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Editors

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Preface

SocProS, which stands for ‘Soft Computing for Problem Solving,’ is entering its seventh edition as an established and flagship international conference. This particular annual event is a joint collaboration between a group of faculty members from the institutes of repute like South Asian University, New Delhi; NIT Silchar; Liverpool Hope University, UK; IIT Roorkee; and IIT Bhubaneswar.

The first in the series of SocProS started in 2011 and was held from 20th to 22nd December on the IIT Roorkee Campus with Prof. Deep (IITR) and Prof. Nagar (Liverpool Hope University) as the general chairs. JKLU Jaipur hosted the second SocProS from December 28 to 30, 2012. Coinciding with the Golden Jubilee of the IIT Roorkee’s Saharanpur Campus, the third edition of this international conference, which has by now become a brand name, took place at the Greater Noida Extension Centre of IIT Roorkee during December 26–28, 2013. Afterward, in 2014, it has been organized at NIT Silchar, Assam, during December 27–29, 2014. The next conference series was held at Saharanpur Campus of IIT Roorkee during December 18–20, 2015. In the last year, Thapar University, Patiala, has hosted the conference during December 23–24, 2016.

Like earlier SocProS conferences, the focus of SocProS 2017 is on soft computing and its applications to real-life problems arising in diverse areas of medical and health care, supply chain management, signal processing and multimedia, industrial optimization, image processing, cryptanalysis, etc. SocProS 2017 attracted a wide spectrum of thought-provoking articles. A total of 164 high-quality research papers have been selected for publication in the form of this two-volume proceeding.

We hope that the papers contained in this proceeding will prove helpful toward improving the understanding of soft computing at teaching as well as research level and will inspire more and more researchers to work in the field of soft computing.

The editors would like to express their sincere gratitude to SocProS 2017 patron, plenary speakers, invited speakers, reviewers, program committee members, international advisory committee, and local organizing committee; without whose support, the quality and standards of the conference could not be maintained. We

express special thanks to Springer and its team for this valuable support in the publication of this proceeding.

Over and above, we would like to express our deepest sense of gratitude to the 'Indian Institute of Technology (IIT) Bhubaneswar' to facilitate the hosting of this conference. Our sincere thanks to all the sponsors of SocProS 2017.

SAU New Delhi, India — Jagdish Chand Bansal
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About the Book

The proceedings of SocProS 2017 will serve as an academic bonanza for scientists and researchers working in the field of soft computing. This book contains theoretical as well as practical aspects using fuzzy logic, neural networks, evolutionary algorithms, swarm intelligence algorithms, etc., with many applications under the umbrella of 'soft computing.' The book will be beneficial for young as well as experienced researchers dealing across complex and intricate real-world problems for which finding a solution by traditional methods is a difficult task.

The different application areas covered in the proceedings are image processing, cryptanalysis, industrial optimization, supply chain management, newly proposed nature-inspired algorithms, signal processing, problems related to medical and health care, networking optimization problems, etc.

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About the Editors

Dr. Jagdish Chand Bansal is Assistant Professor at the South Asian University, New Delhi, India, and Visiting Research Fellow at Liverpool Hope University, Liverpool, UK. He has an excellent academic record and is a leading researcher in the field of swarm intelligence, and he has published numerous research papers in respected international and national journals.

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Power Distribution Network Reconfiguration Using an Improved Sine–Cosine Algorithm-Based Meta-Heuristic Search

Usharani Raut and Sivkumar Mishra

Abstract This paper proposes an improved sine–cosine algorithm for solving power distribution network reconfiguration (PDNR) problem. The sine–cosine algorithm is a recently proposed population-based meta-heuristic optimization algorithm which uses the mathematical sine and cosine functions for searching the solution space. The search procedure looks for the best solution by repeatedly making small changes to an initial solution until no further improved solutions are found. To maintain a balance between local and global search, four random variables (r_1, r_2, r_3 and r_4) are integrated into this algorithm. For applying this algorithm to the PDNR problem, some improvements are proposed in this meta-heuristic search algorithm along with a new data structure-based load flow method to minimize power loss as the single objective. The effectiveness of the proposed PDNR algorithm is tested by considering five standard test distribution systems (33, 69, 84, 119 and 136 buses).

