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BOOK REVIEWS

Cellular automata machines edited by Tommaso Toffoli and Norman Margolus. The MIT Press, 55, Hayward Street, Cambridge, MA 02142, USA, 1987, pp. 259, $ 30. Indian orders to Affiliated East-West Press, Madras 600 010.

This book is presented in three parts, *viz.* Overview, Resources and Physical Modelling; each part consists of a number of rather short chapters. It gives an insight into cellular automata, where the primitive ingredients of the physical system that go into a model are reduced in to a single primitive ingredient, namely, the 'unit cell' governed by simple rules and coupled to identical cells by a uniform interconnection pattern.

In the first part, the authors have presented a historical review of Cellular Automata Machines (CAMs). The authors have also discussed CAM-6, the CAM developed at MIT, Massachusetts, which is the standard modelling environment used by the authors in developing physical models. Some rules pertaining to CAM-6 and a few trivial examples have also been presented in separate chapters. The four chapters in this part could have been merged into one single chapter without any discontinuity.

CAM rules are again discussed in the second part with some illustrative examples. The sources of information for computing the new state of the unit cell are discussed exhaustively in several chapters. Some of the methods for computing the new state and the related examples are explained in a rather circuitous manner. However, certain concepts like psuedo neighbours and Margolus neighbours have been presented lucidly. More significantly, the expressive power of these concepts as well as the occurrence of a random variable have been projected to indicate the direct mapping of cellular automata on to physical realizations and their suitability to a variety of modelling tasks.

The last part is devoted to express the role of cellular automata in physical modelling, which the authors claim to be complementary to that of differential equations. This claim is authenticated by some well illustrated models. To cite an example, the models on diffusion and equilibrium of gases and evolution of particle density in a gas discussed in the chapter on Diffusion and equilibrium. Similarly, the models on phenomena in hydrodynamics, Ising systems and optic waves underscore the power of cellular automata.

On the whole, the book is brought out in a systematic manner, the approach is good — the authors have started with the basic rules, modelling resources, then trivial modelling examples and have finally presented the nontrivial models. The book has a fair amount of programming examples in Forth, the language used for modelling physical phenomena in CAM-6. The CAM-6 software is supported on PC-DOS environment. The appendices in the book present a tutorial on Forth and the CAM architecture. The tutorial

on Forth is just adequate to follow the examples given elsewhere in the book. Forth is a stack oriented language and the execution of individual processes is pipelined. The suitability of Forth for supporting parallel execution of processes in cellular automata is not very convincingly brought out by the authors.

The book can be recommended for researchers in computer architecture and physicists.

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Large scale scientific computing edited by P. Deuflhard and Engquist. Birkhauser Verlag, CH-4010, Basel, Switzerland, 1987, pp. 388, S. Fr. 58. Indian orders to Springer Book (India) Pvt Ltd., Panchasheel Park, New Delhi 110 017.

The book deals with computations involved for solving a variety of scientific and engineering problems. Mathematical models are used to describe the real life processes and numerical methods have been proposed to solve the associated large scale computations.

The book is a compilation of papers presented at a meeting on "Large scale scientific computing" held in July 1985. The book is organised into six parts with twenty-two chapters in all. The contents of the parts and chapters are briefly summarised below.

Part I covers initial value problems for ordinary differential equations (ODE) and initial boundary value problems (IBVP) for parabolic partial differential equations (PDE). Chapter I gives an introduction to numerical computations involved in semiconductor device modelling. The models used represent 3-D nonlinear PDEs which require enormous computations.

The second chapter is on the use of hierarchical bases in finite element computations, which are commonly used for 2-D elliptic PDEs. The new approach is promising for strongly coupled parabolic PDE systems. The next chapter reports about the extrapolation techniques developed for the numerical solution of quasilinear implicit ordinary differential equations arising in chemical reaction kinetics. The following chapter covers the combustion problem which requires the afore mentioned extrapolation techniques and multistep techniques. Physical considerations lead to the suggestion of a numerical scheme valid for large time scales, in the subsequent chapter. The last chapter in this part gives an algorithm for the numerical simulation of saturated–unsaturated flow through porous media.

