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Book Reviews

The age of intellgent machines by Raymond Kurzweil, MIT Press, 55, Hayward Street, Cambridge, Mass 02142–1399, 1990, pp. 565, Sfr. 39.95

This is an excellent introductory book for those who want to understand the implications of clothing machines with intelligence, often called artificial intelligence (AI), written by an author who has made a living out of it. Though the book seems overly evangelistic about machine intelligence, he concentrates both on soft and hard AI and so makes his points quite reasonably. This is so as his idea of an intelligent machine (or AI?) includes speech and image processing and sometimes even CAD! (see pictures on p. 293 (Sony NEWS workstation), p. 302 (CAD system for VLSI design) where the word 'intelligent' is used as a qualifier for both). It is fair to say that the author's canvas includes anything that incorporates "thinking", though many would not call it AI, or for that matter, machine intelligence.

In the prolog, the author sets the stage for intelligent machines and their impact on the world's economy. The importance of "brain work" over "brawn work" in the coming decades is discussed but the author's conclusion that there is likely to be more prosperity for all with intelligent machines is certainly not incontestable. This is especially true as third-world countries may not be able to keep their populations fully employed. Full employment has been achieved to a good extent in the first world by upgrading the manpower but optimism about third-world countries being able to achieve the same seems too sanguine. To give an example, India has not yet been able to achieve more than 52% literacy due to various social and political problems (including those created by imperial powers like Britain & US between countries like India and Pakistan by first dividing, then keeping nations apart and selling arms to both!). It is a bit far fetched right now to say that once intelligent machines are around, the social and political systems would respond aggressively to take care of socital needs: something that has not happened for almost a century since intelligent machines made their appearance! Hence this reviewer finds the pejorative dismissal of "Luddites" unconvincing. Reference may be made also to the short discussion in the book on p. 434 on future warfare technologies designed with machine intelligence!

The first chapter discusses AI and discusses an important problem for its supporters: the moving definition of what is AI. When computing was in its infancy (till the late 50's), even ability to do, say, high-school algebra was considered intelligent. Once this capability was understood, the technical subject of symbolic mathematics was born and it is rare for anyone working in this area to call their field AI. This is the same problem that "natural philosophy" also faced—there was a time, when it subsumed physics, astronomy, etc. All these subjects have grown and moved out of its awnings. The core "natural philosophy" that remains is fuzzy as ever compared to physics!

The next chapter is a good overview of the philosophical foundations of AI. It discusses, through a quick historical survey, logical positivism and its counterpoint, existentialism, and locates the former as the inspiration for much of the work on AI. This chapter, like many in the book, has additional pieces by well-known writers exploring a theme through a conundrum or by an opinion piece.

The second chapter looks at the mathematical roots of AI, which not surprisingly are also that of computer science. It discusses Russell's paradox and its impact on set theory, then looks at Turing's work including the Church–Turing hypothesis and the Turing test. The busy beaver problem is introduced to model an "intelligent" function whose capabilities for computing increase at a very rapid pace. In the next chapter, universal Turing machines are introduced that can simulate any Turing machine followed by a discussion of recursion and how it can be employed in various problem solving strategies (like for playing tic-tac-toe, chess, go). The author then introduces "Three levels of intelligence" which roughly correlates with three games in terms of the complexity of the domain: the first level (completely analysable and simple: tic-tac-toe), the second level (in principle analysable and simple: tic-tac-toe), the second level (in principle analysable completely by node-evaluation procedures but the number of nodes is very large: chess) and the third level (needs insight as there is no "obvious" node-evaluation procedure that can provide a solution: go). Finally there is a discussion on other approaches to modeling intelligence: random nets (primitive neurons: perceptron), pandemonium ("intelligent" neurons), Minsky's "society of mind" and more recent proposals.

The mechanical roots of intelligence are next explored through a survey of calculating machines devised by Napier, Pascal, Babbage and Hollerith. The next chapter looks at the electronic roots: the German Z machine of Zuse, Turing's Ultra that broke the German's Enigma enciphering machine, Aiken's Mark I and ENIAC. However, this reviewer finds the pejorative way of dismissing Atanasoff (who built a pioneering machine at Iowa that is now considered to be the first electronic computer) not in good taste. Burns and Burns[1] have written a definitive study of Atanasoff's original and seminal contributions and shown their very major influence on ENIAC.