Keywords Radial distribution networks · Network reconfiguration · Sine–cosine algorithm

1 Introduction

The power distribution network reconfiguration (PDNR) is an old but quite relevant power optimization problem, which is a process of changing the topology of the power distribution network by altering the open/closed status of the switches. The main objective of the technique is to find a radial operating structure that minimizes the power losses of the distribution system under normal operating conditions. PDNR belongs to a class of complex combinatorial optimization problems where complexity arises from the requirement of radial network topology and nonlinear power flow

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constraints. Meta-heuristic search-based techniques are the most preferred ones as they always guarantee global minimum results.

Several meta-heuristic-based PDNR methods are available in the literature [1]. In these methods, a population rather than a single agent is considered for searching the solution space. Maintaining a balance between the local search (exploitation phase) and global search (exploration phase), these optimization algorithms converge to a global optimum value without getting trapped in local optimum values. However, these methods are slow in convergence as it stochastically moves in the solution space and it has to check the fitness for every member of the population. So, in a population-based meta-heuristic PDNR method, it is almost necessary to carry out load flow for each member of the population for every generation. Simultaneously, the configurations are also to be checked for radiality and connectivity. In PDNR problem, the most popular objective is the overall active power loss minimization (APLM), although there are other objectives when considered simultaneously makes the optimization problem multiobjective. Bus voltage deviation minimization (BVDM), load balancing index minimization (LBIM), voltage profile improvement (VPI), improvement of voltage stability index (VSI) and number of switching minimization (NSM) are some of the other commonly adopted objectives in PDNR. Similarly, to improve the system reliability, the objectives can be considered as to minimize the reliability-based indices like system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI) and energy not supplied (ENS).

In Table 1, a survey of the recently proposed PDNR methods using meta-heuristic algorithms, such as genetic algorithm (GA), particle swarm optimization (PSO), gravity search algorithm (GSA), symbiotic organism search (SOS), runner root algorithm (RRA), grey wolf algorithm (GWA), harmony search algorithm (HSA), artificial bee colony algorithm (ABCA), flower pollination algorithm (FPA), galaxy-based search algorithm (GbSA), artificial immune algorithm (AIA), teaching–learning-based algorithm (TLBA), invasive weed optimization (IWO), cuckoo search algorithm (CSA), plant growth simulation algorithm (PGSA), and fireworks algorithm (FWA), is presented.

Sine–cosine algorithm (SCA) is a recently proposed meta-heuristic algorithm [17] and has promising features for application to PDNR problem. Several modifications are being proposed during the last one-and-half year for improving the basic SCA. Hafez et al. [18] successfully implemented SCA for feature selection without any change in the original algorithm. Sahlol et al. [19] also used SCA (without any modification) for improving the prediction accuracy of liver enzymes of fish fed by nano-selenite by developing a neural network model based on SCA. Bureerat and Pholdee [20] proposed an adaptive SCA by integrating differential evolution mutation operator for updating the population to detect structural damage. In [21], an interactive SCA is proposed to improve power system security where a micro-SCA is introduced for enhancing the local search. Sindhu et al. [22] proposed an SCA with elitism strategy to update new best solution for feature selection. Kumar et al. combined SCA with Weibull and pareto distribution functions in [23] and Cauchy and Gaussian distribution functions in [24] to enhance the global exploration ability

Table 1 A survey of recent meta-heuristic-based PDNR methods

Author(s) (year)	Meta-heuristics	Objective(s)	Salient features
Faria Jr. et al. (2017) [2]	GA	APLM	Biased random key-based GA
Fathy et al. (2017) [3]	PSO and GSA	APLM, SAIFI, SAIDI and ENS	Hybrid GSA-PSO-based meta-heuristic approach
Sedighizadeh et al. (2017) [4]	SOS and PSO	APLM, BVDM and LBIM	Hybrid SOS-PSO with fuzzified objective approach
Abdelaziz (2017) [5]	GA	APLM	GA with varying population
Nguyen et al. (2017) [6]	RRA	APLM, BVDM, LBIM and NSM	RRA-based fuzzy multiobjective approach
Muthukumar and Jayalalitha (2017) [7]	GWO	APLM and improvement of VSI	GWO-based PDNR with renewable distributed generators (DGs)
Siavash et al. (2017) [8]	PSO, HSA and ABCA	APLM and improvement of VDI	Hybrid HSA-ABCA-based
Namachivayam et al. (2016) [9]	FPA	Minimize cost of energy loss, capacitors and voltage penalty	FPA-based PDNR with capacitor placement
Tolabi et al. (2016) [10]	GbSA	APLM, LBIM and VPI	GbSA-based fuzzy multiobjective approach
Souza et al. (2016) [11]	AIA	Minimize cost of energy	AIA-based PDNR with fixed and variable demands
Lotifour et al. (2016) [12]	TLBA	APLM and VPI	Discrete TLBA-based PDNR
Rani et al. (2015) [13]	IWO	APLM, BVDM, NSM and LBIM	Pareto-based multiobjective PDNR using IWO
Nguyen and Truong (2015) [14]	CSA	APLM and VDIM	CSA-based PDNR
Rajaram et al. (2015) [15]	PGSA	APLM	PGSA-based PDNR in presence of DGs
Imran et al. (2014) [16]	FWA	APLM and VPI	FWA-based PDNR

