A Systematic Study on Differential Evolution over Benchmark Electromagnetic Inverse Scattering

Anyong Qing
School of Physical Electronics, University of Electronic Science and Technology of China, Chengdu 610054, China

1. Extended Abstract

Among the rapidly expanding family of natural optimization algorithms, differential evolution (DE) [1, 2, 3] is a very simple but very powerful evolutionary algorithm.
There are two mechanisms to evolve the population in DE. The classic DE (CDE) [1, 2], also known as two-array method, applies static one while the dynamic DE (DDE) [3, 4], or one-array method, evolves the population dynamically. A close analogy between the relationship between CDE and DDE and that between Jacobi and Gauss-Seidel method in linear algebra can be made. Although it is well known that Gauss-Seidel method might converge faster more reliably than Jacobi method, it is claimed that there is "no dramatic difference in performance between the one- and two-array methods".
Differential mutation has been established as the crucial evolutionary operator leading to the success of DE. It has been a consensus in DE that different differential mutation bases balance the exploration and exploitation processes in DE differently. Accordingly, strategies with different differential mutation bases may have different performance. An anonymous reviewer commented that "in practice, DE/rand/1 is the most widely used strategy. Moreover, DE/best/1 is more prone to being trapped in a local optimum".
The successful innovation of differential mutation unfortunately shades other important ideas in DE as crossover does in genetic algorithms (GA). One of the victim operators in DE is crossover. It has been claimed that "The crossover method is not so important although Ken Price claims that binomial is never worse than exponential".
The above statements together with other misleading ones have been well circulated in DE community. However, accumulating evidences pose stronger and stronger challenge against them. Serious measures have to be taken to examine these dubious statements.
An ambitious effort to reveal the relationship between DE strategies, their intrinsic control parameters and mathematical features of optimization problems was triggered in 2004 [3]. One of the fundamental activities in this effort is a systematic study on DE. DE strategies, their corresponding intrinsic control parameters, termination conditions, toy functions and benchmark application problems, their corresponding non-intrinsic control parameters, form a testing system.
The benchmark electromagnetic inverse scattering problem [4, 5] serves as one of the benchmark application problems in this study. Representative strategies with a full sweeping of intrinsic control parameters are applied to solve the benchmark electromagnetic inverse scattering problem so that a systematic picture of DE can be drawn. Numerical results are presented to rebut the questionable statements. The advantage of dynamic evolution is re-confirmed. Best differential mutation base and exponential crossover are also observed more competitive. More insights extracted are presented to advise DE applicants to avoid further damages to applicants' confidence in DE.
Moreover, parametric and stochastic crimes are defined to promote appropriate practice of applying and comparing stochastic and/or intrinsic control parameters-dependent optimization algorithms.

2. References

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