The history of cybernetics and the beginnings of AI are discussed after the proliferation of the first batch of electronic computers. Distinctions on analog and digital representations; irreversible models of time as the basis for computation, communication and intelligence are then brought out. Some of the major milestones like the Dartmouth conference, LISP, ELIZA, SHRDLU, and various landmarks that were summarized in Minsky's book "*Semantic Information Processing*" are then discussed.

The second part of the book, "the moving frontier", has chapters on pattern recognition, expert systems, computational metaphors for arts (musical, visual, literary), some exploratory thinking on the visions for the future once machine intelligence becomes pervasive and impact on social aspects like employment and economy, nature of work, communications, warfare, music, medicine, politics, and nature of self. All these are written for a layman and more accessible than some chapters of the first part. Much of the latter sections (especially, on the visions for the future and social impact) are highly US-centric and sometimes too facile. A good example: Gilder's opinion piece, "A Technology of Liberation", says that ideas as not used up as they are used but this does not seem to take cognisance of the realities of the modern world with patents on algorithms becoming commonplace through legal obfuscation. One may also quote the US Govt's action on preventing the Russian Space Agency from supplying cryoengines to India.

Overall, the book is excellent and recommended to anyone who has an interest in understanding the philosophical and basic technical aspects of machine intelligence. The typesetting is also very pleasing.

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High noon on the electronic frontier edited by Peter Ludlow, The MIT Press, 55 Hayward Street, Cambridge, Mass 02142–1399, 1996, pp. 536, $ 50.

This book is a collection of articles on new issues emerging in cyberspace such as intellectual property rights, trespass and intrusion in the digital domain (Sections 1, 2); privacy, freedom of speech, security, forbidden behaviour and law enforcement (Sections 2, 3, 4); community and identity (Section 5). The author has selected articles to present an impressionistic view or "raw artefacts" of the debate on these subjects to capture some of the emotions and to provoke debate. Even though most of the articles were authored before '94 and the book seems to be a bit outdated for a '96 imprint, it is still very useful book to get a snapshot of the debates raging around '94. It is not an academic analysis of the debates as the author (a philosopher!) finds much of the academic discourse sterile, being infused with an excess of "pomo" (postmodern, for those who are not familiar!) cant.

The first article by John Perry Barlow (a lyricist for the Grateful Dead and a cofounder of the Electronic Frontier Foundation that supports and litigates for freedom of speech in the digital domain) is a cogent and engagingly well-written exposition on why older models of property rights are not appropriate in the digital domain. The next two chapters are on why patents are bad for software: the authors are from either the Free Software Foundation or the League for Programming Freedom. These are also well-written but the points made by them would have greater force with the inclusion of some of the more recent writings of some distinguished scholars, both in law and in computer science, like Reichman, Samuelson, Karjala, Davis and Kapor who have advocated a rethinking of IPR for software from both legal and technical perspectives[1]. Briefly, they advocate that, "a new form of intellectual property protection must be developed that protects computer programs long enough to prevent market failure and to ensure that incentives exist to invest in program development. Copyright protection has been used for computer programs, but the law of copyright fails to recognize that both the text of the program and the behaviour of the software need to be protected to minimize cloning. Simply extending copyright or patent law to cover software behaviour would establish overbroad monopolies. A possible solution would be to protection programs from cloning for a fixed period [such as 2–3 years]."

The next piece by Paul Heckel controverts the earlier three articles, but in the opinion of this reviewer, does not address the crucial question of how one can prevent large corporations from developing monopolies by their ability to create large patent portfolios that could be used to prevent others from engaging in software production. Barlow makes the observation that those large corporations that indulge excessively in lawyering will not be able to find the resources to actually do software development that will stand in the marketplace but the problem is that with crucial patents (especially, like the one on RSA algorithm) entire product lines can be preempted.

Mike Godwin's article discusses an important case in '90 when a hacker broke into a telephone company and passed on for publication some harmless details of the emergency system of the telephone network. The company took the hacker and the publisher to court and asked for a large amount as damages for "stealing" the document but the case was later thrown out as the defense was able to show that the same document was publicly available for $13! There are other brief chapters on some other cases, especially, the conviction of a "gentleman" hacker, Phiber Optick, for trespass into some computers of a phone company and a transcript of the congressional testimony of a publisher of a magazine that gives details of vulnerabilities of commonly used gadgets like cellular telephones, etc. Dorothy Denning has another chapter (written in '90) on the subculture of hackers and gives a sympathetic hearing to the motivations of hackers but reverses almost all her positions in the addendum authored in July '95 where she takes the stern law enforcement perspective.