for maximum power point tracking of a photovoltaic array. Tawhid and Savsani [25] proposed the SCA for multiobjective optimization using elitist non-dominated sorting method and diversity preserving crowding distance approach of NSGA-II.

In the light of above developments, the objective of this paper is to propose an improved SCA-based PDNR. The organization of the paper is as follows: in Sect. 2, the improved SCA (ISCA) is explained. In Sect. 3, a graph theory-based load flow method is presented. The load flow used to implement ISCA works independent of any particular numbering and ordering scheme of nodes and system data. This algorithm first checks the radial nature of the given distribution network and then the connectivity of all the nodes to substation node using the data structure-based technique. In Sect. 4, the algorithm is implemented for several test RDNs and the results are presented and analysed.

2 Improved Sine–Cosine Algorithm

The SCA is a population-based optimization method proposed by Mirjalili [17]. The main success of a population-based meta-heuristic optimization algorithm is achieved by maintaining the balance between global search or exploration and the local search or exploitation. This balance in turn maintains the population diversity which helps to avoid early convergence to local optimum values. In SCA, the cyclic pattern of the sine and cosine function is utilized to explore and exploit the search space. Compared to other methods, SCA method has fewer control parameters and is far simpler to implement. The search procedure for SCA is similar to other meta-heuristic methods which includes three main steps, population initialization, population updating and population selection. The search process of SCA starts with an initial population, and after evaluating the objective function for each member of the population, the best solution is found. The new population for the next generation is then updated by using Eq. (1), and the objective function values of its members are calculated as $f\left(x_{i},_{i=1 \text{ to population size}}\right)$.

$$x_{\text{new},i} = \begin{cases} x_{\text{old},i} + r_1 \sin(r_2)\left|r_3 x_{\text{best},i} - x_{\text{old},i}\right| & \text{if } r_4 < 0.5 \\ x_{\text{old},i} + r_1 \cos(r_2)\left|r_3 x_{\text{best},i} - x_{\text{old},i}\right| & \text{otherwise} \end{cases} \tag{1}$$

Here, $x_{\text{best},i}$ is the current best solution of ith iteration. The variables r_2, r_3 and r_4 are random parameters in the ranges of [0, 2π], [0, 2] and [0, 1], respectively. The variable r_1 is an iterative adaption parameter (conversion parameter) as calculated by (2), a is a constant parameter, t is the current iteration number and $t_{\max}$ is the maximum number of iterations.

$$r_1 = a\left(1 - \frac{t}{t_{\max}}\right) \tag{2}$$

The current best is compared with the best solution of the newly generated population, and the better one is saved to the next generation. The process is repeated until a termination criterion is met.

While applying SCA to PDNR problem, authors observed that the conversion parameter (r_1) has an important influence on the optimization performance of the algorithm. The performance bettered with a quadratic decreasing parameter (r_1) in place of the linearly decreasing one. So, in this work, SCA with a nonlinear decreasing conversion parameter is suggested as an improvement as per Eq. (3).

$$r_1 = a\left(1 - \frac{t}{t_{\max}}\right)^2 \tag{3}$$

In addition to this, a heuristic-based approach [26] is considered to generate the initial population, which also enhances the convergence of the overall search. Moreover, a robust load flow algorithm [27] is used for PDNR, which is explained in the next section.

3 Load Flow Method for Implementing the PDNR

Several repeated load flows need to be executed while solving the PDNR problem for a distribution system using a meta-heuristic approach [27]. Hence, a fast and efficient load flow is very important for the successful implementation of any meta-heuristic algorithm as it promptly checks the fitness of any valid configuration which are the members of a population considered. The load flow must be adaptive for the changing network topologies, and it must simultaneously ensure that the overall network remains radial and all nodes are connected to the root node. In other words, an efficient load flow method not only checks the fitness but can also be used to eliminate the invalid candidates (configurations) by checking the radiality and connectivity. In this paper, a graph theory-based load flow method is used which has all the above features and it is successfully integrated with the ISCA for solving the PDNR problem.

