Brachytrupes Algorithm for Solving Optimal Reactive Power Problem

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ABSTRACT

In this work Brachytrupes Algorithm (BA) has been utilized to solve the optimal reactive power flow problem. Brachytrupes are predominantly cylindrical, and vertically flattened one. Its head is sphere-shaped with extended slender antennae arise from cone-shaped scapes. Pronotum is trapezoidal in shape, vigorous, and well-sclerotinized. A pair of long cerci is present at the tip of the abdomen. Ovipositor shape is cylindrical, long, narrow, smooth and shiny in the female brachytrupes. Back pair of legs generally known as the femora are significantly enlarged for jumping. A number of moveable spurs are there in the hind legs. One or more tympani are present in the tibiae of the front legs which are used for the reception of sound. Projected algorithm presumes that the probability of a Brachytrupes sound for resentment is p which is between 0 and 1. Once a Brachytrupes makes sound for resentment, it is whispered that they randomly walk to another male Brachytrupes for brawl. The convincing Brachytrupes takes consign of the solution and eradicate the loser Brachytrupes. Female Brachytrupes are seduced by male Brachytrupes sound for mating while remaining male Brachytrupes will move away. Brachytrupes will mate and generate offspring. They progress to an innovative place, which means they are taken to enhanced location in the search space. Proposed Brachytrupes Algorithm (BA) has been validated in standard IEEE 57, 300 test systems. Real Power loss has been reduced when compared to other standard reported algorithms.

1. INTRODUCTION

Reactive power optimization problem plays key role in protected & profitable operation of the power system. Numerous conventional methods [1-6] have been used already for solving the problem. A variety of drawbacks have been found in the conventional methods and mainly difficulty in handling the inequality constraints. Last two decades many evolutionary algorithms [7-14]. In this work Brachytrupes Algorithm (BA) has been utilized to solve the optimal reactive power flow problem. Brachytrupes are predominantly cylindrical, and vertically flattened one. Its head is sphere-shaped with extended slender antennae arise from cone-shaped scapes. Pronotum is trapezoidal in shape, vigorous, and well-sclerotinized. A pair of long cerci is present at the tip of the abdomen. Ovipositor shape is cylindrical, long, narrow, smooth and shiny in the female brachytrupes. Back pair of legs generally known as the femora are significantly enlarged for jumping. A number of moveable spurs are there in the hind legs. One or more tympani are present in the tibiae of the front legs which are used for the reception of sound. On the body of Brachytrupes the wings are lie in flat mode and the fore wings are elytra made of tough chitin, stand-in as a protective guard for the soft parts of the body. In male Brachytrupes, stridulatory organ are present for the making of sound. Frequency and velocity of the sound is calculated. Secondly, when one Brachytrupes make sound for resentment other male Brachytrupes are beguile and other female Brachytrupes will move away. But All Brachytrupes will not make sound for resentment. Projected algorithm presumes that the

probability of a Brachytrupes sound for resentment is p which is between 0 and 1. Once a Brachytrupes makes sound for resentment, it is whispered that they randomly walk to another male Brachytrupes for brawl. The convincing Brachytrupes takes consign of the solution and eradicate the loser Brachytrupes. Female Brachytrupes are seduced by male Brachytrupes sound for mating while remaining male Brachytrupes will move away. Brachytrupes will mate and generate offspring. They progress to an innovative place, which means they are taken to enhanced location in the search space. Proposed Brachytrupes Algorithm (BA) has been validated in standard IEEE 57, 300 test systems. Real Power loss has been reduced when compared to other standard reported algorithms.

2. PROBLEM FORMULATION

Objective of the problem is to reduce the true power loss:

$$F = P_L = \sum_{k \in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_iV_j\cos\theta_{ij} \right) \tag{1}$$

Voltage deviation given as follows:

$$F = P_L + \omega_v \times \textbf{Voltage Deviation} \tag{2}$$

Voltage deviation given by:

$$\textbf{Voltage Deviation} = \sum_{i=1}^{Npq} |V_i - 1| \tag{3}$$

Constraint (Equality)

$$P_G = P_D + P_L \qquad (4)$$

Constraints (Inequality)

$$P_{gslack}^{min} \leq P_{gslack} \leq P_{gslack}^{max} \qquad (5)$$

$$Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}, i \in N_g \qquad (6)$$

$$V_i^{min} \leq V_i \leq V_i^{max}, i \in N \qquad (7)$$

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in N_T \qquad (8)$$

$$Q_C^{min} \leq Q_C \leq Q_C^{max}, i \in N_C \qquad (9)$$

3. BRACHYTRUPES ALGORITHM

Brachytrupes are predominantly cylindrical, and vertically flattened one. Its head is sphere-shaped with extended slender antennae arise from cone-shaped scapes. Pronotum is trapezoidal in shape, vigorous, and well-sclerotinized.

