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# Book Review: *Monte Carlo Methods. Volume I: Basics*

**Monte Carlo Methods. Volume I: Basics.** M. H. Kalos and P. A. Whitlock, Wiley, New York, 1986.

The Monte Carlo method—that somewhat less than august title for the approach to problem-solving based on statistical sampling—is now solidly established as a method for treating model systems that cannot be solved analytically and that are equally unapproachable by detailed numerical study. Several decades of achievement notwithstanding (*Physics Abstracts* for 1986 lists some 900 articles on the subject), the battery of techniques covered by the Monte Carlo label has yet to become a part of the standard university curriculum. Perhaps the reason for this state of affairs is to be found in the statement by Stanislav Ulam, one of the founding fathers of the approach, who summarized his reaction to the success of the method in dealing with otherwise intractable problems as "intellectually surprising, and if not exactly humiliating, it gives one a feeling of modesty about the limits of rational or traditional thinking."

The book under review, written by two practitioners of the Monte Carlo art, is a step in the direction of introducing the subject at the advanced undergraduate or introductory graduate level. The material covered can be divided into two parts: the first two-thirds of the volume introduces some of the basic concepts and underlying theory, while the remainder provides a series of examples taken from fields where Monte Carlo is gainfully employed.

The first part develops a reasonable background in the concepts of probability theory that are necessary to appreciate the Monte Carlo approach. Several sampling methods are described in detail, including rejection techniques, the ever-popular "Metropolis" method, importance sampling, and schemes for variance reduction. What is missing, however, is a discussion of convergence—a particularly important issue when studying systems that are reluctant to equilibrate, of which spin systems near



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their critical points and spin glasses are familiar examples. Somewhat surprisingly, there is no mention of Markov processes in the Index.

The examples of the second part are taken from fields in which the authors have worked. There are chapters dealing with statistical physics (the hard-sphere fluid and a very brief mention of the Ising model), radiation transport (a simple example including absorption and scattering), random walks and integral equations, and Green's function Monte Carlo. The majority of the references do not extend beyond the 1970s; in the case of statistical physics, for example, the reader is told nothing of the contribution of Monte Carlo to our understanding of spin systems (glassy or otherwise), polymers, and combinatorial optimization.

The subject of random numbers, that all-important raw ingredient, is relegated to an Appendix. The so-called "random" numbers that are produced algorithmically are an oxymoron, being at best "pseudorandom" (whatever that implies), and a good deal of effort has gone into developing generators whose products are statistically reliable. Some of the basic tests for reliability are discussed, but it is well known that subtle correlations can still be present in sets of purportedly random variates that pass these simple tests (a classic example being $n$-tuples that lie in a too-small number of hyperplanes) and these can adversely influence the very results one is attempting to observe. In view of its central nature, more could have been said on the reliability issue.

The book is subtitled *Volume 1: Basics*, but there is no intimation as to what subsequent volume(s) might contain. What this reviewer would like to see (publisher take note) is an expansion of the coverage of case studies involving Monte Carlo techniques. Equally desirable would be a series of "recipes," examples of how to go about tailoring the basic Monte Carlo techniques to particular physical problems, including a detailed treatment of the technical aspects (some, perhaps, left to the reader in the form of exercises). This would then result in a self-contained series of volumes that could be used to introduce students to theory and practice in Ulam's world of intellectual surprises.

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