3.1 Basic Load Flow Method

The equivalent current injection (ECI) at bus i for kth iteration of a radial distribution network (RDN) [28] can be written as Eq. (4), where P_i and Q_i are the constant active and reactive power loads connected at bus i. I_i^k and V_i^k are the ECI and bus voltage of ith bus and for kth iteration, respectively.

$$I_i^k = \left(\frac{P_i + jQ_i}{V_i^k}\right)^* \tag{4}$$

The relation between ECIs at all buses and bus voltage deviations from the substation bus voltage for the $k+1$th iteration can be expressed using a distribution load flow (DLF) matrix [29] as:

$$\left[\Delta V^{k+1}\right] = [\text{DLF}] \cdot \left[I^k\right] \tag{5}$$

The DLF matrix can be found directly using a *path* array proposed in the next subsection. A diagonal element of DLF is found by adding the impedances of all the lines stored in the *path [ ]* concerning a particular bus, and an off-diagonal element is found by adding all the impedances of the lines which appear in common in the *path[ ]* between two concerned buses. The order of the *DLF* matrix is (nb − 1) × (nb − 1), where nb is the number of buses in the RDN.

3.2 Proposed Arrays

In order to find DLF matrix directly from the system data, the following arrays and matrices are proposed. The proposed matrices are *Adjm* and *G* (the sparse version of *Adjm*). An entry of the adjacent matrix $Adjm(u, v)= 1$ if the bus 'u' is connected to bus 'v'; otherwise it is zero. Similarly, the proposed arrays are *path[ ]* and *dist [ ]*. Two pointer arrays *mf [ ]* and *mt[ ]* are also introduced to store the start and end locations in the *path* array. First, the *dist[ ]* array is formed using Dijkstra's algorithm [30], and then, the *path* array is formed using the *dist* array. The *dist[ ]* using Dijkstra's shortest path is presented in Algorithm 1.

Algorithm 1

STEP 1: (Initialization)

- Assign the distance of root node 's' from itself as zero and its status as permanent (p), i.e. the state of node 's' is (0, p).
- Other nodes are assigned distances of value as ∞ (a very high value) and their status as temporary (t), i.e. the states of other nodes are (∞, t).
- Designate the node 's' as the current node.

STEP 2: (Distance values and current node update)
Let 'u' be the index of current node.

(1) The set V of nodes with temporary status can be reached from current node 'u' by a link (u, v), where $v \in V$ from the system data.
(2) For each $v \in V$, the distance value $dist_v$ of node v is updated as follows: $dist_v = \min\{dist_v, dist_u + Adjm(u, v)\}$
(3) Change the status of 'v' to permanent, and designate this node as the current node.

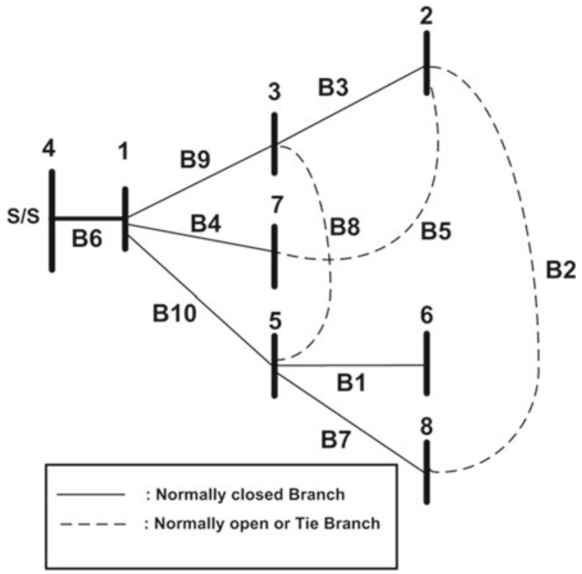

Fig. 1 Eight-bus sample RDN

STEP 3: (Termination)
If all the nodes are reached from the root node, then stop. Otherwise, go to STEP 2.

STEP 4: (Output)
The *dist* array stores the distance values of all the nodes from the root node.

Using the above algorithm, the contents of *path* and *dist* and the pointers *mf* and *mt* for a sample 8-bus RDN (Fig. 1) are formed and presented in Table 1. It is to be noted that in the sample RDN considered in Fig. 1, the nodes or buses as well as the branches (including the open switch or tie branches) are numbered and ordered arbitrarily. Even the root node is arbitrarily numbered as '4'. This arbitrariness can also be maintained in the data set of the system as the algorithm based on the proposed arrays is completely independent of any order or numbering scheme to carry out the load flow (Table 2).

