Book Review


D. Poole, A. Mackworth and R. Goebel, *Computational Intelligence: A Logical Approach*


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This review examines four relatively recent general purpose AI textbooks. Each aims to offer a broad-ranging introduction to the subject in more or less formal terms. That is, each is aimed mainly at undergraduate or graduate students with some mathematical or computer science background rather than at students expecting to study from a Cognitive Science perspective, with backgrounds in psychology, linguistics or philosophy.

These books thus fall into the same general category as, say [2,5,6], but have been updated for the mid–late 1990s. Although taking account of contemporary concerns within AI such as “situatedness”, by outlook they are all books predominantly in the tradition of good old fashioned AI (GOFAI). That is to say, they all put representation at the heart of the subject.

Before discussing each book in turn, let me offer some general comments. They are all well-written, detailed and offer a good introduction to the subject. They all cover, *inter alia,*

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what might regarded as the standard topics including knowledge representation, reasoning (with both certain and uncertain information), learning, search and planning. Each provides exercises (though not answers), pointers to further readings at the end of each chapter, a comprehensive index and a long bibliography. Three of the books, though not that by Dean et al., make extensive use of the term “agent” and to differing extents organize their material around the notion of agents of increasing complexity. For example, Nilsson starts with a chapter on stimulus–response agents and concludes with a short chapter on agent architectures which makes some general observations about how the various individual processes described in the book, such as planning, mediate between perception and action.

A New Synthesis

As someone who learned much of his AI from Nilsson’s classic books, such as [4], I opened this new textbook with pleasurable anticipation. It offers a refreshingly broad view of AI covering, in Nilsson’s phrase, the “middle ground between theory and applications” and uses the notion of agents of increasing complexity to provide a general, overall framework for the material. Nilsson is at pains to identify, motivate and explain what he regards as important AI ideas (e.g., as opposed to applications) such as generalization in neural networks and other learning mechanisms. The book does not contain programs or pseudocode (strictly speaking), but does describe algorithms in terse English. Overall the style is similar to his earlier books, cited above.

The book’s sub-title, “A New Synthesis”, is justified as the material is both up to date and comprehensive. For example, the phrase “evolutionary artificial intelligence” occurs on the first page of the Preface and there are ten pages on genetic algorithms and evolutionary computing.

The book is organized into five sections: Reactive Machines, Search in State Spaces, Knowledge Representation and Reasoning, Planning Methods Based on Logic, and Communication and Integration. The middle three sections cover classical material, though now with the inclusion of Bayes Nets and The Situation Calculus. The initial section on Reactive Machines contains chapters on stimulus–response agents, neural networks, machine evolution, state machines and robot vision. The final section on Communication and Integration contains chapters on multiple agents (involving reasoning about other agents), communication among agents (including some NLP material) and agent architectures.

In the Preface to the book Nilsson says that his aim is to “present a modest-sized textbook for a one-semester introductory college course”. He explicitly compares this book to his earlier book [4] in terms of its approach and explains that he has left out much in the way of bibliographic and historical remarks partly because “the longer text by Russell & Norvig has already done such a thorough job in that regard”.

It is instructive to explore further the differences between the current Nilsson book and his earlier one [4]. In some ways the comparison is a little unfair as the earlier book was aimed at graduate students who already had a degree in, say, computer science, and it deliberately omitted chapters on application areas such as vision and NLP in favour of what were regarded then as the core parts of AI. But the comparison does show up the
kinds of issues that have come to the fore in the intervening two decades. It also indicates, I believe, a different understanding about intelligent agents, not so much as disembodied reasoning systems, but as systems that interact in and with the world in a way that naturally pulls the topics vision and language back towards the core of the subject.

The earlier book started with a theoretical analysis of production systems and search, went on to examine predicate calculus, resolution refutation and rule-based deduction systems. This was followed by two chapters on planning and a chapter on structured object representations, such as semantic networks. One of the unifying themes of that book was that of a generalized production system.

