REVIEW OF DDLAB

Discrete Dynamics Lab (DDLab) is powerful software which can be a valuable aid to learning about the dynamics of cellular automata (CA) and random Boolean networks (RBN) and, perhaps, to exploring their behavior in specific research applications.

Researchers use CA and RBN to model various phenomena and processes in the study of complex systems, with applications in biology, physics, and artificial life. DDLab is an interactive graphics program for research into the dynamics of finite binary networks which makes the often complex behaviors of these simple networks accessible. The software is the creation of Andrew Wuensche, currently of the Santa Fe Institute.

Versions of DDLab are available for UNIX/XWindows, MSDOS and Macintosh platforms. The MSDOS version also runs in full screen under Microsoft Windows. This review pertains to the December 1996 revision of the software, MSDOS version, although nearly all statements apply equally to the March 1996 revision. The author has used DDLab in his own RBN research for approximately one and a half years.

STRENGTHS

DDLab provides the user with great flexibility in choosing the parameters of 1-d and 2-d CA or RBN for study. The complete basin of attraction field (i.e., all network state transitions) can be drawn for networks with up to 32 cells and 13 inputs ("wires") per cell. The program can generate space-time patterns and single attractor basins for much larger networks. Options permit random selection of architectures with various user-specified constraints, or the user can input desired architectures (whole or partial). Wiring and transition rules can be modified "on the fly" or at the end of a run.

A wide range of graphical presentation options permit visualization of network architecture and dynamics: wiring diagrams and histograms, attractor basin graphs and sub-graphs, space-time patterns (2-d and 3-d isometric projections), and state-space scatterplots. DDLab makes creative use of colors, highlighting, and labels to assist in understanding dynamical features. (Colorful images from DDLab have been used as artwork in a few publications.) The program allows the user to change the size and screen location of graphical images, as well as to isolate individual attractor basins, trees, and subtrees within basins.

DISCRETE DYNAMICS LAB (DDLAB)

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http://www.santafe.edu/~wuensch/ddlab.html

Cellular Automata
Random Boolean Networks

DDLab computes and displays various statistics describing network architecture (e.g., in degree, λ and Z parameters) and dynamics (e.g., number and size of attractor basins, garden-of-eden state density). The program can provide histograms and other graphs of many statistics. In addition, the user can output to a file much about a network and its dynamics for separate analysis and/or for input to subsequent runs with DDLab.

WEAKNESSES

The user interface makes DDLab somewhat difficult to learn at first and may deter some people from using the software. Menus of options appear only in a predetermined sequence, often depending on choices made earlier. It can be hard to find a particular menu, the appearance of which may depend on prior selections. Revising previous choices generally requires going backwards through the menu structure until reaching the place where the desired change can be made, then forward again through the menu sequence. One often feels unsure which if any earlier choices might be altered by this backward and forward process. Implementing options on each menu (other than defaults) requires typing in the appropriate code (and in the proper case). Little use is made of the mouse. Many menu options are displayed quite cryptically. There is no on-line help facility. In my opinion DDLab would benefit greatly from a modern Windows-style interface with drop-down menus, dialog boxes and on-line help.

DDLab currently cannot output data or graphical images directly to a printer, except to a small number of supported printers. Attempting to print on the

Books Received

Consciousness Lost and Found, by Lawrence Weiskrantz, Oxford University Press, New York, NY, 1997, pp. 294, $25.00 (cloth)

Foundations of Genetic Algorithms 4, edited by Richard K. Belew and Michael D. Vose, Morgan Kaufman Publishers, Inc., San Francisco, CA, 1997, pp. 463, $74.94 (cloth)

From Complexity to Creativity Explorations in Evolutionary, Autopoietic, and Cognitive Dynamics, by Ben Goertzel, Plenum Press, New York, NY, 1997, pp. 376, $95.00 (cloth)

Monad to Man: The Concept of Progress in Evolutionary Biology, by Michael Ruse, Harvard University Press, Cambridge, MA, 1996, pp. 628, $49.95

Using Playback, by Robert A. van de Geijn, MIT Press, Cambridge, MA, 1997, pp. 194, $27.50 (paper)

Nonlinear Dynamics, Mathematical Biology, and Social Science, by Joshua M. Epstein, Addison-Wesley Publishing Co., Reading, MA, 1997, pp. 164, $34.38 (paper)

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author's HP Lazerjet IV from within DDLab produces many pages of garbage. Although a bit inconvenient, this problem is not difficult to overcome, for example, by using the clipboard under Windows.

DDLab offers "learning" algorithms which, in this author's experience, have limited utility. In Wuensche's concept the network's memory resides in the vertex states of the dynamical tree structure (not limited to attractor states) and learning implies sculpting the basin of attraction field to achieve a desired configuration.[1] For all but the smaller networks, the basin of attraction fields tend to have many trees and subtrees. The algorithms in DDLab permit the user to identify a particular network state to which one wishes to attach specified states as immediate preimages, i.e., states for which the next successor is the desired state. Problems with the methods provided are: 1) typically, unwanted changes ("side effects") occur elsewhere in the basin structure as a byproduct of learning; 2) the user can address only one vertex state at a time and previous learning steps generally will be modified ("forgotten") in unpredictable ways; 3) the user must decide which vertex states to use and in what order to approach a desired end result. The combinatorial explosion of possibilities inherent in RBN networks makes it nearly impossible to achieve meaningful sequential learning involving multiple vertex states with the methods provided.

AVAILABILITY AND DOCUMENTATION

DDLab is available free for noncommercial use. As this is written, the March 1996 version can be downloaded from the internet (http://www.santafe.edu/~wuensch/ddlab.html), as can a user manual (Word for Windows and html formats). The manual provides extensive documentation. "Quick Start" examples introduce the user to the available range of graphical presentation options.

OVERALL EVALUATION

This author enjoys using DDLab and has found it very useful in his work. The interface difficulties largely can be overcome with experience. There are a few features I would like to see added or changed, but these are specific to my work and may not be relevant to others. I highly recommend this software to anyone whose work involves CA or RBN, or who is simply interested in learning more about them (or who enjoys colorful and dynamic graphics!).

NOTE

1. Wuensche, A., The ghost in the machine: Basins of attraction of random Boolean networks. In: Artificial life III, C.G. Langton (Ed.) Santa Fe Institute Studies in the Sciences of Complexity, Reading, MA: Addison-Wesley, 1994.

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CHAOTIC DYNAMICS OF NONLINEAR SYSTEMS

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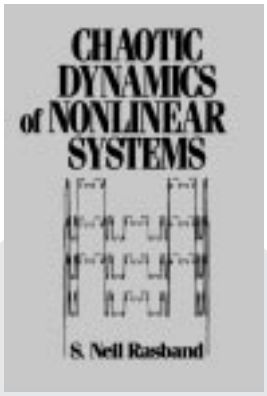

Chaotic Dynamics of Nonlinear Systems presents the major models for the transitions to chaos exhibited by dynamic systems. The author introduces "classical" topics and examples that have emerged as fundamental to the discipline. The most important routes to chaos are described in a unified framework and supported by integrated problem sets.

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