3.3 Algorithm for Checking the Radial Configuration

Checking the radiality for a given data is an important feature of this approach. This check promptly sorts out the invalid members (non-radial topologies) from the population in meta-heuristic approaches before the time-consuming fitness evaluation through load flow. The Algorithm 2 describes the radiality check of the network followed by the pseudo-code to implement it.

Table 2 Contents of various arrays formed for the 8-bus sample RDNs

Bus no. [*i*]	[*m*]	*mf* [*i*]	*mf* [*i*]	dist [*i*]	path [*m*]
1	1	1	1	1	6
2	2, 3, 4	2	4	3	3, 9, 6
3	5, 6	5	6	2	9, 6
4	7	7	7	0	0
5	8, 9	8	9	2	10, 6
6	10, 11, 12	10	12	3	1, 10, 6
7	13, 14	13	14	2	4, 6
8	15, 16, 17	15	17	3	7, 10, 6

Algorithm 2

STEP 1 Create adjacency matrix (*Adjm*).
STEP 2 Create sparse matrix *G* of *Adjm* (***sparse*** is a MATLAB command of the data structure tool box, which stores only non zero entries).
STEP 3 Use depth first search (***DFS***) algorithm to find the order of bus traversal. (***DFS*** is a MATLAB command of the data structure tool box).
STEP 4 The path is mapped out between the predecessor node and the discovered node.
STEP 5 If the length of the path is equal to 2, the network is radial. Otherwise loop is present.

3.4 *Algorithm for Checking the Connectivity of All Nodes to the Root Node*

Checking connectivity of all nodes to the substation bus or root node is another important condition for PDNR which needs to be verified before fitness evaluation for a given topology. Thus, after confirming the radiality of a given network the connectivity of all nodes to the substation node is checked. For this, the traversed path for the given network is found out. If the number of buses in the traversed path is equal to the total number of buses in the network, then the graph representing the system has all nodes connected to the substation node; otherwise, discontinuity is there. Pseudo-code for this is given as Algorithm 3.

```
bus_order = graphtraverse(G, 's','Method','DFS')
if
      length(bus_order) = nb
```

```
            'The system is connected'
      else
            'The system is not connected'
   end
```

3.5 Application of the Load Flow for PDNR Problem

This load flow can be effectively used to solve the PDNR problem, particularly with a meta-heuristic approach. In a typical population-based meta-heuristic approach, each member of the population is checked for fitness in every iteration based on the objective to be fulfilled. In PDNR problem, execution of load flows for all the members of the population is almost mandatory for fitness evaluation. However, this has to be carried out only for the valid radial and fully connected topologies. The inclusion of radiality and connectivity checking before load flow execution in this proposed algorithm makes it perfectly suitable for meta-heuristic-based searching for its ability to sort out invalid members from the population before fitness evaluation. For applying the algorithm in any meta-heuristic approach, the step of random generation of open switches can be replaced by the respective local or exploitation and global or exploration-based search procedures. Last but not least that this proposed algorithm considers the set of open branch numbers as the input set for successive load flow execution. The overall flow chart for implementing the proposed ISCA-based PDNR is shown in Fig. 2.

4 Results

The proposed algorithm is implemented in MATLAB (R2011a) following the flow chart in Fig. 2. The reconfiguration results for the five test distribution systems (33, 69, 84, 119 and 136 buses) are presented in the next subsection.

4.1 Reconfiguration Results of 33, 69, 84, 119 and 136 Bus RDNs

As the overall active power loss minimization (APLM) is considered as the objective of PDNR in this paper, accordingly the reconfiguration results for the five standard RDNs (33, 69, 84, 119 and 136 buses) by the proposed ASCA algorithm are presented in Table 3. The system data for all these RDNs are available in [1]. Similarly, the