In the new book, a unifying theme is provided by the notion of an agent. Production systems do get mentioned, but they do not play a large role. Neural networks, genetic algorithms and vision now set the scene early on for explaining reactive machines. Search is then addressed in a similar way to the earlier book, though now it also brings in iterative deepening, links search and learning, but gives less emphasis to AND/OR search methods. The introduction to logic is gentler, going via propositional calculus, to predicate calculus, resolution and then knowledge-based systems. Again, links to learning are made that were not made so explicitly in the earlier book. The new book has completely new material on reasoning with uncertain information—indeed, the earlier book had no index entry for Bayes. Like the chapters on search those on planning do bear a reasonable resemblance to those in the earlier book, though again the role of learning is now explored. Finally, the new book addresses issues that were hardly touched on in the earlier book, namely issues to do with interactions between agents, including the use of language to achieve goals.

**Theory and Practice**

Dean, Allen and Aloimonos state that their book is

“designed to teach students about the theory and practice of building computer programs that perform interesting and useful tasks. With the exception of some diversions in the introductory chapter, we leave the philosophical conundrums to the philosophers and focus on techniques, algorithms, and analytical tools that we believe students will find useful in building sophisticated (even intelligent) computer programs”. (p. xviii)

This book provides code in Common Lisp to exemplify the algorithms discussed and includes, in Chapter 2, a brief introduction to Common Lisp. There is also a downloadable (FTP) instructor’s guide and solutions manual as well as source code in both Common Lisp and C++.

The book is organized into chapters on symbolic programming, representation and logic, search, learning, advanced representation (including temporal logic), planning, uncertainty, image understanding (a detailed 80 pages) and natural language processing (also detailed at 50 pages). Of the four books, this is perhaps the most avowedly GOFAI and provides the strongest emphasis on applications of AI, though there are about six pages on genetic algorithms with program code examples.
A particularly pleasing feature of the book are the frequent examples of applied AI systems (illustrated with photographs) such as Carnegie-Mellon’s autonomous vehicle or Microsoft’s use of probabilistic networks to diagnose hardware faults. These examples do much to help illustrate the utility of the techniques on offer. For instance, the introductory chapter includes examples on NASA’s mission to explore Mars. These provide a sense of realistic immediacy to the issue of how a practical, autonomous robot might make its way in the world. Unsurprisingly, it is the only book of the four containing colour illustrations, in the chapter on image understanding where there are also sections on analysis of visual motion, flow vectors, and active vision. This latter is exemplified by a section on autonomous vehicle navigation.

The main contrasts to Nilsson are the much stronger emphasis on applications and the inclusion of program code—together these two factors are likely to make the book appeal to a slightly different kind of student (and instructor). Compared to Nilsson, the coverage on Vision and NLP is much more detailed.

Computational Intelligence: A Logical Approach

Like the book above, Poole, Mackworth and Goebel describe algorithms in program code, though in this case they use Prolog. They state that

“the book works as an introductory text in artificial intelligence for advanced undergraduate or graduate students in computer science, or related disciplines such as computer engineering, philosophy, cognitive science, or psychology. It will appeal more to the technically-minded; parts are technically challenging, focusing on learning by doing: designing, building, and implementing systems”. (p. xv)

Thus the book is very much an introduction to AI using a logic programming language, rather than being an analysis of the logical foundations of AI e.g., in the style of [3]. Like Nilsson and Russell & Norvig the authors make use of the notion of an agent operating in a world. So, for example, they cover some issues concerning situated robotics and provide Prolog code for controlling such a robot (an interesting confluence of GOFAI and nouvelle AI).

The book is divided into chapters on computational intelligence and knowledge, a representation and reasoning system, using definite knowledge, searching, representing knowledge, knowledge engineering, beyond definite knowledge, actions and planning, assumption-based reasoning, using uncertain knowledge, learning, and building situated robots. It contains two appendices: one an introduction to Prolog; the other offering Prolog code to illustrate various of the techniques. Unlike the other books it has no chapter on vision or image processing, indeed neither of these words appear in the index. The section on NLP (13 pages) is of roughly similar complexity and coverage to Nilsson (20 pages). However it does have a chapter on knowledge engineering, though this is largely about implementing and debugging expert systems based on meta-interpreters.

