Preface

The first issue of the 25th volume of this journal (1996) appeared as a special issue on simulated annealing applied to combinatorial optimization. In the preface to that issue, the editors (René Victor Valqui Vidal and Zbigniew Nahorski) wrote:

> "The 1980s spotted the development of general heuristic methods, potentially applicable to any hard optimization problem after some adaptation. These type of currently known heuristics include simulated annealing, taboo search, genetic algorithms, target analysis, and [...] neural networks. To distinguish them from other methods, more tailor-made heuristics, the term *metaheuristics* has been coined".

This special issue is on evolutionary computation techniques (the best known type of an evolutionary algorithm is genetic algorithm mentioned in the citation above). In general, evolutionary computation techniques are stochastic algorithms whose search methods model some natural phenomena: genetic inheritance and Darwinian strife for survival. The popularity of these methods can be explained by their simplicity and robustness: the general idea of propagating good characteristics of a potential solution in subsequent populations is quite simple and problem independent.

The general-purpose nature of evolutionary techniques cannot be over-stated. All evolutionary techniques maintain a population of potential solutions. Better individuals are selected for reproduction and their offspring replace worse individuals. Generation after generation the population "improves itself"; eventually the algorithm converges and the best individual represents a reasonable, near-optimum solution. Evolutionary techniques have been successfully applied to variety of difficult problems. These include numerical optimization, machine learning, optimal control, cognitive modeling, classic operation research problems (traveling salesman problem, knapsack problems, transportation problems, assignment problems, bin packing, scheduling, partitioning, etc.), engineering design, system integration, iterated games, robotics, signal processing, and many others.

The volume starts with a tutorial paper by Schoenauer and Michalewicz introducing the basic components of evolutionary computation in their historical perspective, based on the author's own experiences.

The following tutorial paper by Venturini, Rochet, and Slimane, surveys the historical advances for the simple binary genetic algorithm, from the basic Schema Theorem to the concept of deceptiveness.

Recent theoretical investigations on evolutionary algorithms aim at obtaining convergence rates rather than abstract results on convergence in probability. The major drawback is that some restrictive hypotheses have to be made on the fitness functions to be optimized. The paper by Rudolph presents an elegant derivation of such bounds on the convergence rates for a class of convex functions.

Surry and Radcliffe present in their paper a new approach to constraint handling, based on multi-objective optimization techniques: The constraints are viewed as other criterion to be optimized, with the difference that they must be satisfied in the end. Classical evolutionary treatment of multi-objective optimization problem is slightly modified to handle this problem, and experimental results are presented.

Another method allowing constraint handling as a by-product is the ant-algorithm presented by Wodrich and Bilchev. Originally devoted to combinatorial optimization, the ant algorithm is based on a slightly different natural paradigm, the cooperation of local "blind" agents through pheromone layouts to reach high level goals. This paper presents a modification of the Ant algorithm to parameter optimization problems, with impressive experimental results.

Traditional genetic algorithms favor the (natural) two-parents crossover. Eiben and van Keremade argue in their paper that the use of multi-parent recombination operators can indeed be beneficial, and experimentally demonstrate its usefulness.

Yet another variant of an algorithm based on mutation is introduced by Yao and Liu. The standard mutation operator in evolution strategies is the Gaussian mutation, in which the repartition of offspring follow a normal distribution around the parent. They advocate the use of Cauchy distributions, which favors larger mutation step-size. Their thorough experimental investigation demonstrates the benefit of such modification of the standard algorithm.

The Cauchy-distributed mutation is also used by Fogel, Wasson, Boughton, Porto, and Shively: they apply evolutionary programming as an alternative method for tuning the weights of a neural network (with fixed topology), in order to avoid local traps in which backpropagation methods often fall. The application domain is the classification of breast cancer cases.

A totally different approach of evolutionary neural network learning is proposed by Michel, based on the morphogenesis of networks. He evolves "genomic networks", DNA-like structures which are later decoded and generate an artificial neural network, mimicking the translation of DNA to synthesize proteins. The approach is validated by the the design of a controller for the little Khepera robot.

The volume would not have been complete without a paper on genetic programming, the art of automatic program design. Nordin and Banzhaf introduce on-line learning with genetic programming, directly evolving machine-code and thus achieving tremendous increase in learning speed allowing to approach real-time learning. Note that the application domain is (again) the control of a moving robot and (again) a Khepera robot is used.

Finally, the volume ends with an overview of open issues by one of the pioneers of the field, Ken De Jong: he summarizes the recent trends, and carefully enlights the promising directions for fruitful research in evolutionary computation.

We feel that this volume might be of assistance to many researchers and practitioners involved in solving complex real-life problems. We hope that it may also help many individuals who are currently just 'interested' in evolutionary techniques; the included papers, apart from providing a broad overview of possibilities of applying these techniques to a real-life problems, report on theoretical aspects of evolutionary algorithms.

Note, also, that there are several recent texts (by 'recent' we mean texts published during the last decade) available which provide introductory material on evolutionary techniques (the list does not include numerous proceedings of various international conferences, special sessions, special issues, etc). In 1987 Davis edited a volume with thirteen independent articles on applications of genetic algorithms and simulated annealing; the first article gives an overview of these techniques. Goldberg's book (1989) provides a systematic treatment of genetic algorithms: their theoretical foundations and some applications. Another volume edited by Davis (1991) contains a detailed tutorial on genetic algorithms together with several independent articles on their applications. The second edition of Holland's (1992) seminal book explains fundamental ideas behind adaptive systems in general and genetic algorithms, in particular. In 1992 the first edition of Michalewicz (1996) appeared as well: apart from introduction to the topic, the book describes methods for incorporating a problem-specific knowledge into evolutionary techniques. Book by Schwefel (1995), which is the revised and extended second edition of his 1981 book, concentrates on methods of optimization in general and evolutionary methods for numerical optimization, in particular. Bäck (1995) provides a general overview of evolutionary methods together within a rigorous and formal framework. Fogel (1995) aims at exploring a connection between evolution and intelligence. Another introductory text for genetic algorithms was written by Mitchell (1996), whereas last February a huge volume (edited by Bäck, Fogel, and Michalewicz, 1997) was published to report on the state-of-art developments in the area of evolutionary computation.

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