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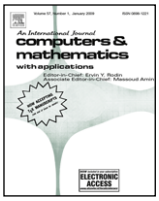

Hybrid pattern search and simulated annealing for fuzzy production planning problems

P. Vasant, N. Barsoum *

University Technology Petronas, 31750 Tronoh, Perak Dr, Malaysia
Curtin University of Technology, Miri, Sarawak, Malaysia

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ABSTRACT

In this paper, the hybridization of PS (Pattern Search) method and SA (Simulated Annealing) are incorporated in the optimization process. This is in order to look for the global optimal solution for the fitness function and decision variables as well as minimum computational CPU time. The real strength of SA approach has been tested in a case study problem of industrial production planning. This is due to the great advantage of SA for being easily escaping from trapped in local minima by accepting up-hill move through a probabilistic procedure in the final stages of optimization process. In the Ph.D. Thesis by Vasant (2008) [4], 16 different techniques were provided of heuristic and meta-heuristic approaches in solving industrial production problems with nonlinear cubic objective functions, eight decision variables and 29 constraints. In this paper, fuzzy technological problems have been solved using hybrid techniques of pattern search and simulated annealing (HSAPS). The simulated and computational results are compared to other various evolutionary techniques.

1. Introduction

Hybrid Simulated Annealing Computation (HSA) has been recognized as an incredible tool for solving optimization problems among Engineering, Science, Information Technology and Economics researchers over the last two decades. In this regard, the suitability of using hybrid simulated annealing computation for optimization will be explored indicating the advantages and disadvantages from the optimization point of view.

For many real world optimization problems, the environment is uncertain or fuzzy, leading to dramatic changes in the fitness or objective function values of individual solution. The industrial production planning problems with uncertainty in the profit function is a good example. Optimization under uncertain environment can be handled nicely by hybrid evolutionary techniques [1]. The industrial production planning problems can be handled successfully in an uncertain environment.

Based on the above-mentioned advantages of hybrid evolutionary computation, the following listed objectives are thoroughly investigated in this research work. This research work:

- Provides a new formulation of the industrial production planning problem with the global solution approaches by Jimenez, Sanchez, Vasant and Verdegay [2] who have formulated the above problems with quadratic objective function and solved by fuzzy evolutionary approach. But in this research work the author has formulated a new objective function in the form of a cubic function. The idea of cubic objective function was obtained from the reference [3]. Lin and Yao [3] solved a theoretical problem of fuzzy optimal profit with cubic function by using genetic algorithm approach without

* Corresponding author at: University Technology Petronas, 31750 Tronoh, Perak Dr, Malaysia.
E-mail addresses: pvasant@gmail.com (P. Vasant), nnb3@hotmail.com (N. Barsoum).

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fuzzy membership function. In this research the cubical objective function with 21 inequality constraints and 8 bound constraints was solved by various hybrid evolutionary optimization techniques with fuzzy modified s-curve membership function.

- Reports the best known approaches, its results and findings for the real world application problems. The major approaches which were adopted in the research work of Vasant [4]: Hybrid Genetic Algorithms and Line Search, Hybrid Genetic Algorithms and General Pattern Search, Hybrid Genetic Algorithms and Simulated Annealing, Hybrid General Pattern Search and Simulated Annealing, Hybrid Mesh Adaptive Direct Search and Genetic Algorithms and Hybrid Line Search and Simulated Annealing. All the above methods are successfully utilized and solved applied to real world problems of industrial production planning.
- Investigates the optimization of the objective function with constraint handling approaches of the problem. Various methods have been provided by Vasant [4] on constraint handling techniques. The majority of these techniques are related to penalty function approaches. The main drawback of penalty functions is the careful fine tuning required by the penalty factors, which determine the severity of the penalization. Moreover it is difficult to use penalty function approaches for the large scale problem with many constraints. Based on this limitation, several approaches have been proposed to deal with it and also alternative techniques such as hybrid approaches have been adopted in this research work.
- Proposes a new form of the hybridization approaches as global solution procedures.

There are 11 different techniques of hybridization which have been utilized in this research work for solving a nonlinear cubic objective function of industrial production planning. The problems are with 21 constraints and 8 bound constraints representing the eight decision variables. The nonlinear cubic objective function contains 24 coefficients for the 8 decision variables.

- Finds the optimal solution for the objective function with respect to decision variables, level of satisfaction, vagueness factor and computational time.

The fuzziness and uncertainty in the technological coefficients of constraints in the industrial production planning problems will be represented with by fuzzy membership function of modified s-curve [5–7]. The optimal profit function depends on the major factors such as vagueness and computational time.

- Compares classical approaches versus hybrid approaches in solving optimization problems of industrial production planning.

Four non-hybrid approaches such as genetic algorithms; general pattern search, mesh adaptive direct search and line search have been adopted in solving this problem. On the other hand 11 hybrid techniques have been utilized in solving the similar problem [4].

The scope of this paper is to propose novel methods, which would take benefit of newly formed hybrid approaches: being sufficiently general to be used for particular real world problems of industrial production planning, it should still be able to incorporate specific knowledge about this problem.

The final goal is therefore to achieve best possible findings with respect to the optimal profit for the industrial production planning problems, with nonlinear objective function with 21 constraints and eight decision variables with respect to decision variables, level of satisfaction, vagueness factor and computational time. To perform this task, the methods proposed in this paper should succeed in finding optimal but realistic solutions for the implementation.

2. Pattern search (PS)

Pattern search methods are a class of direct search methods for nonlinear optimization. Since the introduction of the original pattern search methods in the late 1950s and early 1960s (Abramson, 2002), they have remained popular with users due to their simplicity and the fact that they work well in practice on the variety of problems. The fact that they, more recently, are provably convergent has generated renewed interest in the nonlinear programming community.

Pattern search (PS) is a valuable algorithm, but the application of non-smooth analysis techniques in [8] showed its limitations due to the finite choice of directions in [9]. Mesh Adaptive Direct Search (MADS) removes the PS restriction to finitely many poll directions. We have long felt that this was the major impediment to stronger proofs of optimality for PS limit points (and better behavior), and more satisfying optimality process for MADS in addition to opening new possibilities for handling nonlinear objective function.

The following is the two attractive features of pattern search algorithms:

- They can be extremely simple to specify and implement.
- No explicit estimate of the derivative nor anything like Taylor's series appears in the algorithm. This makes these algorithms useful in situations where derivatives are not available and finite-difference derivatives are unreliable, such as when $f(x)$ is noisy.