The Micro-genetic Operator in the Search of Global Trends

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ABSTRACT

This work studies the mGA operator (Micro Genetic Algorithm), that has been proposed in literature as a "local search" operator for optimization with Genetic Algorithm. A new interpretation for this operator behavior is proposed, showing the role that this operator can have in a "global search". Such interpretation will possibly allow the definition of some directives for this operator parameter tuning, leading to more efficient GA that reach the optima with greater probability, spending less objective function evaluations. Some preliminary tests, conducted over problems of nonlinear functions with continuous variables, are presented, leading to some specific conjectures about what should be such directives.

Categories and Subject Descriptors

G.1.6 [**Mathematic of Computing**]: Numerical Analysis—*Optimization*

General Terms

Algorithms

Keywords

Genetic Algorithms, micro genetic algorithms, local search

1. INTRODUCTION

An important kind of additional operator that can be incorporated into Genetic Algorithms (GA's), in addition to the basic operators of mutation, crossover and selection, is the class of *local search operators*. These operators perform a search in the neighbourhood of some points that constitute a subset of the population, using strategies which increase the search efficiency.

The Micro-Genetic Operator (mGA) has been proposed in reference [1]: inside the GA, a small version of this algorithm is run (possibly via a recursive call of the same algorithm) with a smaller population. This small version is expected to converge much faster to a point of local optimum which is close to the best current point.

GECCO'08, July 12–16, 2008, Atlanta, Georgia, USA.
ACM 978-1-60558-130-9/08/07.

In the reference in which the mGA is proposed, a detailed analysis of its properties shows its usefulness as a local search operator.

Here, the mGA operator is examined from a point of view which is not mentioned in [1]. The results presented in this paper suggest that the mGA also executes an operation which is named "search of global trend": *An algorithm performs a "search of global trend" when it uses samples of the objective function, searching for consistencies in its behavior which are not locally observable, which can give indications related to the location of the global optimum.* The thesis to be discussed is that the mGA operator is a valuable tool for performing a "search of global trend", enhancing both the convergence certainty and the computational effort that is needed for convergence, in a global fashion, rather than being a local search operator only.

The situation examined is a real-coded GA, over some test problems with continuous variables. The results presented suggest that the mGA is capable of doing searches of global trend, even under difficult circumstances.

2. THE REAL-CODED GA

The genetic algorithm with real-variable encoding, used for the tests of the mGA operator, follows the description presented in [2]. The micro genetic algorithm (mGA) employed in this case is basically the same real-coded genetic algorithm with the following modifications: the mGA population is a fraction of the GA population; the mGA center is the best individual of the current population; the population of the mGA is created according to an uniform distribution whose radius is a fraction of the GA radius; the mGA is executed once in each iteration. If an enhancement of the current best solution is obtained, then this point is replaced by the new point. All other characteristics of the GA are kept in the mGA.

3. RESULTS

Preliminary tests have been conducted for the purpose of characterization of the behavior of the mGA operator. All tests have used a population of 200 individuals for the GA and a size of 10 for the spreading radius. The convergence criteria used is a distance smaller than 10^{-3} to the known point of optimum. The center for generating the population has been a point chosen randomly in a square box which has width of 40. All tests are referred to averages obtained for 100 runs of each version of the test algorithm.

This Rastrigin function is employed with 2 variables; see [2] for its definition. The population of the mGA has been defined as 10 per cent of the GA population. The results when the mGA operator is included are shown in Table 1, for several spread radius of the mGA and for the pure GA.

Table 1: Results for the Rastrigin with the mGA, varying the mGA radius

radius of mGA	% of convergence	function evaluations
0.01	77	4431
0.51	75	4472
0.61	81	11196
0.71	96	5390
0.81	100	6489
0.91	100	4802
1.01	100	2332
1.51	100	2052
2	100	1914
4	100	1910
6	100	2040
8	100	2054
10	100	2346
15	100	2364
18	100	2436
21	100	2262
24	100	2406
30	100	2234
pure GA	45	11192

It is remarkable the improvement gained on the average number of evaluations to reach the point of optimum and also the increase in successful performances of the algorithm to reach the optimum point. Another interesting result should be highlighted: for very small radius, the effect of the mGA operator is not that significant, although it is still positive. However, for radius beginning from 0.81, the mGA operator starts to cause the convergence of the GA to the optimum point in 100 per cent of the executions. Note that the distances between two consecutive local optima are always nearly 1.0. The mGA keeps this effect even for 'big' radius like those of the same size of the initial population itself.

For examining the number of evaluations as a function of the radius, it can be noticed that the number of evaluations is expressively better in the mGA performances compared to performances which use only the pure GA, in the cases of very small radius.

The Rastrigin function has a particularity that could be excessively favorable for some genetic algorithms: its local minima are organized in such a way that they are aligned. In order to exclude the possibility of some of the conclusions taken before being dependent on such function particularity, another function that does not present such behavior is used too. This function consists of nine attraction basins which have their minima separated by a distance of 5.0, which are not aligned. The attraction basins are isolated and surrounded by 'plateaus' on which the function is practically constant.

A test is made using this function for investigating whether the property of *searching of global trend* of the mGA operator is associated with the consecutive displacement of the best current point from one attraction basin to a close another one. The 'global trend' of the mGA operator is then characterized by contiguous successively better basins.

Table 2: Behavior of GA with the mGA

radius of mGA	% of convergence	function evaluations
1.00	71	2347
2.50	74	2621
5.06	100	2439
7.60	100	2637
11.40	100	2704
17.10	100	3244
25.60	100	3123
30000.00	78	11548
radius of GA	% of convergence	function evaluations
10	50	1022
100	70	20746

The behavior of the GA with the mGA operator is shown in Table 2, considering various radius for the mGA. It should be noticed that the GA with the mGA operator, for radius starting from 5.0 (which is the distance between consecutive minima) has converged for 100 per cent of the performances. For a radius equal to 10, the pure GA has converged just for 50 per cent of the cases, although it has spent a much smaller average of evaluations compared with the best case obtained with the use of the mGA. It is most likely that this has occurred because the problem is a low complexity problem (few minima): when the algorithm converges, the process is very fast. However, when the algorithm does not converge, the information pattern which exists in the problem is not favorable for allowing for a next convergence, even the algorithm spending many evaluations of the function. In this case, the mGA operator allows for some processing in the information pattern of the problem, and convergence can be obtained even in the most unfavorable cases.

4. CONCLUSIONS

This paper has studied the micro-genetic operator under a different viewpoint than the one it has been proposed: instead of viewing it as a local search operator, it has been shown to possibly have its main role in the "search of global trend".

This feature has been studied, preliminary, in the context of GA's for optimization of nonlinear functions with continuous variables. The micro-genetic operator has performed consistently as a tool for enhancing the GA reliability and the GA computational cost, in the cases that have been examined.

Acknowledgment

The authors would like to thank CNPq, CAPES and FAPEMIG.

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