# Editorial Introduction to the Special Issue on Bridging Theory and Practice

## 1 Theory and Practice Don't Talk to Each Other

There is a growing gap between theory and practice. This is the result of theoreticians rarely being application people (and *vice versa*), and also of the lack of a forum where theoreticians and practitioners can meet and discuss (with the notable exception of the "Genetic Programming Theory and Practice" workshop series (Riolo and Worzel, 2003; O'Reilly et al., 2004; Yu et al., 2005; Riolo et al., 2007) the focus of which, however, is limited to genetic programming).

There are many theoretical approaches to the study of evolutionary algorithms. These include the dynamical system approach, schema theorems, Markov chains, statistical mechanics, No Free Lunch theory, the study of representations and fitness landscapes, the small-model engineering perspective, and the unified study of randomized search heuristics. However, often theoretical studies in evolutionary computation are criticized for rarely being applicable to the real world. One of the reasons for this is that producing a comprehensive theory for complex adaptive systems such as evolutionary algorithms is objectively very hard-simplifications are often a necessary step in order to make some progress. Still, sometimes theoreticians appear to focus on approaches and problems that are too distant from practice.

On the other hand, despite the effectiveness of evolutionary algorithms, there is a growing need for a theory that can clarify the applicability of different algorithms to particular problems, provide design guidelines and, thereby, avoid the current time-consuming practice of hand-tuning parameters and operators. It is important, though, for practitioners to understand the limitation of theoretical approaches: one cannot expect theory, for example, (quoting Chris Stephens) to give the optimal crossover probability to solve a 445 city grave digger problem with variable coffin size.

## 2 What Can We Do to Rectify the Situation?

It is clear that the situation cannot be rectified with the stroke of a pen. It will take time and effort. However, it is reasonably clear that a work programme for achieving this should at least include the following:

- We need to examine existing theoretical approaches in an attempt to identify what precise contributions they have made and can make in the foreseeable future in relation to the needs of practitioners facing real-world problems.
- We need to identify the key questions that practice would need answered by theory and categorize them on the basis of their difficulty in relation to current theoretical approaches.
- We need to identify to what extent the questions that are unanswerable by theory may be addressed by using empirical studies, and what the relative strengths and weaknesses are of such studies w. r. t. pure theory.

- To help identify open problems already within the realm of current theoretical investigations, we need to identify applications that make them more significant for the purpose of guiding theory.

As a first step in the direction of this programme, we proposed and organised a workshop on bridging theory and practice at the Parallel Problem Solving from Nature (PPSN) conference in September 2006. Five papers were presented at the workshop accompanied and followed by generous discussion. Of course, we could not achieve the ambitious set of objectives listed above, but we felt that the workshop was a good start.

This special issue of the *Evolutionary Computation journal* is a further step in the programme outlined above. All of the presenters at the PPSN workshop were invited to extend their work and submit to this special issue, although the special issue was also open to new submissions. After a rigorous review process five papers were accepted, and are now presented in this special issue. We briefly summarise their contents in the next section.

## 3 The Papers in This Special Issue

Many successful applications of evolutionary algorithms rely on the use of asymmetric genetic operators, which are reported to lead to good solutions faster than more traditional ones. The article "Speeding Up Evolutionary Algorithms through Asymmetric Mutation Operators" by Benjamin Doerr, Nils Hebbinghaus and Frank Neumann investigates the effects of asymmetric mutation theoretically from the run-time point of view for the Eulerian cycle problem (the problem of finding a path that visits every edge of a graph exactly once), explaining the reasons why asymmetry provides a speedup.

An anytime algorithm is an algorithm that computes a result progressively, improving its estimation of it. Therefore, in principle, such an algorithm can be interrupted at any time while still being able to provide an (approximate) answer. Many evolutionary algorithms and other randomised search heuristics have these features. This is one of the reasons why they are appealing to practitioners. Another reason is that they are robust. The article "Comparison-Based Algorithms Are Robust and Randomized Algorithms Are Anytime" by Sylvain Gelly, Sylvie Ruette and Olivier Teytaud studies theoretically randomised search heuristics which perform selection only using comparisons between fitness values (e.g., rank selection or tournament selection) from exactly these two points of view.

Landscape analysis and measures predicting the hardness of fitness functions for evolutionary algorithms are themes of research with a long history in the field of evolutionary computation. Many different measures with very differing properties exPrices subject to change without notice.ist. However, it is known that all have some deficiencies. Jun He, Colin Reeves, Carsten Witt, and Xin Yao describe a formal framework that allows them to classify difficulty measures in a rigorous way. They connect the subject with classic complexity theory and prove (for a particular performance measure) that under well-established assumptions from complexity theory, predictive measures cannot be computed efficiently.

It is very rare to be able to derive theoretically practical recipes for practitioners facing a difficult application. They are interested in questions such as: What is a good representation for my problem? What is the best crossover and mutation operator for my application? What population size should I use? Etc. Starting from the now well-developed theory on geometric crossover (a representation-independent generalization of the traditional crossover defined using only a notion of distance), Prices subject to change without notice.the article “Geometric Crossovers for Multiway Graph Partitioning” by Alberto Moraglio, Yong-Hyuk Kim, Yourim Yoon, and Byung-Ro Moon achieves this difficult goal, deriving theoretically a series of novel high-performance crossover operators for graph partitioning, a really difficult yet very important practical problem.

Many real-life problems are multi-objective. However, empirical evidence shows that multiobjective evolutionary algorithms do not scale well with the number of conflicting objectives. The article “On the Hardness of Offline Multi-objective Optimization” by Olivier Teytaud turns practice into theory by showing that the convergence rate of all comparison-based multi-objective algorithms is not much better than that of the random search, unless the number of objectives is small. This result holds if one takes as the computational cost of running an algorithm the number of comparisons it performs.

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