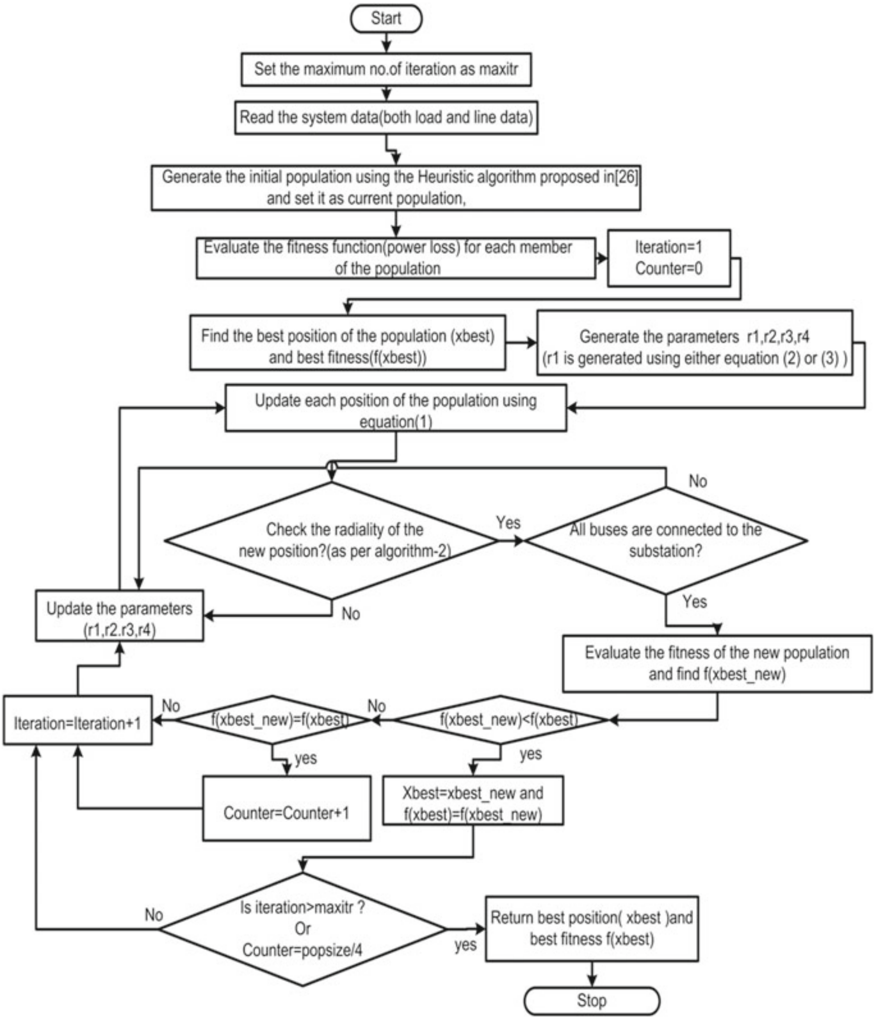

Fig. 2 Flow chart for PDNR with ISCA

optimal results as obtained by various other meta-heuristic methods are presented in Table 4.

Table 3 Reconfiguration results by the proposed method

Test systems	Initial open switches	Initial power loss (kW)	Final open switches	Final power loss (kW)	Exec. time (s)
33-bus	33–37	202.65	7, 9, 14, 32, 37	139.55	5.6
69-bus	69–73	224.97	14, 56, 61, 69, 70	98.605	9.0
84-bus	84–96	530.91	7, 13, 34, 39, 42, 55, 62, 72, 83, 86, 89, 90, 92	463.3	25
119-bus	119–133	1298.1	23, 25, 34, 39, 42, 50, 58, 71, 74, 95, 97, 109, 121, 129, 130	869	34
136-bus	136–156	320.35	7, 35, 51, 90, 96, 106, 118, 126, 135, 137, 138, 141, 142, 144–148, 150, 151, 155	280.2	50

Table 4 Reconfiguration results by other meta-heuristic method

Test systems /method	M–H used	Initial power loss (kW)	Final open switches	Final power loss (kW)	Av. exec. time (s)
33-bus [6]	RRA	202.69	7, 9, 14, 32, 37	139.55	74.7
69-bus [2]	69–73	224.95	14, 57, 61, 69, 70	98.57	26.7
84-bus [13]	84–96	526.97	7, 13, 34, 39, 42, 55, 62, 72, 83, 86, 89, 90, 92	469.1	Not reported
119-bus [16]	119–133	1298	24, 26, 35, 40, 43, 51, 59, 72, 75, 96, 98 110, 122, 130, 131	854.06	7.72
136-bus [31]	136–156	320.35	7, 35, 51, 90, 96, 106, 118, 126, 135, 137, 138, 141, 142, 144–148, 150, 151, 155	280.19	33.98

5 Conclusion

In this paper, an improved SCA has been used to solve the single objective PDNR problem. The initial population has been generated using a heuristic approach. The conversion parameter r_1 has been set to decrease nonlinearly, and a new graph theory-based load flow method has been used for solving PDNR. In most of the test systems, the algorithm has been shown to be faster and capable of obtaining global minimum results. However, the approach still requires fine tuning for avoiding local minimum traps and improving the convergence speed for becoming the best.

