Looking for cooperative organic entities in dispersed generators

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Abstract. Distributed Generations (DGs) may be optimally sized, located, and numbered using Symbiotic Organism Search (SOS), according to this research (SOS). The goal of the challenge is to reduce system power loss, taking into account the restrictions of power balance, bus voltage limitations, DG capacity limits, and DG penetration limits. While other meta-heuristic methods need control variables, the SOS technique does not. Based on the LSF, SOS helps determine the best size and location for DG units as part of a larger plan. The proposed technique has been tested on IEEE 33, 69, and 118-bus radial distribution systems, among others. Researchers have compared their findings to other studies using the SOS approach. SOS may be used to locate dispersed generating units in distribution networks, according to research.

1. Introduction

Customers are directly connected to distributed generation (DG) units through the distribution system or the meter. These include induction generators, reciprocating engines, micro turbines, fuel cells and solar photovoltaic as well as wind turbines and other small power sources. It is becoming more frequent in distribution networks for DG units because of its positive impact on the power grid. Power losses may be reduced, voltage profiles improved, pollution reduced, and power quality improved with the addition of DG units to distribution networks. There are a number of challenges with DG installation and operation that have developed because of the above benefits.

This is the typical Ideal DG Placement (ODGP) issue, which deals with determining the optimal placements and sizes of DG units to be deployed in existing distribution systems, taking into account the electrical network operating restrictions, DG operating constraints, and investment limits. ODGP problem [10], a nonlinear optimization problem involving mixed integers, is challenging to solve. Distributed generation units may have a detrimental impact on the distribution system, such as overvoltage, conductor overloading and increased losses, in addition to the correct location and size of DG units. This has led to an increased interest in the location and size of distributed generation units (DG units).

Many approaches to resolving the ODGP issue have been proposed in the past [2–6]. In addition to gradient-based methods, linear and non-linear algorithms, sequential quadratic algorithms, and dynamic algorithms are also on the list of possible methodologies. To solve a small-scale optimization issue quickly, traditional approaches might be employed. For large-scale challenges that may take a long time or never occur, they may not be able to find a solution.

Numerous academics have also examined the ODGP problem from an analytical standpoint. Using an analytical method, it was possible to reduce power losses in radial and mesh systems, according to [7]. The authors of [8] employed an analytical expression and a strategy based on exact loss calculations when selecting the suitable DG size and location to reduce total power losses. According to [9], an analytical approach that did not employ admittance, impedance, or the Jacobian matrix might determine appropriate location and size of DG to decrease total power losses.

There are several factors to consider when choosing where and how many distributed generation (DG) units to add to an existing distribution system, including the restrictions of the electrical network, DG operation constraints, and investment limits. In nonlinear optimization, ODGP [10] is the mixed-integer version. Distribution systems with high numbers of DG units may experience overvoltage, conductor overloading, and increased losses due to their size and location. The location and size of DG units have been the subject of several research efforts.

In recent years, meta-heuristic search strategies have become increasingly popular for handling the ODGP problem due to their straightforward implementation and ability to uncover near-optimal solutions for challenging optimization challenges.

Meta-heuristic methods such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Tabu Search (TS), Particle Swarm Optimization (PSO), Cuckoo Search (CS), Harmony Search Algorithm (HSA) [8], Grey Wolf Optimizer (GWO), Bacterial Foraging Optimization Algorithm (BFOA) [1], Flower Pollination Algorithm (FPA), Gravitational Search Algorithm (GSA) [(GSA).

[1, 12], and 10] are examples of studies that used GA to optimize the placement and size of DG units in distribution networks for energy storage purposes. This issue may be solved using a combination of single and hybrid approaches, such as a combination of PSO with OPF and a combination of GA and PSO [6–7].

There have been encouraging outcomes using the methods indicated above to locate and size distributed generation units. Many research did not take into account the proper quantity of DG units. Therefore, this study attempts to provide a novel and fast method for determining the optimal number of DG units in distribution networks in order to minimize active power loss. DG unit size, placement, and quantity should be based on the SOS in order to determine the most suitable DG unit for distribution networks. It was a new metaheuristic optimization strategy that Cheng and Prayogo devised in 2014 [28] with the invention of the SOS algorithm.

This method was honed by observing the interactions between many species in their natural habitats. This approach may be used to tackle a wide range of numerical optimization problems. LSF is utilized to identify which bus is most sensitive, and SOS is used to compute ideal unit sizes at potential sites to reduce the objective function for DG installation. IEEE 33, IEEE 69, and IEEE 118 bus systems were all employed in the testing. The findings of the proposed approach were compared to those of previously reported methods.

2. Formulation of a Problem

The ODGP challenge is to decrease active power loss while fulfilling operational restrictions. Mathematical formulation of ODGP issue:

The Objective Function

Goal function described below:

$$F = \min(TPL), \tag{1}$$

where TPL is the system's total active power loss.

Discussion of the Data and the Findings

Population sizes from 0.1 to 1.0 have been used to determine the optimal option. In this investigation, SOS will employ the lowest population size feasible, given by the fitness function. Twenty trials are run for each system to discover the best way to operate. This reexamination will examine fixed and optimal DG unit counts. SOS results for systems with a fixed number of DG units.

It has also been done in the case of an optimum DG unit count to compare results. A total of 10000 fitness function evaluations may be performed for each of the three test systems using the following PSO control parameters: 100 for each system, c1 = c2, 2, wmax = 0,5, wmin = 0. Additional 20 independent PSO runs were done to ensure the optimal solution was found.