Part II of the book covers boundary value problems for ODEs and elliptic PDEs. It includes five papers on the subject. The first one has an efficient path following technique applied to ODE-BVPs. Algorithmic details and numerical comparisons are the special features of this paper. The second paper is on the use of hierarchical basis tech-

niques to reduce the computational effort of computing bifurcation diagrams for large non-linear parameter dependent systems. The next paper covers special ODE/PDE version of the pseudo-arc length continuation method. The procedures adopted to simplify the computations cannot adequately predict the detailed behaviour resulting from complex kinetics calculations. A subsequent paper by the authors promises to circumvent this drawback. The next paper has a hybrid numerical method for calculating complete theoretical seismograms. The last chapter in this part presents an efficient numerical algorithm for partial differential equations arising in 3-D geometries for viscous fluid flows.

Part III is on hyperbolic fluid dynamics. It has two articles. The first one is about a special class of shock capturing methods for the approximation of hyperbolic conservation laws. The method produces non-oscillatory solutions. Its special feature is that the computational stencil is always adapted to the solution. This results in a stability of the scheme. The second paper in this part addresses itself to a numerical method to solve compressible or incompressible Euler equation in 3-D using finite volume method with up to 6×10^5 grid cells.

Part IV shortly surveys some recent results for inverse problems in integral equations. The first two chapters deal with two alternative ways of treating the inverse radon transform problem arising in computer tomography. The third chapter presents numerical techniques for identification and optimal control in parabolic PDEs in a theoretical framework. The method, however, has to still address to some open questions.

Part V emphasises on large scale optimisation and optimal control problems. The first paper surveys the state-of-the-art solution techniques for solving large scale integer optimisation problems. MIMD architecture appears better suited problems than pipelined for vector machines for integer programming. Feedback control techniques for control and state constrained problems have been worked out in the setting of the multiple shooting method for ODE-BVPs in the next chapter. Two interesting applications have been presented. The feature meriting special mention is that the algorithm suggested is the only one capable of the treatment of control problems with control and state constraints. The last chapter of this part concerns the optimal control of a storage power plant.

The last part of the book has adaption of algorithms to supercomputers. This part has three chapters. Three main approaches used in the direct solution of sparse unsymmetric linear equations have been discussed in the first chapter. The next chapter presents a modification of adaptive gridding developed specially for supercomputers. Experience from the actual implementation of this concept is reported. The last chapter describes several approaches for adapting the existing numerical algorithms for use on supercomputers. A new iterative algorithm suiting vector computers has been developed.

Briefly, the book presents recent issues in large scale scientific computing covering initial and boundary value problems, inverse problems for integral equations and real life optimisation problems. The fields of application dealt with include semiconductor design, chemical combustion, seismology and fluid dynamics. The book is useful to

scientists and engineers with interests in the computational aspects of ordinary and partial differential equations.

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AI in the 1980s and beyond–An MIT Survey edited by W. Eric. L. Grimson and Ramesh S. Patil. The MIT Press, 55, Hayward Street, Cambridge, Mass, 02142, USA, 1987, pp. 374, $ 24.95. Indian orders to Affiliated East-West Press, Madras 600 010.

This edited book brings together a collection of twelve papers by MIT staff members who participated in a conference in January 1986 entitled "Artificial intelligence: Current applications, trends and future opportunities". MIT has been a pioneering institution in AI since the birth of the field in the early 1960s. In the almost three decades of its existence AI has grown to be an evolutionary force in high technology industry and several laboratories in Japan, Europe and North America have joined the race. In India, 1987 has witnessed the establishment of a laboratory, Centre for Artificial Intelligence and Robotics (CAIR) in DRDO and the Department of Electronics has initiated the fifth generation computer project at five national institutions in India (TIFR, NCST, ISI, IISc and IITM). The MIT perspective is undoubtedly very important to the Indian R&D community in this frontier area of computer science.

