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J.-M. Alliot E. Lutton E. Ronald
M. Schoenauer D. Snyers (Eds.)

Artificial Evolution

European Conference, AE 95
Brest, France, September 1995
Selected Papers

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A la mémoire de Joëlle Biondi ...

Preface

The Artificial Evolution conference was originally conceived as a forum for the French-speaking Evolutionary Computation community, but has acquired a more European audience. In future it will be held every two years, alternating with PPSN, which remains the main European conference. This volume collects extended versions of papers presented in the first and second AE conferences, held in 1994 and 1995.

In 1994 the organizing committee, preferring a secluded provincial setting to Parisian pomp, sited the conference at ENAC in Toulouse, and supplied the food and beverages which the Gallic temperament regards as necessary fuel for the shaping of scientific theories. This must have been a success, because in 1995, various "foreigners" from such non-francophone countries as Germany and Hungary submitted papers, came to the ENST campus near the coastal city of Brest and consumed cider.

In the morning, the participants suffered through their hangovers. In order to provide time for them to wake up, keynote speakers were invited. These speakers presented viewpoints divergent from the conventional bitstring Genetic Algorithms framework: Nick Radcliffe's oral presentation in Toulouse asked the question "Why binary isn't always best?", while Thomas Bäck and David Fogel introduced in Brest the two other pillars of the EC building, namely Evolution Strategies and Evolutionary Programming.

The papers reproduced in this volume have been grouped into seven sections.

1. **Invited Papers** by Thomas Bäck, and David B. Fogel and Lawrence J. Fogel, present the state of the art in ES, and in EP; see above.
2. **Theoretical contributions**: Raphaël Cerf in a complex technical paper creates a probabilistic framework for the analysis of GA dynamics, and Gilles Venturini supplies a highly readable overview of the relationship between GA–deceptive and hill-climbing–difficult problems.
3. **GA Techniques**: In this section, authors investigate various novel "mutations" and extensions of the basic GA. Márk Jelasity and József Dombi present a new niching technique, Cyril Godart and Martin Krüger introduce steady-state reproduction inside a heterogeneous parallel implementation, Caroline Ravisé, Michèle Sebag, and Marc Schoenauer use inductive learning to supervise the GA, and Rémi Viennet, Christian Fonteix, and Ivan Marc exploit diploidy for multi-objective optimization.
4. **Coevolution**: Alternative evolutionary paradigms are introduced in this section. Paul Bourgine and Dominique Snyers study the coevolution dynamics of interacting species, Renaud Dumeur's symbiotic algorithm is inspired

by the recent ideas of Lynn Margulis, Nicolas Meuleau and Claude Lattaud investigate the influence of selection on the iterated prisoner dilemma and Spyros Xanthakis, Constantinos Karapoulios, Régis Pajot and Ahmed Rozz explore a biological analogy between fault tolerant computing and the immune system.

5. **Neural Nets**, when genetically trained, allow a representation of active behaviors. Frédéric Gruau synthesizes nets that simulate various walking gaits in hexapodal automata. Olivier Michel drives a robot through a simulated or real-world maze. Marc Schoenauer and Edmund Ronald investigate the automatic tuning of net parameters, and present a probabilistic analysis of the time required to train a net by GA.
6. **Image Processing**: Guillaume Cretin, Evelyne Lutton, Jacques Levy-Vehel, Philippe Glevarec, and Cedric Roll solve the inverse IFS fractal representation problem by GP, Jeanine Graf and Wolfgang Banzhaf follow Richard Dawkins in incorporating interactive selection in a GA, Evelyne Lutton and Patrice Martinez apply GAs to graphic primitive detection, and Jean Louchet effects object identification in motion analysis.
7. **Applications**: This section demonstrates the successful applicability of GAs in a broad range of problem domains: Jean–Marc Alliot and Nicolas Durand – evolution of Othello playing programs, Thomas Bäck, Martin Schütz and Sami Khuri – constraint handling techniques on the set covering problem, Jin-Kao Hao and Raphaël Dorne – radio frequency assignment in cellular telephone networks, Vittorio Gorrini and Marco Dorigo – packing and routing problems for a real–world robot, Couro Kane and Marc Schoenauer – specific crossover operators for structural optimization, Frédéric Medioni, Nicolas Durand, and Jean–Marc Alliot – air traffic collision avoidance, and Mohammed Slimane, Gilles Venturini, Jean–Pierre Asselin de Beauville, T. Brouard, and A. Brandeau – the optimization of hidden Markov chains in pattern recognition.

At this point, we would like to extend our thanks to Jean-Louis Latieule, Ghislaine LeGall, and Isabelle Parcoit for their help in making the conferences run smoothly.

Finally, we would like to thank both EA94 and EA95 program committees for their work in ensuring the high scientific content of the papers presented. The names of the individuals, who found time to do the refereeing, are listed on the following page. The following additional referees generously donated their time: J.-M. Ahuactzin, S. Augier, L. Gambardella, V. Gorrini, O. Lebeltel, C. Ravisé, and E. G. Talbi.

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Contents

[1] This paper represents a synthesis of two papers presented at the 1994 and 1995 conferences

[2] This paper was presented at the 1994 conference

Neural Networks

Image-Processing

Applications

Invited Papers

Evolution Strategies: An Alternative Evolutionary Algorithm

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Abstract. In this paper, *evolution strategies* (ESs) — a class of evolutionary algorithms using normally distributed mutations, recombination, deterministic selection of the $\mu > 1$ best offspring individuals, and the principle of self-adaptation for the collective on-line learning of strategy parameters — are described by demonstrating their differences to *genetic algorithms*. By comparison of the algorithms, it is argued that the application of canonical genetic algorithms for continuous parameter optimization problems implies some difficulties caused by the encoding of continuous object variables by binary strings and the constant mutation rate used in genetic algorithms. Because they utilize a problem-adequate representation and a suitable self-adaptive step size control guaranteeing linear convergence for strictly convex problems, evolution strategies are argued to be more adequate for continuous problems.
The main advantage of evolution strategies, the self-adaptation of strategy parameters, is explained in detail, and further components such as recombination and selection are described on a rather general level.
Concerning theory, recent results regarding convergence velocity and global convergence of evolution strategies are briefly summarized, especially including the results for (μ,λ)-ESs with recombination. It turns out that the theoretical ground of ESs provides many more results about their behavior as optimization algorithms than available for genetic algorithms, and that ESs have all properties required for global optimization methods. The paper concludes by emphasizing the necessity for an appropriate step size control and the recommendation to avoid encoding mappings by using a problem-adequate representation of solutions within evolutionary algorithms.

1 Optimization and Genetic Algorithms

In contrast to the title and the overall intention of this article to provide an overview of *evolution strategies* (ESs) [35, 36, 40, 44] (and, to make the reader curious of reading more about them), I take the freedom to start with a brief look at the global optimization problem and those evolutionary algorithms which are widely used to approximately solve this problem: *Genetic algorithms* (GAs) [21, 25]. Although these two different, independently developed branches of evolutionary computation are known since more than thirty years, genetic algorithms have gained much more interest during the past ten years than evolution strategies