Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

HYBRIDIZATION OF A GENETIC ALGORITHM WITH A PATTERN SEARCH AUGMENTED LAGRANGIAN METHOD

[1]Roman Denysiuk, Lino Costa, Isabel A.C.P. Espírito Santo, Edite M.G.P. Fernandes

[1]Department of Production and Systems

University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal

E-mail: denysiukr@gmail.com

KEYWORDS

Global optimization, Augmented Lagrangian, Genetic Algorithm, Pattern Search.

ABSTRACT

Genetic algorithms as most population based algorithms are good at identifying promising areas of the search space (exploration), but less good at fine-tuning the approximation to the minimum (exploitation). Conversely, local search algorithms like pattern search are good at improving the accuracy of that approximation. Thus, a promising idea is combining local and global optimization techniques. We propose a new hybrid genetic algorithm based on a local pattern search that relies on an augmented Lagrangian function for constraint-handling. In this study, we test different hybridization schemes concerning population-handling, as well as local search refinements for a better point. We use performance profiles as proposed by Dolan and Moré in 2002 and a benchmark set of global problems to evaluate the effect of the proposed hybrid algorithms. Population size effect on the algorithm is also assessed.

INTRODUCTION

In this work, the following problem is under consideration:

$$\begin{aligned} &\min f(x) \\ &\text{s.t. } b_i(x)=0,\ i=1,\ldots,m \\ &\quad\ g_j(x)\le 0,\ j=1,\ldots,p \end{aligned} \qquad (1)$$

where x is an n dimensional vector in R^n, $f(x)$ is the objective function, $b_i(x)$ are the m equality constraints and $g_j(x)$ are the p inequality constraints. This type of constrained global minimization problem has many applications in engineering. A common technique in global optimization literature transforms the constrained problem into an unconstrained one, by adding a penalty term to the objective function (Lewis and Torkzon 2002). We propose a Hybrid Genetic Pattern Search Augmented Lagrangian (HGPSAL) algorithm that hybridizes a genetic algorithm with a derivative-free pattern search method to refine the best solution found by the genetic search.

HYBRID GENETIC PATTERN SEARCH AUGMENTED LAGRANGIAN ALGORITHM

A paradigm based on a hybridization of augmented Lagrangians with genetic algorithms has not been attempted. A Genetic Algorithm (GA) is a population based algorithm that uses techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (Goldberg 1989). On the other hand, hybridization of global and local optimizers may provide a more effective tradeoff between exploitation and exploration of the search space. It is well-known that overall successful and efficient general solvers do not exist. Moreover, stochastic population based algorithms like genetic algorithms are good at identifying promising areas of the search space (exploration), but less good at fine-tuning approximations to the minimum (exploitation). Conversely, local search algorithms like pattern search are good at improving approximations to the minimum. A Hooke and Jeeves (HJ) pattern search method (Hooke and Jeeves 1961) is a derivative-free method that performs, at each iteration, a series of exploratory moves around a current approximation, in order to find a new approximation with a lower objective function value.

NUMERICAL RESULTS

In this study, in order to evaluate the performance of the HGPSAL algorithm 24 benchmark problems coded in MATLAB were considered. To compare the performance of the pattern search type algorithms we use the performance profiles as described in Dolan and Moré's paper (Dolan and Moré 2002). We propose and test four different hybridization schemes. They differ in the number of points of the population that are selected to be improved in the local search. The tested alternatives are: just one point, the best point of the population; the 10% best points; the 25% best points; and the 50% best points. For simplicity, we denote the hybridization schemes as follows:

- version 1 that improves the best population point found by GA with HJ;
- version 2 that improves the best 10% population points found by GA with HJ;
- version 3 that improves the best 25% population points found by GA with HJ;
- version 4 that improves the best 50% population points found by GA with HJ.

All parameters of the HGPSAL algorithm were kept constant for all problems. No effort was made in finding the best parameter setting for each problem.

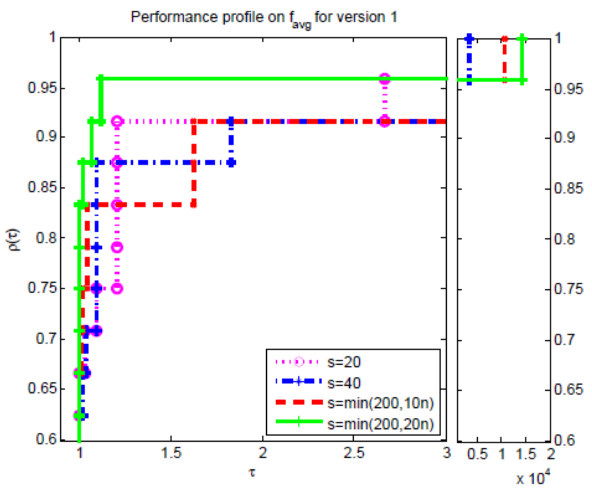

Figure 1: Performance Profile on f_{avg} for Version 1

Figure 1 allows to analyze the effect of the population size on the algorithm performance. The profiles, based on the metric f_{avg}, the central tendency of the best solutions found over the 10 runs, show that a population size of min(200; 20*n*) outperforms the other executions with different (and smaller) population sizes in comparison. Attending on Figure 2, we can observe that version 3 outperforms the other versions, attaining the best average solution in more than 90% of the problems.

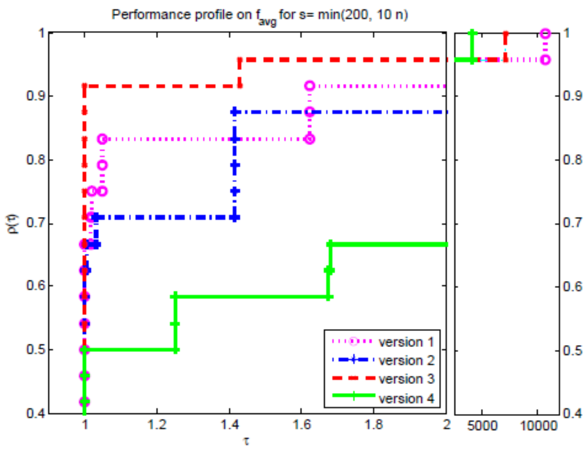

Figure 2: Performance Profile on f_{avg} for Population Size of min(200,10*n*)

CONCLUSIONS

In this work, we proposed four hybridization schemes for constrained global optimization that combines the augmented Lagrangian technique for handling constraints with a genetic algorithm as global optimizer and a pattern search as local optimizer. We performed a comparative analysis on the population size effect, as well as on the population-handling on the hybridization schemes.We show that a population size of min(200; 10*n*) seems to be the more appropriate for the generality of the problems. In general, using an excessive number of points of the population to improve by HJ leads to poor results.

As future work, we intend to perform comparisons with other stochastic approaches and solve other benchmark problems, to improve the integration of global and local search, as well as tuning the parameters of the algorithm.

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