The first paper by Winston is a brief introduction to the evolution of AI. He traces its career through its dawn in 1958, its early promises, the growth of LISP language, the emergence of time-sharing to meet the demands of AI researchers, its dark period in the late sixties and the early seventies and its renaissance in the 1980s with the commercial success of expert systems and the outgrowth of companies such as Symbolics Inc. and the LISP Machine Inc. out of MIT efforts. He discusses the current activities of the AI laboratory at MIT in the areas of robotics including perception, sensing, manipulation of objects and reasoning, language and learning and knowledge-based systems. Winston takes a working view regarding the primary goal of AI as making machines smarter and defines an intelligent robot as one which flexibly connects perception to action. He also raises several interesting questions for debate on expert systems, natural language interaction with machines and the role of robotics in increasing productivity in manufacturing. His main concern is with the commercial exploitation of AI technology.

In the second paper, Davis looks at knowledge-based systems at their stage of evolution in 1986. He notes that while rule-based and frame-based systems have been widely available, the problem of inexact reasoning has not been resolved satisfactorily. The central question is: "what makes a human expert an expert in his domain?" It is difficult to capture the human abilities of common sense reasoning, ability to reason both causally and qualitatively and the ability to learn from experience in the present generation of expert systems. Davis also notes the rapid commercialization of expert system technology and mentions systems such as PLANPOWER™ designed to help in

individual financial planning. The present work at MIT is attempting to overcome the limitations of rule-based technology by exploring the theme of reasoning from first principles.

Szolovits explores the past, the present and the future of expert system tools and techniques. In view of the current revenues in the range of $ 100 m and market projections up to $ 800 m in 1990, an unlimited number of large system building tools and small PC-based tools are in the market. For the Indian readers, this article should provide lot of lessons about the over-blown commercialization and speculation in the field. The author's remarks about the underlying concepts in these together with the reading in between the lines should warn the Indian R&D laboratories not to be carried about by advertisements to buy these tools spending precious foreign exchange. (Indians have already spent enough by buying scores of books on expert systems which convey nothing but stereotypes of MYCIN). First generation expert systems can be designed and built in all good Indian laboratories as graduate or undergraduate projects!

The article by Patil focusses on AIM (Artificial Intelligence in Medicine). Since the phenomenal success of MYCIN at Stanford, medical diagnosis has always been treated as a prime application of expert systems. Patil describes the medical diagnosis problem vividly considering the issues of disease hierarchies, diagnostic reasoning with multiple disorders, etc. He describes the features of a program called ABEL whose knowledge base includes the shallow knowledge of associations between diseases and the deep pathophysiologic knowledge needed for accurate diagnosis. ABEL does more than conventional pattern classification by constructing a model that can explain the patient's illness. The paper ends with a speculation that expert systems might become common place in hospitals by the year 2000.

The paper of Rich and Waters on AI in software engineering is one pointing to a hope wherein real automatic programming may be feasible some day. Natural language understanding is one of the fond hopes of AI since the machine translation days. Berwick deals with intelligent natural language systems which might be able to reduce the imperfect present systems employing thousands of rules. The present effort at MIT aims at making these systems modular, more easily adaptable to future parallel processing architectures and more easily extendable to other dialects and languages. Zue looks at the related problem of automatic speech recognition and understanding. Over four decades of efforts have only produced isolated word recognition systems and recognition of continuous speech remains an elusive goal.

Brady is more optimistic about intelligent vision systems which have diverse applications. Vision poses a formidable challenge for AI presenting it a noisy and uncertain real world. The computational demands are enormous and it is even difficult to say what knowledge is needed for a robot to catch an object, a task which can easily be done by a little child. The entire SDI program depends on vision systems and the applications in defence are unlimited. Brady gives a very readable account of the diverse problems in vision and the trends in present research.

The last three articles are on robotics. The first of these deals with providing robots with sensing abilities and the second with robot programming. The article by Hollerbach

deals with the comparatively mature field of robot hands. Designing multifingered hands places extreme demands on all aspects of robot technology. The final article by Brooks is on autonomous mobile robots which navigate around in environment.

In any book on topics at the forefront of contemporary AI research by a group of twelve authors, there are bound to be wide differences in scope and depth of treatment. This reviewer considers the chapters on medical diagnosis, natural language processing and vision to be particularly good. This book is recommended for all graduate students in AI for a quick and critical overview of the contemporary work in AI in a great institution. It reminds us, those connected with the *Journal of the Indian Institute of Science,* to use this as a medium for documenting the activities at IISc in particular, in a timely manner, to do at least a part of what the MIT Press is doing.

