Chapter 13
Hybrid Bare Bones Fireworks Algorithm for Load Flow Analysis of Islanded Microgrids

Saad Mohammad Abdullah
Islamic University of Technology (IUT), Bangladesh

Ashik Ahmed
Islamic University of Technology (IUT), Bangladesh

ABSTRACT

In this chapter, a hybrid bare bones fireworks algorithm (HBBFWA) is proposed and its application in solving the load flow problem of islanded microgrid is demonstrated. The hybridization is carried out by updating the positions of generated sparks with the help of grasshopper optimization algorithm (GOA) mimicking the swarming behavior of grasshoppers. The purpose of incorporating GOA with bare bones fireworks algorithm (BBFWA) is to enhance the global searching capability of conventional BBFWA for complex optimization problems. The proposed HBBFWA is applied to perform the load flow analysis of a modified IEEE 37-Bus system. The performance of the proposed HBBFWA is compared against the performance of BBFWA in terms of computational time, convergence speed, and number of iterations required for convergence of the load flow problem. Moreover, standard statistical analysis test such as the independent sample t-test is conducted to identify statistically significant differences between the two algorithms.

INTRODUCTION

Metaheuristic optimization algorithms have gained much popularity over the years in solving complex optimization problems. These algorithms work in stochastic manner which implies that there is inherent randomness in the optimization process of these algorithms. Evolutionary and swarm intelligence-based algorithms such as genetic algorithm (GA) (Holland, 1992), simulated annealing (SA) (Kirkpatrick, Gelatt, & Vecchi, 1983), particle swarm optimization (PSO) (Eberhart & Kennedy, 1995), ant colony

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optimization (ACO) (Dorigo & Birattari, 2010), imperialist competitive algorithm (ICA) (Atashpaz-Gargari & Lucas, 2007), grasshopper optimization algorithm (GOA) (Saremi, Mirjalili, & Lewis, 2017) etc. are categorized under the class of metaheuristic algorithms. Most of these algorithms are inspired from some sort of biological or natural phenomenon. Similarly, inspired by observing fireworks explosion, a novel swarm intelligence-based algorithm, named fireworks algorithm (FWA) was proposed in (Tan & Zhu, 2010). Since its inception, several modified versions of the fireworks algorithm have been proposed by different researchers over the years. The bare bones fireworks algorithm (BBFWA) is one of the modified versions of the conventional fireworks algorithm where only the essential explosion operation is kept and remaining less significant operations, i.e. mutation operations are eliminated (Li & Tan, 2018). This results in an algorithm which is easier to implement, dependent on a smaller number of parameters, and computationally less expensive. However, the absence of the mutation operator reduces the global searching capability of this algorithm. Thus, to compensate the absence of the mutation operator, the focus of this chapter will be to include the searching process involved in the grasshopper optimization algorithm (GOA) within the working steps of the BBFWA forming a hybrid bare bones fireworks algorithm (HBBFWA). This hybrid algorithm will then be applied to perform the load flow analysis of islanded microgrid considering the modified IEEE-37 bus system as a case study system. Due to the absence of slack bus, the conventional methods of load flow solution are not applicable for an islanded microgrid. Metaheuristic optimization algorithms can be good alternatives to the conventional algorithms used for load flow analysis. Considering this fact, the proposed HBBFWA will be employed to perform load flow analysis of islanded microgrids. Additionally, this will also justify the applicability of this algorithm in solving complex optimization problems. The following sub-sections include background study on the evolution of fireworks algorithm, a brief literature review on the load flow analysis of islanded microgrid and the main focus of this chapter.

Background Study on Fireworks Algorithm

Fireworks algorithm (FWA) was first introduced in the work of Tan and Zhu (2010), by mimicking the swarming behavior of sparks generated by the explosion of a firework. In conventional FWA, first of all; a certain number of solutions are randomly initialized as the locations of the fireworks. Next step is to generate the locations of sparks for each firework. The generation of sparks is analogous to the process of a stochastic search. In order to ensure diversity of sparks, a few more sparks are generated following a gaussian random process. After the generation of these two types of sparks, new set of solutions are selected from the positions of fireworks and sparks as the locations of fireworks for the next generation. Since the evolution of this new type of swarm intelligence algorithm, it gained much acceptance from different researchers. In order to improve the performance of conventional FWA, a hybrid FWA was proposed in the work of Zheng, Xu, Ling and Chen (2015), by incorporating the steps involved in Differential Evolution (DE) algorithm with the conventional FWA.

Later on, Zheng, Janecek, and Tan (2013) identified few drawbacks of the conventional FWA. This research indicated that conventional FWA works better for some particular benchmark functions which have their optimum at the origin. However, for the objective functions having significant distance between the optimum point and the origin; the performance of the conventional FWA deteriorates. To compensate these drawbacks, Zheng et al. (2013) proposed an enhanced FWA (EFWA) by introducing new ways for checking explosion amplitude and generating explosion sparks, new mapping criterion for sparks, new operator for the generation of gaussian sparks and new selection criterion for the next