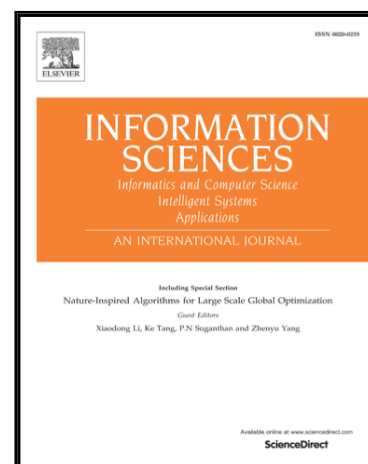


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Burhan Khan , Samer Hanoun , Michael Johnstone ,
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A Scalarization-based Dominance Evolutionary Algorithm for Many-objective Optimization

Burhan Khan, Samer Hanoun, Michael Johnstone, Chee Peng Lim, Douglas Creighton, and Saeid Nahavandi

Institute for Intelligent Systems Research and Innovation (IISRI), Deakin University, Australia

Abstract

Classical Pareto-dominance based multi-objective evolutionary algorithms underperform when applied to optimization problems with more than three objectives. A class of multi-objective evolutionary algorithms introduced in the literature, utilizing pre-determined reference points acting as target vectors to maintain diversity in the objective space, has shown promising results. Inspired by this approach, we propose a scalarization-based dominance evolutionary algorithm (SDEA) that utilizes a reference point-based method and combine it with a novel sorting strategy that employs fitness values determined via scalarization. SDEA reduces computation complexity by eliminating the need for a Pareto-dominance approach to obtain non-dominated solutions. By means of a set of common benchmark optimization problems with 3- to 15-objectives, we compare the performance of SDEA with state-of-the-art many-objective evolutionary algorithms. The results indicate that SDEA outperforms existing algorithms in undertaking complex optimization problems with a high number of objectives, and has comparable outcomes over low-dimensional objective space benchmark problems.

Keywords

Multi-objective, many-objective, optimization, genetic algorithm, evolutionary computation, decomposition, scalarization, reference vectors

1. Introduction

An optimization problem with more than three objectives is regarded as a many-objective optimization problem (MaOP) [36, 37]. Currently, MaOPs are the subject of increased interest in the evolutionary multi-objective optimization (EMO) community. The trend towards MaOPs is encouraged by many real-world requirements, such as molecular design problem with 4 objectives [29], airfoil design problem with 6 objectives [44], flight control system design problem with 8 objectives [16], automotive engine calibration problem with 10 objectives [32], air traffic control tracking filters problem with 12 objectives [19], and complex industrial scheduling problem with 20 objectives [39]. Multi-objective evolutionary algorithms (MOEAs) based on the Pareto-dominance principle have been in existence for some time, such as non-dominated sorting genetic algorithm II (NSGA-II) [13], the strength Pareto evolutionary algorithm 2 (SPEA2) [49], and Pareto envelope-based selection algorithm II (PESA-II) [8]. These approaches are typically used to address 2- and 3-objective optimization problems. Many researchers have reported a myriad of challenges when applying these algorithms to MaOPs [30, 36, 37, 42], which include ineffective convergence due to inefficient selection pressure, diversity preservation in a huge objective space, computationally expensive calculation of performance metrics, and visualization of the high-dimensional objective space.

Considering these challenges, researchers in the EMO community are actively formulating improved optimization techniques. The experimental results using Pareto-dominance based MOEAs for undertaking MaOPs show the phenomenon of a poor selection pressure [30, 42]. Due to the high-dimensional size of the MaOPs, the majority of the obtained solutions tend to be non-dominated when the solutions are ranked in accordance with the non-domination levels in the objective space. To overcome the selection pressure problem, researchers have proposed several methods to scale the Pareto-dominance technique to handle MaOPs, which include modified optimality techniques, new ranking methods, and other preference relation operators. Several modified forms of Pareto-dominance methods reduce the optimality conditions so as to tailor the optimality relation to MaOPs,

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