to the automation of what is now a hand-crafted labor-intensive process.

REFERENCES AND NOTES

1. AUTOMATED PROGRAMMER, KGK Automated Systems, 114 The Colony, Hartsdale, NY 10530.
2. The user must supply the compiler.
3. Actually, in the file created by the AUTOMATED PROGRAMMER editor.
4. Currently only Fortran is supported, but other intermediate forms may be available soon. The C intermediate form is in prototype and an Ada form is planned.
5. Actually, it is the interpretation of the mathematical expression by the AUTOMATED PROGRAMMER and demonstrates the "tightness" of the intermediate code.
6. F. LoSacco, *SIAM News* **1988**, 9 (July 1988).
7. The program was tested on a Zenith 248 system (80286 processor, AT class), with 640 kilobytes of memory, no math coprocessor, a 20-megabyte hard drive, and EGA-compatible graphics.

Chaos on Computers

Chaos appears in areas as diverse as population dynamics, structural mechanics, and economics. However, describing the chaotic behavior of nonlinear systems is somewhat like describing good food—there is no substitute for first-hand experience. Part of this is intrinsic: the study of chaos is the art of teasing complex and varied responses from simple equations. It is best done with numerical methods, and the personal computer is a good laboratory for exploration.

Chaos Demonstrations (version 1.0), written for the IBM PC by J. C. Sprott, a physics professor at the University of Wisconsin, is designed for users of different backgrounds, from the museum goer on through to the advanced undergraduate level (*1*). The opening menu offers 18 different physical or mathematical systems, each portraying a handful of fundamental concepts. Explanatory windows are provided for each demonstration, along with options for plotting different variables or changing the constants in the equations. The computation can be stopped and restarted, and the **"track/untrack"** function permits observing trajectories either as single moving points or as tracings. Some of the demonstrations convert the dynamics into sound. Colors can be changed to give the best rendition while a calculation is running.

Examples from physics, ecology, and pure mathematics cover a lot of ground here. The nonlinear forced pendulum, for instance, takes us back to the playground swing. A sinusoidal forcing function is like the pumping legs, coupling energy into the motion of the swing. The pumping can either match the natural frequency or work against it or move the bob in more mysterious ways. Normal views of the pendulum are given, but there are also phase-space plots (velocity versus position) and the Poincaré section (velocity at $x = 0$ versus the velocity at the previous $x = 0$ crossing). The right choice of frequency and amplitude of kick offers a concrete view of chaos.

Other entrees introduce new flavors of chaos. The nonlinear oscillator (a variant of Duffing's equation with cubic restoring force) shows a progression from periodic motion to period doubling, and then to chaos—the limit cycles are colorful and sharp on the higher resolution monitor. Another selection illustrates the Van der Pol oscillator, which has found application in the study of electronic circuits, lasers, and the pulsating stars called Cepheids. The motion of planets under the gravitational influence of stars is here too, from simple Keplerian ellipses to wild orbital gyrations. The motion around two fixed stars is arresting: the orderly progression of point masses from a celestial starting gate quickly becomes an orbital free-for-all. Another demonstration shows the frantic dance of charged particles in a magnetic quadrupole trap.

The Lorenz attractor, the predator-prey problem, and the logistic equation are all treated well, as are the Mandelbrot and Julia sets, the Weierstrass function, and the Henon Map. The dessert menu includes some programs that simply demonstrate the beauty of fractal geometry. An odd bestiary of fractal snowflakes, ferns, and Sierpinksi gaskets is provided along with a look at diffusion-limited aggregation. The selections on random-walk diffusion, noise, and Conway's game of life, however, seem to have been added as an afterthought, but they are not unwelcome.

Although the explanatory screens are helpful, and despite the above criticism of cookbooks, the user would do well to refer to one of the available texts (*2*). The software is most effective with the higher resolution afforded by the EGA (enhanced graphics adapter), but it will function with a CGA (computer graphics adapter). A math coprocessor is recommended, and the faster 80286 or 80386 computers are best for handling the combined load of calculation and graphics.

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REFERENCES AND NOTES

1. Chaos Demonstrations, Wisc-Ware, 1210 West Dayton Street, Madison, WI 53706, (800) 543-3201 [$50; also available directly from the author at the University of Wisconsin, (608) 262-3595]. Minimum system requirements: IBM PC/XT/AT/PS-2 or compatible; 256 kilobytes of random-access memory; one floppy drive; CGA or HGA graphics; and MS-DOS (or PC-DOS) 2.0 or higher.
2. J. Thompson and H. Stewart, *Nonlinear Dynamics and Chaos* (Wiley, New York, 1986); H.-O. Peitgen and P. Richter, *The Beauty of Fractals* (Springer-Verlag, New York, 1986).