The next section explores cryptography and the problem posed for law enforcement agencies (unbreakable codes if used by criminals and unfriendly governments) and civil rights advocates who find it unacceptable or undesirable that governments have a way of listening into private transactions. Zimmermann who developed a widely available and free cryptography software (PGP) discusses the basics of the technology and why such technology should not be limited by governments. Levy discusses the implications of good quality cryptography in the hands of public and gives a brief biography of Diffie who originated the concept of public-key encryptosystems and also history of the National Security Agency (NSA) of US Government which oversees tapping of communication and intelligence gathering, especially outside US which is completely legitimate according to its charter but probably also collects information inside that country on its citizens.

There is an excellent article by David Chaum, a cryptographer, on how to achieve complete electronic privacy through anonymous mailers and cryptography. Currently, most transactions in the US are mediated through the social security number but this results in voluminous collection of data based on various transactions on a person that could be maliciously used. In the proposed scheme, each person could give a different but verifiable psuedonym to every organization with which a transaction is desired (so that dossiers are not possible) and also pay for goods in untraceable electronic cash or present digital credentials without revealing identity.

Tim May presents a "crypto-anarchist" manifesto ('88) that argues for a realization of the potential in Chaum's work. For provoking debate, he also introduces a hypothetical "Blacknet" that can guarantee a secure, two-way untraceable and fully anonymous channel between an individual and "Blacknet" through encryption, anonymous remailers and public postings of encrypted messages. The problems or worries that could result for law enforcement agencies from an actual realization of such a network (hit squads become too easy!) is tremendous and he tries to answer some of the objections by saying that misuse of a technology by some is not a good enough reason for banning it.

The next section on censorship and sysop liability explores attempts at censoring newsgroups, at CMU, Iowa State Univ, (approx '90, '92) etc., that carried sexually-oriented material and the response of organizations like ACLU in protesting against such abridgement as violative of both "freedom of speech" guaranteed under the US constitution and academic freedom. There is an article on how community standards criterion that has been the judicial norm for deciding on obscenity in the US since the '70s is subverted by the Internet which knows no geographical boundaries. Another article explores the responsibilities of and possible strategies for system administrators some of whom have been hauled to court for "allowing" sexually-oriented material through their computers.

The last section on "self and community on line" explores social aspects of the ability to create artificial personae in cyberspace. Issues explored, among others, are gender swapping and a "rape" in cyberspace involving an artificial person in a multiple-person game and the intense reactions that were generated by the participants of the game.

The appendix has another article by Barlow on his discussions with Acid Phreak, a hacker who surprised him by easily getting into huge dossiers maintained by TRW and other megacorporations on people based on financial transactions and also telephones networks; and also his encounters with personnel from law enforcement who did not have the slighest clue on the nature or ambience of cyberspace. Another appendix explores the nationwide crackdown on private bulletin boards in Italy '94 and explores an interesting angle that they were motivated by certain political forces still in league with fascists (reaching all the way to the) prime minister '93) and who were not happy about certain peace groups that were using bulletin boards.

As mentioned earlier, one of the major shortcomings of this volume is that it is dated. There is almost nothing of the Web phenomenon ('94 was the critical year) and its implications. For example, even though sexually explicit material was available on the Internet for atleast a decade, with the Web, children can access it without a steep learning curve. Now many parents are concerned about the availability of these materials which was not the case earlier. This has created complications for those who liked the freewheeling and open style of Internet: interested parties are now portraying Internet as the refuge of deviants, and using that as a protext to police it.

Another major conflagration on the Internet (the Scientology debate '91–'94) could have been covered [2]: this particular case had very interesting implications for IPR "infringement" (some body posted the "secret" teachings of Scientology onto the Usenet), the nature of "war" in cyberspace (postings and cancellation war that erupted as Usenet allows posted articles to be "unposted"; the development of new weapons such as "cancelbots"), the extensive use of anonymity in this warfare through anonymous mailers, the involvement of law enforcement agencies in trying to shut down these mailers, the fluidity with which information seeps through (Scientology could obtain seizure orders to close down some machines but "information" went elsewhere), the lack of a geographical or organizational center (most of the warfare occurred on alt.religion.scientology, which is a "distributed database around the world").

