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Augmented Lagrange Hopfield network based Lagrangian relaxation for unit commitment

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ABSTRACT

This paper proposes an augmented Lagrange Hopfield network based Lagrangian relaxation (ALHN-LR) for solving unit commitment (UC) problem with ramp rate constraints. ALHN-LR is a combination of improved Lagrangian relaxation (ILR) and augmented Lagrange Hopfield network (ALHN) enhanced by heuristic search. The proposed ALHN-LR method solves the UC problem in three stages. In the first stage, ILR is used to solve unit scheduling satisfying load demand and spinning reserve constraints neglecting minimum up and down time constraints. In the second stage, heuristic search is applied to refine the obtained unit schedule including primary unit de-commitment, unit substitution, minimum up and down time repairing, and de-commitment of excessive units. In the last stage, ALHN which is a continuous Hopfield network with its energy function based on augmented Lagrangian relaxation is applied to solve constrained economic dispatch (ED) problem and a repairing strategy for ramp rate constraint violations is used if a feasible solution is not found. The proposed ALHN-LR is tested on various systems ranging from 17 to 110 units and obtained results are compared to those from many other methods. Test results indicate that the total production costs obtained by the ALHN-LR method are much less than those from other methods in the literature with a faster manner. Therefore, the proposed ALHN-LR is favorable for large-scale UC implementation.

1. Introduction

Unit commitment (UC) which is considered as a large scale, nonlinear, mixed-integer optimization problem plays a very important role in optimal operation of power systems. Solving the UC problem is a complex decision making process since multiple constraints must be satisfied and a good UC solution method can substantially contribute to annual savings of production cost. The objective of the UC problem is to minimize the total cost of thermal generating units while maintaining sufficient spinning reserve and satisfying the operational constraints of generating units over a given schedule time horizon. An optimal solution to the UC problem in power system operation can be obtained by a complete enumeration. However, the requirement of the excessive computational resource is impossible to be implemented in practice. Therefore, many research efforts have been focused on efficient UC algorithms for lower total production cost and computational time.

Many conventional methods were applied to solve the UC problem such as priority list (PL) [1], branch and bound method (BB) [2], dynamic programming (DP) [3], mixed-integer linear programming (MILP) [4], Lagrangian relaxation (LR) [5]. Among these methods, the PL method is one of the earliest and simplest approaches to solve the UC problem. Most priority list schemes are built around a shut down algorithm based on the relative efficiency of each unit. However, the PL method can not deal with the systems of moderate size since the large number of combinations can not be properly handled, leading to relatively higher operation cost. The BB and DP methods suffer from the "curse of dimensionality" if the size of a system is too large or scheduling period is too long. When applying a MILP problem formulation, solving large-scale problems requires a large amount of computing effort and can result in relatively high computational time. The LR method is considered to be the most realistic and efficient method among the conventional methods for large-scale systems. The LR method is superior to the DP method due to its higher quality solution and faster computational time. However, due to the non-convexity of the UC problem, the optimality of the dual problem does not guarantee the feasibility of the primal UC problem. An enhanced adaptive Lagrangian relaxation (ELR) to overcome the drawback of the LR method has been proposed in [6] based on adaptive Lagrangian relaxation enhanced by a heuristic search for identical units. ELR is favourable for large scale implementation in terms of the total production costs and computational times.

Recently, meta-heuristic techniques have been widely used for solving the UC problem such as artificial neural network (ANN)

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