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Hybrid Taguchi-Immune Algorithm for the thermal unit commitment

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ABSTRACT

In this paper, a Hybrid Taguchi-Immune Algorithm (HTIA) is presented to deal with the unit commitment problem. HTIA integrates the Taguchi method and the Traditional Immune Algorithm (TIA), providing a powerful global exploration capability. The Taguchi method (TM) is incorporated in the crossover operations in order to select the better gene for achieving crossover consequently, enhancing the TIA. It has been widely used in experimental designs for problems with multiple parameters. The effectiveness and efficiency of HTIA are demonstrated by presenting several cases, and the results are compared with previous publications. Our results show that the proposed method is feasible, robust, and more effective than many other previously developed computation algorithms.

1. Introduction

The objective of unit commitment (UC) is to find an optimal schedule for dispatching the units, so that the operating cost of the whole scheduling period can be minimized while satisfying the numerous operating constraints. Developing an improved UC schedule could result in major savings for utilities, always a significant task in the daily operation of power systems. UC can be a difficult decision-making process because of the complex constraints that must be considered in all of the commitment's schedules. The exact solution for UC can be obtained by a complete enumeration of all feasible combinations, a process which can not be applied to actual power systems because of the prohibitive computational complexity [1]. To determine the best dispatching system, efficient tools are needed to solve the UC problem.

The UC problem can be formulated as a non-linear mixed-integer combinatorial optimization problem. Various approaches have been developed in the past. Refs. [2,3] summarize the publications relevant to UC problem-solving prior to 2003. The major disadvantages of numerical techniques are the curse of dimensionality, computational time, and local optimality when the number of units and operating constraints are increased. Most artificial intelligence techniques may have the ability to conquer restrictions, but good performance is more difficult to obtain.

Recently, some artificial intelligence algorithms based on meta-heuristic techniques have been presented to solve the UC problem and have shown their effectiveness [4–9]. Ref. [10] presents a fast technique for UC using GA, based on unit clustering, to improve computational time. With the simulated cases duplicated from the initial 10 units, clustering rules can be easily formulated and calculated by users. Senjyu et al. [11] proposes an extended priority list method for UC using a problem-specific heuristic programming to fulfill operational constraints with the priority list being used. Ref. [12] presents a double-filtration algorithm, using two strategies to divide the units into potential combinations, and employing economic dispatch to determine the optimal schedule. Ref. [13] presents Improved Pre-prepared Power Demand (IPPD) table to solve the UC problem and then the Muller method solves the economic dispatch (ED). A memory-bounded ant colony optimization (MACO) is developed to solve the UC problem [14]. Benhamida and Abdelbar [15] proposes an Enhanced Lagrangian Relaxation (ELR) solution to the generation scheduling problem of thermal units. Being different from the classic ON/OFF state definition, a 4-state unit is developed to solve the UC problem [16]. However, UC involves a high complexity in the searching space, which manifests itself in the form of complicated constraints imposed on the probable large number of variables in the scheduling process. Although some evolutionary algorithms can accommodate more complicated constraints to achieve a better solution, the inefficiency and sub-optimal problems remain major concerns. On the other hand, for a large-scale complex problem, the solution might get trapped in a sub-optimal state where the variation operators cannot produce any offspring capable of outperforming their parents.

The Taguchi method (TM) [17], uses many concepts derived from statistical experimental design for evaluating and implementing

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