

Joseph Liouville was a true genius who contributed more to modern mathematics than most of us realize.

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**Simulated Annealing and Boltzmann Machines: A Stochastic Approach to Combinatorial Optimization and Neural Computing.** By *Emile Aarts and Jan Korst*. John Wiley, Chichester, UK, 1989. xii + 272 pp. \$49.95. ISBN 0-471-92146-7. A volume in the Wiley-Interscience Series in Discrete Mathematics and Optimization.

The book consists of two parts. Part I provides an introduction to the Simulation Annealing algorithm, its convergence properties (Chapters 2 and 3), empirical analysis of polynomial-time cooling schedules (Chapter 4) and illustrates the practical use of Simulated Annealing for a number of combinatorial optimization problems. Neither the theory of convergence nor the analysis of polynomial time cooling schedules are treated in depth. Instead, the authors' intention was to provide an easy-to-read treatment of the fundamental facts together with a large number of references for further reading (the bibliography has of more than 200 entries and seems to contain everything relevant in the context of Simulated Annealing).

The main concern of the present book is to investigate the use of Simulated Annealing for designing and analyzing so-called Boltzmann Machines (Part II). Roughly, a Boltzmann Machine is a neural network consisting of a number of units (or nodes) which may be either "on" or "off" and which are connected via links (or edges) of a certain strength. We may then define a "consensus function" by taking the sum over all strengths of connections linking two units which are both "on." It is easy to see that many combinatorial problems, i.e., 0-1 problems, can be transformed to the problem of maximizing the consensus function of an appropriately defined Boltzmann Machine. The question then is whether we can (approximately) solve such maximization problems by using a parallelized version of the simulated annealing algorithm, where units are allowed to switch between "on" and "off" more or less independently, i.e., based on local

information exclusively. The mathematical analysis of convergence for the parallelized version becomes much more involved and leaves several interesting open problems for future research (Chapter 8).

Boltzmann Machines have been successfully used for solving classification problems (pattern recognition) and they also provide a promising tool for "learning" (Chapters 10 and 11). These two fields have received rapidly increasing interest during the last years, and therefore I think it is very important to see how Simulated Annealing may be used to approach these problems for appropriately adjusting the connection strengths.

Summarizing, I believe that the book contains interesting applications of Simulated Annealing, which are worthwhile to look at not only for the Simulated Annealing expert but also for the general theoretical computer scientist, especially when working in the area of machine learning. The material is presented very clearly (though sometimes both the plain text as well as the mathematics tend to be somewhat lengthy) and should also be readable for nonmathematicians.

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**The Stable Marriage Problem: Structure and Algorithms.** By *Dan Gusfield and Robert W. Irving*. The MIT Press, Cambridge, MA, 1989. xvii + 240 pp. \$27.50. ISBN 0-262-07118-5. A volume in the Foundations of Computing series.

Gale and Shapely introduced and solved a problem called the Stable Marriage Problem in 1962. The Stable Marriage Problem can be stated as follows: In a group of  $n$  boys and  $n$  girls, each girl ranks the  $n$  boys according to her preference, and each boy ranks the  $n$  girls according to his preference. A Marriage is a perfect matching between the boys and the girls (i.e., each person has exactly one partner of the opposite sex). A marriage is unstable if there is a pair who are not married to each other but who like each other more than they like their respective spouses, otherwise it is stable. Since this paper appeared, there has been a flurry of papers (at least 124) written and two books published. One reason for this is that this problem could be used for a variety