A useful feature of the book is the way that it exemplifies issues through the use of three repeated applications: an autonomous delivery robot (for a laboratory environment), a diagnostic assistant (for a domestic electricity system) and an “infobot” (for helping
A Modern Approach

By far the longest of the four is the book by Russell & Norvig. It has 932 pages whereas the other three are still substantial but each less than 600 pages. It aims to provide a “unified presentation of the field”, based on “intelligent agent design”, with “comprehensive and up-to-date coverage”, demonstrating “equal emphasis on theory and practice”, while facilitating “understanding through implementation”. The authors intend it “for use in an undergraduate course or course sequence” and also hope that its comprehensive coverage makes it suitable as a “primary reference volume for AI graduate students and professionals wishing to branch out beyond their own subfield”. As such, the book has a rather wider intended audience than the other three being reviewed. At Sussex it has been used successfully both as an introductory undergraduate AI text and as a text for specialised third-year undergraduate and some masters options such as Planning.

Each chapter provides its own detailed historical and bibliographic notes as well as a large number of pseudocode examples (and a definition of the syntax of that pseudocode in an appendix). In addition the program examples can be downloaded either in Lisp or C++.

The book is divided into eight sections: Artificial Intelligence, Problem Solving, Knowledge and Reasoning, Acting Logically, Uncertain Knowledge and Reasoning, Learning, Communicating Perceiving and Acting, and Conclusions. The Introduction and Conclusion are both brief but broad-ranging and ambitious. For example, the Introduction provides various perspectives on the foundations of AI. The one from a philosophical viewpoint (428 B.C.–present) covers dualism, materialism, empiricism, and logical positivism. The one for mathematics (c. 800–present) introduces notions of the algorithm, the incompleteness theorem, intractability, reduction, NP-completeness and decision theory. That for psychology (1879–present) covers behaviourism and cognitive psychology. There is also an excellent and realistic dozen page history of AI, including a section entitled “A Dose of Reality (1966–1974)”. One can see why Nilsson (see above) felt there was no need to compete on this front. The Conclusion briefly addresses three important questions “Have we succeeded yet?”, “What exactly are we trying to do?”, and “What if we do succeed?” and provides an interesting contrast to the more applied approach of Dean et al.

Because the book is much longer than all the other three, it has the space to develop most topics in more detail. An exception is Vision (33 pages) which does not cover as much as Dean et al. which is much stronger on active vision and interactions of vision and motion. In its favour Russell & Norvig does include a detailed section on speech recognition within...
the chapter on perception—like chess one of those areas in which AI has played a role in
the production of applications that are now taken for granted. In keeping with the whole
agent metaphor, and the attempt to cover both GOFAI and some nouvelle AI topics, there
is a section on genetic algorithms.

Conclusion

The book by Nilsson offered me the possibility to examine how AI, and some textbooks
on AI, have changed in recent years. The four books reviewed here have responded to
the changes in focus of the subject to different degrees and in different ways. Reasoning
with uncertainty and neural network representations now figure in all of them and they
all involve systems interacting with the world rather than simply reasoning through a
representation of the world. But none of the books, I believe, would satisfy those in AI
for whom the notion of representation has become deeply suspect.

Each of the books has its strengths with no obvious “best buy”, as that would depend
very much on the style of teaching you wish the book to support. If you are particularly
keen to emphasise applications or want detailed chapters on Vision and NLP, then Dean
et al. looks a good bet. If you want a book that is based on Prolog that goes further in AI
terms than, say, [1] and is based around a small number of recurring examples, then Poole
et al. would be good. If you want a book that is strong on machine learning’s relationship
to many parts of AI and brings together most issues of concern in contemporary AI, then
choose Nilsson. Finally, if you want a single book that covers a very large amount of
material in an up-to-date and coherent manner, then choose Russell & Norvig.

References

1990.