The IEEE 33-Bus Radial Distribution System

To put this system through its paces, there are 33 main buses and 32 side branches. Maximum amount of DG power that may be absorbed is 4.369 MVA. 12.66 kV is the voltage at which this system operates at its lowest point.

In the system, the active and reactive power losses are 210.99 kW and 143.13 kVAr, computed from the power flow. Indicators from the LSF are used to identify possible buses for the DG site. All buses' LSF values may be seen in Tab 1.

It has been shown that a step-size increment of 20 was the most effective way to determine the ideal population size for SOS. Because of this, the optimal size is 50, which has the best fitness function value. It's important to use size of 50 and a maximum fitness function evaluation count of 10000 for SOS in this part.

Tab. 1: The 33-bus system's LSF values.

Bus No.	(descending order)	norm(i) = $V(i)/0.95$	**Base Voltage**	**Flag of DG**

6	0.0173317	0.9994401	0.9494681	1
3	0.0139407	1.0346128	0.9828821	0
28	0.0138088	0.9826654	0.9335321	1
29	0.0103590	0.9740129	0.9253122	1
8	0.0103237	0.9813551	0.9322874	1
5	0.0080811	1.0188907	0.9679462	0
4	0.0080733	1.0267079	0.9753725	0
30	0.0060512	0.9702674	0.9217540	1
9	0.0047535	0.9746892	0.9259547	1
24	0.0047501	1.0238154	0.9726247	0
13	0.0045614	0.9595139	0.9115382	1
10	0.0045149	0.9685237	0.9200975	1
27	0.0037555	0.9947096	0.9449741	1
31	0.0030365	0.9658863	0.9175920	1
2	0.0028204	1.0494889	0.9970145	0
26	0.0027433	0.9974088	0.9475384	1
23	0.0026717	1.0308381	0.9792962	0
25	0.0023800	1.0203152	0.9692995	0
20	0.0022880	1.0451668	0.9929084	0
14	0.0013972	0.9571033	0.9092482	1
7	0.0013803	0.9957298	0.9459433	1
12	0.0013538	0.9660146	0.9177139	1
17	0.0011808	0.9519908	0.9043912	1
16	0.0009111	0.9541467	0.9064393	1
15	0.0008107	0.9556014	0.9078213	1
11	0.0007965	0.9676092	0.9192287	1
32	0.0006456	0.9649225	0.9166764	1
18	0.0004473	0.9513452	0.9037779	1
21	0.0004155	1.0444252	0.9922039	0

22	0.0003599	1.0437542	0.9915665	0
19	0.0003317	1.0489327	0.9964861	0
33	0.0002027	0.9646238	0.9163927	1

Number of DG Units to Use

The best way to decide how many DG units to put in a system is to do a thorough investigation of the various installation alternatives. That's why it takes a certain amount of DG units to solve the problem more than once. According to our research, it is best to have as few DG units as possible in order to get the lowest active power loss possible.

To get the lowest active power loss by unit number, use the 12th DG, which has an active power loss of 76.767kW.

For PSO and SOS, Table 3 gives the most efficient unit count. However, the overall power loss experienced by suggested strategy is somewhat smaller than that of PSO method even if both methods achieve the same optimal number DG units. Recommendation for a strategy As a result,proposed SOS-based technique may be useful for determining the best position and size for DG units in an IEEE 33-bus radial distribution system.

Tab. 3: A 33-bus system with 12 DG units yielded the following SOS and PSO results:

Power loss (kW)		**Total DG power output (MW)**	
PSO	**SOS**	**PSO**	**SOS**
77.033802	76.967104	2.509317482	2.509000089

Number of DG Units to Use

According to the proposed method, different DG unit counts from 1 to 22 were analyzed to find the appropriate number of DG units used to reduce total power losses & active power loss.

Tab. 4: For the 69-bus system with a set number of DG units, outcomes were compared.

Method	**Number of DG Units**	**Optimal result**			
		DG size in MW (location)			**Loss (kW)**
		DG1	**DG2**	**DG3**	
HSA [19]	1	1.4363 (65)	-	-	112.10
	2	0.0544 (65)	1.5932 (64)	-	96.56
	3	0.0149 (65)	0.1416 (64)	1.6283 (63)	86.66

GA [27]	1	-			
	2	-			
	3	0.9297 (21)	1.0752 (62)	0.9925 (64)	89.0
PSO [27]	1	-			
	2	-			
	3	0.9925 (17)	1.1998 (61)	0.7956 (63)	83.2
TLBO [33]	1	-			
	2	-			
	3	1.0134 (13)	0.9901 (61)	1.1601 (62)	82.172
SOS	1	2.087 (57)	-	-	118.62
	2	0.3612 (57)	1.6948 (58)	-	102.92
	3	0.2588 (57)	0.2 (58)	1.5247 (61)	82.07

Conclusion

Using an SOS-based technique, researchers were able to deal with best placement of scattered generators in distribution systems. Considerations such as distribution unit's location and size, as well as how many were needed. It is important to consider the loss sensitivity factor while deciding how many generators (DGs) to utilize. Tests of the suggested technique have been conducted on IEEE 33-, 69-, and 118-bus radial distribution systems, and the results obtained have been confirmed by comparing them to those obtained by other methods described in the literature. An SOS-based strategy has been shown to be successful in tackling the challenge of optimally locating dispersed generators.

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