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Reinforcement Learning approaches to Economic Dispatch problem

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ABSTRACT

This paper presents Reinforcement Learning (RL) approaches to Economic Dispatch problem. In this paper, formulation of Economic Dispatch as a multi stage decision making problem is carried out, then two variants of RL algorithms are presented. A third algorithm which takes into consideration the transmission losses is also explained. Efficiency and flexibility of the proposed algorithms are demonstrated through different representative systems: a three generator system with given generation cost table, IEEE 30 bus system with quadratic cost functions, 10 generator system having piecewise quadratic cost functions and a 20 generator system considering transmission losses. A comparison of the computation times of different algorithms is also carried out.

1. Introduction

Reinforcement Learning Problem in general is a problem of learning from interaction to achieve a specified goal. The learner (decision maker) continuously interacts with the environment (system). The interaction is through actions and associated rewards. The agent performs an action from the permissible set of actions at the particular state of the environment. The environment gives back a numerical reward which is a measure of the goodness of the performed action. Such a learning scheme is widely employed in solving several difficult problems such as control of inverted pendulum, Playing Backgammon and other computer games, Elevator control [1–5], etc. There are few applications of Reinforcement Learning in Power System problems also. It has been applied for Load Frequency Control of generators [6], Unit Commitment problem [7], Power system transient stability enhancement [8], Auction Based Pricing [9], Optimal bidding of a Genco [10].

As far as power generation control is considered, it is basically having three time based control loops: Unit Commitment, Economic Dispatch and Load Frequency Control [13]. In Economic Dispatch problem, cost of generation of power has been represented in a variety forms including cost tables, quadratic functions, etc. For getting more accurate representation, cost functions are also sometimes expressed as piecewise quadratic functions. For solving this scheduling problem, so many computational and intelligent techniques have been developed so far. Some of the strategies applied for solution of this problem are explained in [14]. Fast computation Hopfield neural network along with dynamic programming is used for getting the schedule of generation in [15]. The work presented in [16] explains the application of Hopfield Neural Network for Economic and Emission Load Dispatch. The work presented in [17] also gives out the idea of using Hopfield Neural Network as a tool for solving this control problem. [18] and [19] considers the security constraints of the problem also and is solved through decomposition and coordination algorithms and variable scaling hybrid differential programming method respectively. [20] uses an immune based method known as Clonal algorithm. Using Radial Basis Function Network to compute optimum value for lambda and then using lambda iteration method the problem is solved in [21]. Simple Genetic algorithm is used for finding optimum dispatch [22] and simulated annealing is used as tool in [23]. Piece wise quadratic functions are considered and solution is made through an improved genetic algorithm in [24]. Recently a direct search method viewing the non convex nature of economic dispatch problem is employed in the work presented in [25] and [26] also gives out a direct search approach. Different kinds of efficient evolutionary algorithms are developed in [27] and [28]. Particle swarm optimization is the technique used by the researchers in [29] and [30] while a new optimization based algorithm: ‘Taguchi method’ is used in [31].

Reinforcement Learning seems to provide better flexibility and easiness in accommodating randomness in the cost strategies associated with complex systems. Also since this learning strategy relies on an evaluative feedback approach, like other intelligent techniques, it can work on systems with ill defined models. In

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