Chapter 18
Applications of Particle Swarm Optimization in Composite Power System Reliability Evaluation

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ABSTRACT

This chapter introduces a novel technique to evaluate composite power system reliability indices and their sensitivities with respect to the control parameters using a dynamically directed binary Particle Swarm Optimization (PSO) search method. A key point in using PSO in power system reliability evaluation lies in selecting the weighting factors associated with the objective function. In this context, the work presented here proposes a solution method to adjust such weighting factors in a dynamic fashion so that the swarm would always fly on the entire search space rather of being trapped to one corner of the search space. Further, a heuristic technique based on maximum capacity flow of the transmission lines is used in classifying the state space into failure, success, and unclassified subspaces. The failure states in the unclassified subspace can be discovered using binary PSO technique. The effectiveness of the proposed method has been demonstrated on the IEEE RTS.

1. INTRODUCTION

Composite system reliability evaluation aims at determining the reliability of the given power system taking into consideration both transmission and generation systems. In recent years, the task of composite system reliability evaluation has become more complicated. This complexity can be attributed, in

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part, to the rapid increase in electrical demand and the liberalization of the electricity markets. In fact, the time and computational burden that are spent in evaluating system indices and their sensitivities with respect to the control parameters are of great concern to many researchers and companies all over the globe. Since the inception of reliability evaluation methods, a reasonable amount of work has been presented in the literature to handle the task of reliability evaluation efficiently. Numerous techniques have been proposed in the literature to assess composite system reliability. In this context, analytical and Monte Carlo simulation methods have been used for composite system reliability evaluation (Deng & Singh, 1992; He, Sun, Kirschen, Singh, & Cheng, 2010; Oliveira, Pereira, & Cunha, 1989; Wang, Guo, Wu, & Dong, 2014). It is worthy pointing out here that, composite system reliability evaluation based on analytical approaches are extremely fast; however, they tend to be tedious as the system size increases. On the other hand, Monte Carlo simulation has the ability of handling reliability analysis of complicated systems and has been used for that purpose for a long time. However, the major downside of using Monte Carlo simulation in composite system reliability evaluation is that the time consuming during the course of reliability evaluation increases with system size. These concerns have led to the development of several Population-based Intelligent Search methods, (PIS), such as Genetic Algorithms, Particle Swarm Optimization, Ant colony, and so forth. These population-based techniques along with the some other reliability assessment methods such as importance sampling, state space pruning, and state space decomposition would be helpful in reducing the search space and handling the task of reliability evaluation efficiently.

The use of Binary Particle Swarm Optimization in power system reliability has been found to be an efficient tool in evaluating the reliability indices. However, the task of choosing the weighting factors that are associated with the objective function tends to be tedious and time consuming as trial and error approaches are usually used to prevent the particles from being flying in one direction. In view of these reasons, the development of an automated approach to adjust these weighting factors could save some effort in solving the task of reliability evaluation efficiently.

Composite system reliability indices include, but are not limited to, loss of load probability (LOLP), loss of load frequency (LOLF), loss of load expectation (LOLE), expected energy not supplied (EENS), and expected demand not supplied (EDNS). Even though these indices are of a great importance in both planning and operational power system reliability evaluation, they lack the ability of identifying the influence of each area or equipment on the system reliability. Due to these reasons, significant efforts have been devoted to this area in recent years to evaluate what the system's reliability justifications are and where the best location to invest is which is referred as sensitivity analysis.

Several methodologies for calculating the sensitivity of some reliability indices with respect to the variations in components parameters and system operating limits have been introduced in the literature. One of the advantages of using sensitivity analysis is that it allows planners to enhance the overall system reliability by improving the reliability of each component in a separate manner. The study of the sensitivity of these indices can be viewed as measures of deficiency in both generation and transmission subsystems and, hence, provide sense to the areas that to be reinforced.

In performing sensitivity analysis of the reliability indices as well as the evaluation of the system reliability, the computational time is of concern especially for the online applications. In this chapter, a heuristic technique is used to prune the state space; and thereby reduce the computational effort in evaluating the well-known reliability indices and their sensitivities with respect to component parameters and system operating limits. The heuristic technique differs from the already existed pruning techniques in that it classifies the state space into success, failure and unclassified subspaces instead of pruning the