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Optimal placement of switches in a radial distribution network for reliability improvement

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ABSTRACT

This paper proposes differential search (DS) algorithm to solve distribution system reliability optimization problem. Optimum number and location of remote control switch (RCS) have been found, in order to enhance reliability of a radial distribution system. A multi-objective formulation has been considered with a view to enhance reliability at a compromised cost. DS algorithm utilizes the Brownian-like random-walk movement used by an organism to migrate. Simulation results obtained by DS algorithm have been compared with that of particle swarm optimization (PSO), differential evolutionary algorithm (DE), genetic algorithm (GA), ant colony optimization (ACO) and gravitational search algorithm (GSA). Results show that DS algorithm provides considerably superior performance, in terms of quality of solution obtained and computational efficiency.

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Introduction

Distribution system reliability has proved to be of great concern in the present days of power system operation. With the deregulation of power system and enhanced competitive environment, the demand for uninterrupted quality power has increased. As distribution system has the greatest contribution to the interruption of supply to a consumer [1], hence, improving distribution system reliability is of serious concern in today's power market. The enhancement of reliability always incurs a cost as it involves some additional preventive and corrective measures. So, the reliability improvement methods need to be adopted keeping in view the cost involved in the process. Failure rate, repair time and restoration time are some important parameters of defining reliability. Reducing the values of one or more of the above parameters can improve reliability considerably. Several approaches can be adopted to improve reliability, out of which, the present authors have adopted optimal placement of remote control switch (RCS) in the radial distribution network. RCSs are devices, which can isolate or connect a section of a network. Suitable locations of RCSs in a network may reduce the time to restore power and thus improve reliability. Placing one RCS at each segment of a network definitely improves reliability greatly, but at the same time it may incur a high installation and maintenance cost, as the number of RCSs required is large. Hence, a compromise is required, and here lies the importance of optimal allocation of RCSs. While adopting the present work, numbers of literatures have been reviewed in which similar type of work have been done. Some of these are briefly discussed here.

Bouhouras et al. [2] used an artificial intelligence technique with multi agent system for performing cost/worth assessment of reliability improvement in distribution networks. Haifenga et al. [3] adopted Monte-Carlo simulation based approach for providing a basis for using a parallel computing environment in power system reliability and cost evaluations. With the recent trend of automation, RCSs are gaining importance in reliability improvement studies. Some studies have been carried out in order to develop strategies for RCS without covering allocation of switches [4,5].

Allocation of switches has been considered in [6,7]. Optimal placement of switches and reclosers has been considered in [8,9]. Bernardon et al. [10] proposed a methodology to consider the impact of RCS when computing the reliability indices and the algorithm for multi-criteria decision making to allocate these switches. Benavides et al. [11] proposed a new iterated sample construction with path relinking (ISCPR) to solve distribution system switch allocation problem. Zheng et al. [12] studied the quantitative impact of automatic switches on the reliability of power

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distribution systems. Esmaeilian and Fadaeinedjad [13] adopted a Binary Gravitational Search Algorithm (BGSA) for network reconfiguration and capacitor placement in distribution system with a view to improve reliability. Tippacon and Rerkpreedapong [14] adopted multi-objective ant colony optimization (MACO) whereas Pombo et al. [15] adopted a memetic algorithm combining Non dominated Sorting Genetic Algorithm II (NSGA-II) with a local search algorithm for switch and recloser allocation in order to minimize the reliability indices namely system average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI) as well as the cost of equipments. Golestani and Tadayon [16] used Linear Fragmented Particle Swarm optimization for optimal switch placement in distribution system. Assis et al. [17] proposed a memetic algorithm based optimization methodology to sectionalizing, tie, manual, and automatic switches in distribution networks. Amanulla et al. [18] used binary particle swarm optimization-based search algorithm to find the optimal status of the switches in order to maximize the reliability and minimize the real power loss. Zou et al. [19] adopted methods including feeder reconfiguration, recloser installation, recloser replacement, and distributed generation (DG) installation to minimize SAIDI, an important reliability index. Brown et al. [20] used sequential feeder method and a multi-objective genetic algorithm (GA) together to solve the optimization of the feeder addition problem in an islanded distribution system with DGs. Vitorino et al. [21] presented the application of an improved genetic algorithm (IGA) to optimize simultaneously loss and reliability of a radial distribution system through a process of network reconfiguration as an optimization. Zhang et al. [22] proposed a reliability-oriented reconfiguration (ROR) method for improving distribution reliability and energy efficiency, based on interval analysis. Pfitscher et al. [23] presented a new methodology for automatic reconfiguration of