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V. V. S. SARMA

Systems that learn: An introduction to learning theory for cognitive and computer scientists by Daniel N. Osherson, Michael Stob and Scott Weinstein. The MIT Press, 55, Hayward Street, Cambridge, Mass. 02142, USA, 1986, pp. 205, $ 28.75. Indian orders to Affiliated East-West Press Pvt. Ltd., 6, Roselyn Gardens Apartments, 20/1A Barnaby Road, Madras 600 010.

There is a resurgence of interest in learning systems as there is a tremendous expansion in the field of artificial intelligence and as computers move towards the fifth generation. The book by Osherson *et al* is an attempt to build a learning theory from first principles.

Every theory is a product of its time. The present trend in cognitive science is to give a computer model for many phenomena. In keeping with this trend, the present book centres on the mathematical development of learning theory using fundamental concepts from computer science such as computable functions and recursion. One could contrast this approach with the classical work of Bush and Mosteller on stochastic models of learning which dealt with updating schemes for choice probabilities and was based on the theory of stochastic processes. The motivation for the present work comes from the acquisition of the first language by children and this theme is repeatedly used as an aid to intuition.

According to the paradigm of the book, learning typically involves 1. a learner, 2. a thing to be learned, 3. an environment in which the thing to be learned is exhibited to the learner, 4. the hypotheses that occur to the learner about the thing to be learned on the basis of the environment. Learning is said to be successful in a given environment if the learner's hypothesis about the thing to be learned becomes stable and accurate. On the basis of the above, learning theory is the study of systems that map evidence into hypotheses.

The book is divided into three parts. Part I advances a model of learning called identification suggested by Gold in 1967. Identification is intended as a model of language acquisition by children. However, the authors are conscious of several inadequacies of the model in explaining language acquisition. This is probably the reason why language acquisition is emphasized only as a motivating factor for the theory that is developed. It also makes some interesting speculations. One such speculation is that children may respond to a linguistic input not with one grammar but with a finite array of grammars each associated with some subjective probability.

Part II is devoted to a family of learning paradigms that results from modifying the definitions proper to identification. It examines various construals of "stability" and "accuracy" in the context of alternative criteria of successful learning.

Part III discusses efficient learning which has two demands. The learner must not examine too many inputs before settling for good on a correct hypothesis and second, the learner must not spend too long examining each input. This part also considers issues such as input required from the environment for learning and some aspects of probabilistic learning.

While the learning theory developed here is general, it is doubtful whether it can, in its present form,cover all aspects of learning. One weakness appears to be the nonutilization of the reaction of the environment for each hypothesis made by the learner. Such feedback exists in many situations in a probabilistic form, as for instance, in the two-armed bandit problem. Even in language acquisition, the child's parents often provide feedback in the form of corrections to the sentences formed by the child. Utilization of this type of feedback is extensively used by Bush and Mosteller and is further developed in models of learning automata. It appears that a much more powerful learning theory could be constructed by combining probabilistic ideas from learning automata and the computability theory of the present book. A glimpse of such a possibility is seen in the closing sections.

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M. A. L. THATHACHAR

Machine interpretation of line drawings by Kokichi Sugihara. The MIT Press, 55, Hayward Street, Cambridge, Massachusetts, 02142, USA, 1986, pp. 252, $ 30. Indian orders to Affiliated East-West Press Pvt. Ltd., 6, Roselyn Gardens Apartments, 20/1A Barnaby Road, Madras 600 010.

Understanding the shape of objects from two-dimensional line drawings is a problem that has received great attention. The importance of a good solution to this problem is apparent in the context of CAD/CAM applications. The 3-D shape data obtained by processing engineering drawings and hand-drawn line sketches of three-dimensional

objects can then be further used in CAD/CAM systems towards meaningful applications. The book by Sugihara addresses itself exclusively to the issues in the specific problem of extracting 3-D shape of objects from a single 2-D line drawing and offers a reasonably exhaustive treatise on the topic put together under one cover for the first time. It consists of 11 chapters which are separately reviewed below.