A pair of long cerci is present at the tip of the abdomen. Ovipositor shape is cylindrical, long, narrow, smooth and shiny in the female Brachytrupes. Back pair of legs generally known as the femora are significantly enlarged for jumping. A number of moveable spurs are there in the hind legs. One or more tympani are present in the tibiae of the front legs which are used for the reception of sound.

On the body of Brachytrupes the wings are lie in flat mode and the fore wings are elytra made of tough chitin, stand-in as a protective guard for the soft parts of the body. In male Brachytrupes, stridulatory organ are present for the making of sound. Frequency and velocity of the sound is calculated. Secondly, when one Brachytrupe make sound for resentment other male Brachytrupes are beguile and other female Brachytrupes will move away. But All Brachytrupes will not make sound for resentment. Projected algorithm presumes that the probability of a Brachytrupes sound for resentment is p which is between 0 and 1. Once a Brachytrupes makes sound for resentment, it is whispered that they randomly walk to another male Brachytrupes for brawl. The convincing Brachytrupes takes consign of the solution and eradicate the loser Brachytrupes. Female Brachytrupes are seduced by male Brachytrupes sound for mating while remaining male Brachytrupes will move away. Brachytrupes will mate and generate offspring. They progress to an innovative place, which means they are taken to enhanced location in the search space.

3.1 Calculation of sound rate

The rate at which Brachytrupes makes sound is depend on relationship of air and temperature
Number of sound per minute (N$_S$) is calculated with temperature (T$_S$)

$$T_s = 49.80 + \frac{N_c - 38.90}{3.85} \qquad (10)$$

Number of sound per minute (N$_S$) is calculated with temperature (T$_S$) in Celsius (T$_{cs}$), is given by,

$$T_{cs} = 9.76 + \frac{N_c - 38.90}{6.89} \qquad (11)$$

At certain temperature T$_c$ and T$_f$, the sound rate is given by,

$$N_s = (T_{cs} - 9.76) * 6.89 + 38.90 \qquad (12)$$

$$N_s = (T_s - 49.80) * 3.95 + 38.90 \qquad (13)$$

Brachytrupes sound is computed based on the sound rate N$_s$, with respect to frequency F and velocity V

$$F_{cs} = N_s * \gamma \qquad (14)$$

$$Vl = Fr * \lambda \qquad (15)$$

Each Brachytrupes step size of is computed as follows:

$$distance = \frac{Vl}{Fr} \qquad (16)$$

$$Step\ size = \beta * distance * (location - Best\ location) \qquad (17)$$

New-fangled position of the Brachytrupes is calculated by,

$$New\_fangled\ position = location + step\ size * \gamma \qquad (18)$$

Step 1

By using equations; $T_s = 49.80 + \frac{N_c - 38.90}{3.85}$ or $T_{cs} = 9.76 + \frac{N_c - 38.90}{6.89}$ sound rate of each Brachytrupes will be computed.

By using equations; $F_{cs} = N_s * \gamma$ and $Vl = Fr * \lambda$ Brachytrupes frequency, velocity will be computed.

By using equations; $distance = \frac{Vl}{Fr}$ and $Step\ size = \beta * distance * (location - Best\ location)$ step size will be computed.

By using the equation New_fangled position = $location + step\ size * \gamma$ Brachytrupes new positions will be updated.

Revisit of Brachytrupes towards novel locations
End

Step 2

With respect to new location Male Brachytrupes randomly will pick a female Brachytrupes

A incise point will be chosen for the above procedure

Similar to a crossover in Genetic algorithm; genetic materials of both male and female Brachytrupes will be intermingled with reference to their incise point to generate two new-fangled offspring's.