References

1. Mishra, S., Das, D., Paul, S.: A comprehensive review on power distribution network reconfiguration. Energy Syst. **8**(2), 227–284 (2017)
2. Faria, Jr., H., Resende, M.G.C., Ernst, D. : A biased random key genetic algorithm applied to the electric distribution network reconfiguration problem. J. Heuristics (2017). https://doi.org/10.1007/s10732-017-9355-8
3. Fathy, A., El-Arini, M., El-Baksawy, O.: An efficient methodology for optimal reconfiguration of electric distribution network considering reliability indices via binary particle swarm gravity search algorithm. Neural Comput. Appl. (2017). https://doi.org/10.1007/s00521-017-2877-z
4. Sedighizadeh, M., Esmaili, M., Moarref, A.E. : Hybrid symbiotic organisms search for optimal fuzzified joint reconfiguration and capacitor placement in electric distribution systems. INAE Lett. (2017). https://doi.org/10.1007/s41403-017-0029-5
5. Abdelaziz, M.: Distribution network reconfiguration using a genetic algorithm with varying population size. Electr. Power Syst. Res. **142**, 9–11 (2017)
6. Nguyen, T.T., Nguyen, T.T., Truong, A.V., Nguyen, Q.T., Phung, T.A.: Multi-objective electric distribution network reconfiguration solution using runner-root algorithm. Appl. Soft Comput. **52**, 93–108 (2017)
7. Muthukumar, K., Jayalalitha, S.: Integrated approach of network reconfiguration with distributed generation and shunt capacitors placement for power loss minimization in radial distribution networks. Appl. Soft Comput. **52**, 1262–1284 (2017)
8. Siavash, M., Pfeifer, C., Rahiminejad, A., Vahidi, B. : Reconfiguration of smart distribution network in the presence of renewable DG's using GWO algorithm. In: 2nd International Conference on Green Energy Technology (ICGET 2017), pp. 1–8 (2017)
9. Namachivayam, G., Sankaralingam, C., Perumal, S.K., Devanathan, S.T.: Reconfiguration and capacitor placement of radial distribution systems by modified flower pollination algorithm. Electr. Power Compon. Syst. **13**, 1492–1502 (2016)
10. Tolabi, H.B., Shakarami, M.R., Hosseini, R., Ayob, S.B.M.: Novel FGbSA: fuzzy-galaxy-based search algorithm for multi-objective reconfiguration of distribution systems. Russ. Electr. Eng. **87**(10), 588–595 (2016)
11. Souza, S.S.F., Romero, R., Pareira, J., Saraiva, J.T.: Artificial immune algorithm applied to distribution system reconfiguration with variable demand. Int. J. Electr. Power Energy Syst. **82**, 561–568 (2016)
12. Lotfipour, A., Afrakhte, H.: A discrete teaching–learning-based optimization algorithm to solve distribution system reconfiguration in presence of distributed generation. Int. J. Electr. Power Energy Syst. **82**, 264–272 (2016)
13. Rani, D.S., Subrahmanyam, M., Sydulu, N.: Multiobjective invasive weed optimization-an application to optimal network reconfiguration in radial reconfiguration systems. Int. J. Electr. Power Energy Syst. **73**, 932–942 (2015)
14. Nguyen, T.T., Truong, A.V.: Distribution network reconfiguration for power loss minimization and voltage profile improvement using cuckoo search algorithm. Int. J. Electr. Power Energy Syst. **68**, 233–242 (2015)
15. Rajaram, R., Kumar, K.S., Rajasekar, N.: Power system reconfiguration in a radial distribution network for reducing losses and to improve voltage profile using modified plant growth simulation algorithm with distributed generation. Energy Rep. **1**, 116–122 (2015)
16. Imran, A.M., Kowsalya, M.: A new power system reconfiguration scheme for power loss minimization and voltage profile enhancement using fireworks algorithm. Int. J. Electr. Power Energy Syst. **62**, 312–322 (2014)
17. Mirjalili, S.: SCA: A sine cosine algorithm for solving optimization problems. Knowl.-Based Syst. **96**, 120–133 (2016)
18. Hafez, A.I., Zawbaa, H.M., Emary, E., Hassanien, A.E.: Sine cosine optimization algorithm for feature selection. In: International Symposium on Innovations in Intelligent Systems and Applications. Sinaia, Romania (2016)

