Chapter 11
A Novel Evolutionary Optimization Technique for Solving Optimal Reactive Power Dispatch Problems

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ABSTRACT

Biogeography based optimization (BBO) is an efficient and powerful stochastic search technique for solving optimization problems over continuous space. Due to excellent exploration and exploitation property, BBO has become a popular optimization technique to solve the complex multi-modal optimization problem. However, in some cases, the basic BBO algorithm shows slow convergence rate and may stick to local optimal solution. To overcome this, quasi-oppositional biogeography based-optimization (QOBBO) for optimal reactive power dispatch (ORPD) is presented in this study. In the proposed QOBBO algorithm, oppositional based learning (OBL) concept is integrated with BBO algorithm to improve the search space of the algorithm. For validation purpose, the results obtained by the proposed QOBBO approach are compared with those obtained by BBO and other algorithms available in the literature. The simulation results show that the proposed QOBBO approach outperforms the other listed algorithms.

1 INTRODUCTION

The optimal reactive power dispatch (ORPD) is a very important aspect in power system planning and operation. It is used to determine a secure operating state of power systems.

It is an effective method to minimize the transmission losses and maintain the power system running under normal conditions. In ORPD, the optimal adjustments of voltage control devices or VAR sources such as voltage of generators, tap ratio of transformers, Var injection of shunt compensators are made for optimizing real power losses, while satisfying all the system operational constraints. It is an effective method to improve voltage level, decrease power losses and maintain the power system running under normal conditions.

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In earlier stages, a variety of classical optimization algorithms such as Gradient method (GM) (Lee, Park, & Ortiz, 1984), Newton’s based approach (Bjelogrlic, Calovic, Babic, & Ristanovic, 1990), Newton Raphson approach (Rang-Mow, & Nanning, 1995), linear programming (LP) (Aoki, Fan & Nishikor, 1988), decomposition techniques (Deb, & Shahidehpour, 1990; Granada, Marcos, Rider, Mantovani, & Shahidehpour, 2012), interior point methods (Chebbo, & Irving, 1995; Granville, 1994; Yan, Yu, Yu, & Bhattrai, 2006), quadratic Programming (Momeh, Guo, Oghuobiri, & Adapa, 1994) and dynamic programming (DP) (Lu, & Hsu, 1995) were attempted to solve ORPD problems.

Though most of these conventional methods have excellent convergence characteristics but they face difficulties in handling the nonlinear constraints and solution process slows with complex objective functions. Moreover, these classical techniques are local optimizers in nature, i.e., they might converge to local solutions instead of global ones if the initial guess happens to be in the neighborhood of a local solution. DP method may cause the dimensions of the problem to become extremely large, thus requiring enormous computational efforts.

In last two decades, various heuristic evolutionary optimization algorithms such as evolutionary programming (EP) (Ma & Lai, 1996; Wu & Ma, 1995), genetic algorithm (GA) (Iba, 1994; Lee & Park, 1995; Swarup, Yoshimi & Izui, 1994), particle swarm optimization (PSO) (Kawata, Fukuyama, Takayama & Nakanish, 2000; Li, Cao, Liu, Liu & Jiang, 2009; Zhao, Guo and Cao, 2005), Tabu search (TS) (Yiqin, 2010), differential evolution (DE) (Liang, Chung, Wong & Dual, 2007; Ramesh, Kannan, & Baskar, 2012; Varadarajan & Swarup, 2008; Zhang, Wenyin, & Zhihua, 2013; Chen, Dai & Cai 2010), seeker optimization approach (SOA) (Dai, Chen, Zhu & Zhang 2009a; Dai, Chen, Zhu & Zhang 2009b), EP-SED (Titare, Singh, Arya, & Choube, 2014), ant colony optimization (ACO) (Huang, & Huang, 2012), hybrid evolutionary algorithm (Ghasemi, Ghavidel, Ghanbarian, & Habibi, 2014), BBO (Bhattacharya & Chattopadhyay, 2010), quasi-oppositional teaching learning based optimization (QOTLBO) (Mandal, & Roy, 2013), shuffled frog leaping algorithm (SFLA) (Khorsandi, Alimardani, Vahidi, & Hosseinian, 2010), harmony search algorithm (HSA) (Khazali, & Kalantar, 2011), opposition based HSA (OHSA) (Chatterjee, Ghosal, & Mukherjee, 2012) have been proposed because they found to be robust and flexible in solving optimization problem. These methods (Vasant, Barsoum, & Webb, 2012; Vasant, 2013; Vasant, 2014; Vasant, 2015) are widely applied in many scientific and engineering fields. These methods do not depend on convexity assumptions and are capable of handling non-linear optimization problems. Each of these methods has its own characteristics, strengths and weaknesses; but long computational time is a common drawback for most of them, especially when the solution space is hard to explore. Many efforts have been made to accelerate convergence of these methods.

In 2008, a new optimization technique, known as Biogeography-based Optimization (BBO) was developed by Simon (Simon, 2008). It is based on the concept of biogeography of species. BBO has already proven itself a worthy optimization technique. In BBO poor solutions accept a lot of new features from good ones using migration operation which may improve the quality of those solutions. The unique features of BBO over other evolutionary methods are (i) in most of the evolutionary algorithms solution changes rapidly as the optimization process progresses. Previous solutions of most of the evolutionary based algorithms “die” at the end of each generation. Therefore, many solutions whose fitness are initially good, sometimes lose their quality in later stage of the process. However, in BBO; solutions get fine tuned gradually as the process goes on through migration operation. (ii) In most of the heuristic optimization technique, solutions are more likely to clump together in similar groups, while in BBO, solutions do not have any tendency to cluster due to its unique mutation operation. This is an added advantage of BBO in comparison to other algorithms. (iii) BBO requires few computational steps per
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