Imitation of life: How biology is inspiring computing

By Nancy Forbes
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Computers are everywhere inside cars, washing machines, everywhere in offices, and everywhere in entertainment, hospitals, finance and bureaucracy. Who would have thought that the research that led to the World Wide Web would be commonplace in only ten years? Even the *Times Higher* is on the web!

Despite computers pervading every activity, we still find them difficult to use and unreliable; one need only mention the daily problems we all have with email spam or crashing computers to see that there is still a long way to go.

While society is still coming to terms with computers, they are about to change again, and become even more entwined with human life. Computers can imitate biology, and biology can imitate computers. Cyborgs are just one idea from science fiction that can become reality; what about biocomputing viruses for medicine?

To survive, life has to continually solve many sorts of problems. Evolution solved the problem of finding successful life forms; immune systems solve the problem of microscopic attack; brains solve the problems of where the next meal is coming from; eyes solve the problem of what to chase; and herds or swarms solve problems of social survival. All these biological ideas, and many more, are fundamentally computational. They can inspire new ways of harnessing computers to solve problems by simulating the approaches life takes. Indeed some very successful computer ‘tricks’ have been developed, from artificial neurons to techniques to make computers more reliable. And it works the other way around: we do not need to use traditional silicon and digital circuits to make computers work, we can take ideas from biology, and use DNA or some other chemicals to do the work.

Nancy Forbes’s book *Imitation of Life* is an overview of the wide-ranging activity in these exciting areas. It has ten key chapters that cover the spectrum of research: neural networks, evolutionary algorithms, cellular automata, artificial life, DNA computation, biomolecular self-assembly, amorphous computing (inspired by colonies of cellular systems), immune systems, biological hardware, and biology as computing.

Many of these areas were first charted by the historical giants, Alan Turing and John von Neumann back in the 1940s. Their ideas are only just starting to become a reality. Turing was British and von Neumann was American, having emigrated from Hungary, and it is striking how much of the research reported in this book is still international — but sadly international is now more a euphemism for not being done in the UK. Where the UK is mentioned, it is in conjunction with international collaboration. One conclusion is that we in the UK (and indeed everywhere outside the USA) should start teaching this sort of material to undergraduates before we get totally left behind in this new science.

Perhaps the current generation of undergraduates can get involved? *Imitation of Life* would make an excellent seminar book for first year students to work through, perhaps to complement a more practical book like Gary Flake’s *The Computational Beauty of Nature* (MIT Press, 1998, which I reviewed in the *THES*, Number 1408, p28, 1999). Indeed, the style of *Imitation of Life* lends itself to seminar study — I think otherwise it falls between the two high stools of popular science and textbook exposition, because it is at once too technical to be popular yet has too little working detail for self-study.

Let me give a typical example. On page 61, we are told that Georgia Tech computer scientist Dick Lipton has an efficient method for solving a problem called SAT. Although the journalistic style of being told where Dick works sounds helpful, we aren’t told any details of the science, so we don’t understand anything useful from the book itself. It doesn’t provide references either. But it is enough to go and search the web yourself. Thus I looked up Dick on Google, and found that he is doing some interesting work on email spam. So, as one can see, the bird’s eye approach of the book can be turned in seminars into a stimulating way of learning more, motivating learning about cutting-edge research that will change the world.

Imitation of Life finishes with an all-too brief four page epilogue discussing the impact of the literally life-changing developments the book has reviewed. We desperately need ways to make computers more reliable and more useful. We will also spin off many innovations in biotechnology, medicine, nanotechnology, and there will even be escalation in cyberattacks and biodefence systems. In short, the imitation of life will have an unknown impact on life itself, on us humans and our society. I hope, then, that this short book helps transform undergraduate curricula in computer science departments.

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Imitation of Life. How Biology Is Inspiring Computing. By Nancy Forbes. How scientists are using nature as model and metaphor to reinvent computing: a survey of an emerging field. Buying Options. Buying Options.Â She identifies three strains of biologically inspired computing: the use of biology as a metaphor or inspiration for the development of algorithms; the construction of information processing systems that use biological materials or are modeled on biological processes, or both; and the effort to understand how biological organisms "compute," or process information. Forbes then shows us how current researchers are using these approaches. Surveys the emerging field of biologically inspired computing, looking at some of the most impressive and influential examples. Forbes identifies three strains of biologically inspired computing: the use of biology as a metaphor or inspiration for the development of algorithms; the construction of information processing systems that use biological materials or are modeled on biological processes, or both; and the effort to understand how biological organisms "compute", or process information.Â Biography. Nancy Forbes works as a science and technology analyst for the federal government. She has advanced degrees both in physics and the humanities, and has served as a contributing editor for The Industrial Physicist and Computing in Science and Engineering. Out of Print. Artificial neural networks -- Evolutionary algorithms -- Cellular automata -- Artificial life -- DNA computation -- Biomolecular self-assembly -- Amorphous computing -- Computer immune systems -- Biologically inspired hardware -- Biology through the lens of computer science. Bibliographic information. Includes bibliographical references (p. [159]-162).