



Article

# Variable Decomposition for Large-Scale Constrained Optimization Problems Using a Grouping Genetic Algorithm

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**Abstract:** Several real optimization problems are very difficult, and their optimal solutions cannot be found with a traditional method. Moreover, for some of these problems, the large number of decision variables is a major contributing factor to their complexity; they are known as Large-Scale Optimization Problems, and various strategies have been proposed to deal with them. One of the most popular tools is called Cooperative Co-Evolution, which works through a decomposition of the decision variables into smaller subproblems or variables subgroups, which are optimized separately and cooperate to finally create a complete solution of the original problem. This kind of decomposition can be handled as a combinatorial optimization problem where we want to group variables that interact with each other. In this work, we propose a Grouping Genetic Algorithm to optimize the variable decomposition by reducing their interaction. Although the Cooperative Co-Evolution approach is widely used to deal with unconstrained optimization problems, there are few works related to constrained problems. Therefore, our experiments were performed on a test benchmark of 18 constrained functions under 100, 500, and 1000 variables. The results obtained indicate that a Grouping Genetic Algorithm is an appropriate tool to optimize the variable decomposition for Large-Scale Constrained Optimization Problems, outperforming the decomposition obtained by a state-of-the-art genetic algorithm.

**Keywords:** Grouping Genetic Algorithm; variable decomposition; Large-Scale Constrained Optimization



**Citation:** Carmona-Arroyo, G.; Quiroz-Castellanos, M.; Mezura-Montes, E. Variable Decomposition for Large-Scale Constrained Optimization Problems Using a Grouping Genetic Algorithm. *Math. Comput. Appl.* **2022**, *27*, 23. <https://doi.org/10.3390/mca27020023>

Academic Editor: Claudia Schilling

Received: 26 January 2022

Accepted: 1 March 2022

Published: 2 March 2022

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## 1. Introduction

A constrained numerical optimization problem is defined by finding the vector  $\mathbf{x} \in \mathbb{R}^D$  that minimizes the objective function  $Obj(\mathbf{x})$  subject to inequality  $g_j(\mathbf{x})$  and equality  $h_k(\mathbf{x})$  constraints [1]. This is described by Equation (1).

$$\begin{aligned} & \text{minimize} && Obj(\mathbf{x}) \\ & \text{subject to} && \\ & && g_j(\mathbf{x}) \leq 0, \quad j = 1, \dots, q \\ & && h_k(\mathbf{x}) = 0, \quad k = 1, \dots, r. \end{aligned} \tag{1}$$

where  $q$  and  $r$  represent the number of inequality and equality constraints, respectively,  $\mathbf{x} = (x_1, \dots, x_D)$ , and the search space  $S$  is defined by the lower limits  $l$  and upper limits  $u$  ( $l_i \leq x_i \leq u_i$ ), while the feasible region is defined as the subset of solutions that satisfy the constraints of the problem  $F \subset S$ .

To handle the constrained problem, the constraint violation sum  $cvr$  [2], is calculated by Equation (2).

$$cvr(\mathbf{x}) = \sum_j^q \max(0, g_j(\mathbf{x})) + \sum_k^r \max(0, |h_k(\mathbf{x})| - \epsilon) \tag{2}$$

# Decomposition Of Large Scale Problems

**RD Boyd**



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