The first introductory chapter starts on with an intuitive description of the problem of interpreting 3-D shape of polyhedral objects from 2-D line drawings. It then goes on to give a brief review of the literature on this and related topics. The aim of the book is stated quite unambiguously: "It should be said here that this book places emphasis on engineering rather than human science. Our aim is to construct a computational mechanism by which a computer can practically process line drawing data" (Chapter 1, page 5). In tune with the modular structure of the book, each subsequent chapter deals with one particular aspect of the whole problem. Chapter Two sets forth the assumptions which define the polyhedral and non-pathological nature of the scene whose 2-D line drawing can be meaningfully processed. Later, a set of simple procedural rules, for computing the set of all possible locally consistent edge labellings based on known types of physically possible trihedral vertices, is laid down. Finally, a pidgin Algol algorithm is presented which extracts, by constraint propagation for overall consistency, the small set of edge labelling schemes which are the final "Candidates for spatial interpretation" (Title of Chapter Two). Chapters Three and Four elaborate on discriminating between 'correct' line drawings which represent polyhedral scenes and 'incorect' ones which do not. Hidden line-eliminated drawings are considered in Chapter Three while Chapter Four deals with pictures in which hidden lines are also shown, as in engineering drawings. In both the cases, a necessary and sufficient condition for a correct interpretation of line drawings representing polyhedral scenes is shown to be equivalent to the existence of feasible solutions to a linear programming problem. Chapter Five consolidates the concept of algebraic structure of line drawings developed in the last two chapters and studies the nature and distribution of degrees of freedom in the choice of three-dimensional structure of the object represented in a line drawing. The superstrictness of the algebraic approach prevents it from being flexible such that it can tolerate slight vertex position errors in the line drawing due to digitization or hand-sketching approximation. The method of circumventing this superstrictness is studied in the following three chapters. Chapter Six describes detection of redundancy in the linear algebraic system of Chapters Three and Four. The method of deleting the redundant equations as well as automatically correcting the incorrectness in vertex positions is described in Chapter Seven. Chapter Eight presents an efficient algorithm to check whether an incidence structure (a set of ordered pairs of the form $<v_a, f_j>$ which represents the constraint that vertex v_a lies on face f_j) is generically reconstructible or not, in time proportional to the square of the number of incidence pairs. Chapters Nine and Ten describe how additional information, for example, specified lengths or angles (Chapter Nine), and surface texture and light intensity data (Chapter Ten) can be used to quantitatively fix the unique object shape most consistent with additional cues. This completes the methodological side of the line drawing interpretation problem. The last chapter (Chapter Eleven) is interesting but slightly out of context from the main theme.

It explores the correspondence between line drawings of polyhedral objects and rigidity of planar skeletal structures using a graph-theoretic approach.

There is hardly any noticeable typographical error in the book, but one finds a few minor syntactical errors, and on quite a few occasions, somewhat clumsy English sentence constructions are distracting. Figures are all quite clear, illustrative and unambiguous, except possibly Fig. 3.1 intended to show the orthographic projection of a polyhedral object. Any simple plan-elevation engineering drawing of a simple object would probably have been better illustrative. Mathematical treatments are terse, precise, and do not demand deeper background than basic linear algebra, elementary set theory and some knowledge of optimization techniques. A highly exhaustive set of 145 references is given.

Other than those involved in research in line drawing interpretation, readers interested in computer vision, graphics, artificial intelligence, robotics, and man-machine interaction in CAD systems involving 3-D objects will also find the book useful.

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A vision of C and C: Computer and communications by Koji Kobayashi. The MIT Press, 55, Hayward Street, Cambridge, Mass. 02142, USA, 1986, pp. 190, $ 19.49. Indian orders to Affiliated East-West Press Pvt. Ltd., 6, Roselyn Gardens Apartments, 20/1A Barnaby Road, Madras 600 010.

This book is essentially a report on the various developments that have taken place in the fields of telecommunications, electronics and computers in Japan in the last about 60 years or so. The author of the book is an engineer turned executive, who started his career in 1929 and has grown with the technology. Hence one may expect the report to be authentic and accurate. The book also contains author's projection of how the field of computers and communications (C&C) is likely to evolve and affect the future of mankind.

The book begins with a summary of the pioneering events in Japan in the communications technology in the early years of development. The author springs a few surprises here claiming that many developments in this field took place in Japan much earlier than they did in the US, although most of the world is only aware of the US contribution. For example, the fundamental research results in switching theory published by C. E. Shannon in 1938 were apparently known in Japan by 1935 itself.