Similarly, issues dealing with some of the more recent concerns in IPR (for example, hyperlinks) do not find mention. One other problem is the possible inaccessibility of some of the (unedited) articles as there is sometimes too much slang that may not be accessible to a reader not immersed in the US cyberspace subculture. For example, the following are not defined in the American Heritage Dictionary '81 (p. xvii: pomo: postmodern, p. 461: gunsel, p. 382: perp. etc.).

Overall the book is recommended but it would be worth updating the collection to make it more current.

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Artificial life – An overview by Christopher G. langton, The MIT Press, 55, Hayward Street, Cambridge, Mass 02142, USA, 1995, pp. 399, $42.

Robotics, neural networks, genetic algorithms, computer viruses, self-organization....—the readers of the *Journal of the Indian Institute of Science* will recognize these as some of the most exciting and vibrantly active research fronts. As a smart marketing strategy, these (and a handful of others) are now being packaged and advertised under the brand name *Artificial life*. A sustained and vigorous advertising campaign, this one. The proceedings of an international workshop were brought out under the name *Artificial life* in 1989. This was followed by *Artificial life II* in 1991–92, and in due course, by AL III and AL IV. Inevitably, a journal *Artificial Life* made its maiden appearance in 1994. The first three issues of this journal have next (in 1995) been put together (and sold for $42) as *Artificial life: An overview*, which is the book under review.

A one-line summary for readers with very short attention spans (are there any others?)—an interesting and useful collection of articles, though calling all of them 'artificial life seems very contrived, at best.

What is artificial life all about? One cannot do better than quoting from the lucid and eloquent introduction by the Editor-in-chief Christopher langton—"... an attempt to increase vastly the role of synthesis in the study of biological phenomena...". The two most striking things about the living world are its complexity and diversity. Understanding the regularities, laws or theories behind these has been (and continues to be) a cherished goal of scientists. So far the emphasis has been on analysis—a detailed study of the various living systems. A parallel, and equally (if not more) rewarding approach would involve constructing their analogues. Insights gained during such attempts would add considerably to our understanding of life. Langton's example of chemistry brings out the point much more clearly and forcefully—chemistry advanced both from the analysis of the structures of natural products, as well as from the syntheses of a large number of their variants. "To have a theory of the actual, it is necessary to understand the possible".

In the opening essay of the book, Artificial life as a tool for biological inquiry, Charles Taylor and David Jefferson methodically put forward the four levels of biological organisation (molecular, cellular, organismic and population/ecosystem) and the three distinct approaches used for modelling them. The 'Wetware system' involves chemical reactions between biomolecules, the 'software system' simulates cellular/intercellular phenomena as well as populations and ecosystems, and the 'hardware system' (generally mobile robots) that mimic various organisms. The authors follow this up with a section impressively titled 'Open problems in biology amenable to study by artificial life modelling' - and this is where one begins to notice a false note or two! The open problems mentioned by them include topics such as cultural evolution, origin and maintenance of sex and structure of ecosystems; things which evolutionary biologists have been investigating for decades using the standard techniques of population genetics. It is not at all clear as to what is standard techniques of population genetics. It is not at all clear as to what is accomplished by relabelling the whole exercise as artificial life. The feeling of uneasiness is further strengthened by the next article 'Co-operation and community structure in artificial ecosystems' by Kristian Lindgren and Mats G. Nordahl, which opens with "artificial ecologies consisting of artificial organisms are likely to become useful tools for understanding general principles of how ecological communities are organized". Likely to become? What they call artificial ecologies of artificial organisms is scarcely different from the simple mathematical models (*e.g.*, the famous prey–predator Lotka–Volterra system) known to biologists for over half a century. More than 30 years have elapsed since W. D. Hamilton used 'artificial ecologies of artificial organisms' for making a pioneering contribution towards a genetical theory of social evolution, and about fifteen years since Robert Axelrod and W. D. Hamilton used the iterated prisoner's dilemma game to explain the evolution of cooperation. Let me make clear once again that I do not dispute the importance of the author's findings; these could make welcome contributions to, say the *Journal of Theoretical Biology*, and its other illustrious cousins. It is the continued and pretentious peddling of this stuff under a new name 'Artificial life', that makes it difficult for me to refrain from lashing out.

