



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



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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).

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

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 cvs [2], is calculated by Equation (2).

$$cvs(\mathbf{x}) = \sum_{j=1}^q \max(0, g_j(\mathbf{x})) + \sum_{k=1}^r \max(0, |h_k(\mathbf{x})| - \epsilon) \quad (2)$$

Decomposition Of Large Scale Problems

**Nato Institute on Decomposition,
Cambridge, Eng., 1972**



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Decomposition of Large Scale Problems, 1973 *Decomposition of Large-scale Problems* David Mautner Himmelblau, 1973 *Decomposition of large-scale problems* David M. Himmelblau, 1973 **Large-scale Optimization** Vladimir Tsurkov, 2001-03-31 Decomposition methods aim to reduce large scale problems to simpler problems This monograph presents selected aspects of the dimension reduction problem Exact and approximate aggregations of multidimensional systems are developed and from a known model of input output balance aggregation methods are categorized The issues of loss of accuracy recovery of original variables disaggregation and compatibility conditions are analyzed in detail The method of iterative aggregation in large scale problems is studied For fixed weights successively simpler aggregated problems are solved and the convergence of their solution to that of the original problem is analyzed An introduction to block integer programming is considered Duality theory which is widely used in continuous block programming does not work for the integer problem A survey of alternative methods is presented and special attention is given to combined methods of decomposition Block problems in which the coupling variables do not enter the binding constraints are studied These models are worthwhile because they permit a decomposition with respect to primal and dual variables by two level algorithms instead of three level algorithms Audience This book is addressed to specialists in operations research optimization and optimal control *Decomposition of Large-Scale Problems. Editor* Nato Institute on Decomposition, Cambridge, Eng., 1972, 1973 **Decomposition of Large-scale Problems** David Mautner Himmelblau, 1973 **Decomposition** D. Himmelblau, NATO INST ON DECOMPOSITION., 1973 **II-approximation and Decomposition of Large-scale Problems** E. A. Nurminski, International Institute for Applied Systems Analysis, 1981

Encyclopedia of Computer Science and Technology Jack Belzer, Albert G. Holzman, Allen Kent, 1977-05-01 This comprehensive reference work provides immediate fingertip access to state of the art technology in nearly 700 self contained articles written by over 900 international authorities Each article in the Encyclopedia features current developments and trends in computers software vendors and applications extensive bibliographies of leading figures in the field such as Samuel Alexander John von Neumann and Norbert Wiener and in depth analysis of future directions *Pi-approximation and Decomposition of Large-scale Problems* Evgenii Alekseevich Nurminskii, 1981 Modeling and Managing Interdependent Complex Systems of Systems Yacov Y. Haimes, 2018-10-02 A comprehensive guide to the theory methodology and development for modeling systems of systems Modeling and Managing Interdependent Complex Systems of Systems examines the complexity of and the risk to emergent interconnected and interdependent complex systems of systems in the natural and the constructed environment and in its critical infrastructures For systems modelers this book focuses on what constitutes complexity and how to understand model and manage it Previous modeling methods for complex systems of systems were aimed at developing theory and methodologies for uncoupling the interdependencies and interconnections that

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Large-Scale Optimization Vladimir Tsurkov,2014-01-15 **Cybernetics Approaches in Intelligent Systems** Radek Silhavy,Petr Silhavy,Zdenka Prokopova,2017-09-04 This book discusses new approaches and methods in the cybernetics algorithms and software engineering in the scope of the intelligent systems It brings new approaches and methods to real world problems and exploratory research that describes novel approaches in the cybernetics algorithms and software engineering in the scope of the intelligent systems This book constitutes the refereed proceedings of the Computational Methods in Systems and Software 2017 a conference that provided an international forum for the discussion of the latest high quality research results in all areas related to computational methods statistics cybernetics and software engineering

Decomposition of Large-scale Problems , The NATO Institute on Decomposition as a tool for solving large-scale problems was an interdisciplinary conference held in Cambridge , England , from July 16 - 27 1972 ,1973 **Progress in**

Experimental and Computational Mechanics in Engineering Mamtimin Geni,Masanori Kikuchi,2003-07-15 Proceedings of the International Conference on Experimental and Computational Mechanics in Engineering Dunhuang China August 24 27 2002 **Optimization via Relaxation and Decomposition** Gonzalo E. Constante-Flores,Antonio J. Conejo,2025-05-21

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