19. Sahlol, A.T., Ewees, A.A., Hemdan, A.M., Hassanien, A.E.: Training feedforward neural networks using sine-cosine algorithm to improve the prediction of lever enzymes on fish farmed on nano-selenite. In: 12th International Computer Engineering Conference. Cairo, Egypt (2016)
20. Bureerat, S., Pholdee, N.: Adaptive sine cosine algorithm integrated with differential evolution for structural damage detection. In: Garvesi, O., et al. (eds.) Computational Science and Its Applications- ICCSA 2017. LNCS, vol. 10404, pp. 71–86. Springer, Cham (2017)
21. Mahdad, B., Srairi, K.: A new interactive sine cosine algorithm for loading margin stability improvement under contingency. Electr. Eng. (2017). https://doi.org/10.1007/s00202-017-0539-x
22. Sindhu, R., Ngadiran, R., Yacob, Y.N., Zahri, N.A.H., Hariharan, M. : Sine–cosine algorithm for feature selection with elitism strategy and new updating mechanism. Neural Comput. Appl. (2017). https://doi.org/10.1007/s00521-017-2837-7
23. Kumar, N., Hussain, I., Singh, B., Panigrahy, B.K. : Single sensor based MPPT of partially shaded PV system for battery charging by using Cauchy and Gaussian sine cosine optimization. IEEE Trans. Energy Convers. (2017). https://doi.org/10.1109/tec.2017.2669518
24. Kumar, N., Hussain, I., Singh, B., Panigrahy, B.K.: Peak power detection of PS solar PV panel by using WPSCO. IET Renew. Power Gener. **11**(4), 480–489 (2017)
25. Tawhid, M.A., Savsani, V. : Multi-objective sine-cosine algorithm (MO-SCA) for multi-objective engineering design problems. Neural Comput. Appl. (2017). https://doi.org/10.1007/s00521-017-3049-x
26. Mishra, S., Das, D., Raut, U.: A simple branch exchange based network reconfiguration method for loss minimization with distributed generation. In: 1st IEEE WIE Conference on Electrical and Computer Engineering, pp. 1–5. Dhaka, Bangladesh (2015)
27. Raut, U., Mishra, S.: A robust load flow algorithm to solve power distribution network reconfiguration problem with population based meta heuristic approach. In: 6th IEEE International Conference on Computer Application in Electrical Engineering-Recent Advances (CERA-2017), pp. 74–79. Roorkee, India (2017)
28. Mishra, S.: A simple algorithm for unbalanced radial distribution system load flow. In: IEEE Region 10 Conference (TENCON-2008) Hyderabad, India, pp. 1–6 (2008)
29. Teng, J.H.: A direct approach for distribution load flow solutions. IEEE Trans. Power Delivery **18**(3), 882–887 (2003)
30. Hernandez, M., Ramos, G.: Meta-heuristic reconfiguration for future distribution networks operation. In: IEEE/PES Transmission and Distribution Conference and Exposition (2016)
31. Duan, D.L., Ling, X.D., Wu, X.Y., Zhong, B.: Reconfiguration of distribution network for loss reduction and reliability improvement based on an enhanced genetic algorithm. Electr. Power Energy Syst. **64**, 88–95 (2015)

Artificial Neural Network for Strength Prediction of Fibers' Self-compacting Concrete

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Abstract This paper investigates the applicability of artificial neural network model for strength prediction of fibers' self-compacting concrete under compression. The available 99 experimental data samples of fibers self-compacting concrete were used in this research work. In this paper, computational-based research is carried for predicting the strength of concrete under compression and model was developed using ANN with five input nodes and feed-forward three-layer back-propagation neural networks with ten hidden nodes were examined using learning algorithm. ANN model proposed analytically was verified, and it gives more compatible results. Hence, the ANN model is proposed to predict the strength of fibrous self-compacting concrete under compression.

1 Introduction

Artificial neural network (ANN) is a computing tool based on the process of genetic neural networks. The ANN techniques are applicable to civil engineering problems, because of their potentiality of learning straightly from examples. Correct response to deficient work, their ability to extract the results from minimal data, and their generalized results production are the other important properties of ANN [1]. The capabilities mentioned above give rise to ANN a very commanding mechanism to determine solution for several engineering problems, where data is insufficient [2]. The basic idea of ANN-based mathematical model for material performance is, to educate an ANN system using that material for series of experiments including enough information in the results, about the materials behavior, to succeed as a material model [3]. Such trained ANN system replicates the outcome of experiments and is also able to estimate the outcome in other experiments through their simplification potential [4].

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