Foreword

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I was delighted when I was asked to write a foreword to this special issue on genetic algorithms (GAs) and evolutionary computation (EC) in image and signal processing edited by Riccardo Poli and Stefano Cagnoni for two reasons. First, the special issue is another piece of the mounting evidence that GAs and EC are finding an important niche in the solution of difficult real-world problems. Second, in reviewing the contents of the special issue, I find it almost archetypal in its reflection of the GA/EC applications world of 2003. In the remainder of this discussion, I briefly review a number of reasons why genetic and evolutionary techniques are becoming more and more important in real problems and discuss some of the ways this issue used to both demonstrate effective GA/EC application and foreshadow more signal and image processing by evolutionary and genetic means.

There are a number of reasons why GAs and EC are becoming more prevalent in real applications. The first reason is what I call *the buzz*. Let us face it, GAs are cool. The very idea of doing a Darwinian survival of the fittest and genetics on a computer is neat. But *cool* and *neat*, while they may attract our *attention*, do not merit our *sustained* involvement.

Another reason for which GAs have become more popular is the *motivation from artificial systems*. Although decades, even centuries, of optimization and operations research leave us with an impressive toolkit, the contingency basis of the methodology leaves us somewhat cold. By this I mean that the selection of an optimization technique or OR is *contingent* on the type of problem you face. If you have a linear problem with linear constraints, you choose linear programming. If you have a stage decomposable problem, you choose dynamic programming. If you have a nonlinear problem with sufficiently pleasant constraints, you choose nonlinear programming, and so on. But the very nature of this list of methods that work in particular problems is part of the problem. One of the promises of biologically inspired techniques is a *framework* that does not vary and a larger class of problems that can be tackled within that framework.

This vision of greater *robustness* is now being realized, but it is tied to whether the solutions obtained using these techniques are both *tractable* and *practical*. Results about a decade ago showed that simple GAs in common practice had a kind of Dr. Jekyll and Mr. Hyde nature. Simple genetic and evolutionary algorithms work well (subquadratically) on straightforward problems, but they require exponential times on more complex ones. This is not the place to review these results in detail, and the interested reader can look elsewhere (D. E. Goldberg, *The Design of Innovation: Lessons from and for Competent Genetic Algorithms*, Kluwer, Boston, 2002) but it suffices to say that work on *adaptive* and *self-adaptive* crossover and mutation operators is overcoming the tractability hurdle on real problems, resulting in what appears to be broadly scalable (subquadratic) or *competent* solvers.

Yet, theoretical tractability is of little solace to a practitioner who faces the daunting prospect of performing a million costly function evaluations on a 1000-variable problem. As a result, increasing theory, implementation, and application are showing the way toward *principled efficiency enhancement* using parallelization, time utilization, hybridization, and evaluation relaxation, and these methods are moving us from the realm of the competent (the tractable) to the realm of the practical.

These fundamental reasons—the buzz, the need, the tractability, and the practicality of modern genetic and evolutionary algorithms—are driving an ever-increasing interest in these methods, and this volume reflects that range of interest in terms of the application areas, operators, codings, and accoutrements on display.

In terms of application, the use of GAs and EC in this volume spans such disparate applications as filter tuning, sensor planning, system identification, object detection, bioinformatic image processing, 3D model interpretation, and speech recognition. The range of different applications here is a reflection of the breadth of application elsewhere, and the utility of the GA/EC toolkit across this landscape is empirical evidence of the robustness of these methods.

Looking under the hood, we see a wide range of codings and operators in evidence, from floating-point vectors to permutations to program codes, from fixed to adaptive operators, and from crossover to mutation with various

competitive or clustered (or niched) selection mechanisms. Additionally, many of the papers here demonstrate an understanding of the importance of efficiency enhancement in real-world problems, and a number of them combine the best of genetic and evolutionary computation with local search to form useful and efficient hybrids that solve the problem. Too often, methods specialists are enamored with the method they helped invent or perfect, but in the real world, efficient solutions are obtained with an effective combine of global and local techniques.

In all, this special issue is a useful compendium for those interested in signal and image processing and the proper application of genetic and evolutionary methods to the unsolved problems of these domains. To the field of genetic and evolutionary computation, this special issue is a growing evidence of the importance of what that field does in areas of human endeavor that matter. To audience members in both camps, I recommend without reservation that you study this special issue, and absorb and apply its many lessons.

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