The author brings out that a single important factor that led to the tremendous growth in postwar Japan is the decontrol of the radio waves which were made available to the private sector in the early 1950s for radio and television broadcasting. As brought out by the author, it is interesting to learn that Japan had built its early computers using a device

called parametron, which is a kind of resonance circuit, consisting of a small magnetic core, coils and capacitors, that works on the parametric excitation principle. Various developments and the process of coming together of the computers and communications have been well described by the author. He also presents well the social impact by expounding what he calls the concept of Man and C&C.

By the time one comes to the end of the book one feels a little tired of the claims made by the author. The book is so full of them that one wonders at the veracity of at least some of the statements. For example, the author claims to have envisioned the concept of integrating computers and communications, which he first presented in 1977. I quote here from a paper by R. M. Fano in 1972.

"The marriage of computers and communications has been celebrated and consummated. By now the honeymoon is over and the two partners are begining to face the realities of their interdependence".

If the reader is mentally prepared to put up with the many claims made, he would find in the book a very vivid account of the remarkable developments that have taken place in Japan in the field of C&C in the last about 60 years and that are likely to take place in the foreseeable future. The author's fond hope is that automatic real-time machine translation systems, that would enable people of different countries to converse freely with one another without having to use a common language, would become a reality before 2000 A.D. Let us too hope so.

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T. VISWANATHAN

Knowledge-based tutoring: The GUIDON program by William J. Clancey. The MIT Press, 55, Hayward Street, Cambridge, Massachusetts 02142, USA, 1987, pp. 377, $ 34.50. Indian orders to Affiliated East-West Press Pvt. Ltd., 6, Roselyn Gardens Apartment, 20/1A Barnaby Road, Madras 600 010.

This book describes a computer program called GUIDON that interacts with a student to teach him the knowledge needed for medical diagnosis problems. The specific field is that of diagnosing certain infectious diseases which is the field of expertise of MYCIN, the celebrated knowledge-based consultation program. The objective of GUIDON is to build an effective instructional tool utilising the knowledge base and problem-solving strategies of MYCIN.

There are many teaching programs developed which utilise an expert problem solver in the domains to teach the techniques to a student. But almost all such efforts are restricted to fields like geometry and algebra which have a precise formulation and well

established norms as to what is the correct approach to a problem. As opposed to these, fields like medical diagnosis which are characterised by uncertain, heuristic knowledge and where there are no universal guidelines for evaluating problem-solving approaches, are much more difficult to handle. The GUIDON program described in this book is one of the first attempts at utilising a complex expert system at the heart of a teaching program. Since it is the first attempt, the results are not very exciting. But the book should still be of interest because it does provide some insights into this difficult teaching problem.

Briefly, the method followed by GUIDON is this: It maintains teaching knowledge distinctly from the domain knowledge MYCIN uses for actual problem solving. The program begins by getting MYCIN's solution on an example problem. This would have been obtained through MYCIN's backward chaining of rules. For GUIDON, MYCIN is modified to leave a detailed record of this problem-solving process. Then GUIDON constructs an AND/OR tree representation of MYCIN's solution which details the various rules tried, the failed subgoals, the data needed for determining the validity of different subgoals, etc. With this structure, GUIDON can rerun MYCIN's solution, but now in the forward direction, to determine which data is needed when, what inferences can be made with currently available data, etc. This AND/OR tree is what GUIDON uses to guide the student through the solution process. It gives the student the initial case data and then discusses with him various subgoals, waiting for him to ask for more data or seek help in solving some subgoals. The tutorial session is in mixed initiative mode, that is, either the teacher or the student can guide the conversation at any time. During the session, GUIDON has to develop and update a model of student knowledge to be able to interact with him intelligently. This is obtained by comparing the kind of data he is requesting and the type of inferences he is making against the same phase in MYCIN's solution. This process is fairly complex because the student need not know MYCIN rules in an identical fashion or even if he does, he need not apply them strictly in the same order as MYCIN does. All that can be expected is that given the same data, he should be able to make the same partial inferences as MYCIN does. For maintaining the student model, GUIDON uses its teaching knowledge.

