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New ideas in parallel Particle Swarm Optimization

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Abstract: In the area of global optimization, a variety of techniques have been developed to find the global minimum. These techniques, in most cases, require a significant amount of computational resources and time to complete and therefore there is a need to develop parallel techniques. In addition, the wide spread of parallel architectures in recent years greatly facilitates the implementation of such techniques. Among the most widely used global optimization techniques is the Particle Swarm Optimization technique. In this work, a series of modifications are proposed in the direction of the efficient parallelization for the Particle Swarm Optimization. These modifications include an innovative velocity calculation mechanism that has also been successfully used in the serial version of the method, mechanisms for propagating the best particles between parallel computing units, but also a process termination mechanism, which has been properly configured for efficient execution on parallel computing environments. The proposed technique was applied to a multitude of computational problems from the relevant literature and the results were more than promising, since it was found that increasing the computational threads can significantly reduce the required number of function calls to find the global minimum.

Keywords: Optimization, Parallel methods, Evolutionary techniques, Stochastic methods, Termination rules.

1. Introduction

The global optimization problem is usually defined as:

$$x^* = \arg\min_{x \in S} f(x) \tag{1}$$

with S:

$$S = [a_1, b_1] \otimes [a_2, b_2] \otimes \ldots [a_n, b_n]$$

where the function f is assumed to be continuous and differentiable.There is a wide range of problems in the relevant literature that can be treated as global optimization problems such as problems in physical science [1–3], chemistry [4–6], economics [7,8] and medicine [9,10]. There are several ways to categorize global optimization techniques, but most researchers suggest dividing them into two broad categories: deterministic and stochastic techniques. In the area of deterministic techniques, the one with the greatest spread among researchers is the Interval method[11,12], where the initial interval of values S of the objective function is continuously divided into smaller parts. The segments that may not contain the total minimum are discarded and eventually a very narrow interval of values should be left which will contain the total minimum of the objective function. On the other hand, in the category of stochastic techniques, where the greatest research effort is made, techniques are presented that look for the total minimum using stochastic methods, which of course does not guarantee finding the total minimum. In this vast area of research endeavors one encounters methods such as controlled random search methods[13–15] which can be considered as a direct search method, simulated annealing methods [16–18], differential evolution methods [19,20], particle swarm optimization methods [21–23],

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