Fitness of the offspring will be computed

Movement towards the new locations by the two offspring's and the parents Brachytrupes
End

Step 3

Brachytrupes will walk to new locations when random > P

Fitness value of the Brachytrupes will be calculated in accordance to new locations

Best Brachytrupes will be chosen for further procedure

Movement towards the new locations by the Brachytrupes
End

3.2 Main procedure

Brachytrupes position will be located
Female Brachytrupes has to be chosen
Fitness value of each Brachytrupes has to be calculated
With respect to position choose the most excellent
Brachytrupes $f_{best\_Brachytrupes}$
Set $g_{best\_Brachytrupes}$ as the present $f_{best\_Brachytrupes}$ and in the preliminary generation $g_{best\_Brachytrupes}$-$f_{best\_Brachytrupes}$
While (stop criteria is not met)
Then
Sound for mating – (step1)
Male Brachytrupes to mate with female Brachytrupes – (step2)
Sound for resentment with probability P – (step3)
Fitness value will be calculated
From the innovative positions choose the $f_{best\_Brachytrupes}$,

Modify $g_{best\_Brachytrupes}$ with the present $f_{best\_Brachytrupes}$. When $f_{best\_Brachytrupes}$>$g_{best\_Brachytrupes}$,
End while
Revisit to comprehensive best Brachytrupes at cessation
End

4. SIMULATION RESULTS

Performance of the proposed Brachytrupes Algorithm (BA) has been validated by tested in standard IEEE 57 bus system [15]. Total active and reactive power demands in the system are 1248.23 MW and 334.16 MVAR. Generator data the system is given in Table 1. The optimum loss comparison is presented in Table 2. Figure 1 gives the comparison of active power loss.

Table 1. Generator data

Generator No	Pgi minimum	Pgi maximum	Qgi minimum	Qgi maximum
1	25.00	50.00	0.00	0.00
2	15.00	90.00	-17.00	50.00
3	10.00	500.00	-10.00	60.00
4	10.00	50.00	-8.00	25.00
5	12.00	50.00	-140.00	200.00
6	10.00	360.00	-3.00	9.00
7	50.00	550.00	-50.00	155.00

Table 2. Comparison of losses

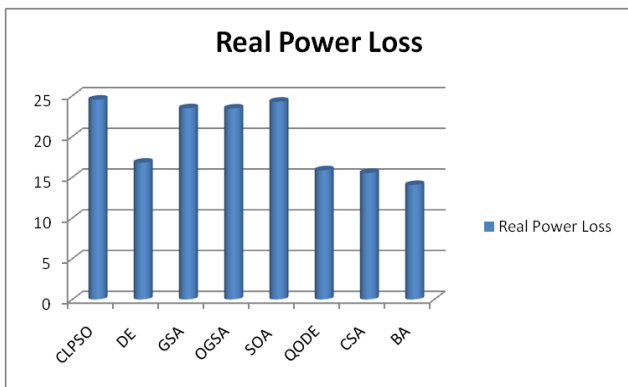| Parameter	CLPSO [17]	DE [16]	GSA [16]	OGSA [18]	SOA [17]	QODE [16]	CSA [19]	BA
PLOSS (MW)	24.5152	16.7857	23.4611	23.43	24.2654	15.8473	15.5149	14.0412

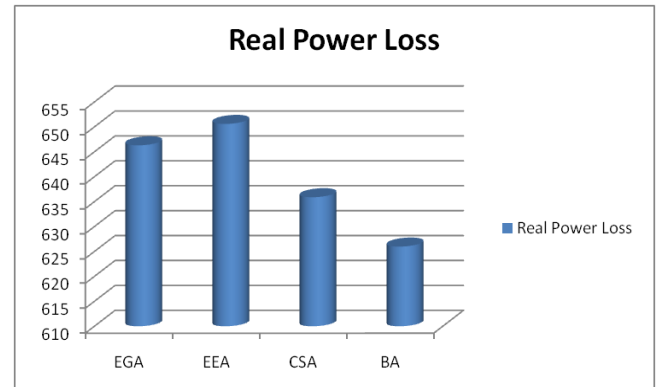**Figure 1.** Comparison of active power loss

Figure 2. Real power loss comparison

Then the performance of the proposed Brachytrupes Algorithm (BA) has been tested in standard IEEE 300 bus system [15]. Table 3 shows the comparison of real power loss obtained after optimization. Figure 2 gives the comparison of real power loss.

Table 3. Comparison of real power loss

Parameter	EGA [20]	EEA [20]	CSA [19]	BA
PLOSS (MW)	646.2998	650.6027	635.8942	625.9864

5. CONCLUSION

In this paper Brachytrupes Algorithm (BA) successfully solved the optimal reactive power problem. Projected algorithm presumes that the probability of a Brachytrupes sound for resentment is p which is between 0 and 1. The convincing Brachytrupes takes consign of the solution and eradicate the loser Brachytrupes. Female Brachytrupes are seduced by male Brachytrupes sound for mating while remaining male Brachytrupes will move away. Brachytrupes will mate and generate offspring. They progress to an innovative place, which means they are taken to enhanced location in the search space. Proposed Brachytrupes

Algorithm (BA) has been validated in standard IEEE 57, 300 test systems. Real Power loss has been reduced when compared to other standard reported algorithms.

