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# Differential Search Algorithm for Multiobjective Problems

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**Abstract**

In this paper, a novel Differential Search Algorithm (DSA) approach is proposed to solve multiobjective optimization problems, called Multiobjective Differential Search Algorithm (MODSA). MODSA utilizes the concept of Pareto dominance to determine the direction of a super-organism and it maintains non-dominated solutions in the external repository. This approach also uses the external repository of super-organisms that is used to guide other super-organisms. It guides the artificial organisms to search towards non-crowding and external regions of Pareto front. The performance of proposed approach is evaluated against the other well-known multiobjective optimization algorithms over a set of multiobjective benchmark test functions. Experimental results reveal that the MODSA outperforms the other competitive algorithms for benchmark test functions.



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## 1. Introduction

Multi-objective optimization is the process of simultaneously optimizing two or more conflicting objectives. Real-life problems contain more than one conflicting objective function. Hence it requires multi-objective optimization approach. The optimal solution is clearly defined in a single objective function optimization. However, multiobjective optimization problems do not restrict to obtain a single objective function [5]. The multiobjective optimization problems (MOPs) contain a set of solutions called non-dominated solutions. Each solution in the non-dominated set is called as a Pareto-Optimal. The Pareto Optimal solutions are mapped in the objective space that are known as Pareto front [6]. The main objective of multiobjective optimization is to obtain the Pareto front of a given a MOP. Generally, the multiobjective optimization problems are computational intensive as the search space for MOPs is very large. The use of metaheuristic algorithms for multiobjective optimization has significantly grown in the last few years [8]. Some of these metaheuristic algorithms are Simulated Annealing (SA), Genetic Algorithm (GA), Tabu Search (TA), Ant Colony Optimization (ACO), Differential Evolution (DE), Particle Swarm Optimization (PSO), and so on. However, any single metaheuristic may not be the best fit for all problems; rather it may be problem specific. Although many metaheuristic algorithms for solving multiobjective problems have been proposed as reported in literature, the results are unsatisfactory. Hence, an improvement to metaheuristic algorithms for solving multiobjective problems is still required.

Recently, Pinar Civicioglu [2] developed a new metaheuristic search algorithm called Differential Search Algorithm (DSA) for uni-objective optimization. DSA simulates a superorganism migrating between the two stopovers sites. DSA has unique mutation and crossover operators. DSA has only two control parameters that are used for controlling the movement of superorgnisms. DSA has been applied for a variety of applications. Till now, it had not been extended to solve multiple objectives. DSA appears more suitable for multiobjective problems as high speed of convergence and less overhead of parameters setting. In this paper, a novel approach named multiobjective differential search algorithm (MODSA), which allows the DSA to deal with multiobjective optimization problems. MODSA is based on non-dominated sorting strategy. The concept of Pareto dominance is incorporated in MODSA to determine which solution is better. The constraint handling mechanism is added in the MODSA to increase the ability of exploration of DSA. MODSA has been compared with other recently proposed multiobjective metaheuristic algorithms and validated on benchmark test functions.

The reminder of the paper is organized as follows. Section 2 gives a brief description of the previous relevant work. Section 3 gives the basic concept of DSA. The proposed MODSA is presented in Section 4, followed by results and discussion are shown in Section 5. The statistical analysis of the multiobjective optimization algorithms is performed in Section 6. Finally, the conclusions are drawn in Section 7.

## 2. Differential Search Algorithm

Differential Search Algorithm (DSA) is a novel metaheuristic algorithm proposed by Civicioglu [2]. It mimics the *Brownian-like random-walk movement.* The main motivation of DSA is the migration behaviour of living beings, which move away from a habitat having low capacity of food resources. The migration process entails movement of large number of individuals comprising a superorganism. A superoragnism moves towards habitat having more food capacity. Once it finds new fruitful habitat named as stopover site, it settles in the new habitat for the time being and continues its migration towards more fruitful habitats. DSA starts by generating individuals of respective optimization problem corresponding to an artificial-superorganism. Hereafter artificial-superorganism tries to migrate from its current position to the global minimum value.

In DSA each individual of a superorganism is represented as $X_i$, $i = 1, 2, ...., N$ and as many members as the dimension of the problem i.e., $x_{ij}$, $j = 1, 2, ...., D$. Here $N$ and $D$ represent the number of individuals and the size of problem respectively. The DSA consists of the following steps [2, 8]:

**Step 1. Initialize the artificial-organism:** Each member of a individual (or artificial-organism) is initialized to a random position. This is achieved as follows:

$$x_{ij} = rand \times \left( up_j - low_j \right) + low_j \tag{1}$$