Economic Load Dispatch Using Oppositional Backtracking Search Algorithm

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ABSTRACT

In this paper, an oppositional backtracking search algorithm (OBSA) is proposed to solve the large scale economic load dispatch (ELD) problem. The main drawback of the conventional backtracking search algorithm (BSA) is that it produces a local optimal solution rather than the global optimal solution. The proposed OBSA methodology is a highly-constrained optimization problem has to minimize the total generation cost by satisfying several constraints involving load demand, generation limits, prohibited operating zone, ramp rate limits and valve point loading effect. The proposed method is applied for three test systems and provides the unique and fast solutions. The new heuristic OBSA approach is successfully applied in three test systems consisting of 13 and 140 thermal generators. The test results are judged against various methods. The simulation results show the effectiveness and accuracy of the proposed OBSA algorithm over other methods like conventional BSA, oppositional invasive weed optimization (OIWO), Shuffled differential evolution (SDE) and oppositional real coded chemical reaction optimization (ORCCRO). This clearly suggests that the new OBSA method can achieve effective and feasible solutions of nonlinear ELD problems.

KEYWORDS
Economic load dispatch, Evolutionary algorithms, backtracking search optimization algorithm, Oppositional based learning, oppositional backtracking search algorithm, prohibited zone

INTRODUCTION

The economic load dispatch (ELD) problem is one of the mathematical optimization issues in operation of the modern power system to schedule the committed generating unit outputs so as to meet the essential load demand while satisfying all equality and inequality constraints of the system at minimum operating cost (Cai, Ma, Li, Peng, 2007; Baskar & Mohan, 2008; Coelho & Lee, 2008). To get a better solution, attract many researchers’ attention because of good solutions from the ELD problem would result in great economic benefits. Several optimization methods have been applied to solve the ELD problems in the past decades. The most popular predictable approach to solve ELD problem is lambda-iteration method (Wood & Wollenberg, 1996; Chen & Wang, 1993)
where continuous and monotonically increasing cost function is needed. Some other conventional approaches have been used to solve the ELD problems such as gradient method (Dodu, Martin, Merlin, & Pouget, 1972), Lagrangian relaxation algorithm (El-Keib, Ma, & Hart, 1994), quadratic programming (Dos, Coelho, & Mariani, 2006), linear programming algorithm (Jabr, Coonick, & Cory, 2000), and etc. Also, many artificial intelligence technologies have been successfully used to solve the ELD problem more efficiently. The heuristic methods are genetic algorithm (Nanda & Badri, 2002; Lee, Lin, Liao, & Tsao, 2011), evolutionary programming (EP) (Yang, Yang, & Huang, 1996; Sinha, Chakrabarti, & Chattopadhyay, 2013), particle swarm optimization (Park, Lee, Shin, Lee, 2005), chaotic particle swarm optimization (Cai, Ma, Li, & Peng, 2007; Cai, Ma, Li, Peng, 2009), hybrid DE (Wang, Chiou, & Liu, 2007), ant colony optimization (ACO) (Yu, & Song, 2001), and chaotic ant swarm optimization (Cai, Ma, Li, Li, & Peng, 2010) have been proposed to solve different types of ELD problems. The gravitational search algorithm (GSA) (Roy, Paul, & Sultana, 2014; Roy, Mandal, & Bhattacharya, 2012; Bhattacharya & Roy, 2012), a new heuristic algorithm inspired by the Newtonian laws of gravity and motion, describing how a natural process can be modeled to solve general optimization problems and has been applied to optimization ELD problems in (Roy, Ghoshal, & Thakur, 2010; Roy & Mandal, 2011) and krill herd algorithm (KHA) (Mandal, Roy, & Mandal, 2014) have been presented to solve ELD. The objective function of the most popular existing approaches should be continuous and differentiable but, the cost function considering valve-point effects are not differentiable. Some heuristic methodologies suffer from premature convergence, especially for ELD problem with multiple local optimums. Due to mentioned drawbacks, solutions of ELD lead to a non-optimal solution with a great economic loss.

RELATED WORKS, MOTIVATION, AND BACKGROUND

The classical calculus-based methods cannot perform satisfactorily for the ELD problems having a large number of constraints and valve point nonlinearities. They often trap to a local optimum solution. Hence, to overcome these drawbacks robust, improved and reliable techniques are required. Various population-based optimization techniques mentioned in the earlier section are adopted by the researcher for last two decades. These techniques have successfully been applied in recent years to solve non-convex, non-smooth and non-differentiable ELD problems. However, due to excessive numerical iterations of these methods, more reliable and fast methods are needed.

Very recently, hybrid chemical reaction optimization algorithm (HCRO) which hybridizes DE with chemical reaction optimization (CRO) was proposed (Dutta, Roy, & Nandi, 2015). The seeker optimization algorithm (SOA) was introduced by Shaw et al. (2011) where opposite numbers were utilized to improve the convergence rate of teaching learning based optimization (TLBO). Civilized swarm optimization (CSO) (Immanuel & Thanushkodi, 2009) was successfully implemented by Immanuel et al. to solve ELD problems. Tang et al. (2008) proposed bacterial foraging algorithm (BFA) to explore the entire search space for finding optimal solution of ELD problem. To solve non-smooth and non-convex environmental constrained ELD problem, Sivasubramani et al. (2011) presented harmony search algorithm (HSA). Chatterjee et al. (2012) in their recent endeavor proposed opposition-based HSA (OHSA), which employed opposition based learning for HSA initialization and generation jumping in order to solve combined economic emission dispatch problem. Many other soft computing techniques (Vasant, 2014; Vasant, 2015) such as artificial bee colony optimization (ABC) (Dutta, Roy, & Nandi, 2014), fuzzy logic controller (Arya, Mathur & Gupta, 2012), active soft switching technique (AST), (Aiswariya & Dhanasekaran, 2014), hybrid biogeography based optimization (HBBO) (Roy & Mandal, 2013) are successfully applied to solve various non-linear optimization problems.

However, some of these heuristic methods face premature convergence on different set of problems. Few of the aforesaid techniques have excellent global search capabilities but, have some
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