Chapter 13 investigates the relationship between the stochastic SGA process, denoted by $\tau(p)$, and its heuristic function $\mathcal{G}(p)$. As has already been pointed out, $\mathcal{G}$ describes the expected behavior of the stochastic dynamical system. That is, only in the infinite population size case, $r \rightarrow \infty$, $\tau(p) \rightarrow \mathcal{G}(p)$. The order in which this occurs is one topic. Another one concerns the convergence time of the $\mathcal{G}(p)$ dynamics to its stable fixed point $\mathcal{G}^{\infty}(p)$.

Modeling the RHS by a Markov chain over the fixed points of $\mathcal{G}(p)$ is addressed in Chapter 14. The intention is to provide a model which is able to explain the temporary stasis often observed in SGA runs, also known as punctuated equilibrium.

Chapter 15 resumes the investigations concerning the conditions under which the heuristic $\mathcal{G}$ is focusing considering the proportional selection case. Chapter 16 collects some results on invariance properties of crossover and $\mathcal{G}$ with proportional selection, respectively.

The remaining three chapters (note that Chapter 20 is an Appendix) are devoted to so-called equivalence relations and models of the SGA heuristics. One aim of these chapters is to provide conditions under which nontrivial equivalence relations do exist such that the dynamics of the SGA and of its model are equivalent. As Vose conjectures, there seems to be hardly any nontrivial equivalence relation which is compatible with $\mathcal{G}$ as a whole. From this perspective, schemata, which form the basis of classical GA theory, cannot adequately represent the GA. That is why they are treated only in Chapter 19. While schemata may be regarded as an equivalence relation compatible with mixing $\mathcal{M}$, it is not possible to make a selection well defined on a nontrivial schemata family. With this result, Vose's book ends.

My overall impression of this book is generally positive. There are some points that are still improvable. As is frequently normal for a first edition, the book contains several typing errors. The general appearance of the figures is below average: the figure captions are less informative or have been dropped totally. Furthermore, axis labels in graphs were omitted in almost all cases, and there are no page references to the color plates which were placed at a "random location" in the book.

Besides these minor points of criticism, the book is an excellent theoretical work written by a leading researcher in this field. While this book may be regarded as a monograph, it also has a "touch" of a textbook. This is underpinned by numerous exercises which are an integral part of the text. The book can be recommended reading for anyone working in the field of EA theory.

REFERENCES

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Swarm Intelligence: From Natural to Artificial Systems—Eric Bonabeau, Marco Dorigo, and Guy Theraulaz (Oxford, England: Oxford University Press, 1999, $65.00 cloth, $29.95 paper). *Reviewed by Alice E. Smith.*

The topic of swarm intelligence, probably most well known using an ant-colony analogy, has attracted much attention within the last five years. The research in this area is flourishing as people from diverse disciplines consider the inspiration of natural colonies for solving difficult problems in design, optimization, and control. The properties of cooperation, robustness, and exploration are particularly applicable for many complex problems in engineering, science, architecture, and mathematics. This book is written by three well-known European researchers in the field. It is very accessible in that it assumes no specialized knowledge of either biology or optimization modeling. The many illustrations, both photos and diagrams, help illustrate the biological components of swarms, as well as the objectives, methodologies, and results from the abstraction of biological swarms to artificial implementations. A comprehensive bibliography of 337 works concludes the book.

The book is comprised of eight chapters, with the first and last being relatively short introductory and concluding remarks, respectively. Chapters 2–7 are fairly independent, and may be read in any order; however, a careful reading of Chapter 2 first is recommended. An especially useful component of this book is that each of these chapters concludes with a "Points to Remember" section in which the key ideas and results of the chapter are summarized.

Chapter 2 is the longest chapter, and covers the important topic of foraging behavior, centering on ants, and how this concept can be used successfully in optimization. The well-known NP-hard problems of traveling salesman, quadratic assignment, job-shop scheduling, and network routing are used to illustrate the method. Seminal work in ant-colony methods and ant systems are cited heavily and discussed in this chapter. The succeeding chapters are a bit shorter, and the topics are probably less well known to the mainstream evolutionary computation community. However, in many ways, this makes their content more interesting and informative, although it is more speculative. Chapter 3 covers the division of labor and specialization in swarms, and emphasizes biological systems, primarily ants. Some descriptive models are put forth, and an application area in bidding or market-based algorithms is discussed. Chapter 4 examines the clustering and sorting behavior of ants (cemetery building and larvae sorting), with obvious extensions to data analysis and clustering. Applications in graph partitioning and robotics are covered. Chapter 5 explores self-organization in ants (as in Chapter 4), but constrains these with templates, such as what occurs when worker ants construct a royal chamber about the queen ant. This analogy can be used for the same applications as in Chapter 4, but allows the user to specify aspects, such as the number or location of clusters. Chapter 6 is a fairly exploratory chapter that centers on the idea of stigmergy, where organisms coordinate activities. This chapter considers other natural swarms such as wasps or termites. The application focuses on construction using discrete building blocks, and considers the resulting architectures when differing degrees of constraint are imposed. Self-assembling robots are also considered. This chapter is quite intriguing, with an unusual set of possible applications that use artificial stigmergy among agents. The transport of food and

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other physical items by swarms is the topic of Chapter 7. Once again, robotic applications are cited as the artificial implementation.

To conclude this review, it is important to mention that the name "swarm" in the title may lead some potential readers to assume that this book includes the paradigm founded by Jim Kennedy and Russell Eberhart, also called swarm or particle swarm. This is not the case. This book really centers on the ant-colony metaphor, with some excursions to other social beings such as wasps. While the two swarm paradigms have many similarities, there are also significant distinctions, and the literature on the two has grown fairly independently.