Hybridization of Biogeography-Based Optimization with Differential Evolution for Solving Optimal Power Flow Problems

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ABSTRACT

The aim of this paper is to evaluate a hybrid biogeography-based optimization approach based on the hybridization of biogeography-based optimization with differential evolution to solve the optimal power flow problem. The proposed method combines the exploration of differential evolution with the exploitation of biogeography-based optimization effectively to generate the promising candidate solutions. Simulation experiments are carried on standard 26-bus and IEEE 30-bus systems to illustrate the efficacy of the proposed approach. Results demonstrated that the proposed approach converged to promising solutions in terms of quality and convergence rate when compared with the original biogeography-based optimization and other population-based optimization techniques like simple genetic algorithm, mixed integer genetic algorithm, particle swarm optimization and craziness-based particle swarm optimization.

Keywords: Biogeography-Based Optimization, Differential Evolution, Optimal Power Flow, Power System Optimization, Valve Point Effect

1. INTRODUCTION

The optimal power flow (OPF) proposed by “Carpentier (1979)”, is an optimization tool through which the electric utilities strive to determine secure operating conditions for a power system. The OPF solution aims to optimize a selected objective function via optimal adjustment of the power system control variables, while satisfying various equality and inequality constraints. OPF problem has been rigorously studied over the past few decades. Many optimization techniques have emerged so far and have been applied to solve the problem. In the past, a wide variety of conventional optimization techniques such as Newton method “Monticelli and Liu (1992)”, linear programming “Stott, Marinho and Alsac (1979)”, dynamic programming “Xie and Song (2001)”, and interior point methods “Wei, Sasaki, Kubokawa and...”
Yokoyama (1998) have been developed to solve OPF problem. Generally, these techniques suffer due to algorithmic complexity, insecure convergence, and sensitiveness to initial search point, etc. Usually, these methods rely on the assumption that the fuel cost characteristic of a generating unit is a smooth, convex function. However, in practical system, it is not possible, or appropriate, to represent the unit’s fuel cost characteristics as convex function. This situation arises when valve-points non-linearities effect of thermal generating units and prohibited operating zones constraints are considered. Therefore, new optimization methods are required to deal with these difficulties.


DE proposed by R. Storn and K. Price “Storn and Price (1995)” is one of the latest evolutionary optimization algorithms. It is a simple but powerful population-based stochastic search technique for solving global optimization problems. Its effectiveness and efficiency have been successfully demonstrated in many application fields. Like other evolutionary algorithms, two fundamental processes drive the evolution of a DE population: exploration of different regions of the search space, and the selection process, which ensures the exploitation of previous knowledge about the fitness landscape. Practical experience, however, shows that DE may occasionally stop proceeding toward the global optimum level and may converge to a local optimum or any other point. This situation is usually referred to as premature convergence, where the population converges to some local optima of a multimodal objective function, losing its diversity. This is due to the lack of exploitation ability of the original DE algorithm.

BBO “Simon (2008)”, is a new global optimization algorithm based on the theory of biogeography, which is the study of the geographical distribution of biological organisms. The feature of BBO is like other biology-based algorithms, such as GA and PSO. However, BBO also has some unique features among biology-based algorithms. One unique characteristic of BBO is that the original population is not discarded after each generation. It is rather modified by probabilistic migration (immigration and emigration) operation. This new technique has already proven itself a worthy optimization technique “Roy, Ghoshal and Thakur (2010a); Roy, Ghoshal and Thakur (2010b); Simon (2008)” compared to other existing techniques. However, since BBO is a new global optimization algorithm, there are some open research questions that need to be addressed, such as the migration operator of BBO lacks the exploration ability and cannot improve the diversity of the population.

In order to utilize the exploration ability of DE and the exploitation capability and BBO, a hybrid technique combining BBO with DE, referred to as hybrid biogeography based optimization with differential evolution (HDBBO), is being proposed for solving OPF problems. Similar concept is introduced by Gong et al. “Gong, Cai and Ling (2010)” and later, it is applied to solve economic load dispatch (ELD) problem “Bhattacharya and Chattopadhyay (2010)”. But this combined application of the BBO and DE concept for solving the OPF problem, has not been applied so far. The
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