Hybrid Mean-Variance Mapping Optimization for Non-Convex Economic Dispatch Problems

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ABSTRACT

The economic dispatch (ED) is one of the important optimization problems in power system generation for fuel cost saving. This paper proposes a hybrid variant of mean-variance mapping optimization (MVMO-SH) for solving such problem considering the non-convex objective functions. The new proposed method is a hybrid variant of the original mean-variance mapping optimization algorithm (MVMO) with the embedded local search and multi-parent crossover to enhance its global search ability and improve solution quality for optimization problems. The proposed MVMO-SH is tested on different non-convex ED problem including valve point effects, multiple fuels and prohibited operating zones characteristics. The result comparisons from the proposed method with other methods in the literature have indicated that the proposed method is more robust and provides better solution quality than the others. Therefore, the proposed MVMO-SH is a promising method for solving the complex ED problems in power systems.

KEYWORDS
Economic Dispatch, Mean-Variances Mapping Optimization, Multiple Fuels, Prohibited Operating Zone, Valve-Point Effects

INTRODUCTION

The thermal generating units of an electric power system utilize coal, oil and natural gas to produce energy supply to required system load demand. The fossil fuel is facing depletion and conservation is used as a way to increase energy efficiency. Hence, the generation of the power plants needs to be optimized at lowest possible fuel cost via economic dispatch (ED). The objective of ED is to determine the optimal power output of generation facilities results in minimum fuel generation cost while satisfying all units, as well as system constraints (Dieu, Schegner, & Ongsakul, 2013).

Traditionally, the single quadratic function is used to represent the fuel objective function of the ED for mathematical convenience (Wollenberg & Wood, 1996). However, it is not exactly
representing the practical problems of the ED problems which including valve point loadings (VPE), multiple fuels (MF) or prohibited operating zones (POZ), which make the input-output characteristics of generators become discontinuous, non-differentiable and nonlinear. For this reason, the practical ED should be considered as a complex optimization problems with the non-convexity in objective function which is difficult to find global solution (Dieu, Schegner et al., 2013). Many heuristic search approaches based on artificial intelligence concepts have been proposed in the literature for solving the non-convex ED problems such as genetic algorithm (GA) (Chiang, 2005), evolutionary programming (EP) (Sinha, Chakrabarti, & Chattopadhyay, 2003), artificial bee colony (ABC) (Hemamalini & Simon, 2010), ant colony optimization (ACO) (Pothiya, Ngamroo, & Kongprawechnon, 2010), hopfield neural network (HNN) (Vasant, Ganesan, Elamvazuthi, et al., 2012) (Dieu, Ongsakul, & Polprasert, 2013), evolutionary strategy optimization (ESO) (Pereira-Neto, Unsihuay, & Saavedra, 2005), differential evolution (DE) (Noman & Iba, 2008) and particle swarm optimization (PSO) (Dieu, Schegner, et al., 2013; Gaing, 2003; Vasant, Ganesan, & Elamvazuthi, 2012), teaching learning based optimization (TLBO) (Banerjee, Maity, & Chanda, 2015), cuckoo search algorithm (CSA) (Nguyen & Vo, 2015), and backtracking search algorithm (BSA) (Modiri-Delshad, Aghay Kaboli, Taslimi-Renani, & Rahim, 2016). Among these heuristic methods, PSO is the most popular method applied for solving the ED problems, especially for non-convex problems. Several improvements of PSO method are proposed for solving the non-convex ED problems such as modified PSO (MPSO) (Park, Lee, Shin, & Lee, 2005), self-organizing hierarchical PSO (SOH_PSO) (Chaturvedi, Pandit, & Srivastava, 2008), anti-predatory PSO (APSO) (Selvakumar & Thanushkodi, 2008), simulated annealing like PSO (SA-PSO) (Kuo, 2008), a newly improved PSO (NIPSO) (Dieu, Schegner, & Ongsakul, 2011), PSO with recombination and dynamic linkage discovery (PSO-RDL) (Chen, Peng & Jian, 2007), new PSO with local random search (NPSO-LRS) (Selvakumar & Thanushkodi, 2007), improved coordinated aggregation based PSO (ICA-PSO) (Vlachogiannis & Lee, 2009), quantum-inspired PSO (QPSO) (Meng, Wang, Dong, & Wong, 2010), and species-based quantum PSO (SQPSO) (Hosseinnezhad, Rafiee, Ahmadian, & Ameli, 2014). Although, the improvement of PSO methods can provide good solutions for the problem, the PSO method is continuously improved for dealing with large-scale and complex problems in power systems. The heuristic search methods can deal with complex optimization problems; however, their search ability often provides near global optimal solution. The non-convex ED problems have been also solved by many hybrid optimization methods such as hybrid evolutionary programming with sequential quadratic programming (EP-SQP) (Attaviriyanupap, Kita, Tanaka, & Hasegawa, 2002), integration PSO with sequential quadratic programming (PSO-SQP) (Victoire & Jeyakumar, 2004), hybrid technique integrating the uniform design with the genetic algorithm (UHGA) (He, Wang, & Mao, 2008), self-tuning hybrid differential evolution (self-tuning HDE) (Wang, Chiu, & Liu, 2007), combining of chaotic differential evolution and quadratic programming (DEC-SQP) (dos Santos Coelho & Mariani, 2006), hybrid genetic algorithm, pattern search and sequential quadratic programming (GA-PS-SQP) (Alsumait, Sykulski, & Al-Othman, 2010), hybrid differential evolution with biogeography-based optimization (DE-BBO) (Bhattacharya & Chattopadhyay, 2010), particle swarm optimization algorithm with modified stochastic acceleration factors (PSO-MSAF) (Subbaraj, Rengaraj, Salivahanan, & Senthilkumar, 2010). These hybrid methods become powerful search methods for obtaining higher solution quality due to utilizing the strong feature of each single method to improve their search capability. However, the hybrid methods may be slower and more complicated than the single methods because of combination of several operations. The non-convex optimization problem is still a challenge
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