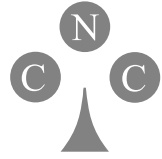


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Frank Neumann • Carsten Witt

Bioinspired Computation in Combinatorial Optimization

Algorithms and Their
Computational Complexity

 Springer

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To Aneta, Linda, Michelle and Ying

Foreword

Bioinspired computing is successful in practice. Over the past decade a body of theory for bioinspired computing has been developed. The authors have contributed significantly to this body and give a highly readable account of it. (*Kurt Mehlhorn, Max Planck Institute for Informatics, and Saarland University, Germany*)

Bioinspired algorithms belong to the most powerful methods used to tackle real world optimization problems. This book gives such algorithms a solid foundation. It presents some of the most exciting results that have been obtained in bioinspired computing in the last decade. (*Zbigniew Michalewicz, University of Adelaide, Australia*)

This book presents a most welcome theoretical computer science approach and perspective to the design and analysis of discrete evolutionary algorithms. It describes the design and derivation of evolutionary algorithms which have precise computation complexity bounds for combinatorial optimization. The book should appeal to researchers and practitioners of evolutionary algorithms and computation who want to learn the state of the art in evolutionary algorithm theory. (*Una-May O'Reilly, CSAIL, MIT, USA*)

The evolutionary computation community has been in need of rigorous results concerning the computational complexity of their approaches for decades. This is the first textbook covering such a fundamental topic. It provides an excellent overview of the state of the art in this research area, in terms of both the results obtained and the analytical methods. It is an indispensable book for everyone who is interested in the foundations of evolutionary computation. (*Xin Yao, University of Birmingham, UK*)

Preface

Inspiration from biology has led to several successful algorithmic approaches. Such methods are frequently used to tackle hard and complex optimization problems. Biologically inspired algorithms such as evolutionary algorithms and ant colony optimization have found numerous applications for solving problems from computational biology, engineering, logistics, and telecommunications. Many problems arising in these application domains belong to the field of combinatorial optimization. Bio-inspired algorithms have achieved tremendous success when applied to such problems in recent years.

In contrast to many successful applications of bio-inspired algorithms, the theoretical foundation of these algorithms lags far behind their practical success. This is mainly due to the fact that these algorithms make use of random decisions in different modules. This leads to stochastic processes that are hard to analyze. This book treats bio-inspired computing methods as stochastic algorithms and presents rigorous results on their runtime behavior.

The book is meant to give researchers a state-of-the-art presentation on theoretical results of bio-inspired computing methods in the context of combinatorial optimization. Furthermore, it can be used as basic material for courses on bio-inspired computing that are meant for graduate students and advanced undergraduates.

The book is organized into three parts. It starts with a general introduction into bio-inspired algorithms and their computational complexity. Later on, different methods that have been developed in recent years are presented in a comprehensive manner. Afterwards, we present some of the major results that have been achieved in the field of single-objective optimization. We consider different problems such as minimum spanning trees, maximum matchings, and the computation of shortest paths. After these studies, we turn to multi-objective optimization. We tackle classical multi-objective problems such as the computation of multi-objective minimum spanning trees as well as show that multi-objective approaches lead provably to better algorithms for classical single-objective problems.

Taking the book as basic material for a course on theoretical aspects of bio-inspired computing, we suggest you spend 12 hours of class time on Part I. This part of the book gives all the basics for the different analyses that are carried out later. Therefore, we see it as mandatory for a teaching course. The chapters of Parts II and III can be studied more or less independently depending on the focus that lecturers want to set during their course. We suggest you spend four hours on each chapter of Parts II and III if they are made to be part of a course.

We thank all our colleagues who worked with us on bio-inspired computation during recent years. In particular, we like to mention the research groups at the University of Adelaide, Technical University of Berlin, University of Birmingham, Massachusetts Institute of Technology, Technical University of Denmark, Technical University of Dortmund, Max Planck Institute for Informatics, and Swiss Federal Institute of Technology Zurich.

Saarbrücken, Kongens Lyngby
September 2010

Frank Neumann
Carsten Witt

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