Many of the subsequent chapters fall into the same category. P. Schuster describes the progress made since 1970s, when Spiegelman introduced the RNAs (ribonucleic acids)-based 'evolution in a test-bute', and followed by Eigen and co-workers' hypercycle models. The idea of the 'shape space' for RNA molecules, described by Schuster, represents a truly monumental contribution—demonstrating how, despite the astronomically high number of different (10^{60}) alternative possibilities, a random (mostly inactive) sequence of RNA could, with as few as 20 odd mutations, transform into a functional, active molecule with a correct shape. To the persistently nagging question of whether there has been enough time for life to have originated *and* evolved on the earth, this finding leads to the first substantially satisfactory response.

As expected, the fashionable fields of fractals and cellular automata make their appearance, complete with the very pretty computer graphics (P. Prusinkiewicz). Can chaos and complexity theory be far behind? Kunihiko Kaneko describes an ingenious example (evolution of imitation of bird-songs) using the edge-of-chaos paradigm. E. W. Bonabeau and Guy Theraulaz handle phenomena as diverse as the recruitment of antibody-producing clones and nest-building activity in wasps, with effortless ease. (Their opening remarks on how one can justify working on artificial life are a delight to read). Michael G. Dyer of the Computer Science Department, UCLA, gives a crisp, up-to-date, clear and comprehensive summary of the various aspects of animal behaviour. As a 15-page guide on animal behaviour for nonbiologists, this is unlikely to be surpassed. The most incisive comment (a mandatory warning to be pasted on the desktop of every artificial-life researcher) comes from the authoritative and comprehensive chapter on genetic algorithms by Melanie Mitchell and Stephanie Forrest: "It is difficult to distinguish between 'yet another cute simulation' and systems that teach us something important and general, either about how to construct artificial life or about the natural phenomena that they model. We suggest that artificial-life research should address at least one of these two criteria and that it is important to be explicit about what any specific system teaches us that was not known before".

While there are other fascinating chapters (*e.g.*, computer viruses as artificial life by Eugene Spafford, artificial life roots of artificial intelligence by Luc Steels), let me conclude by describing the *piece de resistance*. "An evolutionary approach to synthetic biology: Zen and the art of creating life" by Thomas S. Ray, the legendary creator of Tierra (the software simulator of virtual life), can be regarded as the foundation stone of the true science of artificial life. To illustrate the clarity of expression, depth of thinking and breadth of vision of this essay, here is a quotation from the abstract: "Our concepts of biology, evolution, and complexity are constrained by having observed only a single instance of life, life on earth. A truly comparative biology is needed to expand these concepts. Because we cannot observe life on other planets, we are left with the alternative of creating artificial life forms on the earth. I will discuss the approach of inoculating evolution by natural selection into the medium of the digital computer. This is not a physical/chemical medium; it is a logical/informational medium. Thus, these new instances of evolution are not subject to the same physical laws as organic evolution (*e.g.*, the laws of thermodynamics) and exist in what amounts to another universe, governed by the 'physical laws' of the logic of the computer. This exercise gives us a broader perspective on what evolution is and what it does".

Can all this serve any useful purpose? Ray raises a tantalizing speculation. The newer, faster parallel computers are notoriously difficult to program. Furthermore, they can be most profitably harnessed by generally using them for computationally tough problems. The task of developing reliable and efficient software for this purpose is truly formidable. Ray's imaginative answer is 'digital husbandry'. This involves allowing artificial 'living' programs to interact and evolve on the parallel computers, and then 'selectively breeding' them, so that we gradually get more and more efficient and successful programs for specific tasks (exactly the way high-yielding varieites of rice, or cattle, are developed). Fantastic? Certainly so. Impossible? Only time will tell. But this certainly looks like an attractive road to march along.

On the whole, this book is a valuable collection of interesting articles, and the e-mail addresses of the authors (for the first time I've seen in any book) make it particularly easy for anyone to get in touch with them—and keep track of the latest developments in this fast-moving field (I hear that the conference Artificial Life V has recently been held).

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