The book systematically discusses the various problems involved in learning using the knowledge base of a typical expert system. The treatment is fairly general so that it is relevant not just for learning from MYCIN but to many other fields with the same general characteristics. Clancey begins by considering the issues involved in having the subject knowledge as a set of production rules. Chapters 2 and 3 describe the features of MYCIN rule set and what kind of information a teaching program should have about the structure of knowledge base for it to effectively compare student's solution with the expert's solution. The next two chapters address the problem of dialogue management especially in the case where the student maintains the initiative. Chapter 6 describes the teaching knowledge needed to construct and update the student model. The next two chapters contain the author's experiments with program and the extensions to the basic method. Chapter 9 deals with the conclusions of this effort. It contains a frank appraisal of the insights gained and the limitations of this program. A set of appendices (five in number) give details of the program and a full length example session.

GUIDON is an experimental system—a first attempt at trying to automate the teaching of a complex field. Since the program is no longer available, the interest in it is mainly of a theoretical nature. As the author himself points out, GUIDON did not answer any pedagogical questions about methods of teaching medicine. But it did demonstrate the usefulness of a specific representation technique to store the expert's solution in a complex domain. Also, it brought into focus limitations of MYCIN's representation of medical knowledge. Thus the book is of interest to anyone who is interested in computer-aided instruction and wants to know the problems involved when one steps out of simple well-structured domains and tries to teach a fairly complex subject.

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P. S. SASTRY

Programming in FORTRAN by P. V. S. Rao. Tata McGraw-Hill Publishing Company Limited, 4/12, Asaf Ali Road, New Delhi 110 002, 1987, pp. 377, Rs. 45.

Considering the number of books already available on FORTRAN, it is not easy to justify writing yet another. *Programming in FORTRAN* by P. V. S. Rao, however, turns out to be a truly valuable addition to the textbooks on this subject.

The first two chapters lucidly explain the basic features of computers and, more importantly, the concept of algorithms. The detailed step-by-step illustrations should make it extremely easy for a student to understand the process of preparing flow charts.

The next six chapters describe the details of FORTRAN IV. It is the presentation in this section that makes the book not merely a good book on FORTRAN, but an excellent textbook *per se*. The description of each feature is very clear. Important points are repeated in separate paragraphs (liberally sprinkled with underlines) making them stand out from the main body of the text. Well annotated charts, which use a large sized typeface for FORTRAN statements, constitute yet another noteworthy feature, adding to the clarity as well as ease of learning.

Despite being an accomplished scientist and an expert in computer science, the author seems to have a keen insight into the kinds of difficulties and doubts the beginners are likely to be faced with. Thus, in the treatment of the ASSIGNED GOTO statement, the author points out how the reader may at first feel this to be an unnecessary feature, and follows up with an example where the use of an ASSIGNED GOTO statement is seen to improve the efficiency of the program.

The next chapter on 'Errors, efficiency and style' supplies many valuable hints and guidelines, which should go a long way towards making the student a competent programmer. The next chapter on features of FORTRAN-77 is also a very worthwhile addition.

Some of the detailed appendices make the book stand out from others on the subject. The descriptions of assembly language, process of compilation, etc., not normally found

in elementary textbooks are concise, yet clear. The appendix on Numerical analysis, especially with its many solved examples, would undoubtedly make the student familiar with many techniques crucial for writing efficient and reliable programs for scientific and technical computations.

The numerous exercises at the end of each chapter are well designed to judge how well the student has understood the various aspects of every FORTRAN feature. Some of them are interesting enough to make writing programs for solving them a lot of fun. Hints and answers supplied at the end (though somewhat laconic) should make the book ideal for self-study as well.

Negative features, though not entirely absent, are few and far between. The book certainly deserved a better quality paper; the paper used is a little too thin for comfortable reading. The year of publication of the first edition is not indicated, and it is a little odd for a book published in 1987 not to cite any publication later than 1977. There are a few typographical errors and omissions. The style of writing is more pedantic than conversational. Neither of these, however, would seriously handicap the reader. A list of commonly available library functions would have been helpful.

In summary (to use one of the most popular current cliches used for describing software), this is an extremely 'User Friendly' book, and an ideal textbook on FORTRAN.

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