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Preface

The history of the conference

In October 1994, the international conference on parallel problem solving from nature (PPSN) was held for the third time.

The first event of this series took place at Dortmund, Germany, in 1990. It had originally been planned as a small workshop with about 30 participants. To the big surprise of the organizers, the interest was so high that PPSN 1 became an international conference with more than 100 participants. The topics covered were, among others, genetic algorithms, evolution strategies, simulated annealing, neural networks, classifier systems, immune networks, adaptation processes in general, and other natural paradigms and their application to solve real-world problems.

Due to the unexpected success of PPSN 1 in 1990 the organizers were encouraged to plan a follow-up conference, PPSN 2, two years later. Many of the participants from the USA supported this idea although the biennial international conference on genetic algorithms (ICGA) had already been established in the USA in 1985. However, ICGA focused primarily on aspects of genetic algorithms whereas PPSN allowed a broader scope of problem solving paradigms adopted from natural models. Thus, both conferences supplement each other, and it was agreed that ICGA and PPSN should be held alternately, ICGA on odd years in America, PPSN on even years on the other side of the Atlantic.

Accordingly, the PPSN 2 conference was held in 1992 at Brussels, Belgium. Compared to the Dortmund conference, the number of participants increased to about 150. Unfortunately, however, the scope of submitted papers narrowed down. Most of them dealt with evolutionary algorithms and only a few with other biological metaphors. Since 1991, the scope of ICGA also changed a little. Whereas earlier conferences dealt nearly exclusively with "US type" genetic algorithms (characterized, for example, by binary encodings of the decision variables and fixed application rates for the genetic operators), extensions and modifications to include aspects of the "European type" evolution strategies (floating point or integer representation of variables, dynamic adaptation of parameters, etc.), were adopted. Evolutionary programming, a contemporary third way of simulating organic evolution with its own annual conference series at San Diego since 1992, has also been integrated now within the broader stream of evolutionary computation. A witness of that fact was the recent first world congress on computational intelligence (WCCI) at Orlando, Florida, in June/July 1994, where proponents of all three kinds of evolutionary algorithms met.

To ensure continuity in planning further PPSN conference series and to coordinate them with conferences like ICGA, a PPSN steering committee has been set up. Currently, it consists of the following members:

Y. Davidor (Israel) B. Manderick (The Netherlands)
K. De Jong (USA) H. Mühlenbein (Germany)
H. Kitano (Japan) H.-P. Schwefel (Germany)
R. Männer (Germany)

One of the first decisions the PPSN steering committee took was to emphasize the diverse evolutionary aspects covered by the PPSN conference series and to change the conference name into one more indicative of its scope, "international conference on evolutionary computation" with the running subtitle "the third international conference on parallel problem solving from nature" and the acronym "ICEC/PPSN 3".

Invited and contributed talks and posters

Some years ago, theoreticians and practitioners working in the field of evolutionary computation and other biologically motivated paradigms could be found in conferences on physics, biology, computer science, economics, and many others. The PPSN conference series was initiated because there was a need to bring these people together to facilitate interdisciplinary cross-fertilization of ideas. At the first PPSN conference in 1990, this could be achieved in the usual style of a small conference. However, even the relatively small number of oral presentations and long poster sessions did not seem to leave enough time for discussions.

For PPSN 2 in 1992, therefore, the style of the conference was changed radically. It was a nearly poster-only conference, designating only the invited talks as plenary sessions. The success of this programme structure led the PPSN steering committee to repeat the same conference structure for this ICEC/PPSN 3 event.

The conference scope

To increase the theoretical and empirical understanding of algorithms based on natural paradigms, ICEC/PPSN 3 brings together an international community from academia, industry, business, and government. Examples of such algorithms are genetic algorithms (GA), evolutionary programming (EP), and evolution strategies (ES) that are inspired by the organic processes of mutation, recombination, and natural selection in biology; classifier systems (CS), evolving rule based systems; cellular automata (CA), evolving according to local "laws" like physical entities; artificial neural networks (NN); and combinations of the above.

Although PPSN focuses on *problem solving* using such algorithms, ample room is given to contributions advancing the understanding of basic concepts, their extensions and combination. Additional emphasis is put on practical as-

pects: How can these computing-intensive algorithms be implemented on parallel computers? How can they be applied to real-world problems? What kind of tools ease their application?

