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Environmental/economic power dispatch problem using multi-objective differential evolution algorithm☆

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ABSTRACT

This paper presents a multi-objective differential evolution (MODE) algorithm for environmental/economic power dispatch (EED) problem. The EED problem is formulated as a nonlinear constrained multi-objective problem with competing and non-commensurable objectives of fuel cost, emission and system loss. The proposed MODE approach adopts an external elitist archive to retain non-dominated solutions found during the evolutionary process. In order to preserve the diversity of Pareto optimality, a crowding entropy diversity measure tactic is proposed. The crowding entropy strategy is able to measure the crowding degree of the solutions more accurately. In addition, fuzzy set theory is employed to extract the best compromise solution. Several optimization runs of the proposed approach have been carried out on the IEEE 30- and 118-bus test system. The results demonstrate the capability of the proposed MODE approach to generate well-distributed Pareto optimal non-dominated solutions of multi-objective EED problem. The comparison with reported results of other MOEAs reveals the superiority of the proposed MODE approach and confirms its potential for solving other power systems multi-objective optimization problems.

1. Introduction

With the increasing concern of environmental pollution, operating at absolute minimum cost can no longer be the only criterion for economic dispatch (ED) of electric power generation. The generation of electricity from fossil fuel releases several contaminants, such as SO_2, CO_2, and NO_x, into the atmosphere. Recently, the problem that has attracted much attention is pollution minimization due to the pressing public demand for clean air. Since the passage of the U.S. Clean Air Act amendments of 1990 and similar acts by European and Japanese governments, environmental constraints have topped the list of utility management concerns [1,2]. Ideally, the utilities would like to supply power to its customers with minimum total emission as well as minimum total fuel cost. However, minimizing the total fuel cost and total emission are conflicting in nature and they cannot be minimized simultaneously. Hence, the environmental/economic dispatch (EED) problem is a large-scale highly constrained nonlinear multi-objective optimization problem. In recent years, this option has received much attention [3–24].

Many approaches and methods have been reported to solve the multi-objective EED problem. A summary of environmental/economic dispatch algorithms dating back to 1970 by using conventional optimization methods was reviewed in [3]. Another conventional optimization method of linear programming techniques was used to optimize the economic load dispatch multi-objective optimization problem in [4]. However, it is realized that conventional techniques become very complicated when dealing with increasingly complex dispatch problems, and are further limited by their lack of robustness and efficiency in a number of practical applications. Hence, artificial intelligent techniques and heuristics-based methods were tried to solve this problem. An improved Hopfield neural network for EED problem was reported in [5]. In [6], an improved back-propagation NN was also used to optimize the combined economic and emission dispatch problem. However, as well known, NNs are methods based on gradient information and easy to trap to the local optimum. A fuzzy satisfaction-maximizing decision approach was successfully applied to solve the bi-objective EED problem in [7], but extension of the approach to include more objectives is a very involved question. In [8], an evolutionary algorithm based approach evaluating the economic impacts of environmental dispatching and fuel switching was presented. Unfortunately, some of non-dominated solutions may be lost during the search process while some of

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