Solution of Non-Smooth Economic Dispatch Using Interactive Grouped Adaptive Bat Algorithm: Solving Practical Economic Dispatch

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ABSTRACT
This article presents the application of new grouped adaptive Bat algorithm (GABA) based metaheuristic method to improve the solution of economic dispatch (ED) problem considering valve point effect, prohibited zones, ramp rate limits and total power loss. The Bat algorithm is a new swarm intelligence algorithm inspired by the echolocation phenomenon in bats. The Bat algorithm is easy to program, and like many metaheuristic methods has an exploration and exploitation phases which require fine adjustment to achieve the near global solution. A grouped search mechanism is introduced to enhance the performances of the original Bat algorithm. The robustness of the proposed algorithm in term of solution quality and convergence characteristic have been demonstrated of three test systems of various complexities 6 units considering simultaneously the prohibited zones, ramp rate limits and total power loss, 13 and 40 units considering valve point effect. Results show clearly the efficiency and superiority of the proposed algorithm compared with various techniques reported in the recent literature.

KEYWORDS
Adaptive Bat Algorithm, Economic Dispatch, Power Loss, Prohibited Zones, Ramp Rate Limits, Valve Point Effect

1. INTRODUCTION
In today’s power system utilities, energy management of large practical power system is of a great challenge. Economic dispatch (ED) is one of the most sub problems of energy management, which consists in adjusting dynamically and optimally all thermal generating units located at different zones to minimize the total cost while satisfying several practical constraints in power system operations. The original idea for solving the ED problem is firstly introduced by (Carpentier, 1962), and more than fifty years, this problem has been treated and analyzed using various optimization techniques. The determinist methods such as the lambda iteration method, gradient method, Newton’s method, linear programming, interior point method, and dynamic programming have been applied intensively to solve the simplified form of ED based on quadratic form of the objective function and reduced
constraints (Farag, 1995; Irisarri, 1998; Liang, 1992; Frank, 2012). To relieve the drawbacks of mathematical methods such as their sensibility to the form of the objective function, the derivability and initial condition, many modern metaheuristic methods have been developed and applied to improve the solution of the practical ED by considering the valve point effect, the prohibited zones, the multi fuel and the total power loss. A new updated review on optimization strategies for solving combined economic emission dispatch problem is proposed by (Fahad et al., 2017). Among many successful metaheuristic methods applied to solve the ED problem, the particle swarm optimization (PSO) (Gaining, 2003), improved tabu search algorithm (Lin et al., 2002), improved differential evolution approach based on cultural algorithm (Coelho et al., 2009), Differential evolution based decomposed strategy (Mahdad & Srairi, 2011), pattern search algorithm (Al-Sumaite et al., 2008), Ant lion optimizer (Vikram et al., 2015), Symbiotic organisms search algorithm (Duman, 2016), and Quantum-inspired particle swarm optimization (Meng et al., 2010).

It is well known and clearly confirmed in many research area that there is no a generalized optimization method which is capable to solve with accuracy various complex optimization problems and it is also demonstrated that each method has its main advantages and drawbacks. In order to improve the solution quality of practical problems related to power system planning and control, a large number of new algorithms, new variants based original metaheuristic methods and hybrid methods have been proposed. Among the new variants methods, a chaotic mechanism search is introduced and coordinated with the standard Bat algorithm (Adarsh et al., 2016) to improve the performances of the original algorithm-based Bat algorithm, the efficiency of the proposed variant validated on many standard test systems, results found are competitive compared to many techniques reported in the literature. In (Jun et al., 2014) a variant named a random drift particle swarm optimization is developed and applied to solve the ED considering generators constraints. In (Elsayed et al., 2017) an improved random drift particle swarm optimization with self-adaptive mechanism is adapted and applied to solve the non-smooth ED problem, the obtained solutions quality seem to be competitive to other techniques, however, the process search investigate a large number of iteration to achieve the best solution, this limits the application of the proposed variant in solving complex security power system planning with large number of control variables. In order to improve the global searching capability and prevent stagnation to local minima (Neto et al., 2017) proposed a hybrid method based on combination of continuous GRASP algorithm and differential evolution for solving the non-smooth ED. In (Jayabarathi et al., 2016) a new algorithm named grey wolf optimizer is investigated and improved by adding a mutation and crossover operators for solving the ED considering prohibited zones, valve point effect and ramp rate limits. In (Kavousi-Fard & Abbas, 2016) a new hybrid algorithm named θ-modified Bat algorithm is suggested to solve the ED considering practical generator constraints. In (Reddy, 2017) a clustered adaptive teaching–learning-based optimization (CATLBO) technique is proposed and applied to solve the optimal power flow (OPF) considering various objective functions.

Recently, many successful attempts have been proposed to improve the solutions of various power systems planning in terms of solution quality and execution time. In (Mahdad & Srairi, 2017) proposed a new interactive sine cosine algorithm is adapted and applied to solve the security OPF under load growth. In order to speed up the search process (Marmolejo et al., 2017), an adaptive random search for solving the short term generation scheduling considering network constraints. The main particularity of the proposed method is that the noise level of the random search is adaptively controlled in order to create smooth equilibrium between diversification and intensification during search process. The obtained results show that significant improvements have been achieved in terms of solution quality and execution time compared to many commercial solvers. In (González et al., 2015) an efficient decomposition method is applied to solve multi area state estimation; the basic core of the proposed method is based on Lagrangian relaxation method, in (Ghorbani et al., 2017) a novel algorithm based
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