A Novel DE-PSO-DE (DPD) Algorithm for Economic Load Dispatch Problem

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ABSTRACT

This paper presents a hybrid algorithm of two popular heuristics namely Differential Evolution (DE) and Particle Swarm Optimization (PSO) on a tri-population environment. Initially, the whole population (in increasing order of fitness) is divided into three groups – Inferior Group, Mid Group and Superior Group. DE is employed in the inferior and superior groups, whereas PSO is used in the mid-group. It is based on the information sharing mechanism of their inherent property to overcome the shortcomings of each other. The proposed method is called DPD as it uses DE-PSO-DE on a population. Two strategies namely Elitism (to retain the best obtained values so far) and Non-redundant search (to improve the solution quality) have been employed in DPD cycle. Out of a total of 64 DPDs, Top 4 DPDs are investigated through CEC2006 constrained benchmark functions. Based on the ‘performance’ analysis, best DPD is reported and further used in solving 5 engineering design problems along with economic load dispatch problem in order to confirm further the efficiency of the proposed DPD.

Keywords: Benchmark Functions, Constraint Handling Technique, Differential Evolution, Economic Load Dispatch Problem, Elitism, Non-Redundant Search, Particle Swarm Optimization

1. INTRODUCTION

Evolutionary algorithms (EAs) solved a wide range of optimization problems in the electric power systems. Among them, Economic Load Dispatch (ELD) is one of the difficult constrained optimization problems. Consideration of transmission losses, ramp rate limits, prohibited operating zones and valve point effects makes ELD a non-convex optimization problem and hence becomes challenging to solve. The main objective of ELD problem is to reduce the total generation cost, subject to the load demand with other equality and inequality constraints. Modern evolutionary optimization techniques appear to be more efficient in solving ELD problem because of their ability to seek the global optimal solution.

Unfortunately, according to ‘No Free Lunch Theorem (Wolpert and Macready, 1997)’, no single optimization method exist which is able to solve all global optimization problems, consistently. Therefore number of attempts to solve optimization problems, while hybrid
algorithms have shown outstanding reliability and efficiency to solve these problems. Recently, Differential Evolution (DE) (Storn and Price, 1997) and Particle Swarm Optimization (PSO) (Kennedy and Eberhart, 1995) are two well-known optimization techniques have been implemented to solve convex and non-convex ELD problems. Although these optimization techniques do not always guarantee discovering the globally optimal solution in a finite time, they often provide a fast and reasonable solution (sub-optimal, nearly global optimal). But these methods have drawbacks such as premature convergence and after some generations the population diversity would be greatly reduced.

The united effort with their hybridization makes a difference in the solution quality. Due to the information sharing mechanism, it mostly helps to improve the efficiency of the algorithm. A number of such hybrid methods of DE and PSO used in the literature to solve ELD problem (Liu et al. 2010; Niknam et al. 2011; Epitropakis et al., 2012, Sayah and Hamouda, 2013; Zuo and Xiao, 2014). In such hybridizations, DE and PSO are used in the alternative generations during simulation.

However, there has been a continuous modification in the operators and/or the way of applying them. In recent years, parallel employment of DE and PSO is preferred over the sequential one. Here parallel in the sense, DE and PSO are used simultaneously on different part of the same population. Kordestani et al. (2014) proposed a bi-population based hybrid approach (CDEPSO) for dynamic optimization problems. In this paper, the first population uses CDE (Crowding-based Differential Evolution) and the second population uses PSO. The first population is responsible for locating multiple promising areas of the search space and preserving a certain level of diversity throughout the run. The second population is exploiting to useful information in the vicinity of the best position found by the first population. Yadav and Deep (2013) proposed a new co-swarm PSO (called CSHPSO) for constrained optimization problems. It is formed by hybridizing the shrinking hyper-sphere PSO (SHPSO) with the DE approach. Initially, the total swarm is subdivided into two sub-swarms. The first sub-swarm uses SHPSO and second sub-swarm uses DE. CSHPSO is tested on benchmark problems and applied on power system optimization problem with valve point effects. Cagnina et al. (2007, 2011) proposed a dual population based technique which is able to overcome premature convergence. In order to maintain a good balance between local and global search ability, Han et al. (2013) proposed a dynamic group-based differential evolution using a self-adaptive strategy using 1/5th rule. It is based on partitioning the population into two parts in order to apply two different mutation strategies of DE. Authors claimed that it has both exploitation and exploration abilities. Wang et al. (2010) proposed a hybrid technique with a tri-break-up population based mechanism. It maintains three subpopulations to use classical PSO and two DE variants, respectively. The three subpopulations share the global best solution during simulation.

All in all, DE and PSO have achieved their gigantic popularity in the world of optimization for real-time and real-size applications. Inspired by the earlier literature, encouraged by the basic working principle of DE/PSO and motivated by the tri-break-up concept reported in recent literature, an attempt is made in this paper to improve the solution quality further. As a result a novel algorithm called DE-PSO-DE is proposed to work in a tri-population environment.

The rest of the paper is organized as follows. Section 2 presents the general formulation of the ELD problem. Section 3 briefs the basics of DE and PSO. Section 4 presents constraint handling technique used in this present study. The propose algorithm is described along with the selection of best suit mutation operators for DEs employed in the proposed algorithm, in Section 5. Section 6 includes the numerical results and discussions. Finally, the conclusion with some future scopes is drawn in Section 7.
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