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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).

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

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

David Mautner Himmelblau



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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* D. Himmelblau,NATO INST ON DECOMPOSITION.,1973

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Bio-inspired Computing: Theories and Applications Jianyong Qiao, Xinchao Zhao, Linqiang Pan, Xingquan Zuo, Xingyi Zhang, Qingfu Zhang, Shanguo Huang, 2018-10-17 This two volume set CCIS 951 and CCIS 952 constitutes the proceedings of the 13th International Conference on Bio inspired Computing Theories and Applications BIC TA 2018 held in Beijing China in November 2018 The 88 full papers presented in both volumes were selected from 206 submissions The papers deal with studies abstracting computing ideas such as data structures operations with data ways to control operations computing models from living phenomena or biological systems such as evolution cells neural networks immune systems swarm intelligence Encyclopedia of Computer Science and Technology: Curve fitting to Early development of programming languages Jack Belzer, Albert George Holzman, Allen Kent, 1975 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

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Large-Scale Optimization Vladimir Tsurkov, 2014-01-15 *Applications of Evolutionary Computation* Kevin Sim, Paul Kaufmann, 2018-03-07 This book constitutes the refereed conference proceedings of the 21st International Conference on the Applications of Evolutionary Computation EvoApplications 2018 held in Parma Italy in April 2018 collocated with the Evo 2018 events EuroGP EvoCOP and EvoMUSART The 59 revised full papers presented were carefully reviewed and selected from 84 submissions EvoApplications 2018 combined research from 14 different domains business analytics and finance EvoBAFIN computational biology EvoBIO communication networks and other parallel and distributed systems EvoCOMNET complex systems EvoCOMPLEX energy related optimization EvoENERGY games and multi agent systems EvoGAMES image analysis signal processing and pattern recognition EvoIASP realworld industrial and commercial environments EvoINDUSTRY knowledge incorporation in evolutionary computation EvoKNOW continuous parameter optimization EvoNUM parallel architectures and distributed infrastructures EvoPAR evolutionary robotics EvoROBOT nature inspired algorithms in software engineering and testing EvoSET and stochastic and dynamic environments EvoSTOC

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