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## Preface

### Preface to the Second Edition

I have been very pleased to see how well the first edition of this book has been accepted and used by its readers. I have received fantastic feedback telling me that people use it as an inspiration for their own work, give it to colleagues or students, or use it for preparing lectures and classes about representations. I want to thank you all for using the material presented in this book and for developing more efficient and powerful heuristic optimization methods.

You will find this second edition of the book completely revised and extended. The goal of the revisions and extensions was to make it easier for the reader to understand the main points and to get a more thorough knowledge of the design of high-quality representations. For example, I want to draw your attention to Chap. 3 where you find the core of the book. I have extended and improved the sections about redundancy and locality of representations adding new material and experiments and trying to draw a more comprehensive picture. In particular, the introduction of synonymy for redundant encodings in Sect. 3.1 and the integration of locality and redundancy issues in Sect. 3.3 are worth having a closer look at it. These new concepts have been used throughout the work and have made it possible to better understand a variety of different representation issues.

The chapters about tree representations have been reorganized such that they explicitly distinguish between direct and indirect representations. This distinction – including a new analysis of the edge-sets, which is a direct encoding for trees – emphasizes that the developed representation framework is not only helpful for analysis and design of representations, but also for operators. The design of proper search operators is at the core of direct representations and the new sections demonstrate how to analyze the influence of such encodings on the performance of genetic and evolutionary algorithms (GEAs). Finally, the experiments presented in Chap. 8 have been completely revised considering new representations and giving a better understanding of the influence of tree representations on the performance of GEAs.

I would like to take this opportunity to thank everyone who took the time to share their thoughts on the text with me – all these comments were helpful in improving the book. Special thanks to Kati for her support in preparing this work.

As with the first edition, my purpose will be fulfilled if you find this book helpful for building more efficient heuristic optimization methods, if you find it inspiring for your research, or if it is a help for you teaching students about the importance and influence of representations.

Mannheim, August 2005

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## **Preface to the First Edition**

This book is about representations for genetic and evolutionary algorithms (GEAs). In writing it, I have tried to demonstrate the important role of representations for an efficient use of genetics and evolutionary optimization methods. Although, experience often shows that the choice of a proper representation is crucial for GEA's success, there are few theoretical models that describe how representations influence GEAs behavior. This book aims to resolve this unsettled situation. It presents theoretical models describing the effect of different types of representations and applies them to binary representations of integers and tree representations.

The book is designed for people who want to learn some theory about how representations influence GEA performance and for those who want to see how this theory can be applied to representations in the real world. The book is based on my dissertation with the title "Towards a Theory of Representations for Genetic and Evolutionary Algorithms: Development of Basic Concepts and their Application to Binary and Tree Representations". To make the book easier to read for a larger audience some chapters are extended and many explanations are more detailed. During the writing of the book many people from various backgrounds (economics, computer science and engineering) had a look at the work and pushed me to present it in a way that is accessible to a diverse audience. Therefore, also people that are not familiar to GEAs should be able to get the basic ideas of the book.

To understand the theoretical models describing the influence of representations on GEA performance I expect college-level mathematics like elementary notions of counting, probability theory and algebra. I tried to minimize the mathematical background required for understanding the core lessons of the book and to give detailed explanations on complex theoretical subjects. Furthermore, I expect the reader to have no particular knowledge of genetics and define all genetic terminology and concepts in the text. The influence of integer and tree representations on GEA performance does not necessarily require a complete understanding of the elements of representation theory but is also accessible for people who do not want to bother too much with theory.

The book is split up into two large parts. The first presents theoretical models describing the effects of representations on GEA performance. The second part uses the theory for the analysis and design of representations. After the first two introductory chapters, theoretical models are presented on how redundant representations, exponentially scaled representations and the locality/distance distortion of a representation influence GEA performance. In Chap. 4 the theory is used for formulating a time-quality framework. Consequently, in Chap. 5, the theoretical models are used for analyzing the performance differences between binary representations of integers. Finally, the framework is used in Chap. 6, Chap. 7, and Chap. 8 for the analysis of existing tree representations as well as the design of new tree representations. In the appendix common test instances for the optimal communication spanning tree problems are summarized.

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First of all, I would like to thank my parents for always providing me with a comfortable home environment. I have learned to love the wonders of the world and what the important things in life are.

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During my time here in Bayreuth, my colleagues in the department have always been a great help to overcome the troubles of daily university life. I especially want to thank Michael Zapf, Lars Brehm, Jens Dibbern, Monika Fortmühler, Torsten O. Paulussen, Jürgen Gerstaker, Axel Pürckhauer, Thomas Schoberth, Stefan Hocke, and Frederik Loos. During my time here, Wolfgang Güttler and Tobias Grosche were not only work colleagues, but also good friends. I want to thank them for the good time I had and the interesting discussions.

During the last three years during which I spent time at IlliGAL I met many people who have had a great impact on my life. First of all, I would like to thank David E. Goldberg and the Department of General Engineering for giving me the opportunity to stay there so often. Then, I want to say thank you to the folks at IlliGAL I was able to work together with. It was always a really great pleasure. I especially want to thank Erick Cantú-Paz, Fernando Lobo, Dimitri Knjazew, Clarissa van Hoyweghen, Martin Butz, Martin Pelikan, and

Kumara Sastry. It was not only a pleasure working together with them but over time they have become really good friends. My stays at IlliGAL would not have been possible without their help.

Finally, I want to thank the people who were involved in the writing of this book. First of all I want to thank Kumara Sastry and Martin Pelikan again. They helped me a lot and had a large impact on my work. The discussions with Martin were great and Kumara often impressed me with his expansive knowledge about GEAs. Then, I want to say thanks to Fernando Lobo and Torsten O. Paulussen. They gave me great feedback and helped me to clarify my thoughts. Furthermore, Katrin Appel and Kati Sternberg were a great help in writing this dissertation. Last but not least I want to thank Anna Wolf. Anna is a great proofreader and I would not have been able to write a book in readable English without her help.

Finally, I want to say “thank you” to Kati. Now I will hopefully have more time for you.

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*Franz Rothlauf*