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Book review:

Automata Theory and Its Applications

by

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This good book, indeed worth recommending, presents in a consistent and orderly manner the basic results achieved during more than five decades of development of theory of finite automata. A part of the notions and theorems considered are (or at least ought to be) well known to every computer professional: the basics of the automata theory belong, namely, for years to the fundamentals of any curriculum in computer science. Still, this, which is best known, originates mainly from the earlier stages of development of the automata theory. On these earlier stages the automata theory was associated primarily either with mathematical linguistics, understood first of all as the theory of programming languages (phase structure grammars, translation methods, etc.), or, in digital technology—with the problems of synthesis of sequential circuits. The subject of interest was constituted by the automata accepting (or not) the finite sequences over some finite alphabet. The majority of the classical monographs and handbooks treating automata theory revolved around these problem areas.

Yet, it was already in the 1960s that the concepts appeared broadening significantly the theory of finite state models, especially the Büchi and Müller automata, operating over the *infinite* sequences, and the Rabin automata, which operate over *trees* instead of sequences. The former allowed for the expression and investigation of the properties of such objects (e.g. the operating systems, the communication protocols, etc.), in which the valid or accepted behaviors have the character of infinite sequences of states. The latter found application in the theory of games, decision theory, and computational logic. The results obtained were known, however, mainly within the circle of narrower specialists and have not constituted the component of the fundamental theoretical education of the broader community of computer specialists.

The authors of the book (one of them bearing the name of historical significance for the domain in question, suffice to mention the Myhill-Nerode theorem) decided to face the task of summarising in one book, in a unified manner, all the concepts, notions and theorems mentioned, forming together the contemporary automata theory. They succeeded fully, and also showed how and why these theoretical results contribute to the development of other fields of the broadly understood theoretical computer science (or—if you will—contemporary mathematics and logic).

In terms of didactic value the book is exceptionally well written. It was, anyway, construed as a university handbook for the conduct of courses at the faculties of mathematics or computer science, and before publication in the present form of a book it had been subject to the acid test during the five year of teaching practice at four good universities in the United States and New Zealand. The drive towards clarity and self-containment is well felt during reading. The authors do not assume at all that the reader is knowledgeable in algebra, logic, or other fields of modern discrete mathematics. They introduce in the first chapter and comment upon even the so basic notions as set, relation, function, partial order, graph, or tree. They emphasise the importance of explanation of the essence of induction, which is thereafter used many times over as the conceptual tool for proving. The new notions, appearing in the consecutive chapters, are being defined "on place", so that when one wishes to follow the reasoning, there is no need to make use of other handbooks or publications. At the same time, the lecture is mathematically precise and in each sub-chapter it proceeds from the definitions through the proofs of the necessary lemmas to the culmination in the form of the fundamental theorems and their demonstrations. Further—and this is quite important—each such sub-chapter starts from an informal comment on the *purpose* of analysis of a given problem. Each lemma follows the explanation *why* is it necessary, and what should we gain by proving it. In addition, the examples and the proposals of exercise problems to be solved allow for the verification of our understanding of a given fragment of reasoning. Consequently, the volume is an excellent handbook, treating difficult theoretical problems in a legible, interesting, and at the same time formally correct manner.

The title of the book attracts the attention with the suggestion that there will also be a treatment of *applications* of the automata theory. A reader, though, who would expect practical examples—"taken from life"—may feel disappointed. This is first of all an excellent book on the automata *theory*, written by two highly competent theoreticians. In the entire text there are perhaps two examples, in which a finite automaton is not simply a certain directed graph labelled with symbols from the alphabet a, b. The first of them shows the sequence of actions that has to be carried out by a monkey in order to reach a banana, while the second is the commonly known case from the research on concurrency (otherwise quite appalling in hygienic and esthetical terms), namely the problem of five (here reduced to three, for simplicity) philosophers, gorging noodles from the common bowl using common chopsticks. For Khoussainov and Nerode the term "application" denotes the use of notions and theorems from the automata theory *in other theories*: in decision theory, in theory of games, in reasoning on the decidability of some types of logics, in Boolean algebrs, and so on. Thus, the authors show how the notions and theorems from the automata theory allow for the expression and demonstration of the properties of other abstract structures. They do not deal, however, with the ways in which all these intellectual constructs are related to the practical problems.

This, though, can hardly be a reproach. First—this was exactly the assumption of the authors, and second—they emphasise many times over that the theoretical results shown by them find application in the study of concurrency, modelling of program behaviour, image processing, etc. Besides, they have put together a (moderately broad) bibliography, to which an interested reader is referred.

The problem remains, however. It is well known that there is nothing more practical than a good theory: from this point of view the theory of finite automata is very "practical". Programmers and designers of hardware or of embedded systems use in their everyday practice programming languages, compilers, as well as computer-aided design or verification tools, which grew on the basis of automata theory. Yet, interpretation of the properties of actual programs, circuits, or systems in the categories of abstract notions requires definite intellectual effort and is by no means a common skill neither among the practitioners, nor among the theoreticians. None of the two sides (the theoreticians and the practitioners of computer science) appears to evaluate properly the role and the achievements of the other one. It would certainly be good to see on the "real" examples, how is *this* done, to become convinced that this can be done, and that it is *worthwhile*. In particular, the attempts of using automata theory in practice uncover the weaknesses and limitations to the finite-state models, which leads, as a rule, to modifications, extensions, or new types of automata. Suffice to mention the automata with output (like, say, the Moore and Mealy automata, known for decades), the statecharts of Harel's, and the UML's state diagrams, the Extended Finite State Machines (EFSMs), applied in the specification of the communication protocols, the exquisite ideas from the domain of representation of automata using Binary Decision Diagrams, and the methodologies and tools for the verification of complex finite-state models (e.g. symbolic model checking, language containment, SMV, SPIN, COSPAN,C@S, ...). Each of these problem areas represents automata theory in practice: in the advanced IC design, in the design of distributed software, in communication protocols, in embedded systems, etc. It also often happens so that the practical aspects motivate to seek support from the informal ideas, heuristic solutions, simulation, in addition to, or even in place of a "regular" theory. That is why many of these problems still constitute a challenge for the theoreticians of computer science.

The thus outlined subject domain still waits for its Khoussainov and Nerode, the authors who would be capable in an equally competent, consistent, and legible way contain in one book the synthesis of the most important ideas and results (as well as problems to be solved) from the area of the real-life applications of automata theory.

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