Review of submitted papers

To identify the high-quality contributions, all submissions were reviewed anonymously by three independent reviewers who are recognized experts in the relevant fields. Papers whose reviewers disagreed on some important aspect of the submission were reviewed again by the programme and conference chairs to resolve the disagreements. Finally, 61 out of 115 papers, which resulted from this careful filtering process, were selected for inclusion in the conference proceedings and for presentation at the conference. We are confident that this process has ensured that ICEC/PPSN 3 presents original, high-quality contributions to the field of evolutionary computation. Since this is absolutely vital for the success of the PPSN conference series, the help of all reviewers on the Programme Committee listed below is gratefully acknowledged:

Emile H. L. Aarts	Philips Research Labs., Eindhoven	The Netherlands
Jarmo T. Alander	University of Vaasa	Finland
Thomas Bäck	Informatik Centrum Dortmund at the University of Dortmund	Germany
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David Fogel	Natural Selection, Inc., La Jolla, CA	U.S.A.

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It should be noticed that many of the reviewers received considerable help from colleagues. Unfortunately, there is not enough space to mention all of them here. We are very grateful for their important contribution to the quality of the conference and the proceedings. All authors were provided with the reviewers' comments and had the chance to improve their contributions accordingly.

Acknowledgements

Although the work of the reviewers is essential, many more people are required for organizing a successful conference and for editing the proceedings. We want to stress that all PPSN conferences have been and will be non-profit events. Neither the organizers, nor the reviewers, neither the editors of the proceedings, nor the many helpful persons involved in the local organization get any benefits from their work — except the satisfaction of being involved in such an interesting and important activity.

It is therefore a great pleasure for us to thank all those who have worked so hard to make ICEC/PPSN 3 a success and to prepare the proceedings in time. On behalf of all others we want to thank particularly Thomas Bäck and Frank Kursawe from the University of Dortmund, Germany.

Jerusalem, Yuval Davidor, Conference Chair
Mannheim, Reinhard Männer, Programme Co-Chair
Dortmund, Hans-Paul Schwefel, Programme Co-Chair
July 1994

Contents

Genetic Programming

Emergent Computation

Comparison of Different Evolutionary Algorithms

Hybrid Methods

Evolutionary Algorithms for Neural Networks

Parallel Implementations of Evolutionary Algorithms

Applications

Software Tools for Evolutionary Computation

Introduction

Only a few years ago, terms like *genetic algorithms*, *evolution strategies*, *classifier systems*, *genetic programming*, etc. did not mean anything to most scientists let alone practitioners in industry, business, and the general public. However, these research fields, which are united now under the name *evolutionary computation*, have existed for a long time. Three of its most important roots are generally recognized. One is the work of John Holland[1] in the USA, the second the work of Ingo Rechenberg[2] in Germany, and the third is the work of Lawrence Fogel[3], again in the USA. Fogel, Rechenberg, Holland, and some others started already 30 years ago to investigate systems that evolve artificially. Some remarkable theoretical and practical results were achieved already at that time, but they had to wait for their broad acknowledgement.

Today, the scene has changed considerably. Even some newspapers have reported on artificially evolving systems and their application to solve practical problems. There are two main reasons for this change: the apparent simplicity of evolutionary algorithms coupled with the availability of powerful computers, which allow to handle more realistic and thus more complex models now. The basic idea of such algorithms is easily described: *For any optimization problem, generate a number of solutions. Repeatedly, let the worst die out and modify the others at random, until a sufficiently good solution has been found.* Since anybody can understand such algorithms immediately, David Goldberg called them once CP–easy[4]. However, large evolving populations of solutions combined with a long evolution time require high computing power. Nowadays, computers providing that power are available nearly everywhere, in every lab, at home, at school, etc. It is thus very easy to write a short program and have first success.

Yet, artificial evolution is far from being well understood. Until now, there is no comprehensive theory for any type of evolutionary algorithm — only the most simple ones have been analyzed thoroughly, and even that for very simple problem situations only. For most practical applications, the algorithms' parameters have to be crafted manually. In contrast to this lack of understanding, evolutionary algorithms and algorithms based on other natural paradigms have been practically applied with remarkable success. One reason for that is the very high robustness of such algorithms and the fact that they can be applied in many situations, also where classical algorithms fail.

