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Evolution of radial basic function neural network for fast restoration of distribution systems with load variations

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ABSTRACT

This paper proposes a new algorithm to construct the optimal radial basic function (RBF) neural network for fast restoration of distribution systems with load variations. Service restoration of distribution systems is to restore power to the blacked out but unfaulted area. Basically, it is a stressful and urgent task that must be performed by system operators. In this paper, a new algorithm which combines orthogonal least-squares (OLS) and enhanced differential evolution (EDE) methods is developed to construct the optimal RBF network that shall further achieve the fast restoration of distribution systems. The proposed scheme comprises training data creation phase and network construction phase. In the training data creation phase, a heuristic-based fuzzy inference (HBFI) method is employed to build the restoration plans under various load levels. Then an optimal RBF network is constructed by OLS and EDE algorithms in the network construction phase. Once the RBF network is constructed properly, the desired restoration plan can be produced as soon as the inputs are given. The proposed method was tested on a typical distribution system of the Taiwan Power Company (TPC). Results show that the proposed method outperforms the existing methods in terms of convergence performance and forecasting accuracy.

1. Introduction

Service restoration of distribution systems is a complicated combinatorial optimization problem that often has a great number of candidate solutions to be selected by the system operators. When a fault takes place, the blackout area and the number of customers affected depend heavily on the effectiveness of service restoration algorithm. Generally, the system operators including those of TPC tend to restore the electricity power on the basis of their existing knowledge and heuristic rules. However, owing to a great number of feeder and lateral switches in a typical distribution system, it is not easy to restore an out-of-service area solely depending on the past experiences of human operators. Therefore, how to devise a fast and effective restoration plan with various load levels is of major concern in this paper.

Many researches have been devoted to coping with the problems of service restoration. Knowledge-based expert system technique [1] has been employed to incorporate the experts' experiences into the computer codes of service restoration. The disadvantage of this technique is the difficulty in designing an efficient inference engine from much of the knowledge. Combined with the past experiences of humans, the heuristic search approach [2,3] has been developed by the operators at many utilities including those of TPC in order to reach a proper restoration plan in a short period.

Since the experts' experiences and heuristic rules are often expressed in imprecise linguistic terms, the fuzzy reasoning approach [4,5] was then proposed to achieve an efficient inference for the problem of service restoration. To deal with the problem of service restoration with many conflicting objectives, the multiobjective fuzzy reasoning approach was presented in [6,7].

In general, these techniques mentioned above can serve as a useful tool to reach a proper restoration plan for a specific load demand. However, the related inference programs need to be rerun when the system load varies. With the advantages of fast response and real-time natures, the artificial neural network (ANN) method has been used to solve the service restoration of distribution systems [8]. The ANN, however, still has the problem of slow convergence during training and the determination of network structure is problem dependent. In addition, the learning algorithm used by ANN to tune the weighting value in the network may easy to stall at the local optimal points.

To reach the goal of fast restoration of distribution systems, a systematical method which comprises training data creation phase and network construction phase is developed in this paper. In the phase one, a HBFI method [4] is employed to create the training data of restoration plans under various load levels. Then the RBF network evolved by OLS and EDE algorithms is used to train the obtained training data in the second phase. Once the RBF network is

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