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Book Review

*Imitation of Life: How Biology Is Inspiring Computing, b*y Nancy Forbes. Cambridge, MA: MIT Press, 2004. 171 p. + xv. ISBN 0-262-06241-0.

Forbes' book has an interesting premise: how has biology influenced computers and computational methods? Normally, we would ask the reverse question – how have computers affected the practice of biology? – and speak of data storage and modeling, e.g., in population biology or genomics. But Forbes argues that biology has had a number of interesting effects on how computers are designed, how computations are done, and how we think of the limits of computation. First a description of the topics Forbes covers, and then some comments on issues of accuracy.

Forbes deals with nine specific areas where biology has influenced computer science. Chapter 1 discusses artificial neural nets and outlines their conceptual origins in early work by Pitt, McCullough, and Hebbs. From abstract conceptions of how the nervous system handles information came models of artificial neurons that could be concatenated into networks that could "perceive" and "analyze" inputs, for pattern recognition and sound production.

In Chapter 2, she deals with Evolutionary Algorithms, which imitate Darwinian and biological genetic processes in programs that can improve themselves. She illustrates the principles by discussing a robot running a maze, a program for playing checkers, and programs that create graphic art.

Forbes next turns to cellular automata. Based originally on theory from von Neumann and Turing, cellular automata began as self-replicating systems operating under specific rules and led to automata that undergo morphogenesis and evolve new forms that resemble living organisms. She raises some questions if cellular automata are really useful as models for how life works, but they certainly have interested many researchers.

Her next topic is more controversial: the claim that certain programs running in a computer represent artificial life (AL). The strong but controversial AL claim is that these programs really are alive in an ecosystem created by the computer's central processor and memory. Forbes suggests that many workers in AL prefer the weaker claim that such programs imitate life, and thereby help us understand the principles by which living organisms operate.

She also covers DNA computation – the use of DNA either in real test tubes or in the abstract to solve otherwise computationally very difficult problems. The approach has led to efforts to understand, e.g., how ciliated protozoa can unscramble their own genetic information.

Biomolecular self-assembly deals with efforts to create computationally useful components by letting biological molecules assemble themselves into highly-ordered, larger structures, on analogy with how biopolymers create membranes and other intracellular components. The area leads naturally to cutting-edge engineering problems in nanotechnology.

Issues centering on fault tolerance in real electronic components are discussed in a chapter on Amorphous Computing. The art here is to assemble large numbers of individually error-prone but redundant elements that can nonetheless operate together without error.

Forbes ends her catalogue of techniques by discussing computer immune systems, which can recognize and destroy computer viruses, and with efforts to use biological materials to build components of computers. Her final chapter discusses future applications of biology to computational science, and offers a really quite rosy forecast.

The list is quite fascinating – it is longer than at least this reviewer might have thought, and clearly considerable ingenuity has been used by a number of researchers and engineers. However, *Imitation of Life* has a number of very serious problems that undermine its reasoning and presentation.

The book is littered with typographical errors. A few, and we shrug, correcting them mentally; too many and we wonder what other errors may have crept in. More or less at random: on page 4 nerves and neurons are identified with each other – but in fact nerves are bundles of nerve cell axons. On page 17, the genetic terms haploid and diploid are not used accurately. The text says that recombination occurs between chromosomes of haploid organisms, whereas it actually occurs between homologous sets of chromosomes in a single diploid organism, a fact fundamental to genetics. On page 38, the name of the most famous fruit-fly in the world is given as *drosophilia*, whereas it is actually *Drosophila* – a mistake made by generations of careless undergraduates that probably annoys geneticists more than any other single mistake students make. On page 47, an experiment with the bacterium *E. coli* is said to have run for 24,000 generations at 3.5 hours per generation and to be finished in days – the actual time is about 9 years. On page 90, the text says that compiling time was proportional to the number of resources (= elements) in a certain computational architecture, but then says that the larger the system, the faster it ran. On page 138, pearls are said to be organisms, and diatoms are called animals, when they are actually photosynthetic algae.

I counted at least 21 such mistakes. Some are far from minor. In the discussion of DNA computation, the text describes the Traveling Salesman [*sic*, p. 58] Problem, where a salesperson must travel from city A to B to C … to city N (p. 58). This problem, the text says, is computationally extremely difficult, but can be solved with a DNA computer. However, as stated, the problem is trivial. What has been omitted is the all-important constraint that the final path from city A to N must be the shortest, fastest, or least expensive. But because the DNA computer solution is described for the trivial problem, it is impossible to figure out how the DNA computer might have optimized the solution to the actual Traveling Salesperson problem.

I will spare the reader a longer list of errors. They are all serious, and misrepresent crucial details. My guess is that someone at MIT Press did not edit the book properly, because all of these errors should have been caught and corrected while the book was in manuscript. The result is that a fascinating question – how has biology affected computing? – is sabotaged by errors that undermine our trust in the whole book. It's a great shame. The basic document and its arguments are fascinating and significant, but the supporting details do not show the level of accuracy expected for such a work from MIT Press. I hope that someone can address the same questions without the errors.

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