ALGORITHMIC PROBABILITY: A Collection of Problems

by Marcel F. Neuts

A BOOK REVIEW

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(Received October, 1996; revised April, 1996)

A significant increase in computing power has enabled many fields to forge ahead and tackle problems much too complex to be solved analytically. The older researchers among us have seen computing move from slide rules and hand cranked calculators to punch cards and batch processing, then to teletype terminals, and on to the now ubiquitous desktop machines and their networks, packing more power than the mainframes of yesteryear.

Although the growth in computing power has been a catalyst to the growth of many areas of applied mathematics, the ability to harness that power will always depend critically on the analyst's ability to think algorithmically. The cultivation of that ability is not easy, particularly in applied probability, where there are too few good books that incorporate algorithmic methods as an integral part of their exposition. "Algorithmic Probability," by Marcel F. Neuts, a pioneer in this area, makes an invaluable contribution, and can help make the development of critical algorithmic thinking skills an integral part of one's training in probability. Preparing a set of exercises is often the most difficult part of writing a textbook, and it goes without saying that writing an entire book of problems in a growing area like applied probability is a challenge that few can meet. This book bears testimony to the author's many decades of experience in teaching algorithmic methods, and more importantly, to his practice of that discipline through hands-on computing.

What is most remarkable is the way in which the book lives up to its stated ideal of "structuring a body of knowledge to guide the learner to an integrated understanding and to independent, critical thinking." In algorithmic methods, this involves several important steps, including: mathematical modeling to suit an algorithmic approach; identification of key recurrence relations and equations; examination of alternative algorithms and their relative merits; implementations assuring error control, speed, and minimal use of memory; validation through accuracy checks; and the interpretation of numerical results. The book provides practice for the skills needed in each of these areas through a set of problems carefully organized into topical areas and grouped into different levels of difficulty. The student moves gradually from the implementation of standard recursions and equations to a high level of creative algorithmic development and experimentation. The goal is not to teach a set of recipes and cookbook type solutions, but to take an effective approach to an art that cannot be reduced to a set of formulae. Indeed, one is reminded of the famous saying, "Education is what remains after one has forgotten all one has learned," and much will indeed remain in one who takes the trouble of working through even a third of the

problems in this book.

After starting briskly with two chapters that deal with recurrence relations and solving equations, the third chapter presents a variety of techniques and problems on “functions of random variables.” This is followed by two chapters on Markov chains, the mainstay of applied probability. These chapters include many advances in applied probability due to the author and his colleagues based on phase type models and matrix analytic methods. The final chapter on “experimentation and visualization” is the grand finale to the book wherein the student will master many nuances of the art of computation and simulation, and more importantly, the discipline of experimental methodology.

Each chapter begins with a discussion of key concepts and illustrative examples, and these are followed by problem sets arranged into categories: “Easier,” “Average,” “Harder,” and “Challenging.” True to the author’s preface, the problems “do not drill, but involve the student in thought processes” with the more challenging problems providing a useful training ground for research and critical thinking.

The book has three Appendices covering matrix analyses, phase type distributions, and Markovian point processes, and adequately provide the necessary background to tackle the problems. Happily, there is also a set of solutions to selected problems although these are more in the form of copious hints rather than complete and detailed solutions.

The book is a challenging one and does call for a good background in probability and applied mathematics. While this may discourage some from using it, it is our strong belief that one’s education in probability could not be complete without that background, particularly for algorithmic pursuits, the main theme of this book. The real challenge to a professor who uses this book is the preparation of the background material for each chapter. Although that challenge could have been made easier had the author presented more introductory material for each chapter, the present choice of the level of detail in the background material provides greater flexibility for class room use. It is certainly possible to use this book after the standard undergraduate training in linear algebra, calculus, and probability, as long as one is willing to digress occasionally to cover a few topics not usually covered in standard courses.

The potential users of this book are students in applied mathematics, statistics, and engineering. It is our hope that the discipline, philosophy, and critical algorithmic thinking it expounds, will become an essential part of our engineering and science education in applied probability.

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Publisher Chapman & Hall

USA: 115 5th Ave., New York, NY 10003

Publication Year 1995

ISBN 0-412-99691-X

Price \$59.95