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Theory of Evolutionary Computation

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Evolutionary algorithms are general-purpose randomized search heuristics. They have been successfully applied to many different kinds of search and optimization problems. They are popular in practice since they are easy to implement and easy to apply, and yet often find good solutions in reasonable time. This lead to an increased interest in gaining a thorough understanding of their strengths (and limitations). In the past decades, the theory of evolutionary algorithms has become an important and accepted field of research.

This special issue *Theory of Evolutionary Computation* of *Algorithmica* contains expanded research from the theory track of the *Genetic and Evolutionary Computation Conference* and the *International Conference on Parallel Problem Solving From Nature*. All papers have been enhanced, extended, and undergone a critical journal reviewing process. The result is a collection of seven papers that all deal with theoretical aspects of evolutionary computation in a rigorous and accessible way. It contributes to the development of a better understanding of evolutionary algorithms, paving the way for a more informed application of these algorithms.

Ten years after the first publication of a run-time analysis of the most simple evolutionary algorithm, the $(1 + 1)$ evolutionary algorithm, Jens Jägersküpper reconsiders the result. By using the drift analysis method introduced by He and Yao in a sophisticated way, he obtains much more precise bounds on the expected optimization time.

Drift analysis is also the topic of Pietro S. Oliveto's and Carsten Witt's article. They present a theorem that yields exponential lower bounds on the expected op-

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timization time in a very accessible way, making only mild and easy to verify assumptions. Their result will prove useful in future theoretical studies of evolutionary algorithms and other randomized search heuristics.

Hervé Fournier and Olivier Teytaud are also concerned with deriving lower bounds for a large class of evolutionary algorithms. They consider comparison based evolutionary algorithms and prove general lower bounds on the performance by considering the VC dimension of the objective function's level set.

Frank Neumann, Joachim Reichel, and Martin Skutella analyze the performance of evolutionary algorithms for combinatorial optimization problems. For the classical weighted minimum s-t-cut problem they prove that a bi-criteria modeling of the problem inspired by the minimum-flow maximum-cut theorem allows evolutionary algorithms to be efficient, whereas the straightforward single-criterion modeling leads to very inefficient optimization on certain problem instances.

The minimum cut problem is also considered by Dirk Sudholt. Concentrating on straightforward modelings of this problem as well as the knapsack problem and maximum satisfiability, he proves that the simple $(1+1)$ EA fails to be efficient even for relatively simple problem instances. This finding is used as a starting point to develop improved hybrid randomized search heuristics. Combining the $(1+1)$ EA with variable-depth search (known from Kernighan's and Lin's algorithm for the traveling salesperson problem) he obtains a simple memetic algorithm that solves all considered instances efficiently, thus highlighting the advantages of hybrid approaches.

Mohamed Jebalia, Anne Auger, and Nikolaus Hansen consider evolutionary algorithms in a continuous search space. They also use a very simple evolutionary algorithm, the $(1+1)$ evolution strategy, and analyze its performance in the presence of multiplicative noise. For unimodal spherical objective functions they prove that under mild conditions the algorithm is able to remain efficient in the present of such noise.

Martin Dietzfelbinger, Jonathan E. Rowe, Ingo Wegener, and Philipp Woelfel consider a particular aspect of modeling problems, namely the precision of the representation used. They consider different concrete encodings of one-dimensional unimodal problems and prove that even the simple $(1+1)$ EA can have asymptotically optimal performance. On the other hand, limitations for all black-box algorithms when optimizing unimodal functions in at least two dimensions are proven.

We editors would like to thank the authors for writing these deep papers. We are also indebted to the many reviewers for their thorough reading and their constructive comments. Finally, our thanks go to Prof. Ming-Yang Kao, editor-in-chief of *Algorithmica*, and the staff of the *Springer* publishing group for making the special issue possible.