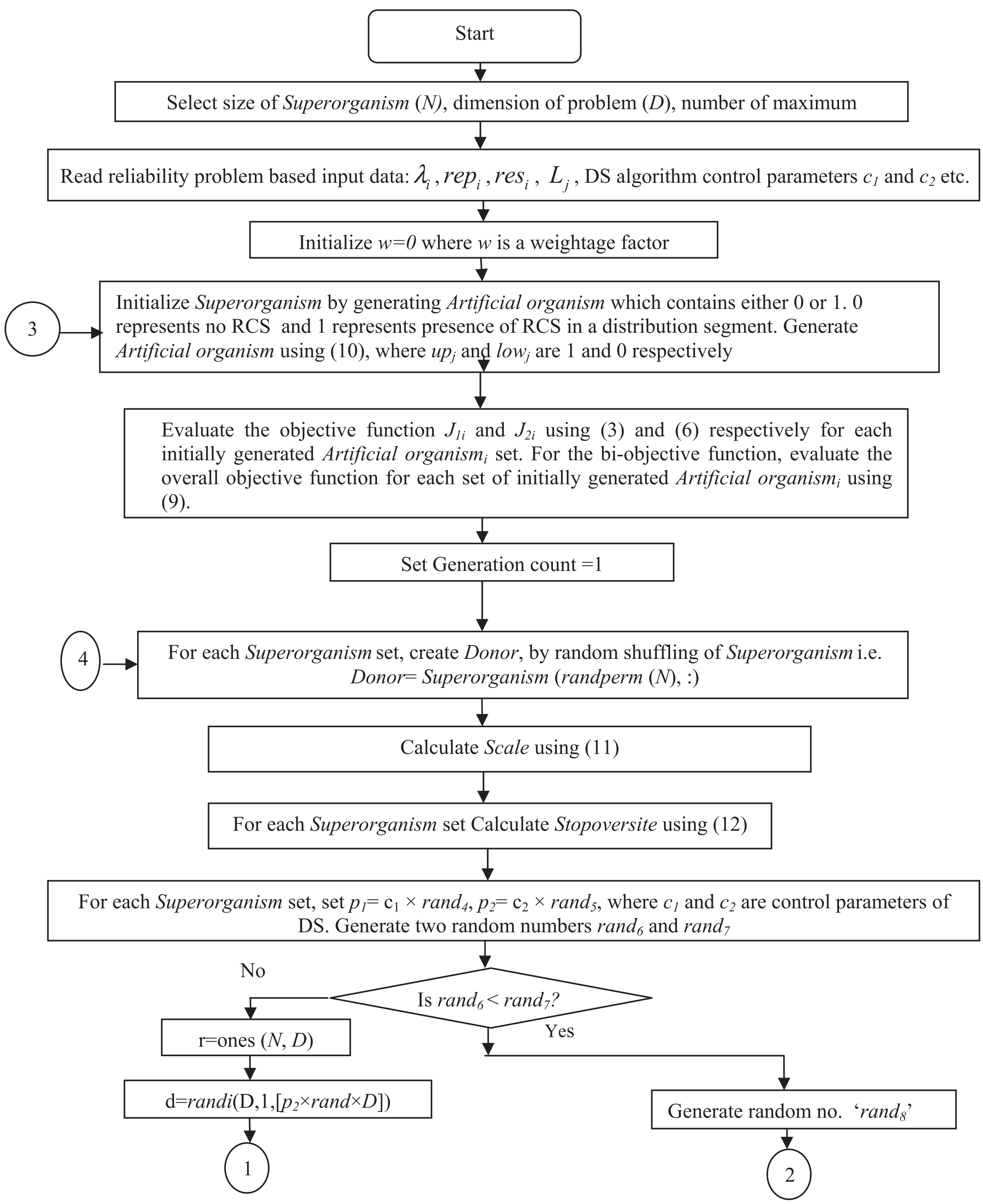

Fig. 1. Flowchart of DS algorithm as applied to the present problem.

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