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A novel differential evolution application to short-term electrical power generation scheduling

A. Şima Uyar [a,*], Belgin Türkay [b], Ali Keleş [a]

[a] Department of Computer Engineering, Istanbul Technical University, 34469 Istanbul, Turkey
[b] Department of Electrical Engineering, Istanbul Technical University, 34469 Istanbul, Turkey

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ABSTRACT

This paper proposes a new way of applying a differential evolution algorithm to short-term electrical power generation scheduling. Traditionally, the problem is divided into two subproblems. An evolutionary algorithm, which works with binary decision variables, is applied to the first subproblem to find a low cost scheduling of power generators, satisfying some operational constraints. Then, the lambda-iteration method, is used to calculate the power generated by the online generators. In this study, the problem is treated as a whole for the first time in literature and an application of a real-valued differential evolution algorithm is proposed. This approach eliminates the use of an iterative local search technique such as lambda-iteration in all solution evaluations. Through comparisons with results from literature, it is shown that the proposed method achieves a similar solution quality to existing methods, without needing the time consuming lambda-iteration step. Finally, the new approach is applied to real-world data from the Turkish interconnected power network.

1. Introduction

Short-term electrical power generation scheduling (SEPGS) is a constrained optimization problem, in which optimal start-up and shut-down schedules need to be determined over a given time horizon, for a group of power generators, under operational constraints. This is also known in literature as the unit commitment problem.The objective is to minimize the power generation costs, while meeting the hourly forecasted power demands. The SEPGS problem has grown in importance recently, not only to promote system economy but also for the following reasons: start-up, shut-down and dynamic considerations in restarting modern generating facilities are much more complex and costly than they were for smaller, older units; systems have grown in size to the point where even small percentage gains have become economically very important; there has been an increase in variation between the peak and off-peak power demands; system planning requires automated, computerized schedulers to simulate the effect of unit selection methods on the choice of new generators.

Commonly the SEPGS problem is treated as consisting of two subproblems [1]: first, a feasible, low cost schedule for turn-on and turn-off times of the power generators over the given time horizon is determined. Then, for each hour, the power outputs of the individual generators scheduled to be online for that hour are obtained in such a way as to minimize the fuel costs, while meeting the forecasted power demands. This second part is termed as the Economic Dispatch Problem (EDP). In literature, the SEPGS problem has been solved using various approaches. These can be grouped as: Simple greedy techniques such as priority lists [2,3] and more recently pre-prepared power demand tables [4]; classical optimization methods such as dynamic-programming [5,6], Lagrangian relaxation [7,8], branch and bound [9], benders decomposition [10]; heuristic search algorithms such as simulated annealing [11,12], tabu-search [13], greedy randomized adaptive search [14]; metaheuristics such as evolutionary algorithms [15–22,1,23–27], particle swarm optimization techniques [28–30], ant colony approaches [31]; and many hybrids, e.g. as in [32,33]. A survey can be found in [34].

Evolutionary algorithms (EAs) [35] is an umbrella term, that covers several slightly differing techniques. EAs are population-based optimization approaches, inspired from classical Mendelian genetics and Darwin's evolutionary theory. A thorough historical perspective is given in [36]. The *Differential Evolution* (DE) [37] algorithm, introduced by Storn and Price in 1995, belongs to the group of evolutionary algorithms for search and optimization in continuous search spaces. DE is a relatively newer technique and has been shown to be promising in many application domains, where the older EAs have been used. DE has not been applied to the SEPGS problem prior to the promising, preliminary results

* Corresponding author. Tel.: +90 212 285 6471; fax: +90 212 285 3679.
E-mail addresses: etaner@itu.edu.tr (A.Ş. Uyar), turkayb@itu.edu.tr (B. Türkay), kelesal@itu.edu.tr (A. Keleş).

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