Within the last years, we see an explosion of interest in evolutionary computation and the application of other natural metaphors like neural networks, simulated annealing, and so forth. The at first relatively small communities of

[1] Holland, J.H.: Adaptation in Natural and Artificial Systems. University of Michigan Press, Ann Arbor, Michigan, 1975

[2] Rechenberg, I.: Evolutionsstrategie — Optimierung technischer Systeme nach Prinzipien der biologischen Evolution. Frommann–Holzboog, Stuttgart, Germany, 1973

[3] Fogel, L.J. et al.: Artificial Intelligence through Simulated Evolution. Wiley, New York, 1966

[4] Cocktail Party easy — can be explained during small–talk.

researchers in the USA and Europe who made progress in these fields during the last decades have grown exponentially, and new ones have been formed, such as the one in Japan. After many very difficult years, governments and industry have recognized the potential behind such algorithms, and funding sources for research have become available. Nonetheless, in all aspects there are so many open questions that every progress made could increase the efficiency and effectivity of such algorithms dramatically and thus open up new fields of application.

ICEC/PPSN 3 tries to advance the state-of-the-art by presenting high–quality original research papers in a number of different topics. Five papers were selected that discuss general aspects of Darwinian and Lamarckian evolution, the relations between genotype and phenotype, the control of population diversity, and co-evolution. Since theory can best improve the applicability of new algorithms, considerable space was allocated to it. Eleven papers were selected that present new theoretical results. They consider either a specific type of algorithm and try to cover as many applications as possible, or focus on a specific aspect of a general class of algorithms. Examples are the convergence rate of evolutionary algorithms and the optimal population size. Despite of the lack of a complete theoretical understanding, researchers have altered the basic algorithms, either by incorporating application specific knowledge or introducing new ideas, and reported improved performance. PPSN 3 presents nine papers of this type. Classifier systems and genetic programming have received less attention than genetic algorithms and evolution strategies, although very promising results have been reported recently. Three papers concentrate on learning in these rule-based systems, one of them in combination with fuzzy logic. Four papers focus on various theoretical and practical aspects of genetic programming. Unfortunately, only a few of the submitted papers deal with other natural metaphors. Four have been selected that have been subsumed under the term "emergent computation", even if this is a little arbitrary. They range from aspects of artificial life to cellular automata. Two papers compare different algorithms or different parameter settings with each other. They are of particular interest to practitioners that want to get a feeling for the behaviour of such algorithms under various conditions. A further topic relates to the combination of different paradigms. Two of the three papers accepted deal with parallel simulated annealing guided by the application of genetic operators. Here and in the following section, at least a few other natural metaphors are presented. Six papers deal with various aspects of the combination of neural networks with evolutionary algorithms.

Whereas the former sections are more on the theoretical side, the following sections relate directly to practical applications. One section considers the parallel implementation of evolutionary algorithms. The four papers presented concentrate on the efficiency gain obtained by implementing genetic algorithms on parallel processors of various type or on a cluster of distributed processors. In one of them a hardware implementation of an evolutionary algorithm is described that increases the processing speed dramatically. The last large section is devoted to specific applications. Up to now, evolutionary computation has been applied to a great variety of optimization problems, and this variety is mirrored

in the selected eight papers. The applications range from optimization of VLSI chips over time tables to the bi-partitioning problem. Finally, one paper presents a software tool that facilitates the application of evolutionary algorithms.

Here is a short list of the topics covered:

- Basic concepts of evolutionary computation
- Theoretical aspects of evolutionary computation
- Modifications and extensions to evolutionary algorithms
- Classifier systems
- Genetic programming
- Emergent computation
- Comparison of different evolutionary algorithms
- Hybrid methods
- Evolutionary algorithms for neural networks
- Parallel implementations of evolutionary algorithms
- Applications
- Software tools for evolutionary computation

We are sure that these papers presented at ICEC/PPSN 3 are of interest to many of the conference participants, the researchers, and the users of evolutionary computation.

Jerusalem,
Mannheim,
Dortmund,
July 1994

Yuval Davidor, Conference Chair
Reinhard Männer, Programme Co-Chair
Hans-Paul Schwefel, Programme Co-Chair