Hybridizing Infeasibility Driven and Constrained-Domination Principle with MOEA/D for Constrained Multiobjective Evolutionary Optimization

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Abstract. This paper presents a novel multiobjective constraint handling approach, named as MOEA/D-CDP-ID, to tackle constrained optimization problems. In the proposed method, two mechanisms, namely infeasibility driven (ID) and constrained-domination principle (CDP) are embedded into a prominent multiobjective evolutionary algorithm called MOEA/D. Constrained-domination principle defined a domination relation of two solutions in constraint handling problem. Infeasibility driven preserves a proportion of marginally infeasible solutions to join the searching process to evolve offspring. Such a strategy allows the algorithm to approach the constraint boundary from both the feasible and infeasible side of the search space, thus resulting in gaining a Pareto solution set with better distribution and convergence. The efficiency and effectiveness of the proposed approach are tested on several well-known benchmark test functions. In addition, the proposed MOEA/D-CDP-ID is applied to a real world application, namely design optimization of the two-stage planetary gear transmission system. Experimental results suggest that MOEA/D-CDP-ID can outperform other state-of-the-art algorithms for constrained multiobjective evolutionary optimization.

Keywords: Multiobjective evolutionary algorithm, Infeasibility driven, Constrained -domination principle, Constrained multiobjective optimization, Penalty functions.

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S.-M. Cheng and M.-Y. Day (Eds.): TAAI 2014, LNAI 8916, pp. 249–261, 2014.

1 Introduction

Most Real world optimization problems require simultaneous treatment of multiple objectives [1], and involve a number of inequality and/or equality constraints which the optimal solutions must satisfy. A generic constrained multiobjective optimization problem can be formulated as follows:

$$\begin{aligned} &Min. && f_i(\vec{x}), && i=1,2,\cdots m, \\ &S.t. && g_j(\vec{x}) \le 0, && j=1,2,\cdots,p \\ & && h_j(\vec{x})=0, && j=p+1,\cdots,m \end{aligned} \quad (1)$$

where $\vec{x}$ is the vector of the solutions $(\vec{x}=(x_1,x_2,...,x_n))$ and $x\in\Omega\subseteq\Re^n,\Omega$ is the set of feasible solutions that satisfy p inequality constraints and $(m-p)$ equality constraints and $\Re^n$ is a n-dimension rectangular space confined by the low boundary and upper boundary of $\vec{x}$ as follows.

$$l_k \le x_k \le u_k, \qquad l \le k \le n \quad (2)$$

where l_k and u_k are the lower boundary and upper boundary for a decision variable x_k respectively. Usually, equality constraints are transformed into inequality form as follows.

$$|h_j|-\varepsilon \le 0, \qquad j=p+1,...,m \quad (3)$$

where ε is an allowed positive tolerance value.

Over the recent years, constraint handling has become an active area of research for which numerous approaches have been proposed. Some of the commonly used constraint-handling techniques are listed below.

a. Penalty functions methods: Penalty functions methods are one of the most commonly adopted forms of constraint handling[2] [15]. This method uses the constraint violation to punish infeasible solutions. In this approach, the fitness of infeasible solutions is degraded using a sum of constraint violations. The penalty functions methods may work quite well for some constraint handling problem; however, some additional parameters are required in implementations of most penalty functions schemes. The result of the optimization process is known to be highly sensitive to these parameters. As a result, the choice of these parameters is very critical to the success of penalty functions methods for constrained optimization problems.

b. Ranking approaches: In order to eliminate the need for a penalty parameter, Runarsson and Yao [2] introduced a stochastic ranking method based on the objective function and constraint violation values, where a probability parameter is used to determine if the comparison is to be based on objective or constraint violation values. Besides, methods based on the preference of feasible solutions over infeasible solutions have been proposed. For example, Deb [3] [18] proposed a constrained-domination principle that is a feasibility-driven rule to compare individuals.