REFERENCES

[1] Lee KY. (1984). Fuel-cost minimisation for both real andreactive-power dispatches. Proceedings Generation, Transmission and Distribution Conference 131(3): 85-93.

[2] Deeb NI. (1998). An efficient technique for reactive power dispatch using a revised linear programming approach, Electric Power System Research 15(2): 121-134. https://doi.org/10.1016/0378-7796(88)90016-8

[3] Bjelogrlic MR, Calovic MS, Babic BS. (1990). Application of Newton's optimal power flow in voltage/reactive power control. IEEE Trans Power System 5(4): 1447-1454.

[4] Granville S. (1994). Optimal reactive dispatch through interior point methods. IEEE Transactions on Power System 9(1): 136-146. http://dx.doi.org/10.1109/59.317548

[5] Grudinin N. (1998). Reactive power optimization using successive quadratic programming method. IEEE Transactions on Power System 13(4): 1219-1225. http://dx.doi.org/10.1109/59.736232

[6] Yan W, Yu J, Yu DC, Bhattarai K. (2006). A new optimal reactive power flow model in rectangular form and its solution by predictor corrector primal dual interior point method. IEEE Trans. Pwr. Syst 21(1): 61-67. http://dx.doi.org/10.1109/TPWRS.2005.861978

[7] Aparajita M, Vivekananda M. (2015). Solution of optimal reactive power dispatch by chaotic krill herd algorithm. IET Generation, Transmission, Distribution, 9(15): 2351-2362. http://dx.doi.org/10.1049/iet-gtd.2015.0077

[8] Hu Z, Wang X. (2010). Stochastic optimal reactive power dispatch: Formulation and solution method. Electric Power Energy Syst 32: 615-621. http://dx.doi.org/10.1016/j.ijepes.2009.11.018

[9] Morgan MAP, Abdullah RH, Sulaiman MH, Mustafa M, Samad R. (2016). Multi-objective evolutionary programming (MOEP) using mutation based on adaptive mutation operator (AMO) applied for optimal reactive power dispatch. ARPN Journal of Engineering and Applied Sciences 11(14): 1-20.

[10] Pandiarajan K, Babulal CK. (2016). Fuzzy harmony search algorithm based optimal power flow for power system security enhancement. International Journal Electric Power Energy Syst 78: 72-79. https://doi.org/10.1016/j.ijepes.2015.11.053

[11] Morgan M, Abdullah NRH, Sulaiman MH, Mustafa M, Samad R. (2016). Benchmark Studies on optimal reactive power dispatch (ORPD) based multi-objective evolutionary programming (MOEP) using mutation based on adaptive mutation adapter (AMO) and polynomial mutation operator (PMO). Journal of Electrical Systems 12-21.

[12] Mei RGS, Sulaiman MH, Mustaffa Z. (2016). Ant lion optimizer for optimal reactive power dispatch solution. Journal of Electrical Systems, AMPE2015 68-74.

[13] Gagliano A, Nocera F. (2017). Analysis of the performances of electric energy storage in residential applications, International Journal of Heat and Technology 35(S1): S41-S48. https://doi.org/10.18280/ijht.35Sp0106

[14] Caldera M, Ungaro P, Cammarata G, Puglisi G. (2018). Survey-based analysis of the electrical energy demand in Italian households. Mathematical Modelling of Engineering Problems 5(3): 217-224. https://doi.org/10.18280/mmep.050313

[15] Power Systems Test Case Archive. Available. http://www2.ee.washington.edu/research/pstca/, accessed on November 11, 2018.

[16] Basu M. (2016). Quasi-oppositional differential evolution for optimal reactive power dispatch. Electrical Power and Energy Systems 78: 29-40. https://doi.org/10.1016/j.ijepes.2015.11.067

[17] Dai C. (2009). Seeker optimization algorithm for optimal reactive power dispatch. IEEE Trans. Power Systems 24(3): 1218-1231.

[18] Shaw B. (2014). Solution of reactive power dispatch of power systems by an opposition-based gravitational search algorithm. International Journal of Electrical Power Energy Systems 55: 29-40. https://doi.org/10.1016/j.ijepes.2013.08.010

[19] Reddy SS. (2017). Optimal reactive power scheduling using cuckoo search algorithm. International Journal of Electrical and Computer Engineering 7(5): 2349-2356.

[20] Reddy SS. (2014). Faster evolutionary algorithm based optimal power flow using incremental variables. Electrical Power and Energy Systems 54: 198-210. https://doi.org/10.1016/j.ijepes.2013.07.019