On the optimization method SCP and applications

Matheus Machado Vieira & Mateus Baltazar de Almeida

Universidade Federal Rural de Pernabumco

{matheus.machadov, mateus.baltazar}@ufrpe.br

Abstract

The very elaboration of programming problems already necessitates their resolution, which depends heavily on their classification, thus generating steps of complexity prior to actually solving the problem. It is then proposed a new method that uses the SCP to solve problems of other domains with the help of other methods, such as ABC, thus generating a new method more comprehensive and more effective.

Introduction

A programming problem has as main characteristic to find optimal values to be applied to something. If a system or a process has a equivalent mathematical model of some number of variables, then there is some tool that allows the choice of variables in order to produce the best possible result. The problem of produce the best possible result is called optimization problem.

The classification of optimization problems varies according to some characteristics, such as problem domain. Considering the behavior, it has deterministic or probabilistic problems. In determinstc problems we have linear (LPs) and nonlinear problems (NLPs).

Nonlinear problems are more complex to work with, and one of the reasons is their classifications and in some cases there is even difficulty in classifying it. Non-convex problems are even more harder, then, an algorithm has been developed that solves this more complex type of problem by trying to simplify it and solve smaller pieces [1].

Objectives

Nonlinear problems differ from linear problems mainly because they contain at least something that is not linear, either a function or a constraint. The function loses some characteristics that would facilitate its evaluation, just as the space formed by the constraints becomes more complex when they are nonlinear.

The main classification is between convex and non-convex problems. Convex problems have well-defined methods that usually solve the problems well. The most usual ways to solve a non-convex problem are by linearization or branch-and-bound algorithms.

We can say that the behavior of a non-convex problem is somewhat more complex and unpredictable than the linear and convex problems. The type of problem is NP-Hard, which raises debate on how to solve this type of problem, appealing to machine learning and more delicate methods of linearization.

The Sequential Cutting Plane (SCP) [1] solves non-convex problems by linearization techniques for more complex problems. The SCP solves problems such as:

Objective function:

$$min(f(x))$$

Constraints:

$$g_j(x) \leq 0, j = 1, ..., m_i$$
$$h_r(x) = 0, r = 1, ..., m_e$$
$$x \in \mathbb{R}$$

The SCP domain is somewhat restricted, it is thought to bring other types of problems to the SCP domain, solve them and check if there is a real advantage in using it so, since in its original domain the SCP competes with other algorithms already established as good for problems. The Vehicle Routing Problem (VRP) is one that can be solved by SCP through continuous approximations of the discrete spaces.

Results

We will begin with a characterization of the algorithm in the determination of the objective function of scope problems and also of the functionality of the algorithm with respect to the delimitations that are commonly conditions.

Considering the prototypical characteristic of the problem determined by differentiable functions of real variables - at least twice as differentiable - we have the scope of the applicability of the SCP method.

One of the adversities of the SCP is the conjuncture of the implicit structure of the algorithm with regard to criteria that come from the determination of the regions of analysis. These structures can be described by the differential and algebraic entities that are the gradient and the Lagrange multipliers respectively.

On the comparative performance of the algorithm

As can be seen in [1], experimental tests of a comparative nature were done with the use of public resolvers, LANCELOT and DONLP2. These results showed the strength of the SCP, considering that, with the use of an algorithm other than SCP, we had a temporal performance of several hours.

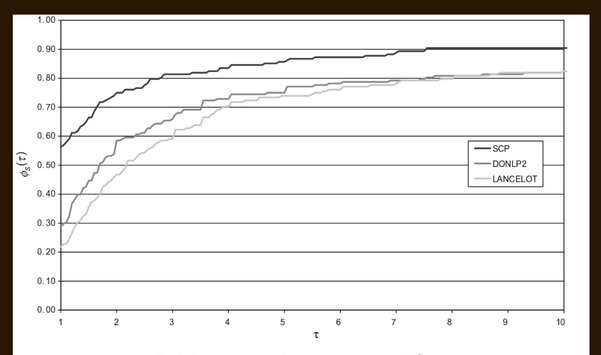

Fig. 2. Test results for the Schittkowski test set ($\epsilon = 10^{-3}$).

About Parallel Performance

Trying to approach multiple application spheres in order to simplify the modeling and, therefore, the object function or constraint parameters, we will add to the SCP a proven algorithm, namely ABC (Artificial Bees Colony).

Conclusion

The SCP method demonstrates great power in solving problems of your original niche compared to other methods and can also be a great help in solving other types of problems.

If the transformation of other types of problems is successful, the creation of a method with less restricted domain can be very useful for the efficiency in solving such problems, especially with regard to the use of proven methods such as ABC.

References

[1] Claus Still and Tapio Westerlund. A linear programming-based optimization algorithm for solving nonlinear programming problems. *European Journal of Operational Research*, 200:658–670, 02 2010.

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