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Multi-objective harmony search algorithm for optimal power flow problem

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ABSTRACT

This paper proposes a multi-objective harmony search (MOHS) algorithm for optimal power flow (OPF) problem. OPF problem is formulated as a non-linear constrained multi-objective optimization problem where different objectives and various constraints have been considered into the formulation. Fast elitist non-dominated sorting and crowding distance have been used to find and manage the Pareto optimal front. Finally, a fuzzy based mechanism has been used to select a compromise solution from the Pareto set. The proposed MOHS algorithm has been tested on IEEE 30 bus system with different objectives. Simulation results are also compared with fast non-dominated sorting genetic algorithm (NSGA-II) method. It is clear from the comparison that the proposed method is able to generate true and well distributed Pareto optimal solutions for OPF problem.

1. Introduction

In real world optimization problems, multiple competing objectives make us solve them simultaneously instead of solving them separately. This gives rise to a set of optimal solution (largely known as Pareto optimal solution) rather than a single optimal solution. In the absence of a knowledge, it is not possible to find a better solution than others from the Pareto optimal solutions [1]. Because, one cannot be better than other without any further information. Therefore, it is necessary to find as many Pareto optimal solutions as possible. Classical methods do convert the multi-objective optimization problem to a single objective optimization problem by a suitable scaling/weighting factor method. This results in a single optimal solution. To obtain a Pareto optimal solutions, it should be run as many times as the number of solutions.

OPF problem is a non-linear, constrained optimization problem where many competing objectives are present. Traditionally, OPF problem has been solved for different objectives as a single objective optimization problem [2–5]. This resulted in a optimal solution which satisfies one objective and not others. Therefore, to satisfy and find a compromise solution between two competing objectives, OPF problem is solved as a multi-objective optimization problem with different constraints.

Traditionally, multi-objective OPF problem has been solved by weighted sum, ϵ-constraint approach and goal attainment method. The weighted sum method converts multi-objective optimization problem to a single objective optimization problem by giving suitable weights to the objectives [6,7]. In ϵ-constraint method [8], the most preferred objective is treated for optimization and non-preferred objective as a constraint in the allowable range ϵ. This range is further modified to obtain a Pareto optimal solution. Ref. [9] solves the multi-objective optimization problem using the goal attainment method. The above mentioned methods require multiple runs to obtain a Pareto optimal solution and need much computational time resulting in a weakly non-dominated solution.

Recently, multi-objective evolutionary algorithms have been reported to solve OPF problems [10–13]. These evolutionary algorithms are proved to be better than traditional method because of their ability to obtain a Pareto optimal solution in a single run. Since evolutionary algorithms use a population of solutions, they can be easily extended to maintain a diverse set of solutions in a single run. Most evolutionary algorithms reported for OPF problem, use non-dominated sorting, strength Pareto approach for maintaining a diverse Pareto optimal solutions. This paper considers the non-dominated sorting and crowding distance method proposed by Deb et al. [14] to maintain a well distributed Pareto optimal solutions.

Harmony search (HS) algorithm has been recently developed [15] in an analogy with improvisation process where musicians always try to polish their pitches to obtain a better harmony. Music improvisation process is similar to the optimum design process which seeks to find optimum solution. The pitch of each musical instrument determines the certain quality of harmony, just like the objective function assigned to the set of variables. The HS algorithm has been successfully applied to many real world optimization problems and proved to be better than other evolutionary

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