Evolutionary Computation

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Book Review: Introduction to Evolutionary Computing

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Introduction to Evolutionary Computing,
by A.E. Eiben, J.E. Smith,
Springer-Verlag, 2003, ISBN 3-540-40184-9, 300 pp.

This book was written by its two authors with the explicit intention that it would become one of the standard text books on evolutionary computation, to rival "the greats", namely those of Goldberg (1989), Davis (1991), Michalewicz (1992 1996), Koza (1992), Bäck (1995), and Mitchell (1996) .

It aims to be a comprehensive account both in theory and in practice of the general field of "Evolutionary Computation". For those familiar with Goldberg's classic text (Goldberg, 1989) and Davis's "how to" book (Davis, 1991), this book combines the strengths of both. It presents the theory in a clear and didactic manner that is pleasing. However if a second edition is published, I hope the authors will do a better job of editing their text. The result would make their book one of the best of its kind. I will take up this issue again at the end of this review.

The real advantage of this book is that it is comprehensive, structured, and modern. It presents its material in a logical linear manner that starts with a brief overview chapter on what evolutionary computation is about, and then launches into 4 comprehensive chapters describing the basics of the 4 main paradigms or "dialects" as the authors call them of evolutionary computation (EC), namely GAs (Genetic Algorithms, founded by John Holland in the US in the 1960s), ES (Evolutionary Strategies, founded by Rechenberg and Schwetel in Germany in the 1960s), EP (Evolutionary Programming, founded by Fogel in the US in the 1960s), and GP (Genetic Programming, founded by Koza in the US in the 1980s).

The authors deliberately take a broad overview of EC, extracting the common features of all 4 paradigms, and then presenting the paradigms one by one in terms of these common themes. Earlier texts were aimed mostly at only one of the 4 paradigms, especially the classic texts of a decade or more ago. Anyone writing a text on EC today is now virtually obliged to present all paradigms, otherwise they would risk being labeled "narrow". It is this comprehensiveness that is one of the major advantages of the book. The only other text aimed similarly to be comprehensive in the above sense is that of Bäck (1995).

Chapters 3 to 6 present the theory of the 4 paradigms spending about 10-20 pages on each, followed by several exercises at the end of each chapter for readers and students to test their understanding. Unfortunately, there are no answers to these exercises at the end of the book, which is another major disadvantage of the book that aims to

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be a text book for EC classes. It would be most useful for students to have source code that they could consult in detail to see how the 4 paradigms are implemented. At the end of each chapter is a reading list, which is helpful.

Once the main paradigms are introduced, chapter 7 launches into "Learning Classifier Systems" (LCS), founded by Holland, taking the same pattern as in the earlier chapters, namely an initial and clear presentation of the theory, followed by several examples.

After chapter 7, the book changes style, becoming more "how to", similar to Davis' book (Davis, 1991), aiming to provide its readers with techniques that are useful for people who aim at building practical EC based systems.

Chapter 8 deals with parameter control in evolutionary algorithms, for example, how to change the step size in mutation, or how to modify penalty coefficients. Several practical examples are given that illustrate the techniques.

Chapter 9 is devoted to multi-modal problems and spatial distributions. It stresses the need for diversity in the evolving population, and how this can be controlled explicitly, using such techniques as "fitness sharing" and "crowding". The second major theme of the chapter is multi-objective EAs using such techniques as "dominance" and Pareto optimality. In this sense, the book is modern, presenting modern techniques and concerns.

Chapter 10 presents hybridization techniques, mixing EAs with other approaches. Included techniques are local search, Lamarkism, the Baldwin effect, preservation of diversity, knowledge based techniques, and others. Chapter 11 is devoted to the theory of EC, which attempts to analyze why EC techniques work or fail to work. It covers such topics as the Schema theorem, Walsh analysis, building blocks or the lack of them, Markov chain analysis, statistical mechanical analysis, and no free lunch theorems. However this is not an exhaustive list.

Chapter 12 deals with constraint handling. Many EAs have to deal with constraints that inhibit traditional EC approaches. Some of the techniques discussed are, penalty functions, repair functions, restricting search to the feasible region, and decoder functions.

Chapter 13 broadens the discussion by introducing special forms of evolution, such as co-evolution, interactive evolution, non stationary function optimization, among other forms.

Chapter 14 discusses working with EAs, for example, using different performance measures and test problems.

Finally chapter 15 summarizes what the book contains and in particular what it does not contain, namely quite a lengthy list of topics that are linked to EC, including for example ant colonies, swarm systems, cultural evolution, artificial immune systems, evolving neural networks, evolutionary robotics, evolvable hardware, artificial life, evolutionary economics, social evolution, and language evolution.

Admittedly, one can only cover so much material in a book of 300 pages, so choices obviously had to be made. However, I was a bit disappointed not to find even the briefest mention of recent attempts to accelerate evolutionary computation by applying statistical or machine learning techniques. For example, Prof Michalski of George Mason University uses concept learning techniques to accelerate the evolutionary solution to mathematical optimization problems by factors of 100s to 1000s (Michalski, 2006).

The fact that such statistical or ML based variants of EC are able to achieve such remarkable speed ups for certain categories of problems is significant and will impact

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EC in the near future. The authors should know about such developments, since these developments have been "around" since the late 1990s. They are not brand new.

I now return to the major disadvantage of this book mentioned earlier in this review, namely its sloppy editing. Despite the considerable strengths of the book, what irked me most in reading it were the many non-English-isms of its first author, who is not a native English speaker. As any reader who has reviewed papers for conferences or journals can testify, fluent, cogent English is a considerable plus. Of course, non native English speaking authors are at a disadvantage in this regard, nevertheless the realities are that many of the potential buyers of this book will be native English speakers who have a choice of other books on similar topics that are written by authors whose English is perfect.

It was painfully obvious which of the two authors wrote which sections. The many non-English-isms made half the text rather unpleasant to read, with singular verbs not matching plural nouns, with missing words, many typos, etc.

What is my "bottom line" opinion on this book? I wish this book well. I just hope it survives into a second edition, so that the authors can revise their sloppily edited text thoroughly, thus converting a potentially good book into a really good one. The book does have the advantage that it is clear, comprehensive and modern, with a global viewpoint across the major paradigms of EC. But, it really is a pity that so much of it is unpleasant to read.

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