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Bidding strategy of generation companies using PSO combined with SA method in the pay as bid markets

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ABSTRACT

This paper proposes a new method that uses the combination of particle swarm optimization (PSO) and simulated annealing (SA) to predict the bidding strategy of Generating Companies (Gencos) in an electricity market where they have incomplete information about their opponents and market mechanism of payment is pay as bid.

In the proposed methodology, Gencos prepare their strategic bids according to Supply Function Equilibrium (SFE) model and they change their bidding strategies until Nash equilibrium points are obtained. Nash equilibrium points constitute a central solution concept in game theory and they are computed with solving a global optimization problem. In this paper a new computational intelligence technique is introduced that can be used to solve the Nash optimization problem. This new procedure, is based on the PSO algorithm, which uses SA method to avoid becoming trapped in local minima or maxima and improve the velocity's function of particles. The performance of this procedure is compared with results of other computational intelligence techniques such as PSO, Genetic Algorithm (GA), and a mathematical method (GAMS/DICOPT). The IEEE 39-bus test system is employed to illustrate and verify the results of the proposed method.

1. Introduction

Recent changes in the electricity industry in several countries have led to a less regulated and more competitive energy market. In this condition each Genco will try to maximize its own profit. For a Genco, it is critical to devise a good bidding strategy according to its opponents' bidding behavior, the model of demand, market mechanism, and power system operating conditions. This type of problems is included in the category of game theory problems. The most commonly encountered solution concept in game theory is that of Nash equilibrium [1]. Therefore the rational Gencos try to bid at their Nash equilibrium strategies to obtain the reliable optimum profit.

In [2–4], a cooperative game was used to analyze the possible coalitions of participants in electricity markets. A non-cooperative incomplete game was employed in [2,5] to choose a Genco's optimal bidding strategy among the sets of discrete bids. In [6], the bidding problem was modeled as a bi-level optimization problem by assuming the complete information on a Genco's opponents. The market clearing problem was modeled as a non-linear optimal power flow (OPF) problem and the Newton approach was employed to solve it, also the market payment is based on MCP. Ref. [7] describes a procedure that uses PSO combined with Lagrangian Relaxation framework to solve a power-generator scheduling problem known as the unit commitment problem. Refs. [8,9] investigate the models for bidding strategies of producers in the constrained electricity market.

This paper develops a more general approach for Genco's optimal bidding strategies, where they have incomplete information about their opponents and the electricity market payment is type of pay as bid. The problem of computing Nash equilibrium points can be formulated as a global optimization problem. This formulation allows us to consider computational intelligent techniques to detect Nash equilibria.

PSO is a stochastic optimization method capable of handling non-differentiable, nonlinear, and multi module objective functions. The PSO approach is motivated from the social behavior of bird flocking and fish schooling. PSO has a population of individual that move through the D-dimensional search space and each individual has a velocity that acts as an operator to obtain a new set of individuals. Individuals, called particles, adjust their movements depending on both their own experience and the population's experience. At each iteration, a particle moves towards a direction computed from the best visited position and the best visited position of all particles in its neighborhood. In this approach, except the particle that is the best experience of particles, the effect of other particles is ignored. So the probability of becoming trapped in the local points is increased. In this paper, to avoid this problem, the PSO algorithm is combined with SA approach. SA employs a

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